Bruce Power
Innovation at work

Bruce Power
Project 2030

Net Zero Progress Together. Now.

Incremental Clean Energy Production and Avoided Emissions: The Case for New and Refurbished Nuclear Power

IESO Background Documentation

About

Bruce Power is an electricity company based in Bruce County, Ontario. We are powered by our people. Our 4,200 employees are the foundation of our accomplishments and are proud of the role they play in safely delivering clean, reliable, low-cost nuclear power to families and businesses across the province and life-saving medical isotopes around the world. Bruce Power has worked hard to build strong roots in Ontario and is committed to protecting the environment and supporting the communities in which we live. Formed in 2001, Bruce Power is a Canadian-owned partnership of TC Energy, OMERS, the Power Workers' Union and The Society of United Professionals. Learn more at www.brucepower.com and follow us on Facebook, Twitter, LinkedIn, Instagram and YouTube.

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings and transportation. We provide engineering, environmental, advisory, architecture, digital and construction services to private and public sector clients.

This report includes reference to information provided in the following report prepared by GHD Limited (GHD) for Bruce Power *GHD Limited (2022) The Energy Sector's Role in Net Zero*.

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Executive summary

With the future of electricity generation so intrinsically tied to climate change and decarbonization, a renewed look at the pathway to decarbonization for Ontario is needed.

Thanks to a clean baseload supply of nuclear and hydro, Ontario has one of the cleanest electricity grids in the world.

26%

of Canada's overall electricity generated in 2019 was produced in Ontario, but only

6%

of Canada's total emissions were from electricity generation thanks to nuclear power.

To achieve Net Zero, it is vitally important to understand the current greenhouse gas (GHG) emissions output profile in terms of both scale and sources. In 2019, Ontario produced 26 per cent of Canada's overall electricity generated, however, total GHG emissions from public electricity and heat generation in Ontario was 3.9 Mt CO_2e, or only 6 per cent of Canada's total emissions from electricity[1] generation. Ontario currently has the sixth lowest carbon-intensive electricity system in Canada. This is largely the result of Ontario's nuclear resources, which provide 60 per cent of Ontario's energy needs daily.[2]

Nuclear power enabled Ontario's coal phase-out program, which stands out as one of the world's largest and most successful GHG and pollution-reduction policies. To achieve this transformation, 35 Terawatt hours (TWh) of low GHG-emission generation was added to Ontario's supply mix, with nuclear generation providing 89 per cent of the energy capacity required.[3] As we further decarbonize the economy, nuclear power will undoubtedly continue to play an integral role in this transformation.

1 GHD Limited (2022) The Energy Sector's Role in Net Zero p. 6
2 GHD Limited (2022) The Energy Sector's Role in Net Zero p. 11
3 Green Ribbon Panel (2020) Clean Air, Climate Change and Practical, Innovative Solutions Policy Enabled Competitive Advantages Tuned for Growth p.18

Clean electricity produced at Bruce Power is displacing GHG emissions that would be produced by fossil fuels, and the case is strong for incremental output from the Bruce Power site, as well as other clean energy resources, to be considered eligible to register for GHG offsets.

Governments around the world have recognized that at the heart of our transition to Net Zero is our electricity system. 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.

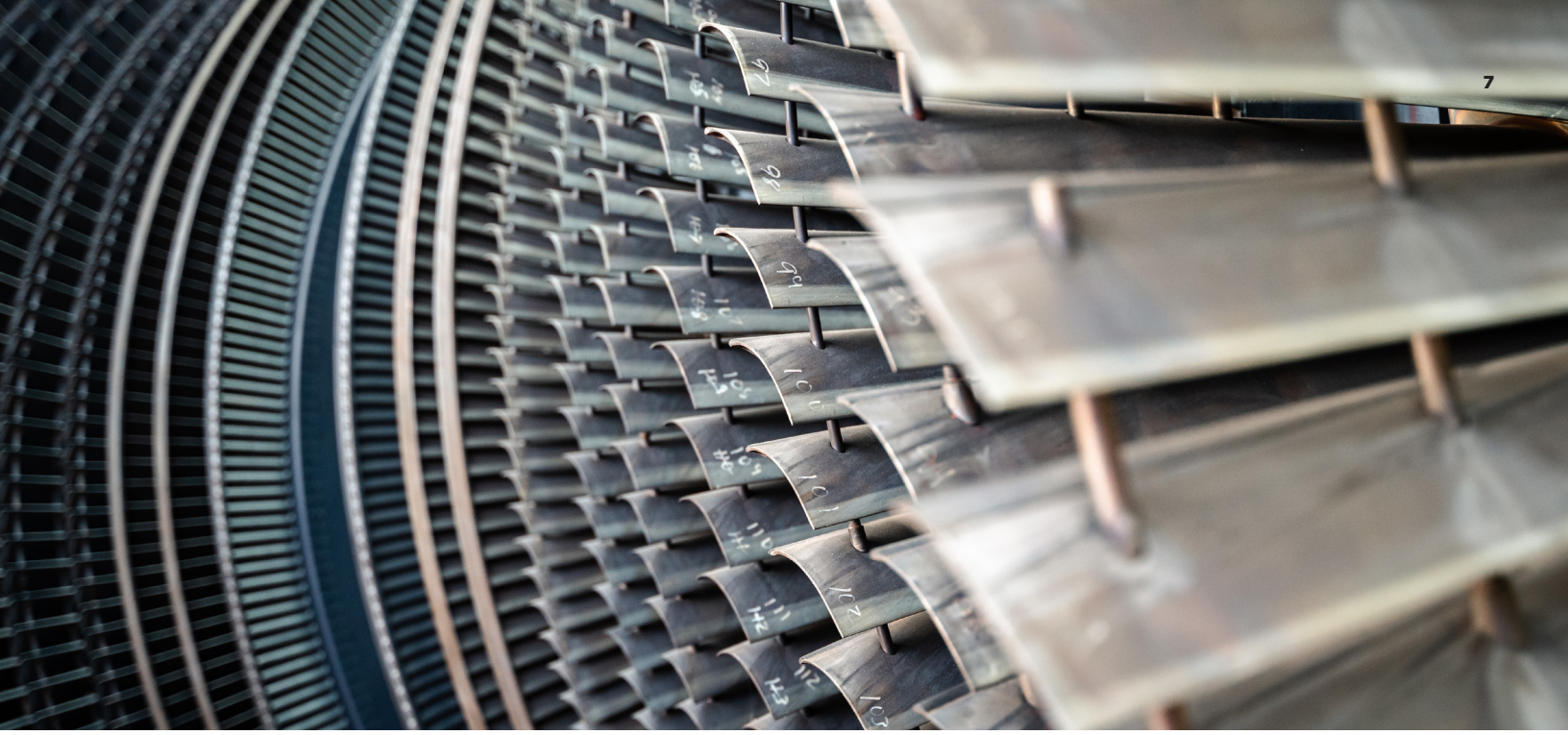
However, unlike energy system decisions of the past which were based solely on reliability and cost, the environmental attributes and benefits of energy sources must now be considered. Clean generation holds many benefits, but most importantly is the role it places in helping to avoid emissions across all sectors of the economy and from other GHG-emitting electricity sources.

In Ontario, the IESO forecasts there will need to be an increase in 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 per cent.[4]

Bruce Power's investment in a series of power recovery projects under Project 2030 will bring incremental power output to 7,000 MW by 2030. The avoided emissions from the initial phase of Project 2030, which will grow site output to 6,750 MWs, are estimated to remove almost 450,000 metric tonnes of CO_2e- annually, the equivalent of taking approximately 100,000 cars off the road. This is just one example, and there are numerous other energy projects underway or in the planning stages that will create similar avoided emissions benefits to Ontario, such as the TC Energy Pumped Storage Project.

Given that these investments will generate additional clean energy and are forecasted to result in avoided emissions from natural gas generation, it is Bruce Power's opinion that the case is strong for incremental output from our site, as well as other clean energy resources, be considered eligible to register for GHG offsets within the appropriate offset program, similar to the Specified Gas Emitters Regulation in Alberta and the quantification protocol for wind-powered electricity generation in terms of avoided emissions from incremental clean energy output.

4 GHD Limited (2022) The Energy Sector's Role in Net Zero p. 11



The opportunity for generating carbon offsets with the Alberta protocol arises from the quantification of reductions in GHG emissions resulting from the implementation of facilities that convert the energy in wind into electrical energy. The protocol quantifies the emission reductions based on the generation of an equivalent of electricity from fossil fuel-based sources. In Ontario, there would need to be a protocol developed that applies specifically to new or refurbished clean nuclear power generation and a specific offset program/registry that factors in local eligibility, additionally, and other offset requirements.

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 — are necessary if Canada and Ontario are to realistically achieve its decarbonization goals. This high-level report details the case for why incremental nuclear power should be considered eligible to register for GHG offset credits.

Incremental nuclear energy output should be considered eligible to register as GHG offsets within the appropriate offset program and registry.

What is Net Zero?

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?

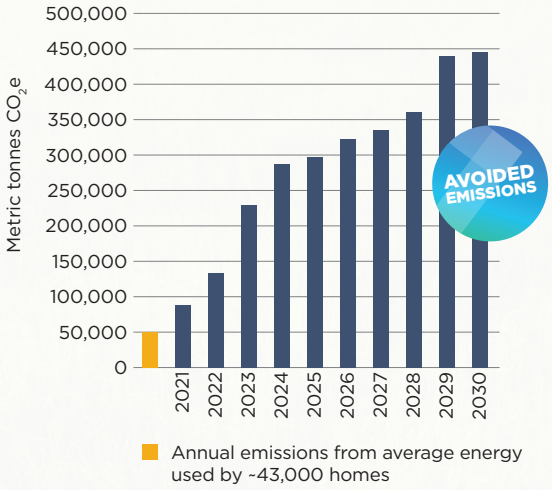
Bruce Power™
Project 2030

WHAT IS PROJECT 2030?

In October 2021, Bruce Power announced Project 2030, which is the company's goal of achieving a site peak capacity of **7,000 MW for the 2030s** in support of climate change targets and future clean energy needs. Project 2030 will focus on continued asset optimization, innovations and leveraging new technology, which could include integration with storage and other forms of energy, to increase the eight-unit peak capacity at Bruce Power.

Project 2030 would see Bruce Power increase its nameplate capacity by 700 MW of incremental output. The initial stage of Bruce Power's Project 2030 will increase site output to 6,750 MW and will lead to avoided emissions, estimated at almost 450,000 metric tonnes of CO_2e-equivalent annually, which equals taking about 100,000 cars off the road.

Figure 2
Avoided GHG emissions from additional incremental output from Bruce Power facility over output generated from fossil fuel natural gas



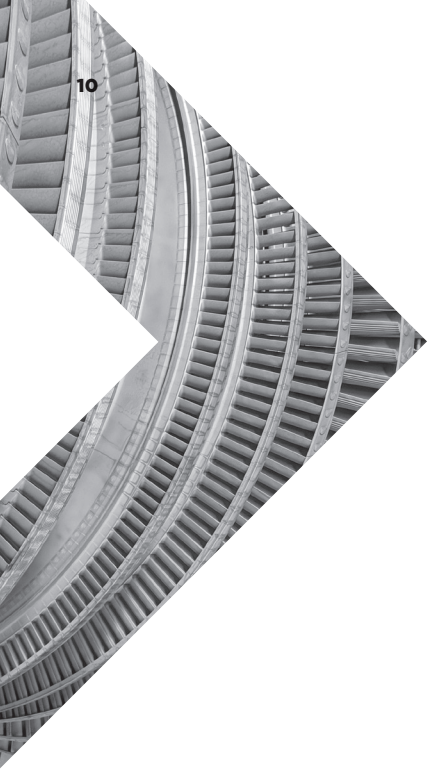
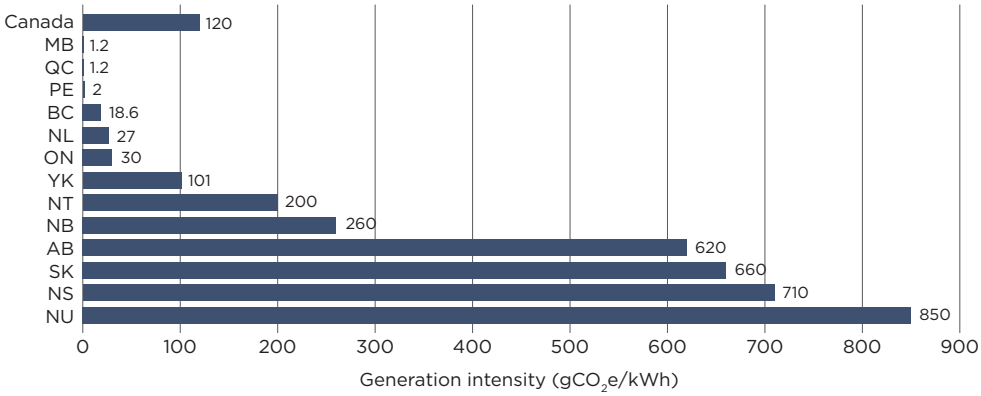


Figure 3
2019 generation GHG intensities for Canada and its provinces and territories



The case for nuclear power

In 2019, Ontario produced 26 per cent of Canada's overall electricity, however, total GHG emissions from energy generation in Ontario was 3.9 Mt CO_2e, which only represents six per cent of Canada's total emissions from electricity generation. Ontario currently has the sixth lowest carbon-intensive electricity system in Canada[5] (Figure 3). This is largely the result of Ontario carbon-free nuclear resources, which provide 60 per cent of Ontario's daily energy needs.

The Independent Electricity System Operator (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 reduced nuclear supply because of the ongoing refurbishment projects. While natural gas is an important part of a diverse supply and critical to providing system reliability during peak hours, it does have a greater GHG intensity then other non-emitting resources.

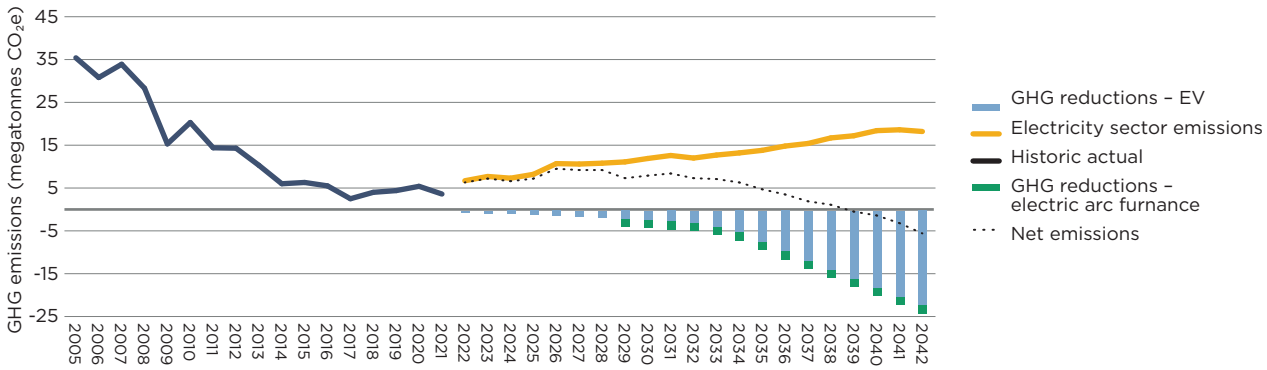
As a result of this increased proportion of natural gas generation, annual emissions from electricity generation are forecasted to increase this decade from a recent average of 5.4 megatonnes (Mt) CO_2e to 11.9 Mt CO_2e in 2030, an increase of 120 per cent.[6] Figure 4 shows how GHG emissions from electricity generation are expected to rise from now through to 2042.

Following the closure of the Pickering nuclear reactors at the end of 2025, the GHG Grid intensity in Ontario is predicted by the IESO to increase significantly 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[7] (Table 1).

Ontario has a very decarbonized electricity supply, and we have to ensure we maintain that advantage in the decades ahead.

5 GHD Limited (2022) The Energy Sector's Role in Net Zero p. 6
6 GHD Limited (2022) The Energy Sector's Role in Net Zero p. 11
7 GHD Limited (2022) The Energy Sector's Role in Net Zero p. 13

Figure 4
Ontario electricity sector GHG emissions
(historic and projected)



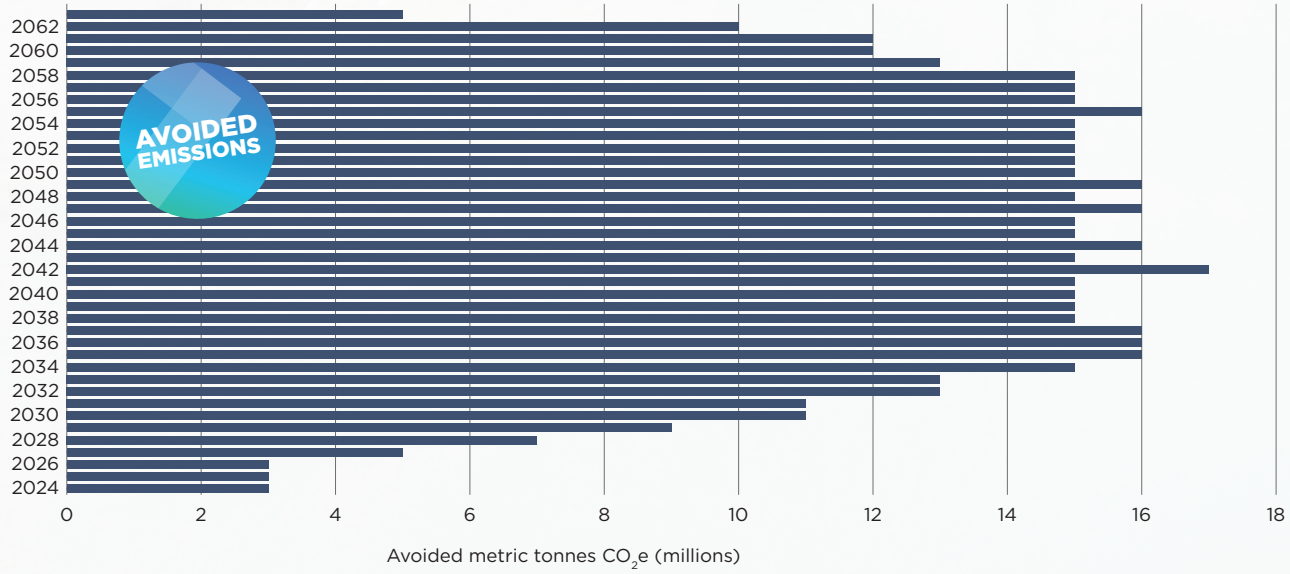
Incremental electricity from **Bruce Power** and other sources can help **keep GHG emissions down in Ontario**.

Table 1
Electricity generation GHG intensity by energy source

Electricity Generation Energy Source	Ontario 2019	Ontario Average	Canada	Ontario 2020	IPCC	UNECE
			gCO_2e/kWh			
Coal	0	0	955	0	860	753 to 1,095
Natural Gas	406	411	475	472	490	403 to 513
Other Fossil Fuels	80	130	565	0		
Nuclear	0	0	0	0	12	5 to 6
Hydro	0	0	0	0	24	6 to 147
Other Renewables	0	0	0	0	11-48	8 to 21 (wind) 7 to 83 (solar)
Other Generation	0	0	0	0	-	
Average	30	29	120	-	-	

A **cleaner electricity system** will contribute to decarbonization efforts in other sectors of the economy.

Figure 5
Avoided GHG emissions from Bruce Power refurbished nuclear over output generated from carbon emitting sources



Note: the avoided emissions in this figure only includes avoided emissions because of refurbishment and does not include the additional avoided emissions resulting from Project 2030.

The case is strong for incremental/additional nuclear output, as well as other clean energy that will displace emissions, to be considered eligible to register for GHG offsets.

Similarly, currently (based on the current mix of the electricity grid) consumers in Ontario who reduce their grid-supplied electricity consumption by 1 kWh will save 30g CO_2e in GHG emissions. However, by 2032, the same electricity saving is predicted to avoid approximately 389g CO_2e.[8]

Considering these rising emissions from Ontario's electricity sector, the value of incremental and refurbished nuclear becomes even more clear. Using 2019 electricity generation intensity data available from the NIR (Table 1), every additional kWh of electricity generated in Ontario from low-carbon sources such as nuclear, instead of carbon-emitting sources, avoids an average of 406g CO_2e.[9]

The initial stage of Bruce Power's Project 2030, as previously mentioned, will increase site output to 6,750 MW and will lead to avoided emissions, estimated at almost 450,000 metric tonnes of CO_2e-equivalent annually, which equals taking about 100,000 cars off the road.

Similarly, Bruce Power's Life-Extension Program and Major Component Replacement (MCR) Project will extend the operational life of each reactor by 30 to 35 years to 2064, and, in turn, help mitigate the predicted increase in the GHG emission intensity of the electricity grid. Most importantly, by 2034, due to the refurbishment process, annual power output of the Bruce Power nuclear facility is predicted to be 37.1 TWh.

As seen in Figure 5, if there was not significant investment in nuclear life extension and instead the same generation capacity was provided by natural gas instead of a non-fossil fuel alternative such as nuclear, the result would be approximately 15 million MT CO_2e per year compared to zero direct emissions from Bruce Power.[10]

To meet the demand from increased electrification, nuclear power will play a critical role, both in providing critical supply to decarbonize other sectors of the economy and in helping to avoid emissions from other GHG-emitting resources.

Given that these investments will generate additional clean energy and are forecasted to result in avoided emissions from natural gas generation, it is Bruce Power's opinion that the case is strong for incremental/additional nuclear output, as well as other clean energy that will displace emissions, to be considered eligible to register for GHG offsets within the appropriate offset or credit program.

8 GHD Limited (2022) The Energy Sector's Role in Net Zero p. 13
9 GHD Limited (2022) The Energy Sector's Role in Net Zero p. 8
10 GHD Limited (2022) The Energy Sector's Role in Net Zero p. 14

By accrediting incremental nuclear, or other clean energy sources, for its role in avoided emissions through the creation of carbon offset credits, additional value and revenue can be generated to support broader system goals, including but not limited to:

- Reducing overall system costs for ratepayers.[11]
- Incentivizing investment in non-GHG emitting sources.
- Developing a validation pathway for avoided emissions that can be utilized globally to support investment in clean energy to support climate goals.
- Solidifying nuclear power as a critical energy source in the fight against climate change.

To ensure the decarbonized grid of today helps to power our Net Zero efforts in the years ahead, clean electricity production must be a top priority and incremental nuclear energy output should be considered eligible to register as GHG offsets within the appropriate offset program and registry.

11 Numerous programs will now measure and pay for every ton of carbon removed from the atmosphere through carbon offset credits. Carbon offsets have proven to be a robust and financially lucrative market across Europe, Australia and Canada. Overall system costs can be reduced through the purchase of carbon offset credits in a voluntary or compliance market for a "set price," with a portion of that revenue shared through an arrangement with the IESO. This would allow a portion of the revenue derived from the sale of carbon credits in a market to be used to reduce customer costs in Ontario.

Conclusion

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), achieving ambitious climate targets by 2050 whilst maintaining the reliability of the power system requires a multi-faceted approach.

We believe that to mitigate rising GHG emissions intensity of our electricity grid, and the associated GHG emissions, necessitates the inclusion of incremental clean energy output — including nuclear — being viable for carbon offset certification.

To that end, given the demonstrated value of nuclear power in avoiding emissions from carbon-emitting resources, Bruce Power believes strongly that our incremental output should be considered eligible to register for GHG offset credits within the appropriate offset program. This will lead to additional value to Ontario customers, generating revenues that would be used to reduce system costs, but will also create opportunities for investment into additional non-GHG-emitting resources required to meet growing energy demand.

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