Annual Planning Outlook

Ontario's electricity system needs: 2025-2050

March 2024

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Executive Summary

The energy transformation in Ontario is gathering momentum. Consistent with previous Annual Planning Outlooks (APO), the demand forecast continues to show steady demand growth year over year, with total demand increasing 60 per cent over the next twenty five years.

The IESO has completed, launched and announced plans for various procurements since the last APO that will ensure Ontario's electricity needs are met through the mid-2030s. While there is still a lot of work ahead in 2024 and beyond to deliver, real progress is being made to reshape our current electricity system to meet the needs of a growing and decarbonizing economy.

Our forecasts continue to show demand will, on average, increase two per cent a year over the coming decades, from 154 TWh in 2025 to 245 TWh by 2050. This is driven primarily by economic and population growth, mining and steel industry electrification, and growth in electric-vehicle industries. Daily electricity use patterns are also changing as consumers embrace electric vehicles, industry begins to electrify their processes and local greenhouses continue to increase agricultural production. The latest forecast shows Ontario transitioning from a summer-peaking region to a dual-peaking region beginning in 2030, with summer and winter electricity peaks being comparable at approximately 27,000 MW.

While demand is growing, consumers are also playing their part. The APO forecasts that more and more consumers and businesses are expected to invest in energy management through increased energy-efficiency standards for buildings and equipment, and participation in conservation and demand management programs, including those providing real-time demand flexibility to the grid. The IESO's CDM programs delivered to consumers under the Save on Energy brand are expected to contribute savings of between 14 TWh to 17 TWh from 2025 to 2050.

Thanks to the efforts of many power suppliers across the province and beyond, the supply outlook for Ontario has improved. Since the last outlook, the IESO has addressed capacity shortfalls that had previously been forecasted for the mid-2020s due to nuclear refurbishments and retirements as well as expiring contracts. These shortfalls have been filled as a result of Resource Adequacy Framework procurements, increased conservation and demand management targets and other government initiatives. These include 1,535 MW of supply from the Expedited Long-Term RFP and Same Technology Upgrades Solicitation, with more capacity to be secured through the Long-Term 1 RFP later this year. The IESO is also set to extend the Brighton Beach contract, and has finalized a contract with the Oneida energy storage project to come in service in 2025.

This APO reinforces the importance of a regular cadence of procurements to flexibly meet Ontario's near- to long-term needs, allowing for a reassessment of needs as time progresses and to take advantage of technological advances and associated reductions in costs. As a result, new to this APO is the incorporation of the information formerly in the *Annual Acquisition Report* that sets out upcoming procurements activities and targets.

Looking ahead, the next annual Capacity Auction is scheduled for Q4 2024 and will continue to be relied upon to secure increasing amounts of capacity to meet reliability needs, with a target of

1,600 MW for the summer 2025 obligation period, and 1,000 MW for winter 2025-2026. The IESO will increase the minimum target capacity for future auctions from no less than 500 MW to no less than 1,000 MW, to set a predictable and stable marketplace. Medium-term procurements to reacquire existing resources with expiring contracts will continue to be executed in accordance with the Resource Adequacy Framework.

Over the 2030-2034 period, the APO shows an approximately 5,000 MW and 15 TWh supply shortfall emerging as a result of increasing demand and expiring contracts. The next long-term procurement (LT2 RFP) will be launching later this year with an expected target of 5 TWh for non-emitting energy supply, with more procurements to follow.

As outlined in the IESO's Evaluating Procurement Options for Supply Adequacy report, when compared to past procurements, the upcoming LT2 RFP is expected to ensure even more cost-effective acquisitions of wind and solar considering pricing trends. As technological advancements and process improvements continue to be made for wind and solar, the capital costs of new wind and solar projects have decreased since 2017 and are expected to continue to fall in the long term.

The IESO’s competitive procurement process is also structured to deliver maximum ratepayer value, helping to ensure the most cost-effective proposals are chosen. For example, the Supply Adequacy report identified current average benchmark prices for current competitively procured wind resources are less than half of the average rate for wind procured through the Feed-In-Tariff (FIT) program of the mid-2000s.

There are also potential options for further expanding Ontario’s nuclear fleet – this APO considers a high nuclear case that looks at a Pickering Nuclear B refurbishment, which has provincial support to proceed, as well as additional units at Bruce C and how they change the adequacy outlook.

An expanded electricity transmission system is the key to delivering new energy supplies and setting the energy transformation in motion. By working with Indigenous communities, municipalities, businesses and residents on regional electricity plans, new lines have been energized to serve growing needs in southwestern Ontario, northern Ontario, Toronto and eastern Ontario to enable economic and population growth.

More work needs to be done to resolve known transmission system issues to support growth while facilitating a changing supply mix. Bulk transmission studies to assess future reliability and capabilities to meet economic and decarbonization goals in western, southern and central Ontario, including the Greater Toronto Area, will kick off in 2024. These efforts are outlined in the Transmission Planning (Schedule of Planning Activities) section. The IESO is developing regional plans, working with local communities and Indigenous communities to ensure the transmission system not only keeps pace with growing needs but also aligns with local priorities.

Ontario’s supply mix post-2035 is highly dependent on the evolution and timing of government policy. While the APO’s analysis of capacity and energy needs starting 2035 did not include the potential contribution of existing emitting resources, these resources are expected to continue to be available. The implementation of the federal Clean Electricity Regulations (CER), as well as the composition of Ontario’s future supply mix, will define how these resources are utilized. As a result, the remaining capacity and energy needs are highly dependent on the CER. Further to the feedback the IESO submitted on the draft federal CER, the provincial government asked the IESO to continue to build on our analysis in a report-back to the Ministry of Energy that assesses the draft regulation's impacts to reliability and cost. Other policy announcements including the government's response to the report and recommendations recently released by the Electrification and Energy Transition Panel and other government actions will be considered in future APOs.

Table of Contents

List of Figures

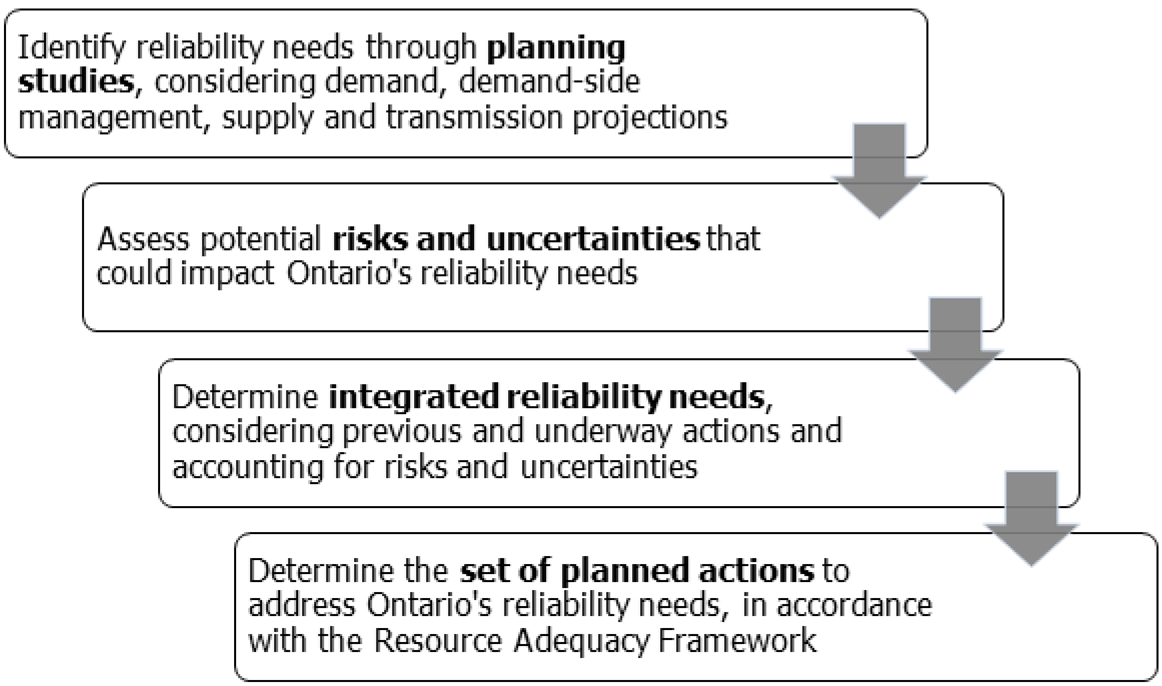
List of Tables

1. Introduction

1.1 How to Interpret the Outlook

The Independent Electricity System Operator's (IESO's) *Annual Planning Outlook* (APO) uses data and market intelligence to identify system needs over the 2025-2050 outlook period as well as the factors that influence these needs, and it provides insights into what will be required to prepare for a reliable, cost-effective and sustainable electricity future in Ontario. The findings inform the development of the planned actions that are required to address future system needs. New this year, the former IESO *Annual Acquisition Report* (AAR) is now integrated into the APO, and the planned actions are included in this document. The planning processes are described in Figure 1 below.

Figure 1 | Process to Determine Planned Actions to Address Reliability Needs



The APO is intended to provide sector participants, governments, municipalities, Indigenous communities and electricity consumers, amongst others, with the data and analyses they need to make informed decisions, and to communicate valuable information to policy-makers and others interested in learning more about the developments shaping Ontario's electricity system.

The assumptions underpinning the APO are based on current system conditions and the best available information about demand, supply, transmission infrastructure and other factors that may influence the results of these studies. The APO acknowledges that there may be uncertainties that impact the outlook, but it does not speculate on future changes to Ontario's demand forecast and supply mix unless they are expected to result from the latest available economic data projections, committed government policy or announced actions by the IESO, government or sector participants.

In reality, significant changes to the factors underpinning the APO are expected during the outlook period, which may influence Ontario's demand and supply mix, and the outlooks presented should, therefore, be interpreted with this expectation in mind. By updating and publishing the APO regularly, and performing other studies on a regular basis, the IESO seeks to better capture the evolving nature of Ontario's electricity system.

1.2 Report Contents

Section 2: Demand Forecast explores long-term demand, walking readers through the changing composition of demand by sector and the resulting effect on overall demand. It also examines the projected impact of conservation and demand management (CDM) programs, building codes and equipment standards, and the Industrial Conservation Initiative (ICI) on reducing that demand.

Section 3: Supply Outlook and Transmission Assumptions assesses the availability of resources over the outlook period. This section also looks at the transmission projects expected to come into service within the outlook period that are considered in the base case for resource adequacy and transmission security assessments.

Section 4: Resource Adequacy compares the demand forecast with anticipated resource performance, taking into account demand forecast uncertainty, transmission constraints and the unavailability of resources due to outages and intermittent generation. This section also examines Ontario's capacity and energy adequacy.

Section 5: Transmission System Reliability explores system needs arising from the requirement to meet transmission planning standards, as well as the impact of government policy. These transmission system needs inform the Planned Actions, including a schedule of transmission plans to be initiated.

Section 6: Operability describes some of the operability assessments that are conducted today to determine the ability of the system to respond to conditions in real time and provides the results of the IESO's regulation needs assessment.

Section 7: Risks and Uncertainties describes factors that could impact Ontario's electricity needs, which were considered in developing the set of planned actions in this report.

Section 8: Integrated Reliability Needs builds on the resource and transmission needs described in Sections 4 and 5 by considering previous and underway actions to meet reliability needs as well as the potential impact of various risks and uncertainties described in Section 7 that may materialize.

Section 9: Planned Actions specifies actions to address needs in the near term as well as the significant capacity, energy and transmission system needs emerging at the end of the decade and into the early 2030s.

1.3 Changes and Updates Since the 2022 APO

This outlook supersedes the outlook published in December 2022.

Major changes to the demand forecast include updated residential building space-heating and space-cooling profiles, incremental industrial sector development, higher transportation sector electricity demand, updated CDM program savings and revised ICI modelling. These changes are further detailed below:

- Updated residential sector building space-heating and space-cooling load profiles with increased geographical specificity, providing increased forecast accuracy.
- Incremental industrial sector electricity demand resulting in higher levels of forecasted demand, stemming from:
  - updated details of announced projects in the primary metal production sub-sector, enabling the province's transition to green steel, at Algoma Steel and ArcelorMittal Dofasco;
  - the development of new additional electric-vehicle (EV) battery cell production and its supply chain in Ontario; and
  - increasing facility electrification and assumed growth in mineral extraction and processing sub-sector in northern Ontario in the long term of the outlook period.
- Similar to the 2022 APO, transportation electrification includes the forecasted impacts from the federal government's target for at least 60 per cent of sales of new light-duty vehicles to be zero-emission by 2030. New for this year, a variety of assumptions have been updated based on recent research, including separately modelled electrification of medium- and heavy-duty vehicles, resulting in higher levels of forecasted demand.
- CDM program savings forecasts have been updated to include budget and target enhancements to the current 2021-2024 Conservation and Demand Management Framework, recent program results as well as changes to federal government-funded programs, resulting in lower levels of forecasted demand.
- The ICI forecast has been updated to reflect the forecasted change in system peak-day seasonality and hourly demand profiles over the course of the outlook period.

The supply outlook includes new and existing resources, including resources committed through actions undertaken by the IESO and/or informed by government policy at the time of development. While the 2022 APO included Capacity Auction forward guidance targets as part of the supply outlook, the supply case in this APO does not include the expected contribution of Capacity Auction resources, to better highlight system needs and establish targets in response to the needs.

The intention of this document is to identify future system requirements and factors that influence them. This then informs the development of actions needed for upcoming acquisitions within the Resource Adequacy Framework.

As with the 2022 APO, this year's assessment does not use a proxy resource to address system requirements; instead, the capacity and energy requirements of the system are represented "as is." The electricity system will see energy requirements grow in 2029. This document does not speculate on future supply mixes as they depend on resources secured in future procurements, government policy and other factors. The diversity of future supply mixes will directly impact interjurisdictional trade, marginal costs and emissions of the electricity system. As such, these system outcomes are not forecasted in this APO. With the province transitioning towards non-emitting resources with low and/or zero fuel costs, any future incremental resource is expected to decrease marginal costs and emissions.

This APO summarizes the results of a comprehensive bulk transmission system study carried out in 2022 that assessed the capacity of the bulk system to reliably deliver power to supply forecasted demand over the long term. The comprehensive study done in 2022 was not repeated for this APO, as the reliability-driven needs established through that work are still valid. The planning studies the IESO intends to initiate over the next few years to address these transmission needs are presented in this APO as an updated "Schedule of Planning Activities." This schedule provides a transparent snapshot of the IESO's bulk system planning workplan covering the next three to five years. The upcoming transmission planning activities outlined in this APO include consideration of the potential implications of more recent policy guidance as outlined in the government's *Powering Ontario's Growth* plan and corresponding letter from the Minister of Energy to the IESO.

Separately from the APO, the IESO published on Dec. 15, 2022, a *Pathways to Decarbonization* (P2D) study. Through the P2D report, the IESO responded to the Minister of Energy's request to evaluate a moratorium on new natural gas generating stations in Ontario as well as develop an achievable pathway to a decarbonized electricity system. Two scenarios – Moratorium and Pathways – were developed to address the Minister's request. These scenarios were not integrated power system plans but rather analyses that identified potential opportunities and challenges to consider. The Pathways scenario illustrated a pathway in which the Ontario electricity system could reach net-zero emissions by 2050. Section 2.4.9 highlights how the P2D Pathways scenario demand compares with this APO Forecast. As the factors impacting both electrification as well as non-emitting resources continue to evolve, the IESO is committed to continuing to update its view of pathways to the decarbonization of Ontario's electricity system, with an update to the P2D analysis planned to commence in 2025.

1.4 Annual Acquisition Report

In previous years, the AAR followed the APO as part of the IESO's iterative provincial planning process. The AAR identified the target amounts of services required to satisfy the reliability needs identified in the APO and the mechanisms that the IESO recommended employing to meet those targets. To reflect policy announcements made in 2023, and to provide a more complete picture of future reliability needs and planned actions to meet those needs, the AAR has been integrated into this APO.

This report, similar to previous AARs, includes planned actions that the IESO intends to pursue over the coming years, to provide the sector with information to help inform investment decisions about existing and future assets. These actions are described in Section 9 of this APO. The integration of the APO and AAR in this report serves as a first step in the evolution of the IESO's planning assessments.

2. Demand Forecast

In this year's APO, electricity demand is forecast to ramp up more quickly and grow at a slightly faster pace than the 2022 forecast. This is driven by: incremental industrial sector projects, including a newly announced electric-vehicle battery factory, prospective EV supply chain facilities and long-term industrial mineral extraction sub-sector growth and electrification assumptions; increased electricity demand from the electrification of the transportation sector attributable to updated adoption, utilization and modelling assumptions; and incrementally higher population growth and household formation.

Electricity demand growth is tempered by an increased CDM program forecast and elevated levels of economic uncertainty. Continuing trends highlighted in prior outlooks include the adoption of the Toronto Green Standard, steady growth in the commercial and agricultural sectors, growth in the majority of industrial sub-sectors, the electrification of rail transit and the assumed continued delivery of conservation and demand management programs beyond the existing 2021-2024 CDM Framework period.

The IESO forecasts that the system will become dual-peaking (with summer seasonal system peaks and winter seasonal system peaks reaching similar magnitudes) by 2030.

The IESO's forecasts of long-term electricity demand incorporate uncertainties about future events, including economic growth, changing customer preferences and a rapidly evolving policy environment. The uncertainties associated with forecasts will naturally increase with the length of an outlook period and reflect the interdependencies of underlying assumptions. The long-term electricity demand forecast (the "Forecast") presented here, covering the period 2025-2050, therefore, includes the most current economic and demographic projections as well as announced projects and policies known at the time of forecast modelling.

2.1 Overview

The IESO's Forecast anticipates the level of electricity demand required to be met from supply and transmission, and is an input into the long multi-year process required to plan, site, build or refurbish energy resources to meet system needs. The Forecast also informs system reliability assessments and investment decisions, and sets the context for the APO, resource procurements and bulk power system plans.

Future demand is affected by many factors, including but not limited to: the state of the economy; population; demographics; technology; energy prices; input fuel choices; equipment-purchasing decisions; consumer behaviour; government policy; and CDM.

Since 2020, Ontario has experienced significant fluctuations in demand as a result of the COVID-19 pandemic. The pandemic and the resulting economic changes have caused persisting structural changes to the both the economy and society at large. These changes have been reflected in the APOs published since 2020.

This year's Forecast continues to reflect economic expansion as well as electrification initiatives that began in 2021, leading to higher electricity demand in the near, medium and long term, relative to today's levels.

The Forecast exhibits strong and steady growth through the end of this decade, driven primarily by economic growth and electrification in the following sectors: industrial mineral extraction, steel production, EV battery materials processing and cell manufacturing, hydrogen production, and nascent and accelerating transportation sector electricity demand, including increased adoption and utilization of light-, medium- and heavy-duty EVs. For the remainder of the outlook period, electricity demand growth continues, but is moderated on the basis of slowing provincial population and household growth, and subsiding adoption of EVs.

The IESO expects the industrial mineral extraction sub-sector will initiate a growth cycle based on market demand, the development of significant potential mineral deposit supplies in northern Ontario and long-term mining facility electrification. These assumptions are informed and supported by studies the IESO has conducted since the 2022 Forecast as well as policies such as Ontario's Critical Minerals Strategy.

Throughout this year's Forecast, the commercial and "other" sectors grow slowly but steadily. The agricultural sector growth is consistent with prior Forecasts, with greenhouses in the West of London area expected to proliferate until the early 2030s. The Forecast assumes a stable economic climate, with gross domestic product (GDP), employment, inflation and interest rates moderating to historical normal levels in the near term and persisting through this outlook period. Actual demand will diverge from the Forecast as such conditions diverge from these assumptions.

The IESO forecasts that under current policy conditions the system will transition from a summer seasonal demand peaking characterization to dual seasonal demand peaking by the early 2030s. This expected transition is attributed to: managed charging of EVs; building space-heating electrification coinciding with the winter system peak; and reduced overall summer peaks with the effects of the recently enhanced 2021-2024 CDM Framework and slowing summer demand growth in the agricultural sector.

Overall, system level net annual energy demand is projected to grow from 154 terawatt-hours (TWh) in 2025 to 245 TWh in 2050, a difference of 92 TWh, or 59 per cent in 25 years, with an average annual growth rate of 1.9 per cent. System-level net summer seasonal peak demand is projected to grow from 25 gigawatts (GW) in 2025 to 35 GW in 2050, a difference of 10 GW, or 42 per cent in 25 years, with an average annual growth rate of 1.4 per cent. System-level net winter seasonal peak demand is projected to grow from 23 GW in 2025 to 35 GW in 2050, a difference of 12 GW, or 53 per cent in 25 years, with an average annual growth rate of 1.7 per cent. In this and each subsequent Forecast sub-section, all calculation summaries may not match exactly due to rounding.

Figure 2 illustrates the forecasted changes in energy demand over the planning horizon. Figure 3 shows summer and winter peak demand.

Figure 2 | Annual Energy Demand

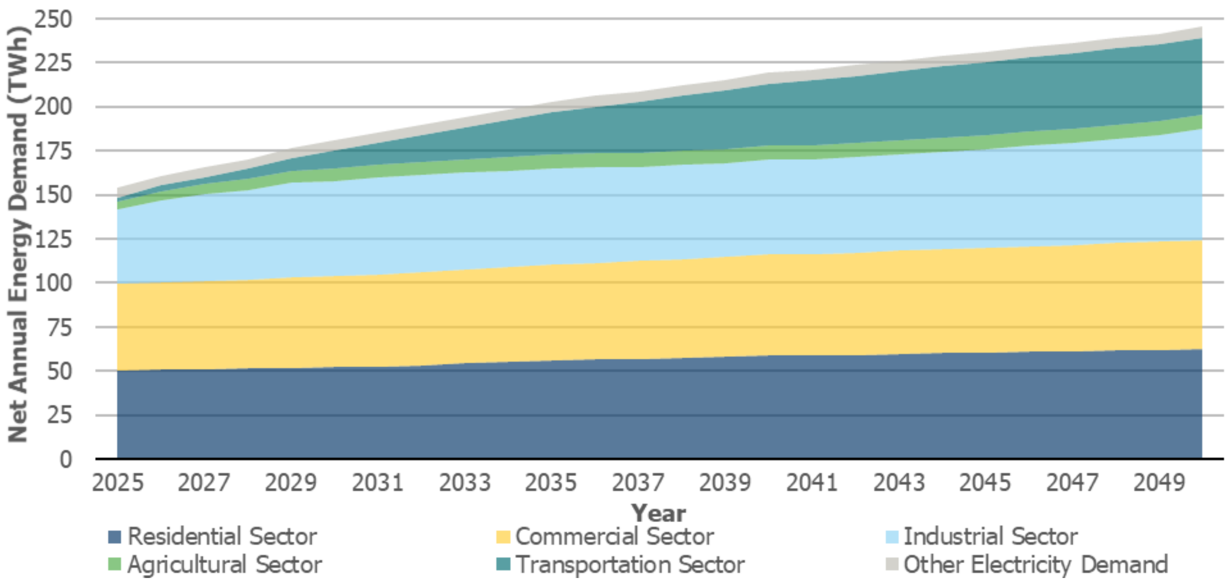
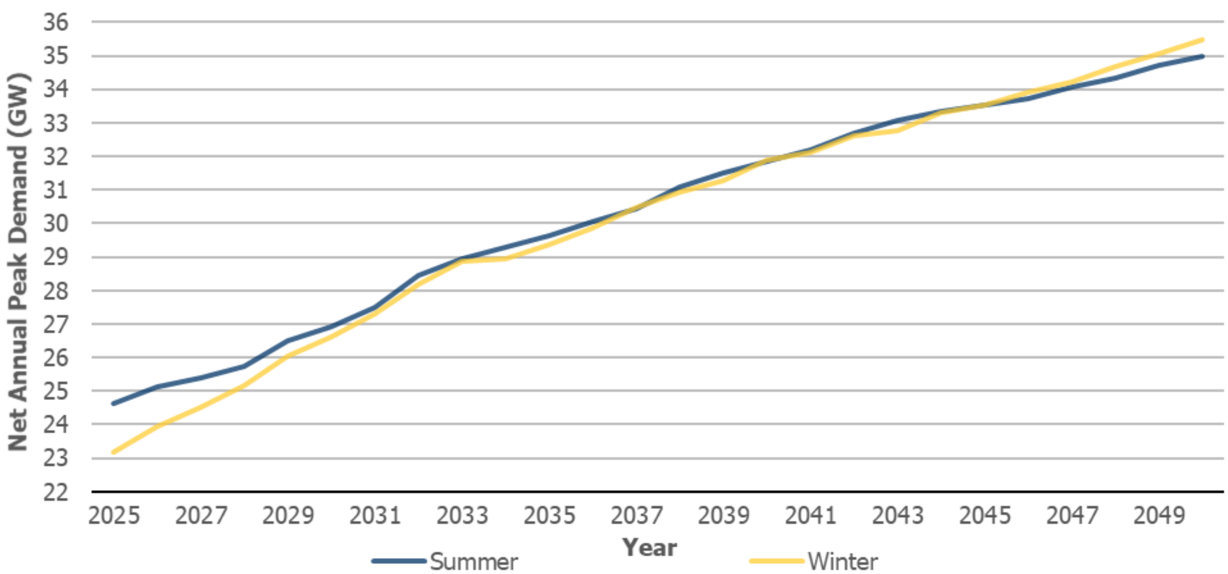


Figure 3 | Seasonal Peak Demand



A significant change in system demand forecasted over the outlook period is the change in daily system load profiles attributed to the substantial differences in electricity consumption patterns expected over the outlook period. A variety of forecasted changes will influence the shape of the daily demand curve – including year-round EV battery charging and an increase in winter-season electric space-heating, especially in the city of Toronto – that each results in heightened demand in the evening-to-dawn periods.

Increased agricultural greenhouse consumption will also affect the daily demand profile, as their consumption is greatest in the winter season between late evening and late morning, and lower in the summer season during the afternoon and early evening. Additionally, the connection of multiple large industrial facilities will cause demand to increase on an overall basis.

Figure 4 and Figure 5 illustrate the forecasted changes in hourly energy demand in a typical mid-winter and mid-summer business day over the planning horizon.

Figure 4 | Mid-Summer Business Day: Hourly Profile

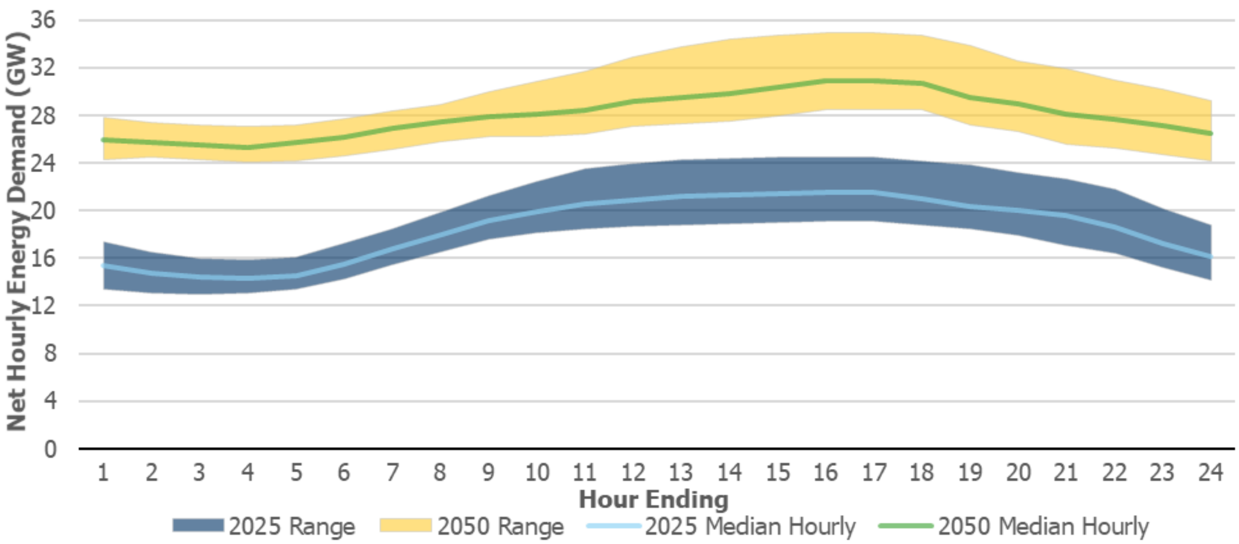
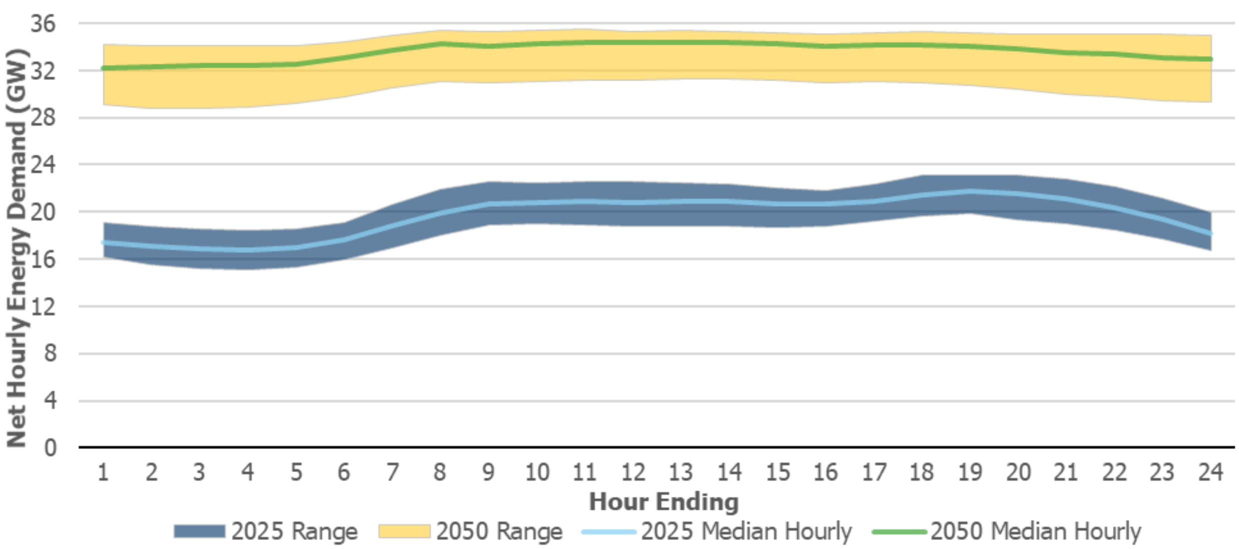


Figure 5 | Mid-Winter Business Day: Hourly Profile

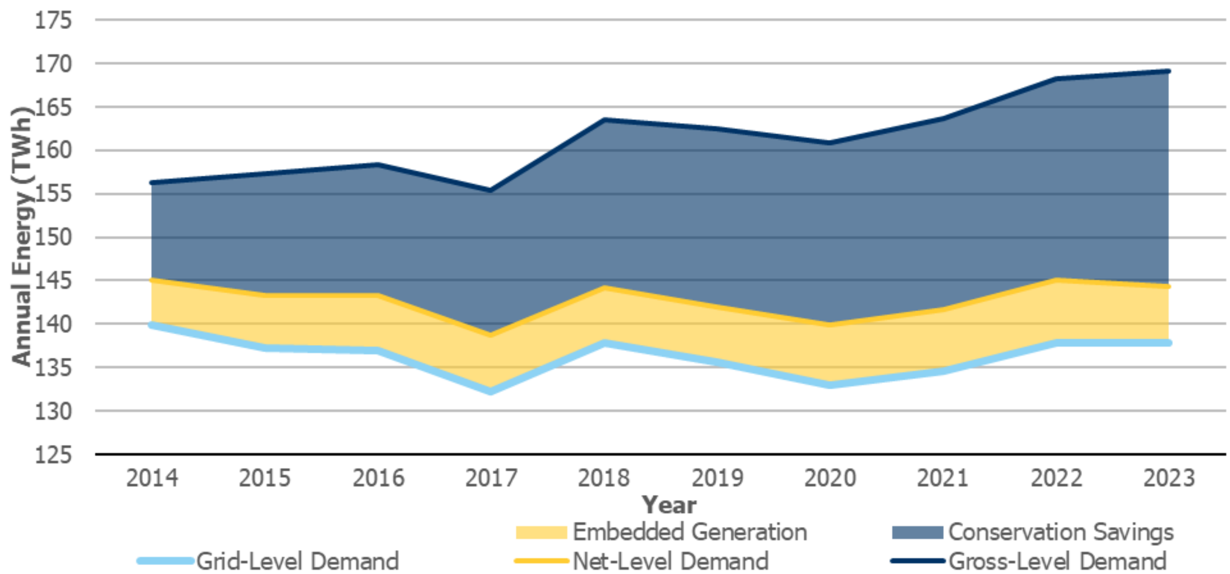


2.2 Historical Energy Demand

Grid-level demand[1] over the past 10 years (2013 through 2022) has been mostly flat, ranging between 132 TWh and 140 TWh, as shown in Figure 6.[2] This is primarily the result of changes in the economy, conservation and demand management program savings and embedded generation,[3] all of which reduced the need for grid-supplied energy. Conservation and demand management savings have grown from approximately 9 TWh a year to approximately 23 TWh a year, while embedded generation has supplied approximately 4 TWh to 7 TWh of energy each year.

Figure 6 illustrates the grid, net and gross-level energy demand[1] observed over the last 10 years.

Figure 6 | Historical Energy Demand



Note: While historical energy demand has been presented in Figure 6 on an actual realized weather basis and shown at the grid, net and gross levels, the Forecasts presented are on a normal weather scenario[4] basis and at the net level.

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[1] Gross-level demand is the total demand for electricity services in Ontario prior to the impact of demand-side management (including programs and regulations) but includes the effects of naturally occurring conservation (energy savings that occur without the influence of incentives or education programs and regulations). Net-level demand is gross-level demand minus the impact of conservation. Grid-level demand is net-level demand minus the demand met by embedded resources. It is equal to the energy supplied by the bulk power system to wholesale customers and local distribution companies.

[2] Historical energy demand presented is actual observed demand based on actual weather and has not been weather-normalized.

[3] Embedded generation describes generators that are not registered participants in the IESO-administered wholesale electricity market, which are typically but not necessarily distribution-connected and which reduce demand through the bulk electricity system.

[4] Some end-use specific energy demand and fuel-specific generation is weather sensitive (e.g., building space-heating, building space-cooling, lighting, solar resources, wind resources, etc.). Actual weather energy demand and embedded generation are observed values affected by actual realized weather conditions. Normal weather is expected average weather conditions for the related geographic region and normal weather scenario energy demand and embedded generation production are levels of energy that are expected under normal weather. The actual resulting weather in any given year can be random and may vary in temperature, precipitation, sun exposure, wind and/or humidity, each potentially affecting energy demand and/or production. Note: Normal weather scenario energy demand and embedded generation production account for expected weather only, not climatic change. For more information on weather normalization, see the 2024 APO Demand Forecast Methodology.

2.3 Forecast Summary

The IESO's forecasts focus on understanding the causes of future changes in demand by examining demographic, economic, sector and end-use level trends. However, future forecasted changes in demand also reflect many dependencies and incorporate uncertainties that increase with the length of the outlook period. The Forecast presented in this section considers a number of factors: all known demographic projections; sector-level market, economic announcements and trends; fuel rates forecasts; the current statuses and projections of large commercial and industrial sector projects with significant electricity demand; actual grid-connection request queues; and committed policy. New for this year's Forecast, the IESO has included demand from significant future industrial projects that have a reasonable probability of being completed, with estimates of such demand adjusted for the assumed uncertainty. The inputs for the Forecast were finalized in April 2023, and any changes to factors since then will be considered in future APOs.

With the emerging transformation of the economy driven by climate change mitigation, including fuel-switching away from greenhouse gas emitting fuels towards electrification, as well as potential economic development and policy stimuli, a high level of uncertainty is present in the latest Forecast. An assessment of these uncertainties and their potential impacts on the Forecast is outlined in Section 7.1.

The latest Forecast covers the period from 2025 to 2050. It includes a reference year of 2024 with forecasted grid-level annual energy demand of 139 TWh and a net-level annual energy demand of 147 TWh, one terawatt-hour below what was expected in the 2022 Forecast. This difference is attributable to general economic conditions materializing differently than expected since the development of the 2022 Forecast. Sector-level forecasts have been calibrated with the latest available data from sources including the IESO's Smart Meter Data Repository, the Ontario Energy Board's (OEB) *Yearbooks of Electricity Distributors*, as well as the IESO's own sector-level wholesale demand data sources.

2.4 Forecast Drivers

All sectors of the economy – residential, commercial, industrial, agricultural, transportation and others – contribute to province-wide energy demand. This Forecast has been developed using sector-level segmentation and corresponding individual assessments.

Projected increases in the Forecast are supported by climate change mitigation and economic development policies, stable electricity rates and increasing natural gas rates, which include increasing greenhouse gas emission costs, over this outlook period.

2.4.1 Residential Sector

The IESO forecasts demand from the residential sector to show steady growth over the outlook period based on current housing supply policies. Several factors support this growth, including progressive national immigration policies (tempered by interprovincial emigration); a supportive provincial policy environment for new home construction; persisting levels of pure and hybrid work-from-home trends, which result in higher daily household occupancy; continued increases in the adoption of electronic appliances; and the planned implementation of the Toronto Green Standard, version 6, in 2028, which would change municipal permit requirements to require buildings constructed in Toronto on or after 2030 to be near zero emissions.

Other updates to the residential sector forecast include updated household count forecasts that expect home growth to revert to pre-pandemic trends of concentration in urban areas, such as the Toronto and Ottawa zones, and updated hourly load profiles for heating and air conditioning that improve resolution for specific geographic climate zones in addition to building types and efficiency levels.

Overall, residential sector level net annual energy demand is projected to grow from 50 TWh in 2025 to 62 TWh in 2050, a difference of 12 TWh, or 25 per cent in 25 years, with an average annual growth rate of 1 per cent.

2.4.2 Commercial Sector

The IESO expects commercial sector demand to be largely consistent with levels forecasted in the 2022 Forecast. Continued slow, steady electricity demand growth is expected over the outlook period, supported by a continued shift to the digital economy, which affects many sub-sectors: hybrid work models moderating demand in the office and hospitality sub-sectors; broadening e-commerce affecting demand in the retail, warehouse and data centre sub-sectors; and meal preparation and delivery services reducing overall demand in the restaurant sub-sector. The commercial sector will also be affected by the Toronto Green Standard referenced above, influencing some demand growth in a small component of the economy and time period. The commercial sector is also expected to be the most sensitive to changes in economic conditions. The IESO continues to monitor changes in economic conditions and the resulting demand as they happen.

Overall, commercial sector level net annual energy demand is projected to grow from 49 TWh in 2025 to 62 TWh in 2050, a difference of 12 TWh, or 25 per cent in 25 years, with an average annual growth rate of 1 per cent.

2.4.3 Industrial Sector

The IESO expects the industrial sector to grow more than previously forecasted, accelerating recent demand forecast trends. Several factors contribute to the latest Forecast's incremental demand growth including: Ontario's support for a provincial EV supply chain, including the Volkswagen EV battery plant (announced in April 2023) and local supplier industry in and around St. Thomas, with increased electricity demand forecasted to materialize in the late 2020s; potential realization of multiple additional prospective EV battery supply chain facilities; progress in the hydrogen production sub-sector as it moves towards implementation goals; and growth in the mineral extraction and processing sub-sector. Due to the number of unknowns, including project realization, implementation timelines and, ultimately, electricity demand levels, the industrial sector continues to be the sector with the highest levels of forecast uncertainty.

The IESO expects the mining sub-sector in northern Ontario to adopt industrial process electrification in existing mines to improve operational economic efficiencies and reduce greenhouse gas emissions. The sector is also expected to resume a long-term growth cycle starting in the 2040s, developing new extraction and processing facility projects of currently unidentified mineral deposits. Both of these assumptions have been informed by sub-sector-level studies conducted by the IESO since the 2022 APO.

The newly identified projects for the latest Forecast, in addition to previously identified projects in prior Forecasts (Algoma Steel's electric arc furnace in Sault Ste. Marie, ArcelorMittal Dofasco's electric arc furnace project in Hamilton, LG and Stellantis's EV battery factory in Windsor, Umicore's battery-material processing facility in Loyalist and several specific mineral extraction projects in northern Ontario), represent a small number of projects with high levels of uncertainty in terms of the precise levels and profiles of electricity demand and implementation timelines. With each year's Forecast – and as each project's implementation milestone nears – levels of forecasted risk are reduced as these details become more certain.

The broader industrial sector continues to be supported by both local production-capability building and economic development, a "nearshoring" trend that began in the pandemic era and growing societal electrification and greenhouse gas emission reduction over the outlook period. However, it is expected that over the longer term the automobile manufacturing sub-sector will experience some level of attrition as the sector transforms from producing internal combustion engine-based vehicles with complex mechanical supply chains, to electric motor-based vehicles with relatively simpler supply chains. Expectations continue for slow growth in all other sectors (e.g., petroleum, plastic, rubber, paper, etc.).

Overall, industrial sector-level net annual energy demand is projected to grow from 42 TWh in 2025 to 63 TWh in 2050, a difference of 21 TWh, or 50 per cent in 25 years, with an average annual growth rate of two per cent.

2.4.4 Agricultural Sector

Demand for electricity from Ontario's agricultural sector continues to grow, driven by both greenhouse expansion and the proliferation of artificial lighting in greenhouses producing fruits, vegetables, flowers and cannabis, primarily in the West of London area. Growth and recent planning work have centred on Kingsville-Leamington in southwestern Ontario. Sector-level demand growth is consistent with the 2022 Forecast, with growth focusing on vegetable production. Energy demand for this sector is significantly higher in the winter season rather than summer season, affecting system seasonal peaking patterns.

Overall, agricultural sector-level net annual energy demand is projected to grow from 5 TWh in 2025 to 8 TWh in 2050, a difference of 3 TWh, or 63 per cent in 25 years, with an average annual growth rate of 2 per cent.

2.4.5 Transportation Sector

In 2022, the Government of Canada strengthened its climate plan, focusing on a shift to cleaner fuels for vehicles to decarbonize the transportation sector. Additionally, several rail transit electrification projects are underway across Ontario. EV and rail transit projects are the two categories of transportation electrification analyzed in this Forecast. Their respective electricity demands are estimated below.

Overall, transportation sector-level net annual energy demand is projected to grow from 2 TWh in 2025 to 44 TWh in 2050, a difference of 42 TWh, or 1,912 per cent in 25 years, with an average annual growth rate of 12.8 per cent.

2.4.5.1 Electric Vehicles

By the end of 2023, there were nearly 151,000 EVs registered in Ontario, representing 1.7 per cent of all vehicles in the province. As the federal government rolls out initiatives and strengthens plans to decarbonize the transportation sector, it is projected that there will be significantly more EVs on the road in Ontario by mid-century.

The Government of Canada published regulations in December 2023 that require manufacturers and importers to meet annual zero-emission vehicle sales targets. These will begin for the 2026 model year, with a requirement that at least 20 per cent of new light-duty vehicles offered for sale be zero-emission vehicles, which will increase annually to at least 60 per cent by 2030 and 100 per cent for 2035. The IESO's EV adoption forecast is in line with these regulations. It is projected that the number of light-duty EVs on Ontario's roads will increase from nearly 400,000 in 2025 to 11.5 million in 2050. Policy measures, improved technology, matured production and consumer preference continue to contribute to the shift from internal combustion engine vehicles to EVs.

Currently, the vast majority of automobiles in the province are light-duty vehicles. Medium- and heavy-duty vehicles combined represent less than three per cent of total vehicles on the road. Various technologies continue to progress and compete in the electrification of medium- and heavy-duty vehicles. It is assumed that adoption of battery-powered medium- and heavy-duty vehicles will lag light-duty EVs, reaching 90,000 units by 2050, 22 per cent of total medium-/heavy-duty vehicles. Regarding fuel-cell medium- and heavy-duty vehicles, electricity demand for hydrogen production is captured separately in the Industrial sector forecast and does not necessarily assume that all provincial demand for hydrogen is met by production within the province. No uptake of catenary vehicles is assumed.

Besides EV adoption, which determines the quantities and types of vehicles, fuel efficiency and driving distance also have impacts on electricity demand levels. EV sub-sector electricity peak demands from light-, medium- and heavy-duty vehicles are largely influenced by charging patterns that can be influenced by rate structures and other programs. In addition to adoption projections, the IESO has updated other EV demand forecast assumptions, including charging profiles, to reflect recent research and EV-related initiatives, such as the introduction of the Ultra-Low Overnight rate option for residential and small business customers.

2.4.5.2 Rail Transit Electrification

Mass rail transit electrification is also underway across southern Ontario. GO Transit rail corridor electrification projects, local light-rail transit projects and subway projects are at various stages of planning, construction and operation. Their electricity demands are high-level estimates for this APO and will be updated in future outlooks as more information becomes available.

The IESO is monitoring the High Frequency Rail project that is proposed for the Quebec City-Toronto corridor and will capture the project in future outlooks as it proceeds and more information becomes available.

2.4.6 Other Electricity Demand

The IESO's Forecast accounts for all electrical energy and peak demand in the province. However, certain areas of demand do not fall under any of the previously discussed sectors and are, therefore, classified as "other electricity demand." These include:

- the connection of remote communities over the outlook period
- electricity generators[5]
- street lighting
- municipal water treatment

Demand from remote communities that were connected to the IESO-controlled grid at the time of Forecast development is included in the appropriate sector-level forecasts. Remaining remote community system connections over the course of the outlook period will have their respective forecasts included into explicit sector-level forecasts in future APOs as they are connected.

Overall, the other electricity demand component's net annual energy demand is projected to grow from 5 TWh in 2025 to 6 TWh in 2050, a difference of 1 TWh, or 18 per cent in 25 years, with an average annual growth rate of 0.6 per cent.

2.4.7 Conservation and Demand Management

The IESO's Forecast is decreased as a result of CDM programs, a form of resource acquisition, and regulations, a form of market transformation.

2.4.7.1 Conservation and Demand Management Programs

CDM programs continue to play a key role in the power system. Initiatives funded by provincial and federal agencies are underway, achieving energy and peak demand savings and, in turn, reducing energy and capacity needs.

The IESO-managed 2021-2024 CDM Framework is the central existing initiative. It is delivered to consumers under the IESO's Save on Energy brand. In September 2022, the IESO received a ministerial directive in connection with the Framework to enable additional CDM programming through a budget increased to $1 billion. This new funding and programming will deliver additional electricity demand savings of 1.1 TWh. It is forecasted that the enhanced Framework will achieve 4 TWh in annual savings when fully implemented.

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[5] Electricity generators such as gas, oil and nuclear generating stations themselves can experience electricity demand through their facilities' lighting and heating, ventilation and air-conditioning loads.

Other programs funded by the federal government are expected to result in additional electricity savings in Ontario. The Green Municipal Fund targets the commercial sector, with a goal of reducing energy consumption and GHG emissions from fossil fuels. The Canada Greener Homes Grant and the Canada Greener Homes Loan Program help homeowners across the country implement CDM and GHG emission-reduction retrofits. The electricity demand savings in Ontario from these programs are estimated to increase to 0.4 TWh in 2027. The IESO is monitoring developments with the Canada Greener Homes Grant and will reflect changes to federal programs in future planning outlooks.

This Forecast assumes the delivery of CDM programs will continue after the current Framework. It is assumed that the annual savings of new programs will be consistent with levels forecasted for the enhanced 2021-2024 CDM Framework, on a proportion of gross demand basis.

Overall, the level of annual electricity demand savings from all CDM programs in Ontario is forecasted to fluctuate between 14 TWh and 17 TWh from 2025 to 2050. This accounts for the expiring savings as past CDM programs conclude.

2.4.7.2 Conservation and Demand Management Regulations

CDM regulations, which consist of building costs and equipment standards that are both currently in effect and have a relatively high level of certainty of being implemented, are an effective energy-efficiency tool. These electricity demand savings estimates are based on expected improvements in codes for new and renovated buildings and the regulation of minimum efficiency standards for new equipment.

The IESO estimates savings attributable to CDM regulations by comparing the Forecast at the gross level with the Forecast adjusted for the impacts of the regulations. The IESO has identified savings since 2006 and thus uses that year as a base year. Most of the savings from increased CDM regulations will be realized in the residential and commercial sectors. The CDM regulations savings forecast is largely the same as in the 2022 APO, as are gross-level demand and regulations. Going forward, as changes to regulations are announced, the IESO will analyze their impacts and include them in forecasts and outlooks as they are published.

Overall, annual energy demand savings from CDM regulations since 2006 are projected to grow from 10 TWh in 2025 to 17 TWh in 2050, a difference of 7 TWh, or 72 per cent in 25 years, with an average annual growth rate of 2.2 per cent.

2.4.8 Load Modifiers and Demand Measures

In addition to sector-level demand and CDM forecasts, the Forecast is adjusted for load modifiers, initiatives and policies that affect demand or prices. These include the ICI and – new for the Forecast – the Save on Energy Peak Perks residential demand response program, a demand measure that is a controllable initiative. Both load modifiers have material impacts on the forecasted seasonal peak demand of each year.

2.4.8.1 Industrial Conservation Initiative

ICI is a form of demand response that enables large customers – known as Class A customers – to reduce their electricity costs by curtailing electricity consumption during periods of system peak demand.

The IESO has revised its ICI forecasting methodology for the latest Forecast to better anticipate the impacts of the program in future years when system demand hourly profiles are expected to vary materially compared with current trends. Previously, ICI forecasts were based on historically observed program response on peak system demand days, assuming consistent response in future years. Currently, summer system peak days have a daily minimum in the mid-overnight hours, a considerable ramp-up towards 9 a.m., a peak at about 5 p.m., followed by a steady decline. Winter system peak demand days are typically dual-peaking at 9 a.m. and 8 p.m. and have an early-afternoon trough in between. With the expected increase in transportation electrification, agricultural sector development and some extent of building heating electrification, system peak demand day hourly profiles will change and existing ICI response patterns are anticipated to no longer be applicable. ICI forecasts have now been created with a load-following methodology, with ICI day program response profiles based uniquely on dynamic forecasted hourly system demand profiles.

Consistent with previous Forecasts, ICI levels are based on the latest observed program responses for the summer 2022 and winter 2023 seasons. The ICI forecast now assumes 15 ICI response days each year, with each individual ICI day's response modelled as commensurate with the ICI day's level of system peak demand relative to other ICI days in the same year, consistent with latest observed program responses. This is in contrast to the previous forecasting methodology of using 10 ICI response days, stratified into two response levels for: 1) the average of the top five system peak demand days; and 2) the average of the second top five system peak demand days. Annual ICI response is expected to change consistent with forecasted levels of demand from the industrial sector on a zonal and annual basis. That is, ICI response is expected to grow through the end of this decade and remain largely consistent until the early 2040s before starting to slowly grow again. The IESO expects that ICI drivers, including customer ICI program investment and global adjustment levels, will inevitably change over time and, thus, ICI impacts on future Forecasts and ICI forecast methodology will be reassessed on a regular basis.

Overall, peak ICI annual summer seasonal demand savings are projected to grow from 1,727 megawatts (MW) in 2025 to 2,248 MW in 2050, a difference of 520 MW, or 30 per cent, in 25 years, with an average annual growth rate of 1.1 per cent. Peak ICI annual winter seasonal demand savings are projected to grow from 1,237 MW in 2025 to 1,634 MW in 2050, a difference of 398 MW, or 32 per cent, in 25 years, with an average annual growth rate of 1.1 per cent.

2.4.8.2 Residential Demand Response

On May 25, 2023, the IESO launched Peak Perks, a new program to help families save money by conserving energy and reduce demands on the provincial grid. Peak Perks is a residential demand response (RDR) program delivered by the IESO, pursuant to the governmental directive from Sept. 29, 2022, targeting residential sector central air conditioning. The program is committed within the parameters of the current 2021-2024 CDM Framework. For the purposes of this Forecast, it is assumed to persist to the end of the outlook period, consistent with the long-term CDM program assumptions.

RDR is expected to reduce system demand by up to 125 MW in 2025 and is included in the Forecast for years 2025 to 2050. RDR is expected to be activated on the 10 highest system peak demand days each year during weekdays from June 1 to Sept. 30, have a maximum of one activation per day for three contiguous hours, and a peak response on the middle hour. RDR capacity is forecasted to grow and match responses consistent with forecasted zonal residential air conditioning unit installations in Ontario.

Overall, RDR annual peak demand savings are projected to grow from 95 MW in 2025 to 138 MW in 2050, a difference of 43 MW, or 45 per cent, in 25 years, with an average annual growth rate of 1.5 per cent.

2.4.9 2022 Pathways to Decarbonization Study Pathway Scenario Comparison

The Forecast in this APO is based on the latest available economic data projections (population, GDP, income, fuel rates, households, commercial floor space, industrial employment/output), committed policy and projects as well as probable projects known at the time of Forecast input finalization (April 2023). The IESO does not speculate on future changes to committed policy, and potential or unconfirmed policy. With these considerations, the Forecast is what the IESO determines as the most likely level of demand, for the purposes of resource adequacy and transmission security assessments and any required resource acquisition mechanisms.

Separately from the APO, the IESO published on Dec. 15, 2022, a *Pathways to Decarbonization* (P2D) study, which included a Pathway scenario for the purposes of illustrating a pathway in which the Ontario power system could reach net-zero emissions by 2050. In this scenario, a complementary electricity demand scenario, reflecting an Ontario economy that transitions to net-zero greenhouse gas emissions, was developed. This forecast was based on theoretical, aggressive transition in the building heating, transportation and industrial sectors, a transition that will not materialize without drastic changes in policy, technology and customer behaviour. The electricity demand scenario developed for the Pathway scenario is not a Forecast, but similar to the modelling approach taken to determine a decarbonized supply mix and corresponding transmission system analysis, is one of many pathways Ontario could take to attain a net-zero power system.

It is understood that the state of the economy, policy, projects, technology and customer behaviour is constantly evolving, and the potential exists that some assumptions included in the latest APO Forecast and the P2D Pathway scenario's electricity demand scenario could converge. The P2D study illustrates a potential high-demand bookend that could be seen in an economy transitioning to societal decarbonization. The IESO is constantly observing how policy evolution pushes towards decarbonization and an assessment of the APO Forecast and P2D is conducted in this section to track such convergence.

One year after the development of the P2D study, the APO Forecast assumptions have largely remained consistent with previous Forecasts as a distinct reference scenario. Notable convergences between the APO Forecast and P2D's Pathway scenario include: 1) increased electricity demand from the industrial mining sub-sector, in terms of both long-term growth and the assumption of the decarbonization/electrification of fossil-fuelled processes; 2) increased transportation sector electrification demand; and 3) increased conservation and demand management program savings forecasts. Major assumptions in the Pathway scenario electricity demand scenario that have yet to materialize are: 1) broad-scale building space heating electrification, which specifically increases winter seasonal peak demand; 2) broad-scale industrial sector fuel-switching for process heating from greenhouse gas-emitting fuels to electricity; and 3) policy to pursue all estimated cost-effect achievable CDM program savings potential. A summary of the variances is provided in Table 1. Detailed P2D demand scenario assumptions can be found in the IESO's stakeholder engagement feedback published on July 19, 2022.

Table 1 | Summary of Variances

#	Driver	IESO 2024 APO	IESO 2022 P2D – Pathway Scenario	IESO 2022 APO
1	Residential Sector	Toronto Green Standard, version 6; Updated heating and cooling profiles	Province-wide building space- and water-heating electrification	Toronto Green Standard, version 6
2	Commercial Sector	Toronto Green Standard, version 6	Province-wide building space- and water-heating electrification	Toronto Green Standard, version 6
3	Industrial Sector	Increased: a) automobile manufacturing – EV production projects; b) mining sub-sector; i) electrification assumption over the course of the outlook period; ii) long-term (2040+) growth assumption	a) Development of northern Ontario mining sub-sector, including: i) Currently identified potential projects; and ii) northern Ontario potential assumption; b) Broad sector-level transition from natural gas as a heating fuel source to electricity	Industrial projects supporting electrification, announced at time of Forecast development
4	Agricultural Sector	No decarbonization	Building space- and water-heating electrification	No decarbonization
5	Transportation Sector	Increased EV adoption and utilization, relative to IESO 2022 APO and P2D – Pathway scenario	Increased adoption of medium- and heavy-duty EVs, relative to IESO 2022 APO	Latest EV and rail transit electricity demand forecast at time of Forecast development
6	Other Electricity Demand	Consistent, no decarbonization	Consistent, no decarbonization	Consistent, no decarbonization
7	Conservation and Demand Management	Increased CDM program savings forecast relative to 2022 APO based on enhanced 2021-2024 CDM Framework budgets, targets and updated actual results	Full achievable potential as identified in IESO and OEB's 2019 Integrated Ontario Electricity and Natural Gas Achievable Potential Study	Latest CDM program savings forecast at time of Forecast development

The annual energy and seasonal peak demand for all three forecasts are within a very narrow band of one another for the near- to mid-term period with the following exceptions:

- 2024 APO annual energy demand is higher than 2022 APO annual energy demand due to incremental industrial automobile production projects and higher demand from EV charging;
- 2024 APO annual energy demand is lower than 2022 P2D Pathway scenario demand from 2033 due to the absence of broad province-wide building space- and water-heating and industrial sector electrification/fuel-switching, both from 2030, and higher industrial mining sub-sector development from 2040; and
- 2022 P2D winter seasonal peak demand is significantly higher than other forecasts due to the broad adoption of building electrification, including space- and water-heating

Figure 7 | Annual Energy Demand By Forecast

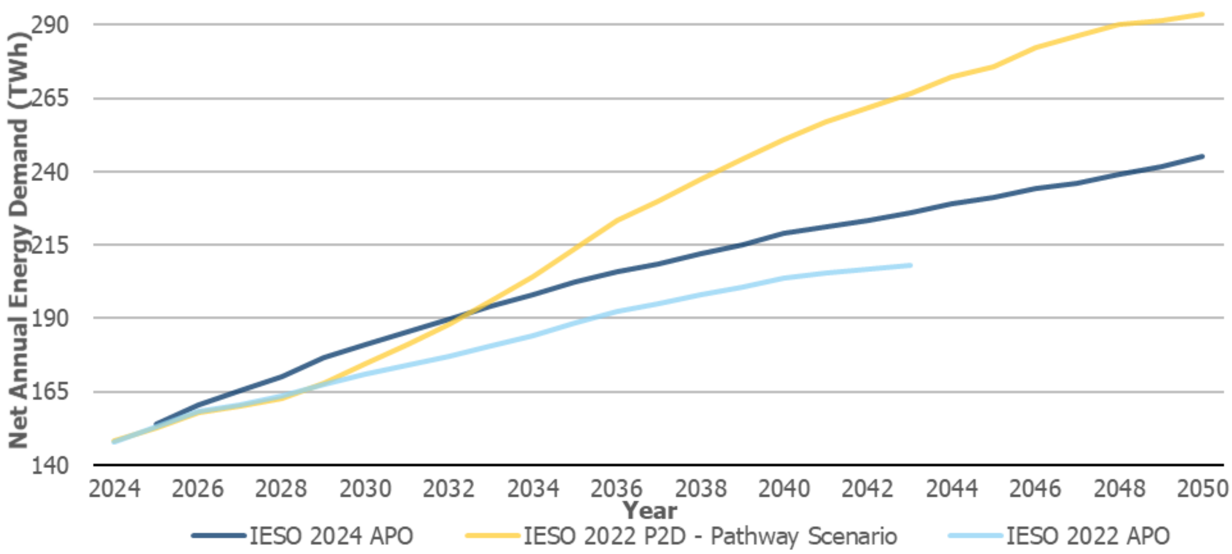
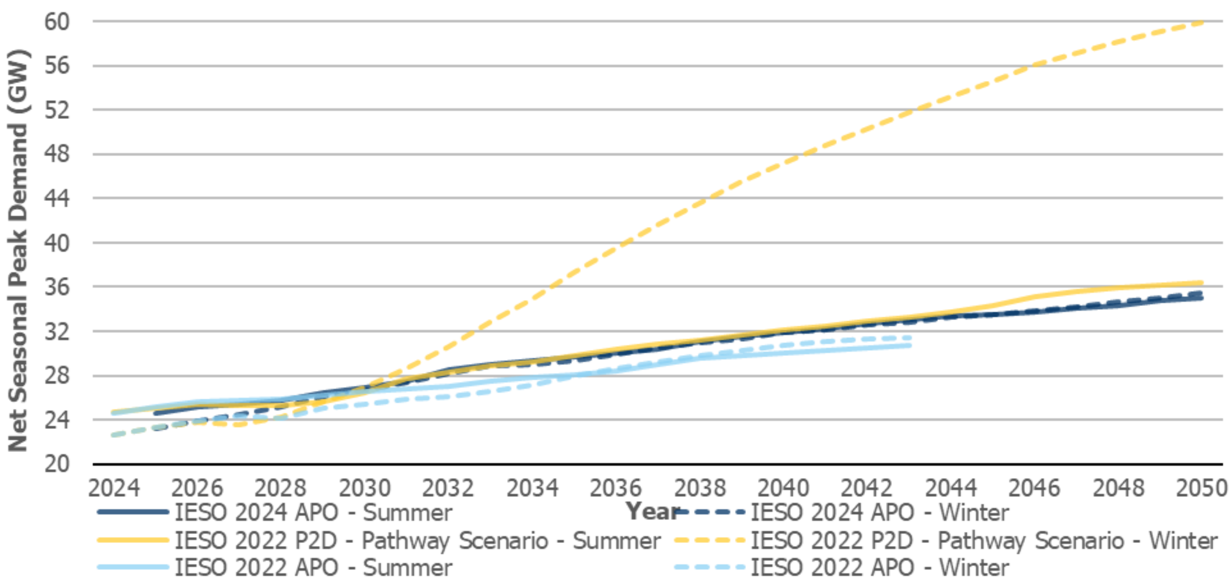


Figure 8 | Seasonal Peak Demand By Forecast



3. Supply Outlook and Transmission Assumptions

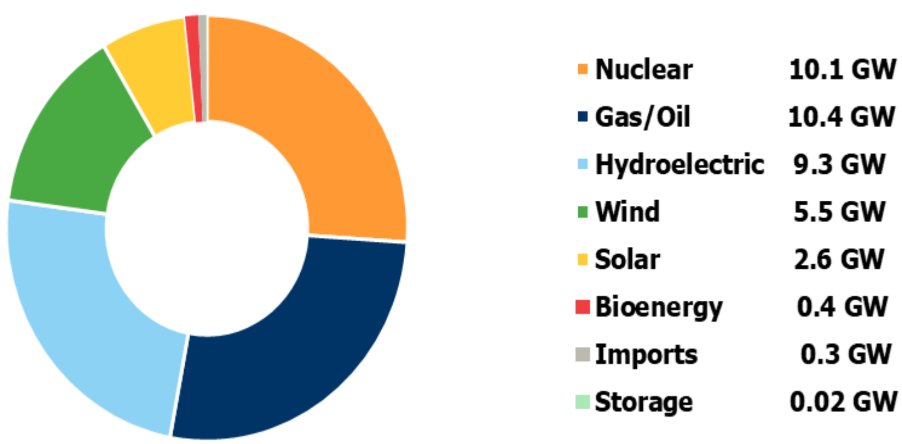
Ontario's supply mix will undergo significant change over the next two and a half decades as the available capacity from its nuclear fleet continues to be affected by refurbishments and retirements and as other resources reach end of contract. Should Ontario phase out natural gas generation, it could result in a decrease in supply. However, available generation and storage are expected to increase due to actions taken by the IESO and resulting from government policy. To support the growing supply fleet, a significant growth and expansion of transmission infrastructure across the province will be required to connect and reinforce new areas and facilitate deliverability of the new resources. This expansion of transmission infrastructure will also facilitate the economic development goals set out in *Powering Ontario's Growth* and the decarbonization of the economy.

This chapter describes the availability of the province's existing supply resources over the outlook period, the ability of the bulk transmission system to continue to supply electricity where it is needed, and the various major transmission projects that are underway to maintain system reliability and enable growth.

3.1 Installed Capacity, 2024

Ontario has 38.7 GW of installed capacity consisting of a diverse mix of resources, as shown in Figure 9.

Figure 9 | 2024 Installed Capacity by Fuel Type



The majority of Ontario's installed capacity comes from nuclear (26 per cent),[6] gas (27 per cent), and hydroelectric (24 per cent) resources, with the remainder from wind (14 per cent), solar (7 per cent) and bioenergy (1 per cent). Imports (1 per cent) represent non-firm imports.[7] Energy storage's contribution to the province's installed capacity is expected to increase as new storage resources come online over the next few years.

Both transmission- and distribution-connected resources visible to the IESO are included in the capacity assessment.

3.2 Supply Outlook

This section provides an outlook for both installed capacity, or a resource's maximum output, and effective capacity, which takes into account factors such as fuel availability, ambient conditions and/or outages. This makes effective capacity a more meaningful measure of a resource's ability to meet reliability needs in each season.

Two supply cases are presented in this year's APO to provide a view of possible system conditions under different scenarios. The first case, the As Is case, consists of existing and committed resources, including resources committed through actions undertaken by the IESO and/or informed by government policy, until their contract or commitment period ends.[8] The major supply changes in this year's APO from the 2022 APO are: the inclusion of three additional small modular reactors (SMRs), as announced by the provincial government in July 2023; an increase in storage resources and natural gas generation as a result of the Expedited Long-Term (E-LT1) RFP; the inclusion of gas resources secured from the Same Technology Upgrades Solicitation as of June 2023; the inclusion of the Brighton Beach contract extension and expansion; and the incorporation of an update to the contract period for the Oneida storage project. As compared with the 2022 APO, the cases in the 2024 APO exclude resources expected to be cleared from upcoming Capacity Auctions. This change in methodology was performed to better identify system needs and establish targets in response to the needs. Other resources that are expected to connect to the system as a result of in-flight procurements (e.g., resources expected from Long-Term 1 [LT1] RFP and others) are also excluded. These resources are considered in the Integrated Reliability Needs assessment to inform future planned actions and are further described in Section 8.

The second case, the High Nuclear case, provides insight into the potential impact of nuclear policy decisions. In addition to the As Is case resources, the High Nuclear case also includes the continued safe operation of Pickering B Nuclear Generating Station (NGS), the provincial support to proceed with refurbishment of Pickering B, along with the addition of new generating units at Bruce NGS (Bruce C).

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[6] Nuclear installed capacity does not include nuclear units on refurbishment.

[7] Non-firm imports are included in resource adequacy assessments and are consistent with the approach resulting from the IESO's Reliability Standards Review Engagement. System- and generator-backed imports cleared from the 2022 Capacity Auction are not considered as they do not contribute to the supply tabulation for 2024.

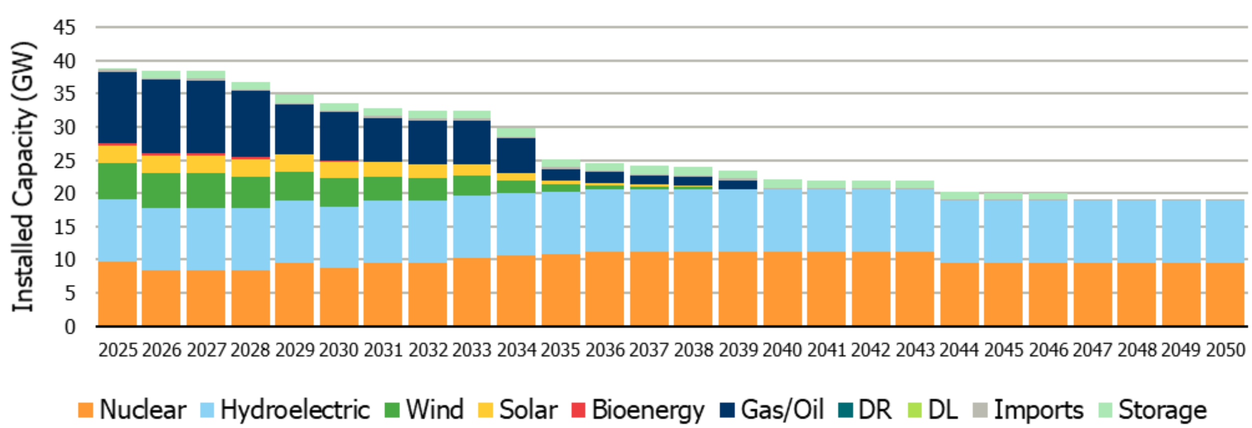
[8] For the assessment, hydroelectric resources are assumed as perpetual assets and continue to operate, regardless of ownership, age of facility, etc.

Table 2 | Ontario's Summer and Winter Effective Capacity by End of 2024

Fuel	2024 Installed (GW)	2024 Summer Effective (GW)	2024/25 Winter Effective (GW)
Nuclear	10.1	9.9	8.3
Gas/Oil	10.4	8.7	9.3
Hydroelectric	9.3	6.5	7.3
Wind	5.5	0.8	1.5
Solar	2.6	0.6	0.0
Bioenergy	0.4	0.4	0.4
Import	0.3	0.3	0.2
Storage	0.02	0.01	0.01
Total	**38.7**	**27.1**	**27.0**

Figure 10 shows the total installed capacity by fuel type for the outlook period for the As Is case, which assumes resources under contract/commitments are not reacquired[9] after their contract ends, aside from hydroelectric resources.[10] Installed capacity decreases from around 39 GW to 29 GW in the next decade, before levelling off at approximately 19 GW in the mid-/late 2040s.

Figure 10 | Installed Capacity (As Is Case)



[9] Resources as assumed to be available until its contract/commitment ends. Resources may not necessarily align with the performance standards in the federal draft Clean Energy Regulation.

[10] For the assessment, hydroelectric resources are assumed as perpetual assets and continue to operate, regardless of ownership, age of facility, etc.

Figure 11 shows the total installed capacity by fuel type for the outlook period in the High Nuclear case. It factors in continued safe operation of Pickering B, Pickering B refurbishment and new nuclear at Bruce C, in addition to the As Is case resources. Installed capacity varies between 31 GW and 39 GW in the next decade, before levelling off at 26 GW in the mid-/late 2040s due to contracts expiring.

Figure 11 | Installed Capacity (High Nuclear Case)

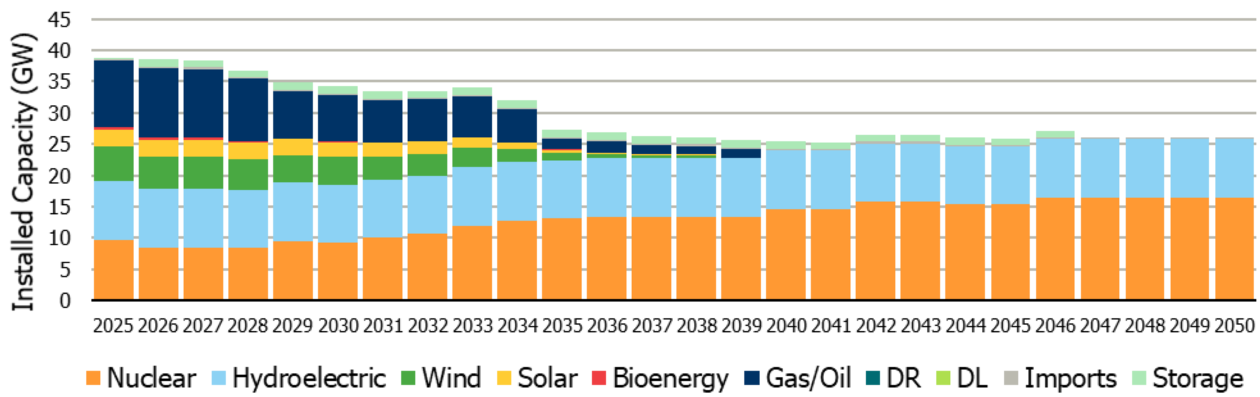


Figure 12 shows the summer effective capacities by fuel type for the outlook period in the As Is case. Summer effective capacity varies between 22 GW and 27 GW during the 2020s, due to the refurbishment of the nuclear fleet, and then levels off around 15 GW in the mid-/late 2040s due to contracts expiring.

Figure 12 | Summer Effective Capacity (As Is Case)

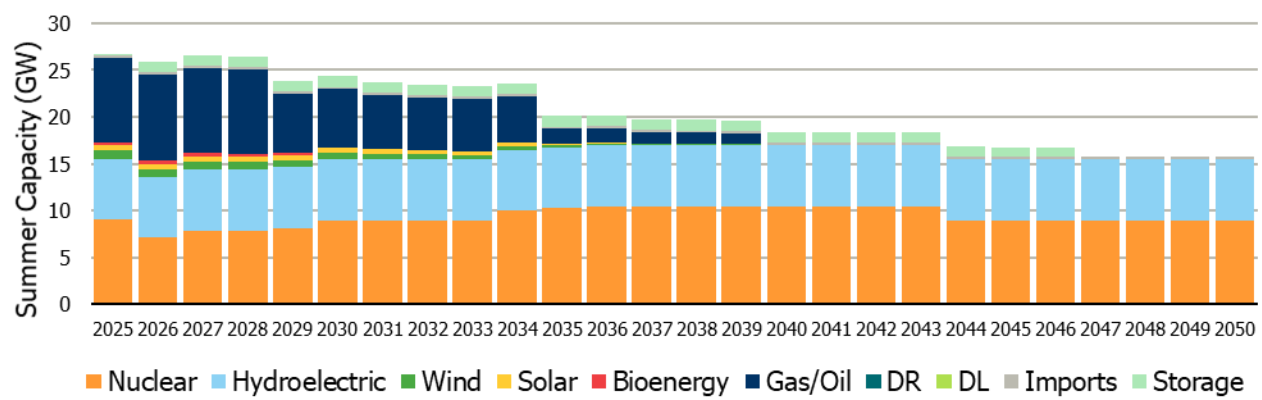


Figure 13 shows the summer effective capacities by fuel type for the outlook period in the High Nuclear case. Summer effective capacity varies between 23 GW and 27 GW during the 2020s, due to the refurbishment of the nuclear fleet, and then levels off at 22 GW in the mid-/late 2040s due to contracts expiring.

Figure 13 | Summer Effective Capacity (High Nuclear Case)

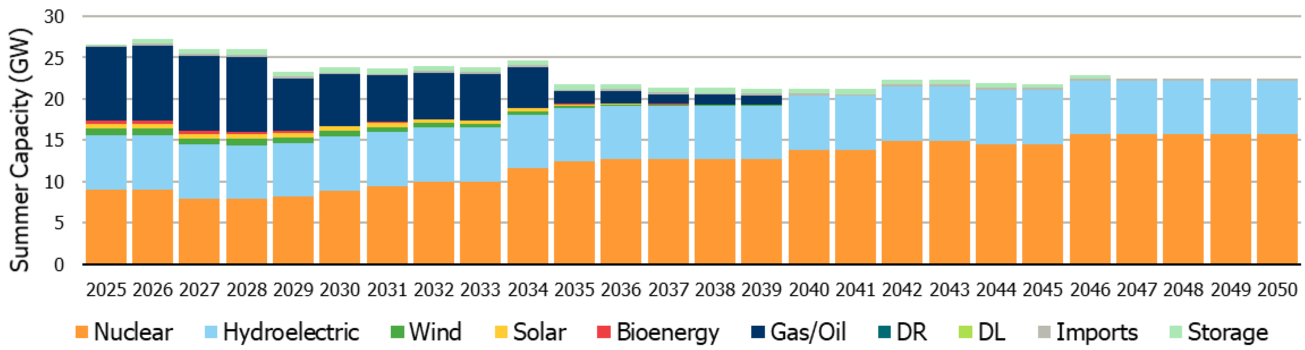


Figure 14 shows the winter effective capacities by fuel type for the outlook period in the As Is case. Winter availability of the fleet ranges between 24 GW and 28 GW in the next decade, levelling at 16 GW in the long term due to contracts expiring.

Figure 14 | Winter Effective Capacity (As Is Case)

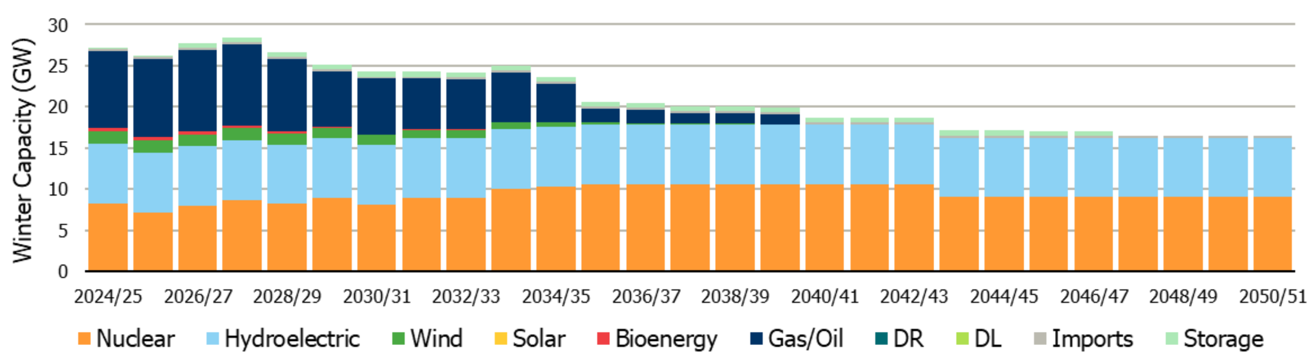
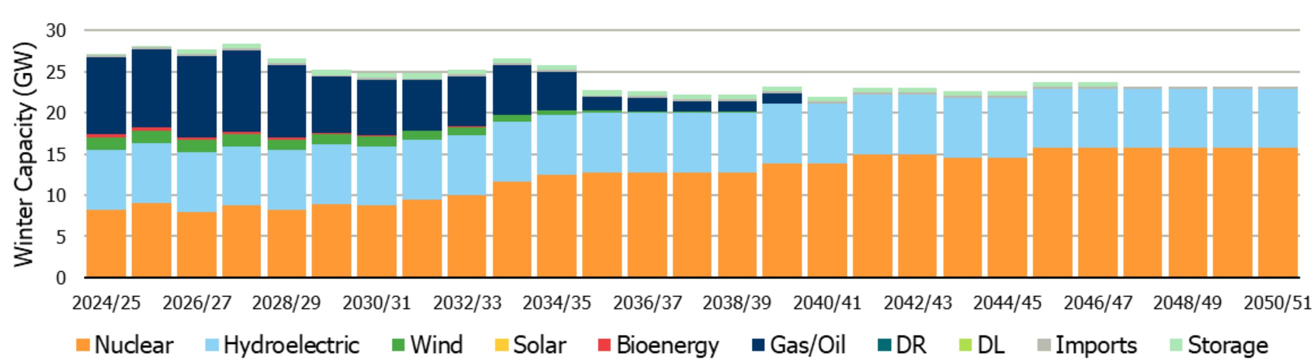


Figure 15 shows the winter effective capacities by fuel type for the outlook period in the High Nuclear case. Winter availability of the fleet ranges between 24 GW and 29 GW in the next decade, plateauing at 23 GW in the long term due to contracts expiring.

Figure 15 | Winter Effective Capacity (High Nuclear Case)



3.2.1 Nuclear Refurbishments and Retirements

Throughout the 2020s, Ontario's electricity system will see a significant change in the available capacity of its nuclear fleet. The scheduled retirement of Pickering NGS, as well as various refurbishments that will result in long-term outages at Darlington NGS and Bruce NGS, will increase resource needs. Figure 16 illustrates the retirement of Pickering at the end of 2025, which is assumed in the As Is case. The continued safe operation of Pickering B, which is not shown in Figure 16 but is assumed in the High Nuclear case, would extend its operation through September 2026. Refurbishment at Pickering B, as recently supported by the Ontario government to begin refurbishment plans, is also not shown in the figure, but is assumed in the High Nuclear case.

The nuclear refurbishment and retirement schedule assumed for the assessment is shown below. Since the time of the assessment, the nuclear refurbishment schedule has evolved. Updates to the nuclear refurbishment and retirement schedule will be incorporated in future analyses.

Figure 16 | Nuclear Refurbishment and Retirement Schedule[11]

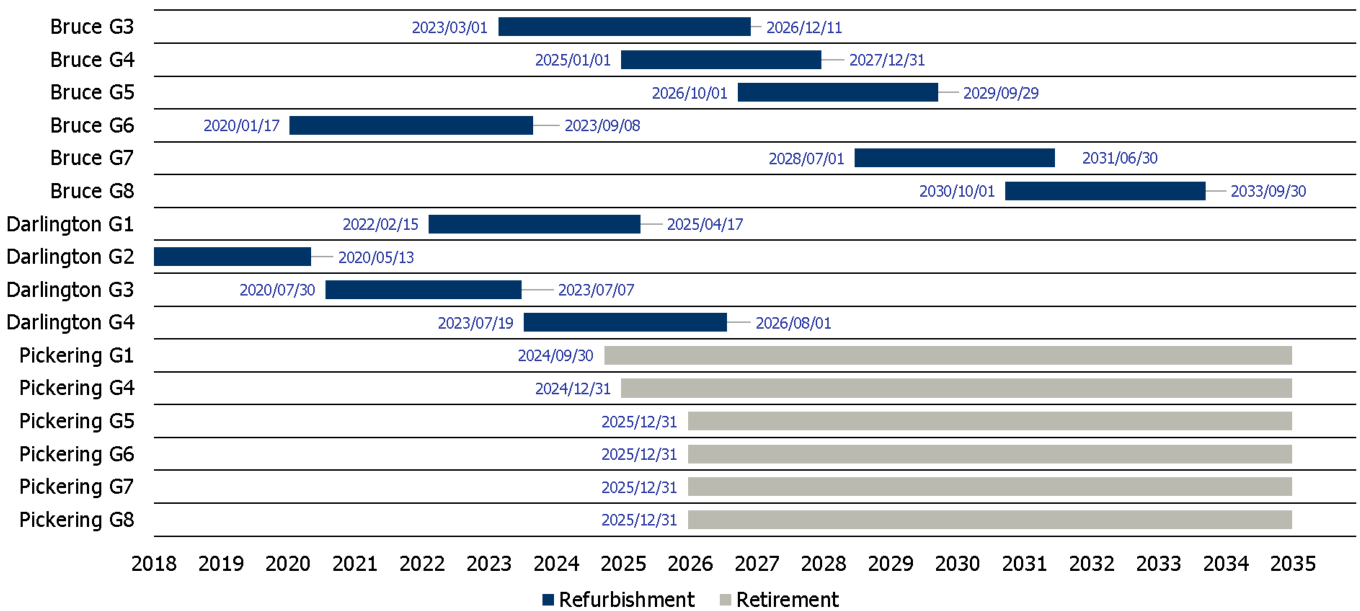


Figure 17 shows that refurbishment activity has increased in recent years, with between two and three units undergoing refurbishment concurrently over the summer periods. The Darlington and Bruce refurbishments are expected to be complete in 2026 and 2033, respectively, and by the end of 2033, a total of 8.4 GW of nuclear capacity will have undergone refurbishment. Bruce A Units 1 and 2 will reach the end of their contract term in December 2043.

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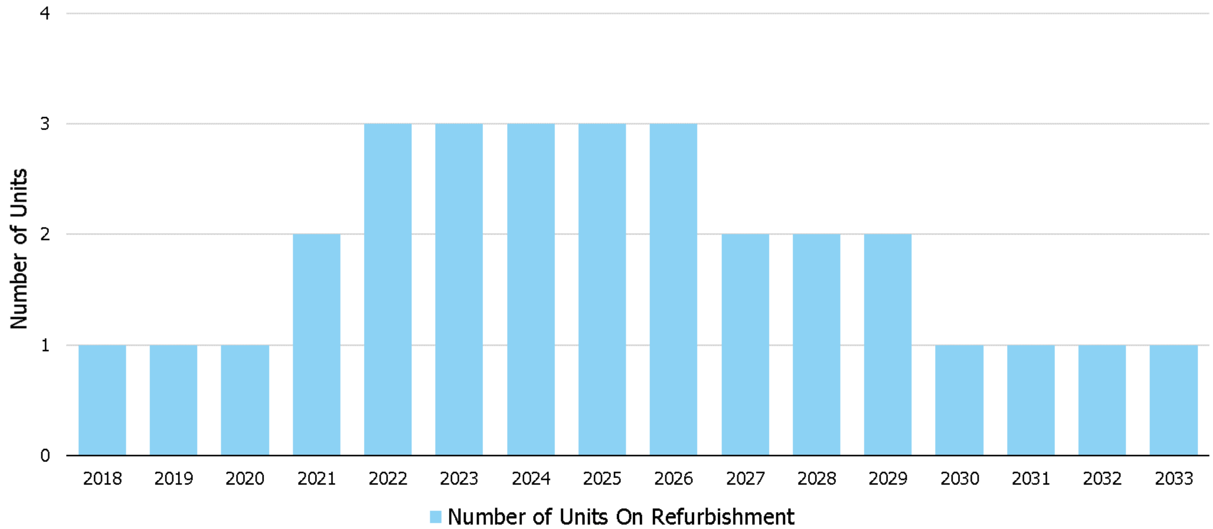
[11] The forecast schedule was provided by Ontario Power Generation and Bruce Power. Historical dates have been updated to reflect actual refurbishment start/end dates based on unit output measurement from IESO data.

Figure 17 | Summer Refurbishment Outages



3.2.2 Contracts and Commitments Ending

Over the course of the outlook, many commitments and generation contracts held by the IESO or the Ontario Electricity Financial Corporation will expire. As shown in Figure 18, many contracts will reach their end of term over the course of the outlook, and expirations increase significantly before the end of this decade (e.g., Lennox GS) and in 2034-2035 (e.g., other existing gas). In addition to the procurement of new resources, growing demand is also expected to be met by the recommitment of many existing resources that are reaching contract expiry in the next few years.

Figure 18 | Existing Resources Post-Contract Expiry by Fuel Type

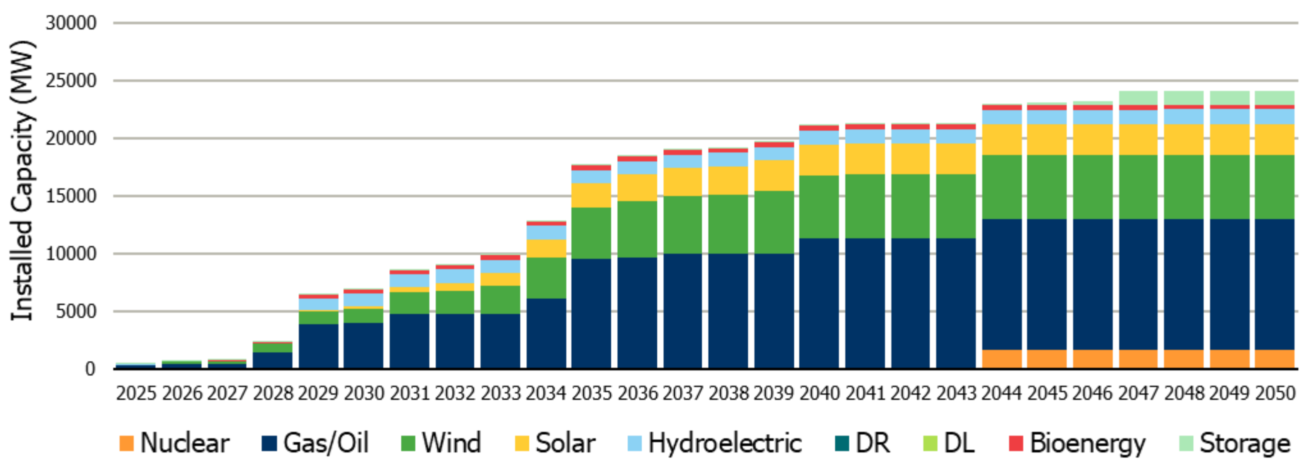


Figure 19 shows the summer effective capacities, by fuel type, that will reach their end of term over the course of the outlook.

Figure 19 | Summer Effective Post-Contract Expiry by Fuel Type (Existing Resources)

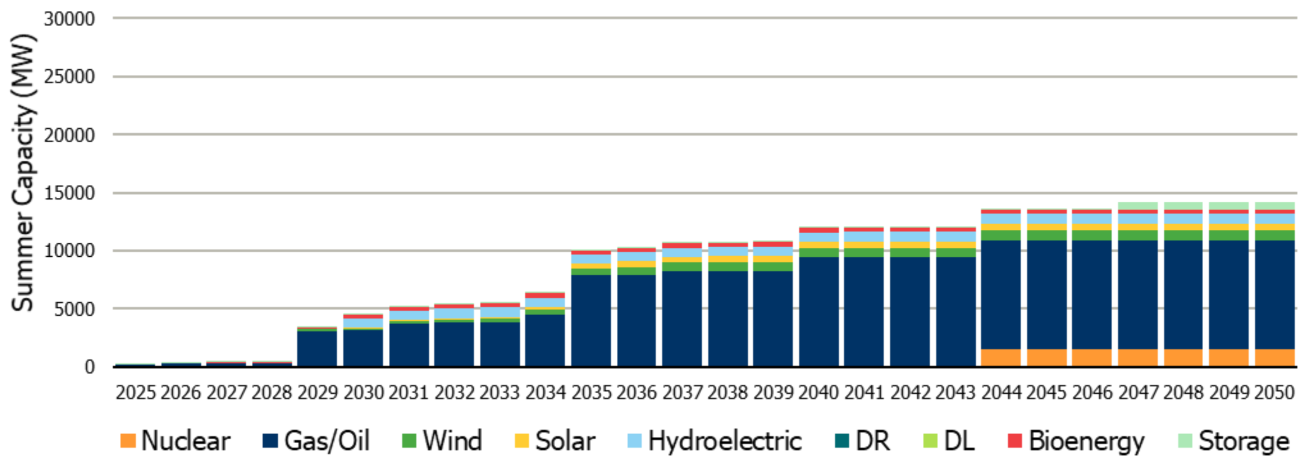
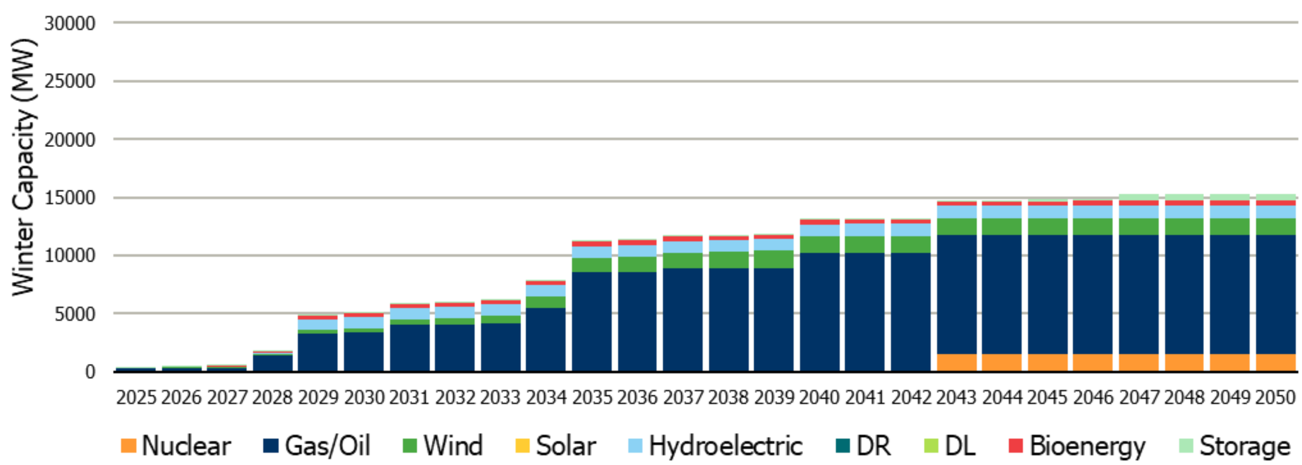


Figure 20 shows the winter effective capacities, by fuel type, that will reach their end of term over the course of the outlook.

Figure 20 | Winter Effective Post-Contract Expiry by Fuel Type (Existing Resources)



3.3 Transmission System Outlook

This section provides a basis for understanding the role of the transmission system in transporting electricity, that is, delivering power from producers to consumers across the province. There are constraints inherent in the existing transmission system that can limit the amount of power that can be transported at different times and under different circumstances. This includes the ability for power to be imported and exported into and outside of the province over a limited number of interties with Quebec, Manitoba, New York state, Michigan and Minnesota. Over time, as transmission assets age or retire, and as new facilities come online, the transmission system capability changes. New transmission facilities that will be incorporated into transmission assessments are summarized in this section.

3.3.1 The Existing Bulk Transmission System

The "bulk" transmission system refers to the network of high-voltage transmission lines and stations that transport power in high volumes over long distances. This network is critical for ensuring power generated by supply resources is able to balance system demand at all times – under normal operating conditions, and during and after disturbances that may constrain high-voltage transfer capability across the province. Within Ontario, transmission interfaces that form the boundaries between the 10 defined IESO electrical zones are used to describe the capabilities of the bulk transmission system. The potential for power to flow across these transmission system interfaces is a key input to resource adequacy assessments, because limitations on the ability to deliver power from one part of the province to another can contribute to demand-supply imbalances at a zonal level. Over time, as the transmission system is reinforced or facilities reach their end-of-life, the nature of power flows changes and new restrictive interfaces may emerge.

Power is transferred between Ontario and neighbouring jurisdictions via bulk transmission "interties," which are points on Ontario's borders where transmission lines and associated facilities interconnect this province with its neighbours. These interties provide a number of system benefits that include economic trading opportunities and the potential for contractually secured imports and exports to manage resource needs. Other benefits of participating in an interconnected system include system stability, frequency regulation and voltage support.

Ontario's internal transmission interfaces and interties with neighbouring jurisdictions are shown in Figure 21. More information about the transfer capabilities of Ontario's transmission interfaces and interties is provided in the Transmission Interfaces and Interties Module.

Since the publishing of the 2022 APO, several transmission facilities that were in development have been completed and are now in service, providing benefits for all Ontario ratepayers. These projects include the refurbishment and upgrade of transmission lines between Ansonville and Kirkland Lake in the Northeast zone, the Hawthorne-to-Merivale reinforcement in Ottawa, new reactors at Lennox Transformer Station (TS) near Napanee in the East zone, and replacement of phase shifters at the New York intertie at St. Lawrence, also in the East zone.

Figure 21 | Ontario's Major Transmission Interfaces, Electrical Zones and Interties

3.3.2 Anticipated Transmission System Expansion Projects

Transmission projects that are expected to come into service within the outlook period are included in the IESO's system plans, as these projects are sufficiently far along in their planning and development to be considered committed projects for the purpose of long-term system planning.

The system needs and drivers for the included planned projects have been described in detail in past bulk system planning studies, stakeholder engagements, regional plans and regulatory approval submissions to the OEB.[12]

The locations of these transmission projects are shown in Figure 22 and a summary of each is provided in Table 3.

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[12] Individual planning studies are published to the IESO's Planning web page at www.ieso.ca/Get-Involved/Regional-Planning.

Figure 22 | Planned Transmission Projects

Note: The voltage control devices described in Table 3 are not shown in the map.

Table 3 | Description and Status of Planned Bulk Transmission Projects

Project	Description/Status	Expected In-Service Date
Wataynikaneyap "Watay" Power Transmission Project	This project is coming online and continues to connect several off-grid remote First Nation communities to the IESO-controlled grid; it is nearing completion, and several communities have been connected to the grid in a phased manner throughout the construction	Q3 2024
Etobicoke Greenway Project (formerly the Richview TS to Manby TS Transmisson Line Reinforcement)	This reinforcement will improve the bulk transmission supply into the city of Toronto to supply the urban centre's growing demand; the project has received approval to proceed from the OEB	Q2 2026

Project	Description/Status	Expected In-Service Date
Waasigan Transmission Line (two phases)	This new transmission line will increase supply to the region west of Thunder Bay; the IESO recommended a second phase of this line in early 2023. An environmental assessment has been completed, and the proponent (Hydro One) is currently seeking approval to construct from the Ontario Energy Board	Q4 2025 (phase 1) Q4 2027 (phase 2)
Flow East Towards Toronto (FETT) Capacity Upgrade (formerly the Richview-Trafalgar Reinforcement)	The Richview-Trafalgar reinforcement will increase the FETT transfer capability by approximately 2,000 MW through upgrades to sections of the existing 230-kilovolt (kV) lines between Trafalgar TS and Richview TS, and it will enable some of the capacity required east of the FETT interface to be replaced with capacity sited elsewhere in the province	Q4 2026
West of Chatham Area Reinforcements	Strong and sustained growth in the agricultural sector is one of the main drivers of increasing demand in Ontario, as well as growth in the automotive sectors, which has resulted in a need for additional capacity in the Windsor-Essex region This multi-phase reinforcement project consists of a new Lakeshore TS and two sub-stations,[13] and a new double-circuit 230 kV transmission line from Chatham SS to Lakeshore SS. The Chatham to Lakeshore line is currently under construction	2025 for Chatham to Lakeshore line
West of London Area Reinforcements	In addition to the West of Chatham reinforcements, this project is required to supply the agricultural sector growth in the Windsor-Essex region The reinforcement project consists of a new double-circuit 230 kV transmission line from Lambton TS to Chatham SS, and a new single-circuit 500 kV transmission line from Longwood TS to Lakeshore TS	2028 for Lambton to Chatham line 2030 for Longwood to Lakeshore line

[13] Note that previous iterations of this table included a new Lakeshore TS comprising two new DESN-type sub-stations (South Middle Road DESN 1 and DESN 2). The TS and first sub-station was completed in 2022, while the second sub-station is planned to be in service in 2025.

Project	Description/Status	Expected In-Service Date
J5D Phase Angle Regulator (PAR) Replacement	The existing PAR on J5D, a critical part of the interconnection between the high-voltage grids in Ontario and Michigan (in the Windsor area), is due to be replaced at its end of life. The PAR will be upgraded to increase its capability and improve control of scheduled intertie flows between the two jurisdictions	2028
Northeastern Ontario Bulk Transmission System Reinforcements	Electricity demand in northeastern Ontario is growing, particularly in the City of Sault Ste. Marie and City of Timmins areas. This growth is primarily driven by strong economic development in mining and other industry, electrification and decarbonization initiatives, and government policies, requiring transmission reinforcements, including: • New single-circuit 500 kV transmission line between Mississagi TS and Hanmer TS, and two new autotransformers at Mississagi TS • New double-circuit transmission line between Mississagi TS and Third Line TS • New single-circuit 230 kV transmission line (built to 500 kV standard) between Wawa TS and Porcupine TS	2029 for Mississagi to Hanmer 2029 for Mississagi to Third Line 2030 for Wawa to Porcupine

Project	Description/Status	Expected In-Service Date
Bulk System Reactive Requirements in Northern Ontario	A number of reactive support devices across northern Ontario are required to address operational challenges in managing high voltages on the system, and to support the integration of several transmission line projects planned in northern Ontario, including the Watay and Waasigan transmission line projects. The reactive support devices consist of: • Two new shunt reactors at Porcupine TS, and two new shunt reactors at Lakehead TS by 2027 (for voltage control) • One new line reactor at Mississagi TS, and two new Static Synchronous Compensators at Mississagi TS and at Algoma TS by 2029 (for voltage stability) While not directly recommended as part of the Bulk System Reactive Requirements in Northern Ontario plan, the study referenced additional devices previously recommended through other studies that are still needed to help manage voltages in northern Ontario: a Static Synchronous Compensator and shunt reactor at Lakehead TS, and two shunt reactors at Mackenzie TS	2027-2029
Eastern Ontario Bulk System Reinforcement	New double-circuit 230 kV transmission line from the eastern Greater Toronto Area to Dobbin TS	2029

4. Resource Adequacy

Under a scenario with the demand, supply and transmission forecast identified from the previous sections, electricity needs in the near term are expected to be met by resources secured through upcoming Capacity Auctions. In the medium term, needs, as compared with the 2022 APO, have decreased owing to the increase in supply from resources committed through the Same Technology Upgrades Solicitation and the Expedited Long-Term RFP, as well as the announced development of the three SMRs at Darlington. In the long term, needs have increased as compared to the 2022 APO, due to contract expiries and the relative growth in the demand forecast.

A key aspect of power system reliability is resource adequacy, which describes the balance of supply and demand on the system. The IESO calculates capacity requirements by performing a probabilistic resource adequacy assessment, which compares the Forecast with anticipated resource performance to simulate the range of possible future system conditions. Loss of load expectation (LOLE), a measurement of resource adequacy, is defined as the average number of days per year during which supply is expected to be insufficient to meet demand. Reliability criteria[14] require that the IESO maintain enough capacity such that the LOLE is no greater than 0.1 days per year.

Probabilistic assessments are standard practice across North America and are part of the IESO's regulatory requirements. Over time, as forecasted demand changes, resources enter and exit the market, and the composition of the supply outlook changes, the IESO's capacity requirements will change.

The IESO also considers a number of risks in resource adequacy assessments. For example, actual demand may be higher or lower than forecasted depending on weather conditions. Resources may be unavailable in real time due to planned maintenance or equipment failures. Variable generators – such as wind and solar – may provide relatively low levels of effective capacity, depending on environmental conditions. Finally, major projects such as ongoing nuclear refurbishments may face return-to-service delays and experience a higher outage rate after they return.[15] These risks, and other risks that can impact resource adequacy needs, are discussed further in Section 7.

4.1 Reserve Margin

The IESO annually publishes a five-year forecast of reserve margin requirements at the time of projected annual peak. The reserve margin requirement is the amount of resources Ontario needs to have available over and above peak demand under normal weather conditions (represented as a percentage of peak demand).

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[14] See the NPCC's Regional Reliability Reference Directory #1 Design and Operation of the Bulk Power System, Section R4, page 6, and the IESO's Ontario Resource and Transmission Assessment Criteria, Section 8.

[15] See the 2024 APO Resource Adequacy and Energy Assessment Methodology for additional information.

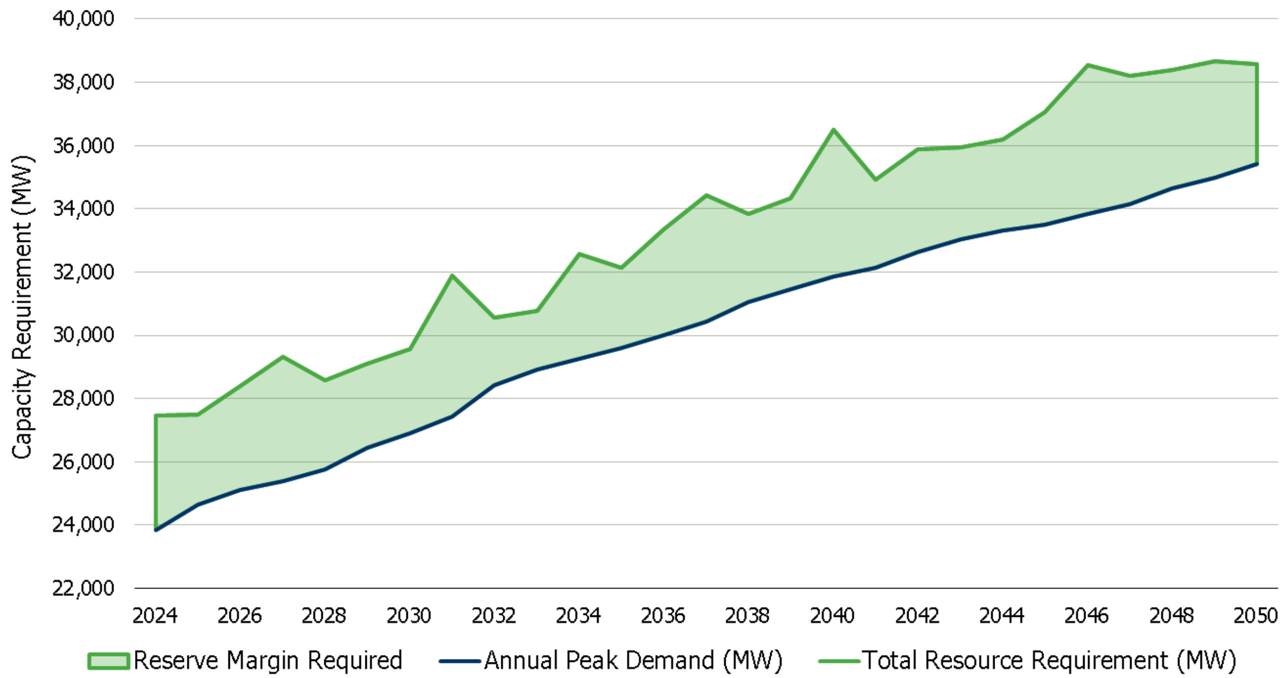
There are various reasons for year-to-year variations in the reserve margin requirement. In addition to the allowances for uncertainties identified by the Northeast Power Coordinating Council (NPCC), the IESO includes additional reserve to account for risks associated with nuclear refurbishments, with the amount varying depending on the refurbishment schedule. A year with higher-than-average planned outages will also have a higher reserve margin requirement.

The reserve margin requirements for the next five years are shown in Table 4, and the full horizon in Figure 23. The High Nuclear case was used for the calculation of reserve margins. The APO Resource Adequacy and Energy Assessments Methodology describes how the reserve margin is calculated.

Table 4 | Five-Year Reserve Margin (High Nuclear Case)

Five-Year Reserve Margin	2024	2025	2026	2027	2028
Annual Peak Demand (MW)	23,845	24,636	25,125	25,398	25,751
Existing Effective Capacity at Time of Peak Demand (MW)	27,149	26,627	27,258	26,082	25,960
Total Resource Requirement (MW)	27,454	27,489	28,395	29,336	28,577
Reserve Margin Available (MW)	3,304	1,991	2,133	684	209
Capacity Surplus/Deficit (MW)	-305	-862	-1,137	-3,254	-2,616
Reserve Margin Available (%)	14	8	8	3	1
Reserve Margin Requirement (%)	15	12	13	16	11

Figure 23 | Reserve Margin Requirement, 2024-2050



4.2 Provincial Capacity Adequacy Outlook

Capacity adequacy can be represented in terms of surplus or deficit, relative to a set of demand and resource assumptions. Resource adequacy is assessed for the summer and winter seasons using the demand forecast outlined in Section 2, and the supply and transmission outlook in Section 3.

In this section, the capacity deficit represents the total amount of capacity, on an effective capacity basis, that the IESO must acquire to satisfy LOLE requirements. The capacity deficits for summer and winter periods for the As Is case and the High Nuclear case are shown in Figure 24 and Figure 25.

In Ontario, summer capacity needs are generally higher than winter capacity needs. There are two drivers for this. The first is demand. Currently, summer peaks, driven by air-conditioning loads, tend to be higher and more variable than winter peaks. The other driver is resource performance. Existing resources, particularly gas, hydroelectric and wind, also provide less effective capacity in the summer than in the winter. While the province is expected to switch from summer-peaking to dual summer-and-winter peaking in the 2030s, Ontario continues to show higher summer needs during this period. The methodology used to calculate effective capacity for each resource type also affects the reserve margin. Summer capacity needs emerge in 2025 and are expected to be met with previous planned actions, as further discussed in Section 8. Near-term needs have increased compared with the 2022 APO forecast owing to a methodology change on the exclusion of resources expected from upcoming Capacity Auctions from the supply cases. This approach was taken to help understand the needs to establish targets for procurement actions. Medium-term needs have improved due to the increase in supply from resources procured via the Same Technology Upgrades Solicitation and E-LT1 RFP. In the long term out to 2050, system requirements are driven by resources reaching contract expiry and an increased growth in demand.

Figure 24 | Summer Capacity Surplus/Deficit

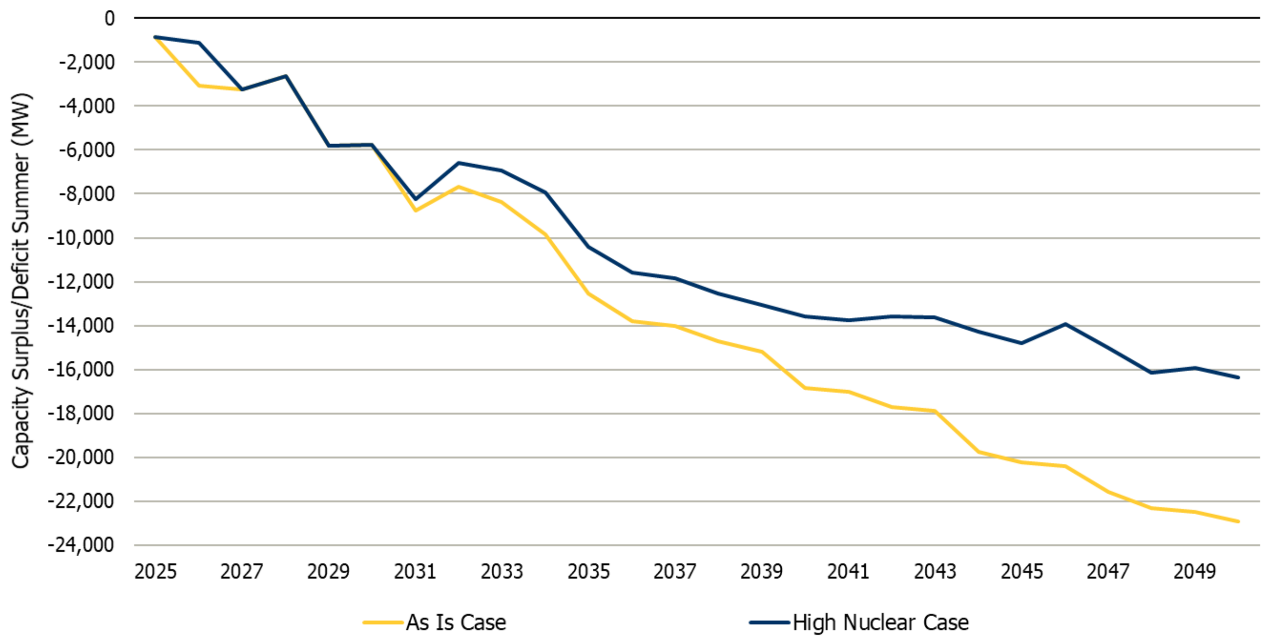
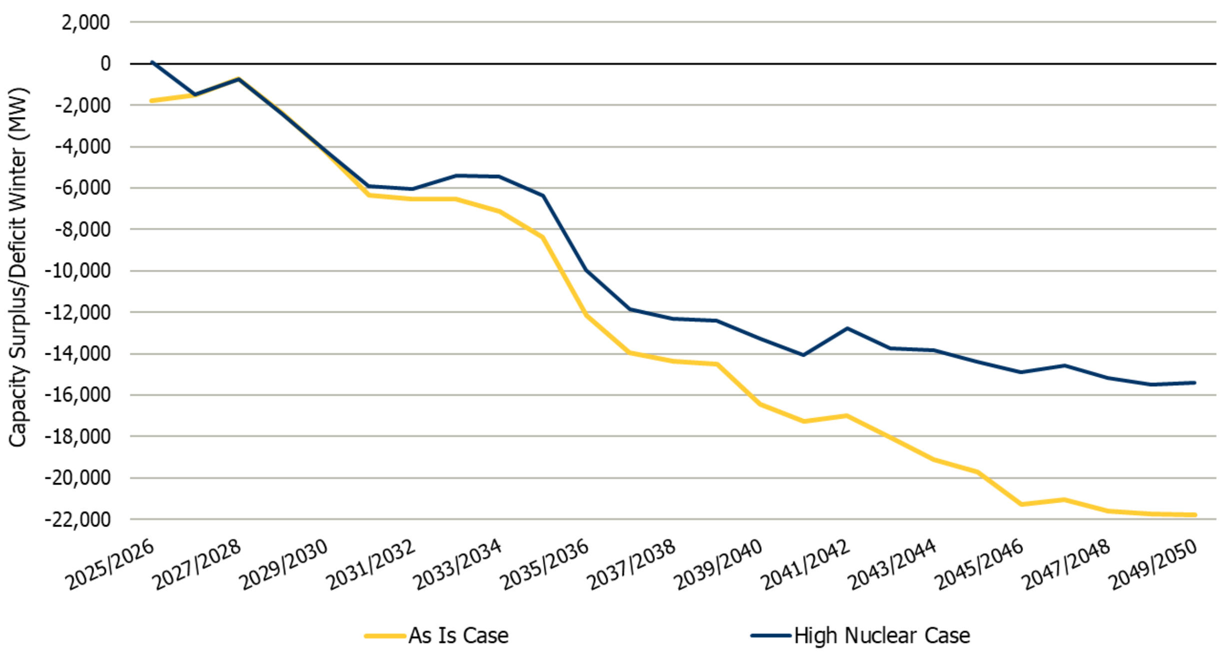


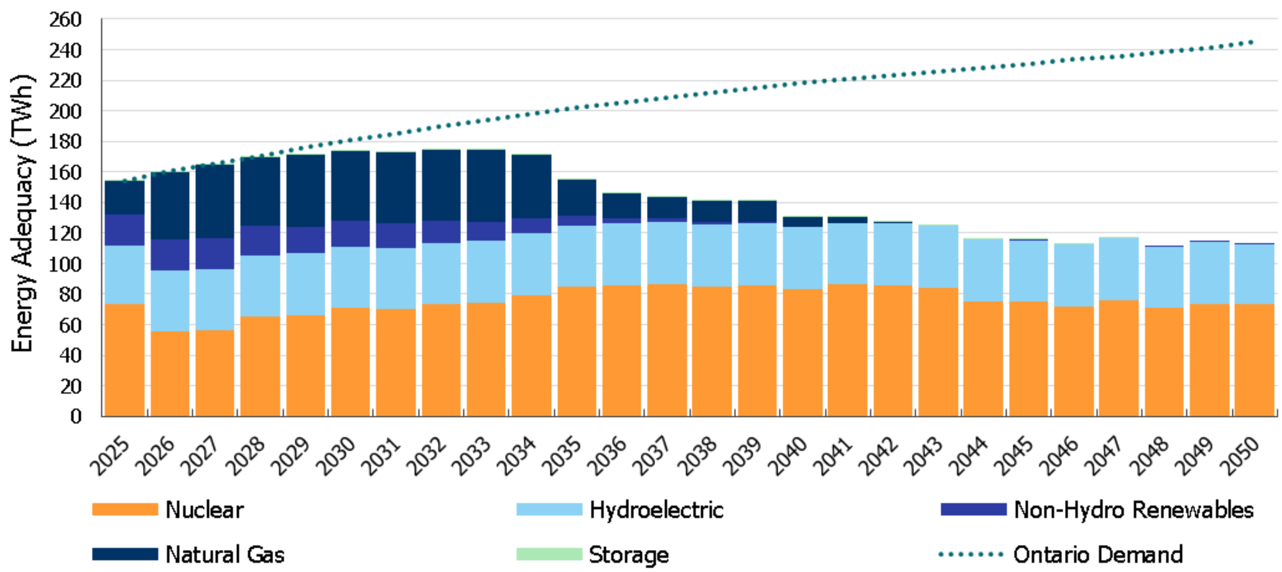
Figure 25 | Winter Capacity Surplus/Deficit



4.3 Provincial Energy Adequacy Outlook

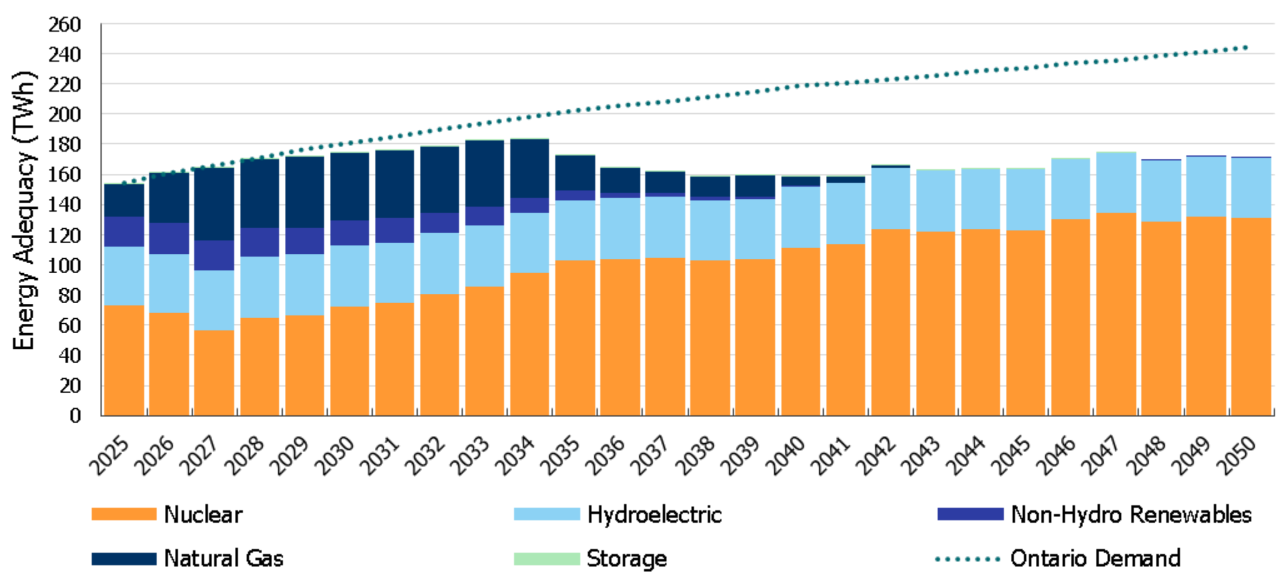
In addition to capacity adequacy, the provincial energy adequacy outlook helps determine Ontario's ability to meet electricity needs and to characterize the nature of those needs. The energy adequacy assessment does not include any economic imports or exports across Ontario's interconnections, as self-sufficiency is assumed in evaluating the system. An energy gap begins to grow in 2029, consistent with previous outlooks. In the long term, the extent to which an energy adequacy need emerges will depend on the availability of existing resources post-contract expiry.

Figure 26 | Energy Adequacy Outlook (As Is Case)



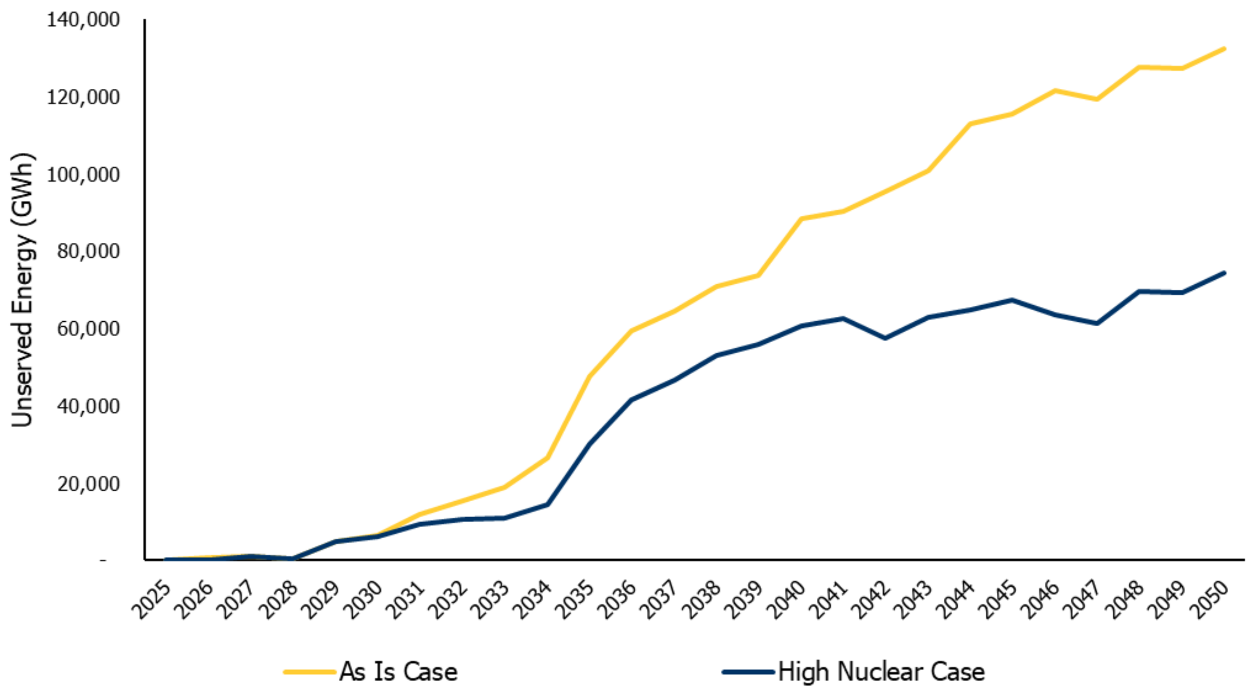
With the inclusion of baseload nuclear, the energy gap still emerges in 2029 but diminishes in the long term. The energy shortfall continues to emerge driven by increases in demand requirements.

Figure 27 | Energy Adequacy Outlook (High Nuclear Case)



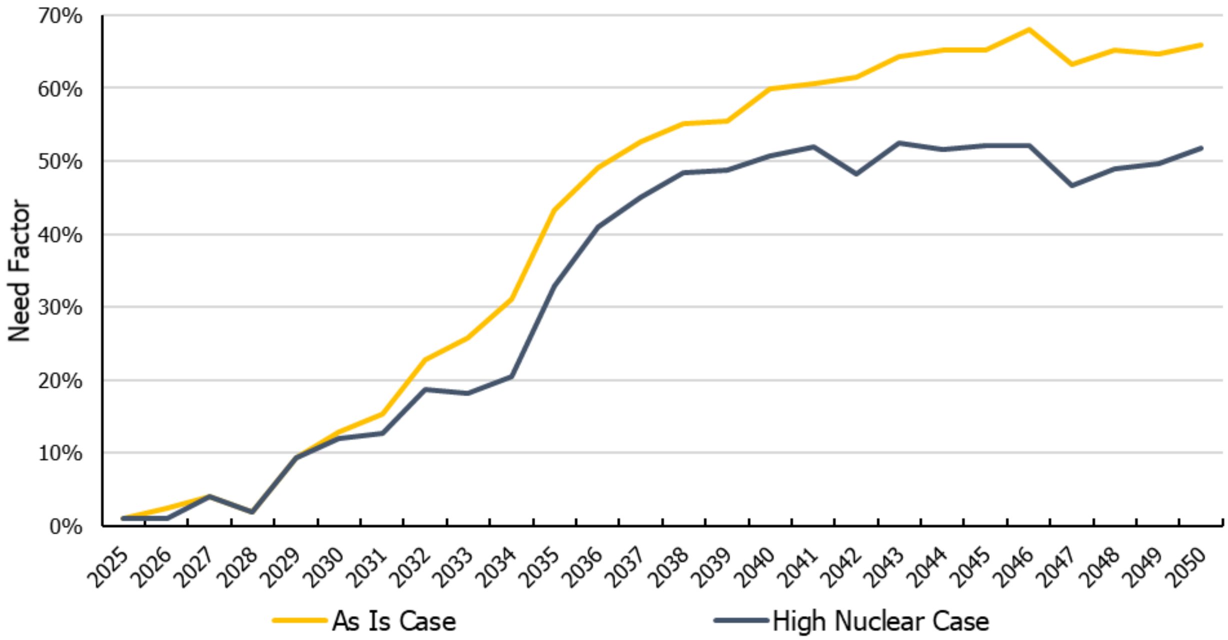
The results of the energy adequacy outlook are the amount of unserved energy, which is defined as the amount of energy that the system is unable to meet. If existing resources exit the market post-contract expiry (As Is case) and the capacity shortfall grows, the potential for unserved energy would increase sharply in 2029, surpassing 132 TWh by the end of planning horizon in 2050. With additional nuclear units (High Nuclear case), the unserved energy could be close to 74 TWh.

Figure 28 | Potential Unserved Energy



The unserved energy can also be represented by a "need capacity factor," which is calculated by dividing the annual energy need by the annual capacity need. The need capacity factor is used as a means to illustrate the utilization of the portfolio of resources that will be required to meet system requirements. The unserved energy represented as a need capacity factor, becomes more prominent starting in 2029. By the end of the planning horizon, in the As Is case, the need capacity factor increases to about 66 per cent, and to about 52 per cent in the High Nuclear case, illustrating that the requirements of baseload resources are persistent in the longer term.

Figure 29 | Capacity Factor of Need Requirements



5. Transmission System Needs

With capacity and energy needs forecast to increase in the planning horizon, a robust transmission system will continue to play a critical role in ensuring that resources can supply forecasted demand both provincially and to customers locally. This APO summarizes the known transmission system issues that will limit the ability to reliably supply forecasted growth over the next 25 years, while facilitating the coming shifts in the provincial resource mix. The public policies that will further drive the energy transition and transmission expansion are also considered, and will shape the scope of the transmission plans to come, which include beginning to look for strategic transmission expansion opportunities to align with the longer-term outlook to 2050 and beyond.

The system needs described in this section are summarized from the comprehensive transmission study that was completed for the 2022 APO, as well as from other sources of planning information, including IESO studies and regional plans that are underway or recently published by the IESO. Also reflected in this section are considerations from the *Powering Ontario's Growth* plan and subsequent transmission policy from the Minister of Energy. An updated Schedule of Planning Activities, in Section 9.5, outlines the studies that are ongoing and/or anticipated, to respond to the specific needs and policy summarized in the following sub-sections.

5.1 Drivers of Transmission System Expansion

The issues described in this section represent the outlook for transmission constraints on the reliable supply of electricity over the next two and a half decades, driven primarily by the forecasted growth in demand, from urban densification and end-use electrification more broadly, and growth in large industrial customers that typically connect directly to the high-voltage transmission system. In addition, an evolving resource mix will fundamentally change the nature of bulk power flows on the system, and an aging transmission system will require careful consideration of what to do with transmission facilities as they approach their end of life. All of these factors will contribute to a significant amount of transmission expansion, reinforcement and renewal in the coming decades.

Transmission plans over the next few years will also consider the impact of public policy direction and the energy transition towards net zero. This includes planning for scenarios that account for a shift from natural gas generation, incorporating new resources and exploring transmission's role in unlocking additional non-emitting resource development potential. Specifically, the IESO will identify transmission alternatives necessary to allow for the development of new nuclear, including SMRs and the proposed Bruce C complex, long-duration storage and hydroelectric resources. In carrying out its transmission planning mandate, the IESO will stay mindful of the opportunities to proceed with early planning and development work for transmission projects that can better position Ontario to capitalize on strategic opportunities to support future growth and development, while meeting public policy objectives. This includes continuing to co-ordinate with government to identify opportunities for protecting land corridors for future transmission development and reinforcing transmission linking northern to southern Ontario to unlock new opportunities for growth and resource development, and new transmission needed to maintain a reliable supply to support community growth and electrification.

These emerging needs, as further described in the sub-sections that follow, will be considered in the scope of the studies and plans being contemplated by the IESO.[16] If additional focused studies are needed to address additional needs as they emerge or to fully account for public policy direction, then the IESO will revise its Schedule of Planning Activities to maintain a transparent view into how and when this work will be carried out. In keeping with the government's *Powering Ontario's Growth* plan, the IESO will report back to the Minister by the end of 2024 on the status of this planning work.

The sub-sections that follow represent a snapshot of the transmission system needs that will be addressed by the IESO in transmission studies and plans. Some of these planning activities are already underway, and others will be carried out over the next few years. These plans are focused mainly on the bulk transmission system and are generally organized broadly by region: southern Ontario, which includes southwestern Ontario and the Greater Toronto Area (GTA); eastern Ontario, which includes the Ottawa region; and northern Ontario, inclusive of the Northeast and Northwest zones.

5.2 Transmission Needs in Southern Ontario

5.2.1 Central-West Ontario Bulk Transmission (Hamilton to Windsor)

Economic development opportunities in southern Ontario, including the potential connection of new large industrial customers, could stress the bulk transmission system between Buchanan TS (near London) and Middleport TS (near Hamilton-Brantford). In early 2023, it was announced that a large EV battery cell manufacturing facility was locating in this area near St. Thomas, and as one the world's largest facilities of its kind, additional suppliers associated with this plant are likely to seek to locate nearby.

The EV battery facility is forecasted to materialize in the late 2020s, and as a result, the IESO initiated a Central-West Bulk Study earlier than the planned 2024 start. The scope of the study was also broadened to account for growth and economic development from Hamilton all the way to Windsor. This study is currently underway and is estimated to be completed in the first half of 2024.

The IESO is aware of other potential new customers interested in connecting to the grid in this area and is following the status of these new connections closely. Consideration of these new connections, future changes to the supply mix and potential decarbonization of the electricity supply are being rolled into a subsequent "Southern and Central Ontario" bulk study.

5.2.2 Southern and Central Ontario Bulk Transmission Needs

Several changes anticipated to impact the bulk transmission system across southern and central Ontario have prompted the IESO to propose a comprehensive bulk planning study for the area. This

[16] The studies that the IESO intends to carry out are and documented in the Schedule of Planning Activities in Section 13.5 of this APO.

will be a follow-up to the Central-West bulk study and will roll in the scope of two previously anticipated studies: the GTA bulk supply and the Essa area studies. This will allow the IESO to account for many changes using a consistent set of models and consider interdependencies to make recommendations to reinforce the transmission system to accommodate the anticipated changes in the resource mix, including the expansion of the Bruce NGS, addition of SMRs and the potential for phasing out natural gas-fired generation. Each of these changes will impact bulk electricity flows over a wide area.

This plan will also be an opportunity to consider if new or expanded land corridors could be preserved for future transmission development, and other policy considerations from the *Powering Ontario's Growth* plan.

This study will ramp up over the first half of 2024 and will aim to conclude by mid-2025. The drivers for the GTA and Essa area components of this study are summarized below.

5.2.2.1 Greater Toronto Area Bulk Supply

Within the next 10 years, the electricity demand in the GTA load centre is forecasted to reach the capability of the bulk transmission system to deliver sufficient capacity to the area. This is because the electricity demand is expected to continue to grow in an area where there are few local generation resources. Customers in the GTA rely heavily on the bulk transmission system for reliable electricity supply. In central Toronto, this demand-supply imbalance is particularly acute, with the only transmission-connected generation resource being the 550 MW Portlands Energy Centre.

There are six major autotransformer stations that supply the GTA from the 500 kV transmission network, including the recently constructed Clarington TS in the east of the GTA. These bulk delivery points supply the 230 kV network, which in turn supplies the 115 kV network in central Toronto and the local distribution networks serving all the businesses and households throughout the region.

Since most of the internal GTA supply capacity comes from natural gas power plants,[17] plans for the area will need to consider expanding the links between the bulk transmission network and the GTA. The needs and analysis of options in the GTA are being considered in the scope of the broader planning study that covers central and southern Ontario, as there are other changes that will impact flows across a much wider region, including the connection of major loads and future expansion at Bruce NGS.

5.2.2.2 East GTA Bulk Transmission

Some of the 230 kV transmission lines in the eastern part of the GTA are forecasted to reach their thermal capacity limits in the mid- to late 2030s. These lines, linking two major autotransformer stations, Clarington TS and Cherrywood TS, will carry more power from the east to supply the growing local electricity demand during potential Pickering refurbishment outages. The most limiting section of these circuits is between Clarington TS and Wilson Junction, which supplies the electrical demand in Oshawa and other fast-growing areas in east GTA.

[17] Including the aforementioned Portlands Energy Centre in downtown Toronto, York Energy Centre in the northern GTA, Halton Hills Generating Station in west GTA and the comparatively smaller Greater Toronto Airports Authority.

Through the IESO's ongoing procurement activities it has also been demonstrated that the 500 kV transmission path between Bowmanville and Cherrywood is a limitation on the potential for new large generation projects to locate in the Eastern Ontario electrical zone (east of Bowmanville).

The IESO will review the transmission needs in east GTA with the assessment of broader GTA long-term bulk supply options as part of a larger, co-ordinated study. The future plans for SMRs at Darlington and development of other provincial supply options east of the GTA are supply consideration that will be considered in the scope of this study.

5.2.2.3 Essa Area Transmission

Essa TS, east of Barrie, is a major bulk transmission hub linking northern and southern Ontario and bulk power delivered from the Bruce NGS. Issues affecting the 500/230 kV autotransformers at Essa TS were also found in the Barrie-Innisfil Integrated Regional Resource Plan[18] (IRRP) published in May 2022. There is a risk that the loss of one autotransformer at Essa TS will overload its companion transformer. The Barrie-Innisfil IRRP recommended this issue be addressed through bulk system planning.

Two of the 230 kV transmission lines from Essa TS supply Orillia and Minden. The lines near Minden TS are expected to reach their thermal capacity in about 2032 or shortly after. This issue is expected to progressively worsen as the demand in the area grows.

The need for additional autotransformer capacity at Essa TS will be assessed as part of a broader IESO bulk planning study that will consider possible transmission interconnection options for an expanded Bruce NGS, and that is co-ordinated with assessing the capacity of the bulk transmission system separating northern and southern Ontario. While the Essa electrical zone, including Essa TS, is located in central Ontario, there are transmission facilities in this area that are critical for electricity flows from north to south and vice-versa. Therefore, aspects of the bulk system planning for some facilities in this area may overlap between central and southern, and northern Ontario plans.

5.3 Transmission Needs in Northern Ontario

5.3.1 Northeast and Northwest Ontario

The IESO recently completed a bulk planning study that made specific transmission expansion recommendations for accommodating future industrial growth in northeastern Ontario. A follow-on study has recommended voltage control devices to enable better control of system voltages in the north. The facilities that have been recommended in these studies are summarized in Table 3.

Changes that are anticipated in the northern supply mix and industrial demand growth will further impact the bulk transmission system in northern Ontario and thus require planning. The Flow North/Flow South interface comprises two 500 kV circuits connected into Essa TS from the north and one additional 230 kV circuit eastward. Electricity flows across this interface can already be limited in periods of low or high hydroelectric production in the north. The potential for expansion of new

[18] Information about this study and the IRRP can be accessed here: https://www.ieso.ca/en/Sector-Participants/Engagement-Initiatives/Engagements/Regional-Electricity-Planning-Barrie-Innisfil

non-emitting resources including wind, solar and hydroelectricity in the north could strain the grid's capability to deliver the additional flows from the resources to customers in southern Ontario across the Flow South interface. Conversely, increasing demand in the north could stress this interface during periods of low hydroelectric production.

Generation resource expansion in the north is one driver behind a proposed bulk planning study for the northern region. The study will also consider forecast load supply requirements, including scenarios considering long-term economic development, both in the north and in the south, as the transmission out of the north is critical for delivering power to the GTA.

Transmission alternatives to enable connection of remote First Nation communities and prospective mining developments in remote northwestern Ontario will be considered through the Northern Ontario Connection Study. The study will evaluate socio-economic and environmental benefits of the proposed connection options and explore opportunities to connect new hydroelectric generation to the transmission system.

5.4 Transmission Needs in Eastern Ontario

5.4.1 Eastern Ontario Bulk Transmission Needs

The IESO proposes to initiate a comprehensive bulk planning study for eastern Ontario to examine a number of interdependent transmission needs arising across the area. Studying the various needs together will allow the IESO to account for the many changes in the area while developing recommendations to reinforce the transmission system in eastern Ontario in a co-ordinated manner. This plan will also be an opportunity to consider if new or expanded land corridors could be preserved for future transmission development, evaluate the potential phasing out of natural gas-fired generation and examine the potential for new and/or expanded interties.

The Eastern Ontario Bulk Transmission Needs study will be initiated during the second half of 2024 and will aim to conclude by early 2026. The study will focus on key areas described below.

5.4.1.1 Ottawa Area Bulk Supply

Within the next 10 years, the electricity demand in the Ottawa area is forecast to exceed the bulk transmission system's ability to provide sufficient capacity to the area. Electricity demand in the area is expected to grow significantly due to electrification, new housing and commercial developments. While there are a number of smaller transmission- and distribution-connected generators located in Ottawa, the area relies heavily on the bulk transmission system to supply its electricity requirements.

5.4.1.2 Lennox Area Transmission

Lennox TS, located in Lennox and Addington County, is a major bulk transmission hub linking central and eastern Ontario and connects a number of gas-fired generation facilities in the area. Lennox TS supports the 230 kV system in the area, which supplies the municipalities of Belleville and Kingston, as well as a number of industrial loads. Demand in the area is growing, and transmission reinforcements may be required in the medium-to-long term to ensure the transmission supply capability to the area is sufficient and to accommodate economic development opportunities. In addition, the study will need to consider multiple Lennox GS operating scenarios, including shutdown at the end of its contract term in 2029 and continued operation to 2035.

5.5 Interties with Ontario's Neighbouring Jurisdictions

Ontario's interties are critical for enabling import and export activity, as well as enhancing system stability through participation in the eastern interconnection. The IESO participates in co-ordination activities with Ontario's neighbouring electrical jurisdictions to share data and information related to the interties and to address issues that could have interjurisdictional impacts.

A screening study of Ontario's interties identified interties where a long-duration equipment outage could result in reliability impacts for electricity customers in this province. It was identified that an unexpected failure of unique, non-standard transmission equipment, such as a phase angle regulator (PAR, also known as a phase shifter),[19] could have a high impact on flows across the intertie and take a long time to replace. A joint intertie study was carried out between the IESO and Midcontinent Independent System Operator to study end-of-life options for replacing the existing PAR on J5D, a critical part of the interconnection between the high-voltage grids in Ontario and Michigan (in the Windsor area). As a result, the PAR on circuit J5D will be replaced, and upgraded, to increase its capability and improve control of scheduled intertie flows between these two jurisdictions.

A second study is underway to assess major equipment at the Ontario-Manitoba intertie, including two PARs and two step-up transformers that are approaching end of life. A joint study was initiated between the IESO, Manitoba Hydro and Minnesota Power to create a plan to replace and/or upgrade this critical intertie equipment.

5.6 Development of a Transmitter Selection Framework

The IESO is currently engaging with stakeholders, transmitters and communities on a potential future transmitter selection framework. The energy transition, electrification and major renewal of the generation supply mix will require a significant transmission expansion and reinforcement in the future. In order to better manage the costs of new transmission and promote innovation, a transmitter selection process would open up opportunities to new parties to participate in transmission development. The IESO will report back to the Minister in summer 2024 with options and advice on a transmitter selection framework that formalizes a more timely, transparent, predictable and competitive process for constructing future lines.

[19] These are highly specialized transformers that are purpose-built pieces of equipment that help control the power flow between two interconnected transmission systems.

6. Operability

A reliable system is one that is both resource-adequate and operable. In addition to requiring that energy and capacity needs are met, Ontario's resource mix must contain the reliability services needed to support reliable grid operations and respond to the inherent variability and uncertainty of electricity supply and demand. More information on the services needed for the reliable operation of the electricity system is provided in the Operability Module.

As the resource mix evolves, assessments of operability needs will become more critical to ensuring reliable operations in the future and will inform design considerations for future procurements on the value of resources that can provide the reliability services that are needed. The IESO anticipates that attributes such as dispatchability, capability to provide frequency support, voltage support and flexibility (the ability to respond quickly to changing system needs)[20] will be increasingly valued in future procurements. Historically, the IESO has acquired services such as frequency and voltage support through ancillary service contracts; going forward, other avenues of acquiring these essential reliability services may be explored.

6.1 Ancillary Services Needs Assessments

6.1.1 Regulation Service

Regulation service ("regulation") is one of four ancillary services that the IESO contracts to help ensure the reliable operation of the power system. Regulation provides minute-to-minute balancing to ensure electricity supply matches demand and is currently provided by generation facilities with automatic generation control capability, which permits them to vary their output in response to signals sent by the IESO. The IESO schedules a minimum of ±100 MW of regulation, as required by the market rules; this helps to maintain the balance between Ontario's supply and demand and the IESO's compliance with the relevant reliability standard, as established by the North American Electric Reliability Corporation (NERC).

6.1.2 Regulation Needs Assessment

Each year, the IESO conducts an assessment to determine if there are incremental regulation needs within the province over the next 10 years. The assessment takes into account the forecasted load growth presented in this APO, load profiles with the expected addition of industrial loads with highly fluctuating operating profiles and the evolving resource mix within Ontario. The objective of the assessment is to assess the impact of these changes on the amount of regulation needed to maintain a sufficient balance between electricity supply and demand. This regulation needs assessment

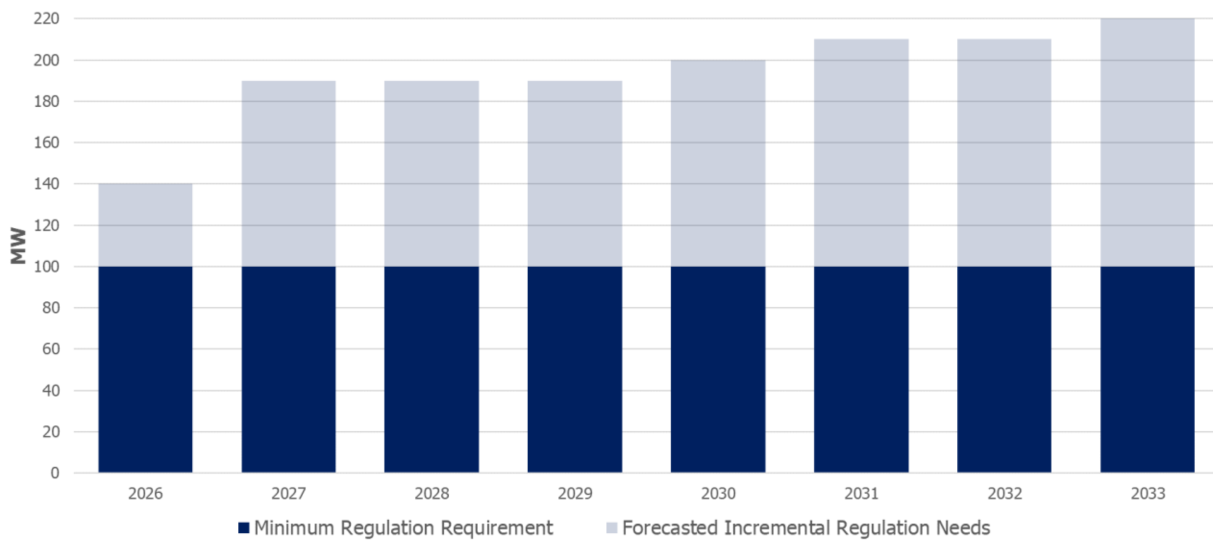
[20] Flexibility services include, but are not limited to, regulation, operating reserve and ramping capability.

supersedes previous assessments performed by the IESO. Further information on the assessment methodology is provided in the Operability Module.

This year's assessment found that maintaining sufficient balance between supply and demand over the next decade will require incremental regulation service of approximately 40 MW beginning as early as 2026, which is anticipated to grow to an incremental need of 120 MW in 2033. Approximate needs are shown in Figure 30. The IESO is currently assessing ways to meet the need.

Future regulation needs may change based on updates to the demand forecast, changes to the in-service dates or size of the expected industrial loads, or increased penetration of variable generation resources. The IESO will continue to assess needs that incorporate these and other dynamic factors and will adjust future regulation needs accordingly.

Figure 30 | Forecasted Incremental Regulation Needs



7. Risks and Uncertainties

In addition to the risks considered in the IESO's resource adequacy assessments (described in Section 4), a number of risks and uncertainties could have an impact on Ontario's reliability needs, ranging from the amount of electricity demand to supply constraints. This section provides a description of uncertainties related to demand, supply, policy and regulations, and climate change and resiliency risks. The potential impact of some of the risks and uncertainties described in this section is considered in the Integrated Reliability Needs assessment in Section 8, informing the development of the set of planned actions in this APO. Incorporating potential risks and uncertainties in the resource adequacy assessments ensures that reliability needs are addressed in a timely manner while balancing factors that could drive oversupply or inefficient outcomes.

7.1 Demand Uncertainties

The Forecast is based on an understanding of current states and foreseen changes to Forecast driver variables, and the current state of policy and regulations. Forecast driver variables include:

1. **Economy**: state of economy and changes of state in economic cycles (income, employment, output, etc.), commercial and industrial sector expansion levels (including project-specific changes in electricity demand levels and implementation timelines), industrial sector output, emerging industries (battery materials production, hydrogen production, cryptocurrency mining, etc.), etc.
2. **Demographics**: population changes and geographic migration, residential sector household count growth and type shares.
3. **Fuel rates**: global fuel commodity prices, costs of provincial electricity generation resources, etc., which can affect marginal commodity costs of electricity based on natural gas rates, discretionary, elastic demand for electricity, and contributes to economic-based fuel source decisions for capital expenditure such as building space-heating using electricity or natural gas.
4. **Technological capabilities**: end-use fuel substitutability (building heating, transportation, industrial heating), end-use capabilities, efficiencies and characteristics (building space- and water-heating from heat pumps including cold-climate performance and ambient temperature-dependent coefficients of performance, lighting technologies), etc.
5. **Climate**: weather-sensitive end-use demand and hourly load profiles, such as building HVAC, and transportation electrification (see Section 7.4).
6. **Policy and Regulatory:** see Section 7.3.
7. **Other**: global pandemic, geopolitical conflicts, customer preferences, etc.

The IESO makes best efforts to identify, assess and determine current and most probable future levels of all Forecast drivers in each Forecast. As drivers of the Forecast are constantly evolving, the IESO continuously monitors all drivers. Should Forecast drivers change after Forecast finalization, the IESO will incorporate its latest assessment of Forecast drivers in the next APO.

7.2 Supply Uncertainties

7.2.1 Existing Resources

A number of uncertainties related to the future participation of existing resources could have an impact on Ontario's supply and influence the outlook on both resource adequacy (capacity and energy) and transmission adequacy.

7.2.1.1 Aging Assets and Decreased Performance

Ontario's existing resources consist of facilities of varying ages, with a large portion of the fleet that is aging. Aging supply infrastructure applies upward pressure on future resource adequacy requirements, as the level of performance typically decreases over time and is observed through increased frequency and duration of planned outages and higher forced outage rates. This can be further exacerbated by climate events and extreme weather conditions (see Section 7.4). Investments in the facilities may be required to maintain the same level of reliability and performance that existed before and to maintain adherence to regulations.

7.2.1.2 Refurbishments and Outage Management

The nuclear refurbishment program, currently underway, has multiple nuclear units scheduled to be out of service for years at a time. Given the size of each unit, there is a significant risk to resource adequacy if the return of units is delayed. Conversely, an advancement in the refurbishment schedule could shift the timing of resource adequacy needs. The resource adequacy assessment in Section 4 reflects additional planning reserve to manage the risk of nuclear refurbishment and is further described in the 2024 APO Supply, Adequacy and Energy Outlook Module.

Co-ordinating outages is expected to become more challenging during the years where new replacement facilities and supporting infrastructure are under construction and commissioning. Outage co-ordination will also be challenged as physical climate changes affect the duration of shoulder seasons, which tend to be more optimal periods for scheduling of outages. In combination with the increased risk of forced outages resulting from an aging fleet, these factors increase uncertainty in the availability of supply and transmission to meet adequacy needs.

7.2.1.3 Market Exit

The 2023 NERC Long-Term Reliability Assessment indicates an increasing risk to resource adequacy as generators retire but are not yet replaced, highlighting the importance of managing the pace of generation retirements to mitigate the risk to reliability. Factors such as aging assets, revenue uncertainty and policy uncertainty may drive a portion of existing resources to exit the market, putting downward pressure on supply.

Stakeholders have indicated that options are being explored to continue operating resources beyond contract expiry. While the number of market exits prior to 2035 is anticipated to be low and more likely to be made up of smaller and older resources, decarbonization policies such as the proposed federal Clean Electricity Regulations (CER) are anticipated to have an impact on the number of resources that exit the market in the mid-2030s; the IESO will continue to monitor this risk and the resulting impact on resource adequacy.

7.2.2 New Resources

As Ontario enters a period of significant and increasing resource acquisition through the energy transition, new resources of both existing and emerging technology types are anticipated to be integrated into Ontario's electricity system to help meet resource adequacy needs. New technologies are anticipated to play an important role in future procurements and a diverse portfolio of non-emitting resources will be critical to meeting future reliability needs.

Towards the end of this decade and into the 2030s, relatively new technology types are anticipated to contribute to meeting reliability needs, including energy storage resources and SMRs. While batteries and other storage technologies are proven and currently participate in Ontario at a small scale, participation of these resources is expected to increase in the middle of this decade as a result of IESO actions and government announcements. To maximize the benefits of these resources, the IESO is expediting the implementation of the enhanced models for storage and hybrids as well as elements of the enhanced model for DERs. The contribution of storage resources to capacity needs may also be influenced by overall provincial resource mix changes and the proliferation of storage itself. The IESO continues to explore mechanisms to enable participation of emerging resources, including initiatives under the Enabling Resources Program. Resource adequacy analyses will be updated in future APOs as necessary as these new resource types come into service.

In the longer term, resources utilizing fuel types such as hydrogen and renewable fuels are anticipated to contribute to meeting reliability needs. As the use of these fuel types is largely in the innovation and testing phase and they are not yet commercially available at scale, there is some uncertainty around their ability to contribute to meeting reliability needs.

With any new resource type or new-build facility, there are various risks that may materialize at any point, from the contracting stage through to facility operation.

7.2.2.1 Acquisition Targets Not Met

Various factors could result in a target for a given acquisition not being met. One factor is the risk that projects will be proposed in areas of the province with transmission limitations. To mitigate this risk, the IESO's deliverability assessment process ensures that procured resources are located such that they avoid areas with limited connection availability due to transmission and/or distribution system limitations. Deliverability assessments are conducted for each acquisition process, and in some, only projects that are deemed deliverable are allowed to participate in the procurement. As the period of high acquisition activity continues, deliverability limitations may increase until sufficient transmission and distribution infrastructure is in place – infrastructure that could have longer lead times than the proposed projects.

The deliverability studies conducted as part of the Same Technology Upgrades Solicitation, E-LT1 RFP and LT1 RFP indicated areas of the province where accommodating additional capacity from resources is challenged due to transmission constraints that are present during the expected in-service dates of the proposed projects. Deliverability assessments that are part of future acquisition periods may have different results, as:

- Transmission upgrades identified in regional and bulk planning studies come into service;
- Transmission system upgrades that were recommended to Hydro One as part of the deliverability assessment for the Same Technology Upgrades Solicitation and E-LT1 RFP come into service, that are expected to improve deliverability and allow more projects to contribute to meeting system needs;
- Existing generation assets retire or exit the market;
- The nature of the reliability need changes (i.e., energy versus capacity); and
- Policies that influence the development of industry, housing and decarbonization continue to be developed.

In addition to deliverability challenges, the risk of acquisition targets not being met could result from lower participation in procurements, driven by external factors such as competition for capital, potential opportunities in other markets, policy and regulatory uncertainty pertaining to resource eligibility, corporate environmental, social and governance mandates or inability to secure municipal support.

7.2.2.2 Commercial Operation Not Achieved

Reaching commercial operation is not guaranteed after capacity or energy from a resource is contracted through a procurement process; this uncertainty has materialized in past procurements primarily due to an inability to secure the necessary permits for a project. Other reasons for not reaching commercial operation can include challenges with community support or securing financing. Resources that are acquired through the IESO’s procurements but are unable to reach commercial operation would increase resource adequacy needs.

7.2.2.3 Project In-Service Delays

All projects face development risk that can lead to in-service delays driven by a number of factors. As the IESO experienced in the transition from coal generation to replacement supply, only 30 per cent of projects were in operation on schedule, with 60 per cent falling behind by an average of 10 months and the remainder failing to reach commercial operation.

Supply chain disruptions driven by shortages and challenges in securing raw materials, increases in costs and geopolitical events increase the risk of delays in project development. These factors are anticipated to continue to pose risks, particularly in the development of new supply resources, which could increase resource adequacy needs.

7.2.2.4 Reliable Operation of Contracted Resources

Experience has indicated that after a new resource comes into service, there is a period where the risk of equipment failure and forced outages is higher. While this risk decreases over time, the initial period of uncertainty can result in an increase in resource adequacy needs. In addition, new market participants may be unfamiliar with operating in the IESO's real-time market, which can result in a resource not being available when expected. With newer technologies expected to participate in upcoming procurements, the integration and reliable operation of new resource types is anticipated to take time and may put upward pressure on resource adequacy needs.

7.3 Policy and Regulatory Uncertainties

7.3.1 Demand Forecast Policy and Regulatory Risks and Uncertainties

The Forecast incorporates electricity demand impact assumptions based on currently announced policy and regulations. Any future changes in policy or regulations at the federal, provincial or municipal levels may impact the Forecast. Policy and regulatory risks and uncertainties can generally be categorized in one of four broad categories:

1. **Energy**: includes impacts on fuel rates (Ontario Electricity Rebate, global adjustment), electricity rate structures (time-of-use electricity pricing structure, ICI, Ultra-Low Overnight electricity rate, Interruptible Rate Pilot, dynamic pricing pilot, etc.), CDM initiatives (programs and regulations), etc.
2. **Economy**: includes government revenue, interest rates, economic development, job creation and trade, mines, northern development (Bank of Canada monetary policy and interest rates, Ontario Critical Minerals Strategy, Ontario Low-Carbon Hydrogen Strategy, Ontario Driving Prosperity automobile production plan, Northern Ontario Heritage Fund, project-specific funding support), etc.
3. **Climate change mitigation**: includes GHG emissions reduction, and fuel-switching (direct and indirect electrification) in other sectors. This is being achieved through vehicle emission requirements and GHG emission cost structures such as the federal 2030 Emissions Reduction Plan, federal fuel charge, federal CER, federal 100 per cent sales target for non-emitting vehicles, Toronto Green Standard municipal building permit requirement, Canada's net-zero emissions target for 2050, etc.
4. **Other**: includes population, immigration, housing, geopolitics, transportation, public health and pandemic mitigation, climate change adaptation, etc.

7.3.2 Supply Forecast Policy and Regulatory Risks and Uncertainties

Ontario's supply mix continues to be informed by, and adapt to, government policy. Some of the initiatives below, if pursued, will result in an overall increase in supply. While the High Nuclear case provides insight into the potential impact of the nuclear initiatives described below, the contribution of these resources is subject to policy and regulatory decisions – subsequent planning outlooks are anticipated to reflect any decisions that are made. In addition, other factors that can affect Ontario's resource adequacy needs include agricultural land use and decarbonization efforts led by both the federal and provincial governments, including the proposed federal CER and the work of the Electrification and Energy Transition Panel (EETP).

- **Pickering Continued Safe Operation:** The resource adequacy assessment in the High Nuclear case assumes the continued operation of Pickering Units 5-8 to September 2026, aligning with the Ministry of Energy's announced support on Sept. 29, 2022, and indicated in the *Powering Ontario's Growth* plan. Continued operation of the Pickering units requires regulatory approval by the Canadian Nuclear Safety Commission (CNSC), which is pending as of this APO release.
- **Pickering B Refurbishment:** The resource adequacy assessment in the High Nuclear case assumes the refurbishment of Pickering B units. As indicated in the *Powering Ontario's Growth* plan, the Ministry of Energy asked Ontario Power Generation (OPG) to update its feasibility assessment for refurbishing Pickering B units, and in January 2024, the government announced its support of OPG's plan to proceed with the next steps. The refurbishment would allow the facility to operate for an additional 30 years. OPG will now proceed with the Project Initiation Phase of refurbishment, which will last through the end of 2024. The refurbishment of Pickering B is also subject to regulatory approval by CNSC.
- **Bruce Power Expansion:** The resource adequacy assessment in the High Nuclear case assumes the addition of new generation at the Bruce nuclear site, as indicated in the *Powering Ontario's Growth* plan. The potential expansion would increase the province's generating capacity by up to 4,800 MW and is in the early stages of pre-development work, as required by the CNSC's multi-stage licensing process for new large-scale nuclear stations.
- **Pumped Storage Projects:** On Jan. 9, 2024, the Minister of Energy asked TC Energy to provide the IESO with a breakdown of the estimated costs of pre-development work on the Meaford Pumped Storage project and a project schedule of this work. After receiving the submission of estimates and project schedule, the Minister has asked the IESO to conduct an assessment of the proposed costs and provide a recommendation to proceed with pre-development of the project within 45 days of submission. If approval to proceed is granted, subsequent planning outlooks are anticipated to reflect the resource adequacy contribution of this project.

- **Opportunities for New Hydroelectric Development:** On Feb. 9, 2023, OPG published the *Made-in-Ontario Northern Hydroelectric Opportunities* report in response to the Ministry of Energy's letter dated Jan. 20, 2022, requesting an examination of opportunities for new hydroelectric development in northern Ontario. The report identified 3,000 MW to 4,000 MW of hydroelectric potential in the region, the majority of which would require reinforcements to the existing transmission system to release new generation to load centres. As indicated in the *Powering Ontario's Growth* plan, the Ministry of Energy has requested that OPG propose options to optimize electricity generation from existing sites and engage with Indigenous communities on future hydroelectric generation projects.
- **Municipal Council and Indigenous Support Requirements:** Municipal council and Indigenous support has been an important design element in the IESO's E-LT1 and LT1 RFP processes and is expected to remain a requirement for future procurements, aligning with the directive for the LT1 RFP dated Aug. 23, 2023. Recognizing the de facto veto power of municipalities in supporting or rejecting projects for reliability-based procurements, and aligning with the Minister's request in the letter dated Nov. 14, 2023, the IESO will continue to engage with communities on local projects to ensure that municipal councils are appropriately informed on future needs, understand the overall procurement and development process and their critical role in the process.
- **Agricultural Land Use Restrictions and Permitting:** In response to the letter dated July 10, 2023, from the Minister of Energy, the IESO will be further assessing and engaging on agricultural land use, including impact on past procurements, engagement feedback and potential mitigation strategies. Significant restrictions on using agricultural land could limit opportunities to repower/expand existing facilities, impact the volume and timeliness of new resources that are needed to maintain reliability and increase the need for availability of other types of land.
- **Clean Electricity Regulations:** On Aug. 10, 2023, the federal government released a draft of the CER as part of its *Powering Canada Forward* plan to achieve net-zero emissions in the electricity system across Canada, with emissions restrictions starting in 2035. The IESO provided its submission on the proposed CER during the federal government's 75-day consultation period, acknowledging the efforts taken by Environment and Climate Change Canada to develop a framework for eliminating the use of emitting generation in a manner that considers system reliability and affordability. The IESO's submission highlighted that the emissions restrictions in the draft regulations are unachievable in Ontario by 2035 without risking the reliability of the electricity system, electrification of the broader economy and economic growth, recognizing the insufficient amount of time to plan, acquire and build suitable alternatives to natural gas generation and build transmission infrastructure at the scale required. Further, the draft CER could jeopardize Ontario's ability to meet the electricity needs associated with the province's expected significant population growth. Recognizing that the proposed CER could play an important role in guiding the future path toward the elimination of emissions from the electricity grid, the IESO's submission included amendments that would be required for Ontario to decarbonize its electricity grid in a manner that supports the orderly phase-out of natural gas generation. On Feb. 16, 2024, an update on the CER was released, summarizing key concerns raised by stakeholders and potential changes under consideration to address them. The final CER is anticipated to be published in 2024.

- **Electrification and Energy Transition Panel Report:** The EETP was established in 2022 by the Ministry of Energy to help Ontario's economy prepare for electrification and the energy transition. The Panel released its report, *Ontario's Clean Energy Opportunity*, along with its recommendations, on Jan. 19, 2024. This report was published following finalization of the APO; as such, these recommendations are not explicitly reflected in this APO. The IESO will continue to work with the Ministry and others to support and implement the recommendations relevant to the IESO's work.
- **Cost-Effective Energy Pathways Study:** The Ministry of Energy has undertaken an independent integrated Cost-Effective Energy Pathways Study to understand how Ontario's energy sector can support electrification and the energy transition. The study will inform the government's decisions related to integrated long-term energy planning and policies for the province and was considered in the work of the EETP. The timing of publication of this study was not known at the time of publication of the APO.

7.4 Climate Change Risk and Resiliency

Climate science has demonstrated that the global climate is changing due, in part, to an accumulation of GHG emissions in the atmosphere.[21] These changes in Canada are well documented in the Climate Atlas of Canada. This change creates risk for the reliability and resilience of the electricity system. Various reports have captured this trend, including NERC's *2023 ERO Reliability Risk Priorities Report* and the International Energy Agency's *Energy Security 2021* report. The path to net-zero GHG emissions in the broader economy means an increased reliance on the electricity system, since increased electrification and decarbonization of the wider economy puts upward pressure on today's electricity system due to increasing and changing usage profiles in demand.

7.4.1 Overview of Climate Risk

Because of the accelerating effects of climate change, scientists forecast that Ontario's weather patterns will change over the coming decades. These changes will have a major impact on how demand increases and decreases throughout the day and affect the performance of the electricity system and the integrity of its infrastructure. These weather and climate impacts could result in significant costs to the Canadian economy, as reflected in a report from the Canadian Climate Institute.

As a result, the IESO will need to continually assess, mitigate and adapt to impacts of changing weather.

As indicated in the IESO's 2022 *Pathways to Decarbonization* report, the IESO plans to more explicitly assess and address the risks of climate change in its planning and procurement processes. The risks of climate change are often characterized as two types – physical and transition, as described in the following table. In general, climate change mitigation actions/responses aim to reduce factors causing climate change such as GHG emissions, while adaptation actions/responses aim to increase

[21] https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-3/

resiliency to, and reduce damage from, actual or anticipated climate change impacts and to decrease the time and costs associated with recovering from those impacts.

Table 5 | Comparison of physical and transition climate risks[22] [23]

Type of Climate Risk	Definition	Example Sources	Response
Physical	Risk owing to change in physical environment and natural conditions driven by climate change and other factors	Acute: more frequent, higher intensity and longer duration extreme weather events – e.g., wildfires, tornadoes, heat waves, etc. Concurrent, combination, and cascading extreme weather events can worsen conditions and stress on the electricity system Chronic: longer-term change in average conditions – e.g., higher average temperatures, changing precipitation patterns, increased cloud cover, etc. Variability: increase in range and uncertainty associated with climate and weather patterns – e.g., change in the tails of the temperature distribution	Climate change adaptation – action taken to avoid, reduce or rebound from the actual or anticipated impact of acute and chronic climate-driven changes; action taken to increase resiliency
Transition	Risk owing to response to climate change to transition to a low-carbon future, which includes technological, regulatory, policy, market changes, reputation, etc.	Climate policy shifts – e.g., draft CER Provincial plans – e.g., *Powering Ontario's Growth* New technology – e.g., EVs, hydrogen fuels, utility-scale battery storage Consumer preferences – e.g., non-emitting resources	Climate change mitigation – action taken to reduce greenhouse gas emissions (e.g., decarbonization, electrification) Climate change adaptation – as above, but transition risk comes from policy-driven shifts targeted at adaptation

22 https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf
23 https://www.ipcc.ch/site/assets/uploads/2021/02/Risk-guidance-FINAL_15Feb2021.pdf

7.4.2 Transition Climate Risk

Various risks and uncertainties associated with transitioning to a low-carbon future, including electrification and decarbonization of other sectors or the decarbonization of the electricity system itself, have been discussed in other parts of Section 7. Uncertainties can come from both the magnitude and pace of electrification and decarbonization in each sector, which can be driven by regulations and policy as mentioned in Section 7.3.

In addition, actions taken to adapt to physical climate risk (Section 7.4.3) could lead to transition uncertainties. For example, changes in building codes/municipal standards to include mandatory cooling in all buildings to deal with the impacts of climate change (rising temperatures, heat waves) could increase demand. Moreover, it is uncertain how federal climate adaptation policy will impact actions taken across the economy in Ontario, which could in turn impact the electricity system. For example, the federal government has set a goal for all infrastructure systems in Canada to be climate-resilient and undergo continuous adaptation to adjust for future impacts to deliver reliable, equitable and sustainable services to all Canadians, as outlined in its recent National Adaptation Strategy and supporting Action Plan. Impacts on the planning of the electricity system will depend on the outcomes of the Action Plan, and any related policy.

7.4.3 Physical Climate Risk

In August 2023, the Ontario government released the Ontario Provincial Climate Change Impact Assessment to help inform adaptation decisions and priorities across Ontario sectors and sub-regions. It highlighted that the electricity system has a medium-risk profile under current climate conditions and that the profile is expected to increase to high-risk by mid-century (2050s).

When discussing physical climate risk and its impact on power system planning and operations, it is important to distinguish between climate and weather. Weather refers to short-term changes in the atmosphere on the order of minutes and days, whereas climate describes what the weather and natural conditions are like over a longer period of time in a specific area on the order of 30 years or more.[24] [25]

Increasing uncertainty has been observed in the predictability of weather, which creates challenges for grid operators and planners. As historical patterns are disrupted, there will be more unprecedented weather events. Near-term planning and operations align with weather considerations, while long-term planning and investment decisions align with consideration for a changing climate. Examples of uncertainties as a result of physical climate risk include:

Demand uncertainty:

- Acute: heating, cooling and ventilation loads in response to more frequent and longer cold snaps, heat waves and wildfires
- Chronic: heating, cooling and ventilation loads in response to increasing number of cooling degree days and decreasing number of heating degree days

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[24] https://climateatlas.ca/climate-vs-weather
[25] https://education.nationalgeographic.org/resource/weather-or-climate-whats-difference/

Supply and transmission uncertainty:

- Acute: wildfire, tornado and freezing rain disruption and/or damage to generation, transmission and distribution assets
- Chronic: changes in wind and solar resources, changes in precipitation and stream flow for hydroelectric resources, higher air temperatures reducing allowable transmission limits and affecting thermal power generation performance, and changing shoulder season duration affecting windows for outage management

As the IESO continues its work to ensure grid reliability and resiliency, work has begun to assess the extent to which the IESO is already considering physical climate change risk to reliability and resilience in the bulk electricity system and develop a plan to address any material gaps. The plan will include consideration of the increasing uncertainty in weather, the longer-term changes anticipated in physical climate under different scenarios, the changing posture of the electricity system due to the energy transition, the IESO's current processes and role, the role of others within Ontario and other jurisdictions, and the valuation of resiliency. In addition to participating in NERC, NPCC and Canadian Standards Association standards evolution committees, the IESO is actively participating in the Electric Power Research Institute's Climate REsilience and ADaptation initiative (Climate READi). This is the second year of a three-year initiative, which brings together representatives from across North America to create a common framework for resilience and adaptation in the power system, from planning through operations. As these work streams progress, the IESO will engage with relevant stakeholders.

8. Integrated Reliability Needs

Before identifying planned actions to meet reliability needs, needs based on this APO's High Nuclear case are integrated with the anticipated contribution from actions underway and uncertainties that may impact the contribution and timing of existing and new resources. With new resources and technology types expected in the coming years, setting targets higher than forecasted system needs is prudent and ensures the build-out of nearer-term mechanisms, such as the annual Capacity Auction and conservation and demand management programs. Higher targets also mitigate potential risks to reliability from factors such as market exit, project delays or operational behaviour, and provide investor certainty. They also facilitate participation of newer technologies, fostering a greater level of competition and enhancing the diversity of the resource mix. The analysis to identify planned actions considers uncertainties and can evolve in the future as the IESO learns more; moreover, with some risks resolving themselves or changing, the inventory will continue to be updated in future APOs.

Section 4 previously described the reliability needs of the system using two supply cases. The As Is case accounts for existing resources until the end of their contract/commitment period, as well as resources committed through actions undertaken by the IESO and/or informed by government policy. The High Nuclear case builds on the As Is case by considering the impact of policy decisions from the *Powering Ontario's Growth* plan for nuclear resources in the long term. Without considering the impact of nuclear policy decisions under the High Nuclear case, the magnitude of needs in the long term is expected to be significantly higher.

This section describes the actions that are underway, how the actions impact the needs described in Sections 4 and 5, and what the remaining needs are after accounting for some of the risks and uncertainties discussed in Section 7. The planned actions to address remaining needs are described in Section 9.

8.1 Previous and Underway Actions to Meet Reliability Needs

The integrated needs assessments in this section build on the High Nuclear case by layering anticipated contributions from actions underway and considering some uncertainties in Section 7 that may impact the contribution and timing of existing and new resources, which were not assumed in the adequacy assessment in Section 4.

Recognizing that resources from previous and underway actions can provide different services (e.g. capacity only, or capacity and energy), contributions from the actions described below were only considered in the integrated capacity needs assessment:

- Anticipated capacity acquired through future Capacity Auctions; the amount cleared in the 2022 auction was assumed to be acquired in each year of the outlook period, as 2022 auction outcomes were known at the time of development of the integrated reliability needs assessment;

- Anticipated capacity secured through the LT1 RFP from storage resources;
- Capacity from the 2015 Hydro-Québec Capacity Sharing Agreement, with 500 MW of firm imports anticipated to be utilized in summer 2027; and
- Anticipated capacity from the Memorandum of Understanding with Hydro-Québec, providing 600 MW of firm imports starting in summer 2025 through to October 2031.

The resources listed below are from previous and underway actions and can provide both capacity and energy; as such, contributions from the actions described below were considered in both the integrated capacity needs assessment and the integrated energy needs assessment:

- The last executed agreement finalized through the Same Technology Upgrades Solicitation from the IESO's Resource Adequacy Update of Sept. 18, 2023, in addition to the resources from the Resource Adequacy Update of June 27, 2023 (which were already included in the supply case described in Section 3);
- Anticipated non-storage resources secured through the LT1 RFP; and
- Uprates to Bruce nuclear generating units following refurbishments.

8.2 Integrated Capacity Needs

Considering the assumptions in Section 8.1 and the supply-side uncertainties discussed in Section 7.2 on project in-service delays and a higher risk of forced outages when a new resource comes into service, remaining capacity needs are summarized below and illustrated in Figure 31. In addition, recognizing this potential risk to resource adequacy and informed by stakeholder input, the analysis in this report considers that a portion of existing resources with expiring contracts will exit the market.

Capacity Needs: 2025 to 2028

The previous and underway actions and policy decisions listed above address capacity needs in 2025 and 2026 and the majority of needs in 2027 and 2028 (indicated by the blue bars in Figure 31). Remaining needs in 2027 and 2028 (indicated by the green bars in Figure 31) are expected to be met by resources acquired through future Capacity Auctions (above the amount cleared in the 2022 auction), reacquisition of existing resources reaching contract end, and any resources from LT1 RFP that are in service early or face no delays.

Capacity Needs: 2029 to 2034

Capacity needs that emerge in 2029 continue to grow through 2034, requiring future sustained procurement actions to meet needs. With needs of approximately 2,200 MW in 2029 and 2030 and ranging from 4,300 MW to 5,300 MW between 2031 and 2034, meeting these needs will require a set of actions that includes reacquisition of existing facilities and acquiring capacity from new resources and/or incremental capacity from existing resources.

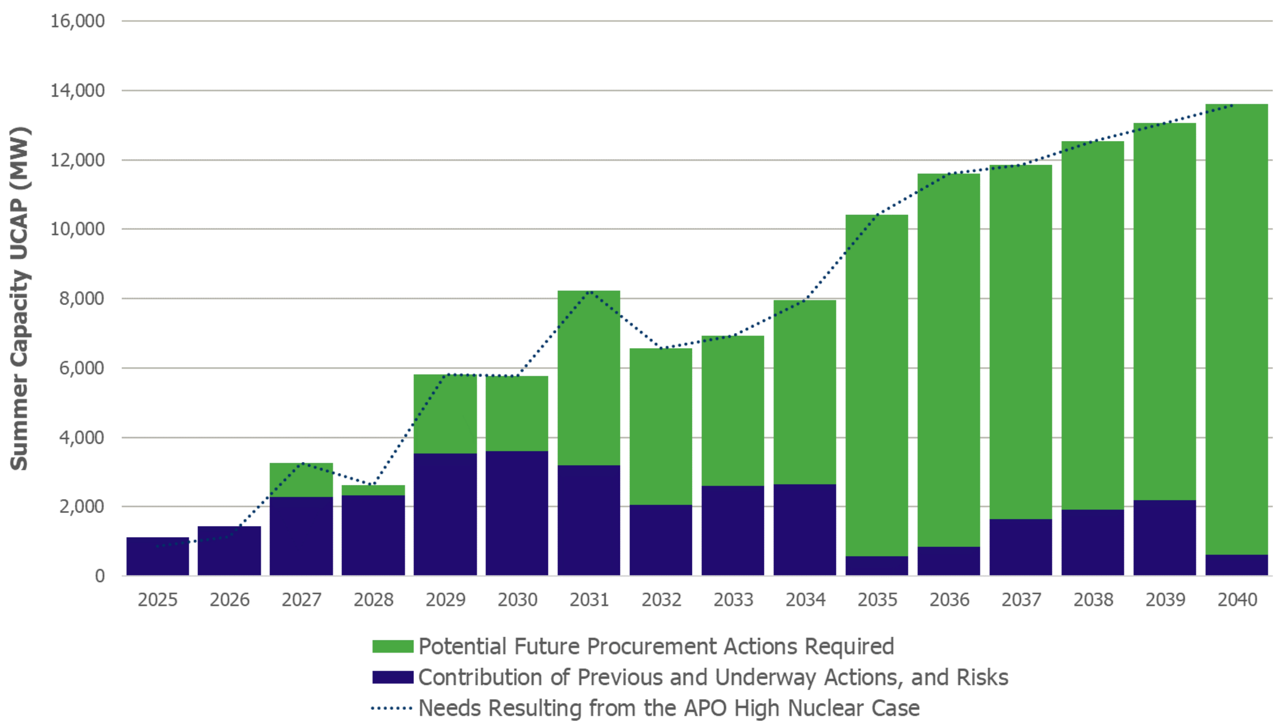
Capacity Needs: 2035 to 2050

Post-2035, a number of uncertainties will influence the extent of capacity needs. Demand is anticipated to grow significantly, with potential for growth that is higher than forecasted depending on the timing and impact of economy-wide electrification. Supply contributions may be lower than anticipated, driven by reduced participation of existing resources as a result of retirements and market exit, or the outcomes of procurements being lower than anticipated.

The timing of federal and provincial policy on the participation of existing emitting resources brings uncertainty to the contribution of these resources starting in 2035. With capacity from emitting resources making up a large portion of existing resources with contracts expiring after April 2035, there is significant uncertainty in the magnitude of new capacity needs in 2035 and beyond. A reduction in the potential contribution of existing resources is expected to result in an increase in the amount of new capacity required on the system to meet resource adequacy needs.

Increasing energy needs over the next two and a half decades, as described below, will require acquisition of resources that can provide energy for longer durations.

Figure 31 | Integrated Capacity Needs



8.3 Integrated Energy Needs

Similar to the assessment for remaining capacity needs, ongoing actions and several of the supply side uncertainties discussed in Section 7 were considered to identify remaining energy needs. These total annual needs are summarized below in two key time periods: 2029-2034 and post-2035. They are also illustrated in Figure 32.

Energy Needs: 2029 to 2034

Energy needs that emerge in 2029 continue to grow through 2034 and require future sustained procurement actions. This is indicated in green in Figure 32; the integrated energy needs are approximately 2 TWh to 4 TWh from 2029 to 2030 and range from 9 TWh to 15 TWh from 2031 to 2034.

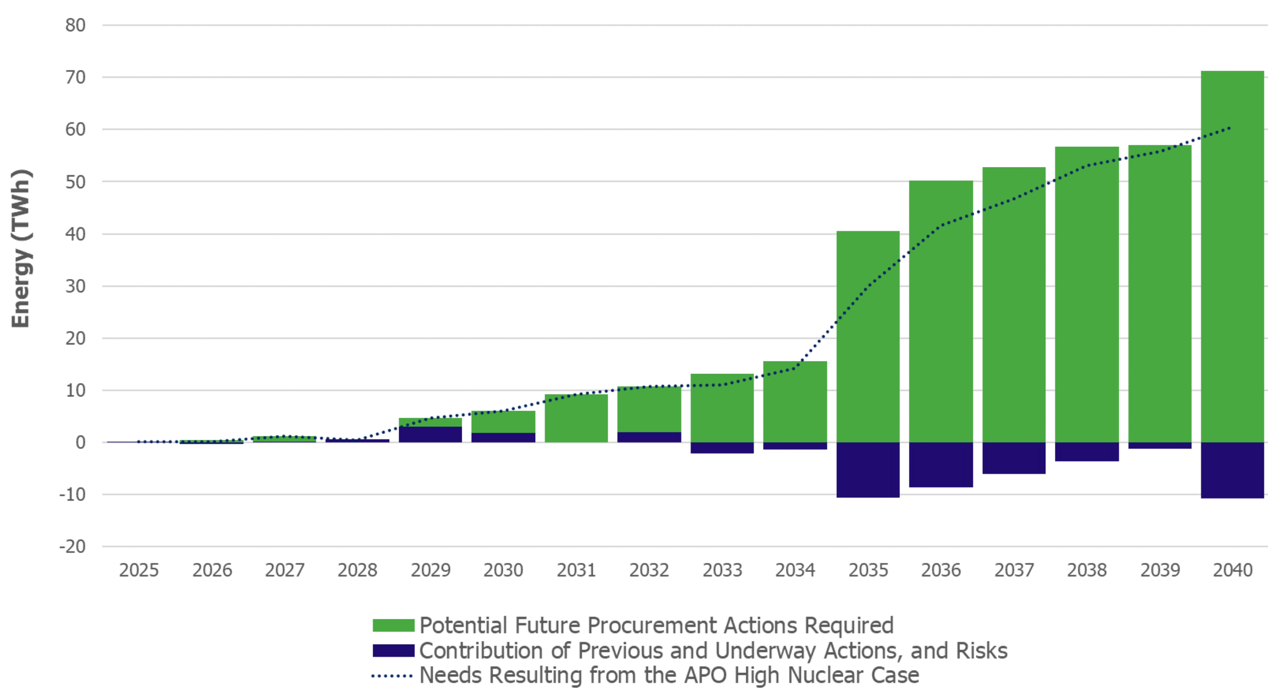
These needs are expected to be met by new or repowered, non-emitting energy-producing resources (that include but are not exclusive to wind and solar) acquired through future long-term RFPs, as well as the reacquisition of existing facilities through medium-term procurements in accordance with the Resource Adequacy Framework.

Energy Needs: 2035 to 2050

After 2035, a number of uncertainties will influence the extent of energy needs, just as they affect capacity needs in the manner described previously. Present analysis indicates that unserved energy could range from 40 TWh to 70 TWh from 2035 to 2050, after accounting for actions that are underway. A demand growth rate that trends higher than is currently forecast, or supply contributions that are less than anticipated due to retirements, market exits or lower procurement outcomes will drive these remaining energy needs even higher.

Most significantly, the timing of federal and provincial policy on the participation of existing emitting resources brings uncertainty to the magnitude of energy needs in 2035 and beyond. Limited potential for energy contribution from emitting resources, combined with general long-term forecast demand growth and nuclear retirements, will result in increasing energy needs. New energy-producing resources will be required on the system.

Figure 32 | Integrated Energy Needs



8.4 Locational Capacity Needs

The APO provides information about areas in the province where capacity is needed for maintaining local area reliability. This is distinct from the IESO deliverability studies that are co-ordinated with IESO resource procurement processes. Deliverability studies evaluate specific resource developments proposing to connect in specific locations, to determine whether the power they inject would be deliverable.

Previous APOs have reported on locational capacity needs, resulting from limitations of the transmission system to reliably deliver power to certain areas, and have identified local capacity requirements in southwest Ontario (West of Chatham and West of London), in northern Ontario, Ottawa, and east of the “Flow East Toward Toronto” (FETT) interface.

As a result of recent resource procurement activities, and transmission system reinforcements that are underway, these locational capacity requirements have either decreased or have been addressed. For example, the southwestern Ontario capacity needs have been addressed through recent resource procurements. Northern Ontario needs will be addressed once new transmission facilities, and new resources come into service. The need in Ottawa will not emerge until at least the mid-2030s once transmission plans are implemented. There is still a need for additional resources east of FETT, which will be reassessed following the results of the LT1 procurement. It is expected that additional capacity additions resulting from the resource procurements currently underway will further mitigate this need, as well as the development of new SMRs, and future transmission system reinforcements, including the projects that are summarized in Table 3 of this APO.

9. Planned Actions

As demand for electricity grows, Ontario's resource mix evolves and the electricity system decarbonizes, sustained resource acquisition actions and system reinforcements are necessary to ensure that reliability needs are met and to prepare for a larger energy transition next decade. This section specifies actions to address needs in the near term, as well as actions to acquire new resources and implement new transmission to meet significant capacity and energy needs emerging in the long term. These actions include leveraging: near-term mechanisms, such as the Capacity Auction; medium-term mechanisms, such as procurements to reacquire existing resources that are reaching their contract end; and long-term mechanisms, such as procurements for new or repowered non-emitting resources[26] with planned in-service dates starting in 2030.

Planned actions also include prioritizing specific future transmission studies, as outlined by the Schedule of Planning Activities.

Recognizing the wide range of uncertainties that arise in developing forecasts, the planned actions in this section focus on addressing needs over the first 10 years of the forecast period. Needs in this section are shown out to 2040, to reflect the potential impact of the federal government's draft Clean Electricity Regulations and complementary policies to decarbonize Canada's electricity system that are expected to take effect in 2035.

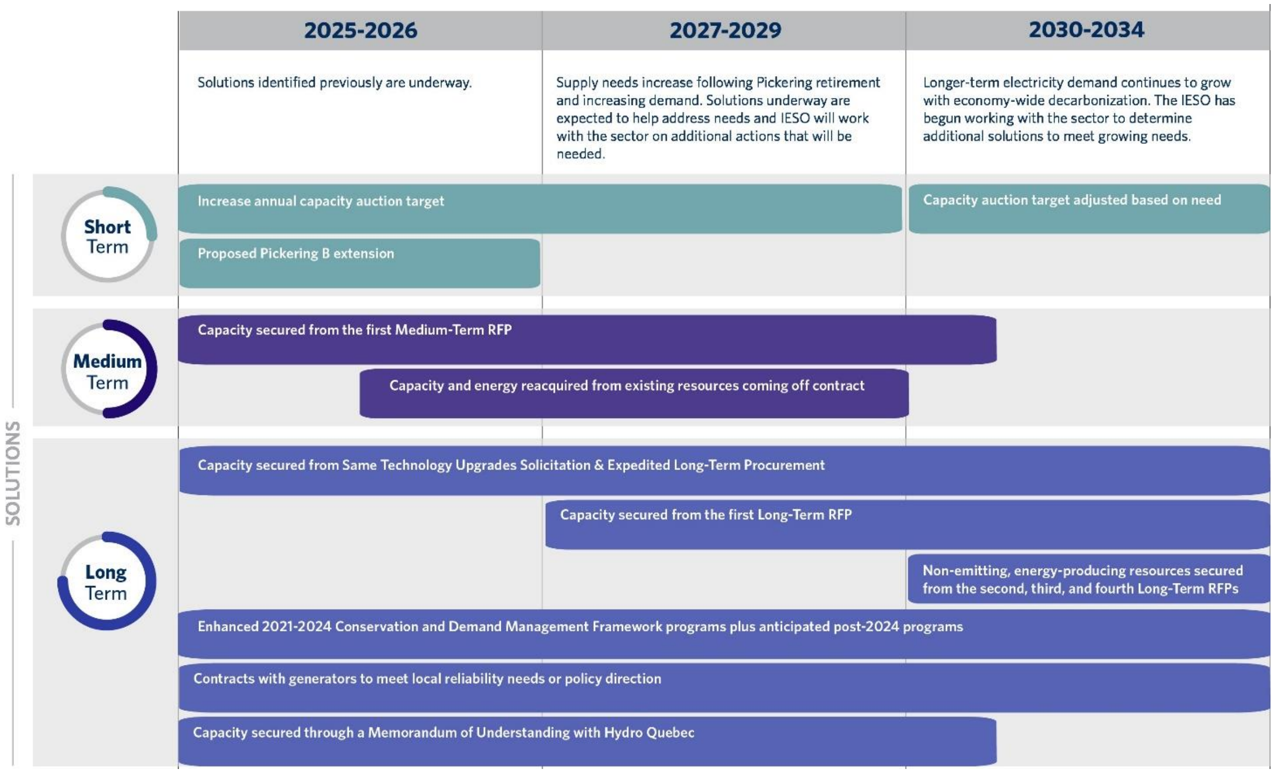
The planned actions described in this section align with the competitive acquisition mechanisms set out in the IESO's Resource Adequacy Framework. While the IESO prioritizes the use of competitive mechanisms, addressing Ontario's growing reliability needs may require execution of the other mechanisms in the framework, including government programs and bilateral agreements. Programs help to meet electricity policy objectives in a more targeted manner as directed, and bilateral agreements secure resources where a need exists that cannot be addressed in a practical and timely manner through competitive processes.

The IESO is planning to implement a cadenced approach to the medium-term (i.e., five-year term) and long-term (i.e., 20-year term) procurements in the 2020s and into the 2030s. This cadenced approach, which is described in Section 9.4, allows for a reassessment of needs as time progresses and to take advantage of continuing technological advances and associated reductions in costs. Further discussion on the current and forecasted capital costs, operating and levelized cost projections, and operational considerations associated with non-emitting resources such as wind, solar, battery storage and hybrid (wind/solar and storage) in the context of a supply mix that will continue to evolve is provided in the Resource Costs and Trends Module.

[26] Non-emitting resources can include wind, solar, bioenergy, hydroelectric, nuclear and other technology types. Resource eligibility for the next long-term procurement is described in Section 9.3.3.1

The section below details the considerations for the suite of future planned actions (also summarized in Figure 33), including targets for the next long-term procurement, which are largely driven by energy needs that emerge in 2029. Procurement targets for after 2035 will depend on significant decisions that are expected to be finalized later in 2024 and in subsequent years, such as the proposed federal CER, and new nuclear at Bruce C.

Figure 33 | Summary of Planned Actions



9.1 Annual Capacity Auction

The annual Capacity Auction will continue as a near-term mechanism to secure capacity with a short forward period. Over at least the next several years, the auction is expected to secure increasing amounts of capacity while providing flexibility to balance changes in reliability needs.

To meet growing capacity targets, the IESO will introduce greater competition from an increasingly diversified resource mix, update demand curve parameters and place a greater emphasis on resource performance. Meanwhile, the IESO will continue to work with stakeholders to investigate future enhancements that ensure the Capacity Auction can adapt to evolving market conditions and continue to be a competitive, transparent and accessible marketplace for a diverse range of capacity resources.

Similar to the 2022 AAR, the IESO is providing three stages of guidance for the Capacity Auction, each informed by the level of certainty about capacity needs going forward. The aim of this guidance is to signal the upcoming period of growth and future revenue opportunity for potential Capacity Auction participants. The first stage of guidance establishes the **firm guidance** target for the auction taking place in Q4 2024. The second stage establishes a **minimum target threshold** for future Capacity Auctions. The third stage provides **forward guidance** on the range of potential target capacities for future auctions beyond the next two years.

9.1.1 Target Capacity for 2024 Capacity Auction

The following section sets out the targets for the next Capacity Auction to take place in Q4 2024, for the May 2025-April 2026 commitment period. The targets described in this section are expressed in terms of unforced capacity (UCAP), reflecting the IESO's transition to the use of a capacity qualification framework in the procurement of resources.

Summer 2025 Obligation Period: 1,600 MW Target

Consistent with the forward guidance target outlined in the 2022 AAR, the 2024 Capacity Auction will target 1,600 MW for the summer 2025 obligation period, representing an increase from the 1,400 MW target for the summer 2024 obligation period. The integrated capacity needs assessment in Section 8.2 identified a modest surplus in summer 2025. Nonetheless, setting the target at 1,600 MW continues the path of growth in the auction targets as this acquisition mechanism continues to mature, providing future revenue opportunity for potential Capacity Auction participants. The higher target also helps mitigate the risk to resource adequacy if one or more of the demand or supply-side uncertainties discussed earlier in this report materialize.

Winter 2025-2026 Obligation Period: 1,000 MW Target

The 2024 Capacity Auction will target 1,000 MW for the winter 2025-2026 obligation period, representing an increase from the 850 MW target for the winter 2024-2025 obligation period. While the integrated capacity needs assessment identified a surplus in winter 2025-2026 (the result of procurement actions and policy decisions that include the continued safe operation of Pickering), setting the target at 1,000 MW will help prepare the auction for growth in future winter obligation periods. In subsequent years, growth in the winter target capacities enables more accurate winter season price discovery and greater alignment between seasonal clearing prices, which helps to reduce reliance on summer clearing prices and revenues to sustain year-round revenue and participation levels.

9.1.2 Minimum Target Threshold for Future Capacity Auctions

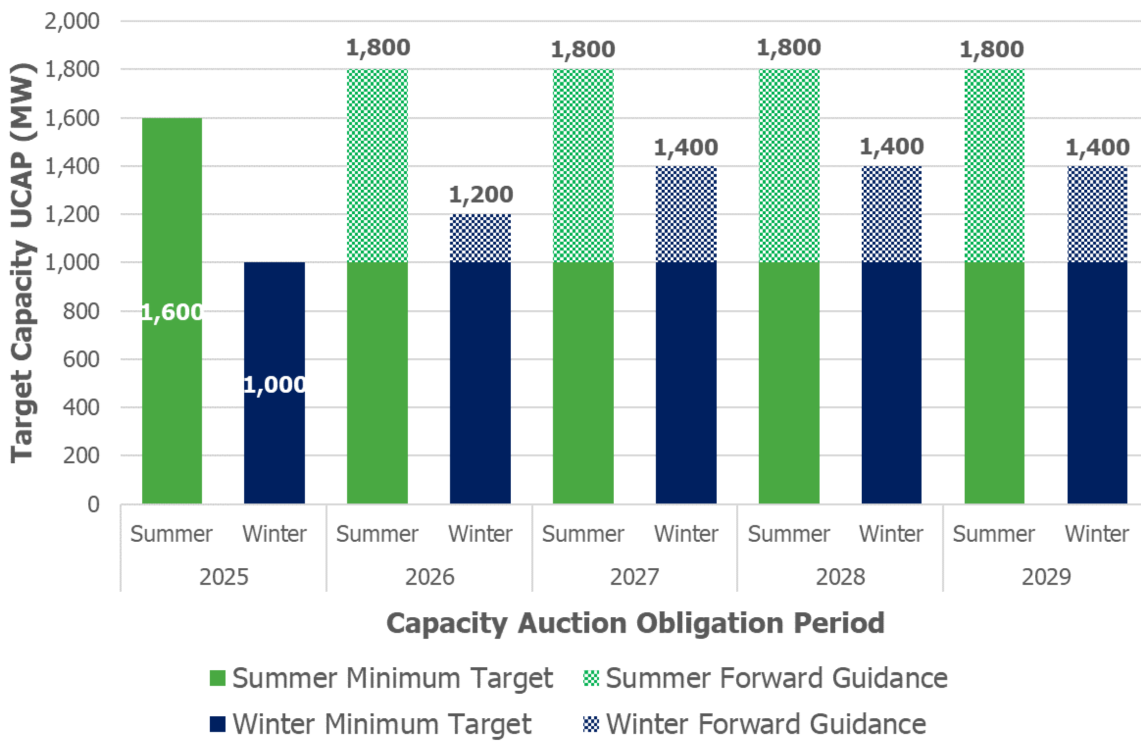
To meet increasing needs, the IESO will increase the minimum target capacity for each obligation period from 500 MW to 1,000 MW to signal a predictable and stable marketplace for capacity suppliers to invest in operations in Ontario and lead to lower costs. The minimum target capacity also provides assurance to the IESO that resources will be available to meet reliability needs.

9.1.3 Forward Guidance for Future Capacity Auctions

Forward guidance is provided up to the summer 2029 and winter 2029-2030 obligation periods. Figure 34 illustrates the forward guidance for both summer and winter target capacities, showing growth to 1,800 MW for the summer 2026 obligation period and 1,400 MW for the winter 2027-2028 obligation period. This reflects the integrated capacity needs for these periods and the use of the Capacity Auction as a mechanism to help address them. The forward guidance targets for both summer and winter are maintained through the summer 2029 and winter 2029-2030 obligation periods, aligning Capacity Auction targets with the growing capacity needs at the end of the decade.

Supported by the increased diversity and growth of the November 2023 auction, the IESO will reassess forward guidance for future auctions and, if required, adjust guidance upwards to help meet system needs.

Figure 34 | Capacity Auction Forward Guidance



9.1.4 Enhancements to the Annual Capacity Auction

The November 2023 auction included several enhancements, including:

- Introducing a qualification process that utilizes historical availability and performance data to derive a UCAP value for each resource, to better represent its likely contribution to system adequacy needs;
- Modifying the performance assessment framework to incent improved performance, with the new framework taking effect in May 2024; and
- Updating the demand curve parameters to help ensure that the auction continues to reflect the economic and system conditions for which the IESO is preparing.

The IESO will monitor the impact of these enhancements and their effectiveness in achieving greater competition and more accurate and reliable resource performance. In preparation for a period of growth in Capacity Auction targets and Ontario's electricity system, the IESO continues to collaborate with stakeholders to identify and prioritize future enhancements to the auction, with the aim of enabling increased competition and greater resource reliability to continue to drive value for ratepayers.

9.2 Medium-Term Procurements

Medium-term procurements are expected to offer an opportunity for both new-build and existing resources to obtain a contract for a five-year term with flexible start dates, providing an avenue for participation until the next long-term RFP or a subsequent medium-term RFP.

As a result of actions to leverage capacity from existing facilities through the Same Technology Upgrades Solicitation and the agreement for the continued operation of Brighton Beach GS, a significant number of existing resources will reach the end of their contract terms in the mid-2030s, as indicated by the reduction in summer capacity shown in Figure 12.

By the end of 2035, there is potential to reacquire more than 9,000 MW[27] of capacity (on a summer UCAP basis) from resources that are expected to reach the end of their contract terms. A smaller portion of this capacity is from resources with contracts expiring later this decade, as discussed in Section 9.2.1, while the larger portion of this capacity is from natural gas resources with contracts expiring by 2035. Though new resources are expected to be eligible to participate in the medium-term procurements, the following sections discuss considerations for existing resources, recognizing the significant amount of resources that are expected to reach contract end over the next decade.

9.2.1 Capacity and Energy from Resources with Contracts Expiring 2026-2029

The second medium-term procurement (MT2 RFP) is anticipated to include the procurement of existing resources with contracts expiring over the 2026-2029 period. Subsequent medium-term procurements will be executed to procure resources with contracts expiring after this period.

Recognizing that there are a number of existing contracts that expire beginning in 2026, the IESO is working with stakeholders to determine the optimal timing of the MT2 RFP and ensure existing assets have the opportunity to continue providing capacity and energy to the system. Mechanisms such as flexible term commencement dates, bridging and contract term extensions may continue to play a role in the Resource Adequacy Framework. The IESO continues to collaborate with stakeholders on considerations to best employ bridging and contract extensions to facilitate the success of the Resource Adequacy Framework.

Targets for the MT2 RFP will be set in a manner that balances both system need and ratepayer value. Depending on eligibility and need, the IESO may consider targets and contracts for both capacity and energy, while adjusting those targets to account for any new-build resources seeking to

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[27] This number does not include hydroelectric resources reaching end of contract, as these resources are anticipated to be reacquired through the Small Hydro Program directed by the Minister of Energy and any initiatives related to the acquisition of larger (>10 MW) hydro resources.

participate. This approach is premised on the IESO's Resource Adequacy Framework continuing to drive cost-effective outcomes by offering numerous avenues for participation.

While most facilities reaching contract end over the next decade are transmission-connected, a portion of these facilities are distribution-connected. Distribution-connected resources are expected to continue to play an important role in ensuring Ontario's resource adequacy. Distributed energy resources (DERs), which are connected either directly to local distribution systems or, indirectly, behind a customer's meter, come in many forms that allow them to generate energy, store energy, or adjust electricity consumption – examples include rooftop solar, combined heat and power facilities, small hydro, biogas and battery storage. These resources currently contribute to meeting resource adequacy needs through participation in programs, micro-grid pilots, net metering or as hourly demand response resources in the IESO's Capacity Auction. In addition, DERs that are 1 MW or greater in size can participate in the IESO-administered markets by registering under their applicable resource participation model. The IESO's Enabling Resources Program continues to work on designing and implementing participation models for DERs that are fewer than 1 MW. The IESO will leverage the mechanisms in the Resource Adequacy Framework to provide opportunities for these resources to continue to provide capacity and energy to help meet Ontario's reliability needs.

9.2.2 Capacity and Energy from Gas Resources with Expiring Contracts

A significant amount of the capacity and energy from resources reaching contract end over the next ten years are natural gas resources. The draft Clean Electricity Regulations brings significant uncertainty with regards to the contribution of emitting resources in meeting Ontario's resource adequacy needs in 2035 and beyond. When identifying the planned actions to address needs in 2029-2034, consideration was given to the significant needs emerging in 2035. As the CER and other government policy are finalized, the IESO's iterative planning process will consider the impact on long-term needs and specify actions as necessary for gas resources with expired contracts.

The Long-Term Procurements section (Section 9.3) of this report considers the uncertainty around reacquiring capacity and energy from existing resources, and the implications to incremental new resource needs.

9.3 Long-Term Procurements

In 2029 and beyond, both energy and capacity needs persist, as indicated by the top teal bars in Figure 35 and Figure 36 even after accounting for:

- Previous and underway actions described in Section 8.1;
- Forward guidance targets for the Capacity Auction provided in Section 9.1; and
- The contribution from existing non-emitting and emitting resources reaching contract end[28] that are assumed to be reacquired through medium-term commitments.

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[28] Capacity from Lennox GS was not included in the potential contribution of existing emitting resources, owing to the facility's age and uncertainty around its continued operation after contract expiry in 2029.

The IESO expects a remaining energy need of approximately five terawatt-hours, as well as a capacity need of about 2,700 MW, during the 2029-2034 period. The actual magnitude may be higher or lower, as these needs will be informed by the outcome of the LT1 RFP and expected capacity and energy contributions from resources acquired in the LT2 RFP. However, both needs, subject to upcoming federal and provincial policies, will grow significantly throughout the 2030s amidst ongoing nuclear refurbishments and should Ontario phase-out natural gas resources.

Targets for the next long-term procurements will be largely driven by energy needs due to the timing of the need and uncertainties regarding the resource options and the need profile. Resources acquired through these procurements will also provide some benefit to meeting capacity needs. The Resource Adequacy Framework offers flexibility through different contract types to meet both energy needs and residual capacity needs – especially if they grow more significantly through the 2030s.

9.3.1 Remaining Capacity Needs

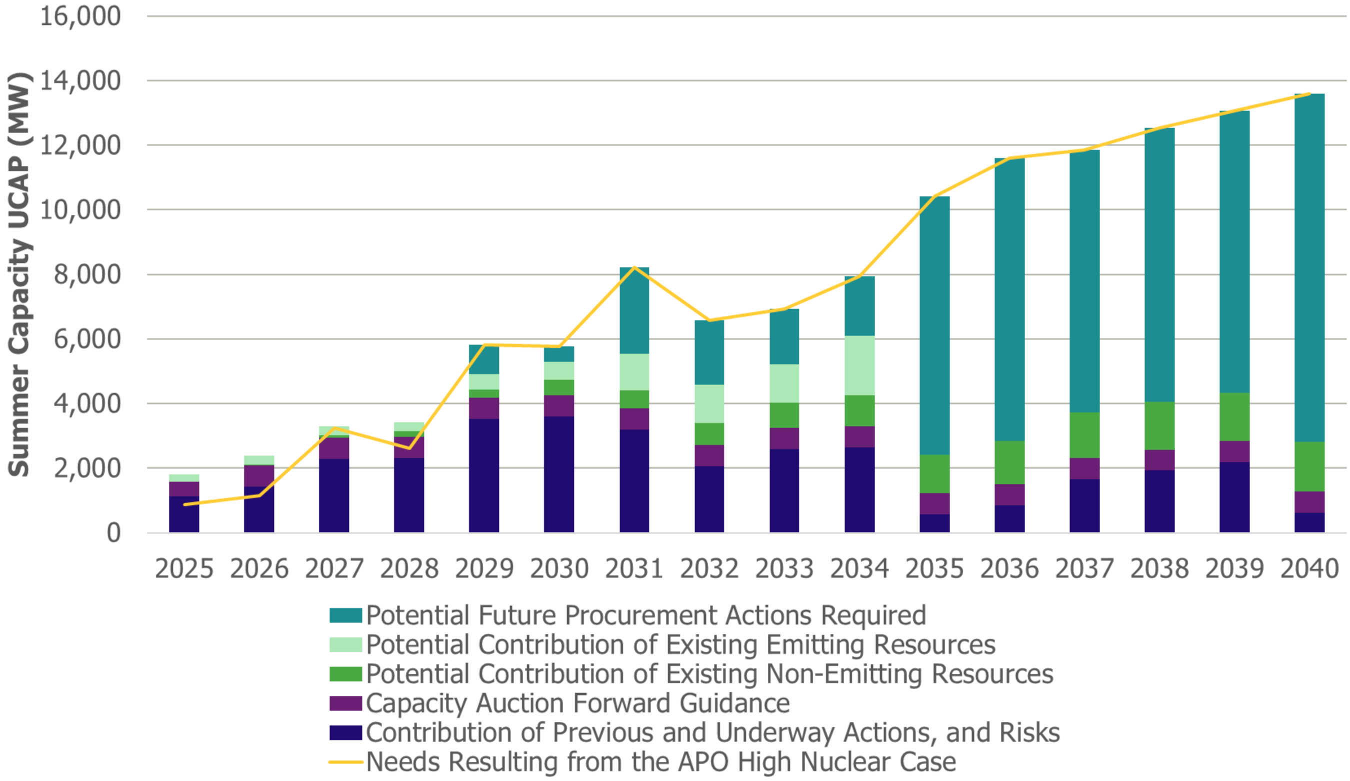
Capacity needs requiring further planned actions emerge in 2029 after considering the potential contribution of existing non-emitting and emitting resources, as well as the forward guidance targets for the Capacity Auction. Figure 35 below illustrates needs that range from 500 MW to 2,700 MW (on a summer UCAP basis) over the 2029-2034 period.

Capacity from Lennox GS, which was not included in the potential contribution of existing emitting resources (owing to the facility's age and uncertainty around its continued operation after contract expiry in 2029), reduces the magnitude of the capacity needs shown in Figure 35 and defers the need for new capacity from 2029 to 2031. The magnitude of the capacity need will be informed by the outcome of the LT1 RFP and expected capacity contributions from resources acquired in the LT2 RFP. Other gas resources besides Lennox GS are assumed to have been reacquired through the end of 2034, but not beyond, pending the final CER; see Section 9.2.2 for more information.

While resources acquired through the next long-term procurements to meet energy needs will also provide some benefit to meeting capacity needs, depending on the mix of resources acquired, further planned actions are needed to address the remaining capacity needs. The IESO proposes to offer different contract types in upcoming procurements to account for the different types of need.

In 2035 and beyond, the magnitude of new capacity needs is highly dependent on the implementation of the federal Clean Electricity Regulations, as capacity from emitting resources make up a large portion of existing resources with contracts expiring in the middle of the 2030s.

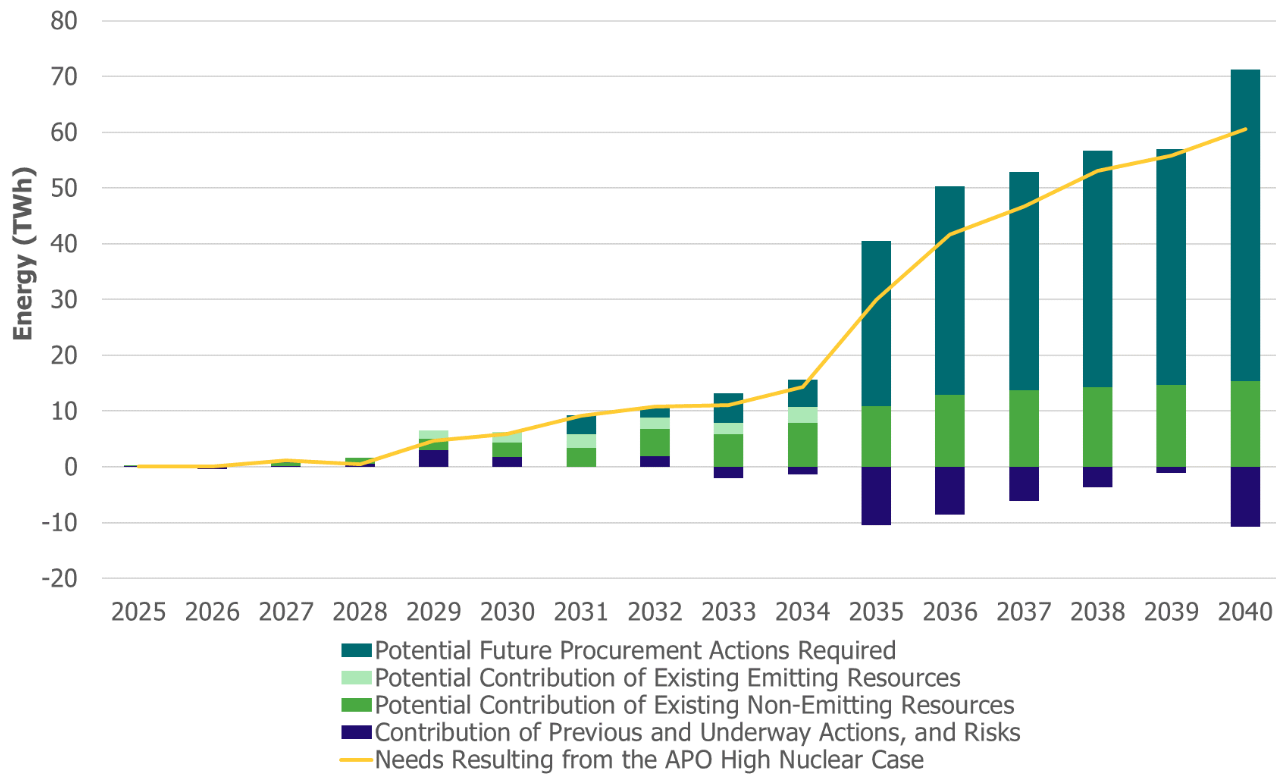
Figure 35 | Remaining Capacity Needs and Potential Future Procurement Actions



9.3.2 Remaining Energy Needs

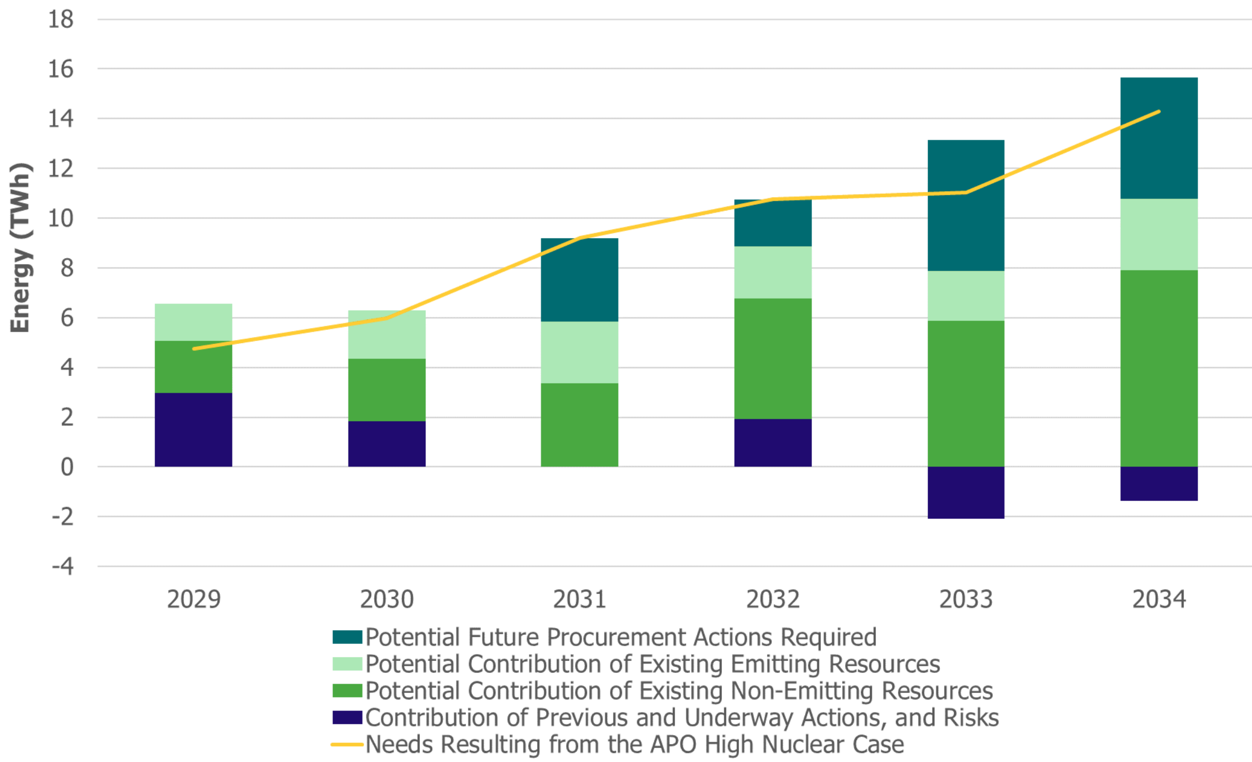
Energy needs identified in the Integrated Energy Needs section of this report (see Figure 32) are deferred to 2031 after considering the potential contribution of existing non-emitting and emitting resources. Figure 36 and Figure 37 below illustrate this need, which grows to approximately 5 TWh by 2034 and increases significantly starting in 2035, at which point needs are highly dependent on the implementation of the federal CER.

Figure 36 | Remaining Energy Needs and Potential Future Procurement Actions[29]



[29] Note that the energy impact of some risks considered in this analysis exceeds the expected contribution of in-flight actions, resulting in negative terawatt-hours (shown in dark blue) and showing the need to procure more energy than is indicated by the 2023 APO High Nuclear case line. Moreover, no energy is accounted for from resources acquired through the Capacity Auction, which specifically targets capacity services.

Figure 37 | Remaining Energy Needs and Potential Future Procurement (2029-2034)



Further planned actions are needed to address these remaining energy needs. Energy from Lennox GS, which was not included in the potential contribution of existing emitting resources shown in Figure 36 and Figure 37 due to the facility's age and uncertainty around its continued operation after contract expiry in 2029, could reduce the energy needs further and defer them to 2033 if operation was extended. With potential contribution from Lennox GS, up to 3 TWh of needs are still observed between 2033 and 2034.

9.3.3 Targets for New Resources

To help meet remaining energy needs, the IESO intends to procure 2,000 MW (installed capacity) of energy-producing resources through the LT2 RFP, targeting a commercial operation date of May 1, 2030 (with potential flexibility depending on the timing of emerging system needs). Subsequent long-term procurements are anticipated to target 1,500 MW each, for a total of 5,000 MW new-build resources for the 2029-2034 period (see Table 6). The figures in Table 6 represent the approximate installed capacity of new non-emitting generation that would be required to meet emerging energy needs. In actuality, the amount of energy realized from installed capacity will depend on factors such as location, need profile, resource capacity factor and technology mix. For instance, 5,000 MW of installed wind capacity may yield approximately 14 TWh of annual energy assuming a 33 per cent capacity factor; 5,000 MW of installed solar may yield closer to 8 TWh with an 18 per cent capacity factor. These estimates do not account for other considerations, such as the coincidence of the energy output to the need, their deliverability or the combination of non-emitting technology types actually acquired. Furthermore, these are illustrative examples and do not represent granular targets specific to wind and solar resources.

Moreover, needs will evolve as in-flight actions and risks materialize. Energy needs in particular arise in 2029-2030, growing up to 15 TWh by 2034 (see Figure 32), or only up to 3 TWh after accounting for the potential contribution of existing emitting and non-emitting resources (including Lennox GS). Preliminary targets for the LT2, LT3, and LT4 RFPs can be updated as required. This can also include setting additional targets for capacity needs that may remain even after acquisitions for energy have been accounted for; these needs will be described in future APOs and in future procurements.

Table 6 | Planned IESO Long-Term Procurements 2029-2034

RFP	RFP Launch Date	Target Commercial Operation Date[30]	Procurement Target (Energy)[31]	Procurement Target (Capacity)
LT2	2025	2030-2031[32]	2,000 MW	TBD
LT3	2027	2032-2033	1,500 MW	TBD
LT4	2029	2034-2035	1,500 MW	TBD
Total			5,000 MW	TBD

9.3.3.1 Long-Term 2 RFP Resource Eligibility Considerations

Long-term procurements are intended for new-builds and repowered facilities and would offer longer-term contracts (e.g., 20 years). The LT2 RFP is anticipated to be open to any non-emitting resources that are able to meet the performance criteria. Participating resources could include facilities directly connected to the grid or connected to distribution systems as DERs.

Wind and Solar Photovoltaic

New wind and solar projects are well-suited to the coming procurements as they can be developed in four to five years once a contract has been issued. The IESO will explore designing its long-term procurements to enable the participation of both new wind and solar, as well as existing facilities willing to repower.

A number of existing wind and solar resource contracts begin to expire over the 2026-2034 period, with the opportunity to repower at existing sites and compete in upcoming long-term procurements. Encouraging competition between existing and new resources can provide greater competition and, therefore, ratepayer value by spurring existing asset owners to make investments in the most efficient manner possible. It would ensure that only repowered assets that provide system value – compared with new assets – are reacquired. Existing resources will also have the option to participate in the IESO's medium-term procurements.

30 The indicated Target Commercial Operation Date is for non-long lead-time resources; long lead-time resources could have a later COD. The IESO is considering allowing for early operation, which could result in earlier commercial operation dates.

31 Long lead-time resources procured under the LT2 RFP may address part of the energy needs for LT3/LT4; therefore, the procurement targets for LT3/LT4 may be adjusted accordingly should any long lead-time resources be procured under the LT2 RFP.

32 The LT2 RFP will be focused on CODs in 2030-2031; however, the IESO has several tools available, including early operation incentives, to address the relatively small portion of the need that emerges in 2029.

Wind and solar resources will have different energy capacity factors.[33] Wind energy production is dependent on seasonal wind patterns, and is also stochastic in nature. Wind energy generation is higher in the winter compared to the summer. Solar energy production is dependent on time of day and season. It is greatest during noon to mid-afternoon in the summer and lower in winter. For instance, approximately 2,000 MW of installed wind could produce more than 5 TWh of energy if assuming an annual capacity factor of 33 per cent, while solar resources produce a lower annual capacity factor than wind, indicating that more installed capacity would need to be procured to meet the energy need. The actual installed capacity required to meet the energy need will depend on the mix of resources successful in the procurement, the location of resources and the need profile.

Biofuels

While biofuel resources that meet eligibility requirements are expected to be able to compete for contracts in the upcoming long-term (and medium-term) procurements, these resources may be better suited as capacity resources. Biofuel facilities are often constrained by their unique fuel supply (i.e., wood pellets, forestry byproducts) and, thus, may not be able to economically meet emerging system energy needs.

Waterpower

New waterpower resources and existing resources that upgrade or expand their facilities and otherwise meet eligibility requirements are expected to be able to participate in the upcoming procurements. While repowered facilities that require a long lead time (such as hydroelectric resources) may be eligible to participate in the LT2 RFP, being in-service in 2030 may be challenging due to the typical timelines required for significant waterpower expansions. The cadenced procurement approaches, coupled with some flexibility on in-service dates, should provide options for waterpower resources to participate.

Distributed Energy Resources

As part of the overarching effort to prepare Ontario’s electricity system for a decarbonized and reliable future, the LT2 RFP is expected to include eligibility for new DERs, tapping into the growing generation resources and other forms of supply within communities. Renewables, flexible load and storage already play a prominent role in powering local communities as they manage population and economic growth that is expected to grow significantly over time. DERs will need to meet the eligibility requirements of the LT2 RFP and be enabled for participation in the wholesale market. The first phase of the DER Market Vision and Design Project identified a foundational participation model that enables dispatchable stand-alone DER models and DER aggregations with a total size of 1 MW or more to provide capacity, energy and operating reserve in the IESO-administered markets. The foundational model design elements are expected to be in place in 2026 and will position DER aggregations to participate in future procurements.

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[33] A capacity factor is a measure of how much energy is produced by a resource compared with its maximum output. It is the ratio of the energy output of a resource during a period of time divided by what could have been produced at a continuous full power output during the same period.

Electricity Storage and Hybrid Resources

With a large volume of electricity storage resources coming online, it is critical that the next procurements drive investment in energy-producing resources to complement the storage; new renewable resources that are acquired will be highly useful in charging Ontario's new storage fleet. While electricity storage on its own is largely a capacity resource and does not meet the outlined energy needs emerging as early as 2029, hybrid systems that combine energy generation (usually from renewables) and storage will be eligible to participate in the coming long-term procurements.

Long Lead-Time Resources

The IESO's cadenced procurement approach aims to provide investment certainty for a number of different resource types, with varying forward periods to allow for project development. This provides an opportunity for developers and investors to begin pre-development work for a subsequent long-term procurement (i.e., LT3 or LT4), but also for those who may wish to submit a proposal for a future target in-service date.

While the IESO intends to stakeholder this approach and create a framework that enables competition, the premise of the approach allows for a proponent seeking to develop an asset with a long lead time (i.e., new hydroelectric) to compete in an earlier procurement (e.g., LT2) but come into service at a later date (e.g., COD 2034). The IESO could, for example, set a second stream in the procurement for those resources proposing a late in-service date and allow like-for-like competition within that stream. Additional cost containment measures that compare between the two streams could be employed to ensure ratepayer value for long lead-time resources.

9.4 Cadenced Approach for Procurements

The IESO expects to run a regular cadence of long-term procurements this decade for new or repowered resources, in addition to cadenced medium-term procurements for new-build and existing resources in Ontario. Initial plans involve executing long-term procurements every two years, with potential to execute medium-term procurements on a similar timeline.

A range of risks and uncertainties could affect the IESO's assessment of needs; as such, targets will be adjusted and confirmed prior to each RFP. Depending on the nature of the needs, the IESO may leverage commercial structures that incent either energy or capacity resources, or both.

Moving to a cadence of frequent medium- and long-term procurements in an integrated manner, is intended to provide benefits that include:

- Enhanced visibility and commitment to subsequent procurements, providing better planning opportunities to developers, including those with long-lead time projects;
- Multiple opportunities to re-bid unsuccessful projects, by eliminating the "one chance" associated with one-off large-scale procurements;
- More opportunity to engage with communities, build partnerships and seek support, as electricity infrastructure development, in support of population and economic growth, continues to increase in Ontario;

- Empowering developers to make informed business decisions on existing resources, whether that be continuing operations with existing assets or exploring repowering opportunities;
- Providing developers and the IESO with the increased flexibility to adapt to macroeconomic trends and policy evolution;
- Enabling the IESO to adapt to changing system needs, while capturing technology advances and cost reduction; and
- Mitigating overbuilding by procuring supply in increments and adjusting targets as circumstances change.

9.5 Transmission Planning (Schedule of Planning Activities)

The transmission system needs described in Section 5 will require planning to develop, evaluate and recommend solutions. A Schedule of Planning Activities provides a snapshot of the IESO's workplan for priority bulk system transmission studies over the next three years. If conditions evolve, for example, if the generation or demand outlooks change, or new public policy direction emerges, then the need, scope and/or timing proposed for these planning studies may be revised. These transmission studies, also referred to as "bulk system plans," are geared toward addressing those system needs that require a detailed evaluation of possible solutions, including transmission and other integrated alternatives, where there is sufficient time to carry out the study and enough lead time to implement solutions. This would typically include needs that emerge at least five years in the future, given the long lead times to implement new transmission or procure resources. These bulk system plans run on their own schedules which vary depending on the scope and complexity of the plan. The IESO carries out stakeholder engagement for bulk planning studies according to each plan's individualized engagement plan, and the final plans with detailed recommendations are published as stand-alone reports on the IESO website.

Given the number of system needs that are the result of common drivers contributing to changing power flows across the bulk transmission system, the IESO will look for opportunities to combine and coordinate individual studies. Some may be carried out in stages to address the most urgent needs first, while finding efficiencies by developing a common set of base case models and assumptions. These can then be used to carry out the various power flow, steady state and dynamic modelling required to assess different solutions, and ensure that the IESO-controlled grid as a whole remains in compliance with all of the relevant reliability standards and planning criteria. This is reflected in the Schedule of Planning Activities below through two integrated bulk planning studies to be initiated in 2024: a "Southern and Central Ontario Bulk Study" and a "Northern Ontario System Bulk Study." Both of these studies will take into account the policy set out in the *Powering Ontario's Growth* plan.

Another key update in this iteration of the Schedule of Planning Activities is the inclusion of an estimate of the duration of each bulk planning study. While the completion dates for these plans will not be fully ascertained until a scope of work is developed, the proposed end dates provide an indication of the IESO's best estimate. Some plans may garner a lot of interest from stakeholders and communities, and the timeline could be extended to accommodate additional stakeholder engagement. The plans may also be shortened or extended based on other factors such as technical or analytical complexity. Changes will be reflected in future iterations of this schedule in subsequent documents and communicated through stakeholder engagement activities over the course of each study.

Table 7 | Schedule of Planning Activities

Area	Study Name	Start - End (Estimate)	Scope / Considerations
Southern Ontario (including the Greater Toronto Area)	Central-West Ontario Bulk Study	2023 to 2024 (underway)	This study was reprioritized to begin in 2023 due to the number of large industrial users locating in the area. It is assessing the future reliability and capabilities of the bulk transmission system from Hamilton to Windsor in the west and is considering the significant potential economic development opportunities in the area. This study, anticipated for completion in Q1 2024, is focusing on ensuring a reliable power supply to the London area as committed industrial customers and ancillary loads ramp up. A previously anticipated second stage of this work to proactively assess transmission options to accommodate additional large new load connections (if and when they materialize) will be rolled into the scope of a broader southern and central Ontario study.
South and Central Ontario (including the Greater Toronto Area)	Southern and Central Ontario Bulk Study (*Powering Ontario's Growth* plan)	2024 to 2025	This study is proposed to review the capability of the bulk system to support future generation connections and demand growth in key areas throughout southern and central Ontario, including the GTA, to enable a decarbonized power system in the future. This study will include a number of considerations: • Sufficiency of the bulk transmission supply to the GTA given future growth in electrical demand, and policy-driven decrease in reliance on local natural gas-fired generation; • Expansion for the 500 kV transmission system between Cherrywood TS and Bowmanville to enable continued expansion of generation, including SMRs, in eastern Ontario;

			• Continuing the assessment of the bulk transmission system between the Hamilton and Windsor areas to understand future transmission needs that could result from further economic development; and • Transmission needed to enable expansion of the Bruce NGS. This work will also consider opportunities to preserve new or expanded corridors for future transmission development. Note: The GTA bulk supply study and parts of the scope of the Essa area study from the 2022 SOPA have been included within the scope of this broader southwestern and central Ontario study. This is in response to the *Powering Ontario's Growth* plan and acknowledges the need to co-ordinate studies that involve large changes to flows on the bulk system.
Northern Ontario	Ontario-Manitoba Intertie Joint Study	2022 to 2024	This study was initiated to proactively plan for the end of life of critical transmission intertie equipment on the Ontario-Manitoba interconnection. This is a joint study between the IESO, Hydro One Networks, Manitoba Hydro and Minnesota Power. Study anticipated to be completed in 2024.
Northern Ontario	Northern Ontario System Bulk Study (*Powering Ontario's Growth* plan)	2024 to 2026	This study will review the capability of the bulk transmission system to facilitate additional power flows from northern Ontario to southern Ontario and vice versa, to support future generation connection and demand growth to enable a decarbonized system. This study will review the capability of the north-south corridor from Sudbury to the Greater Toronto Area by assessing the Flow North/Flow South and CLAN interfaces given changinffg demand patterns and supply mix changes, and anticipated changes to the transmission system. Includes consideration of opportunities to preserve new or expanded corridors for future transmission development.
Northern Ontario	Northern Ontario Connection Study	2024-2025	This study will evaluate transmission options for enabling connection of remote First Nation Communities and prospective mining developments in remote northwestern Ontario.

Eastern Ontario (including Ottawa)	Eastern Ontario Bulk Study	2024 to 2026	This study will examine bulk system transmission supply to Ottawa, the Lennox Area 230 kV system supplying the municipalities of Belleville and Kingston and a number of other industrial loads, the potential shutdown of natural gas-fired generation in the area, potential for new and/or expanded interties, and opportunities to address other system operability concerns in the area.

Updated on March 19, 2024 to reference additional information about benchmark pricing identified in the IESO’s the IESO's Evaluating Procurement Options for Supply Adequacy report.

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