

THE NEXT 50 YEARS

Bruce Power is leading us to Net Zero and beyond

Bruce Power[™]
Innovation at work



NUCLEAR
INNOVATION
INSTITUTE[™]



The Nuclear Innovation Institute (NII) is an independent, not-for-profit organization that provides a platform for accelerating the pace of innovation in the nuclear industry. NII's goal is to shape a Canadian nuclear industry that embraces new thinking, new technologies and new lines of business that play a central role in the global shift to a low-carbon future. Learn more at www.nuclearinnovationinstitute.ca.



Situated on the shore of Lake Huron, Bruce Power provides more than 30 per cent of Ontario's electricity at 30 per cent less than the average cost to generate residential power. Our people 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 across the globe. Learn more at www.brucepower.com.

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THE NEXT 50 YEARS

Bruce Power is leading us to Net Zero and beyond

“When we think of electricity security, when we think of clean electricity to reach our climate targets, in my view nuclear should have an integral part in the countries where governments and citizens are part of the solution.”



Dr. Fatih Birol
*International Energy
Agency, Director General*

Introduction

THE EARLY STAGES of the 21st century have already been a tumultuous time. Rapid technological change is upending our lives. An increasingly globalized world has brought remarkable benefits, but also exposed us to the gyrations of interconnected financial markets and supply chains, as well as the perils of a deadly virus. Meanwhile, the threat posed by climate change has created an imperative for countries to transform how they generate and consume energy, driving a transition away from the fossil fuels of the industrial age to a clean energy future.

The next 50 years will test the ability of coming generations to break old habits and build a better world. They offer new opportunities for smart, equitable economic growth, to live closer in harmony with the natural world, and to discover new tools to fight life-threatening diseases.



Ontario is poised to lead — and to benefit from — this coming shift. The province’s large fleet of nuclear power generating stations provide the reliable clean energy needed to meet an increasing demand for the electricity to power the homes, industries and vehicles of the future. In the process, the nuclear industry will provide thousands of good jobs across a wide range of skill sets. It will develop a plentiful and diverse supply of medical isotopes used in our hospitals to diagnose and treat cancers and other diseases. And the nuclear industry will be a catalyst for innovation in developing new energy sources like hydrogen on the path to net zero emissions.

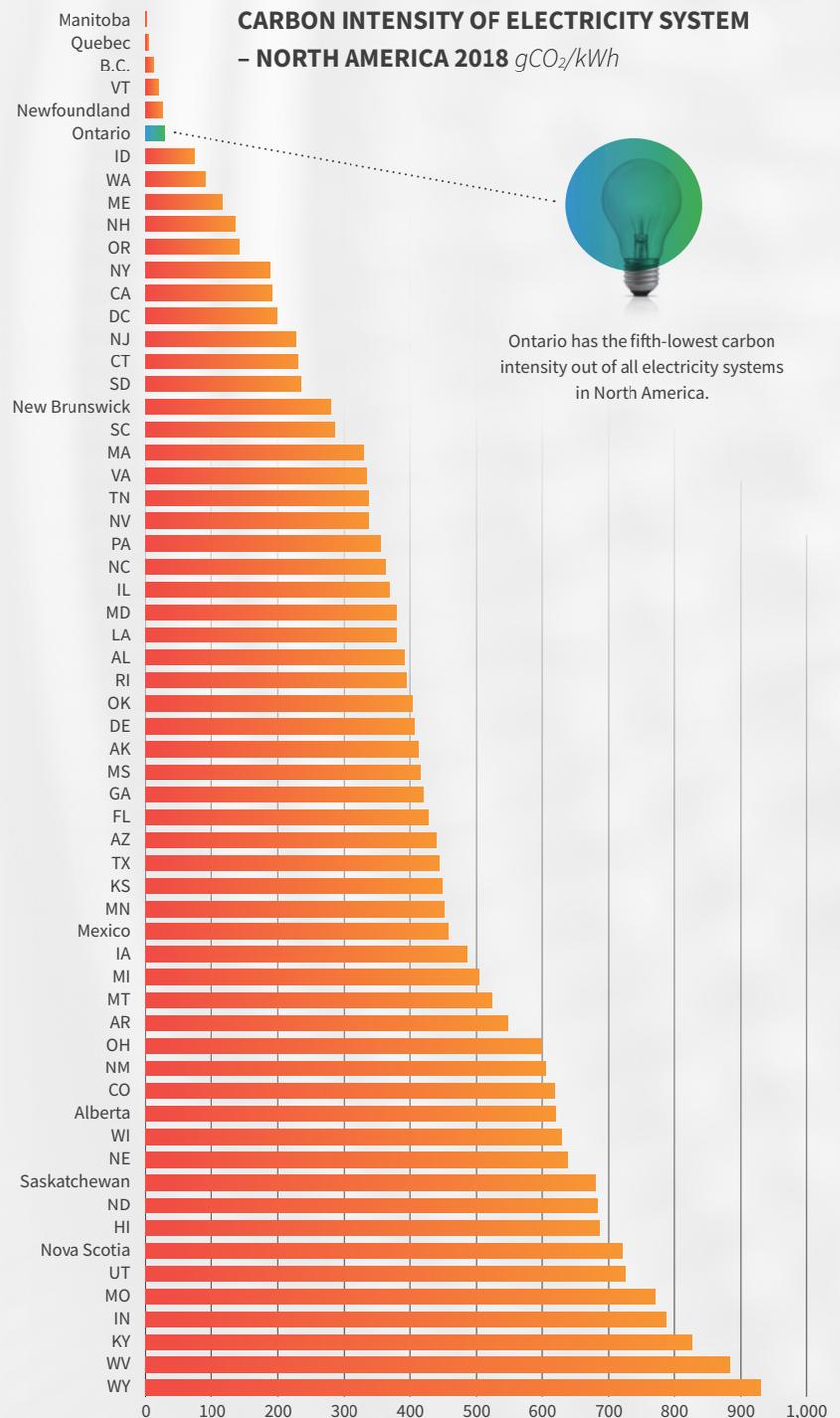
This report looks ahead to the role that the Bruce Power site — the largest operating nuclear plant in the world — will play as a catalyst in establishing the path to a clean energy future.

HOW WE GOT HERE

A producer of clean electricity

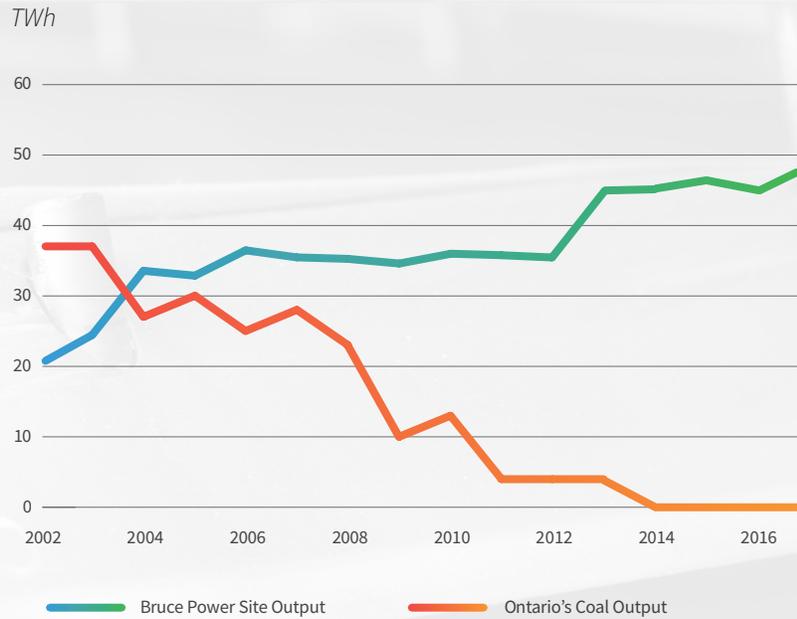
ONTARIO TODAY has one of the cleanest electricity grids in the world. A comparison to other provinces and states across North America draws out what a remarkable achievement this is. Outside of a few jurisdictions blessed with abundant hydroelectric power, Ontario's grid is orders of magnitude less polluting than other states and provinces.

Source: Ontario Energy Association. Based on: Environment and Change Canada. National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada. Part 3. U.S. Environmental Protection Agency, eGRID database. Climate Transparency, Climate Transparency Report 2020.



This clean grid was the result of eliminating coal generation in Ontario. The Bruce Power Generating Station provided 70 per cent of the energy that was needed to make possible the phasing out of coal.

BRUCE POWER SITE OUTPUT AND COAL OUTPUT 2002 TO 2017

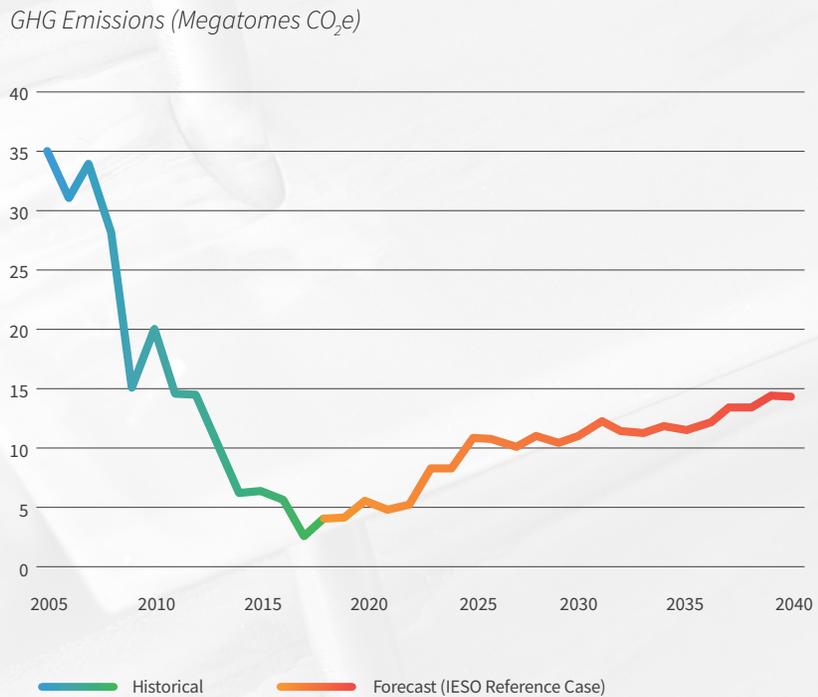


Source: IESO, Historical data.

This phase-out enabled a dramatic reduction in emissions from the electricity sector. As Ontario moves towards net zero, our first priority should be to secure this advantage by keeping emissions from electricity generation low.

The Independent Electricity System Operator (IESO), however, is already forecasting a rise in emissions in the coming years due to reduced nuclear production (mainly the result of retiring the Pickering Nuclear Generating Station) and a steadily rising demand for electricity which is planned to be met by natural gas generation.

ELECTRICITY SECTOR GHG EMISSIONS, HISTORICAL AND FORECAST



Source: IESO, Annual Planning Outlook, 2020.

Looking back

DECADES of investment and innovation have made possible today's clean electricity grid.



1942

The Montreal Laboratory, a joint British-Canadian laboratory, begins work to design a heavy-water nuclear reactor.

1947

Canada's first research reactor started up in Chalk River, ON.



1951

The world's first cancer treatment using Cobalt-60 radioisotopes takes place at Victoria Hospital in London, ON. To date, approximately 35 million cancer patients worldwide have benefitted from this technology.

1954

Government issues approval for the first Canadian power reactor.



1968

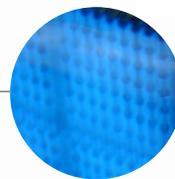
The first commercial CANDU (Canadian-Deuterium-Uranium) power reactor begins operating at Douglas Point, near Kincardine, ON.

1977

The first reactor units of the Bruce site are placed into service.

1980'S

First harvest of Cobalt-60 a medical isotope critical to the sterilization of single use medical equipment completed at site.



2003

Ontario commits to completely phasing out coal-fired electricity.

2003

A software bug in Ohio causes a widespread blackout, affecting an estimated 55 million people throughout Ontario and the northeastern United States. Ontario's nuclear fleet is key to bringing the grid back online, with areas near the Bruce site being among the first to regain power.

2012-13

Units 1 and 2 return to service and life-extension work is completed in Units 3 and 4, providing the bulk of generation Ontario needs to close its coal plants. This successful project set the stage for further refurbishment of Ontario's nuclear fleet, securing baseload nuclear power for future generations.



2015

Cleaner electricity generation allows Ontario to have 0 smog days, down from a high of 53 days in 2005.

2014

Ontario shuts its last coal plant. This effort remains the largest clean-air initiative undertaken to date in North America.



2016

Bruce Power officially begins its Life-Extension Program to refurbish its reactors, part of a commitment to extend the operating life of the Bruce site to at least 2064.

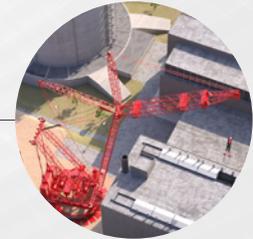
2019

The first harvest of medical-grade Cobalt-60 from a CANDU power reactor is completed at the Bruce. This isotope, also known as High Specific Activity (HSA) Cobalt-60, is at the forefront of innovative new medical technologies as its use can deliver higher doses of radiation to tumours with limited damage to surrounding tissues.



2020

The Major Component Replacement Project of Bruce Power's Life-Extension Program begins on Unit 6.



2020-21

Bruce Power makes extensive contributions to pandemic and recovery efforts, including donating more than two million pieces of personal protective equipment (PPE) to front-line organizations across the province. This represents the largest private-sector donation of PPE in Canada.

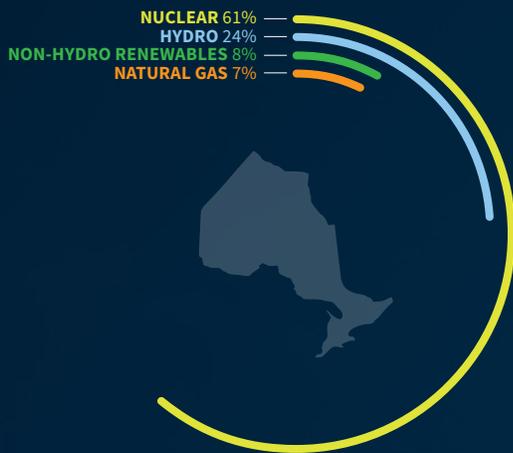
This history provides lessons for the future. We must match the courage and vision of previous generations if we are to secure our own clean energy future.

PREPARING FOR THE FUTURE

Securing a stable foundation

ONTARIO'S clean electricity grid is anchored by a nuclear fleet that generates more than 60 per cent of our power.

ONTARIO'S ELECTRICITY SUPPLY MIX 2018 (% of grid supply; Total = 146 TWh)



Source: IESO. Generator Output and Capability, 2019.



There are currently no alternative generation portfolios that could provide the same supply of low emissions baseload electricity generation at a comparable price to the Nuclear Refurbishment Plan.

FAO report on refurbishment, 2017

Through refurbishment of our nuclear plants, we have secured the benefits of this supply for decades into the future:



Refurbishment of Ontario's nuclear fleet is the largest green infrastructure project in the North America;



It will secure Bruce Power's 6,400 MW of electricity supply until at least 2064, enough to power 30 per cent of Ontario;



Clean, reliable and flexible baseload supply from the Bruce Power site helps to avoid 31 million tonnes of carbon dioxide (CO₂) annually, which is equivalent to taking about six million cars off the road each year and almost equivalent to the air pollution released by all of Ontario's coal plants in 2001;



Supporting more than 50,000 Ontario jobs through the daily operation and support of the nuclear fleet, the ongoing refurbishment program, and throughout the nuclear supply chain.

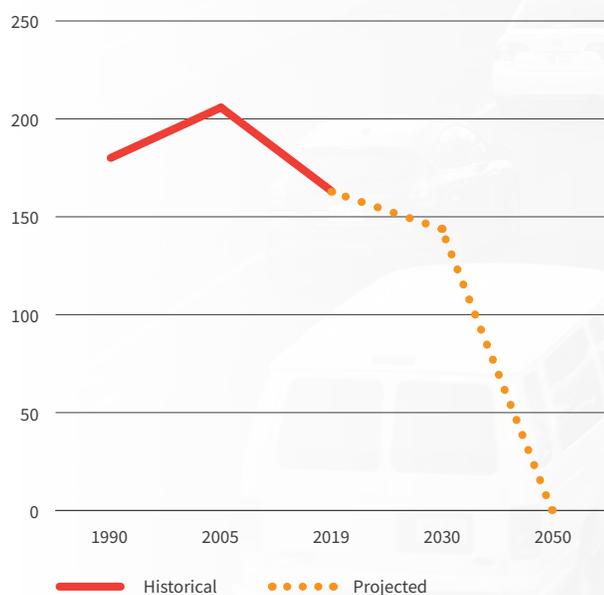
WHAT COMES NEXT?

The next great energy transition



FACED WITH THE CHALLENGE of climate change, our governments have rightly set an ambitious goal of net zero emissions by 2050.

ONTARIO CO₂ EMISSIONS (Mt equivalent)

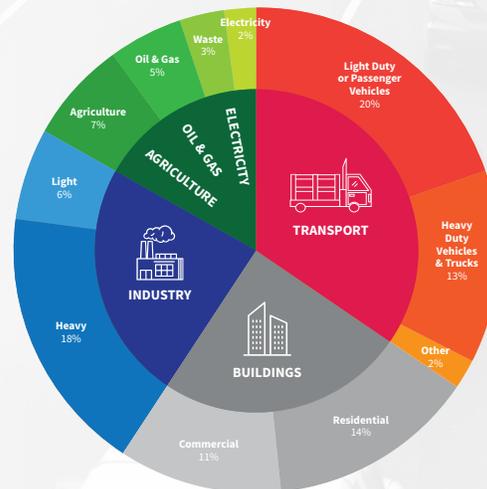


Source: Environment and Climate Change Canada, National Inventory Report 1990-2019: Greenhouse Gas Sources and Sinks in Canada, 2021.

The Ontario government has set strong targets with the emissions reduction goals in its Made-in-Ontario Environment Plan. Achieving the targets set out in this plan will require maximizing the value of our existing infrastructure to meet electrification demands, achieve efficiency gains and encourage the adoption of new technologies. Based on Ontario's current 2030 emissions targets of 143 Mt, demand from electrification could well exceed current planning levels by a significant margin — up to 33 TWh before 2030.

Thankfully, Ontario's clean electricity grid gives us a head start on this task. Most of our emissions currently come from other sectors:

ONTARIO'S GHG EMISSIONS BREAKDOWN 2018 (% of GHG emissions by sector, 165 Mt total)

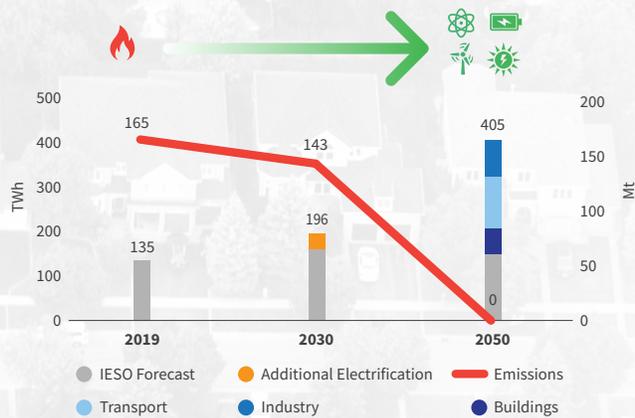


Source: Canada's Official GHG Inventory, 2019.

Decarbonizing these sectors will require increasing electrification, including the adoption of EVs and electrifying heavy industry. This will create a growing demand for clean electricity.

Electrification could increase electricity demand by 2050 by a minimum of 200 TWh over today in Ontario alone, from both direct electrification and demand for electricity from creating hydrogen through electrolysis.

EMISSION REDUCTION & ELECTRIFICATION PATHWAY TO 2050
TWh & Mt



Source: IESO 2020; Larson, et al., 2020; ECCC 2021; EIA 2020; ICCT 2020; NRCan 2021; Strapolec Analysis.

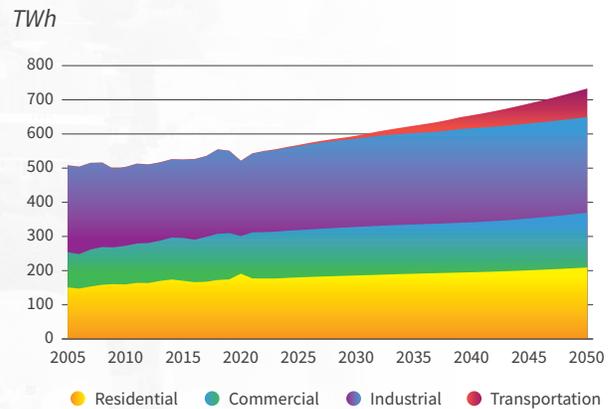
Bill Gates
Co-Founder of Microsoft
and Philanthropist



“Nuclear is ideal for dealing with climate change, because it is the only carbon-free, scalable energy source that’s available 24 hours a day.”

This is reinforced by projections from the federal government that suggest electricity demand will increase by more than a third by 2050. These projections may actually be too conservative, with some industry experts suggesting the increase in electricity demand may be closer to 300%. This will require a massive commitment to sustaining our current generation, while also looking for new, innovative solutions to making up the gap.

FEDERAL GOVERNMENT PROJECTS STEADY RISE IN ELECTRICITY DEMAND



Source: Canada’s Energy Regulator, Canada’s Energy Future 2020.

As the Canadian Energy Regulator found in a 2020 study, “[In the primary Scenario], 90% of electricity generation comes from renewable and nuclear generation in 2050. That compares to 81% today.”

Regardless of what lies ahead, the backbone of Ontario’s low-emission energy future is its hydro and nuclear facilities, which will provide the baseload power we need while also enabling new and emerging technologies.

PAUSE: WHAT WOULD WE DO WITHOUT NUCLEAR?

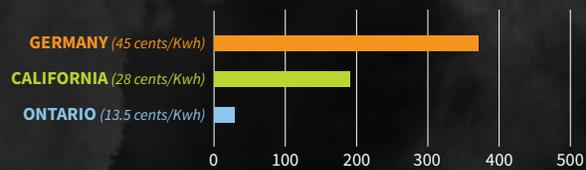
Cautionary tales

IN THE WAKE of the 2011 incident at Fukushima, Germany decided to shutter its nuclear program. The results have been devastating: a power grid that is far more carbon-intensive, expensive, and dependent on foreign fuels.

California has followed a similar path, abandoning nuclear power in favour of large-scale renewables—resulting in higher costs and more emissions.

When viewed side-by-side with Ontario, the contrast is stark:

EMISSION INTENSITY AND COST FROM THE ELECTRICITY SECTOR BY JURISDICTION (gCO_2e/kWh)

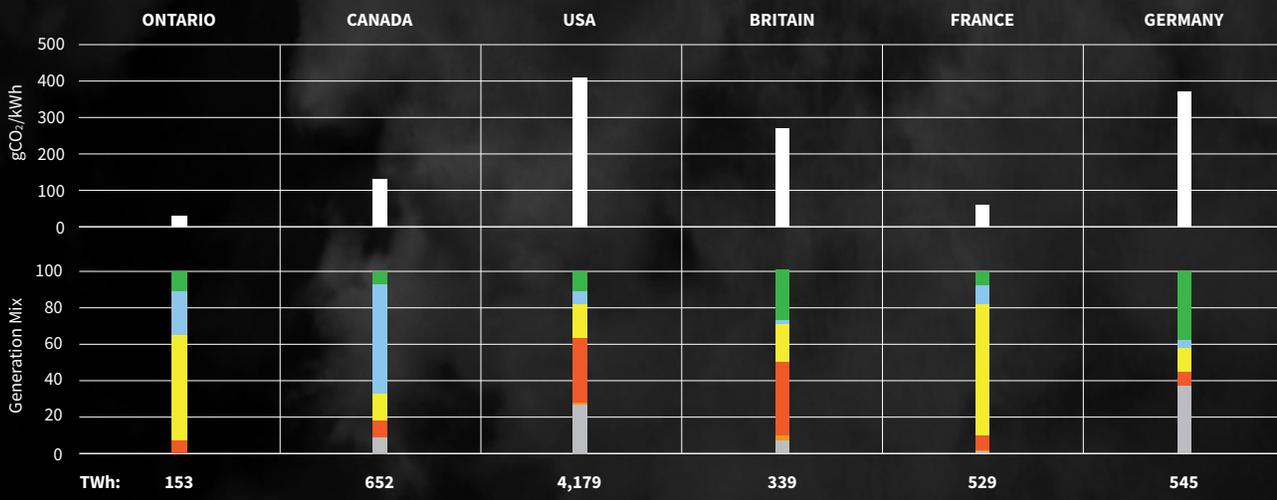


Source: U.S. Energy Information Administration (EIA), 2021, and Eurostat, 2021.

Ontario was once in a similar position as other fossil fuel-burning countries in the world. The Province’s decision to phase out coal demonstrated a commitment to the health and well-being of its citizens. Ontario took on a leadership role to initiate this change, and had it not done so, its emissions relative to other countries would not look the same as it does now.

- Other renewables
- Hydro
- Nuclear
- Gas
- Oil
- Coal

ONTARIO EMISSIONS COMPARED WITH OTHER COUNTRIES



Source: OPG Climate Change Plan, 2020.

LEVERAGING WHAT WE HAVE

Bruce Power: A powerful asset

BRUCE POWER PROVIDES the stable building blocks Ontario needs to plan for the future.

The site has a massive economic impact:

JOBS

Supports more than 22,000 direct and indirect jobs.

ECONOMIC IMPACT

Generates between \$9-11 billion in economic impact across the country.

A CLEAN ENERGY FRONTIER

Refurbishment has attracted more than 60 companies to Bruce, Grey and Huron counties, creating a cluster for innovation and investment in clean energy.

Mike Rencheck
President & CEO,
Bruce Power

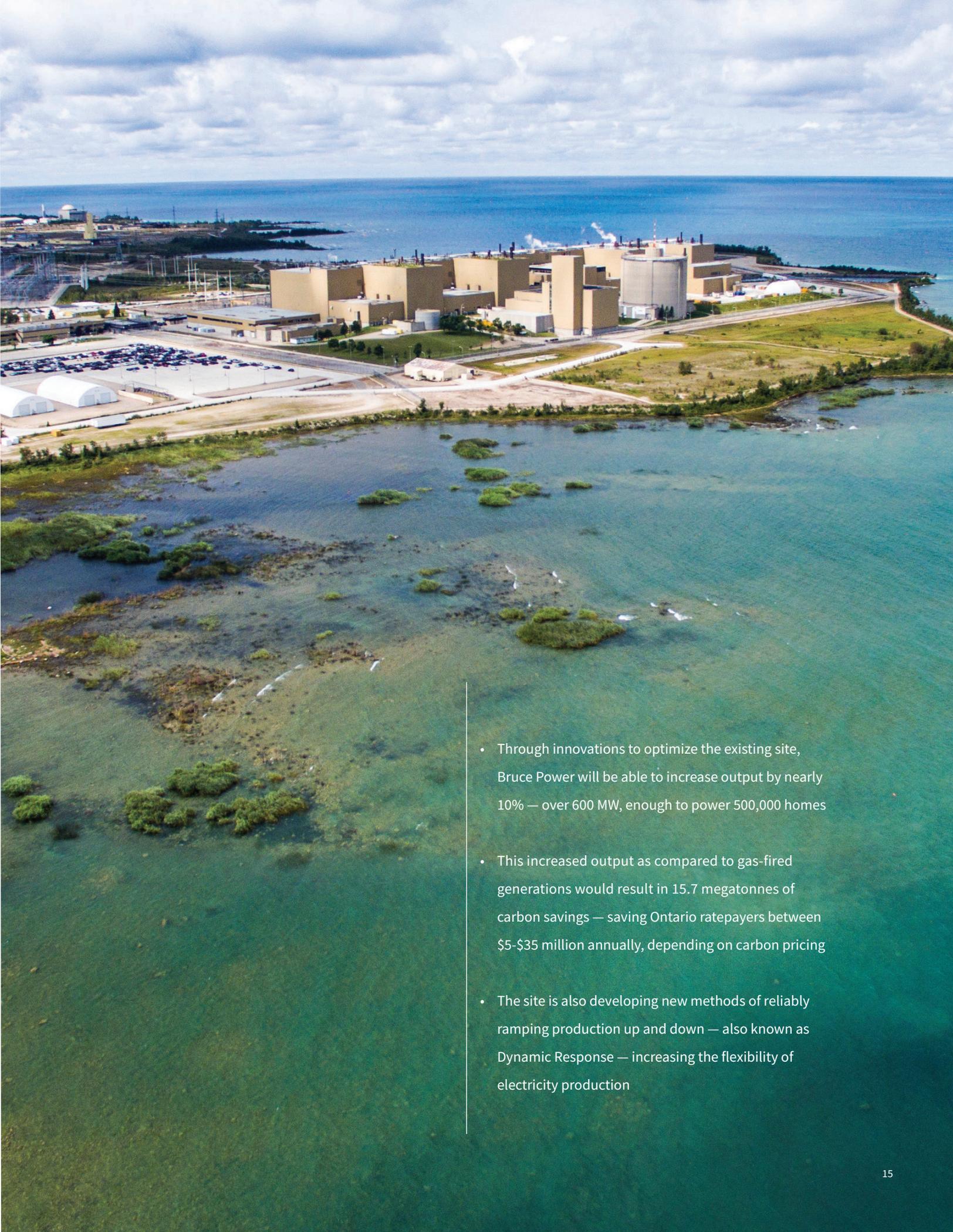


Opportunities exist to leverage this asset even further.

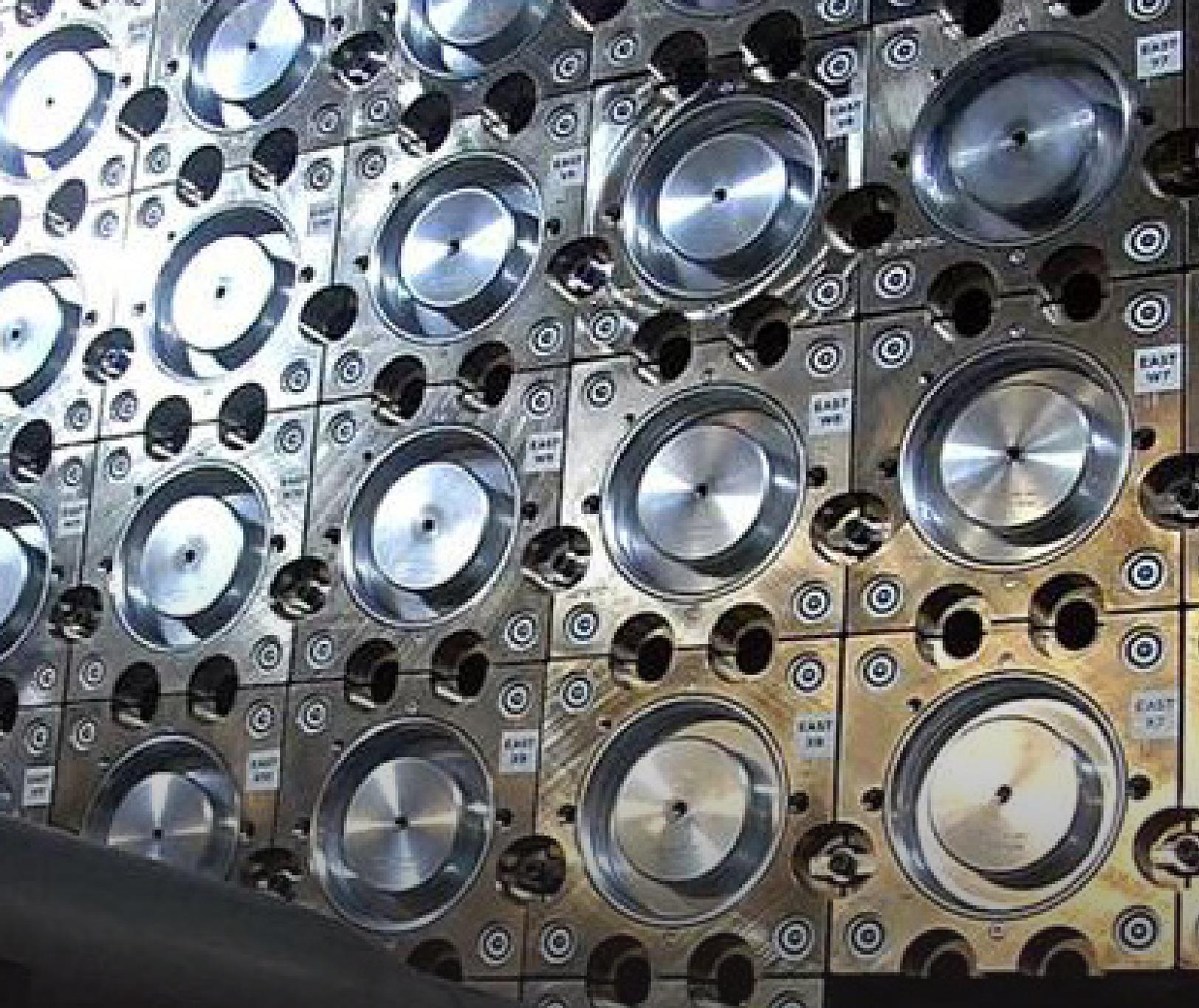
The IESO has already identified that there will be a capacity and energy shortfall in the near term that cannot be met by renewal of existing assets alone.

As the critical foundation of our electricity system, operators of existing large nuclear and hydroelectric facilities will need to explore incremental investment and innovation opportunities for additional generation from these assets. This includes optimizing existing assets from the perspective of output, performance, capabilities/ applications and long-term asset life management.

“At Bruce Power, innovations on-site are leading to greater flexibility from our generators, increased electricity output, and savings for ratepayers across the province. This is key for the province — by optimizing the assets we already have, Ontario can position itself to thrive in a clean energy future.”



- Through innovations to optimize the existing site, Bruce Power will be able to increase output by nearly 10% — over 600 MW, enough to power 500,000 homes
- This increased output as compared to gas-fired generations would result in 15.7 megatonnes of carbon savings — saving Ontario ratepayers between \$5-\$35 million annually, depending on carbon pricing
- The site is also developing new methods of reliably ramping production up and down — also known as Dynamic Response — increasing the flexibility of electricity production



POWERING INNOVATION

Making Ontario's grid safer
and more efficient

AS EXPLORED IN THE TIMELINE on page 8, Bruce County
has long been a source for innovation.

In recent years, innovations have moved at an even faster
pace, enabled by advancements in robotics, artificial
intelligence and advanced manufacturing.

Innovations on the Bruce site include:

- The MCR project has reinvigorated a supply chain of more than 250 companies in Ontario who provide parts, labour, and expert advice for refurbishment. Many of these companies are global leaders in techniques like **advanced manufacturing and retooling**.
- In 2019, Bruce Power announced that new efficiencies created during the refurbishment process had generated **\$200 million in savings** that are being passed on to Ontario's electricity ratepayers.
- Partnerships with leading companies like Rolls-Royce are developing methods of using **artificial intelligence** to predict maintenance needs in the reactor before they occur and perform pre-emptive fixes, improving station performance.
- As part of the Extended West Shift Plus program, Bruce Power has collaborated with BWXT, utilizing robotics to shift fuel channels with greater speed and efficiency.



- Through Major Component Replacement, Bruce Power has worked with partners to develop a new isotope delivery system that allows cancer-fighting isotopes to be harvested directly from a CANDU reactor. This project is the **first of its kind for developing these isotopes from a commercial power reactor**. Due to the sheer fact that power reactors are operating 24/7, 365, and by utilizing these reactors in a way never seen before, we can ensure Canada has the capacity to meet the growing demand for isotopes, providing more consistent and affordable access to these life-saving materials.
- Thanks to the use of these and other technologies, Ontario's nuclear stations today are working better than ever before. In recent years, reactors at both the Bruce Power and Darlington stations have set **new records for consecutive days of operation**.



In 2020, partners in the Bruce region accelerated these efforts with the launch of the Nuclear Innovation Institute, a non-profit which aims to be Canada's leading-edge nuclear applied research facility and centre of excellence for talent development and business innovation.

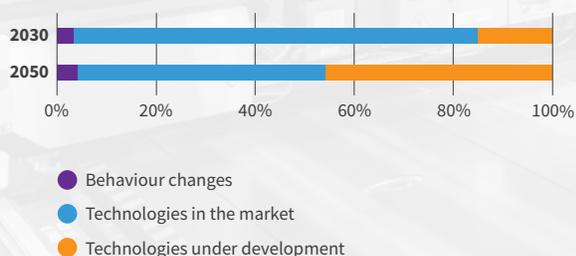
NEW TECHNOLOGY INTEGRATION

An ideal site for energy innovation

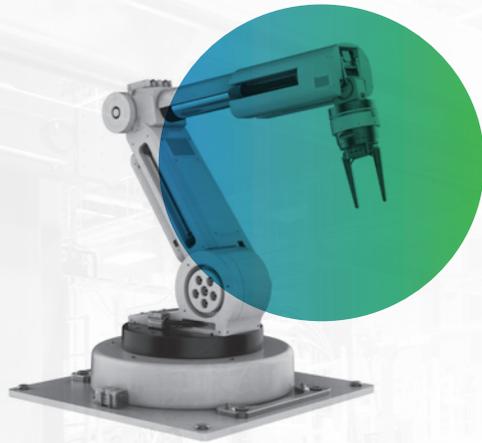
The Bruce site provides the foundation Ontario needs to reduce our emissions. But research has shown that technologies won't be enough to get us to net zero — we'll also need new energy innovations.

The Net Zero by 2050 report from the International Energy Agency (IEA) found that nearly 50 per cent of the emissions reductions required for net zero globally will depend on technologies still under development:

IEA PROJECTIONS OF ANNUAL CO₂ EMISSIONS SAVINGS IN THE NET ZERO PATHWAY, RELATIVE TO 2020



Source: IEA, Net Zero by 2050, 2021.



The Bruce region can be a global leader in the development, testing, and deployment of these new technologies. The region has emerged as a Clean Energy Cluster that is a global leader in energy innovation, with the Bruce site serving as a hub and the refurbishment program providing the stimulus to create the cluster. Ontario can leverage these significant assets, including:

- The largest nuclear plant in the world, with transmission interties, regulatory licences, and deep local experience in energy;
- More than 60 energy companies already operating in the region;
- An experienced and talented workforce;
- Supportive local communities.

Leveraging these assets, the Bruce region can be a nexus for global leadership in the development of new technologies, including:

- New nuclear builds, which—if needed to meet growing electricity demand—will benefit from existing infrastructure, licenses, and local expertise;
- Small Modular Reactors (SMRs), which are estimated to have a global market of \$400-600 billion;
- Hydrogen, which can be generated cleanly from nuclear power, and used as an emissions-free fuel to decarbonize other parts of our economy. The federal government projects that hydrogen will account for 30 per cent of end-use energy by 2050.
- Developments in other promising technologies like batteries, storage, solar, and fusion energy.



With help from the NII and other partners, Bruce Power has already begun exploring opportunities to accelerate these technologies.





HEALTHIER PLANET, HEALTHIER PEOPLE

Advancing global health
through isotopes

MEDICAL ISOTOPES are an essential part of modern health care, used to diagnose and treat disease, sterilize key medical equipment and enable research. Modern medicine is heavily dependent on their availability, using them in 40 million treatments a year around the world.



Bruce Power is a key source of isotopes for Canada and the world:

- 40 per cent of the world’s single-use medical devices are sterilized with Cobalt-60 from the Bruce;
- Cobalt-60 is also used worldwide to combat cancer and treat complex brain conditions;
- Bruce Power is beginning to manufacture Lutetium-177, an isotope proving to be effective in the treatment of prostate cancer. Prostate cancer is the most common cancer among men and the third leading cause of death from cancer for men in Canada; 1 in 7 Canadian men will be diagnosed with prostate cancer in their lifetime;

“Canada has a long history of global leadership in medical isotopes. Bruce Power’s innovative steps to produce cancer-treating isotopes like HSA Cobalt-60 and Lutetium-177 is critical to maintain Canada’s position as a leader in this sector.”

Bruce Power is committed to providing a stable supply of critical isotopes for decades to come. Its reactors are facilitating innovative approaches that are offering new hope in the global struggle to defeat cancer.

Beyond improving patient outcomes, the production of isotopes has created an opportunity for Bruce Power to foster strong, meaningful relationships with Indigenous communities. Bruce Power has partnered with the Saugeen Ojibway Nation (SON) to explore ways of jointly marketing new isotopes in support of the global fight against cancer, while also working together to create new economic opportunities within the SON territory.

By using nuclear reactors and expanding the production of radioisotopes, Bruce Power will continue to keep the country at the forefront of innovations that save lives, improve quality of life, and invest in our economy.



Dr. Karin Stephenson
*Manager of Commercial Operations,
McMaster University's Nuclear
Operations and Facilities*

ACHIEVING NET ZERO

Bruce Power's commitments

In October 2020, Bruce Power unveiled its own NZ-2050 plan, a strategy for contributing to a net zero Canada while growing the economy and supporting innovation. The plan includes commitments to:

1. Optimize and leverage existing investments in Canada's largest private-sector infrastructure project to drive further decarbonization;
2. Foster innovation in new energy technologies including new nuclear and fusion energy;
3. Utilize nuclear power generation to produce clean fuels and electrify industrial processes and transportation with an historic opportunity to contribute to a national hydrogen and clean fuels strategy;
4. Create an ecosystem of "green collar" jobs including the nuclear, manufacturing, and energy development sectors with a focus on diversity and more representation from women, visible minorities and Indigenous peoples; and
5. Inspire innovation by supporting strong social responsibility and sustainability, and providing contributions to global health such as life-saving medical isotopes as the world battles COVID-19.





In April 2021, Bruce Power went a step further by announcing its intention to reduce any emissions associated with operations on-site — including from vehicles, machinery, and buildings — to net zero by 2027. The site will be the first in North America to achieve this goal.

The emissions targeted through this process will include what is known as “Scope 1” emissions — those that result directly from operations, such as from vehicles used on site, or from running safety system tests on standby generators — as well as “Scope 2” emissions that come from energy use on site. These are the GHG emissions that the Net Zero 2027 strategy will target.

Scope 1 GHG Emissions 2015 – 2020 (tons of CO ₂ (eq))					
2015	2016	2017	2018	2019	2020
~10,308	~9,003	~6,278	~8,766	~8,854	~7,862

Scope 2 GHG Emissions 2015 – 2020 (tons of CO ₂ (eq))					
2015	2016	2017	2018	2019	2020
~8,309	~7,334	~5,830	~5,091	~6,658	~7,105



LOOKING AHEAD

Positioning Ontario for the future

The world has committed to an ambitious goal — a net zero future. Ontario's nuclear industry will be a catalyst in this journey by providing a baseload of reliable clean energy, as well as the jobs, innovation, and life-saving isotopes we'll need for the future.

This is an exciting time for Ontario. If we act boldly with an eye to the future, and with a commitment to achieving net zero, we can enjoy living in a world of economic stability and sustainability.



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**Learn more about what Bruce Power and NII are doing to prepare
for the next 50 years by visiting our websites:**

www.brucepower.com

www.nuclearinnovationinstitute.ca