Review of IESO's Planning and Procurement Processes

SUBMITTED BY

Midgard Consulting Inc.

DATE

March 14, 2025

Midgard, established in 2009, provides consulting services across the electrical power and utility sector. Midgard's principals and staff have direct experience in project development, design, contract procurement, finance, construction and operations. This combined experience has translated into mandates in project due diligence, lender's technical advisor, loan guarantee assessments and Independent Engineer roles in Canada, the United States and internationally. Midgard has worked for developers, utilities, government agencies and both project lenders and equity providers.

Midgard's team has extensive experience modeling fuel sources, creating energy yield estimates, reviewing contracts, reviewing pro-formas and assessing project risks from a construction, operations and financial perspective.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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GLOSSARY

AEMO	Australian Energy Market Operator
AI	Artificial Intelligence
APO	Annual Planning Outlook
DR	Distributed Resources
ELCC	Effective Load Carrying Capability
ERCOT	Electric Reliability Council of Texas
EUF	End Use Forecaster
EV	Electric Vehicle
FERC	Federal Energy Regulatory Commission
FIT	Feed-in Tariff
IESO	Independent Electricity System Operator
ISO	International Standards Organization
ISO-NE	ISO New England Inc.
ISP	Integrated System Plan
LOLE	Loss of Load Expectation
MARS	Multi-Area Reliability Simulation Software
MW	Megawatt
MWh	Megawatt-Hour
NERC	North American Electric Reliability Corporation
NPCC	Northeast Power Coordinating Council, Inc.
NRCan	Natural Resources Canada
NYISO	New York Independent System Operator
OEB	Ontario Energy Board
PJM	PJM Interconnection, L.L.C.
REZ	Renewable Energy Zones
RFP	Request for Proposal
RSA	Resource and System Adequacy (Procurement)
RTEP	Regional Transmission Expansion Planning
RTO	Regional Transmission Organization
UCAP	Unforced Capacity
VOLL	Value of Lost Load

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Executive Summary

Midgard Consulting Incorporated (the "Consultant") was engaged by the Independent Electricity System Operator ("IESO") to review its electricity system planning and procurement process. As approved by the Ontario Energy Board ("OEB") in its Order and Decision for EB-2022-0318[1], the review addresses IESO's commitment in its Settlement Agreement with Intervenors for IESO's 2023, 2024 and 2025 expenditures, revenue requirement and usage fees proceeding "to retain an independent third party to review the electricity system planning and procurement process against best practices and identify recommendations for the IESO going forward" and to "post the results on the IESO website by April 1, 2025, including IESO responses."

Accordingly, Midgard reviewed key elements of IESO's planning and procurement processes relating to IESO's Annual Planning Outlook ("APO"), which is IESO's primary public-facing planning document and best captures the processes providing inputs into the energy and capacity models, the treatment and translation of the model outputs, and processes that result in planned procurement actions.

This report provides analysis and recommendations intended to support IESO's mission in a manner that is responsive to the Settlement Agreement commitment and OEB Decision EB-2022-0318.

Current State

IESO ensures a reliable and efficient electrical system by balancing its decisions in consideration of costs, benefits, opportunity costs, risks, and uncertainty. As a public facing entity IESO's decisions, decision-making processes and the transparency thereof are critical to preserving IESO's credibility and reputation with consumers, generators, investors, and policymakers. IESO's current planning and procurement processes as described in the 2024 APO document have successfully delivered on IESO's mandate to date. The APO provides a long-term forecast of electricity demand and supply, along with an assessment of the reliability and adequacy of Ontario's power system over a planning horizon, typically spanning 20 or more years. The APO serves as a critical input for stakeholders, including utilities, policymakers, investors, and other market participants, helping them make informed decisions about future infrastructure investments and policy developments.

IESO's planning and procurement processes are grouped into five major process steps and teams:

1) Demand & Conservation Planning
2) Transmission Planning
3) Resource Planning (Modeling)
4) Resource Planning (Assessment)
5) Resource & System Adequacy (Procurement)

[1] Ontario Energy Board (OEB). (2023). *Decision and order, EB-2022-0318: Independent Electricity System Operator application for approval of 2023, 2024, 2025 expenditures, revenue requirement, and fees*. Retrieved from Link

The planning and procurement process starts with Demand & Conservation Planning and Transmission Planning, combining inputs with Resource Planning (Modeling)'s Supply Outlook to model the capacity and energy needs for the province for a 20+ year period. The Resource Planning (Modeling) group evaluates a portfolio of scenarios that test different risks and uncertainties representing different plausible energy futures for Ontario. The number of output scenarios generated by the Resource Planning (Modeling) team varies to include at least the reference or "as is" scenario but may also generate additional scenarios based upon different policies or market contexts (for example, the High Nuclear case which was included in the 2024 APO). The System Needs Capacity and Energy outputs generated by Resource Planning (Modeling) are provided as inputs to Resource Planning (Assessment).

Taking the System Needs Capacity and Energy, the Resource Planning (Assessment) team performs an Integrated Reliability Assessment which incorporates the capacity and energy contribution of actions that are underway and considers additional risks and uncertainties not captured in the output generated by the Resource Planning (Modeling) team, but which could impact future energy and capacity needs. The outputs of the Post Modeling Assessment are updated values for the province's capacity and energy needs, called Updated Needs. These Updated Needs are discussed with key stakeholders such as the Ministry of Energy and Electrification and socialized internally throughout IESO to assist in developing strategies to address identified gaps. The final outputs are incorporated into the APO, ultimately telegraphing IESO's latest resource adequacy expectations and procurement strategy to the public.

Resource and System Adequacy (Procurement) ("RSA") develops planned actions to meet the Updated Needs, which actions typically include capacity auctions, contracting medium-term and long-term commitments, programs and bilateral negotiations for specific resources.

Opportunities for Continuous Improvement

Through the review process, IESO confirmed its commitment to continuous improvement and expressed openness to considering refinements to its planning and procurement processes, in consideration of the rapidly changing energy landscape in Ontario and the rest of North America. Some of the recommended opportunities for continuous improvement identified in this report were initially raised during interviews with IESO staff, and others were drawn from Midgard's industry experience and knowledge of relevant examples implemented by industry peers in other jurisdictions following the interview process.

In summary, Midgard recommends that IESO take the following actions for continuous improvement of its planning and procurement processes:

1. Implement Effective Load Carrying Capability ("ELCC") (or other industry standard equivalent) resource capacity contribution analysis and specification methodology across its planning and procurement processes.

2. Develop an implementation plan for integrating Value of Lost Load ("VOLL") into its planning processes.
3. Implement least regrets planning in the APO to address both the primary load forecast scenario and the portfolio of scenarios IESO evaluates; associated with this action, IESO should evaluate implementing Renewable Energy Zones in Ontario.
4. Adopt expanded scenario planning to address less probable but credible long-term risks and uncertainties that may require near-term actions to preserve real optionality should those risk or uncertainties ultimately materialize.
5. Track and document cumulative planning process uncertainties, modeling variabilities and output accuracy ranges.
6. Document IESO's planning and procurement processes and continuous improvement processes (including metrics or performance goals that it uses to evaluate and track areas of improvement) and communicate this documentation to IESO staff and external stakeholders.

1 Background and Introduction

Midgard Consulting Incorporated (the "Consultant") has been engaged by the Independent Electricity System Operator ("IESO") to review its electricity system planning and procurement process. As approved by the Ontario Energy Board ("OEB") in its Order and Decision for EB-2022-0318[2], the review addresses IESO's commitment in its Settlement Agreement with Intervenors for IESO's 2023, 2024 and 2025 expenditures, revenue requirement and usage fees proceeding "to retain an independent third party to review the electricity system planning and procurement process against best practices and identify recommendations for the IESO going forward" and to "post the results on the IESO website by April 1, 2025, including IESO responses."

Accordingly, Midgard reviewed key elements of IESO's planning and procurement processes relating to IESO's Annual Planning Outlook ("APO"), particularly the processes providing inputs into the energy and capacity models, the treatment and translation of the model outputs and processes that result in planned procurement actions.

This report provides analysis and recommendations intended to support IESO's mission in a manner that is responsive to the Settlement Agreement commitment and OEB Decision EB-2022-0318. Midgard evaluated IESO's existing electricity planning and procurement frameworks against resource adequacy planning and procurement best practices identified in other jurisdictions. Recommendations are therefore based upon examples of industry peers and business best practices drawn from other jurisdictions and tailored to the unique requirements of Ontarians and IESO.

1.1 Report Outline

The remainder of the report is organized as follows:

Section 2: Describes the current state of IESO's planning and procurement processes and how those processes result in resource[3] procurement actions.

Section 3: Identifies Continuous Improvement Opportunities for IESO planning and procurement processes.

Section 4: Discusses and recommends IESO use of Effective Load Carrying Capability ("ELCC"), a metric to improve the accuracy and reliability of resource capacity contributions calculations.

[2] Ontario Energy Board (OEB). (2023). *Decision and order, EB-2022-0318: Independent Electricity System Operator application for approval of 2023, 2024, 2025 expenditures, revenue requirement, and fees*. Retrieved from Link

[3] "A resource means an IESO-modelled representation of one or more generation units, electricity storage units, or sets of load equipment, existing within the IESO's systems, which is used for the secure operations of the IESO control area, or to participate in the IESO administrated markets; or a boundary entity resource; or virtual zonal resource." Market Rules for the Ontario Electricity Market; MRP Consolidated Draft, Chapter 11-45, Library Record No. MDP_RUL_0002_07.

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Section 5: Discusses Value of Loss Load ("VOLL"), an economic metric that quantifies the financial impact of electricity supply interruptions, and recommends that IESO develop an implementation plan for developing and integrating VOLL into its planning processes.

Section 6: Discusses and recommends that IESO apply Least Regrets Planning, a methodology that can help minimize potential future risks and costs under a range of uncertain future scenarios.

Section 7: Discusses and recommends that IESO implement Expanded (Discontinuity) Scenario Planning, which involves expanding IESO's current scenario planning activities to include evaluating selected boundary scenarios to test electricity system plans against potential future discontinuities.

Section 8: Discusses the input and model accuracy and recommends that IESO explicitly quantify, track and document cumulative uncertainties, modeling variabilities and output accuracy ranges in its planning processes, and communicate that information to its stakeholders.

Section 9: Discusses the benefits of formally documenting planning and procurement processes and continuous improvement activities and recommends that IESO formally document its planning and procurement processes and its continuous improvement processes and communicate this information to IESO staff and external stakeholders.

2 IESO Planning and Procurement Process

To fulfill the requirements of OEB decision EB-2022-0318 and the Settlement Agreement commitment, this report focuses on reviewing the planning processes presently employed to produce IESO's Annual Planning Outlook ("APO") and the procurement processes employed to meet the resource needs resulting from the APO.

2.1 Review Methodology

Midgard's evaluation of IESO processes included documentation review and interviews with five different teams[4] directly involved in the resource adequacy planning and procurement, with specific focus on the processes used to develop the APO and to implement the resource procurements triggered by the APO.

Table 1 cross-references the teams interviewed and the topics covered[5] with the relevant APO sections:

Table 1: Interview Cross-Reference

Team	Primary Interview Topics[6]	Related APO Section
Demand and Conservation Planning	Demand Projection	Demand Forecast
Transmission Planning	Ontario's Bulk Transmission Plans and Transfer Limitations	Transmission System Needs
Resource Planning (Modeling)	Supply outlook and projected system needs (Energy and Capacity)	Supply Outlook and Resource Adequacy
Resource Planning (Assessments)	Projected system needs (energy and capacity) considering underway actions, risks and uncertainties	Integrated Reliability Needs
Resource and System Adequacy (Procurement)	Designing and implementing resource procurement mechanisms	Planned Actions

[4] The term "Team" is used to simplify the report and simply refers to the different groups of IESO staff made available for each of the interviews. The term is not intended to convey that each of these groups represent equivalent IESO corporate structure levels.

[5] For consistency, the names provided to Midgard at the time the interviews took place are used throughout the document. Some of the teams have since been renamed or are part of other departments and business units.

[6] The interviews were not constrained to remain strictly within the team and topic areas listed. When the interview conversations led to information areas beyond a primary focus or responsibility, the interview expanded into those areas as well because insights about team interfaces, mutual internal supports, lines of communication & feedback and data sharing were explored. Accordingly, the table is a guide to primary areas of focus and should not be seen as a deterministic definition of strict organizational boundaries, knowledge or insight.

Interviews focused on capturing each team's processes (i.e., inputs, tools/analysis and outputs) relevant to developing the APO plans and resulting resource procurement actions, as well as soliciting assessments from the people closest to the processes of any challenges and opportunities for continuous process improvements.

Prior to each interview, Midgard reviewed any available associated process documentation and prepared a draft process outline for discussion during the interview. Following each interview, the interviewed team was provided with a summary of the interview findings and an updated process description and then given the opportunity to confirm accuracy and correct any inaccuracies. The validated interview findings were then used to develop a high-level planning and procurement process map along with descriptions of each team's associated process components, as documented later in this section.

Recommendations for planning and procurement process improvements were then developed, drawing upon identified opportunities for continuous improvement, existing process observations and best practices from industry peers in other jurisdictions.

2.2 Current State of IESO Planning and Procurement Processes - Overview

2.2.1 Annual Planning Outlook Document

The stated purpose of the APO 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."[7]

The APO provides a long-term forecast of electricity demand and supply, along with an assessment of the reliability and adequacy of Ontario's power system over a planning horizon, typically spanning 20 or more years.[8] The APO serves as a critical input for stakeholders, including utilities, policymakers, investors and other market participants, helping them make informed decisions about future infrastructure investments and policy developments.

[7] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 14. Link

[8] IESO's planning and procurement processes cover three distinct time periods:

- Long-term planning (1 to 20+ years)
- Operational Planning (Day 2 to 1 year)
- Real Time Planning (Days 0 & 1)

The Operations Planning time period is addressed in IESO's Adequacy Reports (2 – 34 days) and Quarterly Reliability Outlooks (34 days to 1 year). The Adequacy Report also details hourly capacity and energy margins for Days 0 & 1 and considers demand forecasts, outages, variable generation ("VG") forecasts and scheduled interchange. Review of the associated processes and documentation is not included in the scope of this report, which focuses upon IESO's planning and procurement processes associated with the Long-Term planning and procurement period covered by the APO, since there are no significant resource procurement actions associated with the Operational and Real Time planning periods, other than interjurisdictional exports and imports. All subsequent references to planning and procurement processes in this report refer to the Long-term APO-related processes.

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2.2.2 Ontario Electrical Zones

Foundational inputs to IESO's planning and procurement processes apportion the information into ten (10) Ontario electrical zones as illustrated in Figure 1 below. Any mentions in this report of electrical zones, zonal demand, zonal resources or interzonal constraints refer to this map unless otherwise specified.

Figure 1. IESO's Ten Ontario Electrical Zones[9]

2.2.3 Overview of IESO's Planning and Procurement Processes

Figure 2 below provides a high-level overview process map of IESO's planning and procurement processes as of the time of writing. The planning and procurement processes are grouped into five major process blocks, each of which corresponds primarily with the activities of one of the interviewed teams.[10]

It is important to state that Figure 2 represents a simplified map of IESO's planning and procurement processes – there are iterative reviews, feedback loops and day-to-day informal interactions between the different interviewed teams and other internal and external parties which are not identified in this map. Attempting to

[9] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 42. Link

[10] Developed using information and graphics extracted from the 2024 Annual Planning Outlook and further refined based on interviews with IESO's planning and procurement teams.

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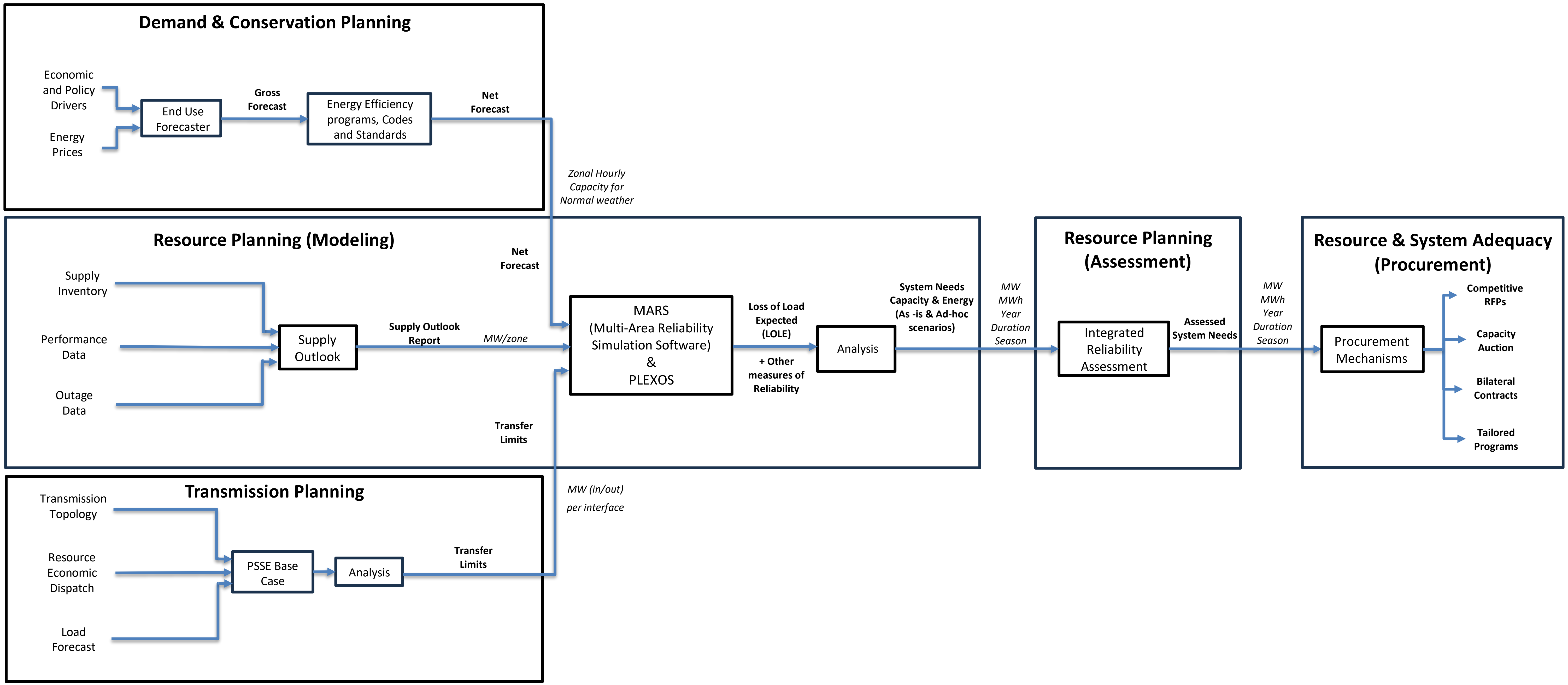
incorporate all formal and informal data and information reviews, feedback loops and information interactions would make the figure unnecessarily unwieldy for the purposes of this report.[11]

[11] Midgard has used terms (capitalized in the text) that are not necessarily the terms used by IESO to provide the reader assistance in navigating the processes, including the inputs and outputs for each of the teams.

Figure 2: Planning and Procurement Process Chart[12 13]



[12] Important factors considered as appropriate throughout IESO's Planning and Procurement processes include Government Policy and Directives, Transmission Constraints and Locational Considerations.

[13] Inputs have no blocks, process are shown as blocks, outputs are bolded and units are italicized

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As shown in Figure 2 above, the Net Forecast[14] (produced by Demand and Conservation Planning), the Transmission Transfer Limits (produced by Transmission Planning) and the Supply Outlook (produced by Resource Planning (Modeling)) are primary inputs into the Multi-Area Reliability Simulation ("MARS") software[15] and the PLEXOS energy modeling software[16] used by Resource Planning (Modeling) to develop a baseline resource adequacy assessment (System Needs Capacity and Energy). The baseline assessment is a 20+ year seasonal forecast of Ontario's incremental system capacity and energy needed to achieve the Northeast Power Coordinating Council ("NPCC") prescribed reliability criterion of 0.1 days per year Loss of Load Expectation ("LOLE").

The baseline resource adequacy assessment is further analyzed and refined by Resource Planning (Assessment) using customized tools[17] to consider a range of additional factors, such as actions that are underway, risks and uncertainties, to develop a refined needs forecast (Assessed System Need).

These refined needs forecasts are then utilized by Resource and System Adequacy (Procurement) to develop a set of planned actions to acquire the resources required to satisfy projected system needs, primary directed towards the first 10 years of the forecast period, using the mechanisms in IESO's Resource Adequacy Framework, except for the bilateral contracts mechanism which is under the Contract Management department.[18]

The following sections further discuss each of the process blocks comprising Figure 2.

[14] A reference demand forecast scenario is included in the APO; however, the demand forecasting team can and does prepare various forecast scenarios for planning studies or adequacy assessments as needed by different IESO groups.

[15] General Electric International (GE). (2018). *GE Multi-Area Reliability Simulation Software Program (MARS)*. Retrieved from Link

IESO uses MARS to model and assess the reliability and adequacy of interconnected power generation systems using Monte-Carlo simulations.

[16] *PLEXOS Energy Modeling Software*. Retrieved from Link

IESO uses PLEXOS to model costs and emissions associated with energy production

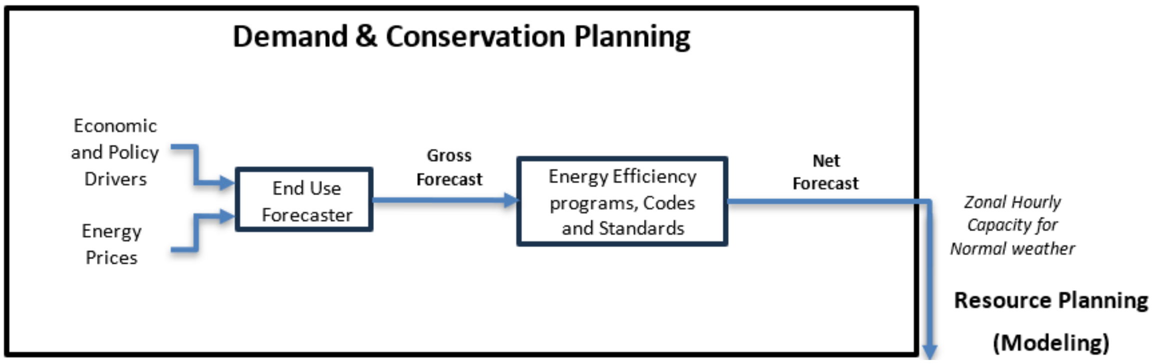
[17] Aside from MARS and PLEXOS, various fit for purpose in-house models and tools are employed in the different process steps.

[18] The Resource Adequacy Framework outlines the competitive roadmap for procuring electricity resources across short, medium and long-term periods

2.3 Current State of IESO Planning and Procurement Processes – Details

2.3.1 Demand and Conservation Planning

Figure 3. Demand & Conservation Planning Process Block



As shown in Figure 3, the Demand and Conservation Planning team generates the Net Zonal Hourly Demand Forecast (“Net Forecast”), which is one of the primary inputs into the Resource Planning (Modeling) process.

Economic and Policy Drivers and Energy Prices are inputs into the End Use Forecast (“EUF”) model, which uses the reference year zonal hourly demand forecast[19] as its starting point. The Economic and Policy drivers consider residential, commercial and industrial sectors along with their sub-sectors. Many sources are used to obtain demand-related information for these sectors, including population/household forecasts, end use surveys, commercial floor space forecasts, Statistics Canada databases, Natural Resources Canada (“NRCan”) databases, etc. Numerous other factors and variables are considered in developing the EUF, including consumers’ choices of fuel type, technology, equipment purchasing decisions, behaviour, demographics, population, the economy, energy prices, transportation policy and electricity demand side management. Electricity and natural gas prices are also inputs into the EUF. End use assumptions are updated periodically via market surveys and other available resources.

Particular attention is given to sub-sectors with the potential to trigger large step load changes. For example, the recent arrival of large data centers and artificial intelligence (“AI”) driven loads may exhibit non-linear growth curves and be highly subject to exogenous factors. Information regarding large step loads that should be considered in the forecast is gathered from multiple sources, including IESO’s transmission planning, resource planning and connection assessments teams, Hydro One, Ministry of Economic Development, Job Creation and Trade and the Ministry of Energy and Electrification.

[19] The reference year zonal hourly demand forecast is aligned with IESO’s latest available Reliability Outlook, thus ensuring that both the APO and the Reliability Outlook are using consistent forecasts for system performance estimates for the overlapping forecast period.

An electric vehicle ("EV") electricity demand forecast is evaluated separately from the EUF. Both the EV forecast and EUF are components of the gross forecast. The EV forecast utilizes government targets and charging profile data provided by a third-party consultant (informed by NRCan research).

The forecasted electricity demand is compared against weather adjusted actuals to assess model performance and remove the impact of weather volatility. Typical or "Normal" and "Extreme" weather conditions are generated using 31 years of historical weather data across six provincial weather stations. This weather data is then converted into a "weather factor" which feeds into the APO demand forecast through the reference year methodology.

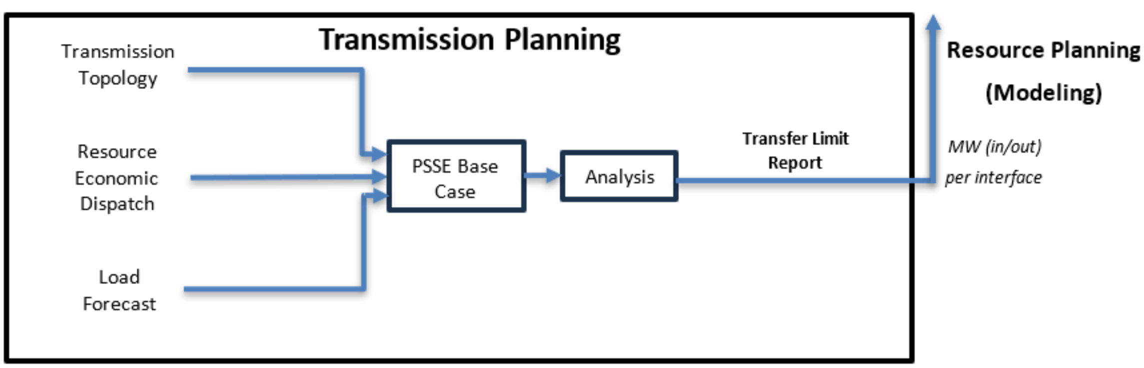
The EUF output comprises a long-term gross demand forecast ("Gross Forecast") by sector, IESO electrical zone and end-use which is transformed as follows. The hourly gross demand forecast is created by multiplying the corresponding normalized end-use level hourly load profiles with individual sectoral and segmental annual energy demand forecasts, which are then aggregated to sectoral level zonal hourly energy demand forecasts and in turn further aggregated to form the zonal hourly energy demand forecasts. Impacts of energy efficiency programs and codes and standards savings are deducted from the gross forecast.

The resulting Net Forecast is a 20+ year net zonal hourly demand forecast under typical weather conditions which accounts for the Industrial Conservation Initiative and behind-the-meter generation (note that embedded generation and grid-and distribution-connected batteries are accounted for in the Supply Outlook).

The Net Forecast is one of the foundational inputs into the Resource Planning (Modeling) process.

2.3.2 Transmission Planning

Figure 4. Transmission Planning Process



Transmission Planning generates annual Transfer Limits, as shown in Figure 4. The Transfer Limits represent the transmission interface limits ("Transfer Limits") which denote the transmission transfer capability between Ontario's ten (10) electrical zones and to/from other jurisdictions with which Ontario is interconnected (i.e., Quebec, Manitoba, New York, Michigan and Minnesota).

The assessment methodologies to determine Transfer Limits comply with North American Electric Reliability Corporation ("NERC") and NPCC regulations. The transmission interface limits assessment uses an extreme weather forecast to determine Transfer Limits as well as an economic resource dispatch based on a base case for the Eastern Interconnection and the existing and expected transmission system topology.

Transmission needs and constraints are also identified through the regular regional planning and bulk planning processes and passed on as an input to the resource planning phase. Regional planning provides an outlook on transmission needs on a regional basis over a period of 20 years. The bulk planning process is aimed at proactively studying the bulk system to consider significant supply resource changes and load growth.

For example, the South and Central bulk plan[20] is currently underway to review the bulk system's capability to support future generation connections and demand growth, including confirming transmission reinforcement to enable nuclear resources expansion, decrease reliance on greenhouse gas emitting resources and supply long-term demand growth under different scenarios such as high economic development and electrification in key growth areas.

Another study underway is the Northern Ontario bulk study[21] reviewing options to increase the transmission transfer capability between northern and southern Ontario. The first area of focus of this plan is to expand the transmission linkages between Sudbury and the Greater Toronto area, to enable new renewable resource development in the North and to allow for additional flow from south to north in times of high demand and low hydroelectric output in the north. A second stage of this study will assess transmission expansion alternatives north of Sudbury, to unlock the potential for additional hydroelectric resource development on northern rivers.

The Transfer Limits identify the transfer capabilities between Ontario's ten (10) electrical load zones under peak load conditions in the form of annual limits for each interface over the 20+ years in the APO forecast. The Transfer Limits also identify grid constraints pertaining to geographical considerations for potential resources and provides recommendations for potential further study to address constraints identified (e.g. through processes such as the regional and bulk planning studies).

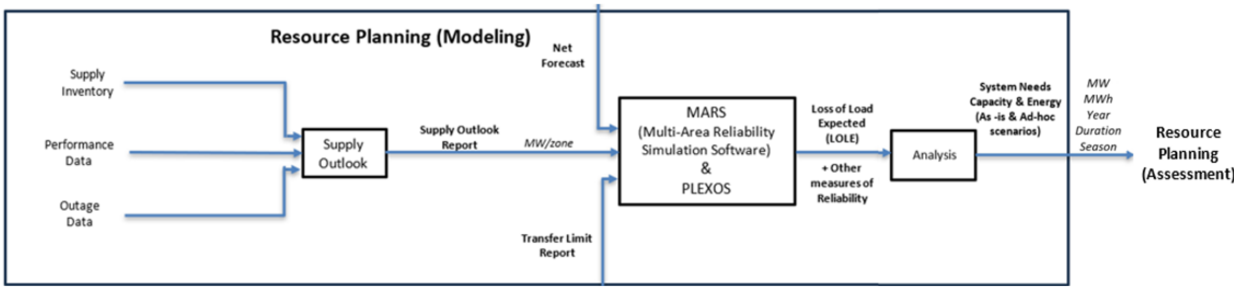
These Transfer Limits are foundational inputs into the Resource Planning (Modeling) process.

[20] Independent Electricity System Operator (IESO). *South and Central Bulk Planning*. Retrieved from Link

[21] Independent Electricity System Operator (IESO). *Northern Ontario Bulk Planning*. Retrieved from Link

2.3.3 Resource Planning (Modeling)

Figure 5. Resource Planning (Modeling) Process Block



As shown in Figure 5 above, Resource Planning (Modeling) first derives and assesses the Supply Outlook which is combined with inputs from Demand and Conservation Planning (see Section 2.3.1) and Transmission Planning (see Section 2.3.2) in the Multi-Area Reliability Simulation Software ("MARS") & PLEXOS to produce the information needed to create the System Needs Capacity and Energy output that is provided to the next step in IESO's planning process.

Supply Outlook

Resource Planning (Modeling) first derives and assesses the Supply Outlook, a database of the resources that are known or expected to be available in each Ontario zone for each year of the planning period. The Supply Outlook database accounts for seasonal variation in effective supply and includes information on installed capacity, fuel type, IESO zone, in-service and out-of-service dates and status of each facility.

Historical and simulated hourly data are used to predict the performance of variable generation resources such as hydroelectric, wind and solar. Generation profiles have been developed by third parties for solar (10 profiles) and wind (30 profiles), where actual data is unavailable. The run-of-river hydro generation profile is based on historical performance. Peaking hydro profiles are based on historical offer data that is used to develop maximum capacity and reservoir storage levels. Distributed resources ("DR") performance assumptions are based on historical performance and DR test results. The performance of storage depends on the type, capacity and energy of each resource, as well as the condition of the system.

Performance of thermal resources is estimated using the equivalent forced outage rate on demand (or EFORD), which is a probabilistically determined indication of whether individual generating units will be fully or partly unavailable due to forced outages or seasonal deratings when there is a need to generate.

System Needs Capacity and Energy

Resource Planning (Modeling) then incorporates the Supply Outlook, the Net Forecast (from Demand and Conservation Planning) and the Transfer Limits Report (from Transmission Planning) into the MARS and PLEXOS models, to derive System Needs Capacity and Energy.

The MARS model evaluates winter and summer system capacity needs (surplus or deficit) for each zone for up to 25 years, ensuring compliance with the NPCC requirement for a 0.1 days per year LOLE. MARS is set to run 500 - 2000 Monte Carlo simulation iterations to evaluate and compare resource availability in each hour against the corresponding hourly demand. When demand exceeds available resources, a LOLE event is identified. The MARS software incorporates resource performance variability, availability and zonal transfer capabilities to determine semi-annual (i.e., summer season and winter season) LOLEs. All planned outages for thermal generation units are scheduled by the software to minimize the modeled impact on grid reliability. The final capacity assessment (i.e. the capacity surplus/deficit) needed to meet 0.1 days per year LOLE is compiled and incorporated into the APO.[22] In addition to the capacity assessment, the Resource Planning (Modeling) team performs an energy assessment using the PLEXOS Energy model. The PLEXOS Energy model is an optimization model that considers median/average future scenarios (demand, wind/solar/hydro production) and uses an hourly optimization algorithm to dispatch resources to meet demand at the lowest cost. PLEXOS enables calculation of potential unserved energy, average marginal price, emissions, etc., as part of IESO's comprehensive approach which ensures that IESO can maintain a reliable electricity supply, meet regulatory standards and make informed decisions about future investments and operational strategies.

The System Needs Capacity and Energy outputs generated using the MARS and PLEXOS models are provided as inputs to Resource Planning (Assessments). The number of output scenarios generated by the Resource Planning (Modeling) team can change from year to year. In addition to the reference or "as is" scenario, the Resource Planning (Modeling) team may generate additional scenarios based upon different policies or market contexts (for example, the High Nuclear case which was included in the 2024 APO).

Figure 6 and Figure 7 below show graphical representations of System Needs Capacity and Energy output results respectively taken from the 2024 APO.

[22] Current standards set by NPCC only require entities to meet the LOLE requirements. However, LOLE is a limited criterion, in that it only measures loss of load frequency. Additional assessments must be undertaken to estimate loss of load durations.

Figure 6. Summer Capacity Surplus/Deficit[23]

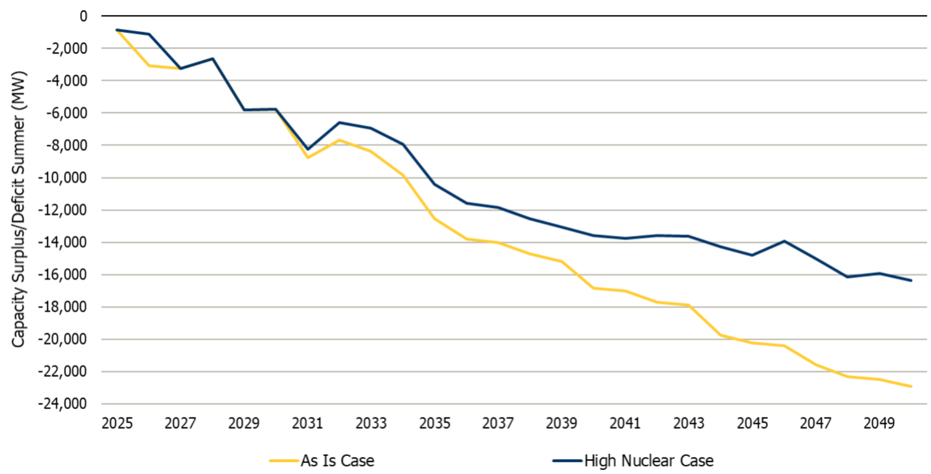
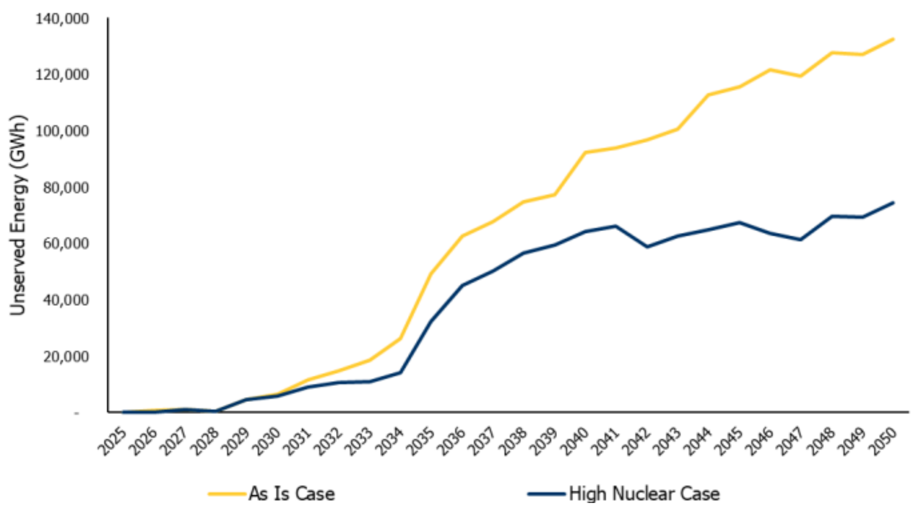


Figure 7: Potential Unserved Energy[24]

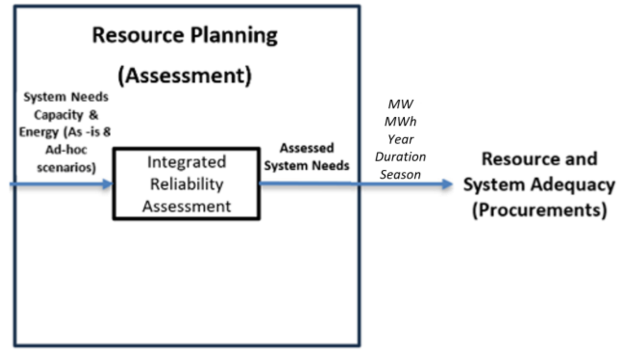


[23] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 49. Link

[24] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 49. Link

2.3.4 Resource Planning (Assessment)

Figure 8. Resource Planning (Assessment) Process



The Resource Planning (Assessment) team performs an Integrated Reliability Assessment on the System Needs Capacity and Energy outputs generated by Resource Planning (Modeling), as shown in Figure 8.

The integrated reliability needs assessment (Integrated Reliability Assessment) incorporates the capacity and energy contribution of actions that are underway and considers additional risks and uncertainties not captured in the output generated by the Resource Planning (Modeling) team, but which could impact future needs. Examples of risks and uncertainties that are considered include resource or transmission acquisition targets not being met, project delays, unreliable operation of new resources and market exits. Integrated Reliability Assessments are conducted outside of the MARS and PLEXOS models and are based on market intelligence and/or best available information on policy, potential risks and other factors that are not suited to simulation modeling.

When conducting Integrated Reliability Assessments, the Resource Planning (Assessment) team interacts with teams including (but not limited to) Demand Conservation and Planning, Resource Planning (Modeling), Transmission Planning and Resource and System Adequacy (Procurement). This multi-team interaction is necessary to understand how actions regarding demand, supply and transmission that are underway may influence future electricity needs. The teams also collaborate to determine the planned actions to needed to meet the system capacity and energy need for the near-term to mid-term in the APO.

The outputs of the Post Modeling Assessment are updated values for the province's capacity and energy needs (Assessed System Needs). These final Assessed System Needs outputs are discussed with key stakeholders such as the Ministry of Energy and Electrification and socialized internally throughout IESO to assist in developing strategies to address identified gaps. The final outputs are incorporated into the APO, ultimately telegraphing IESO's latest resource adequacy expectations and procurement strategy to the public. In sum, the Assessed System Need Output informs the set of planned procurement actions.

For the 2024 APO, IESO considered an "As Is" scenario and a "High Nuclear" scenario for the supply outlook cases. The High Nuclear case, which builds upon information produced by the Resource Planning (Modeling) team, is analyzed and presented in Figure 9 and Figure 10 reproduced from the 2024 APO.

Figure 9. Integrated Capacity Needs[25]

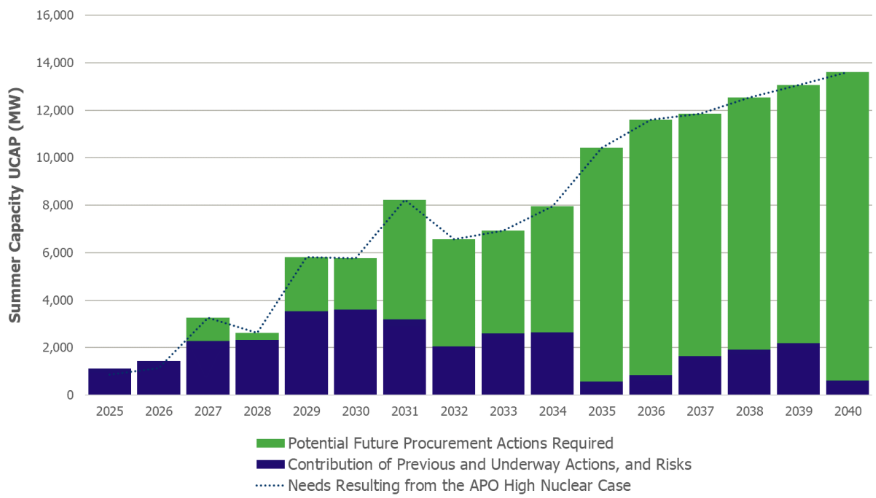
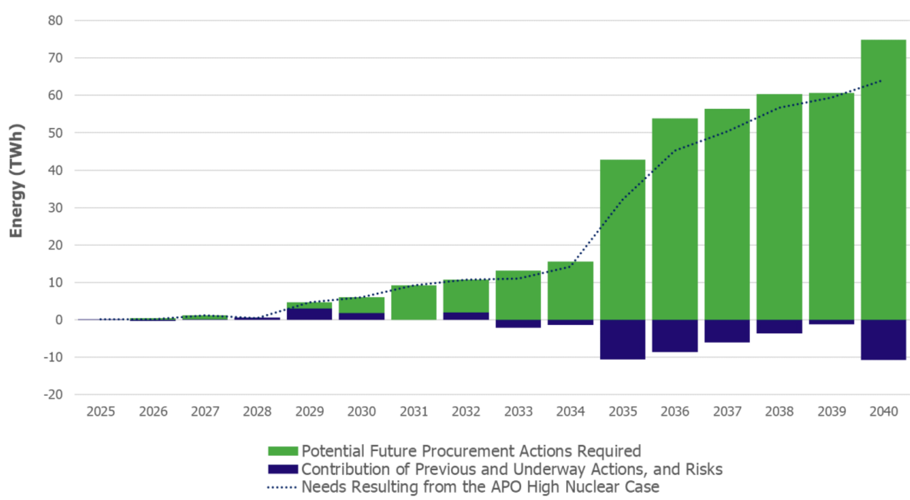


Figure 10: Integrated Energy Needs[26]



[25] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 75. Link

[26] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 76. Link

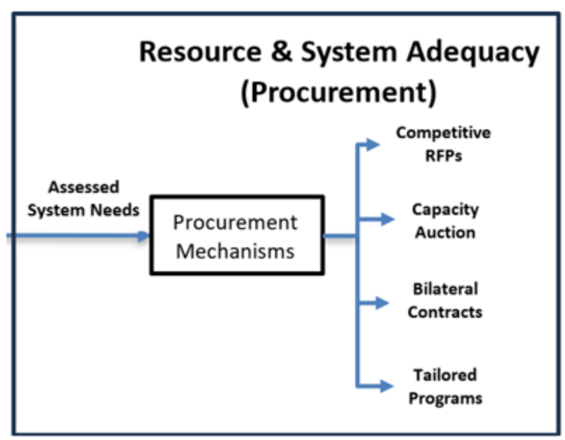
Accompanying the capacity graphic in the APO is the following statement addressing Capacity Needs: 2035 to 2050[27]:

> *"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."*[28]

This statement provides context for the uncertainty-related recommendations introduced in report Section 3.1 and further discussed in Sections 6 & 7.

2.3.5 Resource and System Adequacy (Procurement)

Figure 11. Resource and System Adequacy (Procurement) Process



[27] A similar statement in the 2024 APO addressing energy needs is not replicated here for brevity.

[28] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 74. Retrieved from: Link

The Resource and System Adequacy (Procurement) ("RSA") team is responsible for developing planned actions to meet electricity needs identified in the APO as shown in Figure 11.

Figure 12 describes some of the mechanisms used by the RSA team to procure the resource requirements identified in the Assessed System Need statement.

Figure 12: Summary of Planned Actions[29]

Mechanism	Scope
Capacity Auction	Balances fluctuations in capacity needs from one year to the next, and executed on an annual basis
Medium-Term Commitments	Provides resources greater certainty through longer forward periods and flexible 5-year commitments - cadenced process will provide IESO flexibility to adjust to changes in system needs and adapt processes to lessons learned
Long-Term Commitments	Secures resources with very long forward periods or commitments, such as new-build facilities
Programs	Meets electricity and policy objectives in a more targeted manner as directed
Bilateral Negotiations	Secures resources where a need exists that cannot be addressed in a practical and timely way through competitive processes (i.e. when needs are urgent and/or must be satisfied by supply in a specific location)

The default approach to acquiring resources is through competitive procurement, e.g.: Long-Term 1 RFP.[30] The capacity auction is used to address near-term procurement needs, as outlined in IESO's market rules.

Tailored programs (e.g., the Small Hydro Program) and bi-lateral contracts (e.g., for Lennox Generating Station) are also utilized to follow government policy direction:

> "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."[31]

[29] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 78. Retrieved from Link

[30] Independent Electricity System Operator (IESO). (2024). *Long-Term RFP and Expedited Process*. Retrieved from Link

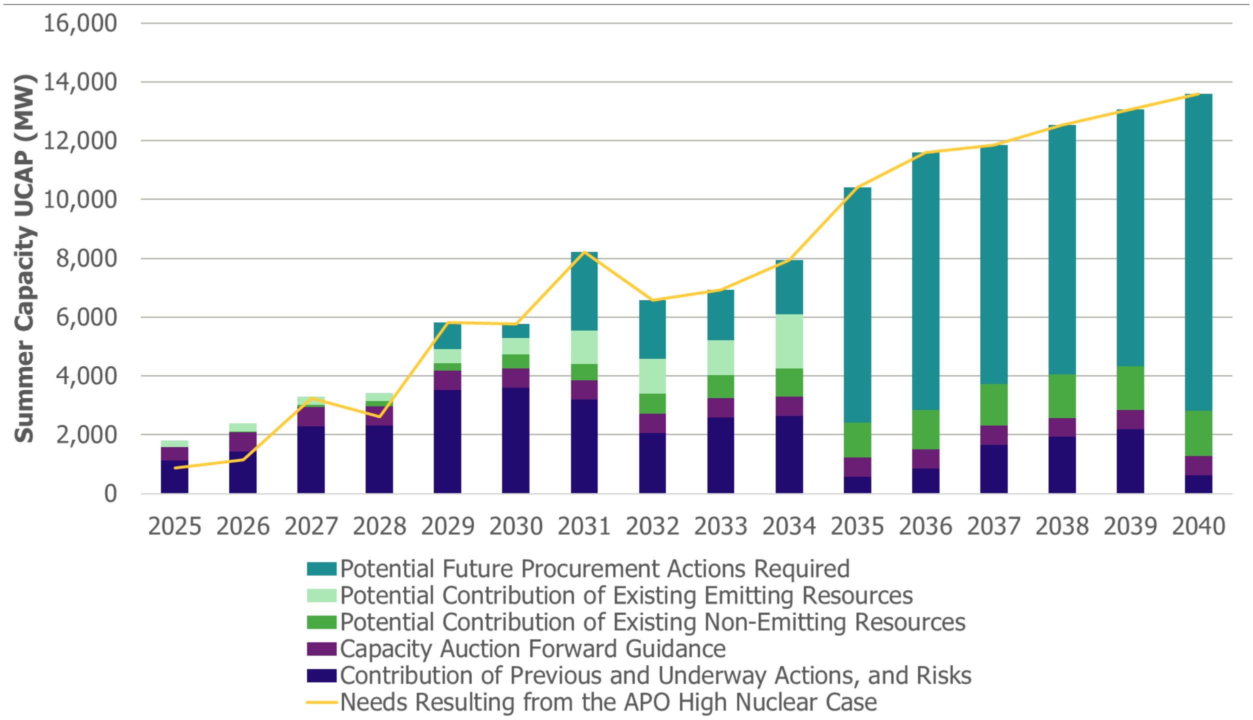
[31] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 77. Retrieved from Link

RSA goals and processes are iterative. The RSA team actively solicits feedback from the broader stakeholder community, including developers of generation facilities, to inform inputs into forecasting and the APO, while also providing information to the stakeholder community regarding policy and IESO expectations.

RSA processes are tailored and refined based upon the action plans because although there are similarities amongst procurements, each procurement has unique characteristics and challenges. RSA output is the execution of procurement action plans outlined in the APO.

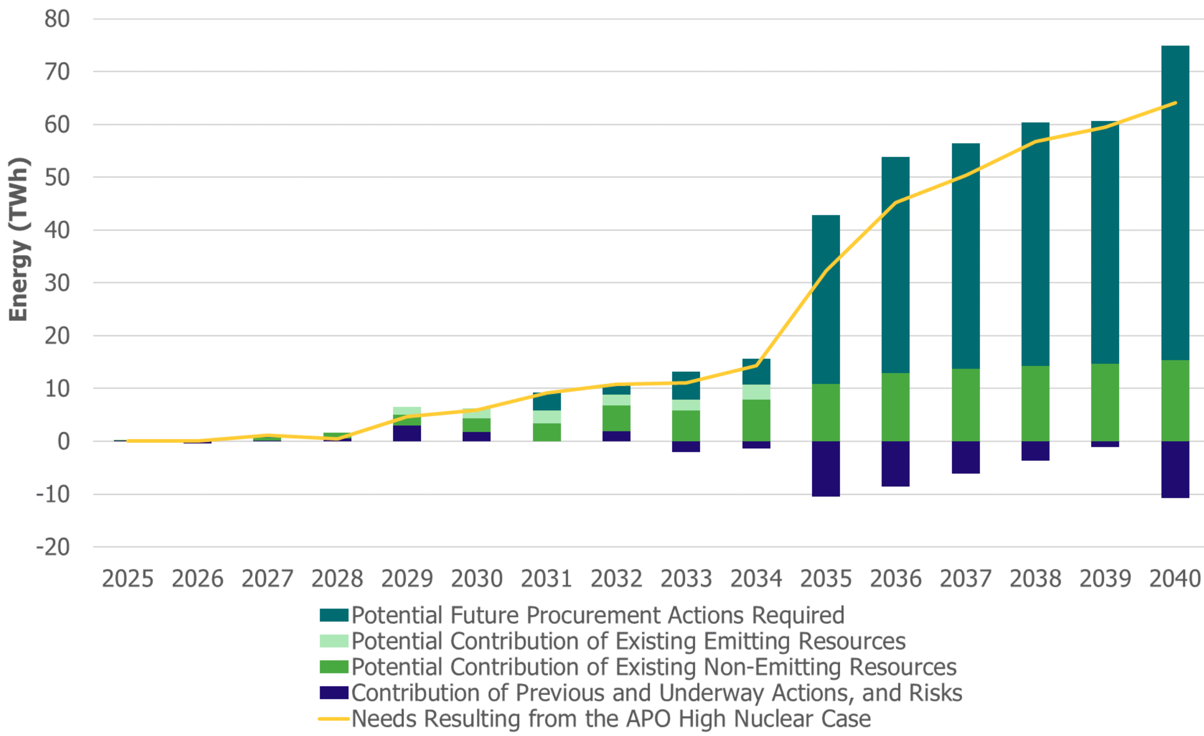
Figure 13 and Figure 14 provide overviews of RSA's anticipated actions in response to the future resource needs identified in the 2024 APO. In the provided examples, a key characteristic of the actions overview is that a single yellow trend line is provided to represent the forecast need for capacity and energy over the planning period.

Figure 13: Identified Capacity Needs and Potential Procurement Actions[32]



[32] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 85-86. Retrieved from [Link]

Figure 14: Identified Energy Needs and Potential Procurement Actions[33]



[33] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 85-86. Retrieved from Link

3 Continuous Improvement Opportunities Overview

IESO ensures a reliable and efficient electrical system by balancing its decisions in consideration of costs, benefits, opportunity costs, risks and uncertainty. Given the public facing nature of IESO's decisions, its decision-making processes and the transparency thereof are critical to preserving IESO's credibility and reputation with consumers, generators, investors and policymakers, especially in a time of great uncertainty when looming energy landscape changes are potentially large.

Opportunities for continuous improvement to enable IESO's continued success were the focus of Midgard's analysis and are the subject of discussion in the remainder of this report. Although the planning and procurement processes used to develop the 2024 APO document have successfully delivered on IESO's mandate to date, through the review process IESO confirmed its commitment to continuous improvement and expressed openness to considering refinements to its planning and procurement processes, especially in consideration of the rapidly changing energy landscape in Ontario and the rest of North America.

Some of the recommended opportunities for continuous improvement identified in this report were initially raised during interviews with IESO staff, and others were developed following the interview process drawing from Midgard's industry experience and knowledge of relevant examples that have been implemented by industry peers in other jurisdictions.

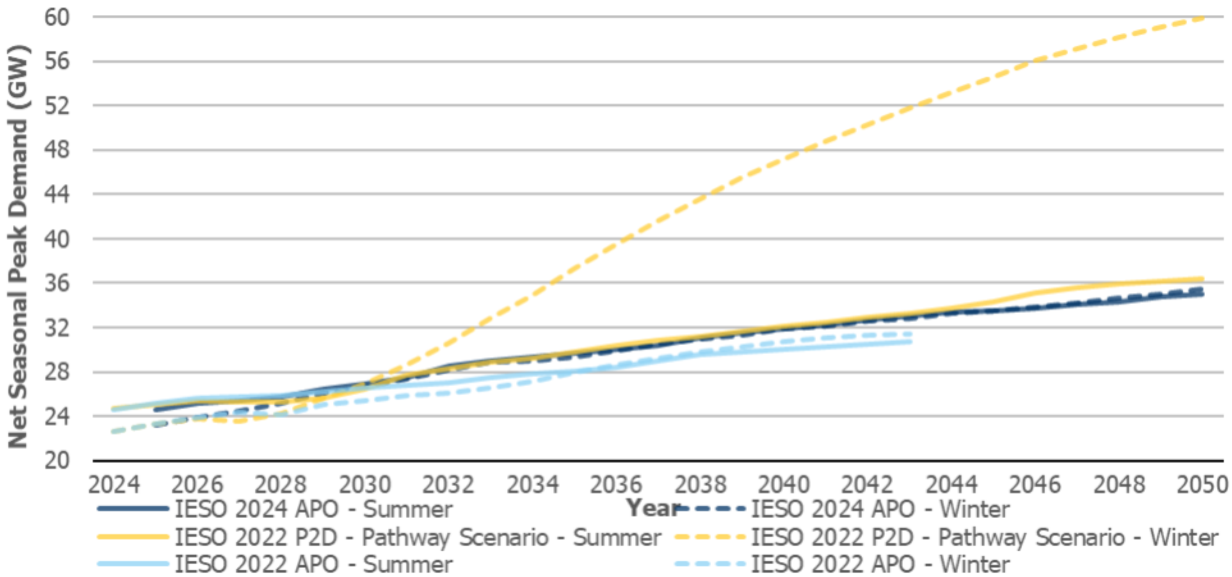
For clarity, Midgard's recommendations are focused on continuous improvement opportunities oriented towards continuing IESO's historic success while improving IESO's ability to prepare for a range of potential Ontario energy futures. Consequently, the following discussion should be read in the context that current and historic practices were prudent, but adaptions are necessary to ensure IESO will continue successfully planning the Ontario electric system and procuring the resources needed to deliver a cost effective, reliable and resilient grid that meets Ontario's electricity needs into the future.

3.1 Opportunities for Improvement

As discussed previously in Section 2.2.1, IESO's Annual Planning Outlook, is a key document that informs IESO's planning and procurement processes. The APO is also necessarily a public facing document because it is used both by IESO and external parties such as government, energy industry participants and the public at large seeking to understand Ontario's expected electricity future and the range of possible futures. The APO has successfully met this multi-use requirement to date but may not into the future because Ontario's energy landscape is changing.

For example, while IESO's Demand and Conservation Planning team incorporates various scenarios (e.g., Extreme Weather) during the development of the APO Peak Demand forecast, as seen in Figure 15 , the extent to which these scenarios influence long-term procurement decisions is not clearly articulated in the APO. These scenarios are used in part as a calibration process, which is crucial for understanding forecast uncertainty and risk, but their impact on procurement strategy remains unclear in the public-facing APO.

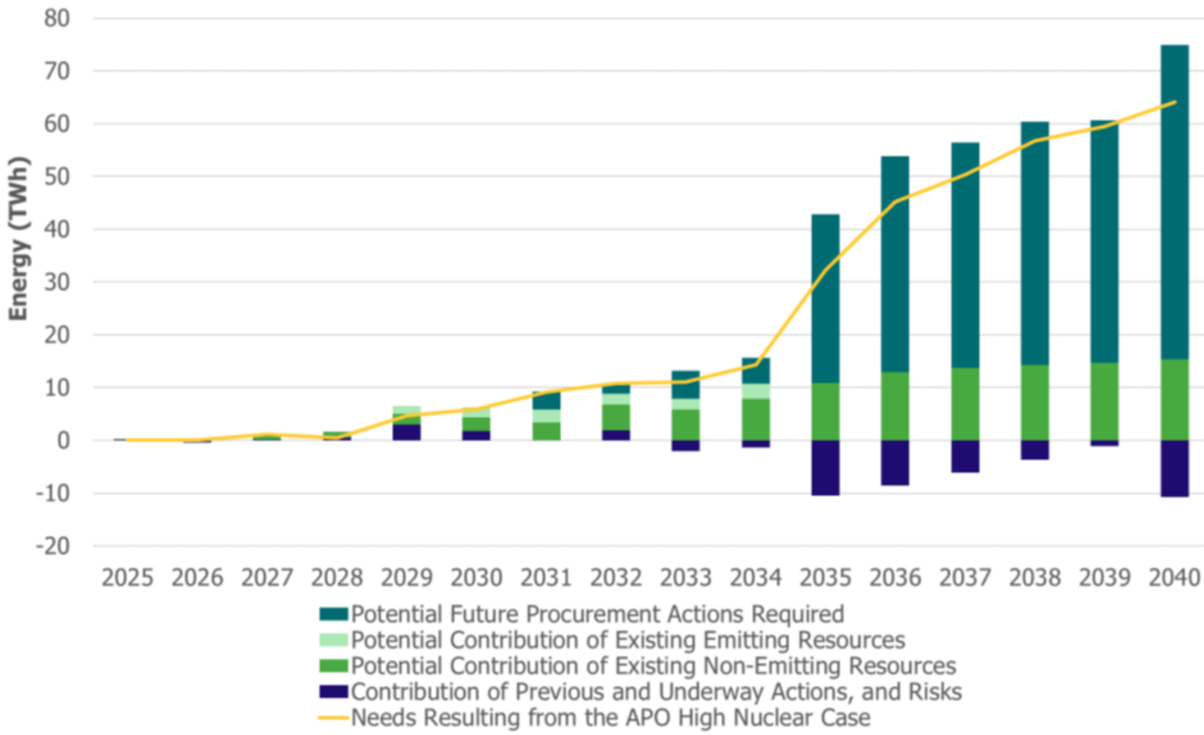
Figure 15: Seasonal Peak Demand by Forecast[34]



Although IESO has internally considered multiple scenarios to validate the APO Seasonal Peak Demand forecast, these scenarios are not described in detail in the APO. The APO provides a single forecast of long-term needs that will drive future procurements, as shown in Figure 16. This single view is the primary pivot for IESO's public-facing procurement plans for the next 10 years.

[34] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 31. Retrieved from Link

Figure 16: Remaining Energy Needs and Potential Future Procurement Actions[35]



Focusing on a single expected projection has potential unintended consequences. First, users of the APO are not informed about the range of possible futures that could occur, there is an increased risk IESO will be constrained to procurements that align with the single expected narrative and IESO is not taking full credit for the work that it performs on behalf of Ontarians, which may lead some to undervalue and fail to appreciate IESO's essential role in electrical system planning.

Should one of IESO's internal scenarios materialize to become the public's reality, its arrival could crystallize Ontario electrical system risks that are not currently fully described in the APO, even though these risks have been internally evaluated (to at least some extent). Surprising the public with a future that was studied but not fully and transparently communicated in advance both restricts the present ability of IESO to prepare for this future on a risk adjusted basis and carries political risk to IESO's credibility. Midgard believes that IESO is the party best equipped to evaluate the needs of the Ontario electrical system because it considers a broad set of inputs by people who are qualified to do so. IESO internally analyzes more than it conveys publicly in the APO, a practice which has been historically expedient and prudent because electricity system changes have been largely incremental for the past few decades. But incrementalism cannot be expected to continue indefinitely as society transitions to an increasingly decarbonized (i.e. electric) economy with increasing penetration of

[35] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 86. Retrieved from [Link]

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non-dispatchable generation resources and retirement of dispatchable (and often carbon intensive) generation resources.

Accordingly, Midgard recommends that IESO undertake the continuous improvement opportunities summarized below – each will be discussed more fully in subsequent sections of the report:

1. **Industry Standard Capacity Formula for Non-Dispatchable Resources**: For fully dispatchable resources, IESO uses industry standard UCAP[36] to assess and convey resource capacity information between planning and procurement, but for non-dispatchable resources IESO uses a customized non-industry standard UCAP with a Performance Adjustment Factor to convey non-dispatchable resource capacity information. Changing to an industry standard formula such as Effective Load Carrying Capacity (ELCC) is recommended to better address the changing Ontario landscape with increasing penetration rates of non-dispatchable resources.
2. **Value of Lost Load:** A comprehensive Value of Lost Load (VOLL) study should be undertaken to enable IESO to explicitly consider validated and quantified ratepayer valuation of system reliability, risk and resiliency when considering trade-offs between costs, benefits, opportunity costs, risks and uncertainty in planning and resource procurement activities.
3. **Least Regrets Planning and Procurement:** Although IESO does evaluate more than a single future scenario when it plans the electric system, the planning and procurement work portrayed in the APO largely focuses on a single load forecast scenario. Representing future system needs as a single forecast trendline under-represents IESO's actual planning efforts and potentially restricts the procurement actions IESO can initiate. Assessing a more comprehensive range of credible scenarios in the APO will allow IESO to preserve options to initiate long lead time resources and facilities that would not be considered optimal under the single APO forecast, but that may ultimately prove necessary to mitigate a credible portfolio of risks, uncertainties and exogenous factors. As a result, Midgard recommends implementation of least regrets planning that explicitly evaluates all studied scenarios on a risk adjusted basis. Midgard cites evaluating Renewable Energy Zones as a specific least regrets action.
4. **Expanded (Discontinuity) Scenario Planning:** As discussed earlier in Section 3, IESO's current scenario planning is appropriate for the incremental growth that has typified the North American and specifically Ontario's, electricity system in recent decades. However, the future promises to be different with the transition to expected higher demand growth rates, higher penetration rates of non-dispatchable resources and a less stable environmental and geo-political landscape. Accordingly, Midgard recommends expanding scenario planning to include select boundary scenarios to test procurement plans against. Expanded scenario planning is common in other industries subject to discontinuities such as those developing for the North American and Ontario's electrical system.

[36] The basic industry standard formula for UCAP is Installed Capacity x (1 – Equivalent Forced Outage Rate on Demand)

5. **Input and Model Accuracy:** The output of IESO's APO document necessarily provides a single forecast upon which the core of its "Planned Actions" (over the subsequent 10 years) is based. However, given the range of possible futures that may materialize for which IESO must prepare, IESO should explicitly track and report on deviations from the forecast so that thresholds that trigger procurement options are monitored.
6. **Process Documentation and Communication:** IESO has been successful planning and procuring resources for the Ontario system to date and enjoys a solid reputation as a result. However, it is reasonable to expect that should unusually severe emerging system needs require IESO to put financially or politically challenging procurement plans before the public, the public will require greater transparency to accept those plans. As a result, Midgard recommends that IESO formally document its planning and procurement processes and its continuous improvement processes and communicate this documentation to IESO staff and external stakeholders.

Table 2 below provides a cross-reference of the above recommendations to the report sections where each is discussed in greater detail.

Table 2: Recommendation Section Cross-Reference

Continuous Improvement Opportunity	Report Section
Industry Standard Capacity Formula for Non-Dispatchable Generation	Section 4
Value of Lost Load	Section 5
Least Regrets Planning and Procurement & REZ	Section 6
Expanded (Discontinuity) Scenario Planning	Section 7
Input and Model Accuracy	Section 8
Process Documentation and Communication	Section 9

4 Industry Standard Capacity Formula for Non-Dispatchable Generation

Electric industry players (i.e. IESO, industry participants, Government and stakeholders) have identified that Ontario's energy landscape is changing rapidly and IESO's planning processes will have to anticipate and adapt to these changes in rates of load growth and the supply resource mix. For example, as discussed previously in Section 2.3.2, IESO Transmission Planning is presently reviewing "…the bulk system's capability to support future generation connections and demand growth, including confirming transmission reinforcement to enable nuclear resources expansion, decrease reliance on greenhouse gas emitting resources and supply long-term demand growth under different scenarios such as high economic development and electrification in key growth areas".

With the provincial generation mix evolving away from emitting and towards non-emitting resources comes a need to ensure that the energy and capacity contributions of the evolving mix of resource technologies in IESO's supply portfolio is accurately understood by IESO stakeholders.

IESO currently uses different resource availability parameters to evaluate the expected performance of the different types of resources being bid into capacity Request for Proposal ("RFP") or auctions. To evaluate dispatchable[37] thermal resources, IESO uses the industry standard definition of Unforced Capacity ("UCAP"):

UCAP = Installed Capacity x (1 – $EFOR_d$)

UCAP = Installed Capacity multiplied by 1 minus the Equivalent Forced Outage Rate on Demand[38]

This definition reasonably describes the expected capacity contribution of such resources during peak demand periods. To evaluate non-dispatchable[39] resources bid into capacity procurements, IESO uses a modified UCAP formula:

UCAP = Installed Capacity x (1 – Equivalent Forced Outage Rate on Demand) x (Performance Adjustment Factor)

IESO derives the Performance Adjustment Factor using historical peak demand period production of existing resources and resource types being bid, to account for the production variability of such resources.[40]

[37] Dispatchable resources can be either emitting (e.g. coal plants, natural gas plants) or non-emitting (e.g. nuclear plants, storage hydroelectricity).

[38] *"For thermal resources, partial forced de-rates/outages are included in the EFORd calculation in planning assessments."* Retrieved from: *IESO Summary of UCAP Discussion for Thermal Resources*. (2021). Link

[39] Non-dispatchable resources are generally non-emitting (e.g. wind, solar, run-of-river hydroelectricity, some demand side measures) but may include emitting resources that have external constraints that prevent their reliable dispatch (e.g. industrial process dependent resources that are less sensitive to electricity market price signals and therefore may across different seasons act more as an energy resources in terms of actual behaviour despite the underlying technology being dispatchable in a purely technical and non-economic or non-seasonal context).

[40] Independent Electricity System Operator. (2023). *Illustrative Examples: Capacity Qualification*. Retrieved from Link

The customized UCAP definition that IESO currently uses for non-dispatchable resources has been adequate to date because non-dispatchable resource penetration rates have been comparatively low and these resources were primarily added in "energy only" procurement processes, such as Feed-in-tariffs ("FIT")[41] and Micro-FIT[42], which do not involve a dependable on-peak capacity evaluation.

However, as penetration rates of non-dispatchable resources increase and they become the more dominant type of resources bid into both energy and capacity procurements (e.g., non-dispatchable resources equipped with batteries may be bid into capacity markets or be recognized for capacity contributions greater than the capacity contribution a purely non-dispatchable version of the same resource would provide), dependable system capacity will become an increasingly important reliability measure. The need to specify and assess the dependable capacity contributions of all newly procured resources will commensurately increase.

Dispatchable resources, whether emitting or non-emitting, historically provided a mix of energy and capacity that was adequately described by standard UCAP and met IESO's reliability objectives. However, as the penetration levels of non-dispatchable resources increases, the prevailing assumptions underlying the capacity attributes and corresponding reliability contributions of the provincial supply resource portfolio may start to break down, particularly should the probability of extreme weather events, such as extended province-wide heat domes/deep-freezes, widespread extended becalming (lack of wind) or persistent heavy cloud cover, increase beyond historical parameters.

This situation is not unique to Ontario – all jurisdictions that have experienced a material penetration of non-dispatchable resources into their supply resource portfolios face similar challenges. The Northwest Power Pool ("NWPP") states in its report "Exploring a Resource Adequacy Program for the Pacific Northwest":

> *Another significant finding,* ***built on the recognition that non-firm resources are inherently limited in their contributions to regional resource adequacy****, is that some form of firm capacity will be needed within the region to ensure long-term resource adequacy, even out through 2050 on a deeply decarbonized system and that the region will face a substantial reliability challenge in the absence of firm resources. That challenge becomes particularly acute in winter peak load events that occur during a region-wide period of low wind and solar output in a drought year. In the absence of firm resources, the region will need to build large amounts of renewables and storage capacity. However, even with levels of renewables and storage that strain plausibility in terms of pace of deployment,* ***the region's electricity system would still be vulnerable to large loss of load events.***[43] *(Emphasis added)*

[41] Independent Electricity System Operator. (n.d.). *Feed-in Tariff Program Overview*. Retrieved from Link

[42] Independent Electricity System Operator. (n.d.). *microFIT Overview*. Retrieved from Link

[43] Northwest Power Pool. (2019). *Exploring a Resource Adequacy Program – An Energy System in Transition*. Page 25 Retrieved from Link

In response to the identified increasing capacity-related reliability risks, it is reasonable to expect that unless other methods are adopted, IESO will need to rely more heavily upon its customized UCAP approach to evaluate planned resource procurements and justify the associated costs to the public and other stakeholders. To avoid exposing itself unnecessary to technical and reputational criticism for using a non-standard custom UCAP definition to evaluate non-dispatchable resources, IESO should consider implementing an industry standard capacity contribution evaluation methodology such as Effective Load Carrying Capacity in its planning and procurement processes.

ELCC is an accepted capacity evaluation methodology that is used in various North American jurisdictions including PJM Interconnection ("PJM") [44] and BC Hydro. As identified by BC Hydro in its 2021 Integrated Resource Plan:

> *The intermittent resources have varying output due to natural changes in their fuel source. Although they may not be a reliable source of capacity individually due to the intermittency of the outputs, they can contribute to meeting the LOLE capacity adequacy when aggregated with the system.* ***Calculating the effective load carrying capability of an intermittent generator allows BC Hydro to reflect the additional system benefits of this type of variable generation*** *and the value is determined by adding the generator to the system and then determining the relative increase in system loads that can be supplied while maintaining the same overall system reliability.*[45] *(Emphasis added)*

The earlier cited NWPP report discusses using ELCC to evaluate resource capacity:

> *Variable energy resource capacity contribution methods vary. Some programs use a calculation of the contribution of these resources during peak periods, while others use more rigorous approaches such as ELCC. Evaluating ELCCs for non-firm resources is a computationally intensive task. For instance,* ***ELCC modeling must capture "interactive effects" where the ELCC attributed to any individual non-firm resource will depend on the composition of the rest of the portfolio*** *and specifically, on the other non-firm resources on the grid.*[46] *(Emphasis added)*

Further to the "interactive effects" mentioned in the above citation, the New York Independent System Operator ("NYISO") is aiming to improve the accuracy of New York State's installed reserve margins and Capacity Accreditation Factors by considering correlated outages in its resource adequacy analysis, to ensure that simultaneous outages due to weather or common mode failures are accurately represented.[47]

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[44] PJM. (2021). *How Effective Load Carrying Capability (ELCC) Accreditation Works*. Retrieved from PJM

[45] BC Hydro. (2021). *Integrated resource plan application*. Pages 5–22. Retrieved from Link

[46] Northwest Power Pool. (2019). *Exploring a Resource Adequacy Program – An Energy System in Transition*. Page 32 Retrieved from Link

[47] New York Independent System Operator. (n.d.). *Evolving Resource Adequacy Models: Correlated Outages*. Retrieved from Link

The ELCC methodology is an industry standard alternative to the customized UCAP approach to specifying and evaluating capacity contributions currently being used by IESO in its planning and procurement processes.

IESO has indicated that ELCC is already on IESO's radar for future adoption.

4.1 Implementation Notes

Concerns were raised by IESO that implementing ELCC would involve significant effort, which directionally aligns with the "computationally intensive" assessment of ELCC calculations cited by the NWPP.

However, based on follow up conversations, IESO staff clarified that the data needed to calculate ELCC is currently being collected, and the resource adequacy modeling currently being undertaken by IESO satisfies all or most of the requirements to implement an industry standard ELCC methodology.

In responding to a past stakeholder inquiry whether ELCC should be used in IESO planning and procurement processes, IESO provided the following response:

> *ELCC is not currently used in the IESO's system planning processes and it is important for planning and procurement of resource adequacy needs to be as closely aligned as possible, while accounting for the requirements of different mechanisms. If in the future, the IESO moves towards incorporating ELCC into the planning models, its use in the Capacity Auction/Acquisition mechanisms may be reevaluated.*[48]

Given that the data collection and analysis needed to support ELCC have already been implemented in IESO's Resource Planning (Modeling) processes, it appears that the remaining barrier preventing IESO from fully implementing the ELCC methodology across its planning and procurement processes is the inability to exchange and apply ELCC specifications and analysis between Resource Planning (Modeling), Resource Planning (Assessment) and Resource and System Adequacy (Procurement) to support resource acquisition initiatives.[49]

4.2 Recommendation

In recognition that ELCC is already on IESO's radar and that IESO has the necessary data and resource adequacy modeling capabilities to support its implementation, Midgard recommends that IESO integrate ELCC into its planning and procurement processes.

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[48] Independent Electricity System Operator (IESO). (2021). *Stakeholder feedback and IESO response: Capacity auction – July 22, 2021 webinar.* Page 6. Retrieved from Link

[49] Although ELCC is targeted at capacity and reliability focused procurements, it is possible that ELCC may also be used to inform energy only procurements in cases where the seasonal shape of the provided energy is desired. Currently energy resource procurements are evaluated on longer timescales (e.g. annually, seasonally) and there may be a future need to express energy needs on shorter timescales (e.g. seasonal, monthly), an evaluation which ELCC and its underlying data would support.

Recommendation: IESO implement ELCC (or other industry standard equivalent) resource capacity contribution analysis and specification methodology into its planning and procurement processes.

5 Value of Lost Load

Value of Lost Load or VOLL is an economic metric that quantifies the financial impact of electricity supply interruptions, representing the monetary value ratepayers place on reliable electricity.[50] Understanding VOLL helps utilities, regulators, policymakers and ratepayers make informed decisions regarding infrastructure investment, pricing and outage management. VOLL helps prioritize investments in infrastructure to cost effectively improve grid reliability by focusing investments in those areas where the investment cost is less than the value received by different ratepayer classes. VOLL provides a quantifiable means to weigh the cost of improving reliability against the cost of potential outages for different ratepayer classes. For example, industrial ratepayers are typically more sensitive to transitory outages than are residential ratepayers and therefore these customer classes have different willingness to pay for investments to address these types of outages.

VOLL allows utilities to balance the expenses investments such as system upgrades, changing maintenance practices, energy storage & backup generation with the economic impact of the types of risks they address, matched with the ratepayer classes that will be asked to pay for those investments. Understanding VOLL helps utilities and system operators develop electrical system plans and procurements that better align with customer values. As a result, VOLL can also inform demand response programs, peak pricing and other non-wires solutions that encourage ratepayers to shift or reduce load during high-risk periods.

In summary, VOLL assists all parties – utilities, regulators, policymakers and ratepayers – to better understand and support justifications for policies around reliability standards, grid modernization, backup generation and energy storage. Better aligning electrical system plans and procurement activities with the value they bring to ratepayers ensures that grid reliability meets societal expectations and economic needs.

5.1 Implementation Notes

Concerns were raised by IESO that utilizing VOLL would require a significant effort because IESO does not currently explicitly evaluate VOLL. IESO understands what VOLL is and its potential uses and identified no fundamental technical barriers to implementing VOLL during the interview process. Rather concerns were primarily related to the implementation cost and timelines of conducting a VOLL study versus the resulting value to ratepayers, since IESO has the expertise to utilize VOLL.

Midgard asserts that evaluating VOLL solely in the context of considering IESO's internal costs may undervalue the considerable benefits that will accrue to ratepayers when VOLL-based economic considerations are utilized in IESO's electricity system planning and procurement processes and also fails to capture the usefulness to

[50] The Brattle Group. (2024). *Value of Lost Load Study for the ERCOT Region*. Retrieved from Link.

IESO's regulator and interveners of being able to more transparently evaluate the balance between IESO costs and the resulting value provided to ratepayers.

It is total ratepayer cost rather than IESO's costs (which are a small fraction of the total ratepayer cost) that should drive the decision to implement VOLL. Accordingly, since IESO does not currently have a VOLL capability, IESO should investigate what would be required to develop this capability and the timelines required to implement VOLL. VOLL as developed for the Electric Reliability Council of Texas ("ERCOT") by Brattle Group offers a structured approach to VOLL that could be tailored by IESO to address unique attributes of Ontario's energy landscape.[51]

5.2 Recommendation

In recognition of VOLL not being a current IESO capability, but a capability that IESO has the expertise to implement, Midgard recommends that IESO develop an implementation plan for integrating VOLL into its planning processes.

Recommendation: IESO develop an implementation plan for integrating VOLL into its planning processes.

[51] The Brattle Group. (2024). Value of Lost Load Study for the ERCOT Region. Retrieved from Link.

6 Least Regrets Planning and Procurement

Although IESO does evaluate more than a single future scenario when it plans the electric system, the planning and procurement work portrayed in the APO largely focuses on a single load forecast scenario, as shown previously in Figure 16 in Section 3.1. Representing future system needs as a single forecast trendline under-represents IESO's actual planning efforts and potentially restricts the procurement actions IESO can justifiably initiate. Transparently forwarding in the APO the more comprehensive range of scenarios IESO evaluates will allow IESO to preserve options required to initiate long lead time resources in a timely manner that would not necessarily be considered optimal under the single APO forecast, but that may ultimately prove necessary to mitigate a credible portfolio of risks, uncertainties and exogenous factors.

"Least Regrets" planning and procurement involves choosing to take actions that are beneficial (or in the worst case, minimally harmful) under a wide range of uncertain future scenarios. According to Dr. Judith Curry's book, *Climate Uncertainty and Risk*[52], least regrets planning focuses on taking actions that provide immediate or near-term advantages while minimizing the risk of adverse longer-term outcomes, making such actions highly beneficial regardless of how future conditions unfold. Examples include enhancing energy efficiency, repairing infrastructure defects and limiting development in flood-prone areas. Implementing least regrets planning and procurement emphasizes investing in adaptable infrastructure to meet future energy demands and to facilitate integration of anticipated generation sources. This pre-emptive approach reduces the likelihood that mitigating upgrades will need to be expedited should challenging circumstances presently judged to be low probability ultimately materialize, which may prove costly or implausible within a constrained timeline.

Evaluating least regrets strategies is crucial for conducting resilient energy planning and procurement amidst uncertainties like volatile demand, technological shifts and potential climate change impacts, while reinforcing public accountability and building trust by demonstrating a commitment to economically prudent and robust decision-making.

IESO has multiple tools and strategies to address future resource adequacy requirements, ranging from short-term operational actions to longer-term resource acquisition solutions. Once planning and procurement needs have been analyzed under a portfolio of scenarios, IESO must decide on when and how to put in place strategies to address the needs gap. The alternatives considered to address the needs gap may be constrained by timelines or infrastructure or policies, but must also align with the primary load forecast scenario forwarded in the APO. IESO's action plans must consider how to justify pre-emptive measures that, although they do not appear to strategically align with the primary APO load forecast scenario, may offer significant benefits and risk mitigations for credible long-term hazards.

[52] Curry, J. A. (2023). *Climate Uncertainty and Risk: Rethinking Our Response*. Anthem Press.

Least regrets planning seeks to determine the most cost effective way to address the system risks resulting from the needs identified in the full range of scenarios evaluated by IESO, even if the benefits cannot be guaranteed because the likelihood that any particular scenario will occur is always less than 100% and it is possible (and in some cases probable) that the benefits associated with that scenario will not materialize.

Least regrets planning seeks to address the risks posed by the full range of scenarios IESO evaluates on a risk adjusted basis, meaning that IESO will not necessarily attempt to mitigate all the risks, but will make an evaluation as to the value of the risks to be mitigated and find solutions that cost effectively mitigate those risks. Ideally, only a modest investment will be required to mitigate most of the risks on an expected value basis, or to preserve options to mitigate most of the risks on an expected value basis. The associated investments can either be included as modifications to the plans necessary to address the primary load forecast scenario, or as stand-alone supplements to the primary plan. In all cases however, the selected least-regrets plan is justified on the basis that it is addressing a range risks beyond the system needs for the primary load forecast.

As a hypothetical example, assume that the primary load forecast is fully addressed by a procurement plan that includes solar and nuclear generation additions and a transmission line. However, the portfolio of scenarios evaluated by IESO identifies a consistent additional capacity gap that requires additional capacity be added in various quantities depending the on scenario evaluated. IESO could quantify the expected range of additional capacity required to address the full portfolio of scenarios and recommend the risk-adjusted economic choice between a set of options such as:

a) Modifying Primary Resource Additions: Modifying the primary plan with supplemental capacity additions that replace some energy-rich but capacity-poor generation with more capacity-rich resource alternatives (such as non-dispatchable plus batteries), or building a new transmission line into a region with high resource development potential with the capability to support two circuits but initially strung only with one circuit.
b) Supplemental Resource Additions: Adding supplemental capacity additions sized to mitigate some of the capacity risk could include (but is not limited to) demand side management measures such as load curtailment, adding peaking generation (e.g. renewable natural gas fired SCGT generation[53]), short duration peaking (e.g. batteries), additional transmission etc.
c) Risk Acceptance: Deeming the risk exposure low enough that the identified risks are accepted, and no additional plans or procurements are required.
d) Option Preservation: Identifying precursor activities to advance so that the timelines for responding to a specific scenario emerging can be mitigated via updated system plans and procurements, for example pre-permitting a transmission right of way to fast-track eventual transmission development

[53] In all cases, the solutions selected must align with IESO planning and procurement constraints such as government policy.

that would be needed in a particular scenario, or pre-emptively triggering construction of a transmission line needed to facilitate development of supply resources that would address demand growth identified in several scenarios other than the base forecast[54], as further elaborated in the Renewable Energy Zone example below.

In all cases, the core concept is advancing enough risk mitigation so that should a high system consequence scenario other than primary load forecast materialize, IESO is already prepared to address the risk in a cost-effective manner as it emerges.

In summary, the potential benefits of implementing least regrets planning and procurement are:

1. Lower Long Term System Costs: Procuring generation and transmission capacity on an expedited basis is more expensive than making such investments over a more measured timeframe.
2. Reduced Stranded Asset Risk: Plans and procurements that are aligned with a scenario portfolio reduces the risk of stranded assets because all the procurements satisfying the primary load forecast scenario can also be utilized in the other scenarios.
3. Reduced Market Inefficiencies: Excess or misplaced capacity can distort market signals, potentially discouraging efficient resource investments, skewing operational decisions by market participants, or reducing participation in demand side management actions
4. Reduced Environmental and Socio-Economic Impacts: Fast tracking large footprint infrastructure investments leads to sub-optimal consideration of environmental and socio-economic impacts, an oft cited issue raised by indigenous nations when infrastructure development timelines and consultation is constrained.
5. Reduced Opportunity Costs: Capital invested is allocated to areas of the power system where it provides superior utilization across a range of scenarios rather than a single scenario.

Finding the right balance between optimal investment to address the primary load forecast scenario and the range of possible scenarios is key. Additionally, all near-term plans and procurement are constrained by existing policy and public expectations even though societal constraints and preferences may change and often do, over longer time horizons. Applying a "least regrets" approach to planning and procurement is useful in determining the right balance of this trade-off because it better addresses a more comprehensive range of future scenarios and reflects that range into current plans and procurement actions.

6.1 Least Regrets Planning and Procurement Example: Renewable Energy Zones

One example of Least Regrets Planning is implementing Renewable Energy Zones ("REZ"). REZs, as described by the Australian Energy Market Operator ("AEMO"), are high-quality resource areas where clusters of large-scale renewable energy projects can be developed. These zones are identified to optimize the integration of

[54] Not all the option preservation solutions listed are available to IESO – these are provided as examples rather than specific prescriptions.

renewable energy into the grid, leveraging the best available resources. REZs are determined through a comprehensive analysis that includes several key factors: [55] [56]

1. Resource Quality/Resource Limits;
2. Transmission Capacity/Upgrades;
3. Geographic and Technological Diversity; and
4. Cost and Feasibility.

To facilitate generation development within REZs, AEMO employs the following transmission planning practices[57] :

1. Integrated System Plan ("ISP").
    - Evaluation of the transmission limits and the options to address constraints (updating critical spans, re-building 220 kV lines with higher capacity, implementing a new 500 kV line);
2. Stakeholder Engagement;
3. Regulatory Framework; and
4. Coordination of Generation and Transmission.

By implementing REZ's the system benefitted by minimizing the risk of stranded assets and overbuild (shared infrastructure and scalability). The REZ process (or its equivalent) has been adopted in jurisdictions other than Australia, largely driven by the increasing share of renewables in the supply mix of these jurisdictions, but also by a desire to enhance the overall resource and geographic diversity of the supply mix for resilience. The REZ concept represents a logical adaptation in jurisdictions transitioning from a historical situation in which large thermal/fossil resources with significant optionality in terms of siting comprised the greatest share of total electricity supply, to a new paradigm in which the grid may need to be expanded into areas more favourable to the development of renewable resources. Such a transition increases the importance of transmission as a linchpin supporting resource development and will necessitate a greater integration between resource planning and transmission planning than would be the case with continued reliance on natural gas generation to fill supply gaps.

6.2 Recommendations

Accordingly, Midgard recommends that IESO consider implementing a "least regrets" planning and procurement approach that is anchored by the primary load forecast scenario but also explicitly addresses the system needs and procurement actions necessary to address the full portfolio of scenarios evaluated on a risk adjusted basis. Midgard further recommends that IESO evaluates implementing renewable energy zones.

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[55] AEMO. (2021). *Appendix 3. Renewable energy zones*. Retrieved from AEMO

[56] AEMO. (2023). *2023 ISP Methodology. Renewable Energy Zones (REZs)*. Retrieved from AEMO

[57] AEMO. (2020). *2020 ISP Appendix 5. Renewable Energy Zones*. Retrieved from AEMO

Recommendation: Implement least regrets planning and procurement in the APO to address both the primary load forecast scenario and the portfolio of scenarios IESO evaluates.

Recommendation: Evaluate implementing Renewable Energy Zones in Ontario.

7 Expanded (Discontinuity) Scenario Planning

As discussed in Section 3.1, IESO's current scenario planning approach is appropriate for the incremental growth that has historically typified Ontario's electricity system in recent decades. However, the future promises to be different, with an anticipated step change transition in electricity demand growth rates, much higher penetration rates of non-dispatchable resources and an increasingly less stable environmental and geo-political landscape. Accordingly, Midgard recommends expanding IESO current scenario planning to include selected boundary scenarios to test electricity system plans and procurement actions against potential future discontinuities. Boundary condition or expanded scenario planning is common in other industries subject to contextual discontinuity risks.

Resilient electric system scenario planning requires evaluating potential futures that include major and potentially precipitous shifts in energy demand, generation capacity, regulatory frameworks, or externally imposed disruptions that affect these parameters. Examples include climatic discontinuity, technological leaps and global or domestic political events. Additionally, scenario-induced simulated failures of the electrical system being studied can be used to fortify the plan with options and identify advanced decision thresholds that will enable system adaptation to mitigate difficult to foresee but credible exigencies.

Expanded scenario planning was originally pioneered by Shell Oil prior to the 1970s energy crisis. Shell's approach to expanded scenario planning[58] involves thorough imaginative projections of a representative portfolio of future scenarios (limited to maintain tractability) that consider base-case, best-case and worst-case situations. This method allows organizations to develop resilient strategies by accounting for a wide range of possible futures and testing current expected case plans against those scenarios. Evaluating the plans of entities like IESO through an expanded scenario planning lens will reveal the Ontario electrical system's preparedness and adaptability to address unexpected events.

For clarity, expanded scenario planning complements and builds upon the Least Regrets planning recommended in Section 6, specifically through the addition of select boundary or "black swan"[59] scenarios developed to test potential discontinuities that could adversely and significantly, impact the Ontario electricity system.

Guidance for developing useful scenarios includes exploring what is plausible, rather than simply what is seen as currently acceptable or probable.[60] Developing robust "boundary scenarios" involves introducing discontinuities from status quo, rather than simply applying high, low and medium growth multipliers to

[58] Harvard Business Review. (2013). *Living in the Futures*. Retrieved from Link

[59] A "black swan" event is a rare, unexpected and highly impactful event that's difficult to predict. The value of planning for "black swan" events is not that the planned scenario is 100% accurate, rather that the scenario reasonably represents the type of event that a "black swan" could be and therefore its risks can be seen more clearly and reasonably mitigated or accepted.

[60] Curry, J. A. (2023). *Climate Uncertainty and Risk: Rethinking Our Response*. Anthem Press. Chapter 9

existing demand forecast trends. For example, innovations such as major adoption of nuclear Small Modular Reactors or multi-MW AI server farms, or disruptive geo-political risks (e.g., pandemics, great recessions, universal natural gas prohibitions. trade-wars, or actual wars) could have a non-linear impact upon supply and demand. To illustrate, a scenario created in 2015 that would have envisioned a quadrupling of localized demand growth rates due to a not-yet-identified technological advance (e.g., AI) would have been seen as highly improbable during an extended period of tepid incremental demand growth, but a very similar scenario is currently occurring in many jurisdictions. For example, Constellation Energy's Three Mile Island Unit 1 reactor is being recommissioned to exclusively supply carbon-free energy for Microsoft's AI data centers.[61]

Organizations attempting to implement expanded scenario planning may inadvertently shy away from exploring the necessarily disruptive or unconventional scenarios that will lead to a better understanding of the full range of credible potential futures and risks that may develop over extended timeframes such as IESO's 20+ year planning horizon. Developing usefully discontinuous or "black swan" type scenarios that are needed to stress-test long-term plans typically involves direct input from and participation by senior management, to overcome any reluctance to strongly challenge the status quo assumptions that typically underpin base case forecasts and plans[62] (while still respecting government policy constraints[63]).

Restricting scenarios to either overly optimistic or overly pessimistic views also carries risk. In overly optimistic planning, worst-case but credible scenarios are downplayed or entirely omitted from adequate consideration given their massively disruptive potential. A reluctance to acknowledge and prepare optionality to address credible but less probable scenarios may create a false sense of security. Similarly, overly pessimistic planning where teams may focus excessively on worst-case scenarios also contains risks. Overly pessimistic mindsets can lead to excessive conservatism, prompting utilities or system operators to over-allocate resources for highly improbable contingencies that will never materialize.

Therefore, while it is crucial to prepare real options to deal with a range of potential credible disruptions, excessively optimistic or pessimistic planning may lead to misallocated capital which ultimately burdens consumers with paying for underutilized capital assets. Accordingly, investment plans based on expanded scenario planning activities should be focused on cost-effectively preserving optionality so that if a severe scenario materializes (or becomes reasonably likely to materialize), real options can be exercised to address the risks posed by the emerging events.

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[61] CNN Business. (2024). *Three Mile Island is reopening and selling its power to Microsoft.* Retrieved from Link

[62] Reluctance to challenge the status quo often stems from a natural and reasonable human preference for consensus, stability and predictability, over disruption and risk.

[63] Midgard respects that whatever boundary scenarios are evaluated they will need to respect government legislation and policy. But in Midgard's scenario planning experience credible alternate scenarios can often be found that are consistent with current policy constraints while still testing similar electrical system impacts.

In summary, electric system operators and utilities should implement robust expanded scenario planning practices to address uncertainties that, if they materialized, would have a material negative impact on the electric system and its ratepayers, thereby undermining public confidence and potentially exposing the public to unsafe conditions.

Robust expanded scenario planning enables a system operator to objectively demonstrate that it is well positioned to meet future energy needs, ensure that the electricity supply remains reliable and secure and preserve real optionality to ensure timely infrastructure investments are available to mitigate a foreseeable range of risks and uncertainties.

7.1 Expanded Scenario Planning Example: PJM Long-Term Regional Planning Process

An example that offers some useful guidance on the value of expanded scenario planning is drawn from PJM[64], a regional transmission organization ("RTO") that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia.[65]

PJM historically managed its transmission planning through the Regional Transmission Expansion Planning ("RTEP") process. However, this approach lacked a well-integrated, multi-value framework to leverage the best available data, incorporate scenario planning and proactively analyze the impacts of planned generation retirements and additions. The RTEP approach relied on a short-term reliability process with a 5-year horizon, while long-term reliability planning used a 15-year horizon. Adding complexity, the RTEP process spanned state boundaries and involved extensive collaboration with over 1,000 members, including multiple opportunities for stakeholder input through forums such as the Transmission Expansion Advisory Committee and Subregional RTEP Committees, ensuring that stakeholders could provide input and recommendations on transmission upgrades and planning activities.[66]

To meet the growing demand for transmission capacity and respond to evolving Federal Energy Regulatory Commission ("FERC") guidelines, PJM initiated a new Long-Term Regional Transmission Planning process aligned with FERC final requirements issued in May 2024 [67] that includes the following attributes:

1. Use a transmission planning horizon of no less than 20 years into the future in developing Long-term Scenarios;
2. Reassess and revise those scenarios at least once every five years;

[64] The acronym PJM was originally derived from the state names Pennsylvania, (New) Jersey & Maryland.

[65]Zimmerman, Z., Gonatas, D., Patel, A., & Gramlich, R. (2024). *Transmission planning for PJM's future load and generation.* Retrieved from Americans for a Clean Energy Grid: Link

[66] PJM. (2023). *2023 Regional Transmission Expansion Plan Report*. Retrieved from Link

[67] Federal Energy Regulatory Commission (FERC). (2024). *Building for the Future Through Electric Regional Transmission Planning and Cost Allocation. Order No. 1920, 187 FERC ¶ 61,068*. (2024). Page 248. Retrieved from Link

3. Incorporate into the Long-Term Scenarios a set of Commission-identified categories of factors that give rise to Long-Term Transmission Needs;
4. Develop a plausible and diverse set of at least three Long-Term Scenarios;
5. Perform sensitivity analysis of uncertain operational outcomes during multiple concurrent and sustained generation and/or transmission outages due to an extreme weather event across a wide area; and
6. Use “Best Available Data” in developing Long-term Scenarios.

7.2 Implementation Notes

Concerns were raised by IESO about the level of effort needed to evaluate a larger portfolio of scenarios, in the context that IESO already performs scenario analysis. Midgard acknowledges that IESO currently performs scenario analysis, but the distinction is that IESO does not explicitly evaluate scenarios that test the boundaries of futures that may credibly materialize over the extended IESO planning horizon of 20+ years. Midgard also recommends that three (3) to five (5) expanded scenarios are an appropriate range to balance effort with effectiveness, with five (5) scenarios representing a practical upper limit based on Midgard’s experience.[68]

Unlike traditional scenario planning, it is essential that IESO senior management (or other equivalent group) becomes involved in expanded scenario formulation, so that organizational “buy-in” is obtained when defining the plausible expanded scenarios. Without organizational acceptance of the boundary condition scenarios evaluated and incorporated into the APO planning process, any resulting procurement actions or justifications based upon the expanded scenario planning will lack organizational support. Involving senior management is another reason that the number of expanded scenarios should be limited, because some scenarios will necessarily be testing boundaries and there will be a limited number of boundaries that senior management will accept as sufficiently credible to warrant analysis.

Finally, if expanded scenario development and acceptance proves problematic in the first few iterations, a possible extension to assist with scenario development and acceptance includes engaging an arm’s length expert, or multi-disciplinary expert group, to develop a limited set of plausible futures against which to test IESO’s plans. The arm’s length group could be internal or external to IESO, but its members should be separate from the modeling team that adopts the expanded scenarios and evaluates the model results.

7.3 Recommendation

To improve IESO’s understanding of the long-term risks faced by Ontario’s electric system, expanded scenario planning provides a time-tested approach to reveal risks that may credibly materialize over the extended 20+

[68] Midgard has found that increasing the number of expanded scenarios beyond five (5) often does not reveal new risk information, but simply increases the granularity of the same risks revealed in the initial few scenarios. Expanded scenario planning reveals major risks, exactly quantifying risk magnitudes are less important than their presence which may need to be addressed (e.g. through real option preservation) or actively addressed by an explicit decision to accept the risk (e.g. because mitigations are deemed economically or legislatively prohibitive).

year IESO planning horizon. Making transparent the range of futures and risks being evaluated by IESO demonstrates the credibility of the planning analysis and associated procurement actions set out in the APO. Midgard recommends that IESO adopt these practices.

Recommendation: IESO adopt expanded scenario planning to address credible but less probable long-term risks and uncertainties that may require near-term actions to preserve real optionality should those risk or uncertainties ultimately materialize.

8 Input and Model Accuracy

IESO necessarily utilizes a single demand forecast as the primary basis for its 10-year procurement action plan. However, given the range of possible futures that may materialize for which IESO must be prepared to address, IESO should document and monitor forecasting uncertainties and modeling variances. Based on interview discussions, it is unclear what the accuracy and uncertainty levels are for the input variables and models used to generate the forecasts and outlooks. Although uncertainty is mentioned in IESO's APO document, aside from the hourly demand profiles[69], accuracies and uncertainties are not clearly quantified or reflected in tables or figures. Moreover, cumulative uncertainties, modeling variabilities and output accuracy ranges are not formally tracked and documented as input data are collected and model outputs passed between teams through the planning and procurement process.

IESO's key challenges dealing with input and model accuracy can be summarized as how to effectively assess and communicate to different internal and external audiences and stakeholders the qualitative definitions and quantitative bounds of the cumulative uncertainties and inaccuracies built into IESO's planning and procurement processes.

Input data are always subject to uncertainties and complex models always introduce inaccuracies. It is unclear that the cumulative impact of input data and modeling inaccuracies and modeling uncertainties through the dependent modeling and analysis cascade comprising IESO's planning and procurement processes are fully understood and documented. Consequently, there is a potential for IESO outputs to be sensitive to specific inputs or modeling inaccuracies that are not fully documented, which may cause the APO to either overstate or understate system needs.

8.1 Recommendation

Midgard recommends that IESO quantify, track and document cumulative uncertainties, modeling variabilities and output accuracy ranges in its planning and procurement processes, and communicate that information to its stakeholders.

Recommendation: IESO should quantify, track and document cumulative uncertainties, modeling variabilities and output accuracy ranges in its planning and procurement processes, and communicate that information to its stakeholders.

[69] Independent Electricity System Operator (IESO). (2024). *Annual Planning Outlook: Ontario's Electricity System Needs: 2025-2050*. Page 20. Retrieved from Link

9 Process Documentation and Communication

IESO has been successful in planning and procuring resources for the Ontario system to date and enjoys a solid reputation as a result. However, it is reasonable to expect that should unusually severe emerging system needs require IESO to put financially or politically challenging procurement plans before the public, the public will require greater transparency to accept those plans. To provide transparency, IESO needs to document and communicate its processes for both internal and external audiences. However, IESO does not presently have a single source of process documentation that is consistently communicated internally, so by extension it cannot be communicated externally. To illustrate the lack of internal documentation and consistency, two examples are provided relating to internal process documentation and the use of standards.

As it relates to internal process documentation, a high-level document equivalent to Figure 2 in Section 2.2.3 (which Midgard created to document IESO's planning and procurement processes) was unavailable during the interview process. Based on the interviews and follow-up feedback provided subsequently, Midgard concludes that IESO planning and procurement teams generally know their roles, responsibilities and interfaces with other teams and there are no apparent unnecessary overlaps, but overall process documentation was absent. As a result, different opinions and understandings were provided by some teams that occasionally conflicted with process information provided from elsewhere in the organization. A consistent process understanding was ultimately resolved (as represented in Figure 2), but a detailed process understanding is not universally nor consistently understood by all staff.

Similarly, regarding the use of standards, when queried about risk and risk standards used internally at IESO, different answers were given by different teams, leading Midgard to initially conclude that a consistent risk standard was not employed. However, it has since been clarified that IESO does in fact employ ISO 31000 as IESO's risk standard. The International Organization for Standardization ("ISO") is a leading international organization that develops and publishes international standards such as ISO 31000 for risk. Since ISO 31000 is a widely recognized risk standard wholly appropriate for use by IESO, IESO should ensure that a consistent organization-wide understanding of ISO 31000 as the applicable risk standard is communicated.

In addition to internally determining the correct and appropriate planning inputs, variables and assumptions, determining the uncertainty boundaries and assessing planning and procurement needs and actions, as a public facing entity IESO must transparently communicate this information to a diverse external stakeholder community.

The requirements for external communications are different from those required for internal communications and effective communication with both internal and external parties is necessary because all parties have their own interests, biases and knowledge of the pertinent topics. Key elements required to create and demonstrate communication effectiveness include:

- Consistency;
- Transparency; and
- Continual improvement.

These elements are integral to ensuring organizations are and are seen as being, reliable, cost-effective and responsive to change. Consistency involves maintaining stable known processes and delivering robust decision-making and effective plans and actions over time. In the context of planning, a consistent approach provides a solid framework for achieving predictable results which reassures stakeholders that the electrical system will continue to deliver on its reliability, resiliency and cost effectiveness commitments.

Transparency is vital for holding an organization accountable and is particularly important for an organization like IESO that provides an essential public service. By openly sharing performance data, decision-making frameworks and operational processes, IESO will demonstrate effective resource usage, regulatory compliance and planning quality leading to a cost effective, resilient and reliable electrical system. Transparency facilitates stakeholder buy-in and enables a collaborative, informed approach to managing future challenges.

Continual improvement focuses on evolving and adapting to new challenges such as regulatory and policy changes, technological advancements, environmental change and geo-political shifts. Embedding a mindset of continual improvement aligns with the principles of industry standard management systems (e.g., ISO 9001, ISO 31000, ISO 55000, Lean/Kaizen, Deming Cycle, etc.) which emphasizes the importance of gradual never-ending improvement. IESO claims to perform continuous improvement but was unable to provide a documented process, findings and measurable results supporting that claim.

Accordingly, it is recommended that IESO document both its planning and procurement processes and its continuous improvement processes including the metrics it uses to evaluate efficacy.

9.1 Recommendations

Documenting IESO's planning and procurement processes is a necessary step towards communicating organizational effectiveness and continuous improvement activities to both internal and external groups. Midgard recommends that IESO adopt these practices.

Recommendation: Formally document IESO's planning and procurement processes and communicate this documentation to IESO staff and external stakeholders.
Recommendation: Document IESO's continuous improvement processes including metrics or performance goals that it uses to evaluate and track areas of improvement and communicate this documentation to IESO staff and external stakeholders.

10 Recommendation Summary

IESO ensures a reliable and efficient electrical system by balancing its decisions in consideration of costs, benefits, opportunity costs, risks and uncertainty. As a publicly facing entity, IESO's decisions, decision-making processes and the transparency thereof are critical to preserving IESO's credibility and reputation with consumers, generators, investors and policymakers. Although IESO's current planning and procurement processes used to create the 2024 APO document have successfully delivered on IESO's mandate to date, based upon potential continuous improvement opportunities identified during the interviews and subsequent Midgard analysis, Midgard makes the following recommendations:

Table 3: Recommendation Summary

SECTION	Recommendation
Section 4.2	Implement Effective Load Carrying Capability ("ELCC") (or other industry standard equivalent) resource capacity contribution analysis and specification methodology across its planning and procurement processes.
Section 5.2	Develop an implementation plan for integrating Value of Lost Load ("VOLL") into its planning and procurement processes.
Section 6.2	Implement least regrets planning in the APO to address both the primary load forecast scenario and the portfolio of scenarios IESO evaluates.
	Evaluate implementing Renewable Energy Zones in Ontario.
Section 7.3	Adopt expanded scenario planning to address less probable but credible long-term risks and uncertainties that may require near-term actions to preserve real optionality should those risk or uncertainties ultimately materialize.
Section 8.1	Quantify, track and document cumulative planning and procurement process uncertainties, modeling variabilities and output accuracy ranges in its planning processes, and communicate that information to its stakeholders.
Section 9.1	Document IESO's planning and procurement processes and communicate this documentation to IESO staff and external stakeholders.
	Document IESO's continuous improvement processes including the metrics or performance goals used to track and evaluate areas of improvement, and communicate this documentation to IESO staff and external stakeholders.

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