April 30, 2019

To: Power Advisory Clients

From: Travis Lusney, Power Advisory LLC

RE: IESO 2019 Planning Outlook -Resource Adequacy Outlook

CONTEXT

- The Independent Electricity System Operator (IESO) has enacted a new annual planning outlook, building on the 2018 Technical Planning Conference (TPC) held in September 2018[1].
- The IESO hosted a stakeholder engagement on April 12th, 2019, on their resource adequacy outlook and to outline their approach to assessing supply need and available resources.
- The resource adequacy outlook is a major component of the annual planning outlook the IESO intends to publish in Q3 2019; the annual planning outlook determines supply adequacy needs which will be used to inform Target Capacities for the Transitional Capacity Auctions (TCAs) and Incremental Capacity Auctions (ICAs).

BACKGROUND

In September 2018, the IESO hosted a TPC to present a new planning approach. The 2018 TPC presentation clearly indicated a resource adequacy gap starting in 2023. The IESO Market Renewal Program[2] (MRP) seeks to implement fundamental reforms to the IESO-Administered Market (IAM). One objective of MRP is to promote more market-based mechanisms to procure required resources to meet system need. As such, the IESO planning process is evolving to support this new framework with the introduction of an Annual Planning Outlook (APO). On April 12th, 2019, the IESO hosted a stakeholder engagement session to discuss the resource adequacy outlook framework and to update stakeholders on the demand outlook. The demand outlook and resource adequacy outlook are the two major components of the APO.

The IESO reviewed stakeholder feedback from the January 31st, 2019, engagement sessions and presented on three areas of resource adequacy:

- Process overview;
- Capacity Adequacy Assessments; and

---

[1] More information on the 2018 TPC, including feedback from stakeholders, can be found here: http://www.ieso.ca/en/Sector-Participants/Planning-and-Forecasting/Technical-Planning-Conference

[2] Overview of MRP can be found here: http://www.ieso.ca/en/Sector-Participants/Market-Renewal/Overview-of-Market-Renewal

- Energy and Operability.

This client note will review each of the areas covered by the IESO and provide our commentary after each section.

STAKEHOLDER FEEDBACK TO THE DEMAND OUTLOOK ENGAGEMENT SESSION

The January 31st, 2019, APO stakeholder engagement session was focused on Ontario's evolving planning process, preliminary demand outlook and the updated reliability outlook[3]. Feedback from stakeholders to the session was robust with over 120 comments and questions submitted to the IESO. In the IESO's view, feedback can be organized into three broad categories: methodology of demand and resource adequacy; reporting and economic analysis; and data transparency. Partially due to the feedback received in addition to continued analysis, the IESO made the following adjustments to the demand outlook:

- The IESO will use the most recent year (2018) as the base year;
- Past conservation savings are included in gross demand forecast, future conservation savings will not include past savings;
- Electric vehicle and public transit forecasts will consider the most recent Federal Budget released in March 2019;
- Natural gas price forecast will be updated; and
- Conservation assumptions updated to reflect the March 21st, 2019, Ministerial Directive[4].

[3] The IESO has regularly published an 18-Month Outlook since 2000 to assess the reliability of Ontario's power system. At the end of 2018, the IESO decided to produce a reliability assessment over a longer 60-month term. The December 2018 is the first 60-month outlook ("the Reliability Outlook"). The IESO intends to publish this 60-month outlook twice a year, in December prior to the winter season and in June prior to the summer season. Further information can be found here: http://www.ieso.ca/Sector-Participants/Planning-and-Forecasting/Reliability-Outlook

[4] On March 20 Greg Rickford, the Minister of Energy, Northern Development and Mines directed the IESO discontinuing the Conservation First Framework (CFF) and the Industrial Accelerator Program (IAP). The Minister further directed that the IESO complete and achievable potential study for energy efficiency in the province by September 30, 2019. The Minister stated that while demand management programs have been successful in the province, these programs are less cost-efficient and less effective in meeting system needs. The Minister issued a second directive to the IESO, also on March 20 to centrally deliver energy-efficiency programs implementing a new Interim Framework to take effect from April 1, 2019 to December 31, 2020. The Interim Framework includes the Retrofit Program, Small Business Lighting, the Energy Manager Program, Process and System Upgrades, Energy Performance Program, Home Assistance Program and energy-efficiency programming for Indigenous communities.

POWER ADVISORY COMMENTARY

Robust feedback from stakeholders demonstrates the importance and value of the IESO's decision to adopt an annual planning process. The electricity sector in general is undergoing significant change and uncertainty. An annual planning process provides both stakeholders and the IESO a consistent opportunity to discuss issues and their impact on system needs. To that end, the IESO should be commended on their response to feedback received from stakeholders which demonstrates that the IESO is attempting to incorporate information to enhance system need analysis.

The APO conclusions will be used to inform Target Capacities in the TCAs and ICAs; therefore, it is important that all stakeholders have a firm understanding and general agreement with the IESO's planning process. Without transparency and openness in the IESO planning process, investors will have reduced confidence in the Ontario electricity market which could increase costs for Ontario rate-payers.

One area that Power Advisory firmly believes the IESO could improve upon is sharing of data and analysis as part of the APO process. The IESO continues to limit the sharing of information, especially in preliminary form (e.g., preliminary net and grid demand outlooks). Preliminary information is important for stakeholders to review and analyze so that their feedback is informed and provided within enough lead time for the IESO to incorporate into the final APO. A common response from the IESO on requests for more availability of data is confidentiality and security concerns. Power Advisory recommends that the IESO consider Critical Energy/Electric Infrastructure Information (CEII) procedures in other jurisdictions. CEII procedures can ensure a person accessing the information is known to the IESO and meets specific requirements for access.

Discontinuing the CFF and IAP will have a significant impact on Ontario's electricity sector. For the IESO, implementing the new directive comes at a time when the organization is already stretched to implement their MRP. In addition, the IESO is moving to meet capacity needs emerging as early as 2020. The reduction in new energy conservation will need to be taken into account as the IESO identifies the Target Capacities for both TCAs and ICAs.

Clients should note that the IESO has stated that the APO is expected to meet their obligations to the Minister of Energy for a technical report pursuant to Section 25.29 (3) of the Electricity Act, 1998 on the adequacy and reliability of Ontario's electricity resources. In other words, the APO is a substitute for the Ontario Planning Outlook that was published in 2016 and used as an input into the 2017 Long-Term Energy Plan (LTEP).

OVERVIEW OF RESOURCE ADEQUACY PROCESS

The IESO provided an overview of the resource adequacy outlook process and how the process coordinates with other Ontario electricity planning process. The objective of resource adequacy

is to assess the ability of electricity resources to meet electricity demand, taking into consideration the demand forecast, supply availability and transmission constraints. In short, resource adequacy is a key component of power system analysis that underpin reliability and other assessments (the other key component is the demand outlook).

Resource adequacy is part of the APO and is related to the IESO's Bulk Planning Process development that is ongoing. The IESO intends to publish the 2019 APO in September of this year and will finalize the bulk planning process in Q3-Q4 2019 (see timeline figure below).

Figure 1: IESO Planning Process Timeline

Generally, resource adequacy is applied to three different areas of power system planning: capacity, energy and operability (e.g., ancillary services). The figure below provides a graphical representation of each of the three areas. For clarity, regulation is an example of an electricity service required for power system operability.

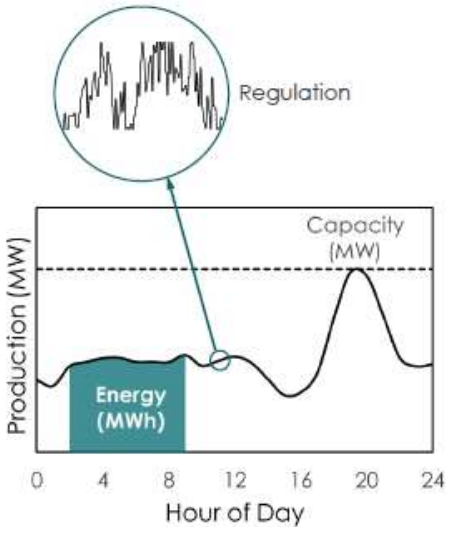

Figure 2: Graphical Representation of Power System Planning Areas

Resource adequacy assessments are completed as part of multiple planning activities (i.e., operational planning, investment planning, and compliance reporting). For operational planning, resource adequacy is assessed from an outage management viewpoint as part of the 18-month and 60-month Reliability Outlook reports. For investment planning, the APO identifies supply adequacy needs over a 20-year time horizon to inform investment decisions. Finally, the IESO has compliance reporting requirements on resource adequacy to the North American Electric Reliability Corporation (NERC) and Northeast Power Coordinating Council (NPCC), see figures below for further details.

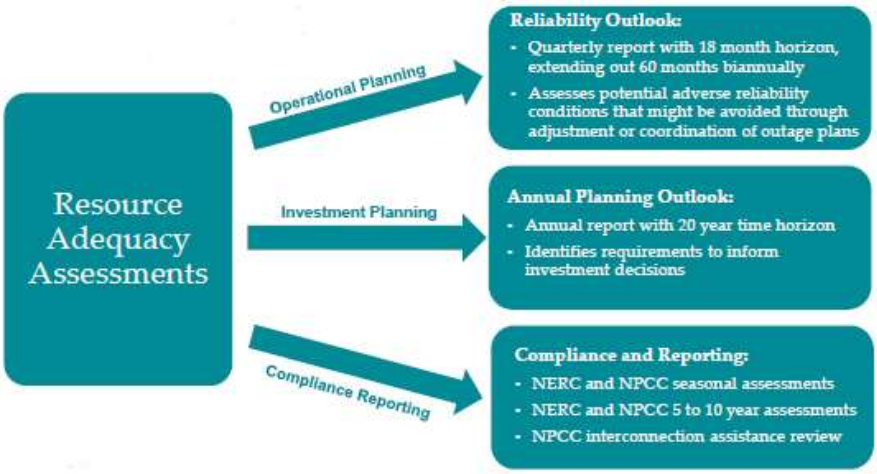

Figure 3: Planning Activities for Resource Adequacy Assessments

Reliability Outlooks	Annual Planning Outlook	Compliance Reporting
• Input data refreshed quarterly	• Input data refreshed annually	• Input data consistent with most recent available IESO assessment
• Outages reflected as submitted by market participant	• Outages adjusted before identifying resource needs	• Considers use of operational measures including imports to meet adequacy requirements
• Considers extreme system conditions	• Considers broader system sensitivities/cases	• Reflects all available resources
• Focus on existing available resources and uncertainty in resource availability	• Focus on need above and beyond existing resource commitments	

Figure 4: Comparison of Planning Publications by IESO

In addition, resource adequacy assessments inform and support a number of IESO activities including:

- Bulk and regional planning processes

- Outage assessment and approval process
- Capacity export decisions
- TCA and ICA Target Capacities

POWER ADVISORY COMMENTARY

Clearly resource adequacy assessments are an important planning process that influences many different areas of Ontario's electricity system. In Power Advisory's view, there are two key impacts resource adequacy will influence in the near-term.

First, resource adequacy will be used to inform Target Capacities for TCAs. At the TCA draft Phase I design stakeholder engagement session on April 18th, 2019 the proposed summer target capacity ranged from 811 MW in 2020 to 4,686 MW in 2024[5]. Those values are subject to APO updates that will be heavily influenced by the resource adequacy assessments. Adjustments to target capacity can change the opportunities available to clients. In addition, from 2020 to 2023 the IESO considers a reliability assurance period where they may set target capacities above total resource requirements to create the appropriate business environment and auction process confidence to sustain and develop resources.

Second, different IESO planning activities related to resource adequacy can have different objectives. The conclusions in the planning reports may not appear to align if the differences in objectives and processes are not well understood. For example, resource adequacy in the Reliability Outlook report is focused on outage management over the next 18 to 60 months, while the APO is focused on total resource requirement over a 20 year forecast period. Clients should take time to understand each planning process and how the conclusions will impact their business and assets.

CAPACITY ADEQUACY ASSESSMENTS

Capacity adequacy assessments determine if there is a heightened risk of using emergency operating procedures or disconnecting firm load due to resource deficiencies. Adequacy standards define which sources of risk to consider and what level of risk the electricity system should be planned to meet. Adequacy standards include applicable NERC and NPCC standards

[5] More information on the TCA phase I design documents can be found here: http://www.ieso.ca/Sector-Participants/Engagement-Initiatives/Engagements/Meeting-Ontarios-Capacity-Needs-2020-2024

as well as the Ontario Resource and Transmission Assessment Criteria (ORTAC)[6]. The primary reliability index used in resource adequacy assessments is Loss of Load Expectation (LOLE). LOLE is defined as the expected number of days per year for which generation capacity is insufficient to serve demand. NPCC standard requires the IESO controlled grid to have a LOLE of no more than 0.1 days/year[7]. **The IESO expects capacity adequacy need to be the main driver for resource investment over the next decade in Ontario.**

The IESO's resource adequacy assessment process is derived from three key inputs: supply outlook, demand forecast, and transmission limits. Probabilistic analysis is used to determine capacity surplus or deficit based on a range of uncertainties for each assumption. The probabilistic analysis is carried out by a software tool called the Multi-Area Reliability Simulation Software (MARS). See diagram of resource adequacy process below.

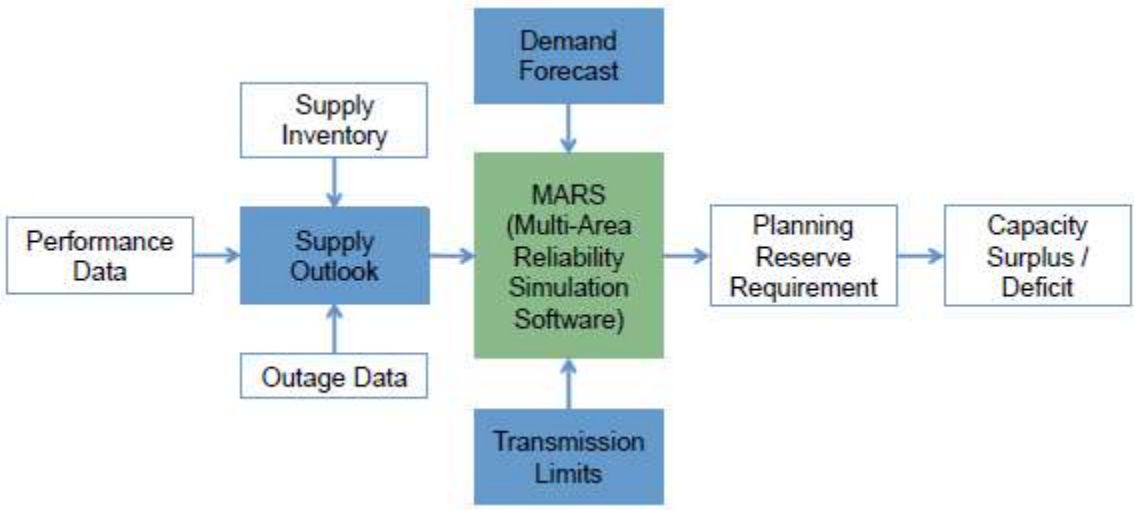

Figure 5: Resource Adequacy Assessment Process

The supply outlook is determined based on three broad data inputs: supply inventory, performance data, and outage data. Supply inventory is determined by information drawn from market participants (e.g., market registration data), contracted resources, rate regulated resources and other supply/data sources. Performance data of generator units is derived from seasonal performance conditions. For example, capacity availability for thermal resources (i.e., gas-fired generation) reflects the impact of ambient conditions. Thermal resources tend to be less efficient in the summer and more efficient in the winter. For renewable generation units,

[6] Information on the application process of NERC and NPCC standards in Ontario can be found in IESO Market Manual Section 11: Reliability Compliance (http://www.ieso.ca/en/Sector-Participants/Market-Operations/Market-Rules-And-Manuals-Library). ORTAC can be found in Section 2.11 (http://www.ieso.ca/-/media/Files/IESO/Document-Library/Market-Rules-and-Manuals-Library/market-manuals/market-administration/IMO-REQ-0041-TransmissionAssessmentCriteria.pdf?la=en)

[7] This is sometimes characterized as "one day in ten years"

energy and capacity limitations are determined by vendor-supplied simulation of hourly profiles that is validated by historical production data in Ontario. Outage data includes planned outages (e.g., maintenance outages), refurbishment outages (i.e., nuclear), and forced outages. Forced outages can come in two primary forms. First, a forced outage where the entire generation unit is unavailable for an unplanned reason (e.g., generation unit stops production for safety reason). Second, a forced de-rate when less total capacity is available for an unplanned basis. Forced outages do not need to be directly related to each generation unit, but can include outages in the local power system that force units offline or de-rate the units for a period of time.

To ensure alignment with the MRP, the IESO terminology for capacity is standardizing on the following terms:

- Nameplate: Resource's full load, sustained output capability as provided by the manufacturer
- ICAP: Maximum output capacity of a resource as assessed by the IESO, or demonstrated by physical tests, for conditions expected at times of peak demand need during each season
- UCAP: Performance adjustment from ICAP of resource for each season (e.g., forecast outages, fuel availability, etc.) including deliverability de-rates due to transmission deliverability

The demand forecast input into MARS is a 20-year period, hourly demand forecast broken down by the IESO zones (i.e., the 10 IESO zones). The demand forecast is a net demand forecast (i.e., gross demand less conservation activities).[8] Both demand response resources and embedded generation (i.e., directly connected to Ontario's distribution systems) are treated as supply side resources, that is similar to generation. Contributions from the Industrial Conservation Initiative (ICI) and embedded generation located behind-the-meter are treated as load reductions within in the net demand profile. The demand forecast uses a single set of weather conditions.

Transmission limits impact the ability of generation units located around the province to contribute to supply adequacy needs. Excess generation in one zone must have enough transmission capability to transfer output to load centers in the province (i.e., deliverability). For example, transmission limits can restrict the value of capacity additions in zones that do not transfer capability to deliver energy production to other zones that require capacity. This deliverability constraint impacts LOLE.

The MARS program undertakes a probabilistic analysis of all the inputs to determine the total resource requirement to meet planning standards. For example, while the net demand forecast uses a single set of weather conditions, load forecast uncertainty is determined based on different probabilities of weather. The IESO simulates demand many times using the last 31 years of weather data. Similar variability of inputs related to fuel availability and equipment availability is used in the MARS program. The result of the MARS resource adequacy assessment is total resource requirement over the forecast period (see figure below from 2018 TPC). Clients

[8] Note that the Reliability Outlook uses a grid demand forecast. Grid demand is net demand less embedded generation (i.e., Distributed Energy Resources (DERs))

should note that the nuclear refurbishment schedule has a significant impact on the total reserve requirement over the forecast period. At times, the higher uncertainty from the refurbishment program increases the total reserve requirement by over 1,000 MW (light blue area is additional reserve requirement for refurbishment risk).

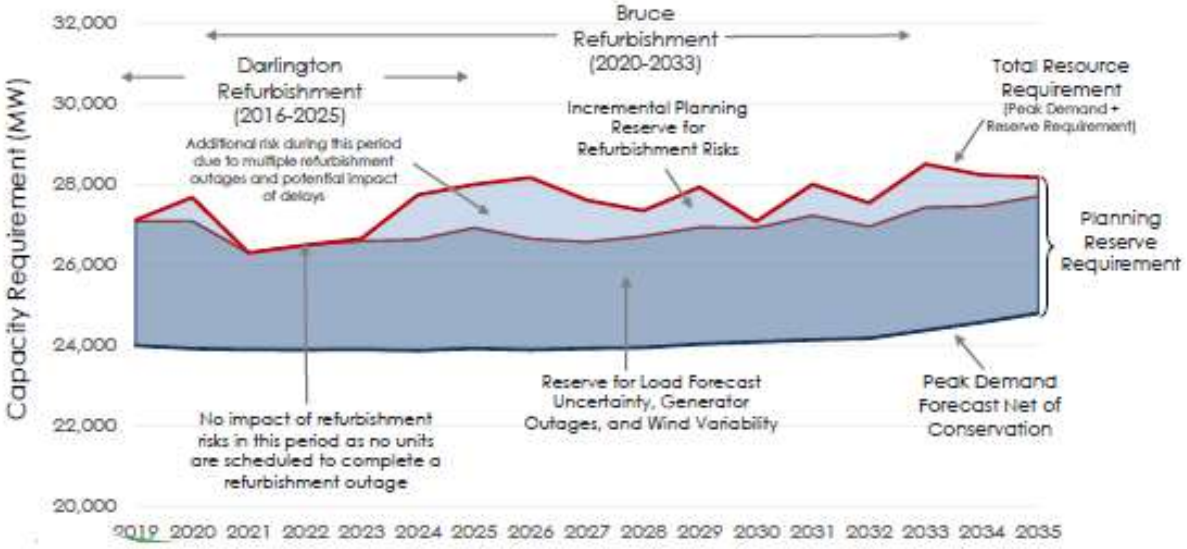

Figure 6: Total Resource Requirement and Nuclear Refurbishment Schedule Impact

Clearly, the nuclear refurbishment schedule is the primary risk for supply adequacy in Ontario over the next 20 years. Other key uncertainties impacting the resource adequacy outlook in the IESO's opinion are detailed in the table below.

Uncertainty	Details	Change in Capacity Need	Relative Impact
Refurbishment schedule risk (up to 1,500 MW)	An additional reserve is included in the capacity outlook to manage the risk of a delayed return to service after refurbishment. Uncertainty with respect to refurbishment schedules will remain into the 2020s.	Up or Down	*Large*
Generation retirements	Generation asset owners may revise when they plan to shutdown a plant. Will depend on condition of asset, cost of continued operation, and revenues generated. Some generation assets due to location and technical capabilities, play an important role in the system beyond providing capacity.	Up or Down	*Large*
Distribution connected generation	Significant amount of non-market participant contracted capacity connected to the distribution system. Uncertainty in availability of these resources post contract expiration. In addition, growth in distributed energy resources driven by customer choice and evolutions in technology and costs can impact the demand forecast.	Up or Down	*Medium*
Existing assets post contract	There is limited information on the ongoing availability of generators with expired contracts. Some may participate in the Incremental Capacity Auction, while others may choose to decommission their facilities, mothball or begin operating as merchant capacity exporters.	Up or Down	*Small to Large*
Regulations	Such as with respect to environment. Can affect the extent to which a resource will continue to operate in the market.	Up	*Small to Large*

Figure 7: Resource Adequacy Outlook Uncertainties

The IESO did not present any updates to the resource adequacy outlook at the stakeholder engagement session. Therefore, the most recent capacity adequacy outlook for Ontario is the results of the 2018 TPC (see figure below). Ontario is forecasted to continue to be a summer peaking jurisdiction. Capacity deficits (not including existing generation with expired contracts) begin in 2020 and grow significantly after 2022. Even including the capacity of existing generation with expired contracts, Ontario requires new supply in 2023 of roughly 1,400.

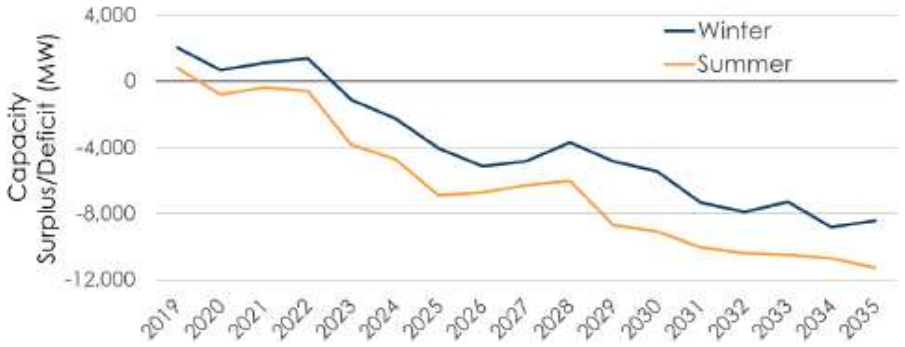

Figure 8: Capacity Adequacy Outlook from 2018 TPC

POWER ADVISORY COMMENTARY

Building on the information delivered at the 2018 TPC, the IESO have provided a considerable amount of detail on the resource adequacy outlook and the capacity adequacy assessment process. As the IESO moves towards adopting ICAs, transparency is required to ensure investor confidence. While no update to total resource requirement was presented by the IESO, they should be commended for the effort in presenting the technical analysis underpinning their planning process.

The standard terminology for capacity is important for clients to understand. This is particularly true for how the IESO applies those terms for defining system need and the capabilities of a client's existing or proposed asset.

At a high-level, Power Advisory agrees with the approach the IESO has presented and the existing total resource requirement. However, there are numerous areas where technical assumptions and details are debatable. Adjustments or disagreements can impact the future capacity need and therefore opportunity for clients. For example, the approach to Demand Response (DR) resources is simplistic and not assessed with the same rigour as other resources such as hydroelectric and thermal resources.

Using 31 years of historical weather data for load forecast uncertainty is abnormal compared to other jurisdictions. Shorter time periods, for example 10 to 20 years, is more common and better captures rising temperatures due to climate change.

Finally, it merits repeating that the IESO is of the view that capacity need will be the primary driver for new investment in Ontario over the next decade.

ENERGY AND OPERABILITY ASSESSMENTS

Energy and operability assessments provide insight on the following parameters (see table below). The IESO uses an hourly energy dispatch model to simulate energy production and economic dispatch of generation resources in Ontario and neighbouring jurisdictions. The outputs include hourly generation outputs, transmission flows and intertie transactions. The

simulations also incorporate energy, ancillary services and multi-regional dispatch while respecting transmission limits.

Parameter	Description
Energy Adequacy and Operability	Determines whether or not Ontario has sufficient supply to meet its forecasted energy demands and to identify any potential concerns
Imports and Exports	Flows across Ontario's interties with various interconnected jurisdictions (i.e., New York, Quebec, Michigan, Minnesota, and Manitoba)
Surplus Baseload Generation	Periods when electricity production from baseload facilities (e.g., nuclear, hydroelectric, wind, etc) is greater than Ontario's demand
Transmission Congestion	Extent to which resources are bottled due to transmission limits
Dispatch Cost	Approximation of the cost of dispatching electricity resources and identifies how system marginal cost change over time
Greenhouse Gas (GHG) Emissions	Amount of GHG emissions from Ontario's generation fleet

Figure 9: Energy and Operability Parameters

The IESO performs two types of energy assessments. The first, energy production, assesses the amount of electricity expected to be produced from the generation fleet including trade with neighbouring jurisdictions (i.e., import and exports). The second, energy adequacy, assesses the self-sufficiency of Ontario to meet internal demand requirements. In other words, the energy adequacy assessments model Ontario as an isolated system. The 2018 TPC results expect energy production to decrease from 160 TWh to 150 TWh in the mid-term (i.e., 2020 – 2026) before growing to 170 TWh by 2035. Ontario's energy adequacy outlook expects energy production to grow to just under 150 TWh by 2035 from 140 TWh in 2019. Unserved energy, that is the amount of electricity demand that cannot be satisfied by Ontario resources only, is expected to grow to over 20 TWh by 2035. Unserved energy does not consider any interconnection assistance or continued availability of resources after contract expiration (see figure below).

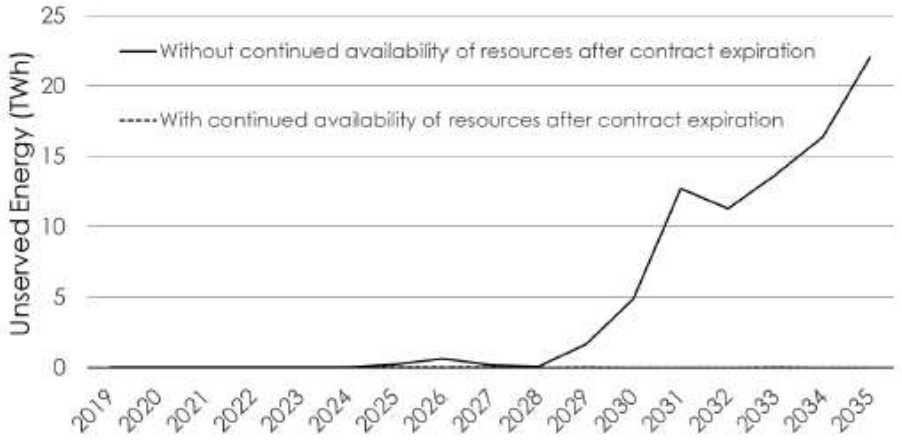

Figure 10: Unserved Energy

The IESO simulations expect gas-fired generation to increasingly play the role of a swing resource and pick up the balance of energy demand needs when output from other sources are lower or when demand rises. The IESO expects the combined-cycle gas-fired generation (i.e., CCGT) fleet to increase its capacity factor from <5% in 2019 to almost 50% by 2026. Depending on continued availability of resources after contract expiration, the capacity factor could grow to over 75% by 2035, or settle at 25% if all existing resources with expired contracts continue to operate. Surplus baseload generation expectations in the 2018 TPC drops from 10 TWh in 2019 to under 2 TWh annually from 2025 to 2035.

For the operability assessment, the IESO considers the many ancillary service products that the IAM procures in addition to other operational needs (e.g., ramping and load-following capability). The IESO believes that there is not pressing need for operability and intends to perform a detailed assessment of operability needs (i.e., flexibility & ramping) in 2020 and ancillary services/essential reliability services in 2021. The current list of ancillary services procured by the IESO is shown below.

Ancillary Service	Description
Operating Reserve	• Stand-by power or demand reduction that the IESO can call on with short notice to manage an unexpected mismatch between generation and consumption.
Regulation Service	• Acts to match generation to load and corrects variations in power system frequency. Operates on a time-scale of seconds. • Facilities vary output automatically in response to regulation signals.
Reactive Support and Voltage Control	• Allows the IESO to maintain acceptable local reactive power and voltage levels on the grid.
Black Start	• Helps in system restoration in the event of a system-wide blackout. • There may be a role to support future grid resiliency with the use of Black Start resources.

Figure 11: IESO Ancillary Service Products

The IESO presented their view of the capability of different resource types to provide ancillary and operability services (see table below).

Typical Characteristics of a Resource and the Services Provided					
Resource	Capacity	Energy	Operating Reserve	Load Following	Frequency Regulation
Conservation	Yes	Yes	No	No	No
Demand Response	Yes	No	Yes	Yes	Limited
Solar PV	Limited	Yes	No	Limited	No
Wind	Limited	Yes	No	Limited	No
Bioenergy	Yes	Yes	Yes	Limited	No
Storage	Yes	No	Yes	Yes	Yes
Hydroelectric	Yes	Yes	Yes	Yes	Yes
Nuclear	Yes	Yes	No	Limited	No
Natural Gas	Yes	Yes	Yes	Yes	Yes

Figure 12: IESO Assessment of Resource Capabilities for Electricity Services

POWER ADVISORY COMMENTARY

There are several take-aways from the energy and operability assessment overview presented by the IESO.

First, the carbon intensity of Ontario's supply mix is expected to rise significant, abet from a low baseline. Higher capacity factors of CCGT units will increase the amount of GHG emissions from Ontario's electricity sector, potentially increasing carbon offset benefits for DERs that reduce Ontario's grid demand and therefore lowers the need for CCGT.

Second, the IESO is forecasting lower SBG in the future. This is a logical conclusion since Ontario is exiting a period of supply surplus that has persisted over the past decade. Lower SBG will reduce global curtailment risk for non-hydro renewables in particular.

Third, Ontario has multiple interconnections with neighbouring jurisdictions that can be relied on during a temporary shortfall in unserved energy. However, relying on imports for too long increases the exposure to activities in other markets that are outside the control of Ontario. It is also worth noting that Ontario was relying on roughly 4,000 MW of imports during the supply shortfall of 2002 to 2005. The supply shortfall at the time was a partial reason for the political action to create the Ontario Power Authority and initiate long-term contracts for capacity adequacy resources. The impact of those decisions 15 years ago still impacts Ontario's electricity sector today.

Fourth, the IESO's assessment of different resource types capabilities to deliver electricity services is overly restrictive. For example, wind and solar generation can offer downward regulation with practically no technological issues (i.e., both resources can reduce their output almost immediately after an outage event if required). The newly launched Market Development Advisory Group (MDAG) is a forum for the IESO to assess and update resource capabilities for different electricity services.

Finally, clients should note that opportunities in providing ancillary services and operability may not solely come from detailed technical need analysis. There are multiple stakeholder engagement processes seeking to expand participation and competition of innovative and emerging technologies (e.g., Innovation Roadmap, Energy Storage Advisory Group (ESAG) work plan, etc.). The stakeholder engagement process may yield investment options and therefore it is important for clients to participate to ensure the opportunities are maximized for their projects or assets.