Bruce Power
Innovation at work

ONTARIO POWER GENERATION

# Ontario Nuclear Collaboration

2023 REPORT

# Land Acknowledgements

## BRUCE POWER

The Bruce Power site is located within the Saugeen Ojibway Nation Territory, the shared treaty and traditional Territory of the Chippewas of Saugeen First Nation and Chippewas of Nawash Unceded First Nation (Neyaashiinigmiing).

Bruce Power is dedicated to honouring Indigenous history and culture and is committed to moving forward in the spirit of reconciliation and respect with the Indigenous communities we work with. We are committed to strong and respectful relationships with the Saugeen Ojibway Nation (SON), the Métis Nation of Ontario (Region 7) and Historic Saugeen Métis.

## ONTARIO POWER GENERATION (OPG)

OPG's facilities across Ontario are located on the treaty and traditional territories of Indigenous people.

To acknowledge the traditional territory is to recognize its history, predating the establishment of the earliest European colonies. It is also to acknowledge the significance for the Indigenous people who lived and continue to live upon it, to acknowledge the people whose practices and spiritualties were tied to the land and water, and continue to develop in relation to the territory and its other inhabitants today.

It's important that we take time to acknowledge the treaties and the territories as it is a reminder that the privileges and benefits we enjoy as citizens of Ontario are rooted in the long standing treaties and historical relationships between Indigenous and non-Indigenous people.

As a company, we remain committed to fostering positive and mutually beneficial relationships with Indigenous people and communities across Ontario.

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# Ontario's Clean Energy – Past, Present and Future

**Bruce Power and OPG are proud to be a part of Ontario's clean energy past, present, and future, leading the province into a new era of clean energy production.**

In 2023, the Ontario government recognized the province's nuclear advantage with the release of its Powering Ontario's Growth plan. The plan noted the importance of nuclear power to meet the demands of a growing economy, and achieve net zero goals. Powering Ontario's Growth is the government's official response to the Independent Electricity System Operator's (IESO) Pathways to Decarbonization report published in December 2022, which forecasts future electricity demands as a result of electrification and economic growth. Bruce Power and OPG are investing now to support a clean energy future through renewals of our existing assets, securing operation of Ontario's zero-carbon nuclear fleet for the next generation.

The relationship between Bruce Power and OPG has provided immense value to the consumer, the Province, and each of our organizations. We've worked tirelessly to connect across our organizations to ensure fluidity of knowledge transfer, lessons learned, innovations and efficiencies strengthening our operations and the nuclear industry in Canada. Our success in this long-standing partnership will continue through the successful completion of our individual refurbishment projects as well as future endeavours as we look to continue delivering the best value to Ontario's ratepayers.

Based on the success of Bruce Power and OPG's collaborations, the generators are currently working together with the Independent Electricity System Operator (IESO) to develop a feasibility study for potential future nuclear generation in Ontario. The partners will complete the study by the end of 2024.

Bruce Power and OPG recognize the importance of our continued collaborative relationship and are proud of the efficiencies and successes we have worked through together to ensure continued benefits for Ontarians. As we build a path toward a clean energy future to secure Ontario's climate change goals, nuclear power will continue to provide a foundation of clean, baseload energy to power the province for decades to come.

Together, Bruce Power and OPG will continue to produce reliable, emissions-free electricity every day to help support Ontario's economic growth and lead the fight against climate change.

*From the Leadership Team at Bruce Power and Ontario Power Generation*

# Background

On November 12, 2015, Bruce Power and OPG signed a Memorandum of Understanding (MOU) that was facilitated by the Ministry of Energy to formalize and provide an annual summary report on the collaboration between the two organizations on nuclear refurbishment and power plant operation.

The resulting Nuclear Collaboration Report focuses on the joint efforts of Bruce Power and OPG throughout the refurbishment of the nuclear reactors at Bruce Power and the Darlington Nuclear Generating Station. This collaborative effort has resulted in efficiencies and innovations that lower costs for ratepayers by sharing lessons learned on refurbishments and leveraging economies of scale to ensure Ontario's refurbishments remain on time and on budget.



# Bruce Power

Bruce Power is a Canadian-owned public-private partnership of TC Energy, Ontario Municipal Employees Retirement Systems (OMERS), the Power Workers' Union and The Society of United Professionals. The company employs more than 4,200 people and, over the past 15 years, has been one of the largest investors in Ontario's electricity infrastructure, providing billions in private dollars to the Bruce Power site, which continues to be owned by the Province. Established in 2001, Bruce Power is Canada's only private sector nuclear generator, producing 30 per cent of Ontario's power each year.

Bruce Power has the privilege of operating our site within the traditional and treaty territory of the Saugeen Ojibway Nation. Bruce Power maintains a strong relationship with other Indigenous communities, including the Métis Nation of Ontario (Region 7) and the Historic Saugeen Métis.

## BRUCE POWER LIFE-EXTENSION PROGRAM AND MAJOR COMPONENT REPLACEMENT PROJECT (MCR)

Bruce Power reached an agreement with the Independent Electricity System Operator (IESO) to advance a long-term investment program to refurbish its nuclear fleet and secure the site's operation until 2064. The Life-Extension Program involves the gradual replacement of older systems in their eight reactor units during regularly scheduled maintenance outages. As part of this program, Bruce Power is carrying out an intensive MCR Project.

The MCR Project began in 2020 and focuses on the replacement of key reactor components in Units 3-8, including steam generators, pressure tubes, calandria tubes and feeder tubes.

Together, the refurbishment will secure an estimated 22,000 jobs directly and indirectly from operations, and an additional 5,000 jobs annually throughout the investment program, injecting billions into Ontario's economy. The life extension of each unit will add approximately 30 to 35 years of operational life, while other investments will add a combined 30 reactor years of operational life to the units.

## CURRENT STATUS

The refurbishment of the Bruce site reactors through its Life-Extension Program is well underway with work on the first of six reactor units completed in 2023 and Unit 3, Bruce Power's second MCR, well underway. Bruce B's Unit 6 was returned to service in September 2023, ahead of schedule and budget despite the challenges of the COVID-19 pandemic, thanks to the efforts of dedicated Bruce Power employees, industry partners and skilled tradespeople. Returning the renewed asset to commercial operation marked the beginning of a new operational life of the unit to provide clean, reliable power to the people of Ontario for more than four decades.

Bruce A's Unit 3 refurbishment began with breaker open on March 1, 2023, following successful planning and preparation work. The project is currently in the removal and replacement series of work for components including 480 fuel channels, 960 feeder tubes, eight steam generators, and many other upgrades. Unit 3 is scheduled to return to service by 2026.

Bruce A's Unit 4 MCR will start in 2025 and once complete, marks the end of life-extension activities at the Bruce A station in Units 1-4. Focus will then shift back to Bruce B to complete refurbishments in Units 5, 7 and 8 for the balance of this multi-billion dollar infrastructure project. The revitalization of the reactor fleet on the Bruce site will continue to supply approximately 30 per cent of Ontario's electricity needs well into the future with a safe, reliable, carbon-free source of power.



# OPG

OPG is owned by the Government of Ontario and is a climate change leader and the largest electricity generator in the province, providing more than half of the power Ontarians rely on every day. OPG employs more than 10,000 people and is one of the most diverse generators in North America, with expertise in nuclear, hydroelectric, biomass, solar, and natural gas technologies.

OPG's facilities across Ontario are located on the treaty and traditional territories of Indigenous people. As a company, OPG remains committed to fostering positive and mutually beneficial relations with Indigenous people and communities across Ontario.

## THE DARLINGTON NUCLEAR REFURBISHMENT PROJECT (DNRP)

OPG's Darlington Nuclear Generating Station (DNGS) is a four-unit facility responsible for generating over 20 per cent of Ontario's electricity, enough to power a city the size of Toronto. In October 2016, after 10 years of detailed planning and preparation, OPG's team of project partners, industry experts, energy professionals, and skilled tradespeople safely and successfully began the refurbishment of Unit 2, the first of four Darlington reactors scheduled for refurbishment over the next 10 years. The project involves replacing core reactor components, as well as associated conventional, control and safety systems to enable the plant to operate safely for more than 30 more years. Each reactor is taken out of service for about three years to allow for:

- Replacement of fuel channels, feeder pipes, calandria tubes, and end fittings.
- Rehabilitation of steam generators, turbine generators, and fuel handling equipment.
- System improvements and plant upgrades to meet current regulatory requirements.

## CURRENT STATUS

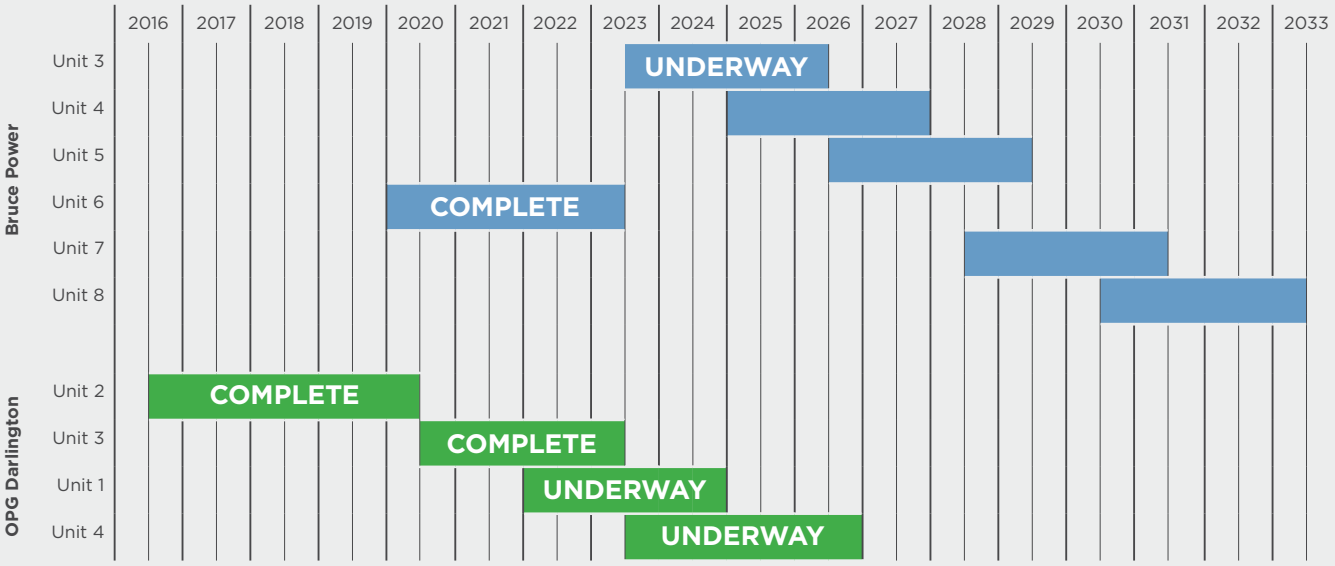
OPG is in year eight of the 10-year execution phase for the $12.8B mega-project, which remains on-time and budget. Units 2 and 3 are complete (returned to service in June 2020 and July 2023 respectively), and more than 6,000 lessons learned have been applied to the planning of Units 1 and 4, which are currently undergoing simultaneous refurbishments.

OPG achieved a major milestone by successfully connecting Darlington Nuclear Generating Station's Unit 3 to Ontario's electricity grid, 169 days ahead of schedule.

On Unit 1, OPG is making excellent progress. In 2023, reassembly of the unit began with the assembly of 480 fuel channel sub-assemblies and then installation inside the reactor. By December 2023, feeder tube installation started; this is the last step of reassembly prior to start-up activities. At the end of 2023, work was 79 per cent complete. The team is progressing work ahead of schedule and is expected to return Unit 1 to service in Q4 2024.

Unit 4 refurbishment started on July 19, 2023, one day after Unit 3 restart. In August 2023, the fuel bundles were removed, allowing unit isolation and reactor disassembly to begin. The lower feeder removal series involved more than 2,000 cuts to remove 960 lower feeder tubes from the reactor face by the end of the year.

# Refurbishment Schedule




Bruce A and Bruce B Stations at the Bruce Power site

## BRUCE POWER'S MAJOR COMPONENT REPLACEMENT

**Start date:** January 2020

**Units:** 3-8

**MCR6:** Completed 57 days ahead of schedule and under budget. Represents the equivalent of 16 major back-to-back outages with more than 500,000 tasks completed

**~2,800 lessons learned** to be carried forward into MCR3 and beyond

**MCR3:** First ever primary heat transport chemical decontamination reduced dose rates by 80%. Bulkhead installation completed in 22 fewer days than MCR6.

OPG's Darlington Nuclear Station

## DARLINGTON NUCLEAR REFURBISHMENT PROJECT

**Start date:** October 2016

**Units:** 1-4

**One in five** homes and businesses are powered by DNGS.

**96 per cent** of DNRP expenditures spent within Ontario.

**704,112** person-years of increased employment

# Areas of Collaboration

In 2015, long-term agreements were made to revitalize Ontario's nuclear fleet at both OPG and Bruce Power to provide decades of carbon-free, baseload electricity to the Province. Together, with the IESO, a long-term schedule was developed to complete Bruce Power's six-unit MCR and Life Extension Program and OPG's four-unit refurbishment at the Darlington Nuclear Generating Station while ensuring the Province has the reliable baseload power it needs. Throughout these projects, a focus on collaboration has led to the sharing of lessons learned, innovations, resources, tooling and equipment resulting in more efficient and successful projects for both companies.

The following areas of collaboration are a summary of the collaboration efforts in 2023; they build upon the efforts and established relationships fostered throughout the projects as outlined in past reports. With OPG completing its first two refurbishments ahead of Bruce Power, there has been significant collaboration to ensure subsequent refurbishments benefit from the lessons learned from preceding work. The value generated through ongoing collaboration includes enhanced safety, cost savings, schedule improvements, risk reduction, resource management, and dose reductions.

Below are some examples of ongoing collaboration efforts related to refurbishments:

- Bruce Power and OPG conduct monthly lessons learned meetings to share best practices and detailed information on complex evolutions. This back-and-forth exchange of information has led to productivity gains through shared best practices, tooling enhancements, improved efficiency and streamlined workflows.
- The Project Risk Management teams have a quarterly collaboration meeting to share lessons learned on current and in-progress initiatives with the goal of improving performance within both organizations.
- Executive team members have weekly calls to address and mitigate risks to projects and schedules.
- Bruce Power's Life Extension team and Darlington's Return to Service (RTS) team meet bi-weekly to share best practices with the integration of daily operations and RTS challenges.
- Bruce Power and OPG meet with the CANDU/ Refurbishment Forum Group to share lessons learned and other experiences across the international fleet of CANDU owners.

**In 2023, collaboration success included, but was not limited to:**

## DOCUMENT AND INFORMATION SHARING

- The sharing of outage lead-out initiatives by OPG allowed Bruce Power to review and compare their testing strategies to potentially align and make system testing comprehensive and simple across the stations.
- Bruce Power and OPG work collaboratively to put planning and execution teams together to share lessons for challenging evolutions such as lower feeder installation, return to service key evolutions, moderator fill, and bulkhead removal. The Bruce Power team has attended lessons learned meetings to hear first-hand from OPG team members involved in refurbishment execution work.
- Information sharing from OPG has helped Bruce Power gain a better understanding on team structure for integration and work management with multiple overlapping units undergoing MCR, understanding of team functions and division of responsibility within work management and integration, and comparison of planning milestone approaches for MCR and Refurbishment.

## TRAINING AND QUALIFICATIONS

- Bruce Power and OPG are continuing to work toward alignment in various training requirements to enable a more seamless transfer of staff between the stations. Last year, Bruce Power added new training content and material for Quality Control inspections, using existing training material from OPG's Quality Control modules rather than starting from scratch.
- Bruce Power and OPG shared series training documentation to determine similarities between Darlington Retube and Feeder Replacement (RFR) and Bruce MCR projects to determine how to leverage training qualifications between Vendor partner and Bruce Power, in order to make it easier for trades to move between projects at Bruce Power and OPG.

## FUEL CHANNEL AND CALANDRIA TUBE INSTALLATION

During the Unit 6 MCR, Bruce Power did not have to replace any newly installed fuel channels (a good news story based on industry OPEX), and therefore did not have much insight or lessons learned in this area of work to build upon for the Unit 3 MCR. Bruce Power met with OPG's Retube and Feeder Replacement teams to obtain operating experience (OPEX) on replacement channels to incorporate into the MCR program for Unit 3 Calandria Tube and Fuel Channel replacement.

## BRUCE POWER UNIT 6 RETURN TO SERVICE LESSONS LEARNED

In November 2023, Bruce Power's Life Extension and MCR team visited with Darlington's RTS and RFR project teams to provide an overview of Bruce Power's successes and challenges during the return to service of Bruce Power Unit 6 following MCR, including successes on dual-fuel bundle push during the fuel load series of work and OPEX on commissioning and alignment activities. These review items will fold into the processes OPG will use in their RFR fuel handling reactor area bridge return to service activities in order to gain efficiencies around alignments and commissioning steps.

## SUB-ASSEMBLY TRANSFER CONTAINERS AND CART

During the preparation of fuel channel sub-assemblies, fabricated at the off-site Darlington Energy Complex, storage capacity is of the utmost importance in maintaining production margins to site's requirements. OPG, along with a contract vendor partner, borrowed Bruce Power's MCR sub-assembly transfer containers and cart. The increase in storage capacity was utilized to maximize the number of completed fuel channel sub-assembles, ready for shipment to the reactor face for final installation. This approach mitigated the risk of schedule delay to the project's critical path.

BY THE NUMBERS

# Nuclear in Ontario

## 53%

of Ontario's annual electricity needs are met by Bruce Power and OPG nuclear power stations

## $89.9 BILLION

in economic benefits for Ontario will be generated by the DNRP and its extended 30 years of operation


The quality of Ontario's air has improved immensely — decreasing smog days from 53 in 2005 to 0 in 2023

More than

## 22,000 JOBS

will be secured directly and indirectly by Bruce Power's Life-Extension Program and MCR Project

## 80 MILLION TONNES OF $CO_2$ EMISSIONS AVOIDED

per year with with nuclear power, roughly the equivalent of taking 15 million passenger vehicles off the road

OPG delivered the world's single largest climate change action to date when their coal stations were closed down in 2014

Together, Bruce Power and OPG directly employ more than

## 14,200 PEOPLE

Bruce Power
Innovation at work

ONTARIO POWER GENERATION

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