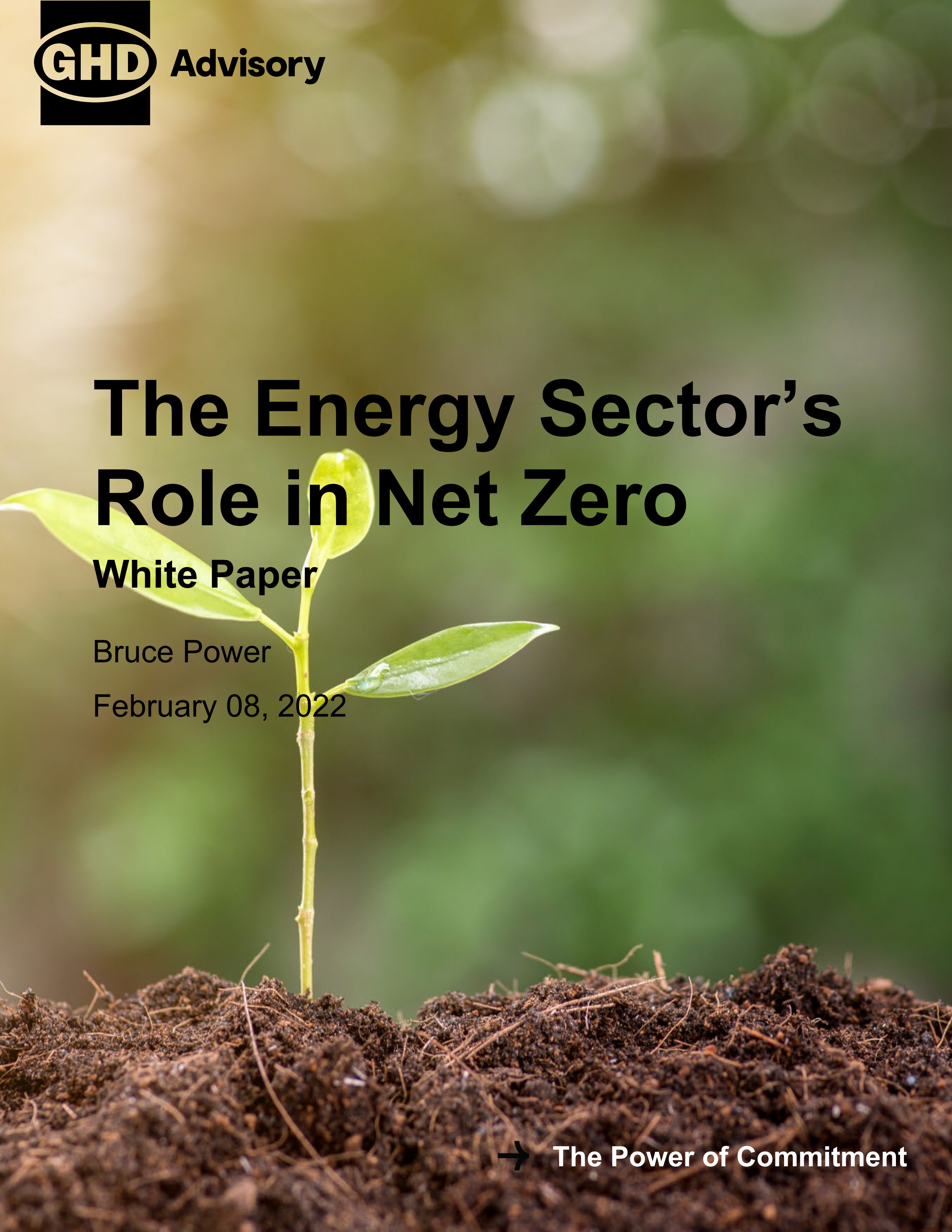

GHD Advisory

# The Energy Sector's Role in Net Zero

## White Paper

Bruce Power

February 08, 2022

→ **The Power of Commitment**

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# Executive summary

In November 2020 the Canadian government introduced the Canadian Net Zero Emissions Accountability Act which formalized Canada's target to achieve net zero by 2050 through a series of increasingly stringent interim emission reduction targets[1]. According to the International Energy Agency (IEA), the energy sector is the source of approximately three-quarters of current global greenhouse gases (GHGs), and therefore, is pivotal in averting the worst effects of climate change[2]. It has become apparent that a significant change to how countries produce energy is needed if limiting the global temperature rise to 1.5°C is achievable. This paper discusses the role that the energy sector and nuclear power can play in the transition to a zero-carbon economy, particularly in Ontario, Canada.

To achieve net zero, it is vitally important to understand the current GHG emissions output profile in terms of both scale and sources. Across Canada GHG emissions vary significantly by province and territory as a result of factors such as population, energy sources, and economic structure. Ontario has made significant investment to develop one of the cleanest electricity systems in the world[3] .Consequently in 2019 only 2% (3.9 Mt $CO_2e$) of Ontario's annual GHG emissions was a result of public electricity and heat generation. At only 2% of the province's total, emissions from public electricity and heat generation in Ontario are lower than the national average of 9.5%[4].

Ontario's electrical generation capacity is made up of a combination of natural gas, nuclear, hydro, and other renewables (wind, biofuel and solar). The amount each source produces impacts the GHG emissions from Ontario's electricity sector (i.e., the higher the portion of electricity supplied from low emissions sources, such as nuclear and renewables, the lower the GHG emissions). The amount of GHG emissions per kWh or electricity generated is referred to as the carbon intensity and is typically calculated on an annual basis. According to the 2019 National Inventory Report (NIR) Ontario currently has the 6th lowest carbon intensive electricity systems in Canada (see Figure ES1).

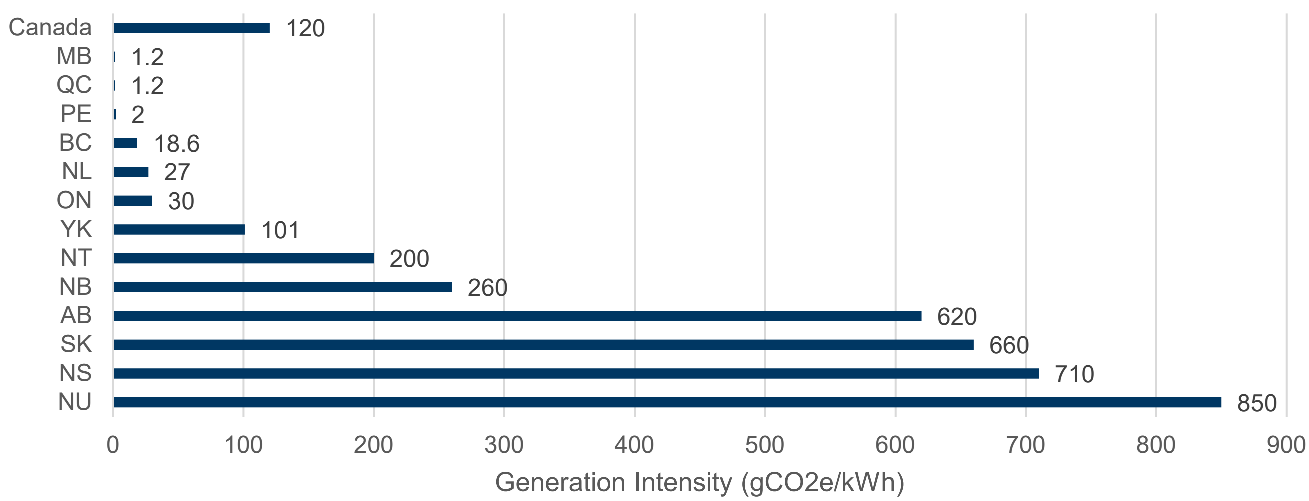


***Figure ES1 2019 Generation GHG intensities for Canada and its provinces and territories[5]***

[1] Net-Zero Emissions by 2050 - Canada.ca
[2] IEA (2021), *Net Zero by 2050,* IEA, Paris https://www.iea.org/reports/net-zero-by-2050
[3] Ontario Energy Association (2021) Net Zero 2050
[4] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*, Part 3, Tables A9-3 and A11-13
[5] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*, Part 3, Table A13-1 to A13-14, (Note values reported in the NIR are rounded to an appropriate number of significant figures based on the uncertainty of the category in question.)

The proportionally low GHG emissions from electricity generation and lower GHG emission intensity in Ontario is a result of a radical transformation to mostly carbon free generation over the last six years, with nuclear providing the bulk of electricity, and through the elimination of coal generation. The successful phasing out of coal-powered generation in 2014 was the largest emissions-reduction initiative in Canada this century. Therefore, Ontario's electricity system is currently well positioned to support the country's net zero commitments. Figure ES2 demonstrates how the historical electricity generation intensity of 230g $CO_2$e/kWh in 2005 compares to the 2013-2018 calendar years and ultimately the 30g $CO_2$e/kWh intensity in 2019, to depict how Ontario has continued to transition to carbon free electricity generation.

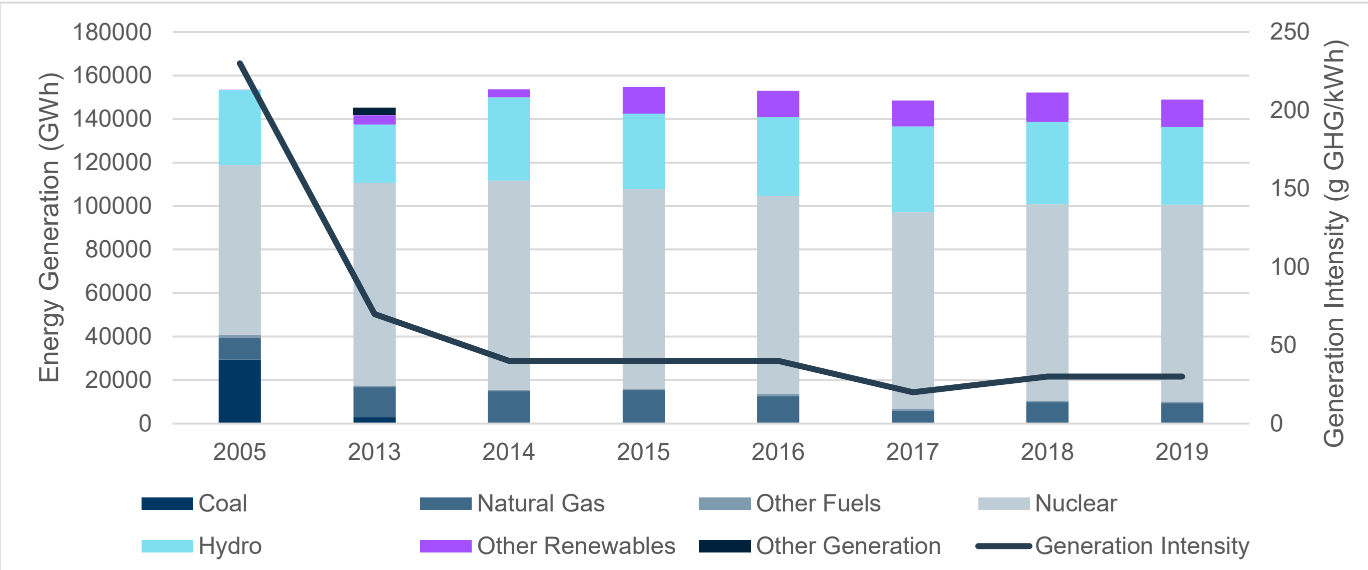


***Figure ES2 Ontario electricity generation GHG intensity and electricity generation by source***[6]

As provided in Table ES1, the NIR also produces annual data that can be used to calculate the electricity generation intensity associated with each specific energy/fuel source used to generate electricity in Ontario. For comparison and context, similar GHG intensity data of different electricity supply sources, available from The Atmospheric Fund (TAF) the Intergovernmental Panel on Climate Change (IPCC) and United Nations Economic Commission for Europe (UNECE), is also included. Note that the NIR and TAF data in the first four columns represent direct emission from the generation plant only and unlike the data presented from the IPCC and UNECE in the fifth and sixth columns, does not include wider lifecycle emissions such as extraction, processing, and fuel transport, which results in inherently higher generation intensity values.

[6] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*, Part 3, Table A13-7

*Table ES1 Electricity generation GHG intensity by energy source*[7]

| Electricity Generation Energy Source | Ontario 2019[8] | Ontario Average 2015-19[16] | Canada[9] | Ontario 2020[10] | | IPCC[11] | UNECE[12] |
|---|---|---|---|---|---|---|---|
| | gCO$_2$e/kWh | | | | | | |
| Coal | - | - | 955 | - | | 860 | 753 to 1095 |
| Natural Gas | 406 | 411 | 475 | 472 | | 490 | 403 to 513 |
| Other Fossil Fuels[13] | 80 | 130 | 565 | 0 | | | |
| Nuclear | 0 | 0 | 0 | 0 | | 12 | 5 to 6 |
| Hydro | 0 | 0 | 0 | 0 | | 24 | 6 to 147 |
| Other Renewables[14] | 0 | 0 | 0 | 0 | | 11-48 | 8 to 21 (wind)<br>7to 83 (solar) |
| Other Generation | 0 | 0 | 0 | 0 | | - | |
| **Average** | **30** | **29** | 120 | **-** | | **-** | |

Therefore, using 2019 data it is estimated that every kWh electricity generated from low carbon sources (i.e., nuclear, hydro, wind biofuel and solar) avoids 406g CO$_2$e compared to electricity generated in Ontario from natural gas and 80g CO$_2$e per kWh compared to other fossil fuels. These values can be useful when assessing the benefit of additional renewable or low carbon power generation in Ontario to potentially eliminate fossil fuel generation.

Although Ontario's electricity system has transformed significantly over the last decade to be currently well positioned to support Canada's path to net zero, the most significant findings from the most recent 20-year forecast for Ontario's electricity system[15] are:

1. As electric vehicles become the norm, homeowners switch to electric heating, and industries move on-site processes (including onsite electricity and heat generation) away from fossil fuels to electric, there will be increased demand in electricity with demand for electricity forecast to rise at rates not seen in many years.
2. There will be a shift in the mix of primary energy used to generate electricity, with natural gas fired generation predicted to account for an increasing share of Ontario's energy production throughout the 2020s. Specifically, the planned refurbishments to extend the life of the Darlington and Bruce Power nuclear reactors and the retirement of the Pickering nuclear generators at the end of 2025. Consequently, the IESO forecasts there will need to be an increase electricity generation/output from the existing natural gas generation facilities to balance the rising electricity demand with the reduced nuclear supply.
3. As a result of this increased proportion of natural gas generation to meet the increased demand, grid supplied electricity in Ontario is predicted to become more carbon intensive and annual emissions from electricity

[7] Given that emissions intensities do vary year to year dependant on numerous factors such as the operational efficiencies and technologies employed at each specific generating facility, data is presented for Ontario for 2019, 2020, an average over 2015-19 and also for Canada to provide additional context and comparison.
[8] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*, Table A13–7 Electricity Generation and GHG Emission Details for Ontario. Note this data represents direct emission from the generation plant only
[9] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*, Table A13–1 Electricity Generation and GHG Emission Details for Canada. Note this data represents direct emission from the generation plant only
[10] The Atmospheric Fund (2021) A Clearer View of Ontario's Emissions: Updated electricity emissions factors and guidelines, natural gas generation emission factor
[11] Lifecycle emissions of electricity supply technologies (gCO2e per kWh) sourced from the 2014 Report by Intergovernmental Panel on Climate Change, Annex III, Table A.III.2
[12] UNEC (2021) *Life Cycle Assessment of Electricity Generation Options*, Figure 37
[13] Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
[14] Includes electricity generation by wind, tidal and solar.
[15] IESO (2021), *Annual Planning Outlook Ontario's electricity system needs: 2023-2042*

generation are forecasted to increase this decade from a recent average of 5.4 megatonnes (Mt) $CO_2e$ to 11.9 Mt $CO_2e$ in 2030, an increase of 120%.

With emissions from the electricity sector in Ontario projected to increase a broad spectrum of measures including enhancing the existing and adding additional zero carbon capacity, decarbonizing natural gas through to increasing energy storage and changing consumer behavior are needed to achieve a reliable decarbonized electricity generation system, if Canada is to realistically achieve its decarbonization goals. **Within Ontario Bruce Power has key role in progressing many of the key zero-carbon pathways identified, specifically:**

1. **Extend life of existing zero carbon electrical generation capacity:** Building new transmission infrastructure and new generation takes significant time, investment, land and resources, with time needed to plan, obtain necessary regulatory and environmental approvals, engage with affected communities, and then build and integrate into the local grid. With its current low-emission electricity system, Ontario has a fundamental advantage in decarbonizing its economy. Therefore, it is important to take advantage of the amount of existing low and zero carbon energy generation capacity assets that currently exist and extend the life of these assets to maximize the increased demand that will be met with zero carbon electricity.

   For example, Bruce Power's Major Component Replacement (MCR) Project will extend the operational life of each reactor by 30-35 years to 2064 and in turn help prevent the predicted increase in the GHG emission intensity of the electricity grid. In addition, by 2034 following completion of the MCR project the annual power output of the Bruce Power nuclear facility is predicted to be 37.1 TWh. However, should the life of the units not have been extended and this same power output be provided from natural gas generation instead of nuclear, this would result in GHG emissions of approximately 15 million MT $CO_2e$ per year compared to zero direct emissions from Bruce Power (See Figure ES3 calculated using 2019 natural gas electricity generation intensity data of 406 $gCO_2e/kWh$ available from the NIR, as shown in Table ES1).

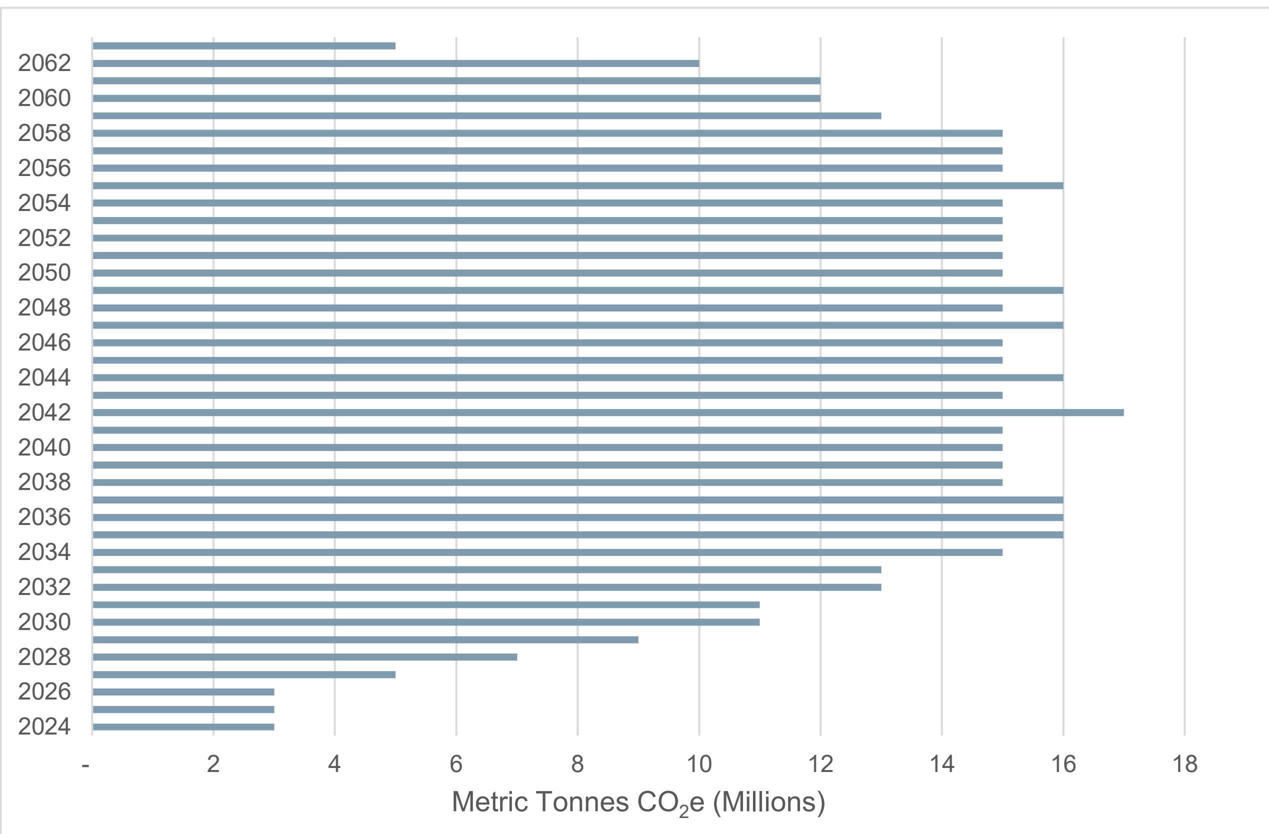


***Figure ES3 Avoided GHG Emissions from Bruce Power nuclear facility over output generated from fossil fuel natural gas***

2. **Increased output from existing low and zero carbon capacity:** Investing in innovation to maximise the output and increase the efficiency of the current clean electricity generation systems to further displace fossil fuel generation can also play an important part in the decarbonization of the electricity system.

   For example, since 2016 Bruce Power has also started to increase the power output capacity through the gradual replacement of older systems in the company's eight reactor units during regularly scheduled maintenance outages. This provides additional zero carbon electricity capacity to meet the IESO's projected energy demands and compensates for the additional supply that is expected to be met with natural gas generated electricity. Since the current IESO forecast assumes any increase in demand is met by increasing natural gas generation, using 2019 natural gas electricity generation intensity data of 406 g $CO_2$e/kWh the total annual avoided GHG emissions from the additional "incremental" power output expected from Bruce Power's power recovery projects can be calculated and are shown on Figure ES4 for 2021-2030. For context 50,000 Metric Tonnes $CO_2$e is equivalent the average GHG emissions generated from the energy used by 42,935 homes in one year[16].

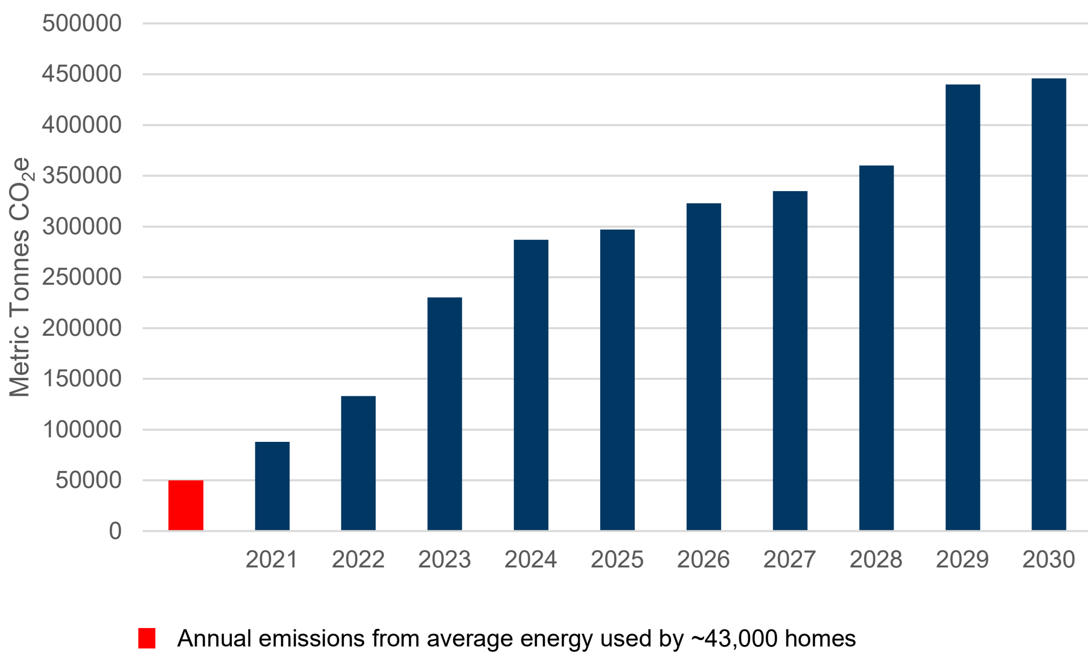


***Figure ES4 Avoided GHG Emissions from additional "incremental" output from Bruce Power nuclear facility over output generated from fossil fuel natural gas***

3. **Reduce emissions from operating existing low and zero carbon capacity:** Although the electricity generated at renewable and nuclear facilities is considered zero carbon, there are some GHG emissions from site operations (e.g., running safety system tests on standby generators). Both Bruce Power and the Ontario Power Generation (OPG) have announced Net Zero goals to eliminate all emissions associated with site operations. Meaning that the GHG emission intensity of electricity generated (including emissions supporting site operations) will be zero.
4. **Replace natural gas with non-fossil fuel alternatives:** Natural gas electricity generation facilities are anticipated to continue playing an important role in Ontario's electricity generation mix, given their current available capacity, role in stabilizing the grid and responding to rapid changes in demand. To reduce and eventually eliminate GHG emissions in the province, the existing and future facilities will need to be built or retrofitted with carbon capture and sequestration (CCS) technology, or fuelled using clean hydrogen, or renewable natural gas (RNG). Green hydrogen is one of the leading options for generating and storing renewable

[16] Source; Natural Resources Canada, Greenhouse Gas Equivalencies Calculator https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/calculator/ghg-calculator.cfm#results

energy and can be blended into existing natural gas pipelines to be used in existing generation facilities. Ontario's existing nuclear capacity is well placed to support the generation of green hydrogen during times of low electricity demand given that nuclear power is one of the few low carbon energy sources that can generate the electricity and heat needed for hydrogen synthesis.

5. **Additional renewable capacity:** To meet the demand from increased electrification significant new clean electrical capacity (nuclear, hydro wind and solar) will be required and to achieve net zero carbon by 2050. Additional nuclear capacity could also support the generation of additional green hydrogen, as discussed in item 4 above.  Whilst new nuclear and hydro plants can require many years to develop, other renewable resources, such as wind and solar can be developed more quickly to meet load increases, however, there are specific land and atmospheric requirements that will need to be considered. In January 2022 the Ontario government announced its intention to develop a voluntary clean energy credit (CEC) registry, which will generate revenue and supports further investment in zero carbon electricity generation in the province such as solar, wind, bioenergy, hydroelectric, and nuclear power.

With the energy sector at the core of the solutions to net zero, Ontario's low carbon intensive electricity system currently serves as a strong foundation to support a zero-carbon economy. With emissions from electricity generated from natural gas currently forecasted to increase in the next few years and reduced nuclear production capacity (due to retirements and refurbishment), it is clear that achieving Canada's ambitious climate targets by 2050 whilst maintaining the reliability of the power system requires a multi-faceted approach. With electricity generation from all available sources of non-emitting energy working together with technology, innovation, and energy consumers, to all play a role in keeping a reliable decarbonized electricity system within reach.

The net zero commitments made over the recent months and years are welcome and a very important step These commitments combined with immediate actions and tangible solutions at all levels of government, industry sectors, and society are the only way to achieve near zero emission over the next 30 years to meet Canada's net zero 2050 goal.

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# 1. Introduction

## 1.1 Purpose of this report

GHD Limited (GHD) has been retained by Bruce Power to prepare an independent report to discuss the potential greenhouse (GHG) benefits of electricity generation from alternative sources of energy, including nuclear, and the role that the energy sector and nuclear power can play in the transition to a zero-carbon economy, particularly in Ontario, Canada. It is anticipated that this report will support Bruce Power's Net Zero strategy and will also assist in decision-making and building the business case regarding investments in refurbishments to increase the electrical output of Bruce Power.

## 1.2 Scope and limitations

This report: has been prepared by GHD for Bruce Power and may only be used and relied on by Bruce Power for the purpose agreed between GHD and Bruce Power as set out in section 1.1 of this report. The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

## 1.3 Overview

GHD has prepared this report to include a discussion on the following specific topics pertaining to the energy sector's role in net zero:

- Canada's current net zero commitments and the Canadian Net Zero Emissions Accountability Act.
- The current GHG emission profile for Canada and Ontario based on the latest 2019 National Inventory Report (NIR)[17].
- The current energy mix of the Ontario electricity grid (i.e., nuclear, natural gas, hydroelectric, wind, solar and bioenergy), and the associated GHG emissions intensity (g$CO_2$e per kWh) of each energy source.
- The forecast electricity demand, supply, capacity and GHG emissions outlook (including avoided GHG emission factors) for Ontario presented in the Independent Electricity System Operator (IESO) 2021 Annual Planning Outlook[18]. Specifically, the impacts of upcoming nuclear refurbishments and retirements which are anticipated to result in gas-fired generation accounting for an increasing share of Ontario's energy production in the future (2022-2042).
- The low carbon options available to both meet the forecast electricity demand and to decarbonize the electricity supply (e.g., wind, solar, nuclear) and the associated GHG benefits of each option. Including the longer term anticipated GHG related impacts of the upcoming nuclear refurbishments and power recovery projects, in terms of both improving the lifecycle GHG intensity of nuclear and supporting the projected increased energy demands.
- The avoided emissions for consumers when comparing each low carbon energy source to electricity generated from natural gas.

[17] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*
[18] Annual Planning Outlook (ieso.ca)

# 2. Energy Sector's Role in Net Zero

The first step in understanding the role of the energy sector in relation to net zero is examining the concept of net zero and how this goal came to be in the first place.

In 2015 the United Nations Framework Convention on Climate Change (UNFCCC) hosted COP21 in Paris, France – a global conference on climate change – where 196 countries ratified the Paris Agreement. Officially coming into force in November 2016, signatories agreed to work towards a goal of limiting the global rise in temperature to well below 2 degrees Celsius (°C), preferably 1.5°C through a reduction of emissions to achieve a carbon neutral world by mid-century (2050)[19]. As part of the Paris Agreement, countries were required to submit their plans for climate action (also referred to as nationally determined contributions (NDCs)) by 2020, some of which incorporated a net zero pledge. Given significant contribution of emissions from the energy sector, this was a particular area of focus for countries committed to the Paris Agreement and was a central theme for the associated climate action plans/NDCs. The November 2021 COP26 was the first opportunity since then for nations to come together to review their commitments and strengthen ambition. The talk resulted in commitments including investment in climate finance, many countries pledging to phase out coal fired generation alongside increased urgency to limit global warming to below 2 degrees Celsius with many business leaders and countries such as India announcing new net zero targets.

**To limit the global rise in temperature we need to reach a balance between anthropogenic GHG emissions and removals. A state known as net zero emissions.**

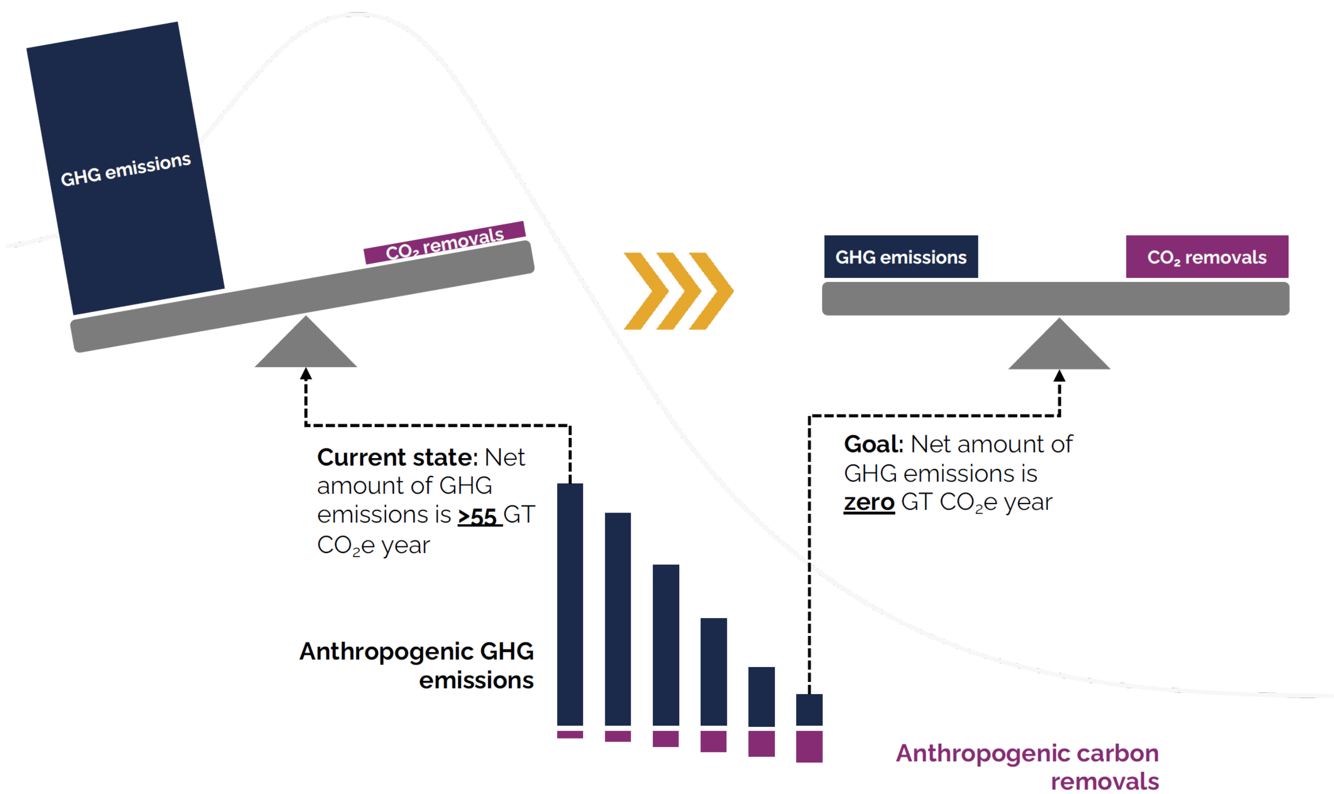



***Figure 1*** ***What does net zero mean***[20]

[19] The Paris Agreement | UNFCCC (link)
[20] Source: SBTi (2021), Net Zero Standard Launch event, The Net-Zero Standard - Science Based Targets (link)

According to the International Energy Agency (IEA), the energy sector is the source of approximately three-quarters of current global GHG and therefore is pivotal in averting the worst effects of climate change[21]. In October 2021, the IEA also released its annual World Energy Outlook[22], which assesses and summarizes the direction of global energy demand and carbon dioxide emissions. This found that despite many countries beginning to introduce and preliminarily start acting on their net zero commitments, the continued growth of renewable energy, and electric vehicles setting new sales records, 2021 is also seeing the second-largest annual increase in $CO_2$ emissions in history, largely due to a large rebound in coal and oil use. Therefore, it has become apparent that a significant change to how countries produce energy is needed to be keep limiting the global temperature rise to 1.5°C within reach.

The route each individual country and region will take to navigate and achieve net zero emissions whilst retaining a reasonable balance of supply and demand for energy during the transition is complex and varied. However, with co-ordination from all governments to drive clean electrification, improving efficiency, reducing methane emissions and an unprecedented push in clean technology and innovation, a global pathway to net zero emission by 2050 is still possible. In the lead up to the November 2021 COP26, there has been a rapid increase in the number of countries announcing long-term goals to achieve net zero GHG emissions over the coming decades.

## 2.1 Canada's Net Zero Commitments

In line with Canada's commitment to the COP21 Paris Agreement, in November 2020 the Canadian government introduced the Canadian Net Zero Emissions Accountability Act. The purpose of this legislation is to formalize Canada's target to achieve net zero by 2050 through a series of interim emission reduction targets[23]. This legislation further underpins previous commitments to emissions reductions including the Pan-Canadian Framework on Clean Growth and Climate Change (PCF, 2016) and A Healthy Environment and a Healthy Economy (2020). Both of these frameworks outline how the government plans to tackle climate change issues while simultaneously growing the economy and fostering a resilient community. On a provincial and territorial level, no formalized net zero plans have been published, however federal legislation will mandate various actions on climate mitigation and emissions reductions for provinces and territories.

Expanding on the commitment made during COP21, in 2021 at the UNFCCC's COP26, the Canadian government announced their plans to both continue and improve climate and energy-related initiatives. Specific to energy and carbon emissions, Prime Minister Justin Trudeau pledged to; continue implementing a price on carbon, proceed with putting a cap on oil and gas emissions, including a methane emissions reduction of 75% from 2012 levels by 2030[24] and double Canada's climate financing, with up to $1 billion put towards the transition away from coal[25]. Further statements from Canada at COP26 showed an increased dedication to transitioning the energy sector away from GHG intensive production, with a promise to end the export of thermal coal by 2030. Falling in line with these statements comes a financial dedication of $185 million to support local coal workers and communities through the decarbonization transition, and a $25 million global donation to support the energy sector management assistance program in partnership with the World Bank[26]. In addition, Canada endorsed action on nature-based climate solutions such as The Glasgow Leaders Declaration on Forest and Land Use, aiming to reverse deforestation by 2030.

Moreover, plans to further Transport Canada's goal of selling 100% zero-emission vehicles (ZEV) by 2035[27], and federal government campaign promises to create a net zero grid by 2035[28] further reaffirm Canada's support for ambitious actions to achieve net zero by 2050.

[21] IEA (2021), *Net Zero by 2050,* IEA, Paris https://www.iea.org/reports/net-zero-by-2050
[22] IEA (2021), *World Energy Outlook 2021*, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2021
[23] Net-Zero Emissions by 2050 - Canada.ca
[24] Canada's Achievements at COP26 - Canada.ca
[25] Prime Minister's remarks delivering Canada's national statement at the COP26 summit | Prime Minister of Canada (pm.gc.ca)
[26] Prime Minister Trudeau announces enhanced and ambitious climate action to cut pollution at the COP26 summit | Prime Minister of Canada (pm.gc.ca)
[27] Canada's Zero-Emission Vehicle (ZEV) sales targets
[28] Clean Electricity: A Net-Zero Grid By 2035 | Liberal Party of Canada

## 2.2 Current GHG Emissions Profile

To achieve net zero, it is vitally important to understand the current GHG emissions output profile in terms of both scale and sources. Canada's official national GHG inventory submitted to the UNFCCC is published annually in the National Inventory Report (NIR). This report breaks down emissions on both a national, provincial, and territorial level. As per the report, Canada's national GHG emissions were estimated at 730 megatonnes of carbon dioxide equivalent (Mt $CO_2$e) for 2019[29] – this is the most recent dataset in the report and is used as a proxy for 2020 and 2021 data until analysis are performed for subsequent years. Overall, the combined emissions output for 2019 represents an approximate 1 Mt $CO_2$e or 0.2% increase from 2018 emissions and a net decrease of 9 Mt $CO_2$e or 1.1% from 2005 emissions. A summary of the national 2019 GHG emissions by sector is provided on Figure 2.

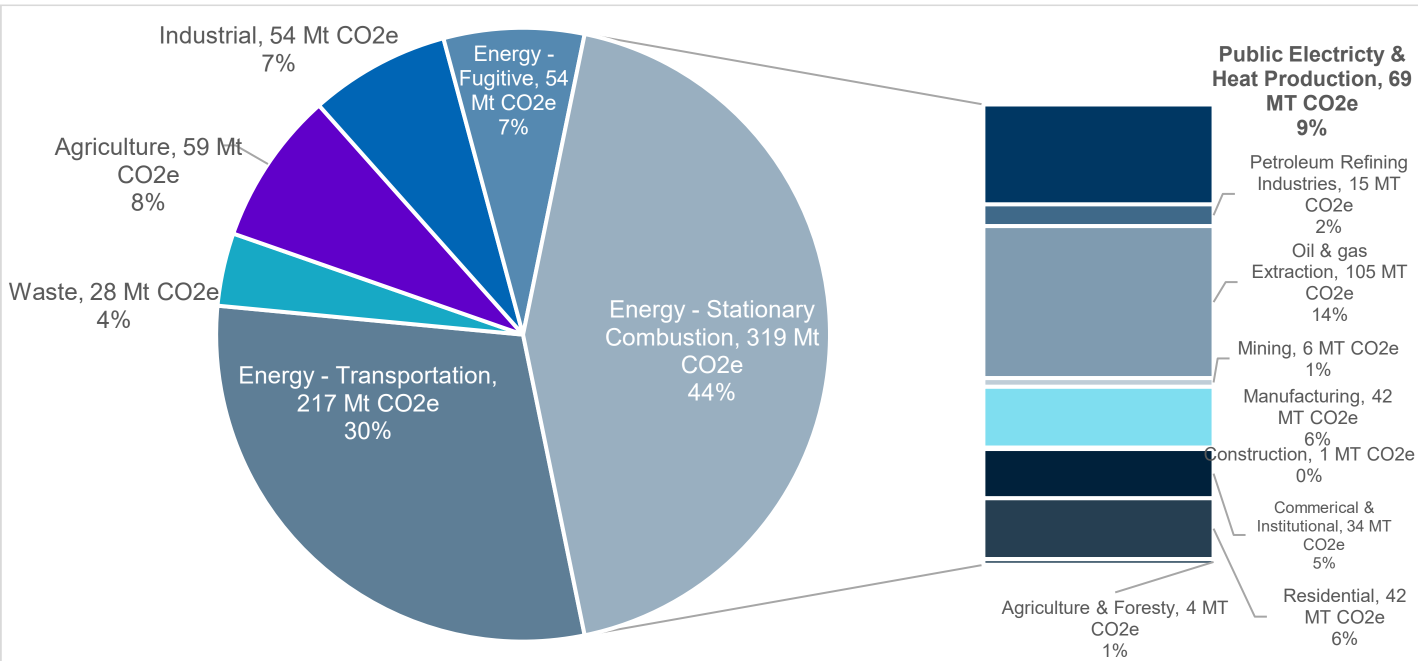



***Figure 2 Canadian national GHG emissions profile by sector, 2019[30]***

According to the 2019 NIR, and as noted on Figure 2, the energy sector (consisting of Stationary Combustion, Transport and Fugitive Sources) emitted 589 Mt $CO_2$e, or 81% of Canada's total annual GHG emissions, of which 69 Mt $CO_2$e was a result of public electricity and heat production[31] and represents 9% of Canada's total emissions. Public electricity and heat production is understood to best represent the emissions associated with typical "grid" electricity and is the 3rd largest contributor to Canada's total 2019 GHG emissions, behind road transportation (153 Mt $CO_2$e or 21% of total) and Oil and Gas extraction (105 Mt$CO_2$e or 14% of total).

Further analysis identifies that overall GHG emissions vary significantly by province and territory as a result of factors such as population, energy sources and economic structure. Of the total 730 Mt $CO_2$e emitted by Canada in 2019, Alberta and Ontario are the highest emitting provinces overall, with Alberta contributing 276Mt $CO_2$e (38%) and 163 Mt $CO_2$e (22%) generated by Ontario[32]. Figure 3 provides a summary of the 2019 GHG emission profile for Ontario.

[29] Government of Canada (2021) *Greenhouse gas sources and sinks: executive summary 2021* - Canada.ca
[30] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021,* Part 3, Table A9-3
[31] The Public Electricity and Heat Generation subcategory includes the GHG emissions associated with the production of electricity and heat from the combustion of fuel in public or privately owned utility thermal power plants whose primary activity is supplying electricity to the public.
[32] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*, Table ES-4

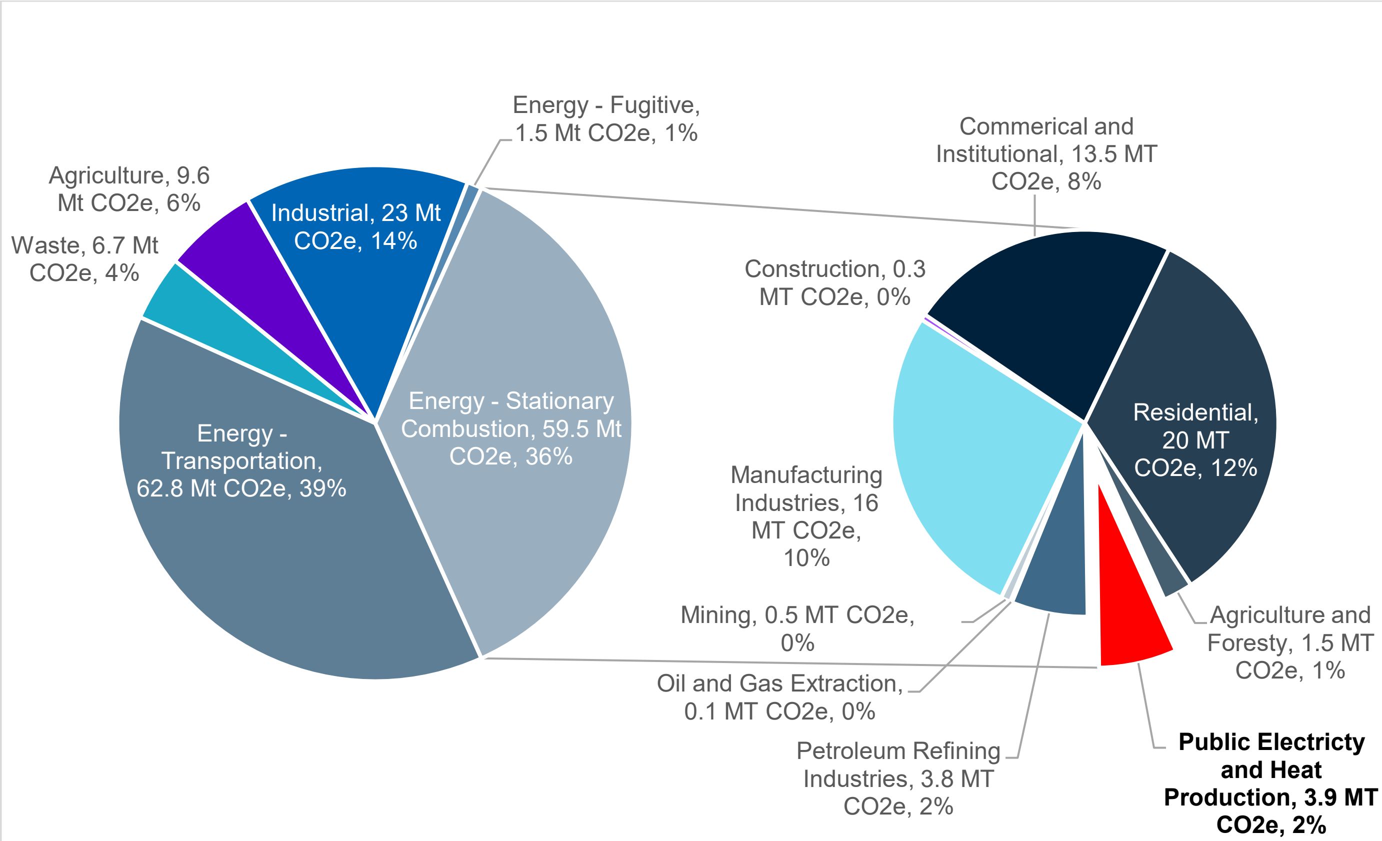



***Figure 3 Ontario GHG emissions profile by sector, 2019***[33]

As shown on Figure 3, within Ontario, the energy sector emitted 124 Mt $CO_2e$, or 76% of the province's total 2019 GHG emissions of which 3.9 Mt $CO_2e$ was a result of public electricity and heat generation and represents 2% of Ontario's annual GHG emissions. At only 2% of the total, emissions from public electricity and heat generation in Ontario are lower than the national average of 9.5%. The proportionally low GHG emissions from electricity generation is a result of a radical transformation to mostly carbon free generation over the last six years, with nuclear providing the bulk of electricity and the elimination of coal generation. Therefore, it appears that Ontario's electricity system is currently well positioned to support the country's net zero commitments. For comparison, in the U.S. the electricity sector accounted for a quarter of all emissions in 2019, while electricity production contributed roughly 21% of total emissions in the U.K.[34].

Many emissions that occur in the other subsectors of the Energy – Stationary Combustion portion of the Ontario emission profile (Figure 3), such as residential, are associated with the consumption of fossil fuels as a thermal energy source and not necessarily to generate electricity. However, through conducting GHG verification projects in Ontario GHD is aware that a number of manufacturing industries, commercial, and institutional facilities generate their own electricity through combusting fossil fuel natural gas in cogeneration engines. Cogeneration facilities of this nature are popular in Ontario because they allow users greater control over their electricity generation/consumption and, in some cases, prevents sole reliance on the electrical grid, while also being cost effective compared to purchasing electricity from the grid. The downside of such systems is that cogeneration engines ultimately increase the annual GHG emissions from that facility when consuming fossil fuel based natural gas. As Ontario and Canada progress towards net zero, it is anticipated that there will be a shift back towards grid electricity supply as a method to reduce facility GHG emissions. This trend will likely be accelerated by the financial impact that the national carbon pricing program will place on individual facilities. Hydrogen and renewable natural gas blending activities along with incentives for

[33] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*, Part 3, Table A11-13
[34] IESO (2021) *Decarbonization and Ontario's Electricity System: Assessing the impacts of phasing out natural gas generation by 2030*

natural gas suppliers to reduce their emissions may have an impact and maintain the viability and practicality of cogeneration engines, however, facilities will typically aim to identify the most cost-effective method to retain power for their facilities. Long-term this could create increased demand on Ontario's electricity grid and impact the overall electricity profile in the province, which is discussed further in Section 2.4.

## 2.3 Ontario's Current Electricity Profile

In 2019, Canada's overall electricity generation was 575 Terawatt hours (TWh), which was produced using a mixture of combustion sources (including coal, natural gas, and other fossil fuels), nuclear, hydro, other renewables[35], and other generation[36]. In the same year Ontario produced a total of 149 TWh of electricity using, combustion (natural gas and other fossils fuel such as fuel oil and diesel), nuclear, hydro, and other renewables. This equates to 26% of Canada's overall electricity generated in 2019, however, total GHG emissions from energy generation in Ontario was 3.9 Mt $CO_2$e, or only 6% of Canada's total emissions from electricity generation. A comparison of how the energy sources used to generate electricity differ between the national grid and Ontario's grid is presented on Figure 4.

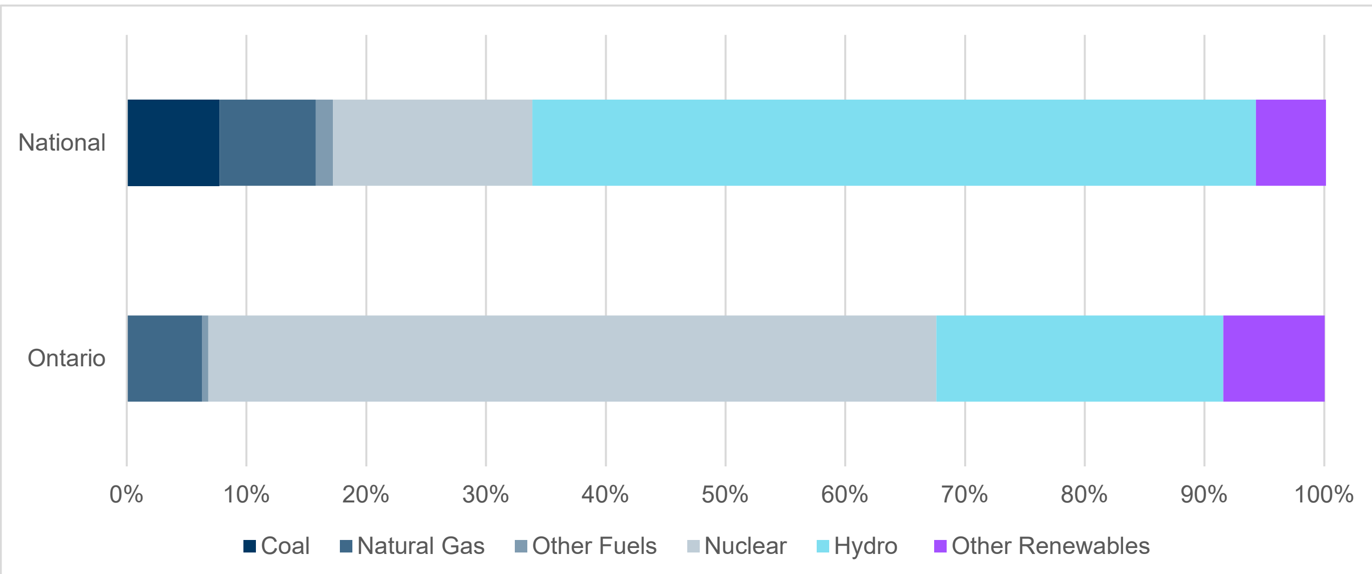



***Figure 4 National and Ontario electricity generation by source summary, 2019***[37]

As shown on Figure 4, Ontario's total installed transmission connected electrical generation capacity is made up of a combination of natural gas, nuclear, hydro, and other renewables (wind, biofuel and solar). The amount each source produces at any one-time changes hour by hour and depends on outages, availability and market factors. The amount each source produces also impacts the GHG emissions from Ontario's electricity sector (i.e., the higher the portion of electricity supplied from low emissions sources such as nuclear and renewables the lower the GHG emissions).

The amount of GHG emissions per kWh or electricity generated is referred to as the carbon intensity and is typically calculated on an annual basis. As shown on Figure 5, Ontario currently has the 6$^{th}$ lowest carbon intensive electricity systems in Canada.

[35] Refers to electricity generation from sources such as wind, tidal, and solar power
[36] Refers to the energy generated from waste heat
[37] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*, Part 3, Table A13-1 and Table A13-7

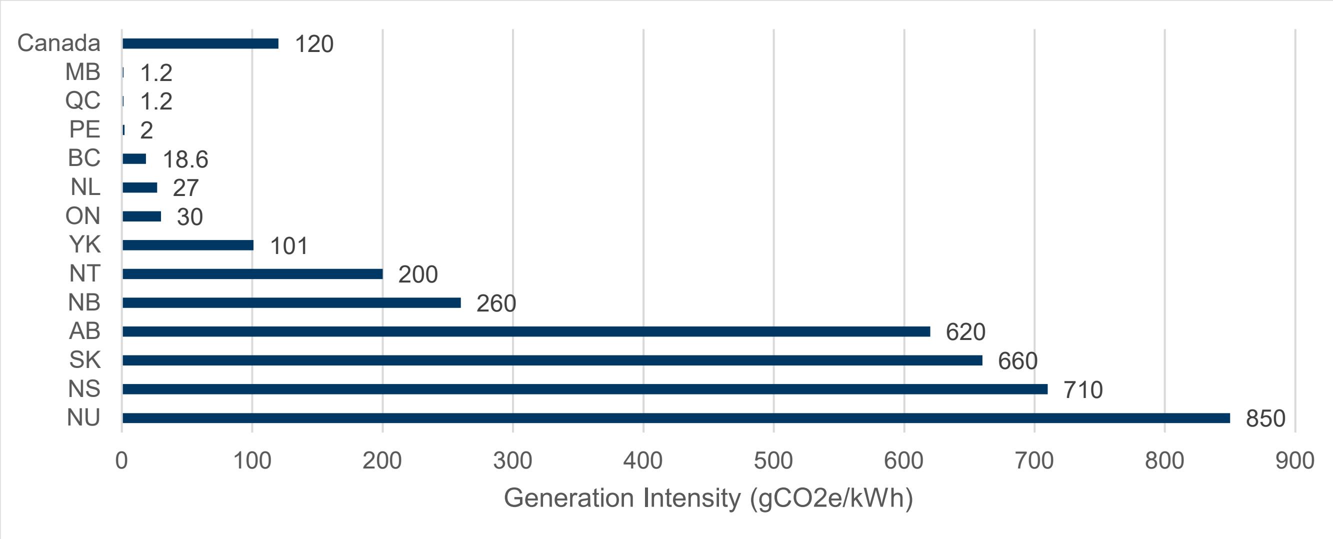



***Figure 5*** ***2019 Generation GHG intensities for Canada and its provinces and territories***[38]

As shown on Figure 5 the amount of $CO_2e$ emitted per kWh of electricity generated in Ontario was approximately 30g $CO_2e$/kWh in 2019, which is significantly lower than national average of 120g $CO_2e$/kWh and other provinces such as Alberta which has a generation GHG intensity of 620g $CO_2e$/kWh. As previously noted, the lower GHG emission intensity in Ontario is a result of the transformation to mostly carbon free generation, transitioning away from coal generation which was a predominant generation method in Ontario pre-2014. The successful phasing out of coal-powered generation in 2014 was the largest emissions-reduction initiative in Canada this century.

Figure 6 demonstrates how the historic electricity generation intensity of 230g $CO_2e$/kWh in 2005 compares to the 2013-2018 calendar years and ultimately the 30g $CO_2e$/kWh intensity in 2019, to depict how Ontario has continued to transition to carbon free electricity generation.

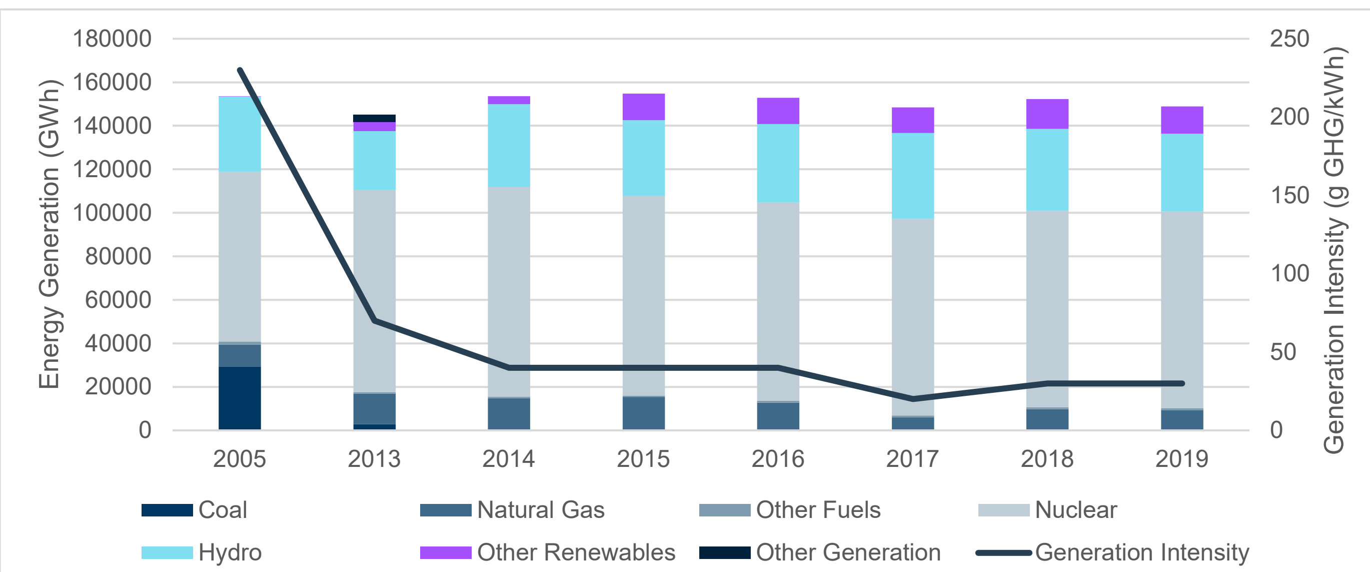



***Figure 6*** ***Ontario electricity generation GHG intensity and electricity generation by source***[39]

[38] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*, Part 3, Table A13-1 to A13-14, (Note values reported in the NIR are rounded to an appropriate number of significant figures based on the uncertainty of the category in question.)
[39] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*, Part 3, Table A13-7

In addition to calculating the annual average electricity generation GHG intensity, the NIR also produces annual data that can be used to calculate the electricity generation intensity associated with each specific energy/fuel source used to generate electricity in Ontario, Canada, and the rest of the provinces and territories.

Provided in Table 1 is the electricity generation intensity per energy type sourced from the NIR, The Atmospheric Fund (TAF) and similar GHG intensity data of different electricity supply sources, available from the Intergovernmental Panel on Climate Change (IPCC) and United Nations Economic Commission for Europe (UNECE).

*Table 1 Electricity generation GHG intensity by energy source*

| Electricity Generation Energy Source | Ontario 2019[40] | Ontario Average 2015-19[16] | Canada[41] | Ontario 2020[42] | | IPCC[43] | UNECE[44] |
|---|---|---|---|---|---|---|---|
| | $gCO_2e/kWh$ | | | | | | |
| Coal | 0 | 0 | 955 | 0 | [redacted] | 860 | 753 to 1095 |
| Natural Gas | 406 | 411 | 475 | 472 | | 490 | 403 to 513 |
| Other Fossil Fuels[45] | 80 | 130 | 565 | 0 | | | |
| Nuclear | 0 | 0 | 0 | 0 | | 12 | 5 to 6 |
| Hydro | 0 | 0 | 0 | 0 | | 24 | 6 to 147 |
| Other Renewables[46] | 0 | 0 | 0 | 0 | | 11-48 | 8 to 21 (wind)<br>7to 83 (solar) |
| Other Generation | 0 | 0 | 0 | 0 | | - | |
| **Average** | **30** | **29** | 120 | **-** | | **-** | |

Given that emissions intensities do vary year to year dependant on numerous factors such as the operational efficiencies and technologies employed at each specific generating facility, data is presented for Ontario for 2019, 2020, an average over 2015-19 and also for Canada to provide additional context and comparison. Note that the NIR and TAF data in the first four columns represent direct emission from the generation plant only and unlike the data presented from the IPCC and UNECE in the fifth and sixth columns, does not include wider lifecycle emissions such as extraction, processing and fuel transport, which results in inherently higher generation intensity values, as detailed in Table 1. Similarly, TAF recommends using a factor of 1.83 to estimate lifecycle emissions from direct combustion emissions (i.e., for natural gas multiplying 472 gCO2e/kWh by 1.83 to give a lifecycle GHG intensity of 864 gCO2e/kWh).

Therefore, using 2019 data from the NIR and provided in Table 1, it is estimated that every kWh electricity generated from low carbon sources (i.e., nuclear, hydro, wind biofuel and solar) avoids 406g $CO_2e$ compared to electricity generated in Ontario from natural gas and 80g $CO_2e$ per kWh compared to other fossil fuels. These values can be useful when assessing the benefit of additional renewable or low carbon power generation in Ontario to potentially eliminate fossil fuel generation.

[40] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*, Table A13–7 Electricity Generation and GHG Emission Details for Ontario. Note this data represents direct emission from the generation plant only
[41] Government of Canada (2021) *National inventory report 1990-2019: greenhouse gas sources and sinks in Canada 2021*, Table A13–1 Electricity Generation and GHG Emission Details for Canada. Note this data represents direct emission from the generation plant only
[42] The Atmospheric Fund (2021) A Clearer View of Ontario's Emissions: Updated electricity emissions factors and guidelines, natural gas generation emission factor
[43] Lifecycle emissions of electricity supply technologies (gCO2e per kWh) sourced from the 2014 Report by Intergovernmental Panel on Climate Change, Annex III, Table A.III.2
[44] UNEC (2021) *Life Cycle Assessment of Electricity Generation Options*, Figure 37
[45] Includes GHG emissions from the combustion of refined petroleum products (light fuel oil, heavy fuel oil, and diesel), petroleum coke, still gas and other fuels not easily categorized.
[46] Includes electricity generation by wind, tidal and solar.

## 2.4 Ontario's Electricity Forecast

Ontario's electricity system has transformed significantly over the last decade to be well positioned to support Canada's path to net zero. Each year the Independent Electricity System Operator (IESO) prepares its Annual Planning Outlook (APO), a 20-year forecast for Ontario's electricity system. The APO includes projected electricity demand, an assessment of whether resources will be ready and sufficient to meet that demand and performance indicators, such as GHG emissions. The demand forecast informs system reliability and investment decisions by anticipating future needs, which are affected by many factors, including the economy, population, demographics, technology, energy prices, input fuel choices, equipment purchasing decisions, consumer behaviour, policy, conservation and other considerations. The most significant findings from the most recent APO[47] are the:

- Increased demand in electricity with demand for electricity forecast to rise at rates not seen in many years, and to grow higher than in IESO's prior outlooks, and;
- Shift in the mix of primary energy used to generate electricity with natural gas fired generation predicted to account for an increasing share of Ontario's energy production throughout the 2020s.

These findings area further detailed in the following subsections.

### 2.4.1 Increased electricity demand

As presented in Section 2.2 currently 39% of GHG emissions in the province come from the transportation sector and 20% from fuel combustion by industries, compared to just 2% from the electricity sector. The relatively low GHG intensity of the current electricity grid therefore offers significant potential to support decarbonization of the transportation and industrial sectors in Ontario through electrification. As electric vehicles become the norm, homeowners switch to electric heating, and industries move on-site processes (including onsite electricity and heat generation) away from fossil fuels to electric, there will be an increased draw on the electrical grid. As a result, within the next few years Ontario is predicted to enter a period of growing electricity demand driven by the combination of this electrification coupled with economic growth in the industrial, mining and agricultural sectors and population growth, as presented on Figure 7.

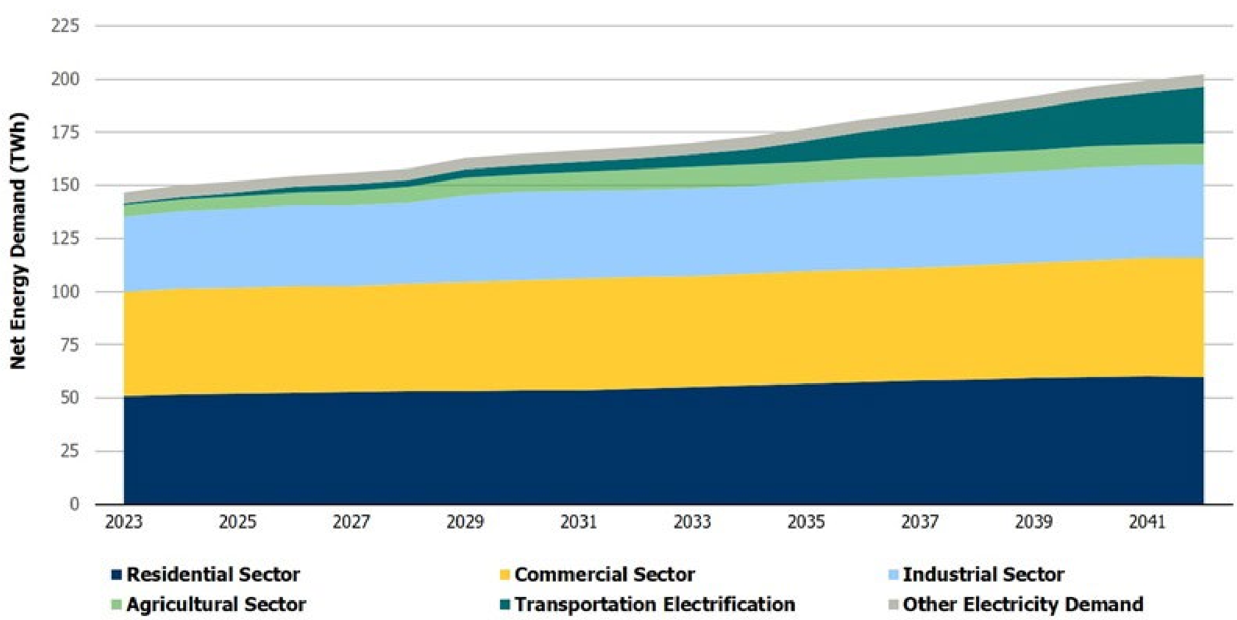



*Figure 7 Ontario projected peak energy demand to 2041*[48]

[47] IESO (2021), *Annual Planning Outlook Ontario's electricity system needs: 2023-2042*
[48] IESO (2021), *Annual Planning Outlook Ontario's electricity system needs: 2023-2042* The 2021 APO in 7 Graphs (ieso.ca)

Increased demand from electrification has already begun, with several notable companies and associations beginning to transition from gas/diesel powered operations to electric. An example being Transport Canada, which has released their zero-emission vehicle (ZEV) incentives campaign in line with the target of 100% ZEV sales by 2035[49]. Major car manufactures' such as General Motors, Toyota, Volvo, and Volkswagen have also since announced their intentions to reduce, and in some cases eliminate, the production of gas/diesel fuelled vehicles in the coming years, transitioning instead to entirely electric vehicles.

An increase in electricity demand and 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, given that the carbon intensity of the electricity system remains well below that of fossil fuels, such as gasoline for automotive transportation or fuel oil for space heating. For example, according to the IESO an electric vehicle (EV) charged up in Ontario, produces only 3% 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% of the emissions compared to its gas counterpart. Figure 8 presents the GHG emission comparison between a gasoline vehicle and an equivalent electric vehicle based on worst case conditions for electricity generation in Ontario.

**Gasoline vehicle**

- 17.16 kg $CO_2$ per 100km

**Electric vehicle**

- 6.94 kg $CO_2$ per 100km

***Figure 8*** ***GHG emission per 100km gasoline Vs electric vehicles***[50]

Ultimately the increased electricity demand in Ontario through 2040 needs to be achieved through different types of energy sources. Surprisingly, from a carbon reduction and net zero perspective, one of those main sources expected by the IESO to support the demand, is fossil fuel natural gas.

### 2.4.2 Increased supply from natural gas generation

Currently Ontario benefits from having a diverse supply mix with no one dominant fuel source. According to the IESO's 2020 data, natural gas generation accounts for 28% of Ontario's capacity to produce electricity, but only 7% of current total system output/use, as displayed on Figure 9. This is because no single resource is capable of producing electricity at maximum output levels at all times due to fuel availability, ambient conditions, demand, or outages.

[49] Canada's Zero-Emission Vehicle (ZEV) sales targets (link)
[50] Source: IESO (2021), *Decarbonization and Ontario's Electricity System: Assessing the impacts of phasing out natural gas generation by 2030*

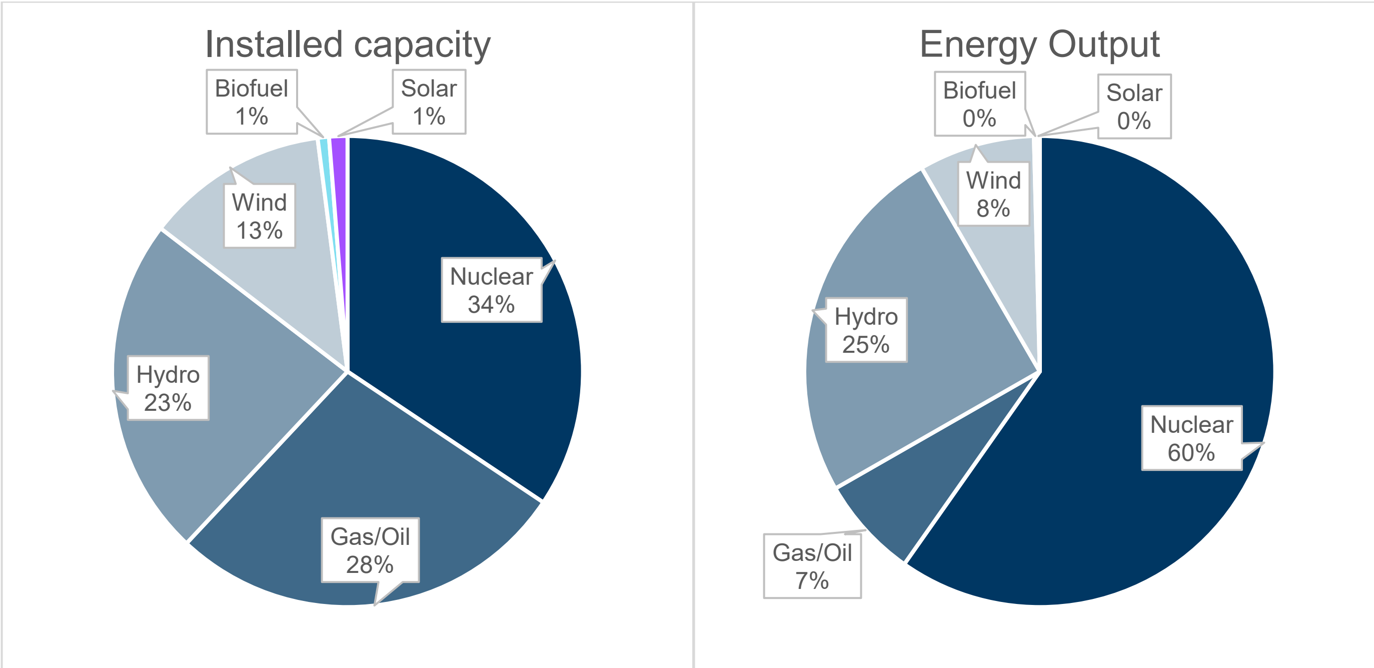



***Figure 9*** ***Ontario 2020 installed capacity vs. output by fuel type[51]***

Nuclear is the one exception, Figure 9 shows that the installed capacity of nuclear represents 34% but the energy output represents 60% which is due to the ability of nuclear to provide a constant and consistent power output throughout the day and night.

Throughout the 2020s, Ontario's electricity system will see significant change in the available capacity from its nuclear fleet, driven by nuclear refurbishments and retirements. There are planned refurbishments to extend the life of the Darlington and Bruce Power nuclear reactors which will cause units to be temporarily off-line (2020 through 2026 and 2033 respectively) and the retirement of the Pickering nuclear generators at the end of 2025 which will reduce Ontario's installed nuclear capacity by 3.1 GW. Consequently, the IESO forecasts there will need to be an increase electricity generation/output from the existing natural gas generation facilities to balance the rising electricity demand with the reduced nuclear supply. As a result of this increased proportion of natural gas generation, annual emissions from electricity generation are forecasted to increase this decade from a recent average of 5.4 megatonnes (Mt) $CO_2e$ to 11.9 Mt $CO_2e$ in 2030, an increase of 120%. Figure 10 conveys how the IESO is expecting the GHG emissions from electricity generation to rise from now through to 2042, with historical data tracking for context and magnitude comparison.

[51] Source: 2020 Year in Review (ieso.ca)

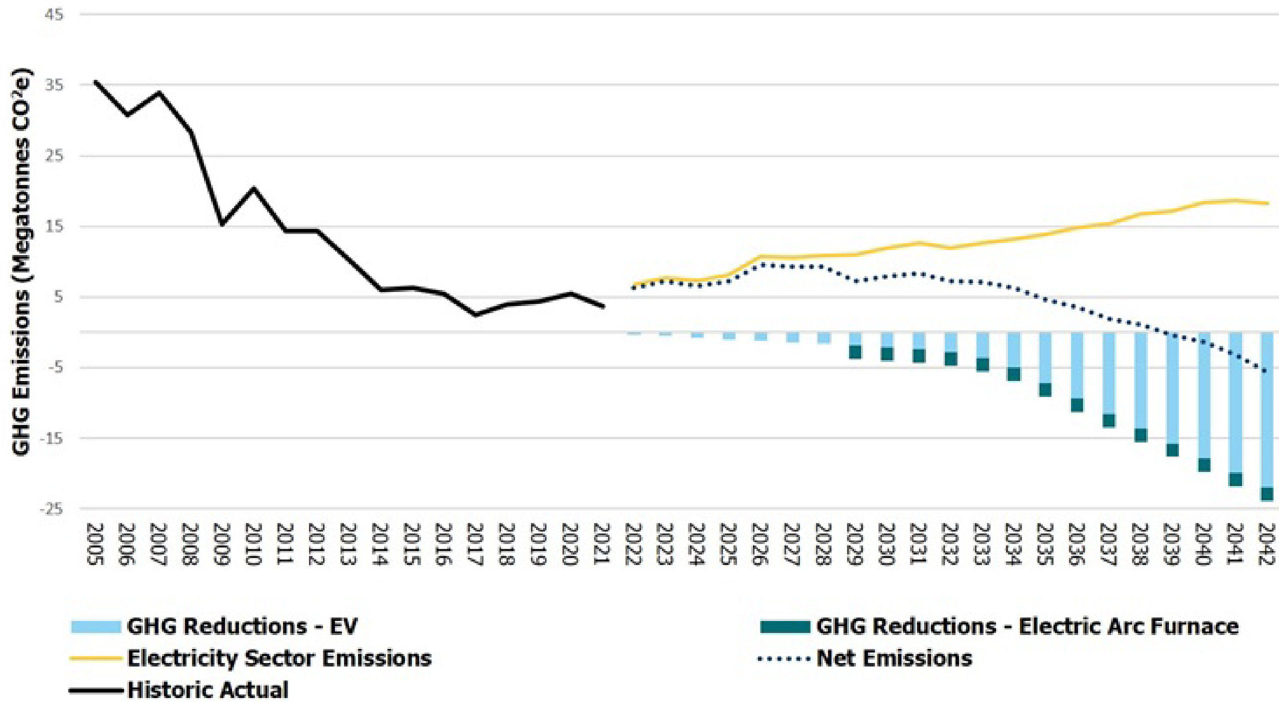



*Figure 10 Ontario Electricity Sector GHG Emissions (historic and projected)*[52]

The IESO outlook report also presents marginal emission factors which can be used to estimate the GHG emissions which would be avoided due to a reduction in demand for grid supplied electricity from smaller energy efficiency projects (e.g., lighting retrofits to reduce electricity consumption by less than 100MW). The emission factors as presented on Figure 11 are reflective of the marginal resource (i.e., which electricity generation facility and associated energy source is expected to increase output to respond to the change in demand) and have been calculated based on the GHG intensity rates of the different generators and the IESO's anticipated increase or decrease in generation. These avoided emission factors can be used as an indicator for the projected GHG emissions intensity of grid supplied electricity in Ontario.

[52] IESO (2021), *Annual Planning Outlook Ontario's electricity system needs: 2023-2042*

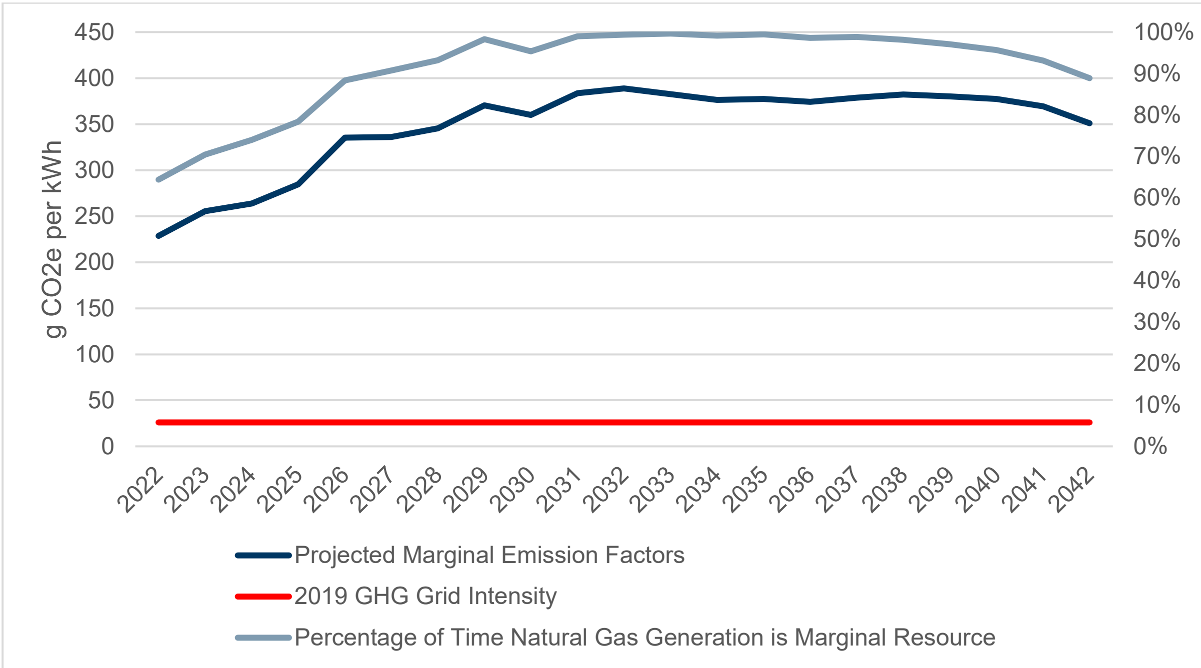



***Figure 11 Marginal annual avoided GHG emission factors*[53]**

As shown on Figure 11 the marginal emissions factor is very closely aligned with the percentage of time natural gas generation is projected to be the marginal resource (since natural gas generation is the only resource type in Ontario's fleet that generates GHG emissions) and is lower in the short term when more zero/low carbon generators such as nuclear will be operating and increase in the medium to long term due to; increased demand, decreased nuclear generation and increased natural gas fired generation. For example, following the closure of the Pickering nuclear generator stations at the end of 2025, the avoided emission factor is predicted to increase significantly from 285g to 335g $CO_2e$ per kWh in 2026 which is over 11 times more carbon intensive than the 2019 average grid GHG intensity of 30 g$CO_2e$ per kWh (see Table 1).

Similarly, currently (based on the current mix of the electricity grid) consumers in Ontario who reduce their grid supplied electricity consumption by 1kWh will save 30g $CO_2e$ in GHG emissions however by 2032, due to the increase in natural gas electricity generation, the same electricity saving is predicted to avoid approximately 389g $CO_2e$

## 2.5 Decarbonization of Ontario's Electricity Generation

With emissions from the electricity sector in Ontario projected to increase, if Canada is to realistically achieve its decarbonization goals and keep a global temperature rise of less than 1.5$^{o}$C within reach, a number of measures are needed to achieve a reliable decarbonized electricity generation system.

**1. Extend life of existing zero carbon electrical generation capacity**

Building new transmission infrastructure and new generation takes significant time, investment, land and resources, with time needed to plan, obtain necessary regulatory and environmental approvals, engage with affected communities, and then build and integrate into the local grid. With its current low-emission electricity system, Ontario has a fundamental advantage in decarbonizing its economy. Therefore, it is important to take advantage of the amount of existing low and zero carbon energy generation capacity assets that currently exist and extend the life of these assets to maximize the increased demand that will be met with zero carbon electricity.

For example, Bruce Power's Major Component Replacement (MCR) Project which began in January 2020 and will complete in 2033 focuses on the replacement of key reactor components in Units 3-8, including steam generators,

[53] IESO (2021), *Annual Planning Outlook Ontario's electricity system needs: 2023-2042 Figure 43*

pressure tubes, calandria tubes and feeder tubes. Without this billions of dollars invested in refurbishments and life extension the plant would go offline 2023-2026. However, MCR will extend the operational life of each unit by 30-35 years to 2064 and in turn help prevent the predicted increase in the GHG emission intensity of the electricity grid going up the 389g $CO_2$e/kWh intensity anticipated by the IESO (refer to Figure 11). In addition, by 2034 following completion of the MCR project the annual power output of the Bruce Power nuclear facility is predicted to be 37.1 TWh. However, should the life of the units not have been extended and this same power output be provided from natural gas generation instead of nuclear, this would result in GHG emissions of approximately 15 million MT $CO_2$e per year compared to zero direct emissions from Bruce Power (calculated using 2019 natural gas electricity generation intensity data of 406 g$CO_2$e/kWh available from the NIR, as shown in Table 1).

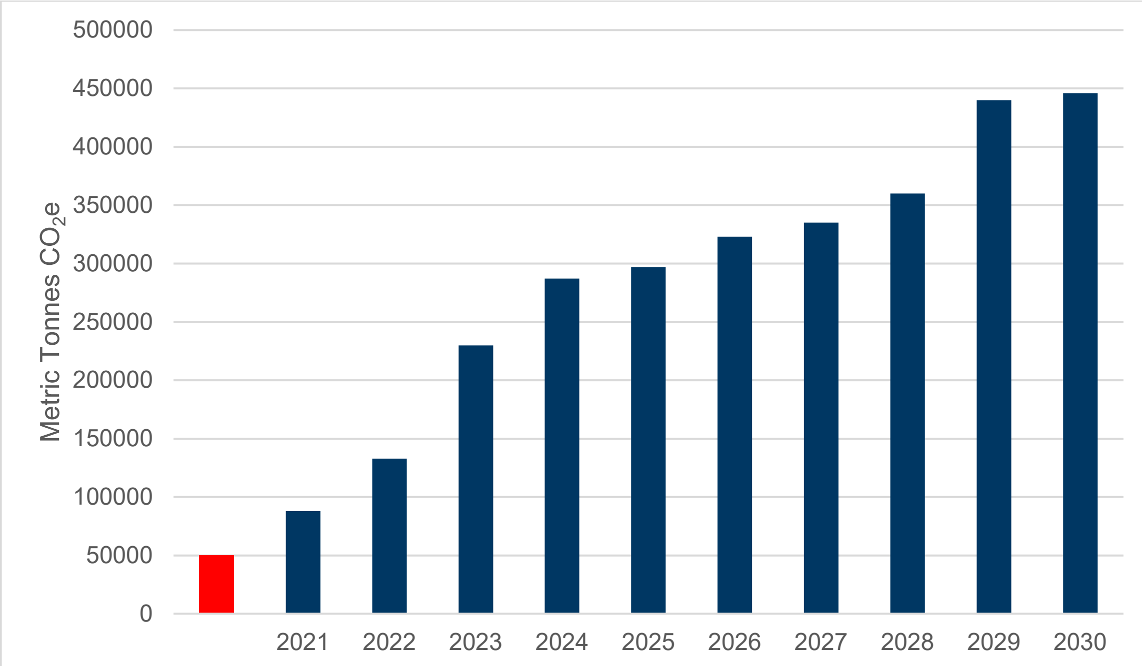
**2. Increased output from existing low and zero carbon capacity**

Investing in innovation to maximise the output and increase the efficiency of the current clean electricity generation systems to further displace fossil fuel generation can also play an important part in the decarbonization of the electricity system.

For example, since 2016 Bruce Power has also started to increase the power output capacity through the gradual replacement of older systems in the company's eight reactor units during regularly scheduled maintenance outages. The site's current generation peak (when all 8 units are operating) is 6,550 megawatts (MW), an increase from 6,300 MW in 2016, building towards a goal of 7,000 MW by 2030. This provides additional zero carbon electricity capacity to meet the IESO's projected energy demands and also compensates for the additional supply that is expected to be met with natural gas generated electricity.

Since the current IESO forecast assumes any increase in demand is met by increasing natural gas generation, using 2019 electricity generation intensity data available from the NIR (as shown in Table 1) every additional kWh electricity generated in Ontario from nuclear instead of fossil fuel natural gas avoids on average 406g $CO_2$e, (which increases to 478g $CO_2$e when wider lifecycle emissions such as extraction and fuel transport are included[54]). Using this 2019 natural gas emission factor the total annual avoided GHG emissions from the additional "incremental" power output expected from Bruce Power's power recovery projects can be calculated and are shown on Figure 12 for 2021-2030. For context 50,000 Metric Tonnes $CO_2$e is equivalent the average GHG emissions generated from the energy used by 42,935 homes in one year[55].

[54] Calculated using data regarding the Lifecycle emissions of electricity supply technologies (gCO2e per kWh) from the 2014 Report by Intergovernmental Panel on Climate Change, Annex III, Table A.III.2. Natural Gas = 490 gCO2e per kWh and Nuclear = 12 g/kWh
[55] Source; Natural Resources Canada, Greenhouse Gas Equivalencies Calculator https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/calculator/ghg-calculator.cfm#results




Annual emissions from average energy used by ~43,000 homes

***Figure 12*** ***Avoided GHG Emissions from additional "incremental" output from Bruce Power nuclear facility over output generated from fossil fuel natural gas***

### 3. Reducing emissions from operating existing low and zero carbon capacity

Although the electricity generated at renewable and nuclear facilities is considered zero carbon there are some GHG emissions from site operations associated with running safety system tests on standby generators, on-site vehicle fleets that supports operations and lighting and heating on-site buildings. However, both Bruce Power and the Ontario Power Generation (OPG) have announced Net Zero goals to eliminate all emissions associated with site operations. Meaning that the GHG emission intensity of electricity generated (including emissions supporting site operations) will be zero.

Bruce Power's Net Zero 2027 strategy, announced earlier this year, aims to meet targets by identifying and implementing energy and emission-reduction projects in its operations, identifying substitutions for high-emission energy sources and, where further reductions are not feasible, pursuing emission offsets. Some of the company's emission-reduction projects include implementing efficiencies for on-site buildings and undergoing a fleet optimization study to look at implementing more efficient practices and moving a portion of the company's vehicle fleet to electric.

### 4. Replace natural gas with non-fossil fuel alternatives

As discussed in Section 2.4, natural gas electricity generation facilities are anticipated to continue playing an important role in Ontario's electricity generation mix, given their current available capacity, role in stabilizing the grid and responding to rapid changes in demand. However, to reduce and eventually eliminate GHG emissions in the province, the existing and future facilities will need to be built or retrofitted with carbon capture and sequestration (CCS) technology, or fuelled using clean hydrogen, or renewable natural gas (RNG).

Green hydrogen is one of the leading options for generating and storing renewable energy and can be blended into existing natural gas pipelines to be used in existing generation facilities. Currently, green hydrogen is not widely produced as it requires renewable energy to run electrolysers with a steady input of clean water. Ontario's existing nuclear capacity is well placed to support the generation of green hydrogen during times of low electricity demand given that nuclear power is one of the few low carbon energy sources that can generate the electricity and heat needed for hydrogen synthesis. Hydrogen can currently be blended into existing natural gas pipelines at up to 10% by volume.

RNG is another potential non-fossil fuel alternative generated from biogas captured at organic waste at landfills, livestock operations, farms, and sewage treatment facilities. The biogas containing significant amounts of methane (50-80%) is upgraded (e.g., by removing impurities) to meet natural gas pipeline specifications. RNG can play an important role in Ontario's clean energy future as it is interchangeable with conventional natural gas but does not carry a carbon signature due to its biogenic attributes.

**5. Additional renewable capacity**

To meet the demand from increased electrification significant new clean electrical capacity (nuclear, hydro wind and solar) will be required and to achieve net zero carbon by 2050. Additional nuclear capacity could also support the generation of additional green hydrogen, as discussed in point 4 above. Whilst new nuclear and hydro plants can require many years to develop, other renewable resources, such as wind and solar can be developed more quickly to meet load increases, however there are specific land and atmospheric requirements that will need to be considered.

In January 2022 the Ontario government announced its intention to leverage its low carbon electricity system and develop a voluntary clean energy credit (CEC)[56] registry, which will enable businesses operating in Ontario to voluntarily purchase and retire these CECs to demonstrate that their electricity has been sourced from a non-emitting resource. The purchase of CECs will also generate revenue and supports further investment in solar, wind, bioenergy, hydroelectric, and nuclear power in the province. The Ontario government intends to have the registry available by January 2023[57].

**6. Small Modular Reactors (SMRs)**

Like existing nuclear reactors, SMRs can provide reliable, GHG emissions free electricity, but with a much smaller land footprint. Their advantage is that they can be deployed not only in large established grids but also in remote off-grid communities and for large 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 and replace carbon intensive micro-grid networks.

Ontario Power Generation is currently proposing an SMR to be in service by 2028 at the Darlington Nuclear Generating Station[58], however the technology and deployment of SMRs is still in its infancy and further investigation will be required into safety, transportation and permitting requirements.

**7. Increased energy storage**

Storage provides the ability to capture excess energy and reinject it into the system when supply is low. Grid-scale batteries are emerging, in particular to support renewable generation by storing excess renewable energy when it is available and releasing it when it is needed. Energy storage will therefore be an important pillar for Ontario's future electricity supply mix as Ontario's electricity system currently has more capacity than it can utilize, particularly at night when zero carbon wind, hydro and nuclear resources have capacity but there is less demand. Energy storage will therefore be a necessary component to leverage and maximize the value of any significant additional intermittent renewables or baseload supply such as nuclear to the system and to reverse the current (and projected increase) reliance on high carbon intensive natural gas supply during periods of peak demand. It is understood the IESO is currently supporting storage technology testing and development including a new 250 MW battery facility. There is also a significant amount of research and development in battery technology globally that may yield a breakthrough in the future to make battery storage projects even more viable.

TC Energy has also received conditional approval for construction of a 1,000 MW pumped-storage hydroelectric plant in Meaford which would pump water from Georgian Bay at night when energy demand is lower, then release it through power-generating turbines to deliver electricity to the grid by day when demand for electricity is higher.

**8. Increased Energy Efficiency and Changing Consumer behaviour**

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[56] Voluntary CECs are certificates that each represent 1 megawatt-hour (MWh) of clean electricity that has been generated from a non-emitting source.
[57] Source: https://news.ontario.ca/en/release/1001486/new-ontario-clean-energy-registry-will-make-province-even-more-attractive-for-investment
[58] Media release > OPG advances new nuclear at Darlington - OPG (link)

Consumers are much more environmentally conscious than ever before and homeowners, businesses, and organizations across many sectors, including municipalities, are actively pursuing new opportunities to accelerate decarbonization. Harnessing this awareness to change behaviours is going to play a key part in achieving net zero. Therefore, energy efficiency programs must continue to work to shift or reduce electricity demand during peak periods and in turn lower GHG emissions.

For example, Under the Save on Energy[59] brand, the IESO delivers a suite of energy conservation programs and educational resources, which help consumers reduce their energy costs and reduce electricity demand on the grid. Ontarians achieved 1.5 TWh in energy savings and 186 MW of demand savings through Save on Energy programs in 2019 and 2020[60].

The Canadian Home Builders Association has also launched their Net Zero Home program in 2021, which provides resources for homeowners to complete the transition to a net zero lifestyle, including the electrification of various aspects and rooftop solar. Simultaneously, the Government of Canada has introduced a Net Zero Buildings fund, supporting the transition to a low-carbon economy through channels such as energy generation and usage.

# 3. Conclusion

The net zero commitments made over the recent months and years are welcome and a very important step, however immediate actions and tangible solutions at all levels of government, industry sectors and society are the only way to achieve near zero emission over the next 30 years to meet Canada’s net zero 2050 goal.

With the energy sector at the core of the solutions to net zero, Ontario’s low carbon intensive electricity system currently serves as a strong foundation to support a zero-carbon economy. However, with emissions from electricity generated from natural gas currently forecasted to increase in the next few years (due to rising electricity demand from electrification) and reduced nuclear production capacity (due to retirements and refurbishment), it is clear that achieving Canada’s ambitious climate targets by 2050 whilst maintaining the reliability of the power system requires a multi-faceted approach. With electricity generation from all available sources of non-emitting energy working together with technology, innovation and energy consumers, to all play a role in keeping a reliable decarbonized electricity system within reach.

[59] Save on Energy | Unlock Your Energy Potential at Work and at Home (link)
[60] IESO (2021), *Decarbonization and Ontario’s Electricity System: Assessing the impacts of phasing out natural gas generation by 2030*

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