Implications of Shutting Down Ontario's Gas-Fired Generators by 2030

Prepared for:

Ontario Energy Association

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Submitted by:

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EXECUTIVE SUMMARY

A number of organizations have recently publicly advocated for the retirement of Ontario's gas-fired generators by 2030. The OEA indicated that it was not aware of any technical analysis of the feasibility of this proposal. Therefore, the OEA asked Power Advisory to examine the feasibility and implications of this proposed action.

Here are the main findings of this report:

- Ontario's electricity grid remains one of the cleanest in the world, and will continue to be, even with a needed increase in electricity supply from gas-fired generators to meet future needs during the mid 2020s to 2030;
- Replacing 11,300 MW of transmission-connected gas-fired generators will cost electricity customers tens of billions of dollars – we roughly estimate this additional cost to be at least $60 billion;
- No one form of alternative supply is singly capable of replacing all of the gas-fired generators this decade, therefore requiring a mix of resources to be developed;
- Gas-fired generators will be necessary for power system reliability in the mid 2020s to 2030 to support:
    - Refurbishments of nuclear generators, until completion in the 2030s, and
    - Variable electricity supply from wind and solar generators;
- Replacing all of the gas-fired generators with supply from Hydro-Québec is not feasible by 2030, as:
    - Existing transmission lines will not provide enough capacity,
    - New transmission across Ontario and Québec will be required, requiring lead times beyond 2030 and public input on location of new transmission lines,
    - Hydro-Québec has never offered Ontario 'firm' supply necessary to replace all of Ontario's gas-fired generators, therefore not matching 'on demand' supply capabilities of the gas-fired generators, and
    - Hydro-Québec has forecasted its own supply 'deficit' over the coming years;
- Gas-fired generators may play a critical role in helping Ontario meet its greenhouse gas emissions reduction objectives facilitating the expansion of Ontario's clean power system to replace carbon fuels.

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1. INTRODUCTION

Power Advisory was retained by the OEA to study the role of gas-fired generators in Ontario. We were asked to:

1. Provide an overview of the role of gas-fired generators within Ontario's electricity market; and
2. Compare the cost of replacing all large (i.e., transmission-connected) gas-fired generators[1] by 2030 with other supply resources.

[1] All references made in this report to replacing gas-fired generators refers to replacing the 11,300 MW of transmission-connected gas-fired generators in Ontario

2. OVERVIEW OF GAS-FIRED GENERATORS IN ONTARIO

Ontario's electricity market is one of the cleanest in the world. Over the last decade, the province's coal-fired generators were fully retired, while large amounts of renewable generators were integrated into the market. As part of that transformation, many gas-fired generators were built to maintain power system reliability and support retirement of all coal-fired generators. Other supply resources, such as Ontario's nuclear and many hydroelectric generators, continue to provide constant baseload supply throughout most of the year and will continue to do so for decades to come.

2.1 Gas-Fired Generators Key to Long-Term Investments and Growing Demand

Gas-fired generators will be even more vital over the next decade, as Ontario's electricity market undergoes another significant change – the rebuilding of a majority of the province's nuclear generators so they can safely and efficiently operate over the next four decades. At the same time, one of Ontario's oldest nuclear generators will be fully retired. These changes will occur while electricity demand is expected to increase annually as the economy continues to grow. Gas-fired generators are already built and strategically located where demand is highest. They will be necessary to meet growing demand at a time when nuclear generators will retire and be refurbished, while avoiding material bill increases for electricity customers and reducing greenhouse gas (GHG) emissions across the entire economy.[2]

While Ontario has had a significant surplus of electricity supply over the past decade, it will increasingly face a shortage over this decade, particularly mid 2020s to 2030. This forthcoming supply need accelerates once the 3,100 MW Pickering Nuclear Generating Station ("Pickering") is retired in 2025. Gas-fired generators will play an important role, not just by limiting the severity of future supply needs, but also supporting refurbishments of nuclear generators. Ontario's Independent Electricity System Operator (IESO) currently forecasts, even with all operating supply resources, a supply 'deficit' in the summer months, when demand is highest. This deficit will increase materially by 2030 – hitting as much as 3,500 MW. But again, this is assuming all existing generators – including the more than 11,300 MW of transmission-connected gas-fired generators – remain in-service.[3]

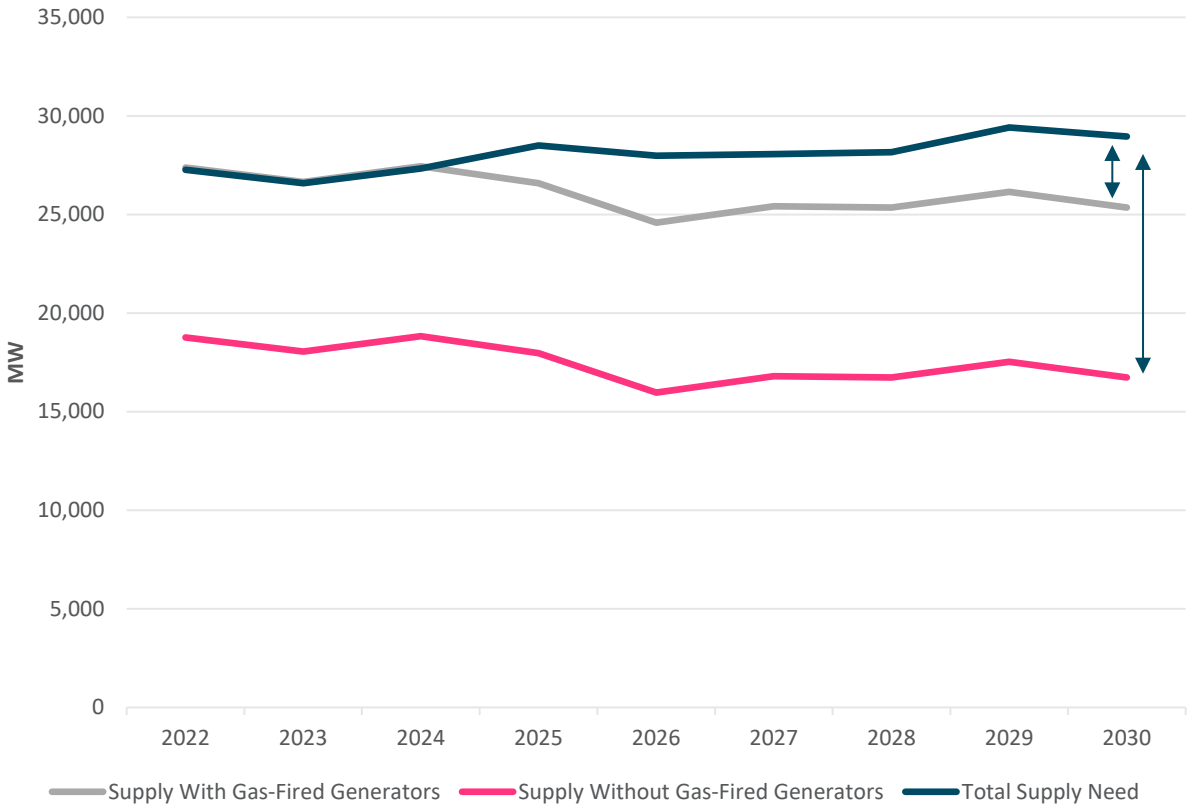
Notably, if all gas-fired generators – both those with IESO contracts that extend beyond 2030 and others with expired contracts – are shut down, the supply deficit reaches approximately 12,200 MW. A supply deficit of that magnitude is equivalent to more than two full Bruce Nuclear Generating Stations (the world's largest nuclear generator) or more than 34 million rooftop solar panels.

Therefore, gas-fired generators will be an integral part of the supply mix during the mid 2020s to 2030, in order to cost-effectively maintain power system reliability and meet forecast supply needs.

[2] See the IESO's 2020 Technical Planning Conference presentation. The IESO's analysis shows that small increases in electricity sector GHG emissions are more than offset in decarbonizing other sectors of Ontario's economy, such as transportation and home heating.

[3] All figures related to installed supply capacity come from the IESO's most recent 20-year Annual Planning Outlook. See https://www.ieso.ca/en/Sector-Participants/Planning-and-Forecasting/Annual-Planning-Outlook

Figure 1 Ontario's Supply Deficit with and without Gas-Fired Generators



2.2 Gas-Fired Generators Provide Multiple Benefits in Ontario

Beyond just filling the supply deficit, gas-fired generators are in many ways unique in Ontario (relative to other supply options), in that each generator provides a variety of supply attributes and fulfills needed roles within Ontario's electricity market, depending on the circumstances of the day. Not many other supply resources in Ontario are capable of fully replicating the range of supply attributes provided by gas-fired generators.

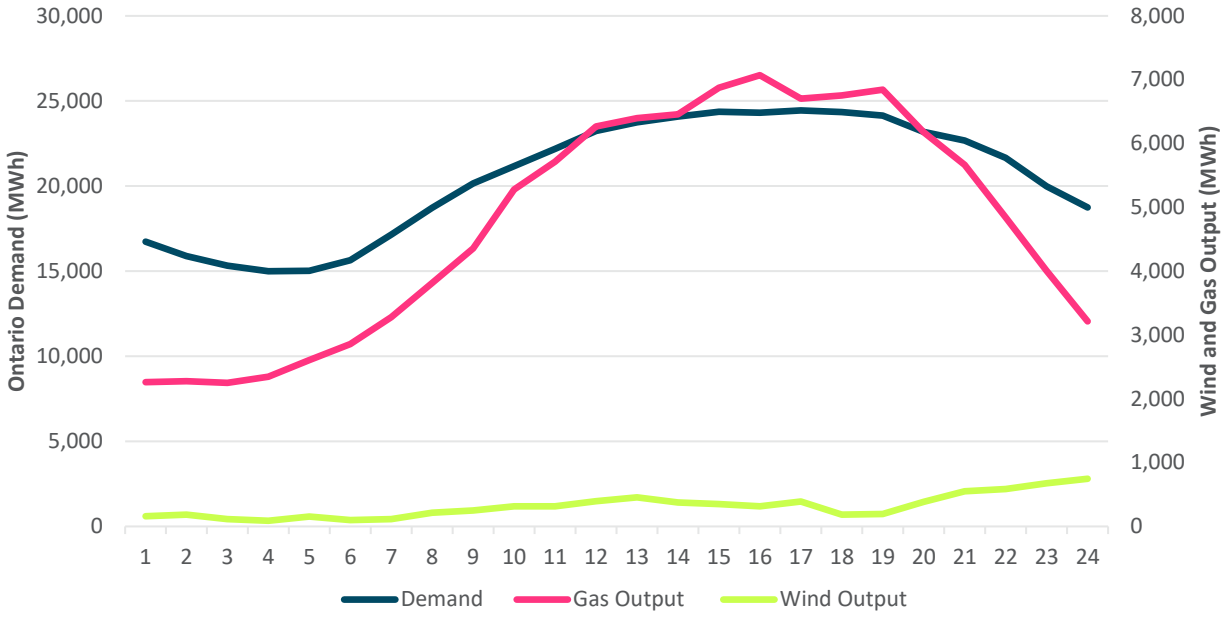
2.2.1 Baseload When Needed During a Time of Nuclear Generator Retirements and Refurbishments

Baseload supply is intended to run nearly continuously to power equipment like refrigerators and operating rooms in hospitals. In Ontario, this role is largely served by nuclear generators and many hydroelectric generators. But demand for electricity – particularly in the summer months when air conditioning drives demand higher – can in many hours, days and weeks be greater than baseload supply and require gas-fired generators to fill the supply gap and operate. The need for this kind of supply will increase due to the combination of the retirement of Pickering and refurbishments of other nuclear generators.

An example of gas-fired generators providing reliable supply occurred on July 9, 2020 when Ontario experienced the highest level of demand in more than seven years (see following graph). While this focuses on a single day, demand was consistently high throughout the entire week – well beyond the supply capacity of the nuclear and hydroelectric generators. Supply from wind generators was also quite low in many hours on that day. As a result, Ontario's gas-fired generators, provided reliable supply throughout the day to maintain power system reliability. They also provided 'peaking' supply that matched demand throughout the day – highlighting two of the capabilities that gas-fired generators provide to the electricity market. At the peak, nearly one-third of all supply from gas-fired generators came from generators located within the Greater Toronto Area (GTA).

If the gas-fired generators were not available, Ontario would have had to find more than 7,000 MWh of supply during the highest demand hours – beyond the supply capability of any of the existing supply resources within Ontario, including demand response[4], and the import transmission connections to neighbouring markets. It would have also had to find around 2,000 MW to 3,000 MW of additional supply throughout the day. Without the gas-fired generators, Ontario would likely have had to implement more drastic actions to maintain the reliability of the power system (e.g., at the extreme, rolling blackouts).

Figure 2 Gas-Fired Generators Supply During Ontario's Peak Demand on July 9, 2020



2.2.2 Supply Flexibility is Vital to Electricity Markets

Gas-fired generators also provide much needed supply flexibility to Ontario's electricity market. While Ontario currently has a large amount of baseload supply, it also has a significant level of variable supply,

[4] Demand response resources are paid to reduce their electricity consumption during peak demand hours

notably more than 5,400 MW of wind generators and 2,700 MW of solar generators.[5] Given that these supply resources are totally dependent on the weather to provide energy, their supply can change very quickly, even minute-by-minute – the result of a sudden change in wind patterns or cloud cover, among many other factors.

Given the physical requirements of the electricity grid – where supply and demand have to be balanced instantaneously in real-time – when one generator suddenly changes its supply output, another resource must respond in kind. Most nuclear generators are unable to change supply quickly. Many hydroelectric generators are capable of such response, but face water or other operational restrictions that can limit their ability to fully react for extended periods of time. Once on-line, gas-fired generators are capable of quickly increasing or decreasing supply in response to conditions on the grid and within the electricity market. In Ontario, the IESO explicitly noted the need for additional supply from gas-fired generators in hours when less supply had been forecast from wind generators. In fact, several years ago, the IESO implemented changes to the market to help address this issue.[6] More broadly beyond Ontario, gas-fired generators have typically been installed on a one-to-one basis with wind and solar generation. A study from the National Bureau of Economic Research noted that in electricity markets around the world, responsive gas-fired generators have grown in tandem with wind and solar generators.[7]

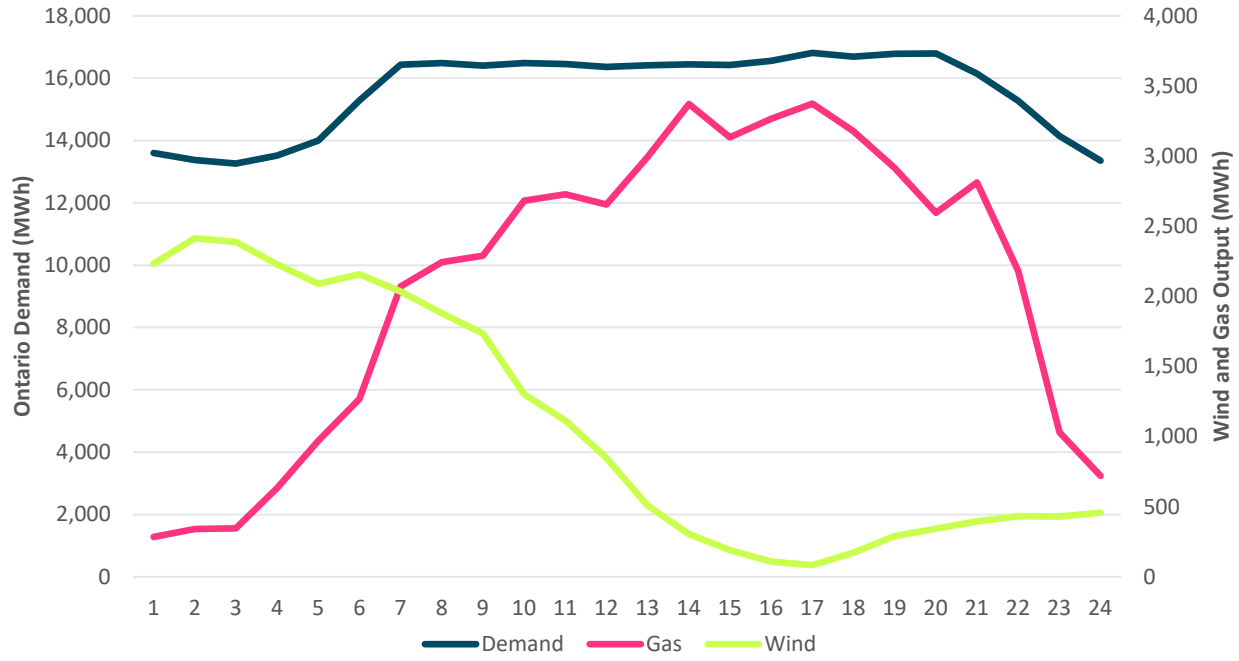
As an example of the importance of supply flexibility from gas-fired generators occurred on April 4, 2019 (among many others). On this day, supply from wind generators suddenly dropped from more than 2,400 MWh in the early morning hours to less than 100 MWh in the peak demand hours in the afternoon, even though demand remained relatively steady throughout the day. Gas-fired generators were able to 'ramp up' their supply to fill that gap and maintain reliability of Ontario's power system. When demand began to taper off in the overnight hours, gas-fired generators were able to respond and reduce supply. Some gas-fired generators can also provide that flexibility on a minute-by-minute basis, responding to variable supply from wind and solar generators.

[5] Most solar generators in Ontario – nearly 2,200 MW – are 'behind-the meter'. These are generators that are not connected to the bulk transmission network and, as such, are beyond the reach of the IESO for dispatch control.

[6] The IESO's name for this is called the "Flexibility Mechanism" and is explicitly targeted for hours when there is a material change in output from wind generators.

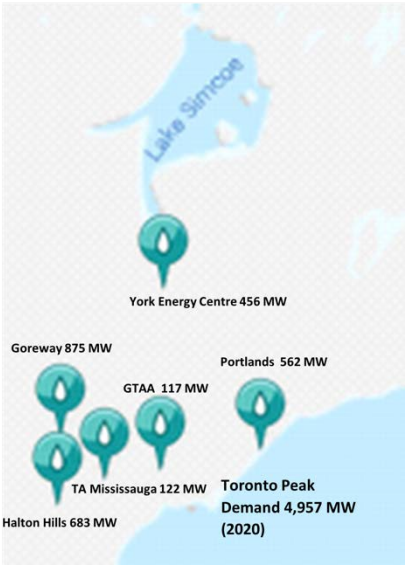
[7] See https://www.nber.org/system/files/working_papers/w22454/w22454.pdf

Figure 3 Gas-Fired Generators Supply Flexibility in Ontario



2.2.3 Gas-Fired Generators are Near Ontario's Urban Centres Where Demand is Highest

Unlike many generators in Ontario that are located in distant regions in the province, gas-fired generators are often strategically located near major demand centres, such as the GTA. As a result, they help reduce the risk of blackouts due to outages on major transmission lines, while also reducing the amount of supply that is lost when it is transmitted over long distances. Being strategically located also helps to reduce congestion on transmission lines that may reduce the amount of supply that can flow from distant generators (e.g., in northern Ontario) to major urban demand centres (e.g., in southern Ontario). Supply imported from neighbouring jurisdictions, such as Québec or Manitoba, often suffer from similar transmission constraints.



Of particular importance is that the current transmission grid cannot manage large-scale supply imports from other jurisdictions (e.g., Québec[8] and Manitoba) without significant investments in new or expanded transmission lines within Ontario and even outside of Ontario within the province where the supply originates.

In the GTA, there are nearly 2,900 MW of gas-fired generators connected to the transmission grid. That is enough to supply the

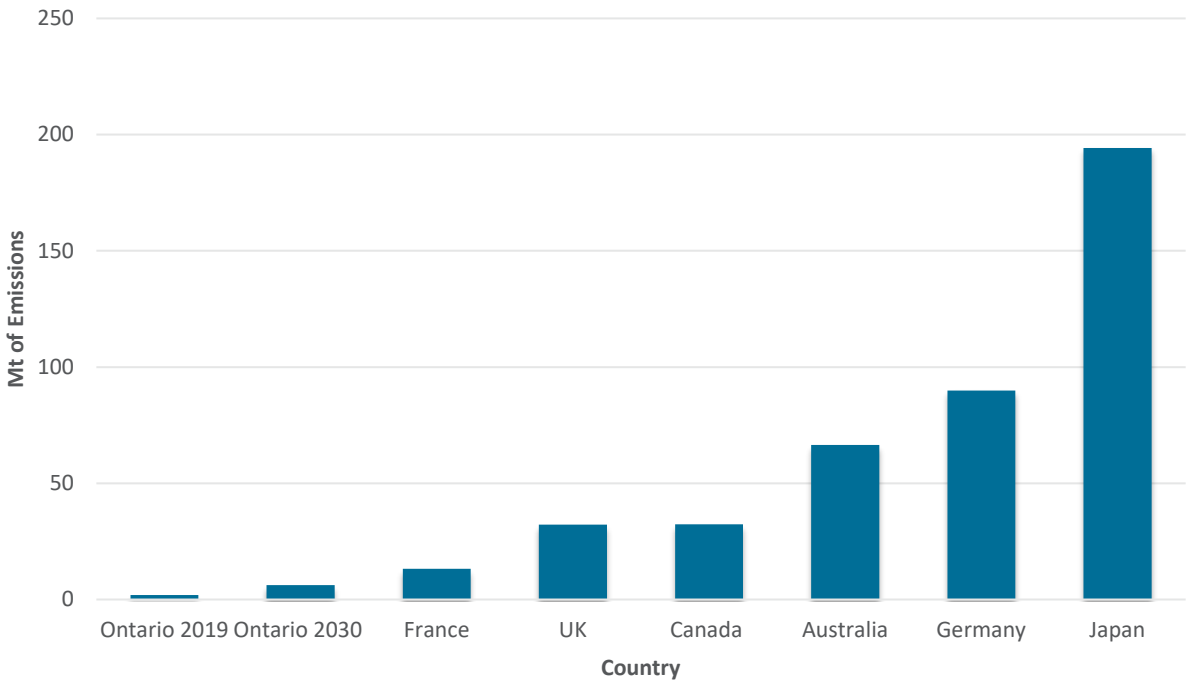
[8] See Case 5 on p. 23 within the IESO report, *Ontario-Quebec Interconnection Capability: A Technical Review*, located at https://www.ieso.ca/sector-participants/ieso-news/2017/05/ontario-quebec-interconnection-capability---a-technical-review

city of Toronto with approximately more than half of its supply needs on a peak demand summer day. If those gas-fired generators were to be removed, moving additional supply into the province's largest urban centre will face transmission constraints – the transmission lines would simply not be large enough to carry that much supply in hours when demand is highest.

2.3 Ontario's Grid is One of World's Cleanest

Ontario has been a success story in terms of GHG emissions reduction and power system reliability. GHG emissions have been reduced by nearly 85% since 2005, while power system reliability has been more than maintained, despite the closure of all coal-fired generators. Ontario's electricity market is cleaner than those of nearly all major developed economies and will remain so over the next decade.

Figure 4 2019 Electricity Sector GHG Emissions [9]



GHG emissions are expected to remain relatively low over the next decade – even with the planned retirement of Pickering and refurbishments of other nuclear generators. By 2030, GHG emissions will be 63% below those of 2005. Additionally, GHG emissions from the province's electricity market will account for just 2% of all GHG emissions – compared to more than 17% of all GHG emissions in 2005. More importantly, a recent analysis from the IESO shows that a slight increase in GHG emissions in Ontario is more than offset by decreases in other parts of the economy due to electrification investments.

[9] The figures from this table are taken from the IESO, both historical and forecast, and the International Energy Agency (IEA). The GHG emissions are calculated based on assumptions of operating characteristics of the different electricity systems and resources.

Therefore, Ontario's electricity market will continue to be a leader in lowering GHG emissions compared to nearly every other jurisdiction in North America.[10]

Notably, investments over the next decade in non-GHG emitting supply resources, particularly with the refurbishment of some nuclear generators, will help mitigate GHG emissions post-2030 and allow innovative investments in new generation to be introduced in a cost-effective manner.

[10] See the IESO's 2020 Technical Planning Conference presentation

3. THE COST AND FEASIBILITY OF REPLACING GAS-FIRED GENERATORS BY 2030

As shown in the previous section, gas-fired generators play a vital role within Ontario's electricity market – both in maintaining power system reliability and meeting supply needs during peak demand hours. Replacing the 11,300 MW of transmission-connected gas-fired generators in Ontario by 2030 – or nearly a third of total installed supply capacity across the province – will range in the tens of billions of dollars in new costs for Ontario's electricity customers.

This is not a repeat of Ontario's closing all of its coal-fired generators. The coal-fired generators were generally replaced on a one-for-one basis with gas-fired generators, which have many of the same supply attributes yet carry a lower environmental cost. Replacing all gas-fired generators by 2030 with alternative supply resources is a much more difficult and challenging exercise – carrying greater financial risk and requiring a more substantial grid-wide transformation. It will also result in stranded natural gas assets – both in the form of gas-fired generators that are still on contracts and must be paid to retire early and numerous pipelines and other forms of long-term infrastructure that will not be required but will continue to be paid for by Ontario's energy customers.

3.1 Costs and Feasibility to Replacing Ontario's Gas-Fired Generators

Any discussion on closing the existing gas-fired generators must include an estimate of the costs and physical feasibility of building alternative sources of supply. Particular attention needs to be paid to the unique supply attributes of gas-fired generators in comparison to alternative supply resources to fully understand whether a full retirement over this decade is financially responsible and physically possible from planning and regulatory viewpoints.

For preliminary indications of potential costs to replace gas-fired generators, prices that the IESO determined to value capacity supply[11] can be used as a starting point. Using the IESO's Maximum Capacity Auction Price of $516/MW-day (CAD) applied for an entire year results in costs of approximately $2.13 billion (CAD) per year to replace 11,300 MW. Therefore, if this logic were applied from 2021 to 2030, this results in in additional base costs of approximately $21.3 billion[12] (CAD). However, this alone would not reflect the full cost to replace 11,300 MW with alternative supply resources for the following considerations and reasons:

- Maximum Capacity Auction Price was used to reflect a larger amount of more expensive alternate supply resources needed to replace 11,300 MW of gas-fired generators, as opposed to IESO procuring only 992 MW from their December 2020 Capacity Auction;
- Resources that receive payments from the IESO's Capacity Auction also receive additional payments within Ontario's electricity market, where, together, all payments ensure recovery of

[11] See http://reports.ieso.ca/public/CA-PreAuction/PUB_CA-PreAuction.xml for pre-Capacity Auction parameters

[12] Assuming no changes to the IESO's Maximum Capacity Auction Price, and assuming no inflation or any other adjustments to costs over time

investment costs plus returns on these investments, therefore costs required to replace the gas-fired generators will be greater than payments received from the IESO's Capacity Auction;

- Methodologies that the IESO used to determine prices proxying capacity value do not take into account more expensive supply alternatives, where these supply alternatives will be required within a mix of resources to replace the gas-fired generators;
- Building on the above point, costs to build new transmission lines and other transmission upgrades were not considered within the methodologies that the IESO used to determine prices proxying capacity value; and
- Financial compensation to the owners of gas-fired generators needs to be added to the replacement costs to retire these generators prior to the end of their useful life.

Therefore, considering the above points, the likely magnitude of costs is over three times greater than the base costs of $21.3 billion (CAD) outlined above. Altogether, we roughly estimate the minimum costs to replace 11,300 MW of gas-fired generators to be at least $60 billion (CAD).

3.2 Alternate Supply Resources to Replace Gas-Fired Generators and Key Considerations

The following table provides important considerations for alternative supply resources regarding their potential to replace Ontario's gas-fired generators by 2030. Overall, no one competing form of supply resource is fully capable of replicating the various attributes of gas-fired generators that currently provides flexible and baseload supply, especially when demand is high. All alternative supply resources carry incremental costs to site, permit, and build, particularly when compared to gas-fired generators that are already built and under long-term contracts, but this is not to suggest that some of these resources cannot provide benefits to Ontario's power system.[13]

[13] See *Unlocking Potential: An Economic Valuation of Energy Storage in Ontario*, located at https://energystoragecanada.org/unlocking-potential

Table 1 Considerations for Replacing Gas-Fired Generators with Alternate Supply Resources by 2030

Resource Type	Considerations and Commentary
Gas-Fired Generators	• Can provide both flexible and baseload supply • Numerous gas-fired generators strategically located near major urban demand centres and require no transmission investment • Produces GHG emissions when supplying electricity and subject to federal carbon pricing
Nuclear Generators	• Can provide consistent, baseload supply over a long-term planning horizon and produces no GHG emissions • Typically has less flexibility, high up-front capital costs and requires years of in-depth planning • Recent proposals for Small Modular Reactors (SMRs) have yet to be proven commercially feasible
Hydroelectric Generators	• Can provide both flexible and baseload supply with no GHG emissions • Limited sites available for large project development in Ontario • Would be built far away from urban demand centres, requiring significant transmission investments • Large hydroelectric generation projects have recently suffered from significant cost and schedule overruns (e.g., Muskrat Falls (Newfoundland & Labrador), Keeyask (Manitoba), Site C (BC))
Wind Generators	• Can provide emissions-free supply and is increasingly cost-effective • Provides variable supply that cannot always be relied upon to be available during high demand hours • Would be sited away from urban demand centres, likely requiring transmission investments
Solar Generators	• Provides emissions-free supply during peak demand hours and can be sited within small and large urban demand centres • Variable supply subject to weather conditions, provides less supply during winter months – requiring investment in back-up supply
Energy Storage	• Provides flexible supply and can be easily built near and in urban demand centres, and commercial and industrial facilities • High up-front cost and supply is limited due to current regulatory barriers • Requires additional supply build in combination with storage build
Distributed Energy Resources (DERs)	• Can provide flexible supply and can be built in urban demand centres and on a variety of sites (e.g., house, businesses, apartments, etc.) and is scalable • DERs need to be developed in combination of developing other resources, due to limits to the amount of supply from small-scale resources
Demand Response (annual cost)	• Flexible resource that can respond to peak demand conditions on short notice cost effectively • Limits to the amount of demand response that can be considered
Conservation and Energy Efficiency	• Can be a cost-effective resource to mitigate demand growth • Limits to how much can be procured and would involve significant regulatory and policy implementation to implement efficiently
Limited Imports Over Existing Transmission	• Can cost-effectively provide emissions-free, flexible and baseload supply • Current transmission system limits imports required to fully replace gas-fired generators • Requires transmission investment for Ontario's grid and likely outside of Ontario within province of the supply origination (e.g., Québec).
Full Imports Over New Transmission	• Can be a flexible source of supply and, potentially, emissions free • Using Québec as an example, will require significant transmission in Ontario, as well as in Québec

Under every scenario, the cost of shutting down Ontario's gas-fired generators by 2030 will range in the tens of billions of dollars. Replacing all of the gas-fired generators will also involve significant additional costs in terms of transmission lines and other grid upgrades, as well as additional regulatory and operational costs, among many others. Transmission investments typically take years of planning, require expropriation of many properties and impose their own environmental impacts – none of which has been adequately assessed. Ultimately, closing all of the gas-fired generators by 2030 will entail an infrastructure build-out orders of magnitude higher than what was needed to shut all of the coal-fired generators, and require years of stakeholder engagement, detailed planning and project development.

Just as important, a number of alternative supply resources are not physically capable of fully filling the supply gap left by removing the gas-fired generators. In many cases there are technological limits to how much of a particular supply resource can be built and relied upon to meet peak demand in Ontario over this decade. Therefore, a combination of alternative supply resources will be needed to replace the gas-fired generators. This report has specifically not attempted to 'optimize' investments by picking and choosing what amount of each alternative supply resource should be chosen to replace the gas-fired generators.[14]

3.3 Feasibility of Replacing Gas-Fired Generators with Import Supply from Québec by 2030

Ontario and Québec have a long history of beneficial electricity trading between the two provinces. Electricity trading between jurisdictions is typically a 'win-win' exercise, with one market providing cheap electricity to another market in need and vice versa. Given that Québec's electricity demand is highest in the winter, while Ontario's demand peaks in the summer, electricity trade between the two provinces makes economic sense within the physical capabilities of the two grids. Even without a long-term deal, Québec has been Ontario's largest electricity trading partner.

Nonetheless, relying on Hydro-Québec (HQ) – the crown corporation that owns and operates that vast majority of hydroelectric generators within Québec – to fully replace even a portion of Ontario's gas-fired generators creates a number of financial and physical obstacles.

The Price of Electricity Supply from Québec

As noted, Ontario currently has 11,300 MW of transmission-connected gas-fired generators. HQ has never proposed replacing that amount of Ontario-based supply with import supply. HQ had previously proposed to provide a much smaller amount of electricity supply at a cost of approximately $61.00/MWh (CAD) – or nearly five-times the average wholesale energy market price in Ontario in 2020 – which the IESO concluded was not cost effective and would lead to higher electricity bills for Ontario's electricity customers.[15]

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[14] IESO recently stated plans to develop a study to assess different scenarios and costs within a variety of alternative supply resource combinations that may be technically feasible to replace gas-fired generators in Ontario. This study is scheduled to be completed later this year.

[15] See the IESO's *Assessment of Hydro Quebec's Updated Electricity Import Proposal and Exploration of Options for Enhancing its Value to Ontario Ratepayers*

More importantly, any long-term deal for such a significant amount of supply from HQ will likely be based on future prices in neighbouring markets (New York and New England in particular) where HQ is active in selling its supply. Prices in these neighbouring markets are expected to hit nearly $70/MWh (USD) by 2030. A deal with HQ will likely be no less than this level for a fixed amount of supply, which would exceed the per unit cost of supply from Ontario-based gas-fired generators and may even be in the form of a 'take or pay' contract – meaning Ontario's customers would have to pay for that supply even in hours when it is not needed.

Québec Facing Its Own Supply Constraints

HQ may currently have surplus supply, but it is forecasting its own 'deficit' over the next decade.[16] Any long-term deal with Ontario will add to that deficit, requiring additional supply investments within Québec – a cost that may likely be included in any contract with Ontario for supply. It will also limit the amount of supply that HQ can offer to Ontario, that is well below the total amount of gas-fired generators in Ontario.

Grid Limitations to Importing Supply from Québec

The current transmission interconnections between Ontario and Québec can accommodate around 2,100 MW of supply – or about 19% of all of the gas-fired generators currently in operation within Ontario. In 2017, the IESO undertook a detailed study on the investment required in order to increase the amount of electricity supply that can be imported from Québec on a 'firm' basis (i.e., reliable supply to meet Ontario's peak demand needs during respective hours) over the 1,250 MW Outaouais transmission interconnection (as the other interconnections proved to not be capable of supplying on 'firm' bases).[17] The study concluded that the maximum supply that would be possible would be a little more than 2,000 MW – or less than a quarter of gas-fired generators in Ontario. Nonetheless, the study concluded that even getting to that amount would require more than $200 million (CAD) in transmission upgrades and five to seven years of planning. Within the Québec grid, significant transmission investments would also be required to expand its capability to deliver the increased volumes of supply to Ontario – with these grid-wide costs likely to be included in any deal with Ontario. These costs will increase as the amount of supply offered to Ontario increases.

Ontario Transmission System Needs to Be Expanded

Much of Ontario's gas-fired generators are located near or within urban centers. Supply is delivered directly to the highest demand locations, limiting the size and cost of Ontario's transmission system. Replacing even a portion of gas-fired generators with import supply will require significant transmission investments in Ontario to move that supply into the largest urban centres, such as Toronto.

Ontario's transmission system has been designed and constructed based on existing load centers and large generators. A shift to large-scale imports would require an expansion of the transmission system that moves electricity from one region of the province to another. Large transmission system expansions generally take seven to ten years to complete and include rigorous environmental assessments, local community engagement (and opposition in some cases) and engineering. In addition, the land use for

[16] See https://www.hydroquebec.com/data/achats-electricite-quebec/pdf/hqd-dae-consultations-20200617-eng-v1.pdf

[17] See the IESO's *Ontario-Quebec Interconnection Capability: Technical Review*

new transmission lines would be significant and require expropriation of properties. If all of the gas-fired generators in Ontario were replaced by HQ imports, it is reasonable to assume significant transmission investment would be required to connect Québec to the GTA.

4. CONCLUSION AND ADDITIONAL CONSIDERATIONS

Gas-fired generators are beneficial to Ontario's electricity market – both by maintaining power system reliability and meeting supply needs.

- *Costly Replacement*: A sudden retirement of all gas-fired generators will result in significant and material increases in electricity costs for all Ontario electricity customers. As highlighted above, alternative supply resources will be costly to construct and will, in many cases, require large-scale upgrades to the grid to accommodate them. Over the last decade, Ontario completed its closure of coal-fired generators and large-scale integration of renewable generators – with gas-fired generators playing a pivotal role in that transformation. The Ontario government has recently moved some portion of those costs to taxpayers in order to provide relief to customers (i.e., ratepayers) across the province. Retiring the gas-fired generators over the next decade is likely to entail costs in orders of magnitude greater than the previous decade.
- *Physical Limitations:* Whether it be difficulty in permitting a new nuclear generator, building new transmission to accommodate new large-scale hydroelectric generator projects, constructing wind generator projects across Ontario, or placing solar panels on roofs in urban centres, no one alternative supply resource is solely capable of physically providing the key attributes of gas-fired generators given its attributes and physical limitations. Instead, such a transformation will require detailed planning in order to determine what the optimum combination of supply resources that can be relied upon to maintain current levels of power system reliability and meet supply needs.
- *Significant Trade-offs*: Replacing gas-fired generators will require trade-offs – in terms of power system reliability requirements, cost increases and planning decisions around the siting and permitting of new supply projects, among other considerations. It will also require Ontario to consider relying on neighbouring jurisdictions to provide 'firm' and reliable supply over long-distance transmission lines and interconnections, rather than supply resources located within Ontario. These trade-offs will have an impact on the province's economy and industry.
- *Stranded Assets:* Most gas-fired generators are under long-term contracts with the IESO. As such, any premature closing of these generators will result in significant costs to Ontario's electricity ratepayers by breaking those contracts and creating stranded assets.[18] If this were the case, Ontario will likely need to create a specific charge to electricity ratepayers under any premature closure of gas-fired generators.
- *Stranded Natural Gas Infrastructure:* Ontario has significant amounts of pipelines and other infrastructure that has been built to reliability supply natural gas to gas-fired generators. Some portion of those assets will no longer be required if all of the gas-fired generators are retired over this decade. Given that many infrastructure assets are paid for over long periods of time, this will

[18] A recent example of costs resulting from stranded generator assets exists in Alberta. In 2016, owners of coal-fired generators reached agreements with the Government of Alberta for over $1.1 billion (CAD) in compensation to retire all coal-fired generators (6,300 MW) by 2030. Considering the 11,300 MW of gas-fired generators in Ontario, the Alberta example sets financial compensation precedent – where much higher financial compensation will be required if all gas-fired generators in Ontario were to retire by 2030.

result in Ontario's natural gas customers facing rate increases to pay for assets that are no longer in-service and thus have no revenue stream.

- *GHG Emissions Outside of Ontario*: Importing supply from neighbouring jurisdictions may result in a net increase in GHG emissions across North America. First, any imported supply would have to be adequately tracked to ensure it did not come from a gas-, coal- or oil-fired generators. Additionally, while non-emitting supply may flow into Ontario, its replacement in other jurisdictions could be high-emitting coal- or oil-fired generators. Any increase in GHG emissions that result from greater import supply, particularly from the U.S., into Ontario should be calculated.