

Darlington Refurbishment Project – Report Back

Ministry of Energy

XXX 2018

WORKING DRAFT

Minister

Deputy Minister

Agenda for Discussion

1. Overview of the Ministry of Energy's Report Back
2. OPG Darlington Refurbishment – Updates, Planning and Preparation and Oversight
3. Darlington Refurbishment “Off-Ramps” – Analysis and Considerations
4. Communications / Next Steps
5. Proposed Recommendation to Treasury Board/Management Board of Cabinet (TB/MBC)

1. Overview of Report Back

Overview of Report Back

- In December 2015, Cabinet approved Ontario Power Generation (OPG) to proceed with the Darlington refurbishment project (i.e., overall project schedule and budget).
 - The Ministry of Energy was directed to report back on the progress and implementation of Unit 2 refurbishment prior to proceeding with the execution of Unit 3 refurbishment.
 - In September 2016, Ministry of Energy's Mandate Letter directed the Minister to continue to implement government oversight of nuclear refurbishments to ensure the projects remain on budget and schedule to protect ratepayers.
- The Ministry of Energy is reporting back to TB/MBC on:
 - A. Progress of Darlington Unit 2 refurbishment, currently underway;
 - B. Planning and preparation for Unit 3 refurbishment (i.e., to commence in late 2019/early 2020 following completion of Unit 2 refurbishment); and
 - C. Update on oversight of Darlington refurbishment project.
- The Ministry's report back also outlines the next steps as OPG prepares to execute Unit 3 refurbishment. This includes analysis and considerations with respect to the government's "off-ramps" for Darlington refurbishment.

Darlington Nuclear Generation Station

- Darlington Nuclear Generating Station is a four-unit station with a net output of approximately 3,500 megawatts (MW), located in the Municipality of Clarington in Durham Region, 70 km east of Toronto.
- Darlington began operating in the early 1990s, and is one of the top ranked nuclear stations in the world. In 2016, Darlington:
 - Received highest safety rating for the 8th year in a row from the Canadian Nuclear Safety Commission (CNSC) – the federal nuclear regulator; and
 - Recognized as one of the safest and best performing nuclear stations in the world for the 3rd time in a row by an international industry assessment. It is the first time a plant outside the United States has received the recognition three times.
- With the Darlington units reaching the end of their planned lives in the 2020-2024 period, refurbishment involves the replacement of core reactor components to enable the plant to operate safely for another 30 years.



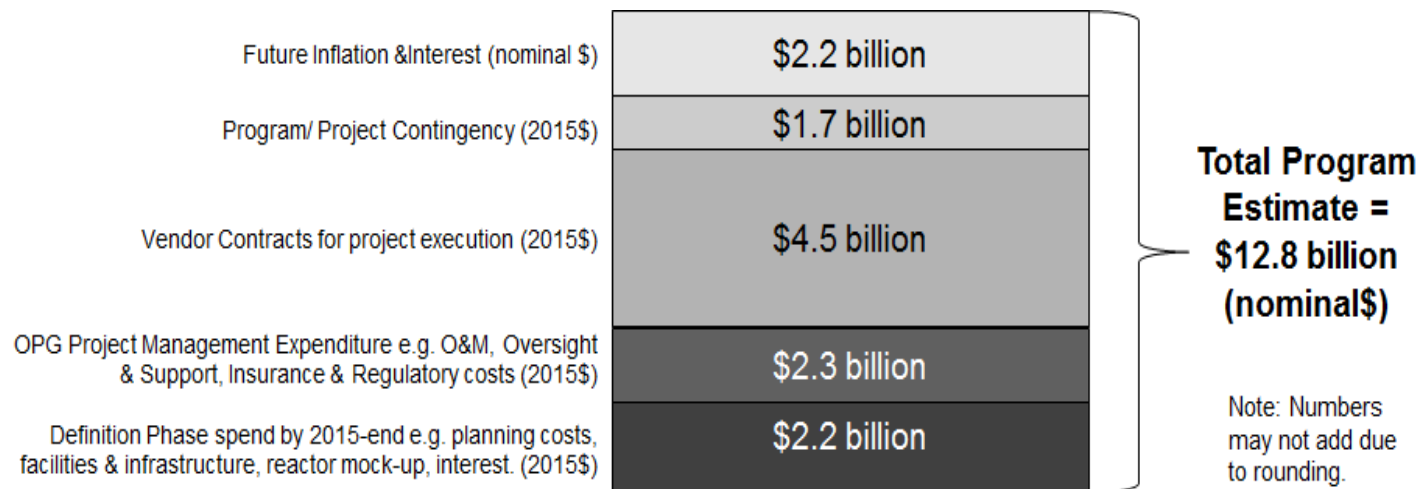
Darlington Refurbishment – Overview

- OPG has undertaken a multi-year phased approach to Darlington refurbishment, based on lessons learned from previous refurbishment projects, which have highlighted the need for in-depth planning and preparation prior to the execution of refurbishment projects.
 - OPG has undertaken comprehensive front-end planning, including building a “first-of-a-kind” full-scale reactor mock-up to train workers and test tools for refurbishment activities.
- In January 2016, the government announced that it was moving forward with nuclear refurbishment at the Darlington Nuclear Generating Station, securing approximately 3,500 megawatts of affordable, reliable and emission-free power.
 - The refurbishment of all four units is expected to involve about 30 million hours of work over 10 years.
- In October 2016, OPG began the execution of refurbishment of Unit 2 at Darlington:
 - Unit 2 refurbishment is progressing well and is on track to be complete within approved project budget and schedule; and
 - Unit 3 refurbishment planning is underway, in line with OPG’s phased approach to refurbishment.

Darlington Refurbishment – Approved Project Budget

- In December 2015, following more than five years of detailed project planning and preparation, Cabinet approved OPG's total budget of \$12.8 billion to refurbish the four nuclear units at Darlington (see chart below).

Approved Budget for OPG's Refurbishment Project

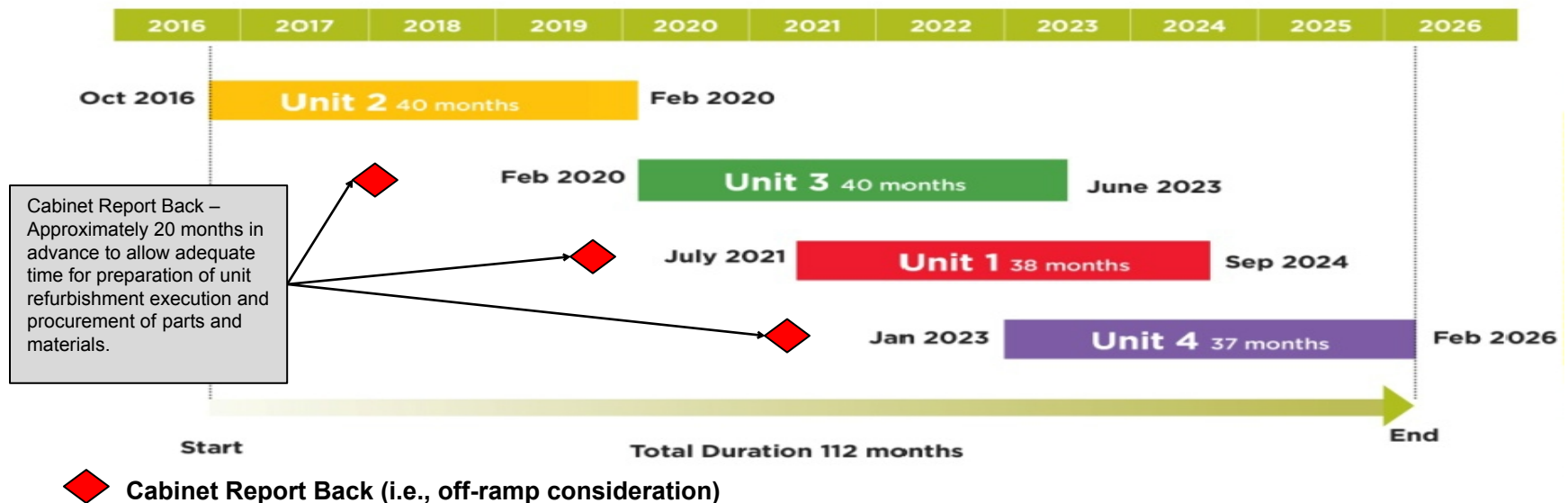


Source: December 2015 Cabinet Submission on Darlington Refurbishment Project

Darlington Refurbishment – Approved Project Schedule

- In December 2015, Cabinet also approved OPG’s total schedule of 112 months to refurbish the four units at Darlington (see chart below).
 - To ensure that lessons learned from the Unit 2 refurbishment are incorporated into subsequent refurbishments, OPG will not commence execution of refurbishment work on Unit 3 until Unit 2 refurbishment is complete.
 - Although Unit 2’s planned refurbishment completion date is February 2020, based on performance to date, OPG is expecting to be ready for execution of Unit 3 refurbishment as early as October 2019.
 - The government has established off-ramps for the Darlington refurbishment project that may be used in the event that OPG fails to adhere to the approved budget and schedule for the project.

Approved Schedule for OPG’s Refurbishment Project



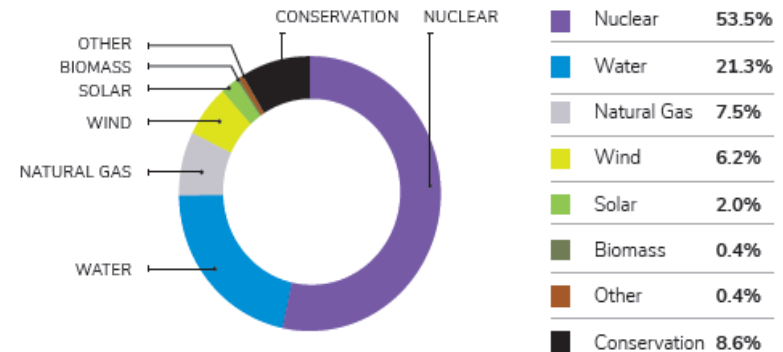
Darlington Refurbishment – Fiscal Impact

- Darlington is owned and operated by OPG, a regulated utility wholly owned by the Province of Ontario.
 - OPG is rate-regulated by the Ontario Energy Board (OEB) which sets the price that OPG receives for all of its nuclear output (i.e., Darlington and Pickering stations) every 5 years;
 - OPG's net income, payments in lieu of taxes (PILs) and net assets are consolidated into the Province's financial statements; and
 - Any OPG income or loss from its nuclear business will be reflected in the Province's fiscal position.
- OPG will recover the cost of refurbishing Darlington by selling electricity to ratepayers at prices set by the OEB, once the reactors are back online following refurbishment.
 - OPG will initially finance Darlington refurbishment with long-term corporate debt and cash generated from operations (equity);
 - The refurbished reactors will be added to OPG's 'rate-base' once they are in-service again; and
 - OEB will set a nuclear price that will incorporate the depreciation of the refurbished reactors over their useful lives plus a return on OPG's refurbishment investment to cover the cost of capital (i.e., debt and equity).
- OPG expects to provide **\$[XX] billion (in 2017 dollars)** in revenue to the Province from the Darlington refurbishment and operation through consolidation of OPG's net income and income tax PILs.

2017 LTEP – Nuclear Refurbishment

- The 2017 Long-Term Energy Plan (2017 LTEP) renewed the government's commitment to maintain nuclear as the single largest generation source, providing about 50% of Ontario's electricity generation over the long-term (i.e., after refurbishments are complete).
- Nuclear power is the backbone of Ontario's electricity system.
 - Nuclear power plants are able to operate reliably and continuously, making them ideally suited to meet "baseload" energy needs (i.e., the minimum demand that is always present in the system).

Ontario's Electricity Generation and Conservation, 2016 (TWh)



Source: 2017 LTEP

- The 2017 LTEP has built in flexibility to address the temporary reduction in nuclear generation as units are taken offline during refurbishment. For example:
 - The government has approved OPG's plan to seek regulatory approval for continued Pickering operation to 2024 to provide reliable baseload power during the period of Darlington and initial Bruce refurbishments;
 - The Independent Electricity System Operator's (IESO) Market Renewal initiative is designed to procure the most competitive resources to meet system needs for additional power, as they arise in the future; and
 - Further reduction of nuclear generation over the long-term (i.e., following an off-ramp), would require procurement of additional firm capacity and energy. This replacement power would likely be primarily new gas-fired generation in order to maintain system reliability (i.e., to replace baseload capacity from nuclear).

2017 LTEP – Nuclear Refurbishment (cont'd)

- The 2017 LTEP re-affirmed Ontario's commitment to refurbish nuclear units at Darlington and Bruce nuclear generating stations:

"The most cost-effective option for producing the baseload generation the province needs while releasing no GHG emissions is to refurbish Ontario's nuclear generating stations."

"Ontario is moving forward with the plans laid out in the 2013 LTEP to refurbish a total of ten nuclear units between 2016 and 2033 – four units at Darlington and six units at Bruce."

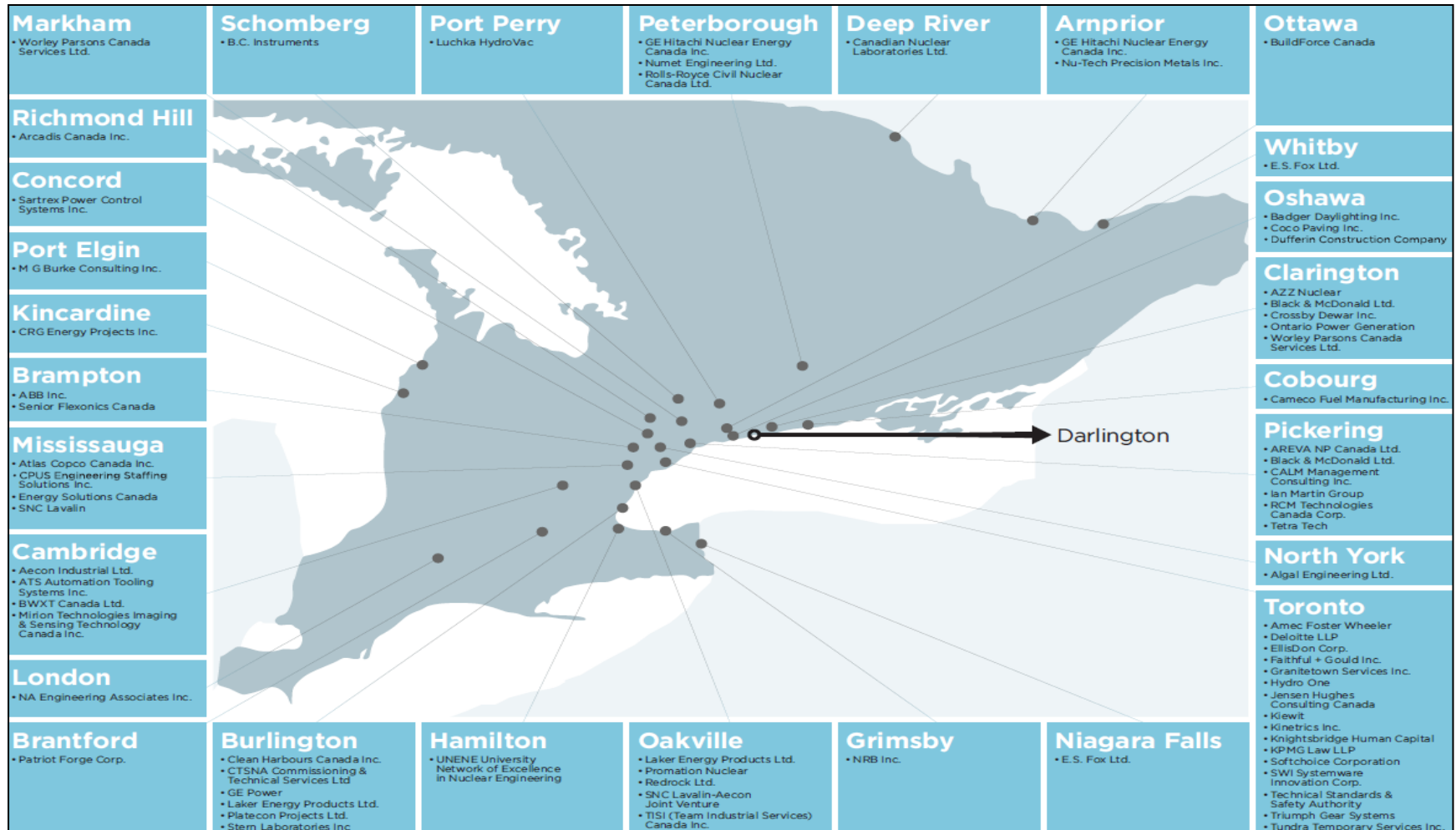
"Refurbishing these 10 units will lock-in more than 9,800 MW of affordable, reliable and emission-free generation capacity for the long-term benefit of Ontario. It will also support the 180 companies and 60,000 jobs that make up Ontario's globally recognized nuclear supply chain."

Darlington Refurbishment – Benefits & Partnerships

- Darlington refurbishment will boost economic activity across Ontario, create jobs and secure 3,500 MW of affordable, reliable and emission-free power for 30-plus years.
 - **GDP and Jobs Impact:** The Darlington refurbishment and continued operation up to 2055 will contribute \$90 billion to Ontario's GDP and increase employment by an average of 14,200 jobs annually, including over 2,600 jobs onsite at Darlington. Currently, more than 5,000 workers are onsite working on the project.
 - **Environmental Impact:** Darlington refurbishment will help reduce Ontario's GHG emissions to the equivalent of taking two million cars off the road each year.
 - **Cost-effective and Reliable Power:** The average cost of power from Darlington nuclear units post-refurbishment is estimated to be about 8 cents per kilowatt hour in 2015 dollars.
- Ontario's world-renowned nuclear supply chain companies and highly skilled labour unions are key partners in the successful execution of Darlington refurbishment.
 - **Supply Chain Partners:** Nearly 200 Ontario companies are participating in Darlington refurbishment (see next slide for examples of key companies involved).
 - **Union Partners:** Electricity sector labour unions (e.g., *Power Workers' Union* and *Society of Energy Professionals*) and Ontario's building trade unions (e.g., *International Brotherhood of Electrical Workers* and *Labourers' international Union of North America*) are involved in Darlington refurbishment.

Note: To ensure smooth and successful execution of refurbishments, all key building trade unions have struck special nuclear project agreements with OPG and Bruce Power that will remain in force through the period of peak refurbishment activities, until December 31, 2032.

Darlington Refurbishment – Industry Partners



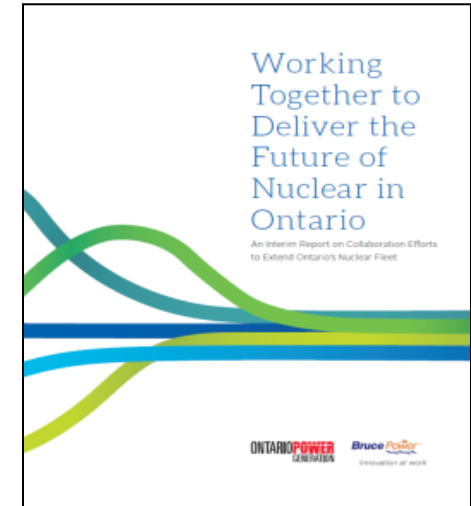
Source: OPG

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OPG and Bruce Power Collaboration Activities

- The 2013 Long-Term Energy Plan (2013 LTEP) outlined the importance of collaboration between the Province's two nuclear operators in order to find ratepayer savings through leveraging economies of scale in the areas of refurbishment and operations.
- In November 2015, Ministry of Energy facilitated a Memorandum of Understanding (MOU) between OPG and Bruce Power that builds on their existing mutually beneficial relationship and identifies area of collaboration with a particular focus on successfully delivering on their refurbishment projects.
- OPG is collaborating with Bruce Power in a number of areas:
 - Collaborating on and sharing lessons learned in refurbishment project planning, training, tooling, procurement and contracting strategies;
 - Collaborating on labour arrangements with Trade Unions involved in the refurbishment, operation and maintenance programs to maximize productivity and efficiency;
 - Working together on the *Nuclear Worker Qualification Initiative* to enhance worker availability and productivity and reduce training costs;
 - Collaborating with industry partners (e.g., SNC-Lavalin) on R&D designed to optimize refurbishment schedules and maximize the value of the current nuclear fleet assets through innovations that extend operating lives of the units, reduce costs and improve productivity; and
 - Working together to identify opportunities to become more efficient in the reduction of waste generated from nuclear facilities and refurbishment activities.



OPG and Bruce Power Collaboration Activities (cont'd)

- Examples of OPG and Bruce Power collaboration activities in specific areas include:
 - Knowledge sharing and mutual support on refurbishment activities:
 - Discussing the most effective way to share knowledge regarding specific elements of the critical “de-tube and re-tube work” at both the Bruce and Darlington sites (e.g., sharing of test results, component procurement and operating experience); and
 - Providing Bruce Power access to OPG’s reactor “mock-up” facility, with a focus on planning, processes and equipment for replacement of feeder pipes – a key reactor component – during the refurbishment project.
 - Labour Arrangements:
 - Regularly discussing work assignment and trade jurisdiction issues related to the distribution of skilled trades work between the various unions to gain improvements and efficiencies in the execution of skilled trades work on their respective generating sites; and
 - Working together in partnership with *Electrical Power Systems Construction Association* (EPSCA) to oversee and evaluate the implementation of a *Nuclear Qualified Worker* (NQW) program, in which the unions will provide trained and pre-qualified workers to the job site, reducing training costs and improving productivity.
 - Asset Life Optimization:
 - Collaborating in R&D work on refurbishment and aging management by *CANDU Owners Group* (COG) – a global umbrella group of CANDU reactor operators, designers and vendors dedicated to sharing of operating experience and conducting R&D on CANDU reactors.

Long-Term Infrastructure Plan – Linkages

- Darlington refurbishment is consistent with the relevant goals and objectives of Ontario's latest Long-Term Infrastructure Plan (LTIP).

2017 LTIP Policy Goals & Objectives for Infrastructure Projects	Darlington Refurbishment Project Impact
Provide Social Benefits and Ensures Inclusive Growth	- Secures supply of critically important medical isotopes that are used for sterilization of hospital equipment and cancer treatment; - Provides fuel for powering deep space probes; and - Supports many local community development programs and initiatives in the Durham region, including the <i>Scientists in Schools</i> program, Bowmanville Memorial Hospital Foundation and a \$15-million investment in educational and apprenticeship programs at Durham College and the University of Ontario Institute of Technology to produce career-ready graduates and skilled trades.
Support Economic Growth, Productivity and Competitiveness	- Generates ~\$90 billion GDP Impact; - Increases employment by an average 14,200 jobs annually until 2055, including highly-skilled jobs in nuclear component and fuel manufacturing, nuclear plant maintenance & operation and nuclear R&D; and - Creates a strong foundation for Ontario's nuclear suppliers to export their products and services to a global nuclear industry.
Stimulate Innovation in the Face of Disruptive Technological Change	- Supports a network of universities and research centers with wide-ranging linkages and innovative applications in nuclear and non-nuclear applications (e.g., medical, agri-food science and aerospace sectors).
Mitigate Climate Change	- Would ensure reduction of nearly 300 million tonnes of GHG emissions, equivalent to removing 2 million cars from the road each year.
Take into Account Ontario's Changing Demographics	- Provides stable, reliable and cost-effective power over the long-term to underpin products and services and mitigate cost pressures on an aging demographic.

Financial Accountability Officer's 2017 Report

- On November 21, 2017, the Financial Accountability Officer of Ontario (FAO) released a report on the financial risks of Ontario's nuclear refurbishment plan.
- The FAO report re-affirms the long-term benefits of Ontario's nuclear refurbishment plan and notes the robust oversight and protections have been put in place to mitigate against risks of refurbishment:

"Overall, despite near-term Nuclear Price increases, the Plan is projected to provide ratepayers with a long-term supply of relatively low-cost, low emissions electricity."

"To mitigate the risk of cost overruns, the Province has options to terminate refurbishments (known as 'off-ramps')."

*"OPG will realize a financial return from the operation of the DNGS and PNGS. OPG is owned by the Province and any return would improve the Province's fiscal position." **

"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."

*DNGS: Darlington Nuclear Generating Station; PNGS: Pickering Nuclear Generating Station

2. OPG Darlington Refurbishment – Updates, Planning and Preparation and Oversight

A. Unit 2 Refurbishment – Update

- Unit 2 refurbishment is on track to be complete ahead of schedule and within budget.
 - As of October 24, 2017, Unit 2 is 40% complete and is 24 days ahead of schedule and \$6 million under budget.
- Infrastructure projects being implemented at Darlington to improve plant safety and to support refurbishment and continued operations of the full site are nearly complete.
 - 17 of 18 projects are in service; and
 - The one remaining project, Heavy Water Storage Facility (HWSF), has experienced cost and schedule slippage. The contract is being aggressively managed and the facility is expected to be in service well before its need date in 2020-2021. Note: It is expected that the cost will be 20-30% over the \$381 million estimate.
- There is no adverse impact for the HWSF delay on the overall approved refurbishment schedule and budget as adequate contingency has already been built in.
 - OPG has taken steps to hold the vendor accountable for project performance and minimize costs by enforcing contractual penalties, negotiating a lower cost for remaining work and capping the overall cost of the facility (See *Appendix* for additional details).

A. Unit 2 Refurbishment – Program Performance

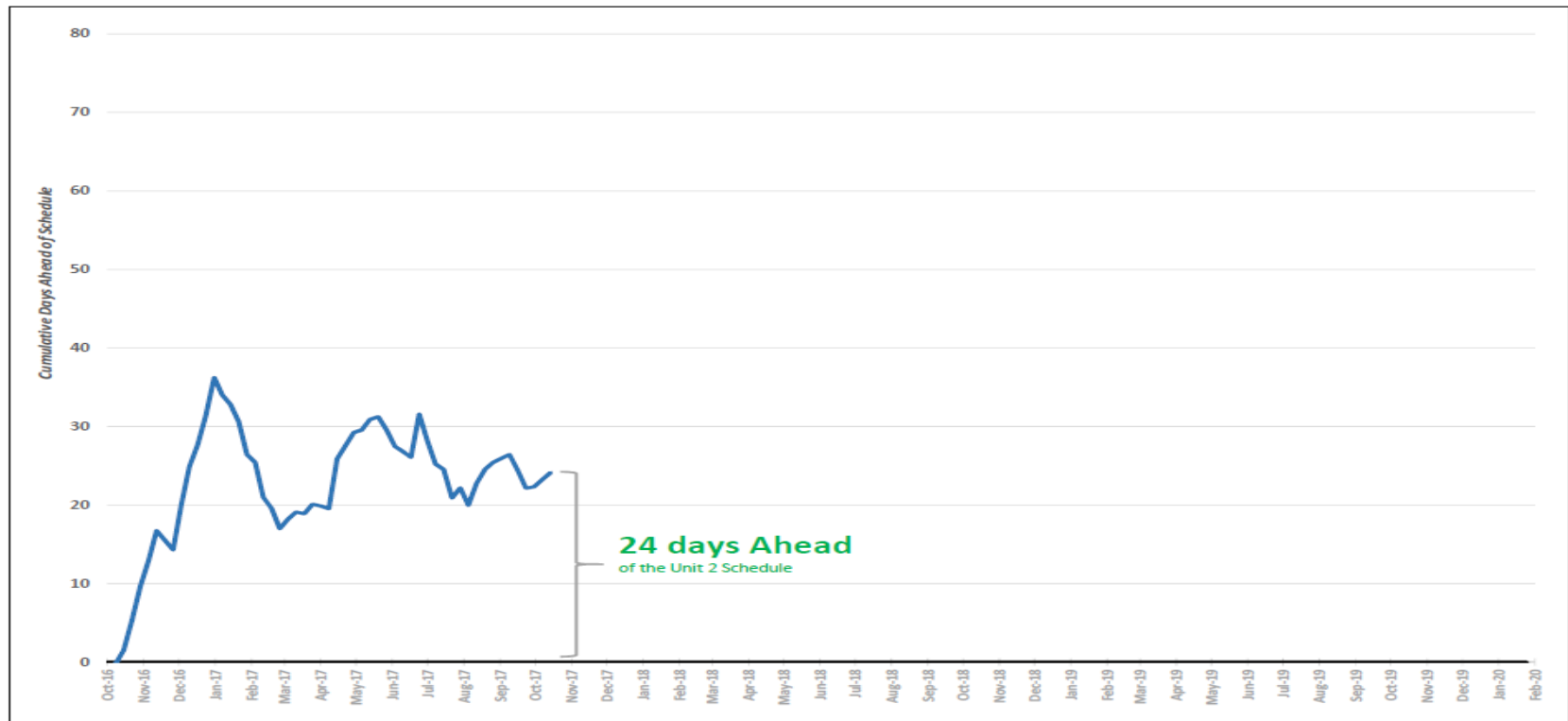
- OPG's Unit 2 refurbishment is on track to be complete within approved project schedule and budget. The project also continues its strong record of safety and quality.

DARLINGTON REFRUBISHMENT PROGRAM PERFORMANCE – UNIT 2			
SAFETY 		QUALITY 	
- No Lost Time Injuries since the launch of the project in early 2010. - All Injury Rate at 0.45 substantially better than General Construction Industry performance in Ontario (4.62 in 2016).		No regulatory non-compliance events on Unit 2 or quality related system failures resulting in loss of generation or impacts to the High Confidence Schedule.	
SCHEDULE 		COST 	
The project is 24 days ahead of the High Confidence Schedule and currently forecast to be complete ahead of the 40 month schedule duration.		- Unit 2 is currently on budget, the forecast to complete Unit 2 remains within the approved budget of \$3.417 Billion. - The forecast to refurbish all 4-units and complete all Facility and Infrastructure and Safety Improvement projects remains within the approved \$12.8 Billion budget.	

 Ahead of Plan
  On Plan
  Marginally Behind Plan
  Behind Plan

A. Unit 2 Refurbishment – Schedule Tracking

- As of October 24, 2017, the Unit 2 refurbishment is 24 days ahead of the approved schedule, which includes planned contingency for known risks.
 - As shown in the graph below, the refurbishment has been consistently ahead of the approved schedule for every day since commencement.



Source: OPG

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A. Unit 2 Refurbishment – Considerations

- OPG's detailed planning and preparation for the Darlington refurbishment project have resulted in strong performance to-date on Unit 2 refurbishment.
 - Training and tool-testing on the Darlington reactor “mock up” facility has enabled OPG and its vendors to maintain a high level of productivity in executing critical refurbishment tasks and avoid any schedule delays; and
 - Rigorous planning and careful execution has also contributed to excellent performance on worker safety and radiation protection.
- OPG continues to focus on reducing costs through improved productivity and optimizing project overheads.
 - OPG has identified productivity during the transition phase between refurbishment tasks as an area of further improvement (e.g., set-up time for equipment during transition from “defueling and islanding the unit” segment to “removal of reactor components” segment);
 - OPG is actively managing its vendors and using weekly meetings to focus on removing barriers to increase productivity on the project site; and
 - OPG is reviewing staffing levels for both its own and its vendors' project management teams to ensure costs are as low as possible without impacting productivity.
- Ministry of Energy continues to closely monitor OPG's performance on Unit 2 refurbishment through regular briefings with OPG management, OPG Board and the government oversight advisor.

B. Unit 3 Refurbishment – Planning and Preparation

- OPG is planning to be ready to execute Unit 3 refurbishment as early as October 2019, one month after the earliest potential completion of Unit 2.
 - With concurrence of the Minister of Energy, OPG’s Board has now released \$242 million to commence design replication, long-lead material procurement and incorporation of lessons learned from Unit 2 refurbishment into the development of the project schedule and budget for Unit 3.
- OPG’s planning and preparation activities for refurbishment of Unit 3 include:
 - Establishment of an independent planning organization;
 - Replication of Unit 2 engineering designs for Unit 3;
 - Engineering for scope specific to Unit 3;
 - Procurement of long-lead materials;
 - On-going incorporation of lessons learned from Unit 2; and
 - Development of the detailed budget and schedule estimates for Unit 3.
- OPG is currently in the process of assembling detailed project schedules and updated budget estimates to support the next funding request of \$164 million for Unit 3 from OPG’s Board in March 2018.
 - The near-term focus is on pre-requisite projects starting in Q3 2018 as well as long-lead procurement leading up to potential Unit 3 “breaker open” in October 2019.

B. Unit 3 Refurbishment – Schedule and Budget

- On November 9, 2017, OPG Board confirmed that the project schedule and budget for Unit 3 refurbishment remains within the 2015 approved Darlington refurbishment project schedule and budget.
 - The estimated average price of power from Darlington post-refurbishment continues to be about 8 cents per kWh (in 2015\$).
- OPG's scope of work for the Unit 3 refurbishment is similar to Unit 2, with the following differences:
 - Exclusion of one-time facility and safety projects and in-station support service projects, which are already in place as part of work to enable Unit 2 refurbishment; and
 - Inclusion of digital upgrade work for the Turbine Generator Control Systems (Note: This work will be performed for Unit 2 at a later date).

OPG Board Approved Refurbishment Project Schedule and Budget Estimate		
Unit 3	2015	2017
Schedule	40 months	40 months
Budget	\$2.4 billion	\$2.4 billion

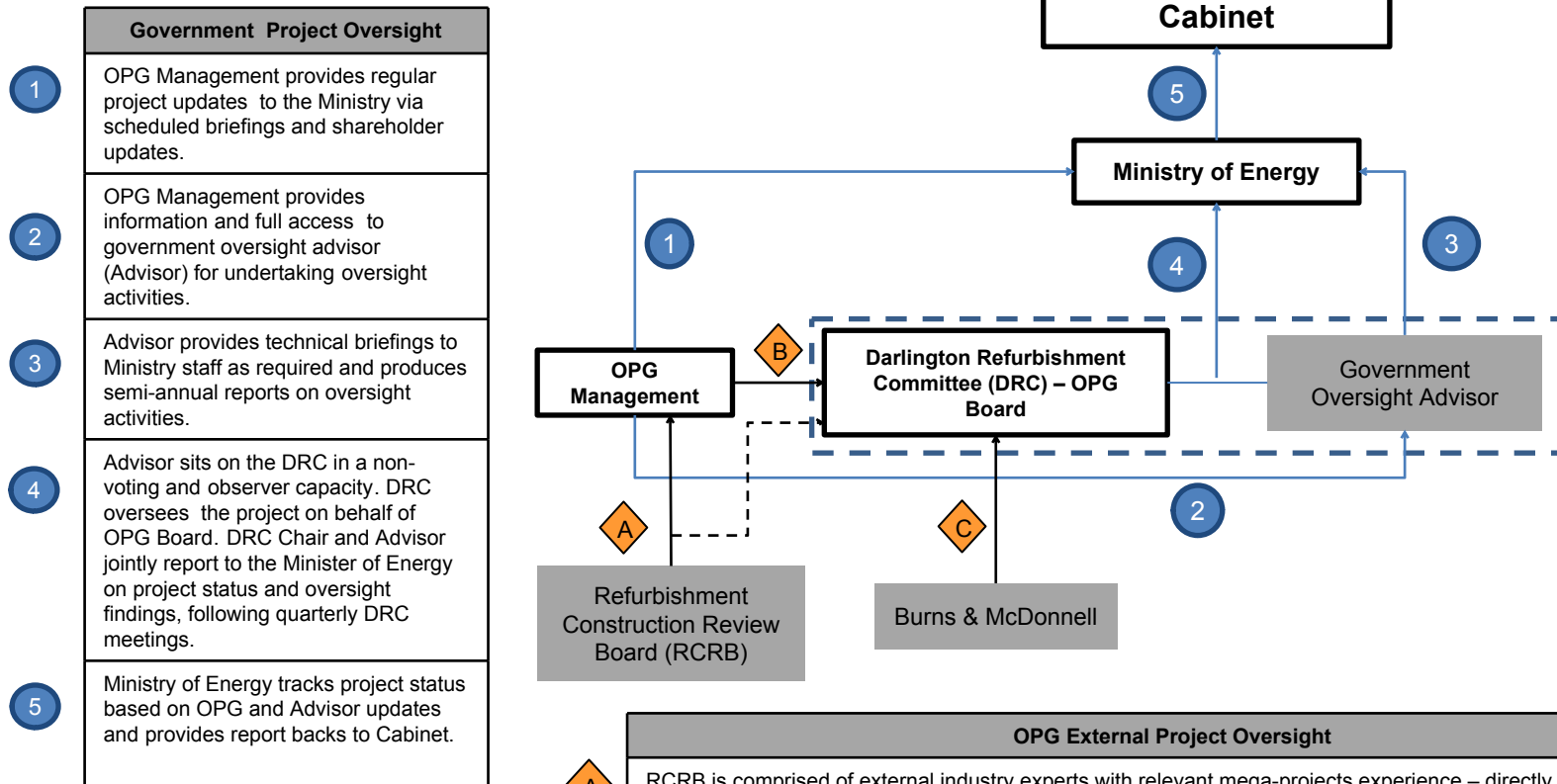
B. Unit 3 Refurbishment – Considerations

- OPG has put in place a formal lessons learned process to benefit Unit 3 refurbishment planning and preparation.
 - Lessons Learned from Unit 2 refurbishment are captured in *Milestone Completion Reports* which are completed at the end of each key refurbishment task;
 - These reports capture suggested changes, revised practices and/or techniques experienced during the execution of Unit 2 refurbishment; and
 - The schedule for Unit 3 and all subsequent units are being updated in real-time based on lessons learned from Unit 2 refurbishment.
- OPG has also created a dedicated *Darlington Unit 3 Innovation Project Team* to identify, review and implement “high impact” innovative ideas with significant opportunity to reduce cost and duration on future units.
- Ministry of Energy is being regularly updated on the status of Unit 3 planning as part of the reporting on the status of Darlington refurbishment project.

C. Oversight of OPG's Refurbishment Project

- The government is committed to strict oversight of OPG during the Darlington refurbishment project in order to ensure that ratepayers are protected and the refurbishments adhere to the approved project schedule and budget.
 - As directed by Cabinet in June 2015, Ministry of Energy developed an oversight structure for the execution phase of Darlington refurbishment project with support from Infrastructure Ontario (IO).
 - An independent oversight advisor (MZConsulting – Milt Caplan) is actively monitoring the Darlington refurbishment project and regularly reporting to the Minister of Energy.
- OPG also has significant project oversight in place to monitor the Darlington refurbishment project and to ensure challenges are identified early and addressed promptly.
 - The Darlington Refurbishment Committee (DRC) of the OPG Board is responsible for overseeing the project's execution including monitoring progress and performance against the approved project schedule and budget and making recommendations to the OPG Board with respect to refurbishment of subsequent units at Darlington.
 - The DRC has also retained external oversight advisors to support the oversight of the project by the OPG Board (i.e., Burns & McDonnell).
 - The Refurbishment Construction Review Board (RCRB) is a panel of industry experts that provides external oversight and advice to OPG's CEO, Chief Nuclear Officer and SVP of Nuclear Projects.
- The Darlington refurbishment project is also subject to regulatory oversight by Canadian Nuclear Safety Commission (CNSC) and Ontario Energy Board (OEB).
 - OEB ensures that ratepayers are only responsible for refurbishment costs that have been prudently incurred.
 - CNSC ensures that OPG is in compliance with all regulatory safety requirements when undertaking the refurbishments.

C. Oversight Structure for OPG's Refurbishment Project



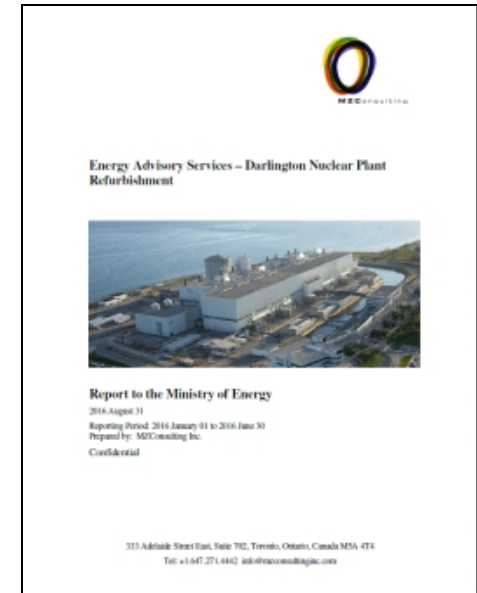
Note: Regulatory reviews by CNSC and OEB will inform government and OPG oversight.

OPG External Project Oversight	
A	RCRB is comprised of external industry experts with relevant mega-projects experience – directly reports to OPG senior management and provides independent assessments of project progress and advises on early intervention and correction of any shortfalls in execution. RCRB also provides annual reports to the OPG Board on the scope and execution of the project.
B	OPG Management regularly reports to the DRC on project status and performance.
C	Burns & McDonnell (BMcD) has been retained by OPG Board to act as its external oversight. BMcD validates project reports from OPG Management to DRC and ensures that the oversight processes are healthy, robust and reviewing the right areas.

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C. Government Oversight Advisor – Ministry Reporting

- The government oversight advisor actively monitors the Darlington refurbishment project and provides regular updates to the Minister of Energy.
 - The advisor has unfettered access to OPG staff and information in performing oversight activities.
- The advisor also prepares semi-annual reports summarizing Darlington refurbishment activities and key findings with respect to the following areas:
 - Progress of the refurbishment project against established targets and milestones, including project schedule and budget;
 - Review of overall project management processes (including but not limited to contractor performance, quality management, risk management and OPG's corrective action programs to address any adverse trends);
 - Evaluation of OPG's risk management strategy with respect to emerging project risks; and
 - Review of processes and ongoing progress on collaboration activities between the Darlington and Bruce refurbishment projects.
- The advisor has provided 3 semi-annual reports covering the following reporting periods (i.e., since the start of Execution Phase of Darlington refurbishment):
 - Jan 2016 – Jun 2016;
 - Jul 2016 – Dec 2016; and
 - Jan 2017 – Jun 2017.



C. Government Oversight Advisor – Due Diligence Report

- To support a Cabinet report back on the Darlington refurbishment project, the Ministry of Energy asked the government oversight advisor to prepare a due diligence report with a summary assessment of the Darlington refurbishment project performance to-date as well as planning and preparation for Unit 3 refurbishment (See *Appendix* for full report).
- Summary of key findings of the government oversight advisor include:

Key Elements	Summary Finding
Unit 2 Performance	- To date, the Unit 2 refurbishment remains on track to meet the committed high confidence schedule and budget. - The use of reactor mock-up at the Darlington Energy Centre has been particularly beneficial for project performance (e.g., testing tools, procedures and lessons learned). - OPG is taking action to improve upon previous challenges experienced with transitions as one element of refurbishment work concludes and the next one begins.
OPG Project Management Performance & Lessons Learned	- OPG has developed and implemented robust project management processes to manage a project of this size and complexity. - A key element of the project is the lessons learned program which includes a “lessons learned review” following completion of each refurbishment task. OPG is successfully transitioning into a strong learning organization and contractor capability is improving. - OPG should be diligent in developing a robust Human Resources program to ensure existing staff resources are sustained and new resources are available over the entire refurbishment period (i.e., to 2026).

C. Government Oversight Advisor – Due Diligence Report (Cont'd)

Key Elements	Summary Finding
Implementation of OPG's Contracting Strategy & Project Risk Management	- OPG's contracting strategy has been implemented to assign risk to the main contractors, incentivise the appropriate behaviours and allow for the necessary transparency and visibility by OPG project management. - The Heavy Water Storage Facility is an example where OPG actively intervened to improve contractor performance including demanding organizational changes and enforcing contractual disincentives. - OPG has a robust risk management process. There is adequate contingency in the project to accommodate the risks as currently assessed. OPG uses a risk management tool to continuously identify new risks and put in place mitigation plans.
OPG & Bruce Power Collaboration	- OPG and Bruce Power collaboration is going well as both parties see the benefit of collaboration and are enthusiastic supporters of working together. - There are strong intercompany relationships at all levels, with both companies initiating contacts whenever there is an issue to be discussed or help is required. - Issues being addressed include safety and development of staff to ensure that there are sufficient qualified people at all levels to implement both utilities' refurbishment projects taking into account the overlap of Darlington and Bruce units post-2020.
Unit 3 Planning & Preparation	- A planning organization is in place and project schedule is being prepared taking into account the actual experience of Unit 2 to-date. - Following the completion of each major refurbishment task for Unit 2, a lessons learned meeting is held to review the outcome and requirements for future units. This is then built into the Unit 3 and subsequent units' schedules. - There is also an updated risk assessment underway that looks at where risks have been reduced and acknowledges where risks may also increase due to any unique aspects of Unit 3. - The project schedule and budget for Unit 3 refurbishment is expected to remain within the estimate approved for the overall Darlington refurbishment project. - As an integral part of the planning process for Unit 3, OPG must continue to focus its efforts on the development of people at all levels of the organization taking into account Unit 2 experience and the collaboration efforts with Bruce Power.

C. Oversight – Considerations

- The government’s oversight advisor’s due diligence report noted that the good performance of the project to-date is a strong testament to the improvements made by OPG in the following areas over the past year:
 - Addressing the complex structure of responsibilities between the station’s “operating” organization and the “refurbishment” organization to improve collaboration and ensure timely decision-making as the project proceeds;
 - Evolving OPG’s workplace culture to increase accountability on maintaining project schedule and budget; and
 - Addressing concerns about contractor readiness to improve contractor accountability and performance.
- The issues identified by the government oversight advisor are consistent with those raised by OPG’s external oversight advisors (i.e., RCRB and Burns & McDonnell) and there continues to be broad agreement in each group’s reporting.
 - OPG is very responsive and open in addressing findings and recommendations from internal and external oversight.
- Both OPG and the advisor conclude that an “off-ramp” is not required based on the performance of Unit 2 and the application of lessons learned to Unit 3.

3. Darlington Refurbishment “Off-Ramps” – Analysis and Considerations

Darlington Refurbishment “Off-Ramps” – Overview

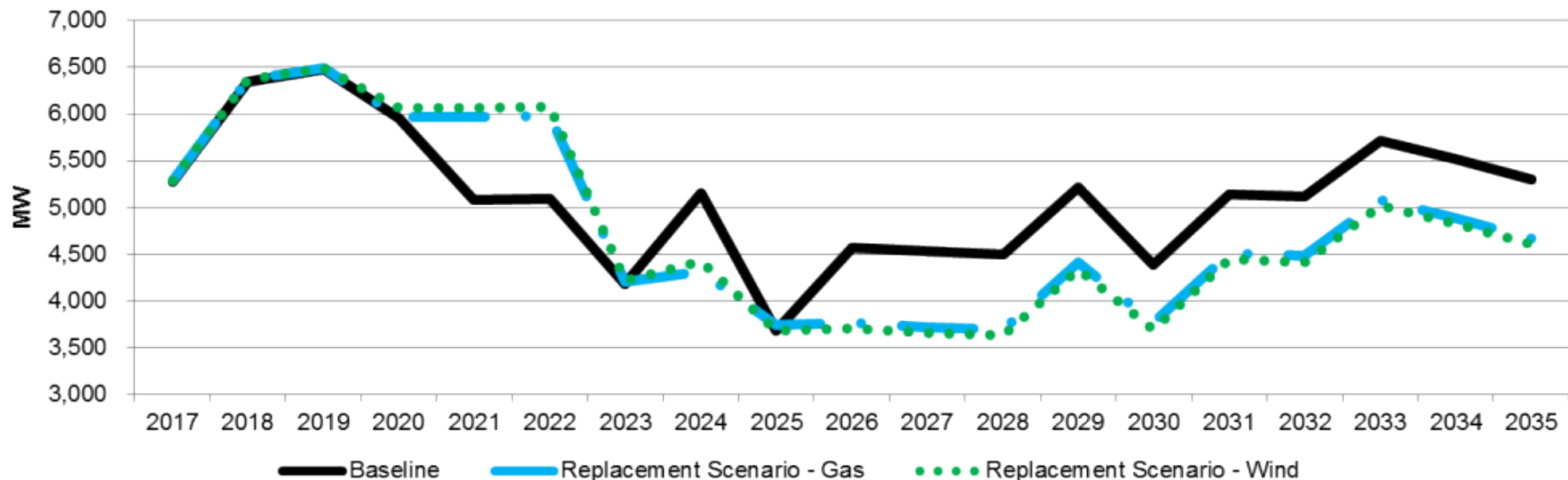
- OPG require government approval before proceeding with each remaining unit refurbishment. These decision points act as “off-ramps” for the project.
 - Unlike Bruce Power’s “off-ramps” which are subject to contractual restrictions, government has greater flexibility in off-ramping Darlington units prior to their refurbishment through a Cabinet decision.
- The government’s decision to proceed with future Darlington unit refurbishments will depend on:
 - OPG’s performance on preceding refurbishments – including adherence to approved schedule and budget;
 - Ongoing value of the Darlington refurbishments to ratepayers; and
 - Different supply options to address future generation capacity needs.
- Potential Darlington unit shutdown sequence following an off-ramp for Unit 3:
 - Unit 3 in June 2020;
 - Unit 1 in October 2022;
 - Unit 4 in March 2024; and
 - Unit 2 in February 2050.

Rational and Impact of Taking an “Off-Ramp” Post-Unit 2 Completion

- Currently, Unit 2 refurbishment on track to be complete within budget and schedule. Nuclear refurbishment remains the most cost-effective option for meeting Ontario’s round-the-clock electricity needs, as confirmed by 2017 LTEP and 2017 FAO report.
- Rational for taking an “off-ramp” before the start of Unit 3 would be based on the on the following considerations:
 - Poor refurbishment performance on Unit 2 (i.e., loss of confidence in OPG’s ability to execute refurbishments);
 - Refurbished nuclear being uneconomic when compared to alternatives (i.e., no longer provides value for ratepayers); and
 - Better supply options to address future generation capacity needs (i.e., triggering a Darlington off-ramp would require new capacity).
- If an off-ramp is exercised before start of Unit 3, OPG is likely to shut down all of the remaining 3 Darlington Units at the end of their safe operating lives and operates the refurbished Unit 2 for an additional 30 years.

Replacement Generation Capacity – Requirements

- If the Darlington off-ramps were triggered for Units 1, 3 and 4, new capacity would be required.
- A combination of options could be considered to satisfy the capacity needs:
 - Simple cycle or combined cycle gas plants, depending on project requirements and cost; and
 - Renewable energy generation via wind.
- Large-scale firm (i.e., guaranteed) imports, particularly from Quebec, are likely not feasible or cost-effective as a replacement for Ontario's nuclear generation.
 - The 2017 FAO report noted that firm imports from Quebec cannot provide cost-competitive replacement of nuclear generation due to a combination of American markets willing to pay higher prices for Quebec's current surplus electricity, transmission limitations, increasing domestic demand in Quebec and the cost of new Quebec generation required to meet Ontario's needs.



Replacement Generation Capacity – Scenarios

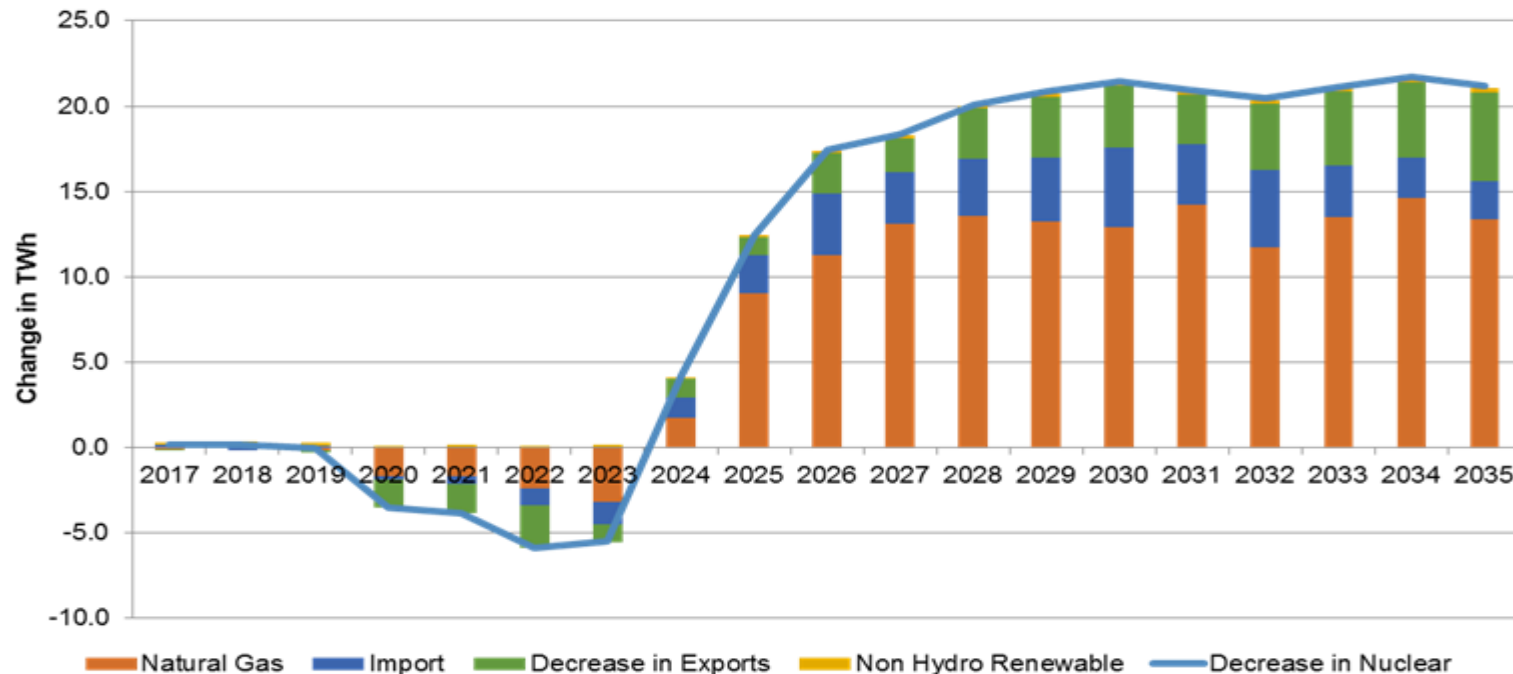
- Two scenarios are being considered to address the future capacity needs:
 - 1) Replacement Scenario – Gas-fired Generation
 - 3,400 MW of simple cycle or combined cycle gas plants are built to replace the capacity lost from the Darlington off-ramp.
 - 2) Replacement Scenario – Wind Generation
 - 3,400 MW of installed wind capacity is built to replace the capacity lost from the Darlington off-ramp on a MW-per-MW basis; and
 - 3,000 MW of natural gas-fired capacity is also required in order to provide firm capacity and ensure system reliability.
- In addition, replacement of this generation of this capacity would require building additional new gas-fired generating units. Note: Additional capacity can be procured via market renewal mechanism.

Scenario	New Gas-Fired Units Built			New Gas-Fired Capacity
	2023	2025	2030	MW
Baseline	4	2	0	1,200
Replacement Scenario – Gas	4	12	1	3,400
Replacement Scenario – Wind	3	11	1	3,000

1) Replacement Scenario – Gas-fired Generation

- The reduced nuclear generation from a Darlington off-ramp would be replaced with a combination of increased natural gas (i.e., 17 new units), decreased exports and increased imports (including from emitting jurisdictions).
Note: Some natural gas operates as baseload.

Estimated Change in Generation

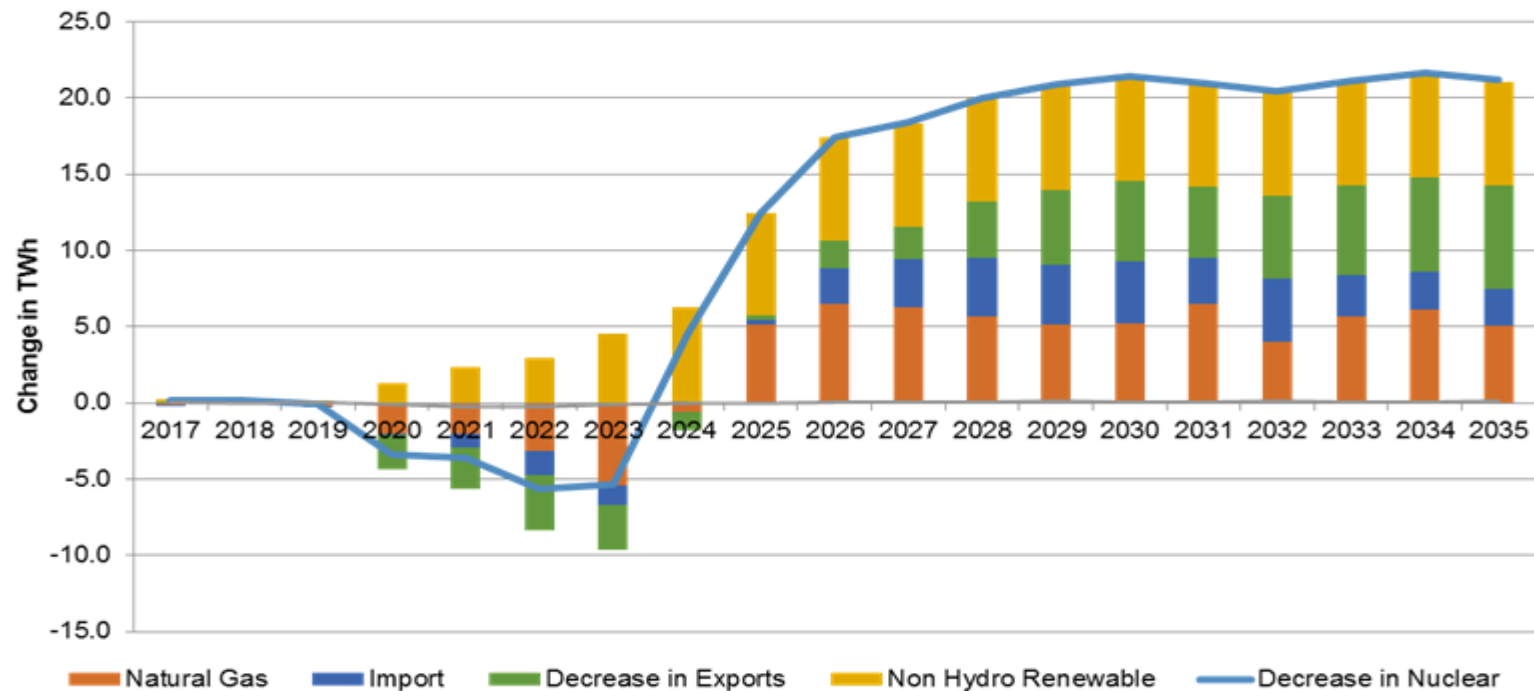


Note: Ministry of Energy analysis. Results are sensitive to fuel price and demand forecasts.

2) Replacement Scenario – Wind Generation

- The reduced nuclear generation from a Darlington off-ramp would be replaced with a combination of increased wind generation, increased natural gas (i.e., 15 new units), decreased exports and increased imports (including from emitting jurisdictions). Note: Natural gas continues operating primarily as a peaking resource.

Estimated Change in Generation

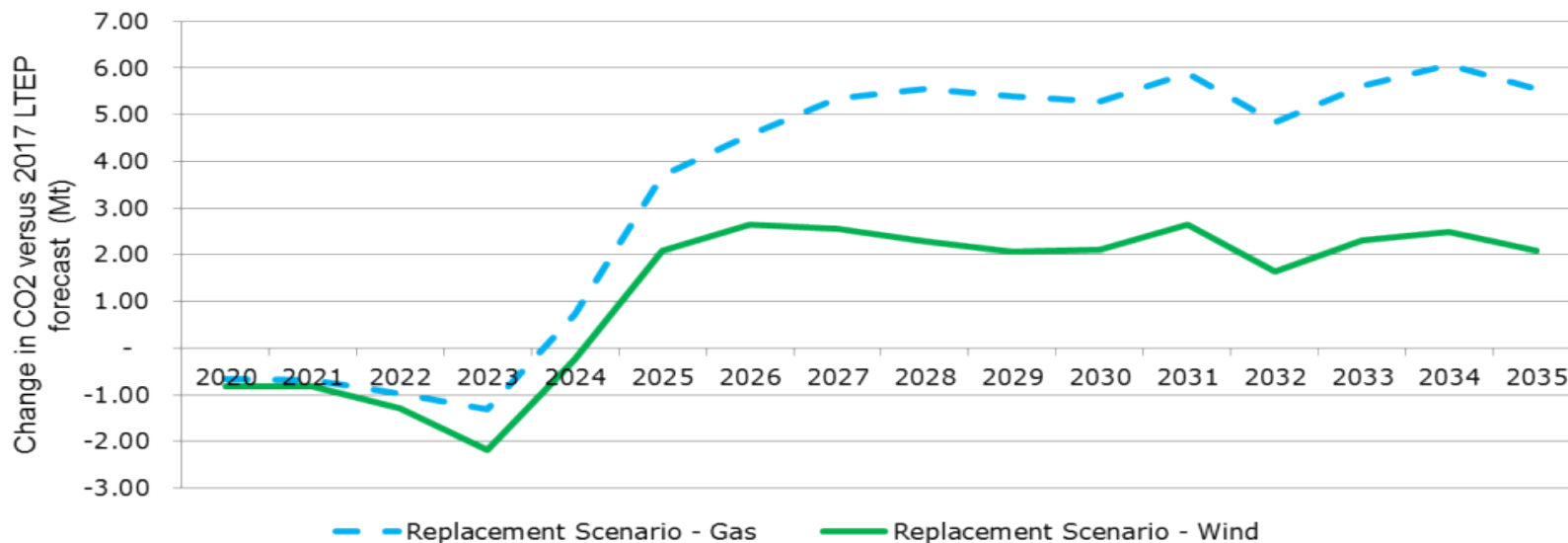


Note: Ministry of Energy analysis. Results are sensitive to fuel price and demand forecasts.

GHG Emissions Impact – Considerations

- Replacing off-ramped Darlington units with gas-fired generation results in an increase in greenhouse gas (GHG) emissions (i.e., about 5-6 Mt over the long-term).
- Replacing off-ramped Darlington units on a MW-per-MW basis with wind reduces GHG emissions relative to the natural gas option, but they are still higher than the base case with all Darlington units in service.
- Replacing off-ramped Darlington units with other generating sources makes it difficult to meet the electricity sector GHG emissions outlooks in the 2017 LTEP.

Estimated Change in Emissions versus 2017 LTEP Forecast



Notes: Emissions are relative to 2017 LTEP forecast. Ministry of Energy analysis. Results are sensitive to fuel and carbon prices and demand levels.

Economic and System Impacts – Considerations

- Off-ramping three out of the four Darlington refurbishments would greatly diminish the employment and economic benefits of the project which is expected to contribute \$90 billion to Ontario's GDP and increase employment by an average of 14,200 jobs annually, including over 2,600 jobs onsite at Darlington.
- In addition to the loss of jobs and economic activity in the local communities around Darlington, the loss of these three refurbishments would severely impact Ontario's nuclear industry which is comprised of more than 180 supply chain companies across the province and supports 60,000 jobs.
- While the total cost to ratepayers from Darlington output would be reduced over time, reflecting lower refurbishment investment and lower nuclear generation, the shutdown of the three off-ramped units will lead to:
 - Loss of more than 2,600 MW of reliable baseload capacity (i.e., more than 25% reduction from 2017 LTEP's long-term nuclear target of 9,800MW);
 - Loss of ~31 TWh of energy annually, at a cost of about 8 cents per kWh (2015\$) on average for the next 30-plus years; and
 - Potential ratepayer exposure to price of carbon from replacement portfolios that include GHG-emitting sources (e.g., natural gas-fired generation).

Fiscal / Ratepayer Impacts – Considerations

- Cancellation of the remaining three Darlington units will have the following impacts on OPG's contribution to Government's income:
 - Foregone net income from capital investment (i.e., return on equity invested in the 3 foregone refurbishments), resulting in a reduction in OPG's contribution to government's income (net income and income tax PILs) of close to [\$525 million/year], on average, or [\$20] billion over Darlington's life;
 - A possible write-off of spend to-date on the Unit 3 refurbishment planning (i.e., [~\$70 million] to-date), if, through a future prudence review, the OEB determines that the planning cost is not reasonable in light of off-ramp; and
 - A possible write-off of capital costs of refurbishing Unit 2, if, through a future prudence review, the OEB determines that the higher per unit refurbishment cost is not reasonable given that it includes significant up-front planning (i.e., ~\$2 billion) that are intended for a 4-unit refurbishment project.

Other Considerations

- According to OPG, substantially reducing OPG's nuclear footprint could impact OPG's financial viability and impair OPG's ability to support Ontario's Fair Hydro Plan.
 - The Funds From Operation (FFO) /Total Debt ratio, which is the key credit metric used to assess OPG's Fair Hydro Plan borrowings, would be driven below the minimum threshold as a result of not refurbishing the remaining three Darlington units; and
 - OPG's credit rating would be impaired, resulting in significant erosion in OPG's ability to borrow and an increase in the cost of that borrowing.
- Upcoming negotiations with labour unions could be adversely impacted by triggering the Darlington off-ramps.
 - In March 2018, OPG is expected to negotiate the next bargaining agreement with Power Workers Union (PWU) which represents thousands of OPG employees; and
 - OPG's objective to realize additional efficiencies (i.e., additional ratepayer savings) would benefit significantly from long-term job security offered by the refurbishments.
- Off-ramping remaining Darlington refurbishments could have adverse implications for the Bruce refurbishment project, by:
 - Introducing significant uncertainty about the future of Bruce refurbishment project, where the planning and preparation for first Bruce unit refurbishment has already commenced;
 - Increasing Bruce refurbishment cost as a result of loss of economies of scale for nuclear suppliers due to fewer expected refurbishments; and
 - Roll-back OPG-Bruce Power collaboration, as OPG prepares to wind down its resource commitments to refurbishments.
- There will continue to be a need for OPG's "Low & Intermediate Level Waste" Deep Geological Repository (DGR) to store the waste following shut down and decommissioning of Darlington.

4. Communications / Next Steps

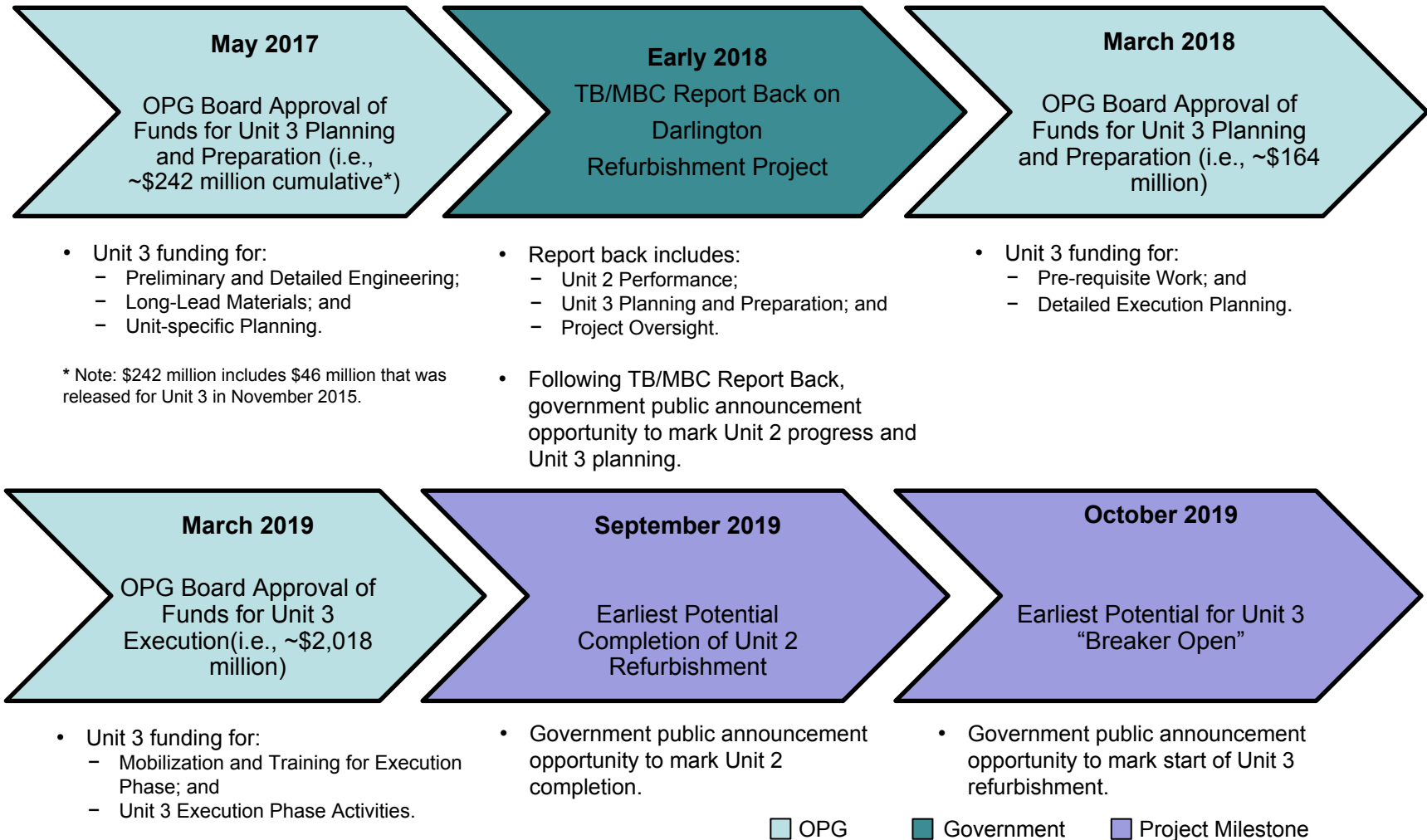
Communications Strategy

- ENERGY will work with OPG and Cabinet Office on a communications strategy to highlight the success of the refurbishment project to date and provide an update on planning for execution of Darlington Unit 3 refurbishment. Potential tactics include:
 - Minister's participation and speech at an event timed around a refurbishment milestone event (e.g., once refurbishment of the first unit reaches 50% completion or when the reactor disassembly phase is complete as expected in March/April 2018);
 - Ministry news release; and
 - Ministry will continue to develop communications materials including key messages, Q&As and issues management plan.
- These materials will balance promotion of success to date with challenge of ensuring ongoing high performance on the refurbishment program.
- Ministry will continue to work with OPG on the broader communications strategy for the nuclear refurbishment program at Darlington.
- Ministry will continue to monitor and track:
 - Media reactions and editorials;
 - Incoming correspondence; and
 - Response by opposition MPPs.

Key Messages

- Ontario's nuclear fleet is our largest source of reliable, affordable round-the-clock power.
- The 2017 Long-Term Energy Plan has re-affirmed plans to proceed with the refurbishment of four units at Darlington.
- The refurbishment and continued operation of Darlington is expected to contribute a total of \$90 billion to Ontario's gross domestic product and increase employment by an average of 14,200 jobs annually.
- Darlington refurbishment is guided by the principles that were set out in our 2013 Long-Term Energy Plan and is subject to strict oversight to ensure safety, reliable supply and value for ratepayers.
- OPG has implemented a robust risk management strategy to ensure that contractors are held accountable and appropriate off-ramps are in place to protect ratepayers against poor performance.
- In addition, the government has an independent set of eyes on the project at all times. An independent advisor is providing continued and effective oversight with support from Infrastructure Ontario.
- Darlington Unit 2 is on track to be complete on time and on budget.
- OPG is undertaking significant planning and preparation for Unit 3 and making sure that lessons learned from Unit 2 are incorporated into Unit 3 refurbishment.

Timeline of Next Steps



5. Recommendation

Recommendation

1. The Ministry of Energy is reporting back to the Treasury Board/Management Board of Cabinet (TB/MBC) on the following:
 - A. Status update on Ontario Power Generation's (OPG) Darlington Refurbishment Project:
 - I. Progress to date on OPG's refurbishment of Unit 2;
 - II. OPG's planning and preparation for the refurbishment of Unit 3; and
 - III. Ongoing oversight activities of OPG's Darlington Refurbishment Project.
2. ENERGY will report back to TB/MBC prior to OPG proceeding with refurbishment of each of the remaining Darlington units.
3. ENERGY will work with OPG and Cabinet Office on a communications strategy.

Appendix – Background Information

- Items in this section include:
 - Independent Oversight Advisor Due Diligence Report
 - Background on OEB Oversight and CNSC Oversight
 - OPG-Bruce Power Collaboration MOU
 - Background on incorporation of OPG Lessons Learned in Darlington refurbishment planning & execution and OPG's Contracting Strategy
 - Status of refurbishment enabling and safety infrastructure projects, including background on Heavy Water Storage Facility (HWSF) Challenges
 - Nuclear Sector Overview (including economic & climate change contributions)
 - Background on Darlington refurbishment budget/schedule/cost of power