Electrification Pathways for Ontario to Reduce Emissions

Procuring Ontario's energy future

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STRATEGIC POLICY ECONOMICS

Executive Summary

In 2020, Ontario's Independent Electricity System Operator (IESO) released its annual planning outlook (APO) that highlighted a shortfall in the province's electricity supply. The release of the APO comes at a time when government and civil society are increasingly accepting that urgent action is required to address climate change. Previous research has shown that the most effective – and popular – strategies to reduce emissions result in greater electricity demand, making climate targets an important factor in electricity planning.[1] Yet the IESO's forecasts offer only limited consideration of the impact of climate on the province's future electricity demand. Furthermore, their stated strategies for meeting the forecast supply gap involve procuring greenhouse gas (GHG) emitting natural gas-fired generation, contrary to the province's climate ambitions and that of many municipalities.[2]

After the release of the APO, Ontario's Ministry of Energy, Northern Development and Mines (MENDM) initiated a consultation on Ontario's energy planning framework. This was a timely initiative given several other important challenges confronting Ontario's energy planning efforts: Pubic concern on the high cost of energy and the impact it has on consumer pocketbooks and the competitiveness of Ontario's industries is driving government to take action; Energy policy with respect to climate is not well framed as it is unclear and has uncertain implications on climate action objectives; and, a plethora of emission reduction solution options create significant complexity to be addressed by energy planners. And yet, the recent APO is devoid of climate considerations, the procurement approach is unprepared to embrace the challenge, and governance of the sector has many gaps in ensuring policy objectives are attained.

This report describes not only the pressing need to consider climate in planning Ontario's electricity system but presents six findings that underscore the urgent need for a paradigm shift in Ontario's electricity planning and procurement process.

1. **Ontario faces an electricity supply shortage and reliability risks in the next four to eight years.**

   Ontario's emerging capacity supply gap was first identified in the IESO's 2013 Long Term Energy Plan (LTEP) and has since widened significantly as no procurement steps have been taken to close it. With the long-expected retirement of the Pickering Nuclear Generating Station (PNGS) in 2025, Ontario faces a capacity gap in 2030 of at least 3.6 gigawatts (GW) for which it has no solution. This gap could widen to 9.5 GW when electrification of the economy is considered. Filling this need is equivalent to doubling Ontario's planned nuclear fleet in eight years.

2. **Achieving Net Zero by 2050 will increase electricity demand by at least 130%.**

   Achieving the goals of Net Zero (NZ) emissions by 2050 being set by the federal government and civil society will require the electrification of the buildings, transportation, and industry sectors. Even assuming significant efficiency gains are achieved, Ontario's electricity demand will increase by at least 130% over current planning forecasts, and potentially by over 190%.

[1] Strapolec, 2016; Green Ribbon Panel, 2020; Canadian Institute for Climate Choices, 2021.
[2] Ontario, A Made-in-Ontario Environment Plan, 2018; The Energy Mix, Toronto City Council Calls for Ontario Gas Phaseout, 2021.

3. **Leveraging electricity, natural gas and hydrogen synergies can reduce supply needs, but 55 GW of new electricity resource will still be needed by 2050 – four times Ontario's nuclear and hydro assets.**

   Emerging forms of energy production and consumption are creating opportunities for low carbon integrated energy solutions involving electricity, natural gas, hydrogen, and demand side management (DSM) innovations to mitigate peak demand and optimize the costs of Ontario's NZ energy future. However, 55 GW of new incremental supply will still be required, with a baseload component equivalent to over 33 new nuclear reactors of the size of those at the Bruce site.

4. **Optimized integrated solutions could enable cost competitive technology options.**

   Low-carbon energy supply solutions such as nuclear, natural gas with carbon capture, renewables, and storage are required for supply Ontario's baseload and variable demand. Cost trends reveal that low-carbon hybrid solutions that combine traditional generation with emerging technologies may be cost competitive. Nuclear-based solutions may be the lowest cost, providing energy at 25% less cost to rate payers than Ontario's current system, however, optimal supply mix choices may vary regionally.

5. **Procurement must begin to avoid a supply shortage in 2030 and maximize emission reductions.**

   Even excluding the impacts of electrification, Ontario has a sustained long-term need for new low-carbon baseload (2 GW) and flexible supply (12 GW). When considering electrification, the need for new low-carbon baseload could increase by an additional 6 GW by 2030. Absent procurement of new non-emitting resources, emissions could increase to levels present when Ontario operated its coal plants. This would put Ontario's status as a clean energy jurisdiction at risk. Procuring any form of low-carbon resources at the scale required could take a decade to site, develop, and commission.

6. **Ontario needs a procurement process to optimize supply options and maximize societal benefits.**

   Increasingly complex energy solutions are undermining the effectiveness and increasing the risks for Ontario's current approach to electricity planning and procurement. Improvements are required that better mitigate risks, accelerate procurement timelines, and optimize the benefits for all Ontarians. An improved procurement approach would: procure resources to fit the type of demand to be supplied, not seeking specific technology; incent dispatchable integrated hybrid solutions; and encourage low-carbon solutions that integrate existing and new energy resources.

   Competitive request-for-proposal (RFP) based procurement approaches are well suited for securing the low-carbon, energy Ontario needs in the long-term. They can also accelerate and maximize the significant societal benefits that result from the hundreds of billions in associated infrastructure investments. Ontario's nuclear technologies are well suited to achieving both goals.

The above findings underscore the great risks and opportunities that lay before Ontario's energy planners. Immediate action is required as a result to mitigate the system reliability risks and enable the significant societal benefits needed to pursue NZ objectives. Developing Ontario's approach to procuring the long-term assets that Ontario needs to replace the PNGS must begin as soon as possible, including stakeholder engagement on approach option viability.

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1 Introduction

In 2020, Ontario's Independent Electricity System Operator (IESO) released its annual planning outlook (APO) that highlighted a shortfall in the province's electricity supply. The release of the APO comes at a time when government and civil society are increasingly accepting that urgent action is required to address climate change. Previous research has shown that the most effective – and popular – strategies to reduce emissions result in greater electricity demand, making climate targets an important factor in electricity planning.[3] Yet the IESO's forecasts offer only limited consideration of the impact of climate on the province's future electricity demand. Furthermore, their stated strategies for meeting the forecast supply gap involve procuring greenhouse gas (GHG) emitting natural gas-fired generation, contrary to the province's climate ambitions and that of many municipalities.[4]

After the release of the APO, Ontario's Ministry of Energy, Northern Development and Mines (MENDM) initiated a consultation on Ontario's energy planning framework. This was a timely initiative given several other important challenges confronting Ontario's energy planning efforts: Pubic concern on the high cost of energy and the impact it has on consumer pocketbooks and the competitiveness of Ontario's industries is driving government to take action; Energy policy with respect to climate is not well framed as it is unclear and has uncertain implications on climate action objectives; and, a plethora of emission reduction solution options create significant complexity to be addressed by energy planners. And yet, the recent APO is devoid of climate considerations, the procurement approach is unprepared to embrace the challenge, and governance of the sector has many gaps in ensuring policy objectives are attained.

This report describes the pressing need to include climate change in Ontario's electricity planning process by forecasting the electricity demand associated with achieving a Net Zero (NZ) 2050 goal and framing it in the context of the low-carbon electricity supply challenge Ontario is facing. The analyses examine the connections between the system conditions in IESO's APO and the implications of an electrified Ontario economy, and the long-term risks facing the reliability of Ontario's electricity system, including those presented by greenhouse gas (GHG) emission reduction objectives. Finally, the report characterizes potential pathways for Ontario's low-carbon energy transition and their timing and suggests ways to reform the province's procurement strategy to better achieve an electrified economy. The report is structured as follows:

- Section 2 summarizes the methodology used in this report and the sources considered by the analyses.
- Section 3 illustrates the supply capacity shortage noted in the IESO's APO and the history of its development.
- Section 4 examines the electrification approach to reducing Ontario's emissions, in the context of other deployable emission reduction options, to estimate the minimum electricity demand implications of achieving NZ by 2050.

[3] Strapolec, 2016; Green Ribbon Panel, 2020; Canadian Institute for Climate Choices, 2021.
[4] Ontario, A Made-in-Ontario Environment Plan, 2018; The Energy Mix, Toronto City Council Calls for Ontario Gas Phaseout, 2021.

- Section 5 reviews the role emerging energy technologies may play in shaping Ontario's electricity system and optimizing how low carbon electricity is supplied.
- Section 6 examines the cost implications of supplying the requisite electricity, including simulated hybrid electricity supply options that combine traditional and emerging low-carbon generation technologies to reduce costs to ratepayers.
- Section 7 outlines the challenges associated with meeting Ontario's forecasted electricity needs, solving the current electricity supply situation, and procuring the supply required to achieve NZ by 2050.
- Section 8 examines the trajectories for Ontario's emissions through to 2050, considering the required electricity demand for electrification, the IESO's current procurement plans, and several procurement scenarios.
- Section 9 considers how the necessary procurements to satisfy Ontario's electricity system needs could be structured to best deliver benefits to government and the public.
- Section 10 proposes a paradigm shift in Ontario's approach to electricity procurement that better addresses the known risks, accelerates timelines, and optimizes the potential system benefits resulting from innovative low-carbon energy solutions.

2 Methodology

This report explores the pressing need to consider climate action in Ontario's electricity planning process. This section summarizes the methodology used to address the critical areas of analysis and identifies the supporting references upon which the analyses relied.

Sizing the electrification opportunity

Central to the study is how electrification and energy efficiency could impact the energy consumption in Ontario and in turn the province's electricity system. The study focused on the three sectors of Ontario's economy that are the largest emitters of GHGs: buildings, transportation, and industry. Overall emissions trends and emission reduction opportunities were drawn from the following reports:

- Environment and Climate Change Canada (ECCC), Pricing carbon pollution from industry, 2021
- Princeton University, Net-Zero America, Potential Pathways, Infrastructure, and Impacts, 2020
- Canadian Institute for Climate Choices, Canada's Net Zero Future, 2021

The trends provided by these works were adapted to Ontario, with additional research conducted where warranted, to help inform the potential for energy efficiency and the minimum electricity demand that may emerge. This demand was added to the IESO's APO forecasts.

Forecasting the implications of electricity demand

Implications are not only determined by the overall forecast electricity demand, but how the hourly demand profiles emerge over a full year. Strategic Policy Economics' used its proprietary models to simulate the daily and seasonal demand profiles for various emission reduction innovations, such as electric heating, EV charging, demand side management (DSM), hydroelectric generation, and storage. The aforenoted reference sources were supplemented by recent research findings on such matters as electric vehicle (EV) charging behavior in Ontario from Fleetcarma.[5]

Costing and scenarios

Future estimates of technology-specific levelized cost of energy (LCOE) were obtained from National Renewable Energy Laboratory (NREL), Lazard and other sources. Costs were applied to Strategic Policy Economics' proprietary models of Ontario's electricity system supply and demand to establish the capacity factors of its assets. Simulations were conducted with full 8760-hour annual supply and demand profiles to model the roles of storage, hydrogen electrolysis, hydro, renewables, natural gas, and nuclear.

Supply gap assessment and NZ resource acquisition challenge

The IESO's various published perspectives on Ontario's supply gap have been summarized and reviewed to highlight specific relevant areas. Strategic Policy Economics simulations were used to assess the capacity impacts in various years resulting from new electricity demand. This analysis was also informed by research into early adoption trends arising in Ontario.

[5] Fleetcarma, Charge the North, 2019.

3 Ontario is facing a supply shortage

The IESO's recent APO highlighted a forecast gap in supply capacity. This approaching gap is cause for concern given the short-timeline available to address it and a key omission — the demand impacts of electrifying Ontario's economy. This section explores the IESO's identified capacity gap and the history of its development.

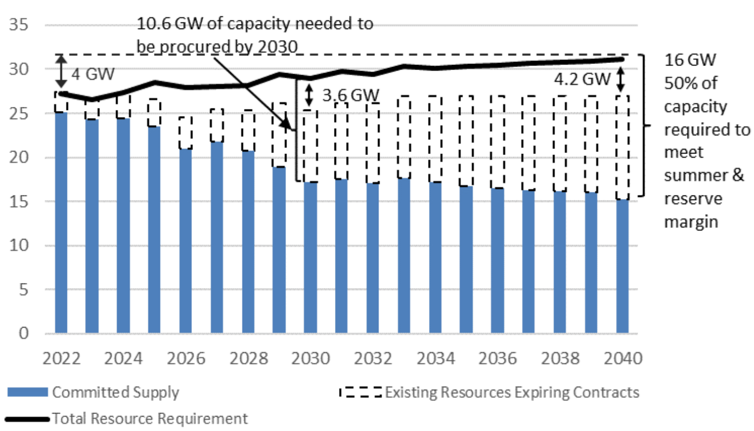
The supply shortage

Ontario's current "business as usual" electricity needs are growing. Concurrently, contracts for existing generation assets are expiring. Furthermore, the retirement of the Pickering Nuclear Generating Station (PNGS) by 2026 will remove 3 GW of firm, low-carbon, baseload electricity from the province's grid. By 2030, Ontario will be 3.6 GW short of the electricity capacity it needs to reliably meet summer demand, creating a *capacity gap*. With increasing demand, the IESO has forecast that this capacity gap will widen to 4.2 GW by 2040, as shown in Figure 1.[6]

The contracts for 11.4 GW of Ontario's existing capacity will expire by 2040.[7] The majority, approximately 8.4 GW of this firm capacity, is GHG-emitting natural gas-fired generation. The remaining 3.2 GW of the expiring contracts is primarily renewables with some hydro, demand response (DR), and biomass. The IESO's planning assumptions rely on the renewal of these existing contracts to minimize the amount of new resources that must be found to ensure system reliability.

By 2030, Ontario's IESO has identified the need to acquire 10.6 GW of new or renewed capacity to replace expiring contracts and the retired PNGS.

Figure 1: Ontario's Summer Peak Supply and Demand Outlook



Source: IESO, APO, 2020; Strapolec Analysis. Note: Total resource requirements includes peak demand and reserve margin.

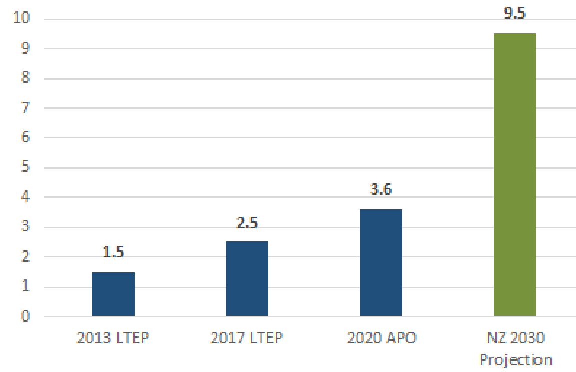
While the contracts for existing resources may be renewed, it is less clear how the additional 3.6 GW of anticipated demand in 2030 will be addressed. Nor has it been established that *all* of the existing assets can be economically reprocured, creating the risk of an even larger gap. In the next ten years alone, Ontario must renew or replace almost 40% of its generation infrastructure. This will be no small challenge.

[6] IESO, APO, 2020.

[7] IESO, APO, 2020.

The emergence of this supply gap is not a surprise or a mystery. Ontario's 2013 Long-Term Energy Plan (LTEP) noted the province's pending supply gap and a need for 1.5 GW of "planned flexibility" by 2030 to address the capacity gap anticipated as a result of the PNGS closure as shown in Figure 2.[8]

Figure 2: Trend in IESO Forecasts of 2030 Capacity Gap
(GW)



Capacity gap is difference between resource requirement and firm supply available
Source: Ontario, Achieving Balance: Ontario's Long-Term Energy Plan, 2013; Ontario, 2017 Long-Term Energy Plan: Delivering Fairness and Choice, 2017, IESO, APO, 2020; Strapolec Analysis.

The IESO's subsequent 2017 LTEP and 2020 APO shows that the gap has been progressively increasing. It now sits at 3.6 GW, more than double the level identified in 2013. This is no surprise since no procurements have been completed to replace the retiring PNGS.[9] The electrification analysis in this report shows that this 2030 capacity gap could almost triple to 9.5 GW.

Instead, plans have continued to rely on the supposed ability to import electricity from Quebec and the U.S.. These have been respectively shown to be infeasible on the one hand and at significant risk from U.S. climate policy objectives on the other. Quebec cannot meet Ontario's growing winter heating load, and instead currently relies on imports from Ontario in the winter. Both import options would lead to less energy security for Ontario.[10]

The IESO has indicated that it does not intend to develop a procurement process to secure the required resources for many years, further delaying Ontario's ability to meet the forecast needs. Compounding the issue, recent surpluses have influenced procurement strategies to rely on near-term contractual renewal of aged assets, deferring long-term procurement decisions.[11] This risk-averse behavior has been influenced by Ontario's surplus baseload capacity that appeared in 2013, which has been indicative of prior over-procurements and high costs.[12] Most importantly, the IESO has not been provided with any policy guidance for them to address the impacts of electrification that will be required to achieve Ontario's emissions targets.[13]

Coupling the lack of supply solutions for the existing known capacity shortfall with the unfolding reality of new electricity demand from electrification of the economy points to a reliability crisis that will be hard to avoid even with immediate policy action.

[8] Ontario, Achieving Balance: Ontario's Long-Term Energy Plan, 2013.
[9] Ontario, Delivering Fairness and Choice: Ontario's Long Term Energy Plan 2017, 2017; IESO, APO, 2020.
[10] Strapolec, Renewables and Ontario/Quebec Transmission System Interties: An Implications Assessment, 2016.
[11] Strapolec, Electricity Markets in Ontario, 2020.
[12] Strapolec, Advancing Ontario's Energy Transition Part 3: Reforming Energy Planning, 2021.
[13] IESO, APO, 2020.

4 Meeting NZ by 2050 will increase electricity demand

Many options for reducing emissions across Canada are being explored, including: fuel switching (primarily electrification and hydrogen); efficiency improvements; carbon capture; and direct air capture.[14] The potential efficacy of these options varies by region across Canada. In Ontario, the largest emission reductions in the province's primary emitting sectors are likely to be achieved via efficiency gains and electrification.

This section examines the electrification approach to reducing Ontario's emissions, in the context of other deployable emission reduction options, to estimate the minimum electricity demand implications of achieving NZ by 2050

Emission Reduction Potential

Ontario's buildings, transportation, and industry sectors are collectively responsible for 82% of the province's 165 million tonnes (Mt) of annual GHG emissions.[15] Fortunately, the potential for fuel switching and energy efficiency in these three sectors is well understood. These sectors can be decarbonized through electrification and energy efficiency. This study assumed aggressive energy efficiency improvements to help determine the minimum electricity demand to achieve NZ by 2050.

Emissions from these three sectors could be reduced by 68 Mt, or by almost 30% with the use of low-carbon fuels and two forms of energy efficiency improvements:

1. **Anticipated reductions** are expected to reduce emissions by 21%.[16] These include increased energy efficiency in buildings, and electrification of transportation in alignment with ECCC forecast assumptions. This analysis assumed that the ECCC's energy efficiency ambitions over the next ten years could be replicated, and hence tripled, for another 20 years. This represents an aggressive assumption as much of the low-hanging fruit may have been realized by 2030.
2. **Additional efficiency** represents an assumed 10% reduction in industrial emissions resulting from process efficiencies and fuel switching, e.g., other fossil sources to natural gas.[17]

Electrification has the potential to eliminate another 91 Mt of emissions, or almost 40% from these sectors. The main drivers are:

1. **Buildings:** Primarily residential and commercial heat pumps and electric water heating;
2. **Transportation:** Primarily EVs for light vehicles and EV and hydrogen options for land-based freight; and,
3. **Industry:** Primarily via electrification and use of hydrogen for industrial processes and process heating, as well as electrification of process cooling, machine drives, and mobile equipment.

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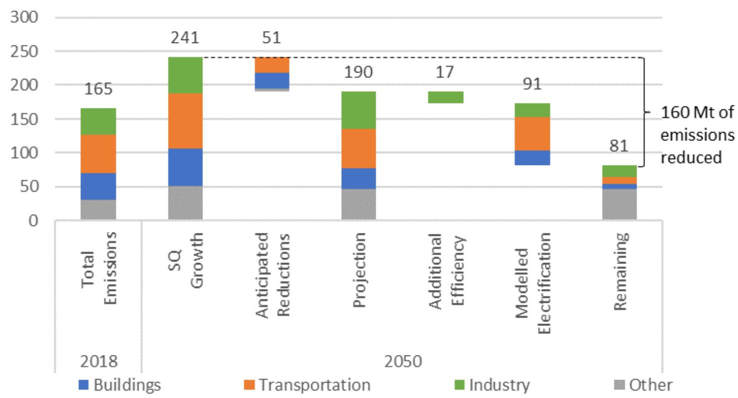
[14] Canadian Institute for Climate Choices, 2021.
[15] Environment and Climate Change Canada, National inventory report 1990-2018, 2020.
[16] ECCC, Canada's Greenhouse Gas Emissions Projections, 2021; IESO, APO, 2020; Princeton University, 2020; EIA, 2020; NRCan 2021; Strapolec analysis.
[17] ECCC, Canada's Greenhouse Gas Emissions Projections, 2021; IESO, APO, 2020; Princeton University, 2020; EIA, 2020; NRCan 2021.

Figure 3: Emission Reductions by Assessed Sectors with Non-Emitting Electricity
(Mt CO_2e)



Sources: ECCC, Canada's Greenhouse Gas Emissions Projections, 2021; IESO, APO, 2020; Princeton, 2020; EIA, 2020; NRCan 2021; Strapolec analysis

Electrification and efficiency gains in these three sectors could reduce future economy-wide emissions by 160 Mt, or 67% as shown in Figure 3.[18]

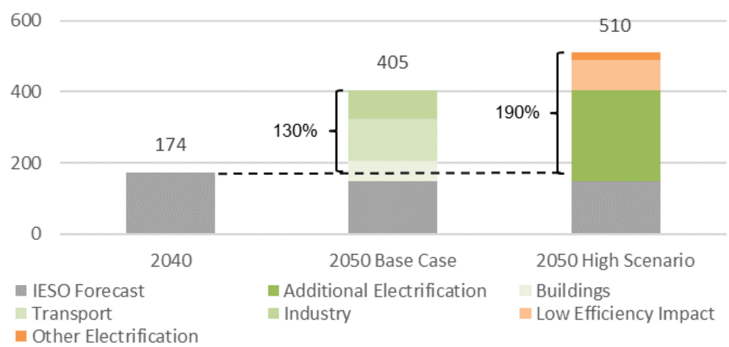
The remaining 81 Mt of emission reductions required to achieve NZ were not assessed. These include refrigerants, water and air transport, industrial processes, and the other sectors of the economy: electricity, agriculture, oil and gas, and waste processing and management. These remaining emissions could potentially be reduced by the more uncertain options of carbon capture, renewable natural gas (RNG), biofuels, and negative emissions technologies.

Impacts on Electricity Demand

Electrification replaces technologies that use fossil fuels (coal, oil and natural gas) with technologies that use electricity as a source of energy directly, or indirectly via other low-carbon fuels produced from electricity such as hydrogen.

In the scenario described above, Ontario's electricity demand by 2050 will increase by between 230 and 345 terawatt-hours (TWh) above the reference case as shown in Figure 4.[19] This increase occurs *after* applying the energy efficiency results to current electricity applications.[20]

Figure 4: Forecast Electricity Demand by 2050
(TWh, NZ2050)



Base case assumes aggressive efficiency gains to determine a minimum estimate. The High Scenario reflects moderate efficiency assumptions and estimates electrification of unassessed areas including carbon capture and direct air capture.

The low end of this forecast, 230 TWh of new demand by 2050, represents a base case crafted to identify the minimum expected new electricity demand. This minimum case represents a need for 130% more electricity in 2050 compared to what the IESO has forecast for 2040.[21] To take climate action, Ontario indisputably needs significantly more non-emitting energy.

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[18] Status Quo (SQ) emission driven by economic factors such as population growth, gross domestic product (GDP) growth, and demand for commercial floor space.
[19] IESO, APO, 2020.
[20] Aggressive energy efficiency reduces the IESO's forecast by an estimated 26 TWh as shown in Figure 4.
[21] IESO, APO, 2020

5 Emerging Energy Trifecta Technologies Could Limit New Capacity Needs to 55 GW

The energy transition required to achieve Canada's NZ goal encompasses more that just electricity. New forms of low-carbon energy production and changes in consumer behavior are creating opportunities for innovative, integrated solutions that can help optimize an affordable energy transition to a decarbonized economy. This will change the meaning of "energy," requiring solutions that can manage the complexities of supply and ever-changing energy demand.

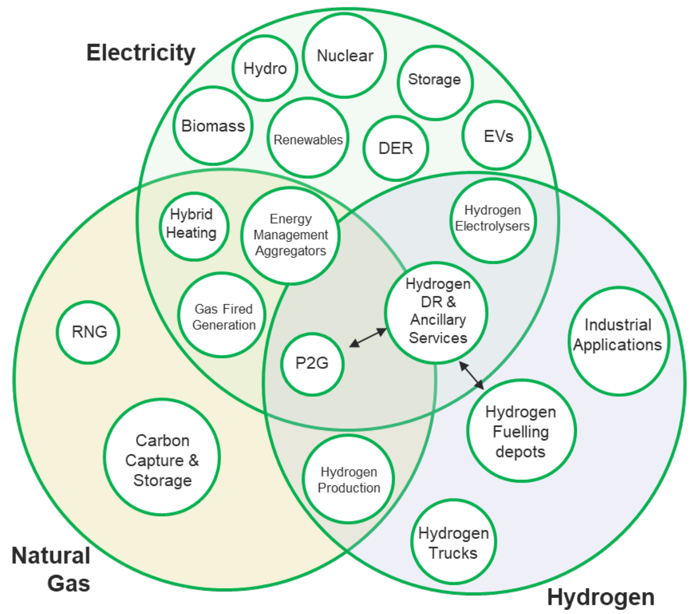
This section reviews emerging energy technologies, describes how demand is shaped by consumer energy use that drive seasonal and daily demand, and then summarizes how the emerging technologies may create system benefits by helping to optimize low-carbon electricity supply.

The Evolving Energy Sector

The energy landscape of the future, illustrated in Figure 5, will be shaped by the interplay of an emerging trifecta of energy infrastructure solutions:

- **Electricity** which must provide the emission-free energy sources of the future;
- **Natural gas** for building heating, industrial heat, and electricity generation as the economy transitions; and,
- **Hydrogen,** a non-emitting fuel that can help displace fossil fuels in Canada's industrial and transportation sectors, as well as be blended into the natural gas delivery system.

Figure 5: The Future Energy Trifecta



Source: Strapolec Analysis

There are evident synergies between hydrogen and low-carbon electricity. The latter can be used to produce hydrogen via electrolysers, which in turn can provide DR and other ancillary services to the electricity system. Electrolytic-based hydrogen can also be injected into the natural gas system as Power to Gas (P2G) to help blend down the emissions of natural gas applications.[22] Natural gas and electricity have several cross over areas beyond natural gas-fired generation. These include hybrid heating solutions that, when coupled with energy management applications, can optimize consumers' use of low-carbon energy. However, the use of natural gas will be impacted by carbon pricing and the viability of carbon capture and storage (CCS) technologies. CCS has the potential to allow for continued use of natural gas for electricity generation and the production of hydrogen using traditional steam methane reforming.

[22] Enbridge is currently running a pilot with support of the OEB and the IESO that combines the functions of the natural gas system, hydrogen production and electricity system ancillary services. Source: Enbridge, 2020.

Opportunities to Change how Energy is Consumed

The integration of these three sectors can be managed to optimize the cost of the energy system by delivering energy in response to when and how consumers demand it. In general terms, consumer behaviour results in three types of demand:

- **Baseload demand** is present 24 hours a day, 365 days a year.
- **Variable demand** comes in two forms, seasonal and daily:
    - **Seasonal variable demand** varies by season (higher for cooling in summer today and heating in winter in the future)
    - **Daily variable demand** fluctuates throughout the day but typically rises during the day and declines at night
- **Peak demand** occurs less than 2% of the time, currently driven by air conditioning on a few extremely hot summer days.

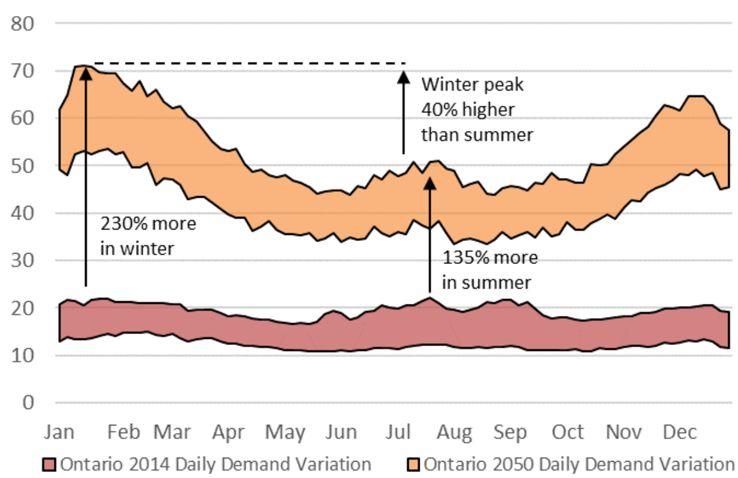
Baseload supply provides the most cost-effective electricity as it maximizes the use of bulk system generation and transmission assets. The relative costs per unit of energy increases for supplying daily, seasonal, and peaking demand due to the associated reduction in use of the asset capacities.

The technologies illustrated in Figure 5 can help optimize the cost of energy by mitigating the cost impacts of seasonal, daily, and peak demand variations.

Mitigating seasonal demand implications

Heating is a major source of emissions in the buildings sector. Electrification of building heating will increase demand in the winter by 230%, making peaks in the winter 40% higher than in the summer, as illustrated in Figure 6.

Figure 6: Evolving Seasonal Demand Profile
(GW by Hour, 2014 vs. NZ2050)



Source: Strapolec Analysis; IESO, 2014.

The costs of supplying future winter seasonal demand can be mitigated by integrated “wires and pipes” solutions that leverage the existing natural gas distribution system. For example, dual-fuelled electricity and natural gas hybrid heating devices are available today that can help reduce peak electricity system demand by switching to natural gas at peak times. Significant emission reductions from the natural gas delivery system can be achieved by reducing the amount of gas consumed and using RNG and P2G.

As well, hydrogen production for P2G applications can be focused in the summer as the natural gas storage caverns are stocked in preparation for the winter season, increasing the need for baseload supply in the summer. These operations can be reduced when high demand stresses the grid during the winter season.

Daily variable demand mitigation

Variable daytime demand has traditionally been met by flexible, carbon-emitting, fossil generation. New technologies offer the same flexibility as they can help smooth electricity demand. Concurrently, these new technologies also increase the need for more efficient baseload energy. These include:

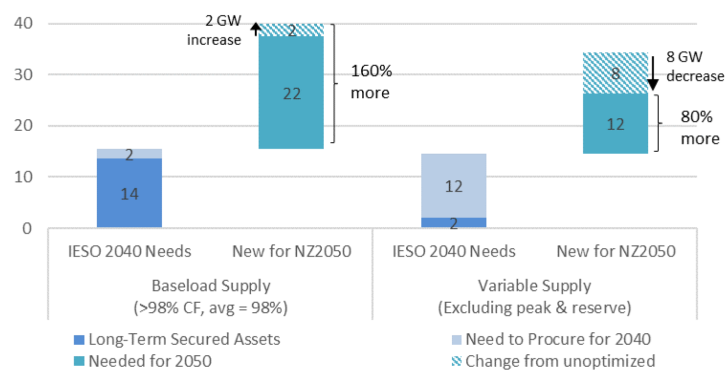
- *DSM systems*, which can optimize home heating, EV charging, and water heating to optimally match system conditions without impacting consumer behavior.
- *Community storage*, which can be located near demand loads to smooth variable demand. This could reduce the costs of the existing grid by enabling greater use of baseload supply. EVs can provide mobile storage and act as virtual power plants by aggregating two-way charging.
- *Hydrogen electrolyzers*, which provide a cost-effective source of DR and ancillary services that could be regionally distributed near load centers (where the benefits are most evident.

Benefits to the system

These integrated low-carbon technology options could yield significant savings for the electricity system. They could reduce Ontario's capacity requirement by 11 GW, or 15%, while saving $2.0 billion per year in system costs.[23] Concurrently these integrated solutions could increase the need for baseload supply by 2 GW and reduce the need for variable supply by 8 GW, as shown in Figure 7. Peak and reserve capacity needs would also be reduced by 5 GW (not illustrated).[24]

Figure 7: Incremental New Supply Required by Demand Type

(GW, IESO 2040 vs. NZ2050)



Source: Strapolec Analysis; IESO, APO, 2020

However, even with these solutions in place, Ontario will still need 160% more baseload and 80% more variable supply than currently forecasted in the IESO's APO. Indeed, the identified 36 GW of additional future bulk system generation requirements will be dominated by baseload supply characteristics, which includes the IESO's known need for 2 GW to replace Pickering.

Combined with the capacity needs identified in the APO, Ontario will need to procure at least 55 GW of capacity, including 26 GW of new baseload supply. This is the equivalent to 33 new nuclear reactors similar in size to those at the Bruce Nuclear Station. Ontario will need an additional 24 GW of variable supply, including renewing or replacing 12 GW of existing resources such as gas-fired generation and 5 GW of peak and reserve supply (not illustrated).

[23] Cost estimate savings based the cost of new electricity generation capacity of $180K/MW per year, based on the LCOE of a CCGT with CCS, operating at a 55% capacity factor (NREL, 2020).

[24] Note that total capacity is driven by peak system needs, whereas capacity needs by demand type are driven by non-coincident demand needs. As a result, these are not strictly comparable.

6 Integrated low-carbon hybrid supply options are cost competitive

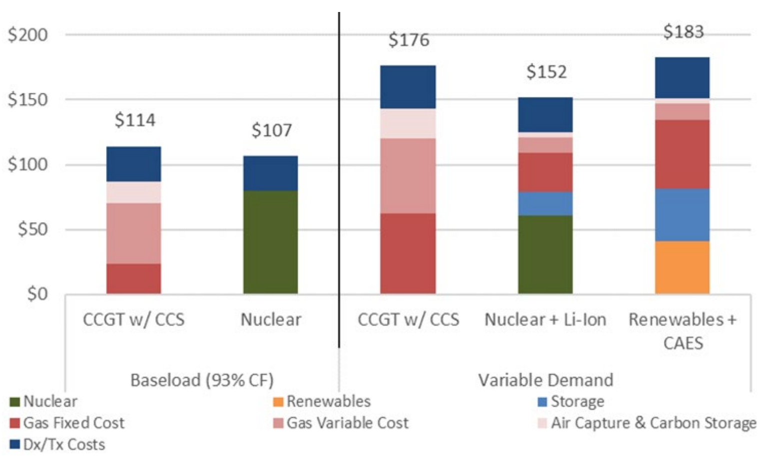
Cost-effective, low-carbon energy solutions that deliver both baseload and variable supply will be required to meet the increased electricity demand resulting from the energy transition to a NZ economy. This section explores the cost of supplying the requisite baseload electricity in the future and examines the cost implications of simulated hybrid electricity supply solutions for variable demand. The focus is on traditional and emerging low carbon generation technologies that can be combined to deliver the desired low carbon results at reduced costs to ratepayers.

Baseload demand

Nuclear power and combined cycle natural gas-fired generation (CCGT) plants equipped with CCS are the most cost-effective ways to meet baseload demand. Between the two, nuclear power offers the lower-cost option, as shown in Figure 8. Nuclear power's cost advantage arises for two main reasons. Firstly, the cost of CCS greatly increases the cost of natural gas-fired generation. To achieve net zero emissions, CCS must be supplemented by direct air carbon capture and the sequestration of the carbon for eternity. Secondly, the current low-interest rate environment has greatly reduced the cost prospects of conventional nuclear generation. Over the past five years, NREL has reduced its cost estimate for nuclear generation in 2035 from $131/megawatt-hour (MWh) to $71/MWh (USD), largely due to changes in assumed financing costs.[25] New nuclear generation could be further supported financially through public-private partnerships and the Canada Infrastructure Bank (CIB).[26]

Figure 8: Integrated Low-carbon Variable Supply Solutions Competitive with Natural Gas

($/MWh 2018CAD, NZ2050)



Note: NREL assumptions for nuclear dropped due to financing assumptions. Costs shown after conversion to Canadian context and include full life cycle costs

Variable demand

Variable daily and seasonal demand could be economically supported by several technological solutions. Flexible supply has typically been provided by natural gas-fired generation. However, variable demand could also be met by less costly, low-carbon hybrid solutions. One such solution is nuclear coupled with distributed lithium ion (li-ion) battery storage and natural gas generation for high demand periods. Renewables (primarily wind) coupled with natural gas backup, distributed battery storage, or compressed air energy storage (CAES) offer another option.[27] A simulation of these three options over the 8760 hours in a year demonstrates that the nuclear option may be the most cost-

[25] NREL, 2020 Annual Technology Baseline, 2020.

[26] Green Ribbon Panel, 2020.

[27] The potential use of CAES as the low-cost storage option may be geographically limited. Assumes CAES is located in close proximity to wind farms. Li-Ion will at least double the storage cost, increasing overall costs to potentially over $230/MWh.

effective option for supplying variable demand at a total system cost of $152/MWh versus the $183/MWh for the renewables-based solution.

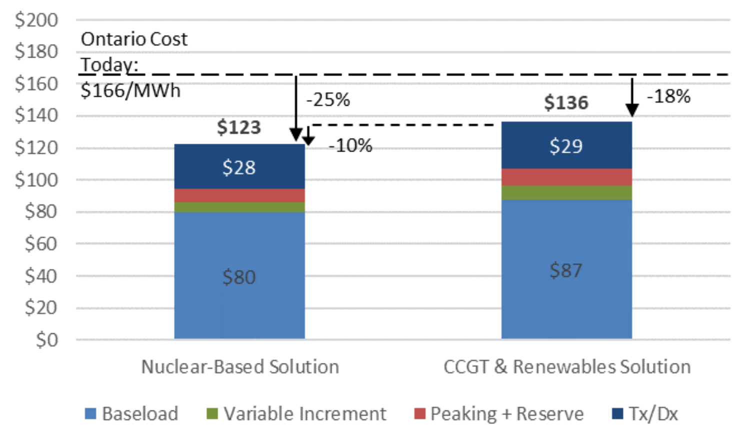
Regional advantages may favor different approaches across Ontario. For instance, carbon capture and sequestration may have limited viability in some regions of Ontario due to local geological conditions.

Nuclear cost advantages

New nuclear based options could also lower other system costs. Firstly, the ability to enable constant operation of hydrogen electrolysis facilities would not only lower the production costs of hydrogen but also allow electrolytic hydrogen to provide economic peaking and reserve options to the electricity system. This would reduce the need for natural gas-fired peaking capacity. Secondly, with a nuclear baseload, storage is used to reduce peaks by smoothing demand rather than account for the intermittency of renewable generation. Finally, the cost of distribution (Dx) and transmission (Tx) delivery infrastructure can be lowered by the improved asset utilization achieved from reduced peaks.

Figure 9: Electricity Costs in Ontario: Nuclear based solution & Renewables-based alternative

($/MWh 2018CAD, NZ2050)



Source: Strapolec Analysis

Costs reflect blended average cost of baseload and variable supply systems, including the benefits of hydrogen as a DR/reserve capacity in the nuclear scenario. Projected future costs are substantially less than today because of increased baseload and more efficient use of Dx/Tx assets. Today cost of $166/MWh reference is prior to shifting contract cost of non-hydro renewables to the tax base. Post this change, generation costs would decrease by $20/MWh.[3] (Ontario, Ontario's Action Plan, 2020).

Ratepayer Implications

An integrated nuclear-based solution could provide ratepayers with energy at a commodity cost 25% less than Ontario's current system, and up to 10% less than the lowest estimate for a future natural gas and renewables-based solution. Ontario's current commodity cost of $166/MWh includes generation, Tx and Dx, and grid operating costs.[28] A significant portion of the total results from renewable and gas-fired generation: the hydro and nuclear component costs $80/MWh with the remainder costing $180/MWh.[29] An integrated, nuclear-based solution could provide power at a cost of $123/MWh, as shown in Figure 9.

These modeled scenario solutions illustrate that an integrated energy system leveraging electricity, natural gas, and hydrogen could significantly reduce the cost to the consumer of the low-carbon electricity that will be required to decarbonize Ontario's economy. The low cost of the nuclear-based solution is enabled by integrating hydrogen flexible load management infrastructure, DSM, and DR to reduce the need for peaking gas plants, which in turn, creates more efficient use of Tx and Dx assets.

[28] IESO, Technical Planning Conference, 2018.
[29] OEB, Regulated Price Plan Price Report, April 2021.

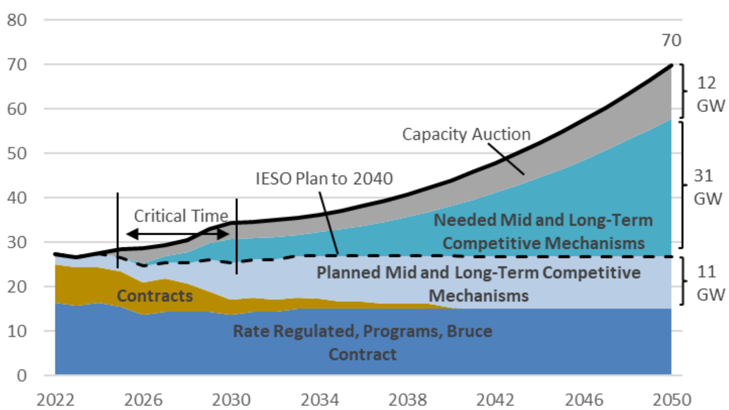
7 Ontario is facing a 55 GW low-carbon electricity supply procurement challenge

Even with a conservatively low electrification demand forecast, achieving NZ by 2050 with integrated wires and pipes optimization and DSM, Ontario will need over 70 GW of capacity by 2050, 2.6 times current levels. Over 55 GW of new generation capacity will need to be procured by 2050, a very aggressive procurement initiative. This section lays out the timeframe to acquiring new capacity, identifies the near-term procurement imperative, and summarizes several challenges Ontario faces in securing the supply required to meet a NZ 2050 goal.

The capacity acquisition timeframe

Figure 10 illustrates a pathway for Ontario to electrify its economy and highlights the new capacity required beyond the IESO's current, planned competitive procurement approach. In addition to the identified need for 4 GW of new peak and reserve capacity illustrated earlier, the IESO's procurement plan to 2040 relies on the renewal of 11 GW of existing capacity assets. This will sustain and increase Ontario's reliance on carbon-emitting natural gas generation, including for the previously mentioned 2 GW of needed baseload capacity. Meeting this 55 GW need for new low-carbon generation by 2050 means Ontario will have to procure another 44 GW of capacity. At present, the IESO has no procurement mechanism in place to accomplish this.

Figure 10: Ontario Procurement Needs with Electrification
(GW by Year)



Source: IESO, APO, 2020; Strapolec analysis

In the near-term, the first milestone on this pathway will materialize in the form of Ontario's 2030 provincial emission target of 143 Mt.[30] Given Ontario's current supply mix and procurement strategy, meeting this target involves 37 TWh of electrified applications that will need new low-carbon supply.

Even without this target, electrification-driven electricity demand is expected to occur organically. Other existing policies incenting EV adoption and charging infrastructure, heating buildings with electricity, and advancing hydrogen technologies will impact demand.

The near-term procurement imperative

To provide the required energy by 2030, the IESO will need to procure another 6 GW of capacity beyond what it has forecast. Combining this figure and the IESO's identified need for 10.6 GW of capacity by 2030 means that Ontario must procure over 16 GW of generation capacity in only 8 years. The possible sources for 9 GW of this supply are currently unknown.

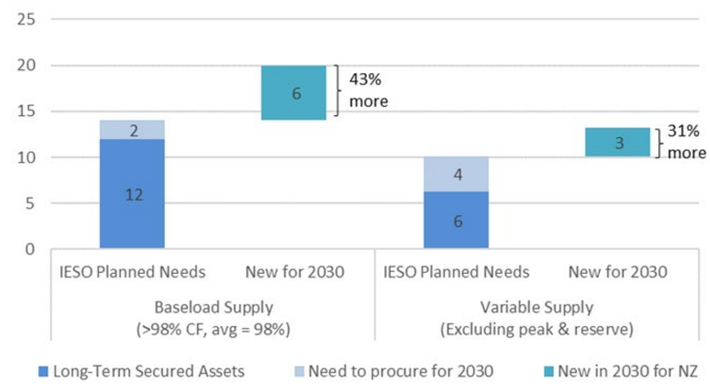
Fortunately, Ontario's existing capacity needs for this period are well known and can therefore be procured against, with electrification potential representing a higher range of likely needs. As shown in

[30] Ontario, A Made-in-Ontario Climate Plan, 2018.

Figure 11, Ontario has an established need for 2 GW of baseload power and another 6 GW by 2030 due to electrification. Ontario already requires 4 GW of variable supply, and potentially needs 3 GW more by 2030 due to continued electrification of the economy. Incremental needs for peaking/reserve supply are expected to be between 2-3 GW, completing the estimated total of 16 GW. [31]

Figure 11: Incremental New Supply Required by Demand Type

(GW, IESO 2030 vs. NZ2030)



Source: Strapolec analysis

However, these pressing procurement needs are materializing at a time when Ontario lacks a coherent procurement approach to address them. The IESO does not plan to begin procurement for long-term needs before 2026, despite the need for those supplies when the capacity gap is forecast to intensify in 2028.

This procurement challenge should not be underestimated. With the short timelines available and lack of preparedness, carbon-emitting natural gas generation may be the only viable option given its short construction timelines.

Procurement challenges to be accommodated in planning

There are several important considerations that must be accommodated in a procurement planning approach. These contribute to the risk that new supply will not be available before 2035:

- **Non-viable U.S. import options**: A recent statement by the North American Reliability Commission (NERC) highlighted the risks of relying on imports from the U.S., noting that many of Ontario's neighboring states are facing capacity shortfalls.[32] Today, the U.S. is also moving forward with its own electrification initiative and NZ 2050-like program.[33] The U.S. supply mix is currently dominated by fossil fuels and is facing a transition of its own. Ontario must confront this reality at home.

- **Gas-fired generation is not a sustainable solution:** While, as the APO suggests, Ontario's existing gas resources may be able to meet most of the known, near-term needs for variable energy supply, there will still be a shortfall. It is also unclear whether this aging asset portfolio can be economically maintained to provide supply to 2050. Furthermore, the associated increase in GHG emissions will undermine the reduction progress achieved by Ontario to date. These assets appear to be better suited for peak and reserve capacity.

- **New gas assets mean stranded cost liabilities:** The IESO's current procurement approach may secure interest from new natural gas-fired generation developers to address the known capacity

[31] Not all numbers are coincident, and do not add perfectly. Net effect is 16 GW of incremental capacity need at peak.

[32] Utility Dive, NERC identifies 4 regions facing potential summer energy shortages, 2021.

[33] CNBC, Biden pledges to slash greenhouse gas emissions in half by 2030, 2021.

gap. However, those and any new facilities procured in the late 2020s to address the emerging demand from electrification will represent at least 20 years' worth of committed cost in carbon-emitting generation that may get stranded.

- **Public opposition to gas plant expansion**: During the last several decades, opposition to new gas generation stations in Ontario has been evident in general and is recently on the rise.[34] Acquiring the necessary environmental approvals and social license for this type of carbon-emitting generation will be a major challenge. Given public concerns about climate change, CCS will be an expected mitigation measure and will add to the cost of this option.
- **Low-carbon solutions will take time to implement.** This analysis has established that Ontario needs substantial low-carbon, baseload electricity generation to achieve its economic and environmental objectives. The new nuclear reactors, hydro stations, biomass plants, wind and solar farms, and battery storage facilities that can provide this baseload are large-scale, complex projects. They require significant investment and multi-step approvals to achieve social license and have multi-year project timelines. Building the required new transmission and distribution infrastructure to deliver this low-carbon electricity to consumers will face the same challenges.

Ontario's sizable capacity challenge is known and the timeline is tight. Without a change in plan, the expected demand in 2030 may already be putting the reliability of Ontario's grid at risk and increasing the prospects of brownouts in the province. Ontario urgently needs a procurement approach and plan that can secure the low-carbon electricity supply needed to ensure reliability, economic competitiveness, energy security, and achievement of Ontario's carbon targets and a NZ 2050 goal.

Ontario should initiate the staged procurement of the required 26 GW of new, low-carbon baseload electricity that will be required over the next 15 years.

[34] Mississauga, Mississauga Council Advocates Province to Phase out Gas-Fired Power Plants in an Effort to Fight Climate Change, 2021; The Energy Mix, Toronto City Council Calls for Ontario Gas Phaseout, 2021.

8 Ontario's unavoidable high emission transition undermines provincial NZ goals

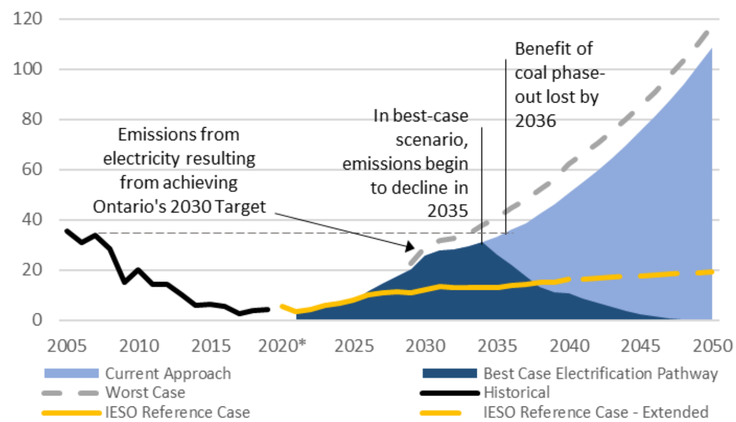
Ontario's current lack of readiness to begin these necessary procurements exposes the province to the risk of a high emission transition to decarbonization. Meeting Ontario's forecast for new demand from electrification without the near-term availability of new low-carbon generation leaves Ontario with no option other than procuring carbon-emitting natural gas-fired generation to maintain reliability. This section examines possible trajectories for emissions from Ontario's electricity system and for the province overall. Outcomes reflect the electricity demand from electrification, the IESO's current procurement plans, and several procurement scenarios.

Electricity System Emission Implications

The emissions implications associated with the four supply scenarios are illustrated in Figure 12.

Figure 12: Emissions Implications Under Emitting and Clean Electricity Options

(Mt, 2005-2050)



Sources: IESO, APO, 2020; Strapolec Analysis

- **IESO Reference Case - APO emission forecast:** The IESO's APO assumes that all existing facilities, including natural gas-fired generation and renewables, will remain available to 2040 and that there will be sufficient generation to meet the province's energy needs. This does not include the impacts of electrification. This APO scenario indicates a 500% increase in Ontario's electricity system emissions over 2017 levels.[35]

- **Current Approach - Gas-fired generation will meet Ontario's new electrification demand:** The current IESO procurement approach suggests that new gas-fired generation will be procured over the next 10 to 20 years to meet Ontario's incremental demand. Under this scenario, the carbon emission benefits of Ontario's coal phase out will be eradicated by 2036.

- **Worst Case - Renewable contracts not extended:** Non-renewal of the existing renewables contracts will increase Ontario's dependence on natural gas-fired generation and/or imports. This results in higher GHG emissions, undermining the benefits of Ontario's coal phase out by 2033 – three years earlier than in the 'Current Approach' case. Challenges facing ongoing renewables operations may include aging, costs, and/or not-in-my-backyard (NIMBY) responses to new terms and configurations.

- **Best Case Electrification Pathway - Low-carbon generation procurement:** Even assuming that procurement of new low-carbon baseload supply could begin this year, the new capacity may not be feasibly available until 2035. Natural gas-fired generation would have to be relied upon until then.

[35] IESO, APO, 2020.

Even so, such an immediate and aggressive procurement of 55 GW of low-carbon capacity between 2035 and 2050 or almost 4 GW per year, would just eliminate electricity system emissions by 2050.

Even with the best-case scenario, Ontario is forecast to experience 15 years of increasing GHG emissions that will return the province to 2006 levels. Under such conditions, Ontario is at risk of losing its clean electricity system status for an extended period of time, a status valued by both the public and business.

Implications of procurement strategies for Ontario's GHG emissions

The emissions profile of Ontario's electricity system will influence the pace at which the rest of the economy can decarbonize. This analysis suggests that Ontario will not be able to decarbonize its economy at the same rate as other parts of Canada. Figure 13 contrasts a potential emissions trajectory for Canada to possible trajectories for Ontario that are anchored by the province's existing 2030 target.[36]

Under an idealized "Targeted Emissions" assumption of immediately available, 100% carbon-free incremental electricity supply, Ontario would begin reducing emissions immediately. The pace would accelerate after 2040, with 60% of the required provincial economy-wide emission reductions occurring in the last decade of the race to 2050. However, even under this ideal scenario, Ontario would be unable to reduce its emissions at a similar pace to the rest of the country. Unfortunately, this ideal case is not feasible under the province's current approach to electricity planning.

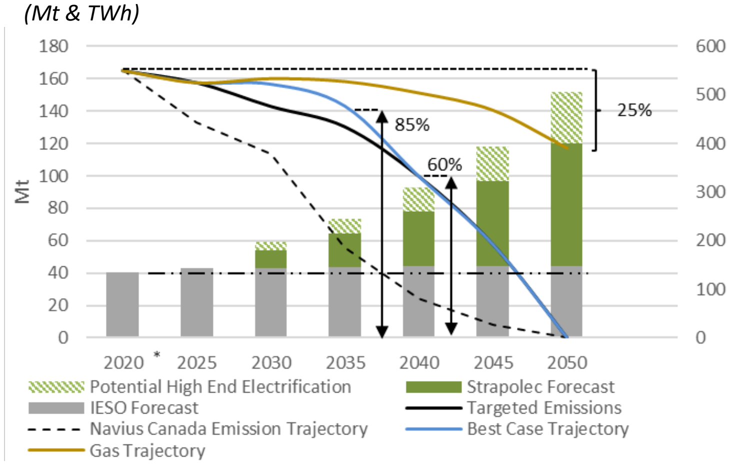
In the worst case "Gas Trajectory", Ontario fails to procure low-carbon resources and electrifies its economy with natural gas-fired generation through to 2050. In this case, by 2050 the electricity sector would be emitting 120 Mt annually, limiting economy-wide reductions to only a 25% lower level. Ontario's overall economy would fail to meet its contribution to NZ by 2050.

In the most optimistic procurement scenario, procurement of low-carbon baseload capacity begins today, with these resources coming online by 2035. In this "Best Case Trajectory", 85% of the requisite emission reductions towards NZ would occur after 2035. Ontario's grid would continue to rely on natural gas-fired generation until that time, with national consequences: the continued emissions from Ontario's electricity sector would set efforts to meet Canada's national 2030 emissions target back by 13%.

The implications are clear: without an immediate low carbon generation procurement strategy, Ontario cannot satisfy its contributions to NZ by 2050.

Figure 13: Ontario's Electrification and Provincial Emissions Reduction Profile

(Mt & TWh)



Sources: IESO, APO, 2020; Navius, 2021; Strapolec Analysis. Note: Includes grid and embedded per IESO, APO, 2020. Assumes carbon capture/sinks address 40% of emissions. Navius, 2021 emission projection scaled to Ontario and scaled to reach 0 Mt emissions in 2050. *2019 IESO emissions used in place of 2020, to remove impact of COVID-19 pandemic.

[36] Navius Research, Achieving net zero emissions by 2050 in Canada, 2021.

9 Procurements should maximize societal benefits

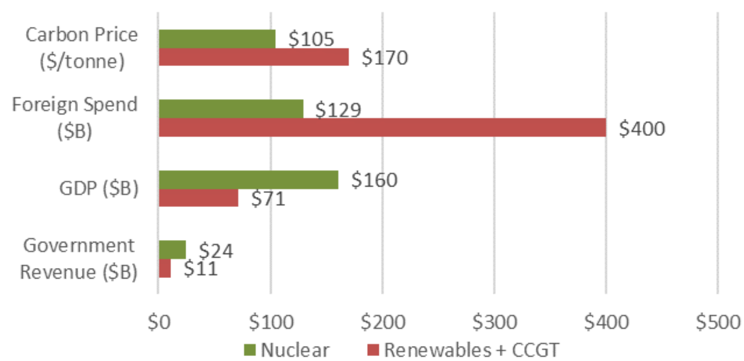
An effective procurement approach requires well defined criteria. The IESO currently relies on reacquiring existing assets and using electricity market mechanisms that favor natural gas-fired generation over low carbon generation options given its low capital and variable costs.[37] However, procuring low-carbon energy resources should be a primary criterion in the IESO's future procurement approach. It is noteworthy that a carbon price is not a cost factor in electricity markets, as Ontario's Emissions Performance Standard (EPS) effectively does not apply a carbon price to natural gas-fired generation. This section considers how the necessary procurements could be structured to best deliver benefits to government, ratepayers, and the public.

A competitive request-for-proposals (RFP) based approach to energy procurements facilitates better management of risks and definition of the desired societal benefits compared to the IESO's market tools adopted from neighbouring, fossil-dependent jurisdictions.[38] The energy transition will require extensive investments in low carbon infrastructure, creating an opportunity for government to maximize the broader benefits to the province of those investments. Adopting this perspective, a comparison of the societal benefits of the available supply options is illustrated by Figure 14. Societal benefits that should be included in Ontario's procurement approach are:

- *Enhance economic growth:* Infrastructure spend creates direct gross domestic product (GDP), jobs, and tax revenues for government. Nuclear-based solutions may generate upwards of $90B more direct GDP than the alternatives. Enhanced GDP provides funds to government to support the cost of the energy transition. Nuclear options could provide double the government tax revenues compared to other solutions.

Figure 14: Economic Impacts of Infrastructure Choices

(For development and construction plus 20-year operations)



Note: Values compared on an equivalent electricity cost basis of $114/MWh. Government revenue illustrated as 15% of GDP. Carbon price from 2016 analysis vs federal backstop to achieve 2030 targets. Foreign spend and GDP based on simulation of options.

- *Accelerate decarbonization:* Low cost, low-carbon electricity can help minimize the carbon price required to accelerate climate action. A nuclear option could achieve decarbonization with a carbon price of as low as $105/tonne versus the federal carbon price of $170/tonne. A lower carbon price reflects a lower societal cost for addressing climate change.

- *Secure domestic energy supply:* Domestically sourced energy provides security against foreign events, such as U.S. natural gas supply shortages, and improves Ontario's trade balance by retaining energy spend in Ontario. A nuclear option could redirect up $270 billion in imported natural gas-fired

[37] IESO, Resource Adequacy Webinar, September 2020; IESO, Resource Adequacy, November 2020; Strapolec, Electricity Markets in Ontario, 2020.

[38] Strapolec, Electricity Markets in Ontario, 2020.

generation fuel costs towards Ontario jobs and GDP. This economic boost from spend that is already occurring could offset many of the costs of Ontario's energy transition.

- *Strengthen industrial policy:* Business opportunity can be created by attracting investment in domestically based, globally competitive firms exporting in emerging sectors, such as zero emission vehicle manufacturing and hydrogen, biomass, and nuclear technologies
- *Enhance Innovation:* Ontario's low-carbon electricity procurements can be leveraged to support growth in programs at domestic universities, colleges, and science and research institutes to develop the trained workforce required to take on the world's energy future. Strategically focused investments in low carbon technologies and innovations can help Ontario achieve this energy transition. Canada's nuclear sector is a leading example of industry/academic collaboration and has yielded advancements in nuclear technologies, material sciences and medical isotopes.[39]

[39] KPMG, A Report on the Contribution of Nuclear Science and Technology (S&T) to Innovation, 2014

10 Ontario's Procurement Approach Requires a Paradigm Shift

The risks to Ontario from the need to procure large amounts of generation in a short period of time are considerable. This is particularly true given that the non-emitting energy solutions of the future are not compatible with the procurement framework being laid out today. This section proposes a paradigm shift in Ontario's procurement approach that would better address the risks, shorten procurement timelines, and optimize the system benefits of the energy solutions being procured.

Three complementary procurement strategies can enable these benefits:

1. Procure against the demand types to be supplied;
2. Seek integrated hybrid energy resources; and,
3. Enable the integration of existing assets to achieve Ontario's transition to a NZ electricity system.

Procure by demand type

Solutions to each of the four demand types – always-on baseload, variable daily demand, seasonal demand, and peak/reserve – have associated cost structures that are well suited to specific demand types. As a result, each type should be procured for separately to enable the most cost-effective solutions. Ontario's electricity markets do not enable such optimization. Furthermore, enabling suppliers to submit integrated bids in response to multiple demand type procurements, may result in further synergies and cost efficiencies. For example, a bidder could make a baseload supply offer a condition of their bid to offer flexible supply using storage. Finally, procuring by demand type would allow better characterization of the demand uncertainty facing Ontario. Known long-term needs for each type could be procured for now with greater confidence. Electricity market mechanisms, such as capacity auction tools to be used for peak/reserve needs, would then be better positioned to address the contingencies around remaining uncertainties.

Integrated hybrid energy resources

The analyses presented earlier confirm that optimal integration of these solutions can reduce the need for system resources. Hybrid resources are defined here as multiple energy resources integrated by one bidder and put forward as a single energy system solution to a procurement need. For instance, if planners specify a desired flexibility of response when characterizing electricity demand, innovators could respond by creating hybrids to match. These integrated options could take many forms, involving different combinations of renewables, storage, gas, nuclear, DSM, hydrogen, and Tx/Dx, all combined to meet a specified demand type identified by a procurement. These integrated hybrid resources may also leverage aggregation of many distributed and smaller assets as envisioned by the aggregator models under development by the IESO.

Integrated hybrid solutions would provide inherent flexibility that is greater than the sum of the individual parts if otherwise separately procured and independently operated. Packaging these disparate resources within one solution may greatly reduce the procurement and dispatching complexity to be managed by the IESO. These solutions present significant system benefits by providing greater flexibility in accommodating variations in demand, maximizing asset operating factor efficiencies, and reducing reliability risks simultaneously at local and system levels.

Such hybrid solutions can also be configured to meet specific regional needs with options for bids to meet the needs of a single region or those of multiple regions simultaneously. This would maximize the benefits of bulk electricity generation, transmission, and distribution assets as well as the integration of non-wires alternatives.

Enable integration of existing assets to achieve the transition

Allowing private sector innovators to combine both new and existing aging assets in proposed integrated solutions to solve specific demand type needs may be the best way to optimize schedule and cost risks while improving the overall system and economic outcomes, provincially and regionally. Existing asset considerations include land holdings, existing generation, the biomass supply chain, private sector assets developed in response to the Industrial Conservation Initiative (ICI), natural gas infrastructure, and under-utilized Tx and Dx assets.

Ontario's future procurement framework could include provisions that allow bidders to sustain the economic life of existing assets, such as gas plants and wind and solar farms, by incorporating them within their offered solutions to long term demand type needs. This would help maximize the economic value of existing assets before their retirement and mitigate the risk of delays in developing the proposed new infrastructure. Assets would become the accountability of the bidders, who would control the operating parameters of their resources to meet the obligations of their bid. This shift of risk to the bidders would equivalently reduce the overall planning and operational risk for the IESO.

While the schedule, capacity, and resources for proposed solution options will vary, the ability to leverage existing resources could benefit the procurement of new large-scale infrastructure such as new nuclear, biomass, hydrogen, and CCS.

Summary: A procurement paradigm shift is needed to manage the risks of achieving NZ

Each of the above procurement reforms shift the resource acquisition focus away from market-based solutions and unlock the potential to reduce planning and implementation cost risks. The changes inherent in these reforms are a significant paradigm shift to the underpinning principles of a procurement framework. Such a paradigm shift is warranted as the non-emitting energy solutions of the future are simply not compatible with the procurement framework being laid out today. By placing the focus on demand needs rather than specific technologies, these reforms allow innovators to help the IESO reduce the procurement risks inherent in the energy transition to NZ. It may well be that innovators are able to optimize the operational risk equation better than the IESO in many areas.

Testing the viability of these approaches with the broader energy stakeholder community is warranted as soon as possible.

11 Conclusion

This report set out to characterize the pressing need for climate-informed electricity planning in Ontario. It provides a forecast of the electricity demand associated with achieving a Net Zero (NZ) 2050 goal and framed it in the context of the low-carbon electricity supply challenge Ontario is facing.

Six key findings underscore the urgent need for a paradigm shift in Ontario's electricity planning and approach to procurement.

1. **Ontario faces an electricity supply shortage and reliability risks in the next four to eight years.**

   Ontario's emerging capacity supply gap was first identified in the IESO's 2013 Long Term Energy Plan (LTEP) and has since widened significantly as no procurement steps have been taken to close it. With the long-expected retirement of the Pickering Nuclear Generating Station (PNGS) in 2025, Ontario faces a capacity gap in 2030 of at least 3.6 gigawatts (GW) for which it has no solution. This gap could widen to 9.5 GW when electrification of the economy is considered. Filling this need is equivalent to doubling Ontario's planned nuclear fleet in eight years.

2. **Achieving Net Zero by 2050 will increase electricity demand by at least 130%.**

   Achieving the goals of Net Zero (NZ) emissions by 2050 being set by the federal government and civil society will require the electrification of the buildings, transportation, and industry sectors. Even assuming significant efficiency gains are achieved, Ontario's electricity demand will increase by at least 130% over current planning forecasts, and potentially by over 190%.

3. **Leveraging electricity, natural gas and hydrogen synergies can reduce supply needs, but 55 GW of new electricity resource will still be needed by 2050 – four times Ontario's nuclear and hydro assets.**

   Emerging forms of energy production and consumption are creating opportunities for low carbon integrated energy solutions involving electricity, natural gas, hydrogen, and demand side management (DSM) innovations to mitigate peak demand and optimize the costs of Ontario's NZ energy future. However, 55 GW of new incremental supply will still be required, with a baseload component equivalent to over 33 new nuclear reactors of the size of those at the Bruce site.

4. **Optimized integrated solutions could enable cost competitive technology options.**

   Low-carbon energy supply solutions such as nuclear, natural gas with carbon capture, renewables, and storage are required for supply Ontario's baseload and variable demand. Cost trends reveal that low-carbon hybrid solutions that combine traditional generation with emerging technologies may be cost competitive. Nuclear-based solutions may be the lowest cost, providing energy at 25% less cost to rate payers than Ontario's current system, however, optimal supply mix choices may vary regionally.

5. **Procurement must begin to avoid a supply shortage in 2030 and maximize emission reductions.**

   Even excluding the impacts of electrification, Ontario has a sustained long-term need for new low-carbon baseload (2 GW) and flexible supply (12 GW). When considering electrification, the need for new low-carbon baseload could increase by an additional 6 GW by 2030. Absent procurement of new non-emitting resources, emissions could increase to levels present when Ontario operated its coal plants. This would put Ontario's status as a clean energy jurisdiction at risk. Procuring any form of low-carbon resources at the scale required could take a decade to site, develop, and commission.

6. **Ontario needs a procurement process to optimize supply options and maximize societal benefits.**

   Increasingly complex energy solutions are undermining the effectiveness and increasing the risks for Ontario's current approach to electricity planning and procurement. Improvements are required that better mitigate risks, accelerate procurement timelines, and optimize the benefits for all Ontarians. An improved procurement approach would: procure resources to fit the type of demand to be supplied, not seeking specific technology; incent dispatchable integrated hybrid solutions; and encourage low-carbon solutions that integrate existing and new energy resources.

   Competitive request-for-proposal (RFP) based procurement approaches are well suited for securing the low-carbon, energy Ontario needs in the long-term. They can also accelerate and maximize the significant societal benefits that result from the hundreds of billions in associated infrastructure investments. Ontario's nuclear technologies are well suited to achieving both goals.

The above findings underscore the great risks and opportunities that lay before Ontario's energy planners. Immediate action is required as a result to mitigate the system reliability risks and enable the significant societal benefits needed to pursue NZ objectives. Developing Ontario's approach to procuring the long-term assets that Ontario needs to replace the PNGS must begin as soon as possible, including stakeholder engagement on approach option viability.

Acknowledgements

This study was proposed by Strategic Policy Economics to explore the pressing need to consider climate action in Ontario's electricity planning process, by modelling the impacts of electrification and energy efficiency on the province's energy consumption, and in turn its electricity system.

Overview of Strategic Policy Economics

Founded by Marc Brouillette in 2012, Strategic Policy Economics helps clients understand the implications of Ontario's energy and climate policy. The firm specializes in characterizing multi-stakeholder issues stemming from technology-based innovations in policy-driven regulated environments such as energy. Reports on Ontario's climate and energy policy have spanned across all major energy and climate issues including the implications of long-term energy planning, emissions reduction, the integration of renewables and imports from Quebec, the economic benefits of extending the life of the Pickering nuclear generating station, the challenges of integrating DER, and the pitfalls of cap and trade.

Production of this report

The Strategic Policy Economics team deployed to develop this report included Marc Brouillette, Qasim Naqvi, Marty Tzolov, Scott Lawson, Anthony Milton, and Jesse Berlin.

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We also thank the individuals within these organizations who shared their views and/or reviewed and commented on draft versions of this report, with particular gratitude to Paul Newall of Newall Consulting Inc.

The Strategic Policy Economics team hopes this report provides a constructive contribution to IESO's approach to procurement and enables Ontario to meet its future electricity system needs in the most effective manner.

Appendix A – List of Acronyms

APO – Annual Planning Outlook

CAES – Compressed Air Storage

CCGT – Combined Cycle Gas Turbine

CCS – Carbon Capture and Storage

CIB – Canada Infrastructure Bank

DR – Demand Response

Dx – Distribution

DSM – Demand Side Management

ECCC – Environment and Climate Change Canada

EPS – Emissions Performance Standard

EV – Electric Vehicle

GDP – Gross Domestic Product

GHG – Greenhouse Gas

GW – Gigawatt

ICI – industrial Conservation Initiative

IESO – Independent Electricity System Operator

LCOE – Levelized Cost of Energy

Li-ion – Lithium Ion

LTEP – Long Term Energy Plan

MENDM – Ministry of Energy, Northern Development and Mines

Mt – Million Tonnes

MWh – Megawatt-Hours

NERC – North American Reliability Commission

NREL – National Renewable Energy Laboratory

NZ – Net Zero

P2G – Power to Gas

PNGS – Pickering Nuclear Generating Station

RFP – Request for Proposals

RNG – Renewable Natural Gas

TWh – Terawatt-Hours

Tx – Transmission

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