Decarbonization and Ontario's Electricity System

Assessing the impacts of phasing out natural gas generation by 2030

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Introduction

Ontario homeowners, businesses, and organizations across many sectors, including municipalities, are actively pursuing new opportunities to accelerate decarbonization. With one of the cleanest power grids in North America, Ontario is at a considerable advantage to decarbonize its economy through electrification.

Less than a decade ago, Ontario's electricity system made a seismic shift with the elimination of coal generation. Today it is 94 per cent emissions-free and contributes only three per cent to the province's total greenhouse gas emissions – with nuclear power supplying the bulk of our energy needs and natural gas generation working to support wind and solar power.

Yet, with emissions from gas generation forecast to increase in the next few years, some Ontarians are asking whether the electricity sector can do more to support decarbonization goals by further reducing its carbon footprint.

The IESO is listening. As the power system operator and planner, we understand the evolving challenges and opportunities in the electricity sector, and are uniquely positioned to inform this discussion.

This study, therefore, examines the question posed by more than 30 Ontario municipal councils in their resolutions calling for the complete phase out of natural gas generation in the province by 2030. We have used our expertise to produce a technical assessment that explores, at a high level, the impacts to power system cost and reliability in removing carbon emissions from the system.

Our study shows that natural gas generation provides a level of flexibility to respond to changing system needs that would be impossible to replace in the span of just eight years. As a highly flexible resource, gas delivers energy when it is needed most, providing almost three quarters of the system's ability to respond quickly to changes in demand. Newer forms of supply, such as energy storage, are not ready to operate at the scale that would be needed to compensate; nor is there enough time or resources to build the necessary generation and transmission infrastructure to replace gas generation within an eight-year timeframe.

Even if these practical considerations could be overcome, the most optimistic assumptions show that without gas generation, Ontario's electricity system would see frequent and sustained blackouts in 2030. As evidenced by the recent blackouts in California, there is a considerable risk in not having a diverse supply mix effectively balanced against the variability of solar and wind output.

In addition, the analysis shows that removing gas from the electricity system would result in a substantial increase in costs to consumers. For the average homeowner, the effect of removing gas would add $100 to the monthly electricity bill, which represents a 60 per cent increase. Rising costs would also stifle investments in decarbonization.

These results, however, are only one part of the broader picture of emissions in Ontario. The study also identifies the work that needs to be done to ensure the system supports demand growth from electrification and at the same time mitigates its own emissions.

While the removal of gas from the grid is not possible by 2030, it can be accomplished in a way that will ensure reliability, given an adequate amount of time for the sector to plan and prepare.

Properly assessing this kind of work will be critical – and can't be done in isolation. Just as this study was informed by input from stakeholders and community feedback, the IESO will continue working within the sector – as well as with businesses, academics, municipalities and other organizations in the broader electrification space – to explore the best approach to leverage the electricity sector to support decarbonization in Ontario.

Study Highlights

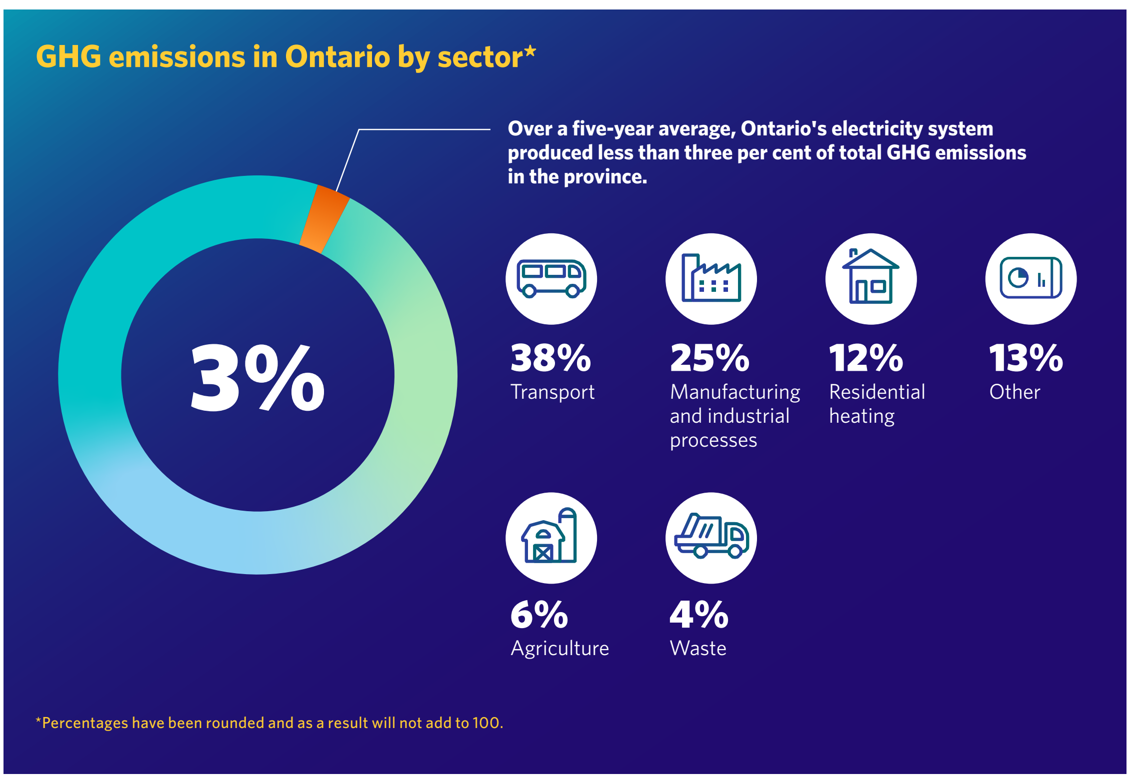
Natural gas generation accounts for 28 per cent of Ontario's capacity to produce electricity, but only seven per cent of total system output. Electricity production from the existing gas generation fleet is, however, expected to increase as a result of nuclear refurbishments and retirements, as well as rising electricity demand.

In this study, the IESO looked at the reliability and cost impacts of moving Ontario's electricity grid to a 100 per cent emissions-free supply mix by 2030. The results provide insight into potential pathways for future system evolution.

Key Findings:

- Analysis shows that a complete phase-out of gas generation by 2030 would lead to blackouts, as electricity would not always be available where and when needed. Gas generation offers a set of services, including quick response time and availability, that keep the grid reliable and help balance the variability of wind and solar output.
- There is no like-for-like replacement supply that can offer similar operating characteristics of gas generation. Because gas is generally always available and can respond quickly, at least 17,000 megawatts (MW) of non-emitting forms of capacity and 1,600 MW of energy conservation would be needed to take the place of 11,000 MW of natural gas generation capacity. Given a longer timeframe, more cost-effective and reliable options would be available for consideration.
- The IESO's modelling of how to replace gas by 2030 would require more than $27 billion to install new sources of supply and upgrade transmission infrastructure. This translates into a 60 per cent or $100 increase on the average monthly residential bill. High electricity costs may deter consumers from investing in carbon reduction, such as through electric vehicles or new equipment.
- The model is also based on a number of very optimistic assumptions. In reality, there are significant practical reasons why it would not be possible to build substantial amounts of new supply and reorient the system to incorporate it by 2030:
  - Building and upgrading substantial transmission and generation infrastructure would need to be completed within the eight-year time frame – this includes regulatory and environmental approvals as well as securing the people, capital and resources to do the work. The development of a single new transmission project today can take at least seven to 10 years under optimal circumstances.
  - Year-round electricity supply would need to be available from Quebec, which is unrealistic given that it is reliant on electricity imported from Ontario and other jurisdictions during the winter months. Quebec is expected to fall below required levels of reserve capacity by 2030.
  - Storage and demand response would need to supply energy and demand reduction in unprecedented quantities – far beyond what is currently attainable.

- Ontario has one of the cleanest systems in the world when it comes to carbon emissions per kilowatt-hour – 93 and 92 per cent lower than the U.S. and German grids respectively, and 81 per cent lower than the rest of Canada.
- An increase in electricity sector emissions does not necessarily mean an increase in economy-wide emissions. For example, an electric vehicle (EV) charged up in Ontario, produces only three per cent of the emissions produced by a similar car that runs on gasoline. Even if that EV is charged on the hottest summer days when gas is used the most, it still would produce only 40 per cent of the emissions compared to its gas counterpart.
- Electrification of other sectors offers a far more cost-effective pathway to decarbonization than removing natural gas from the grid. Phasing out natural gas generation would bring the cost of carbon reduction in the electricity industry to at least $464 a tonne, a steep price compared to other carbon abatement efforts.
- There is also tremendous potential in Ontario to use emerging resources to meet future supply needs. Storage and demand response already feature on the grid with another 5,000 MW of clean energy sources operating at the local level. The IESO has been working to better integrate new technologies on to the grid and with local distribution networks as it prepares the system to meet future energy needs.
- Overall, the study provides important learnings about the new realities of operating power systems, offering a sharper focus for discussions about how Ontario's grid can support the anticipated rapid increase of electrification in the province. The IESO, in partnership with stakeholders in the electricity sector and the broader economy, will develop a work plan to determine what's needed to prepare the grid for a decarbonized future.

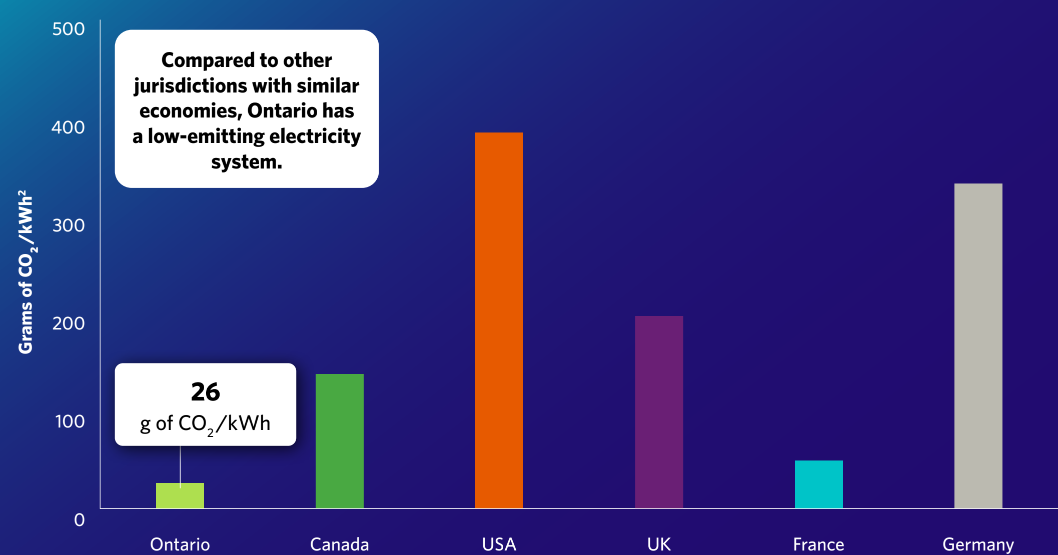


Assessing the Impacts of Phasing Out Natural Gas Generation by 2030

As jurisdictions around the world grapple with the need to decarbonize, electricity systems face a unique challenge. With its low-emission system, Ontario has a fundamental advantage in decarbonizing its economy. Yet like many places, it depends on the flexibility of natural gas generation to ensure a reliable power system.

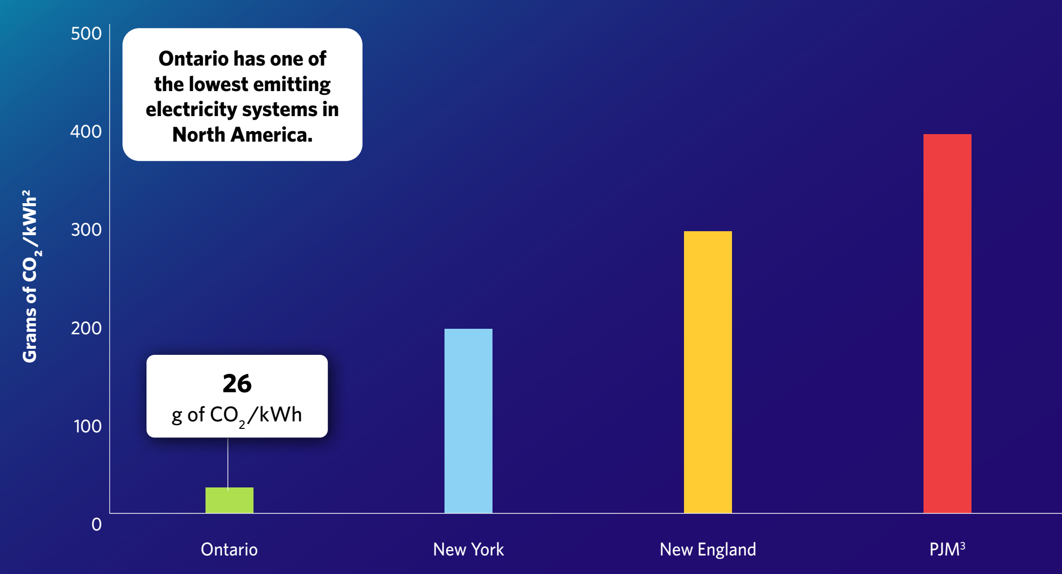
After becoming the first jurisdiction in North America to completely phase out coal-fired generation in 2014, Ontario has one of the cleanest electricity systems on the continent. Including supply on both the distribution and transmission networks, Ontario's electricity system was 94 per cent emissions-free in 2020. On average, it accounts for just under three per cent of emissions in the province. For comparison, the electricity sector in the U.S. accounted for a quarter of all emissions there in 2019, while electricity production contributed roughly 21 per cent of emissions in the U.K., 17 per cent in New York State and 15 per cent in California.

Ontario's electricity system GHG emissions vs. other jurisdictions[1]



[1] This graph shows the amount of CO_2 emitted per kWh of electricity produced. This value is often referred to as the Carbon Intensity (CI).
[2] Based on 2019 data

Yet with nuclear refurbishments underway, Pickering nuclear generators retiring at the end of 2025, and electricity demand increasing annually, there is a need to increase electricity output from other Ontario generating facilities, principally gas generators, to balance supply and demand. As a result, electricity system emissions are forecast to increase this decade from a recent average of 4.4 megatonnes (Mt) to between 10.9 and 12.2 Mt in 2030 – still only one-third what they were in 2005.



[1] This graph shows the amount of CO_2 emitted per kWh of electricity produced. This value is often referred to as the Carbon Intensity (CI).
[2] Based on 2019 data for all regions.
[3] PJM is a regional electricity transmission organization serving parts of the American Midwest and East Coast.

As governments, communities and residents explore options for reducing overall emissions, some have focused on this anticipated increase. This year, more than 30 Ontario municipal councils passed resolutions calling for either the reduction of gas-fired emissions, or their complete elimination, by 2030.

Electricity is key to our quality of life, our economy and the delivery of essential services – which makes understanding the impacts of phasing gas out of the energy supply mix critically important for informing conversations and decisions on a course for the future.

In our unique role as the power system operator and planner, the IESO works with all organizations across Ontario's large, interconnected and dynamic electricity system to deliver on our core mandate of reliability and affordability.

We have explored the feasibility of phasing gas out of the system by 2030 via this study. Our technical assessment examines, at a high level, the impacts to power system cost and reliability that would arise from a decreased reliance on natural gas. It is not a plan, but intended to provide meaningful insight to build a common understanding of the challenges that would need to be addressed in any effort to lower emissions in Ontario's electricity generation supply.

The Fundamentals of Reliability

Ontario's electricity system is a large, dynamic and interconnected machine with many factors working together to ensure the reliable operation of the grid.

To ensure that the right amount of electricity is available when and where it is needed, the IESO forecasts supply and demand, plans for future system needs, acquires supply resources, procures various electricity services to support reliability, and recommends the development of transmission infrastructure. On a real-time basis, the IESO's control room operators administer the wholesale market to efficiently match supply to demand to keep the grid reliable.

In Ontario, gas generation plays a crucial role in the reliability of the electricity grid. It provides a range of services that no other resource today can provide on its own, including producing large amounts of power to meet high demand, and running for extended periods when other resources are not available.

Elements of a Reliable Electricity System

Some of the most important elements of a reliable electricity system are capacity, energy, other ancillary (or reliability) services, and transmission infrastructure. As a result, a supply mix must be able to provide for all these specific needs:

- **Capacity** is the ability of a supply resource to deliver energy – either a generator that increases its output or businesses, institutions or aggregated homeowners that can reduce consumption when needed. To plan a reliable electricity system, the IESO must ensure that adequate capacity is available to supply demand throughout the year, including during peak times.
- **Energy** refers to actual electricity output over a specific period of time.
- **Ancillary Services** – also known as reliability services – are critical to the reliable operation of the grid, and include things like frequency regulation and voltage control.
- **Transmission Infrastructure** delivers electricity from generators along high-voltage power lines to consumers – a key consideration as supply is often limited by where it can be located.

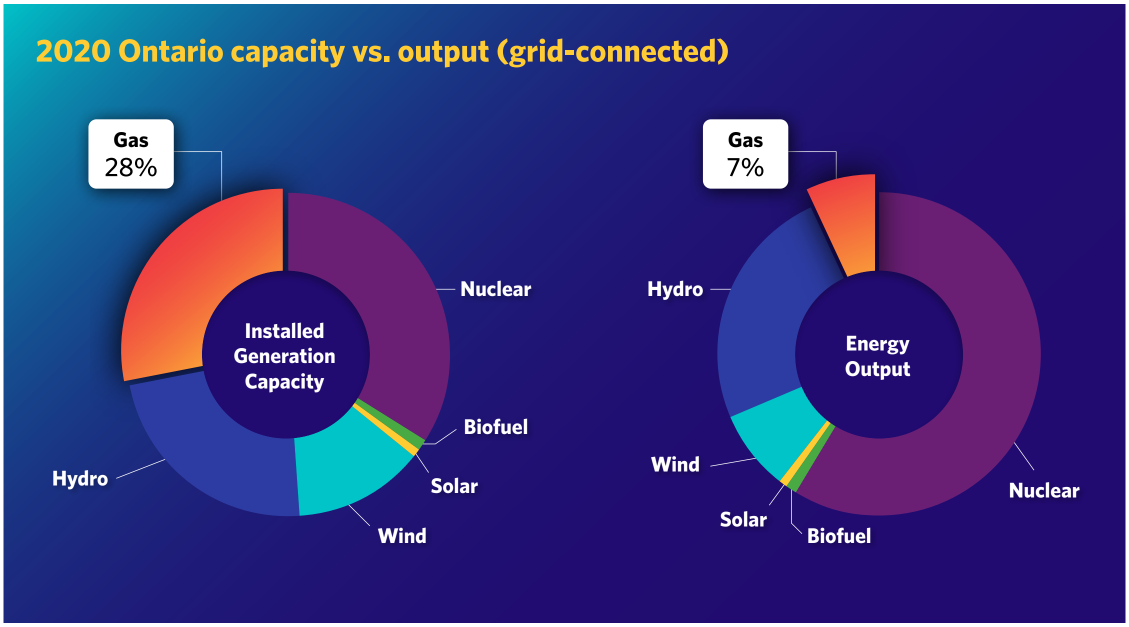
Long-Term Planning

Planning for electricity needs 10 or 20 years into the future requires careful consideration of many different factors that influence both supply and demand. Building new transmission infrastructure and new generation takes many years, with time needed to plan, obtain necessary regulatory and environmental approvals, engage with affected communities, and then build and integrate the resources into the provincial grid.

The IESO's Annual Planning Outlook (APO) provides a 20-year forecast for Ontario's electricity system. The outlook includes projected electricity demand, a resource adequacy assessment, transmission considerations, and performance indicators, such as an emissions outlook. It also identifies the province's energy and capacity needs.

A Diverse and Flexible Supply Mix

Diversity in energy supply strengthens the reliability and resilience of Ontario's power system, as different types serve different functions in order to meet needs. No single energy option can meet all system needs at all times. Maintaining a diverse supply mix, where the different forms of supply complement each other, is an effective way to balance supply and demand to maintain the reliability of Ontario's power system.



The province's demand for energy can fluctuate throughout the day by as much as 10,000 MW from low to peak times – requiring different energy resources to perform different roles. Some sources are needed to produce a constant supply of energy, while others increase or decrease in step with second-by-second changes on the system.

In Ontario, different forms of supply offer different operating characteristics.

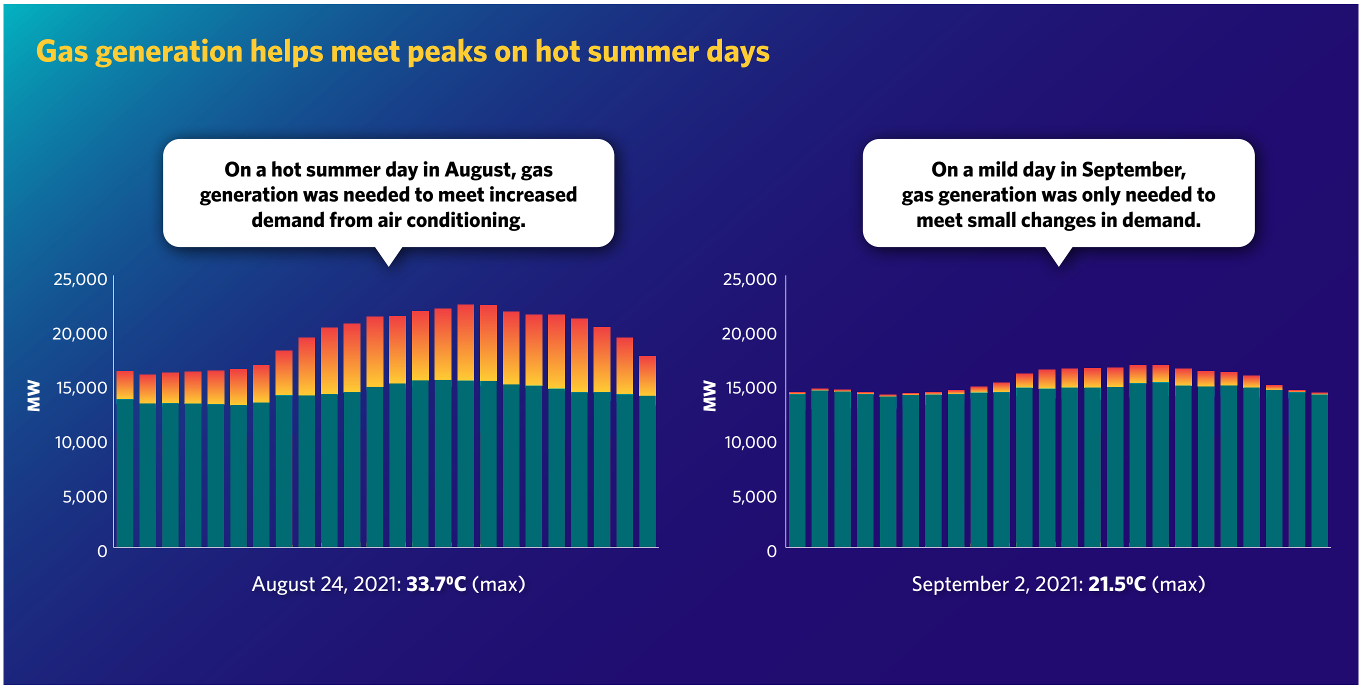
- Nuclear and "run-of-the-river" hydroelectric generation provide constant, steady power 24 hours a day.
- Wind and solar offer variable output depending on the wind and the sun, but can provide some flexibility by reducing production when active.
- "Peaking" hydro generators are able to store water and are very flexible, increasing and decreasing their energy output as needed to match fluctuating demand.
- Imports from neighbouring jurisdictions also play a critical role in maintaining reliability, bringing in power when supply conditions are tight.
- Demand response – energy consumers who reduce energy use when needed – can help reduce peaks on short notice.
- Gas generation has a unique range of operating characteristics needed for the reliable operation of the power system.
- Storage provides the ability to capture excess energy and reinject it into the system when supply is low.

Standards for safety and reliability

As system operator, the IESO is the Reliability Co-ordinator for the province. It is accountable for following reliability standards for planning and operating within the interconnected North American bulk electric system.

The Role of Natural Gas in Ontario

While gas generation comprised roughly 28 per cent of the province's production capacity in 2020, it generated just seven per cent of energy used. As a readily available fuel source in Ontario, it provides energy consistently and confidently when it is needed most. As a result, it provides almost three quarters of the system's ability to match supply and demand under all conditions, a reliability service known as flexibility.

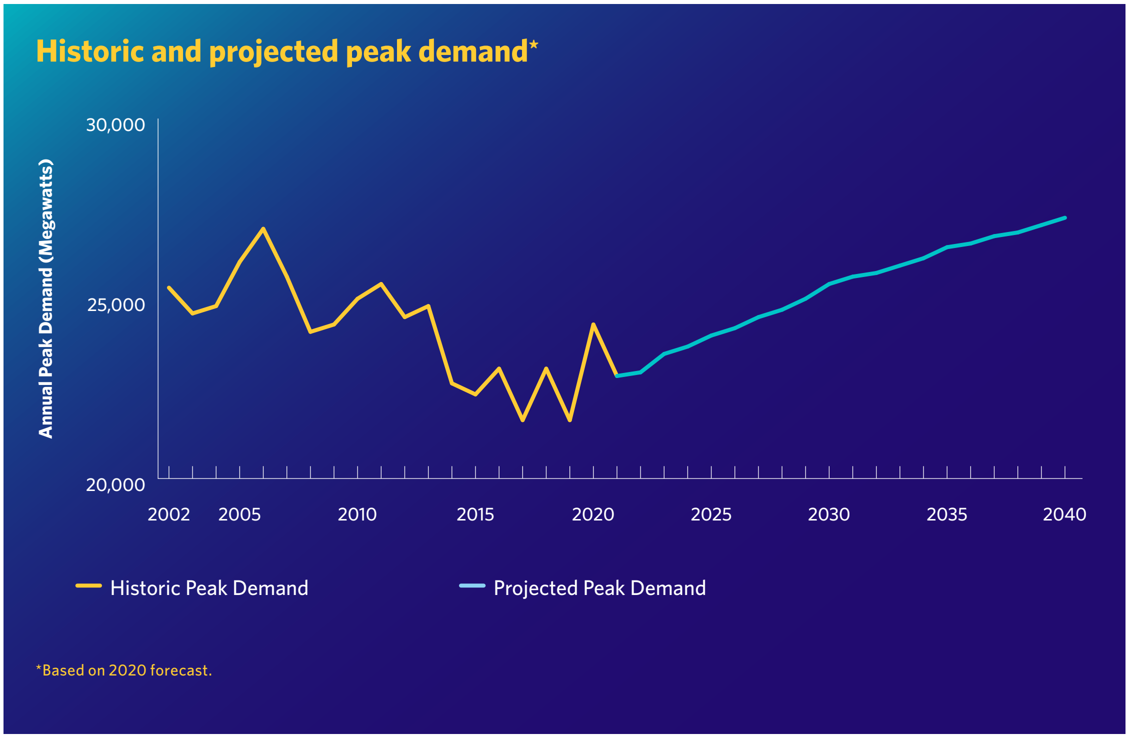


Here are the ways gas generation supports grid reliability:

- With Ontario's robust gas supply infrastructure, gas generation can provide continuous energy when needed as it is generally available at all times of the day throughout the year, under all weather conditions.
- Given its flexibility, gas generation can be ramped up or down within minutes to follow sudden or unexpected changes in demand or in the availability of other generators. This is important when managing the ebb and flow of wind and solar generation and the constant demand changes in the system.
- Gas plants are generally located near large population centres to support local power needs, avoiding the need for potentially expensive or disruptive transmission projects.
- Gas also provides reliability services that help stabilize voltages and frequencies on the transmission grid. Often, these services are also needed close to population centres.

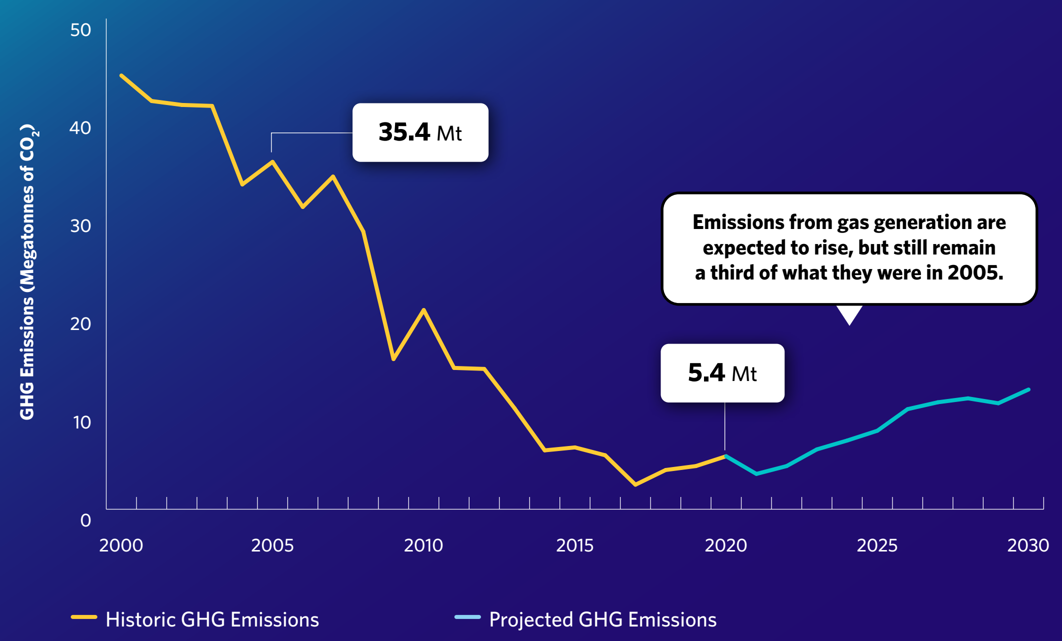
Ontario's Future Supply Needs

After years of strong supply, Ontario is now entering a period of growing electricity needs – most immediately and significantly to meet the need for capacity at times of peak demand, but also to satisfy overall energy requirements towards the end of the decade.



On the demand side, needs are driven by economic growth and electrification. Supply shortfalls arise out of expiring contracts with existing facilities, the retirement of Pickering Nuclear Generating Station and refurbishments to extend the life of other nuclear units in the system.

As electricity demand increases and nuclear production decreases, the IESO expects production from existing gas-fired generation to increase in future, depending on the pace of economic growth.



*Data for 2020 is estimated by the IESO using the APO, Energy Efficiency case forecast.

The IESO is taking immediate steps to acquire supply to meet these increasing needs – using more competitive approaches with relatively shorter commitment periods. Currently, an annual auction secures capacity to help meet peak demands, attracting demand response, imports, storage and local generation.

Soon, a medium-term procurement will seek multi-year commitments from existing generators to bridge mid-decade needs created by the retirement of Pickering Nuclear. The IESO also anticipates a new Request for Proposals (RFP) for longer-term commitments to be issued in late 2022, beginning with public engagement to seek input in advance.

However, no matter how resources are secured, an increase in electricity sector emissions does not necessarily mean an increase in economy-wide emissions. Switching from high-carbon fuels to low-carbon electricity could increase electricity sector emissions while reducing overall province-wide emissions.

The carbon intensity of the electricity system remains far below that of other fuels, such as gasoline for automotive transportation or fuel oil for space heating. As electricity consumption increases, the rise in electricity sector emissions could be reduced by increased energy efficiency, or incorporating more clean forms of supply, but at the right pace to ensure reliability.

The Scope

This study examines the feasibility of phasing out Ontario's gas generation fleet by 2030. It examines the role of gas within the system today, its technical characteristics and the range of reliability services it provides.

It then models a replacement supply mix of low-carbon resources to meet projected electricity demand. The mix includes non-emitting resources with operating characteristics that are well understood today and that could conceivably be in service by 2030, at the lowest-possible cost.

This assessment highlights the impacts of removing gas generation both on costs and on system reliability, ensuring that enough energy is available when it is needed. These are fundamental measures of the viability of any proposed supply mix, which helps with the identification of challenges that will guide the IESO's work in the years ahead.

Modelling a New Supply Mix Scenario

This study examines one potential pathway to phasing out gas by 2030. Based on the demand forecast from the 2020 APO, it builds a theoretical supply mix, without gas, and with additional amounts of non-emitting resources that either provide energy or reduce demand.

This study provides the perspective of a system operator, focusing on electricity system reliability and affordability, and only technologies that can be built with well understood operating characteristics. Technological innovations, policy developments, and grid evolution could change the options available in the near or far future, but they are difficult to predict.

Two other scenarios were also looked at: one that considered a market-based approach with higher gas prices with broader application of carbon pricing, which would reduce the use of gas-fired generation; and one that looked at adding non-emitting resources to the existing fleet by 2030 to reduce emissions, with gas generation still included.

Initial results for these other scenarios demonstrate significant cost increases without material emissions reductions. Given these challenges, and the fact that a complete phase-out of gas-fired generation has been the focus of public discussion that gave rise to this study, these scenarios were not fully developed.

In modelling a new supply mix, results were assessed against basic reliability standards and practical considerations, taking into account a number of assumptions:

Adequacy: The mix had to adequately meet required energy, capacity and reserve power needs, including total annual energy demand, and had to satisfy summer and winter peak demand. Yet, one of the technologies chosen, energy storage, has never been used at a scale this large in Ontario, and another, small modular nuclear reactors, are only in the development phase.

Operability: As power system reliability must be maintained at all times, the mix was analyzed for a balance of characteristics that would allow it to respond to changing conditions. North American and Ontario-specific reliability standards require the flexibility to continuously match supply and demand, as well as ancillary services. Operability was only assessed at a high level as a complete analysis of the impacts to operability would require approximately 18 months.

Location: New transmission, and extensive upgrades to existing transmission infrastructure, would be needed to enable generators in the north, increase imports from Quebec, and deliver supply for the Greater Toronto Area (GTA) and other areas of high consumption. The study also considered the impact of potential locations for new generators or alternative transmission infrastructure to some extent, but was limited by not knowing where they would be located. Finding available locations for new renewable generation, for example, may require off-shore wind facilities.

Cost: To the extent it was possible to predict, the mix was determined favouring the least expensive supply options. Costs could not be calculated in all areas, such as the value of work involved to make the replacement supply mix operable within the power system, or what the expense of necessary transmission upgrades might be.

Timing: The 2030 target limited the number of options available. For example, new hydro generation could not be included due to long development timelines. Similarly, other emerging technologies such as hydrogen storage and renewable gas could not be considered. The scenario also assumed optimistic timelines associated with construction of generation and transmission, even though it is unlikely that the amount of work needed could be achieved concurrently.

Lessons Learned from Coal Retirement

The phase out of coal generation in Ontario still represents the largest GHG reduction initiative in North America and a significant achievement for the electricity sector.

At the time, gas generation was readily available to provide replacement capacity as a mature technology with similar, albeit slightly less flexible, operating characteristics. As such, the IESO's experience in planning for and coordinating the coal phase out has been instructive in its assessment of a potential gas phase out.

The entire effort took 12 years to complete, requiring careful preparation and execution. It involved the introduction of replacement supply including nuclear, gas, wind and solar generation, transmission expansion and the launch of an ambitious energy-efficiency program under the Save on Energy banner.

By 2014, emissions from the electricity sector amounted to just three per cent of all provincial emissions, down from 21 per cent at the outset. Reliability was assured throughout, but added $4 billion in additional costs to ratepayers, impacting affordability and competitiveness.

Bringing on large numbers of generators with different fuel types posed administrative and operational challenges, in particular requiring new approaches to monitoring and operating variable generation. Gas generation was also brought online to meet some very specific flexibility needs.

Transmission impacts were also taken into account. Ontario's coal power plants supported load centres such as the GTA and so new supply was placed in nearby locations to help avoid building new transmission lines. In addition, the Bruce-to-Milton line expansion facilitated supply from new renewable generators and refurbished units at Bruce Power.

In this case, stranded costs related to the coal phase out were relatively small given the age of Ontario's coal generation fleet. Most of the province's gas generators were built to replace coal and still have decades of potential useful life ahead of them.

In implementing the phase out, careful and continuous coordination and adjustment of plans was required. Beyond system planning and operating considerations, environmental and planning approvals, as well as capacity in the construction sector to build new infrastructure, were critical dependencies that impacted timelines.

And finally, the process of ramping down actual coal-fired production was a key consideration. It was essential to ensure that fuel, staffing and maintenance plans were in place for retiring facilities to provide insurance for reliable service during the transition.

While there are many similarities in considering a phase out of gas generation, there are some marked differences. Today, there are no obvious replacements for gas generation as was the case for coal. Yet, there are many opportunities to develop new technologies and integrate them to become efficient and reliable contributors to the system into the future.

The Results

IESO modelling and simulations show that a reliable electricity service cannot be maintained, nor can the system support further electrification or accelerated economic growth if gas generation is phased out by 2030. Even under the most optimistic scenario, the IESO would frequently need to resort to emergency actions such as rotating blackouts to manage energy shortfalls.

Despite Ontario's extensive experience with various supply resources – including renewable generation – developing and building a mix of clean and cost-effective technologies at the scale needed to replace gas generation by 2030 would not be feasible. This would exclude using significant quantities of new hydro and nuclear capability that require more time to build, something to be considered for longer-term zero-emission targets.

A 2030 phase out would require incorporating much larger amounts of established resources, such as wind, solar and demand response, onto the grid. Higher amounts will present more risk, as solar and wind are variable and cannot always produce electricity when needed.

It would mean assuming the availability of certain emerging resources that are not fully tested in the Ontario context, such as a fully operational small nuclear reactor and new storage technologies. Once proven at a commercial level, these technologies can become integral components of the power system of the future.

Ontario would also need to lock in far greater amounts of year-round imports from Quebec that the province currently cannot supply, requiring both Ontario and Quebec to undertake lengthy and expensive transmission expansions specifically to meet Ontario's needs.

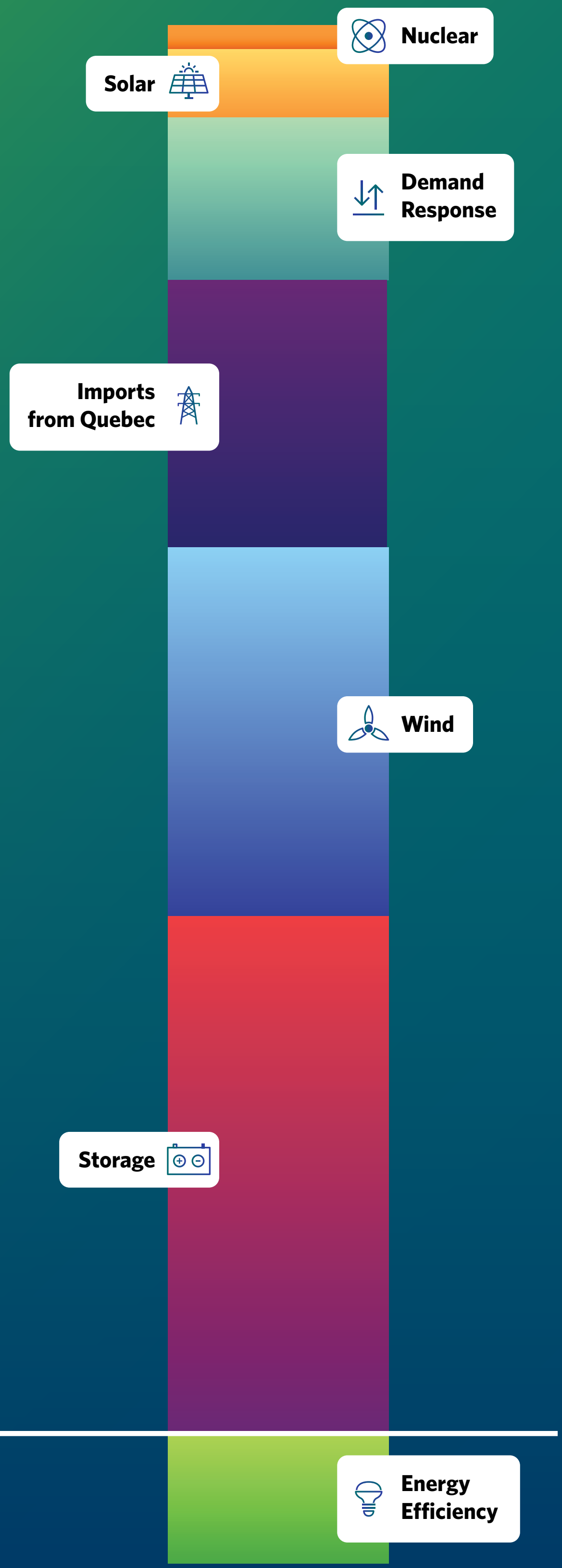
There is also the challenge of managing multiple infrastructure projects at the same time. Whether all these projects could be completed by 2030 would depend on the availability of capital, skilled workers, supplies and equipment.

And finally, the minimum amount of investment required to accomplish this effort as it is currently laid out is estimated to be more than $27 billion, increasing residential bills by 60 per cent.

All this would need to be considered as the IESO projects the need for further electricity supply that will grow throughout this decade and beyond, driven by increasing electricity demand, the expiration of generation contracts, and nuclear refurbishments and retirement.

2030 Gas Phase-Out Scenario

The IESO modelled a potential pathway to replace gas generation by 2030. While this option would not ensure reliability, it does provide a view of possible future changes to the supply mix.



Target Gas Replacement: 17,000 MW new supply and 1,600 MW of energy efficiency to replace 11,000 MW of gas generation.

Nuclear

What was modeled: Another 300 MW, production from a small modular nuclear reactor (SMR).

Where we stand: This technology is currently in development.

What we are doing: OPG is currently proposing an SMR to be in service by 2028 at the Darlington Nuclear Generating Station, the first in Canada.

Solar

What was modeled: An additional 843 MW of solar capacity, a 176% increase in current capacity on the grid.

Where we stand: Large-scale solar farms and transmission would be needed with significant build time. Increasing amounts of variable resources like solar and wind on the grid is also an administrative challenge.

What we are doing: The IESO is supporting projects that pair solar generation with storage technologies, creating a promising hybrid resource.

Imports from Quebec

What was modeled: 3,300 MW of capacity and energy from Quebec all year round.

Where we stand: Quebec currently imports electricity in the winter for heating. It would also need to build new generation facilities specifically for Ontario above what would be required for Quebec itself.

What we are doing: Current infrastructure upgrades have the potential to increase imports.

Storage

What was modeled: More than 6,000 MW of new storage capacity, capturing excess energy to be released when needed.

Where we stand: No storage technology has been tested at the scale required. It is unknown whether it can provide necessary capacity and flexibility during heatwaves and cold spells. Also, this amount of energy could only be provided by exceptionally large facilities – far beyond what could be available over the coming years.

What we are doing: Storage provides some reliability services to the grid today. The IESO is supporting storage technology testing and development and working to allow it to compete with traditional resources. This includes negotiating the contract for a new 250 MW battery facility – which would be one of the largest in the world.

Demand Response

What was modeled: 2,000 MW of additional demand response. Participating businesses would need to reduce energy use 200 times over a year, roughly four days a week.

Where we stand: Ontario currently benefits from up to 1,300 MW in voluntary demand response during peak hours, roughly five times a year.

What we are doing: Committed demand response of 680 MW is already counted for reliability and is growing through the Capacity Auction and pilot projects in local communities.

Wind

What was modeled: An additional 4,545 MW of wind would be needed, doubling the amount of wind energy in Ontario and adding more than 1,300 new turbines.

Where we stand: Large-scale land use for turbines and transmission would be needed, and time to site and build them would be significant.

What we are doing: The IESO is supporting research into hybrid wind and energy storage technologies.

Energy Efficiency

What was modeled: Another 1,600 MW of energy savings, increased energy programs and policies.

Where we stand: Ontarians achieved 1.5 TWh in energy savings and 186 MW of demand savings through Save on Energy programs in 2019 and 2020.

What we are doing: IESO's 2021-2024 Conservation and Demand Management Framework is targeting 2.7 TWh of electricity savings and 440 MW of peak demand savings to help cost-effectively meet system needs.

The Replacement Supply Mix

In assessing the impact of a complete phase-out of gas generation, the IESO constructed a portfolio of replacement supply resources taking into account the varying operating characteristics of each.

In this scenario, new wind, solar, nuclear and imports would provide the bulk of the province's incremental energy needs. Storage and demand response could provide further additional capacity and help balance periods of excess baseload generation or insufficient supply. Energy efficiency would help reduce growing energy consumption.

Given the short timeline associated with a 2030 phase out, the scenario excluded significant quantities of new hydro and nuclear capability that require more time to build, something to be considered for longer-term net-zero targets.

Provincial wind capacity on the grid would double from existing levels, while solar capacity would also increase by an additional 843 MW. While the IESO has experience with these resources, higher amounts will present more risk, as solar and wind are variable and cannot be counted on to produce electricity when needed. This will also present administrative and operational challenges that would be very difficult to overcome.

This supply mix also assumes the availability of certain emerging resources that are currently untested. For example, a limited amount of new nuclear capacity would come in the form of a small modular reactor, which is currently in development in Ontario and expected to be in service by 2028. Once proven at a commercial level, these technologies can become integral components of the power system of the future.

The scenario also considers energy-efficiency savings beyond those identified in the 2020 APO. Enhanced programs with higher incentive levels could tap into the greater conservation potential in the province, delivering an additional 9 TWh in reduced demand by 2030.

Firm energy imports from Quebec with significant hydroelectric portfolios would provide 3,300 MW of capacity year round. While Ontario already imports and exports electricity on an economic basis with its neighbours, "firm" imports would lock in this capacity so that it could not be offered to other jurisdictions.

Establishing additional firm imports from Quebec will be particularly challenging. Quebec is currently an importer of electricity in winter, where the majority of residents use electricity for home heating, and will require additional capacity to meet future domestic demand. Quebec would need to expand its hydroelectric and transmission system to meet Ontario needs. Similarly, Ontario would need to build out its transmission system to deliver imports to major centres of consumption across the province – at a cost of $1 to $1.5 billion.

This portfolio of resources, along with the assumptions presented, satisfied high-level reliability requirements for basic capacity and energy needs and cost effectiveness. This portfolio was then simulated to operate on an hourly basis to determine if it could reliably supply all energy needs at different times of the day, and different seasons, under changing operating conditions.

To address the need for more flexibility, the IESO looked at how storage and demand response could be scaled up to respond to changing system needs. Both supply options currently provide capacity to the system and offer great promise for the future. For example, at the request of the Ministry of Energy, the IESO is currently in negotiations to develop a 250 MW battery storage facility in Haldimand County – which, if successful, would result in one of the largest facilities in the world, providing valuable insights on operating grid-scale storage for the future.

The challenge, however, is that storage does not actually produce energy and is limited by how long or how often it can support system needs. Storage – whether it's pumped storage or batteries – cannot inject energy into the system on a continuous basis as it needs to be replenished once depleted. The scenario calls for up to 47 hours of continuous output from storage. This amount of energy could only be provided by exceptionally large facilities – far beyond what could be available over the coming years.

From a high level, the scenario also assumes demand response capacity of 2,000 MW. This amount of capacity would require participating businesses to reduce their energy use during peak hours approximately four times a week – a level of disruption that would not be sustainable. Indeed, some activations would need to last tens of hours.

While the portfolio can provide enough capacity and energy to meet system needs in its totality, it would not be able to deliver energy precisely when it is needed if stressed by sustained extreme weather and equipment failures.

As a result, IESO system operators would need to activate emergency actions such as conservation appeals, voltage reductions and rotating blackouts to maintain overall reliability. These periodic shortfalls would total 500 GWh, roughly the same amount of energy needed by a city the size of Stratford over the space of a year.

Other Supply Needs

Not all electricity services are about providing large amounts of energy. The IESO also requires specific types of grid support to ensure a reliable service.

Many energy suppliers – including gas generators – step in on short notice to supply energy for unforeseen events like extreme weather conditions and equipment failures. These suppliers provide operating reserve and are available on call to ramp up production, often within minutes, to meet changing system needs. Storage technology is well-suited to provide this service.

Reliability also depends on a number of finely-tuned services that are critical to maintaining voltages, the force that drives current along transmission lines, and frequencies, which keep voltages stable. Gas generators provide frequency support and are particularly well suited to providing active and reactive power to support voltages. Without these services, the system would collapse. The model was not able to adequately provide for these needs, and would require further analysis to determine how to maintain system stability.

Transmission Requirements

Where replacement supply is located is just as important as how much is built. As electricity planners, the IESO looks at how electricity supply is delivered to load centres to assess the maximum amount of power that can be safely delivered along transmission lines.

Much of the 11,000 MW of existing natural gas-fired generation is located in or around the GTA, with the balance primarily in western Ontario. Given the replacement supply mix, it would not be practical to site large wind and solar facilities in large urban or suburban areas given the amount of land they require. Imports from Quebec would necessitate additional pathways throughout the province.

Some natural gas plants are strategically located to supply specific local needs. Any transition of the system to other forms of supply must also take these regional needs into account, including:

- Portlands Generating Station (GS) provides critical support to Toronto's downtown core. Without it, a new transmission corridor may be required.
- The retirement of Pickering Nuclear Generating Station will increase overloading of the transmission infrastructure in the area. Without support from Goreway GS and Halton Hills GS, other transmission enhancements would be needed to address this risk.
- The York Energy Centre plays a critical role in local reliability. New supply will likely be required in the area by 2030, even with this facility in service; without equivalent local generation, a new transmission corridor would be needed.
- Brighton Beach GS, East Windsor GS and West Windsor GS play a critical role in local reliability in Southwest Ontario, an area already experiencing significant load growth and the focus of ongoing transmission expansion.

Most importantly, transmission development takes time. It involves developing the designs and specifications, identifying appropriate sites and routes, extensive consultation, and finally constructing new assets. The lead time for the development of a new transmission project can be at least seven to 10 years.

Costs

Even though this supply mix could not be built within a 2030 timeline, and would not perform reliably, the IESO looked at a potential range of costs to acquire, build and connect this replacement supply in order to learn more about how future evolutions of the system would impact energy bills.

Overall, the capital investment required is estimated to be more than $27 billion – this includes the cost of constructing new supply, upgrades to transmission infrastructure and increasing investment in conservation programs.

This investment in supply mix, together with associated operating costs, will result in an annual system cost increase of $5.7 billion by 2030. As a result, this gas phase-out scenario would increase residential bills by 60 per cent – almost $100 a month for the average residential consumer.

These costs are significant, yet the best way to evaluate the effectiveness of the scenario might be to look at the net cost of carbon reduction. In this case, removing all gas generation from the electricity system would cut carbon emissions in Ontario by 12.2 Mt per year by 2030, and result in Ontario ratepayers paying $464 per tonne of carbon. For comparison, the cost of carbon reduction in the steel sector, based on publicly announced funding, is roughly $14 a tonne.

Indeed, Save on Energy conservation programs are also more cost effective at reducing GHG emissions than phasing out gas generation from Ontario's electricity grid. For commercial and industrial businesses looking to upgrade to more efficient lighting and equipment, reducing carbon emissions will save money.

From this lens, a gas phase-out strategy by 2030 provides a very poor return on investment, and suggests that it would be more cost-effective to direct spending into broader carbon reduction strategies that produce much greater impacts.

The Future

There is no question that reducing emissions, both in the electricity sector and the broader economy, is an achievable goal. The questions are how and when can we get there?

The study shows that the proposed deadline of 2030 could have negative long-term impacts on cost, reliability and the advancement of electrification. Given the burden on electricity bills and the adverse effect to business competitiveness, it would hinder economic growth and electrification as whole.

Ontario's electricity system can enable overall emissions reductions through electrification of other sectors, but only if it continues to be reliable, affordable and scalable to serve increased demand. The recognition of these kinds of challenges and opportunities has been the impetus for a great deal of work already underway to create a more flexible, transparent, affordable and resilient system that is positioned to handle decarbonization and other challenges.

All of this work is designed to ensure that the system can continue to deliver a reliable and affordable electricity supply to meet demand for electricity in the coming decades. This study, however, helps bring attention to important questions about the potential for electrification in other sectors and the electricity system's ability to meet these demands.

Ongoing work to realign the electricity system must be a broad and collective effort, and the IESO will continue to engage with sector stakeholders – including the broader community of businesses, academics, communities and other organizations in the electrification space.

The outcomes of engagement will inform a work plan to prepare the electricity system for decarbonization, aligned with stated policy goals and emission targets, to mitigate future risk to reliability and affordability. Ultimately, this effort will determine the optimal approach to leveraging the electricity sector to address the issue.

Beyond Gas: Ontario's Future Energy Options

While Ontario's electricity system is currently dependent on gas generation, it is also evolving. Over the last 20 years, the system has transformed from a centralized command and control model largely dependent on large-scale generation and transmission infrastructure.

Today, this transformation continues with a shift toward more flexible, non-carbon and localized sources of supply. New technologies are emerging at the local level that have the potential to contribute on a larger scale to the grid. Some of these options are rapidly developing to help meet Ontario's long-term needs, even though more work needs to be done.

Storage: While pumped storage in the Niagara Region has been a contributor to the system for decades, new forms of storage arrived on the bulk system six years ago, providing grid support services. This allowed the IESO to test the effectiveness of new technologies such as lithium-ion batteries and flywheels in grid operations.

This summer, a Sault Ste. Marie storage facility injected energy onto the grid during peak hours for the first time. Grid-scale batteries are emerging on the horizon – in particular to complement renewables – storing excess energy when it is available and releasing it when it is needed. The IESO is currently piloting a solar/storage hybrid facility to learn more about how the two resources can complement each other on the grid.

Distributed Energy Resources (DERs): Small-scale electricity supply in communities is growing, currently meeting provincial energy needs that no longer must be delivered by the high-voltage grid. Work is well underway to understand how to tap into the potential benefits DERs offer to the broader system. A series of pilot projects are demonstrating how locally-based generation, demand response and storage can operate in tandem with broader grid operations.

In fast-growing York Region, for example, the IESO has embarked on a pilot project with the support of the local hydro company, Alectra, to better understand the potential of using DERs by enabling them to operate in real-world applications. This past summer, supermarkets, manufacturers and even homeowners participated in the pilot and provided demand response during hot weather peaks.

Energy Efficiency: Save on Energy programs have helped homeowners and businesses reduce their energy use and energy bills over the last 10 years. In 2019-2020 alone, Save on Energy programs reduced provincial capacity use and energy use by 186 MW and 1.5 TWh respectively – enough to power the City of Oshawa. Ontario's energy-efficiency programs continue to evolve to provide more targeted system support. The IESO is piloting an energy-efficiency auction that secures projects that reduce peak demand.

Demand Response: As with storage, demand response – the ability of customers to reduce energy consumption on short notice – has been a feature of the electricity system for a number of years, and as new technologies allow businesses greater ability to control their energy use, demand response has grown significantly.

Today, businesses participating in the Industrial Conservation Initiative provide roughly 1,300 MW of voluntary demand response during summer peaks. Energy managers and system operators alike are finding new ways to capture demand response in a predictable and trackable way – operating them with the same level of certainty as generators.

There are also other options to mitigate the impact of gas and even take advantage of existing infrastructure.

Small Modular Reactors (SMRs): Like current nuclear reactors, SMRs are designed to provide reliable, carbon-free electricity, but with a much smaller land footprint than current reactors. Smaller plants mean they are more flexible and can be deployed not only in large established grids but also in smaller grids, remote off-grid communities and for resource or industrial projects. While actual performance still needs to be assessed, their designs and features mean that in addition to providing baseload generation, they could have the potential to support intermittent renewable sources like wind and solar.

Hydrogen: Large-scale hydrogen production presents a possible pathway towards the deep decarbonization of industry. Hydrogen is one of the leading options for storing renewable energy, and could also enable long-term energy storage – even from season to season. Hydrogen could also potentially be integrated into natural gas pipelines and used by natural gas turbines.

Looking ahead, hydrogen offers significant potential as production costs could come down, making it more competitive, supported by the development of a Canada-wide hydrogen strategy. Efficient mechanisms for producing hydrogen for the purpose of generating electrical energy, however, are probably a decade away.

Carbon Capture Utilization and Storage: Storing and using carbon solutions will also be a significant part of a longer-term decarbonization strategy. They can be particularly helpful for hard-to-abate emissions that come from industrial processes that might not be able to switch to electricity. Although there is significant potential for large-scale carbon capture in the long-term, this technology is currently unproven in Ontario and depends greatly on the availability of suitable geography in the province. It is also costly, with relatively high capital and operating costs.

Green/Renewable Natural Gas: Renewable Natural Gas (RNG) is methane captured from organic waste at landfills, livestock operations, farms, and sewage treatment facilities, then upgraded (e.g., by removing impurities) to meet natural gas pipeline specifications. The process captures carbon that could otherwise leak into the atmosphere. RNG is interchangeable with conventional natural gas. It can be injected into the existing natural gas distribution system and, like conventional natural gas, can also be used as a transportation fuel in the form of compressed natural gas or liquefied natural gas.

RNG can play an important role in Ontario's clean energy future. However, how much energy can be produced from biomass, and its cost-effectiveness for reducing emissions, is unclear.

Decarbonization and Ontario's Electricity System

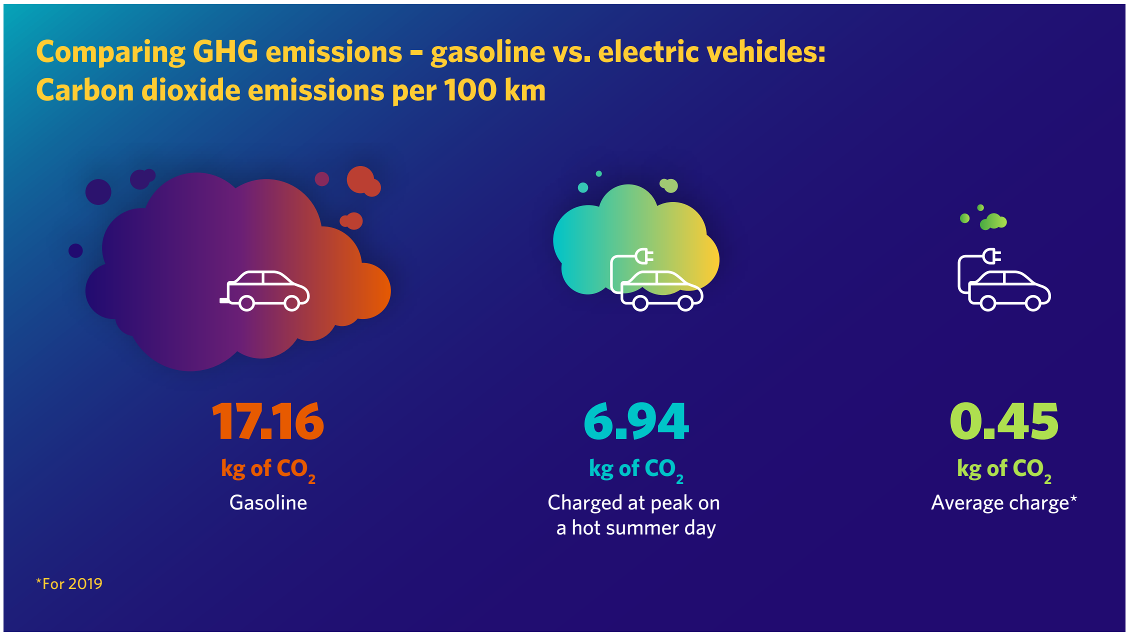
This assessment shows the complexity of change within Ontario's electricity system, but it also reveals the possibilities. It provided important learnings about the new realities of operating power systems and surfaced a series of questions about what would be the best approaches to decarbonization.

The IESO has been working for a number of years to develop a better understanding of how newer, non-emitting technologies like storage, alone and in combination with renewables like solar and wind, expand the options for how and where power is produced across the province.

It is developing a roadmap to tap into rapidly expanding quantities of local generation, storage and other energy supply that serve community needs. Understanding how energy is met on the local level can help balance the grid more efficiently. This includes studying the potential for future growth.

In addition, the IESO is evolving Save on Energy conservation programs to better align with system needs. The Grid Innovation Fund is similarly helping to advance the adoption of cost-effective, non-emitting solutions.

Ontario's electricity system is, and will continue to be, in a strong position to support increased electrification. A gasoline-fueled car produces more than 35 times the carbon emissions of an electric vehicle charged from the Ontario grid in 2019.



In this regard, the IESO's responsibility is to prepare for the change that electrification will bring.

We continually assess and reassess system needs in response to changing circumstances. The upcoming APO will incorporate new demand forecasts that reflect the latest developments in electrification, part of an expanded and continuous effort to prepare for increasing demand. Following the APO, we will undertake a deeper dive into the potential for electrification to increase demand forecasts, taking into account the many variables that influence its growth.

This effort will be part of our broader work plan to prepare the grid for a future aligned with the goals of decarbonization. Work already underway includes updating the IESO's engineering cost study to better understand the relative cost of resources, as well as more research into the value storage can provide the system under different conditions.

As an increasing number of cars, trucks and buses draw from the grid, as homeowners switch to electric heating, and as industries move processes away from fossil fuels, there is a real need for the grid to respond. To do this, understanding just how much electrification will take place, how quickly, and how best to serve it will be key.

As such, this work plan should not be developed in isolation – particularly given the many considerations at play. To that end, the IESO will engage with stakeholders on the approach and structure of this work plan, encouraging participation of a broad range of perspectives. Ultimately, broader decarbonization of the economy requires a stable, reliable and affordable electricity system.

To review the data that was used to generate the graphs in this report, please visit the IESO's website.

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