



TREASURY BOARD / MANAGEMENT BOARD OF CABINET REQUEST ASSESSMENT NOTE

Ministry:	Energy
Meeting Date:	February 6, 2018
Agenda Class:	Discussion
Last reviewed by: Cabinet (December 2015)	Tracking to: Fast Track Cabinet (February 8, 2018)

SUBMISSION TITLE: Darlington Refurbishment Project – Report on Status

I. DECISION BEFORE THE BOARD

Receive an update on the Darlington Refurbishment Project

II. RECOMMENDATIONS (UNDER DEVELOPMENT)

Receive an update on the Darlington Refurbishment Project.	<i>Receive</i>
Approve that the Ministry of Energy will be ensuring that Ontario Power Generation (OPG) proceed with refurbishment of Darlington Unit 3 beginning as early as Fall 2019 consistent with OPG's Release Quality Estimate and the 2013 Long-term Energy Plan principles for nuclear refurbishment.	Approve
Direct the Ministry to include in future report backs to TB/MBC on the Darlington Refurbishment Project: - Projected changes in OPG's contribution to the Province, as well as ratepayer impact from original projections for the Project, and from what's included in the 2017 Long Term Energy Plan. - Provide its recommendation and rationale on whether an off-ramp is required in future report backs to TB/MBC regarding a decision to proceed with refurbishing the next Unit at Darlington.	<i>Direct</i>

III. FINANCIAL SUMMARY

\$ Millions	2017-18	2018-19	2019-20
Initiative cost requested	0.0	0.0	0.0
Initiative cost recommended	0.0	0.0	0.0
Offset recommended	0.0	0.0	0.0
Total Fiscal Impact	0.0	0.0	0.0

IV. KEY COMMENTS AND CONSIDERATIONS

The Ministry is providing an update on the four-unit Darlington refurbishment project now under way.

In December 2015, Cabinet approved OPG's total budget of \$12.8 billion and schedule of 112 months to refurbish the four nuclear units at Darlington (known as OPG's "Release Quality Estimate" for the four-unit refurbishment). Appendix C provides the 2015 Cabinet minute.

In October 2016, OPG began the execution of refurbishment of Unit 2 at Darlington (Followed by Units 3,1,and 4).

This following table on the next page provides an overview of the Ministry's update:

Report Requirement	Update – Highlights (See Appendix D for more details)
Progress of Darlington Unit 2 refurbishment	- As of December 11, 2017: - Unit 2 refurbishment is on track to be complete within approved project budget and schedule - Unit 2 field work 50% complete and 18 days ahead of schedule - Unit 2 spend to-date is \$1.78 billion – currently \$11 million over plan, but forecast to be on budget at completion. - The Heavy Water Storage Facility, one of the enabling projects which is intended to support refurbishment and future operational needs of the Darlington site, has experienced cost and schedule challenges – but is expected to be in service before its needed in 2020-21. - Project is not on critical path for Unit 2 refurbishment; - Overall cost will be 20-30% higher than \$381million estimate but no impact is expected to the overall budget and schedule as appropriate contingency has already been built in; - OEB may review project cost overruns beyond approved budget for prudence and if any are disallowed will need to be written off by OPG/have a fiscal impact on the province; and - Any OEB review of HWSF cost overruns would take place as part of OPG's next 5-year rate application to the OEB to be submitted in 2021
Planning and preparation for Unit 3 refurbishment	- 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. - Unit 3 refurbishment planning is under way, in line with OPG's phased approach to refurbishment - 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 - 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
Update on oversight of Darlington refurbishment project	- FAO – Nov 2017 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 during refurbishment - OEB – Dec 2017 – the OEB issued its decision and determined that OPG's approved budget for Unit 2 refurbishment and supporting infrastructure is prudent, including OPG's proposed contingency amounts - Government's oversight advisor prepared 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 - To date, the Unit 2 refurbishment remains on track to meet the

	committed high confidence schedule and budget – OPG has developed and implemented robust project management processes to manage a project of this size and complexity – citing specifically the lessons learned component informing the next refurbishment – 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 – 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 – The project schedule and budget for Unit 3 refurbishment is expected to remain within the estimate approved for the overall Darlington refurbishment project
Next steps as OPG prepares to execute Unit 3 refurbishment (Includes analysis and considerations with respect to the government’s “off-ramps” for Darlington refurbishment)	• 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 • Currently, Unit 2 refurbishment on track to be complete within budget and schedule • Rationale 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 emerging (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. – Unit 3 in June 2020 – Unit 1 in October 2022 – Unit 4 in March 2024 – Unit 2 in February 2050 – OPG may incur up to \$6 billion in write-offs as a result of cost disallowances by the OEB following the off-ramp. OPG projects that disallowances and foregone capital investment would result in a reduction of OPG’s contribution to government’s revenue of \$1.1 to \$1.4 billion per year on average (\$43 to \$55 billion over Darlington’s lifetime). • 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.

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| | <ul style="list-style-type: none"> • The Ministry recommends the Darlington refurbishment project should proceed as planned and no off-ramp is required prior to the next Darlington unit refurbishment – Unit 3. • The Ministry confirms that government will have an opportunity to exercise an off-ramp prior to each remaining unit (i.e., about 20 months prior to the start of refurbishment according to OPG's approved schedule – Fall 2019 prior to Unit 1, and Spring 2021 prior to Unit 4 proceeding). |
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Financial Implications:

Darlington is owned and operated by OPG, a regulated utility wholly owned by the Province of Ontario. OPG will initially finance Darlington refurbishment with long-term corporate debt and cash generated from operations (equity). OPG will recover the cost of refurbishing Darlington by selling electricity to ratepayers at prices set by the OEB, once each reactor is back online following refurbishment (and over the life of the reactors).

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 (as adjusted for IFRS)), 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.

- The refurbished reactors will be added to OPG's 'rate-base' once they are in-service again
- Once Unit 2 refurbishment is complete, the OEB will compare actual costs against OPG's approved budget (i.e., any savings will be returned to ratepayers; any excess will be reviewed and only allowed for recovery if prudently incurred).
- OEB will set a nuclear price that will incorporate the depreciation of the refurbished reactors over their useful lives to recover the approved capital expenditures plus a return on OPG's refurbishment investment to cover the cost of capital (i.e., debt and equity).

OEB Decision (EB-2016-0152) (December 28, 2017) – Approved OPG's application relating to the Darlington Refurbishment Program (DRP), including the addition of \$4,800 million to rate base in 2020 when the first of the four units to be refurbished is expected to come back online (Appendix F).

OPG expects to provide of \$1.1 to \$1.4 billion per year, on average, in revenue to the Province from the Darlington refurbishment and long-term operation through consolidation of OPG's net income and PILs.

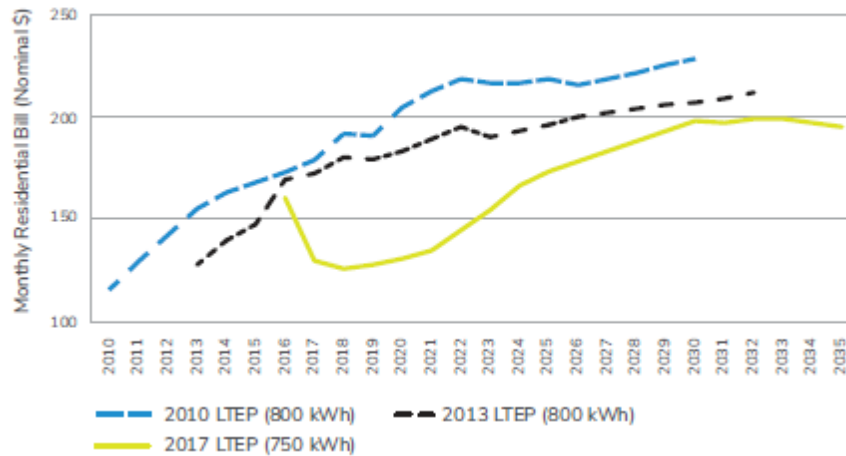
- The projected revenues for the Province is based on achieving the refurbishment and operation of Darlington as per approved plan (i.e., refurbishment project completed on budget and schedule and the station operating as planned post-refurbishment).

The Ministry indicates the estimated average price of power from Darlington post-refurbishment continues to be about 8 cents per kWh (in 2015\$) and includes capacity availability greater than 90%. (For comparison, wind prices under the Feed-In Tariff (FIT) program were about 13.5 cents per kWh with only intermittent generation at about 10% capacity availability).

Ratepayer impact

The 2017 Long-Term Energy Plan (2017 LTEP) includes the following graphic showing projected monthly residential bills. It shows the impact of Ontario's Fair Hydro Plan and includes projected impacts of nuclear refurbishment. There are follow-on decisions pending from the OEB, based on OPG submissions, that will transition the December 2017 decision adding \$4.8 billion to the rate base, to rate smoothed customer bill impacts. The Ministry indicates this will likely be in-line (or minimal) impact with the 2017 LTEP projection.

Electricity Price Outlook – Residential Consumers



The Ministry indicates its rationale for continuing with the Darlington refurbishment is detailed in its submission. At a high-level:

- Darlington refurbishment remains on track to be complete within the \$12.8 billion budget and 112-month schedule, as approved by Cabinet in December 2015;;
- OPG has commenced planning and preparation for the next unit refurbishment, making sure to incorporate lessons learned from the current work;
- The government's independent oversight advisor continues to closely monitor the project and has concluded that based on OPG's strong project performance on the current unit and commitment to continuous improvement, the next unit refurbishment should proceed as planned and an "off-ramp" is not required at this time.
- As recently as in October 2017, Cabinet re-affirmed plan to refurbish all 4 Darlington units when it approved the 2017 Long-Term Energy Plan.
- The Ministry's analysis confirms that triggering an "off-ramp" at this time would negatively impact key government policy priorities by:
 - Increasing the cost of electricity for ratepayers or increasing greenhouse gas emissions from the electricity sector;
 - The loss of thousands of jobs and billions of dollars in economic activity in communities across Ontario; and
 - The loss of billions of dollars in government's revenues from OPG over the long-term.

TBS staff note the Ministry has provided supplementary analysis (to its signed submission) to support its recommendation. Highlights of that analysis are in Appendix F covering total system cost, GHG impact, economic impact and fiscal impact of three replacement scenarios to address future capacity needs should an off-ramp be taken.

- The economic impact is focussed on jobs. The Ministry indicates GDP impacts are not include as the analysis would require more sophisticated inputs and modelling.
- Going forward, this supplementary analysis should be part of the signed TB/MBC submission, and reflect feedback from central agencies and the Ontario Financing Authority, particularly on assumptions, for example the price of renewable wind power (key assumption in total system cost modelling).

Name of analyst:	James Strang	Phone number:	416-327-2071
Date:	{ DATE \@ "MMMM d, yyyy" }	Log number:	

APPENDIX A: PROPOSED MINUTE (UNDER DEVELOPMENT)

Receive the report on status of the Darlington Refurbishment Project.

In this regard,

- i) Approve that the Ministry of Energy will be ensuring that Ontario Power Generation (OPG) proceed with refurbishment of Darlington Unit 3 beginning as early as Fall 2019 consistent with OPG's Release Quality Estimate and the 2013 Long-term Energy Plan principles for nuclear refurbishment:
 - a) Minimize commercial risk on the part of ratepayers and government;
 - b) Mitigate reliability risks by developing contingency plans that include alternative supply options if contract and other objects are at risk of non-fulfillment;
 - c) Entrench appropriate and realistic off-ramps and scoping;
 - d) Require OPG to hold its contractors accountable to the nuclear refurbishment schedule and price (not applicable to the Bruce refurbishments);
 - e) Make site, project management, regulatory requirements and supply chain considerations, and cost and risk containment, the primary factors in developing the implementation plan; and
 - f) Take smaller initial steps to ensure there is opportunity to incorporate lessons learned from refurbishment, including collaboration by operators.

ii) Direct the Ministry to:

- a) Include in future report backs to TB/MBC on the Darlington Refurbishment Project:
 - 1) Its recommendation and rationale on whether an off-ramp is required or not.
 - 2) Projected changes in OPG's contribution to the Province, as well as ratepayer impact from original projections (i.e., Showing historical performance to date, including the latest update) and from what's included in the 2017 Long Term Energy Plan, and any more recent Long Term Energy Plans.
 - 3) The supplementary analysis provided to support the current submission should be updated and part of future signed TB/MBC submissions. Also, the analysis should reflect consultation with central agencies and the Ontario Financing Authority during its development, particularly on assumptions, for example the price of renewable wind power (key assumption in total system cost modelling).
- b) Work with OPG and Cabinet Office on a communications strategy.

APPENDIX B: FINANCIAL TABLES

FINANCIAL IMPACTS: CHANGES TO EXPENSE AND REVENUE				TABLE B1
	<i>Fiscal Plan Basis</i>			<i>Appropriations Basis</i>
\$ Millions	2017-18	2018-19	2020-21	2017-18
Initiative cost recommended	0.0	0.0	0.0	
<i>Expense changes:</i>				
Operating Expense	0.0	0.0	0.0	0.0
Offset	0.0	0.0	0.0	0.0
<i>Revenue changes:</i>				
N/A	0.0	0.0	0.0	0.0
Total Fiscal Impact	0.0	0.0	0.0	0.0

APPENDIX C: 2015 CABINET MINUTE

Cabinet agreed that:

1. ENERGY ensure that Ontario Power Generation (OPG) proceed with refurbishment of Darlington Unit 2 beginning in Fall 2016 consistent with OPG's Release Quality Estimate and the 2013 Long-term Energy Plan principles for nuclear refurbishment:
 - a) Minimize commercial risk on the part of ratepayers and government;
 - b) Mitigate reliability risks by developing contingency plans that include alternative supply options if contract and other objects are at risk of non-fulfillment;
 - c) Entrench appropriate and realistic off-ramps and scoping;
 - d) Require OPG to hold its contractors accountable to the nuclear refurbishment schedule and price (not applicable to the Bruce refurbishments);
 - e) Make site, project management, regulatory requirements and supply chain considerations, and cost and risk containment, the primary factors in developing the implementation plan; and
 - f) Take smaller initial steps to ensure there is opportunity to incorporate lessons learned from refurbishment, including collaboration by operators.
2. ENERGY report back to Treasury Board/Management Board of Cabinet (TB/MBC) and seek Cabinet approval twenty months prior to OPG proceeding with refurbishment of the next Darlington unit and twenty months in advance of all remaining units.
3. In addition to TB/MBC approving OPG's Business Plan annually, ENERGY report back to Cabinet annually to update on progress and implementation of the refurbishment project.
4. ENERGY provide continued independent oversight of Darlington Refurbishment Project including:
 - a) ENERGY formally engaging Infrastructure Ontario (IO) to leverage their expertise; and
 - b) Having third party expertise sit on the Darlington Refurbishment Committee of the OPG Board of Directors as an observer and work with ENERGY and IO to provide independent oversight.
5. ENERGY ensure that OPG proceed with the contracting strategy outlined in ENERGY's November 30, 2015 submission to mitigate project execution risk.
6. ENERGY ensure that OPG work with Bruce Power under the signed Memorandum of Understanding to increase collaboration between the two nuclear operators.

APPENDIX D: MORE DETAILED UPDATE

Unit 2 Refurbishment – Update:

Unit 2 refurbishment is on track to be complete ahead of schedule and within budget. As of December 11, 2017:

- Unit 2 field work is 50% complete and 18 days ahead of schedule; and
- Unit 2 spend to-date is \$1.78 billion – currently \$11 million over plan, but forecast to be on budget at completion.

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 challenges. The contract is being aggressively managed and the facility is expected to be in service well before its need date in 2020-2021.

There is no adverse impact for the HWSF delay on the overall approved refurbishment schedule and budget as appropriate contingency has already been built in.

- The HWSF is not on the critical path for Unit 2 refurbishment.
- 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
- OPG expects that the overall cost will be 20-30% over the \$381 million estimate
- OEB will review HWSF costs for prudence once the project is complete. Any disallowed costs will need to be written off by OPG with a corresponding fiscal impact on the Province.

DARLINGTON REFURBISHMENT PROGRAM PERFORMANCE – UNIT 2			
SAFETY		QUALITY	
• No Lost Time Injuries since the launch of the project in early 2010. • All Injury Rate is at 0.49 incidents per 200k hours worked, which continues to be substantially better than general construction industry performance in Ontario. • Due to a recent increase in near miss safety events, SNC/Aecon stood down their skilled trades workforce to re-inforce the priority placed on safety.		• No regulatory non-compliance events on Unit 2. • No quality related system failures resulting in loss of generation or impacts to the High Confidence Schedule.	
SCHEDULE		COST	
• The project is 18 days ahead of the high confidence schedule and currently forecast to be complete ahead of the 40-month schedule duration.		• Unit 2 is currently \$11 Million over 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 & Infrastructure and Safety Improvement projects remains within the approved \$12.8 Billion budget.	

 Ahead of Plan
  On Plan
  Marginally Behind Plan
  Behind Plan

The Ministry continues to closely monitor OPG's performance on Unit 2 refurbishment through regular briefings with OPG management, OPG Board and the government oversight advisor.

Unit 3 Refurbishment – Planning and Preparation – Update

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, for a cumulative total of ~\$436 million authorized spend.

- 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.

OPG spent approximately \$2 billion in project planning and preparation prior to receiving final Cabinet approval in 2015 to proceed with execution of the refurbishment project.

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\$) and includes capacity availability greater than 90%. Note: For comparison, wind prices under the Feed-In Tariff (FIT) program were about 13.5 cents per kWh with only about 10% capacity availability.

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

OPG has put in place a formal lessons learned process to benefit Unit 3 refurbishment planning and preparation.

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.

Oversight of OPG's Refurbishment Project – Update

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.
- 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
- Jan 2017 – Jun 2017

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.

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 &	• OPG has developed and implemented robust project management processes to manage a project of this size and complexity.

Key Elements	Summary Finding
Lessons Learned	• 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).
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.

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.

APPENDIX E: DARLINGTON REFURBISHMENT “OFF-RAMPS” – ANALYSIS AND CONSIDERATIONS

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.

- OPG requires government approval before proceeding with each remaining unit refurbishment. These decision points act as “off-ramps” for the project

Rationale 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)
- 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.

- Unit 3 in June 2020, Unit 1 in October 2022, Unit 4 in March 2024, Unit 2 in February 2050

If the Darlington off-ramps were triggered for Units 1, 3 and 4, new capacity would be required.

- This new capacity would also be required to produce a large amount of energy to replace the baseload production from Darlington.
- The IESO is undertaking a Market Renewal initiative that is expected to result in lower-cost procurements for any new capacity needs.
- As part of the Market Renewal initiative, the IESO has launched a Non-Emitting Resources Subcommittee (NER-SC) to study how non-emitting resources will participate in the new market designs. The IESO will issue a Request for Information in 2018 to understand the technical, operational and commercial considerations of non-emitting resources.

Two scenarios are being considered to address the future capacity needs (both will require increased electricity imports (including from emitting jurisdictions):

- 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 and meet total system needs.
- Replacement Scenario – Non-Hydro Renewable Generation
 - Renewable capacity (i.e., wind) 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, ensure system reliability and meet total system needs.
 - A greater portion of the replacement energy could be provided by wind, however this would increase the cost and require some form of large-scale energy storage to provide firm capacity/

Replacing off-ramped Darlington units with gas-fired generation results in an increase in greenhouse gas (GHG) emissions (i.e., about 5 - 6 Mt annually starting in 2026).

Replacing off-ramped 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 due to increased use of natural gas. Replacing off-ramped units with other generating sources makes it difficult to meet the electricity sector GHG emissions outlooks in the 2017 LTEP.

Cost Impacts:

Replacing off-ramped Darlington units with gas-fired generation results in similar cost outcomes, however the risk profiles of the two scenarios are very different.

- The primary risk for natural gas is operating cost, as the plants are exposed to natural gas and carbon price volatility. This is very difficult to forecast over a 20-year plant life and will increase end-user electricity price volatility.
- Conversely, the primary risk for nuclear refurbishment is capital cost, with very little variability in operating costs. The Darlington refurbishment is currently within its approved capital budget.

Replacing Darlington with renewables would substantially increase electricity costs as a large renewable build-out would be required. Replacing all of the electricity produced by off-ramped Darlington units would require a near doubling of the installed wind capacity in the province.

Renewable projects must balance three primary factors (Siting renewable projects that satisfy these three criteria would likely be difficult):

1. Wind and solar regime – developments are currently saturated at optimal locations;
2. Transmission connections – transmission congestion limits the amount of low-cost connection points; and
3. Municipal, regional and community support – the pool of supportive host communities is limited.

The Ministry indicates the sunk costs and loss of economies of scale from off-ramping are already reflected in the cost analysis. However, the Ministry notes it is not analyzing the impact of future off-ramp decisions as part of this submission.

Economic Impact:

Off-ramping three out of the four Darlington refurbishments would greatly diminish the employment and economic benefits of the project.

- According to the Conference Board of Canada, Darlington refurbishment and continued operation of the facility up to 2055 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.

Upcoming negotiations with labour unions could be adversely impacted by triggering the Darlington off-ramps.

- In March 2018, OPG's collective agreement expires with Power Workers Union (PWU) which represents thousands of OPG employees;
- OPG begins negotiations for a new collective agreement in early January 2018; 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.

Fiscal Impact Considerations:

OPG may incur up to **\$6 billion** in total "write-offs" as result of cost disallowances by the OEB following the off-ramp, which would be written down against net income to Government, including:

- A possible write-off of spend to-date on the Unit 3 refurbishment planning, if, through a future prudence review, the OEB determines that the planning cost is not reasonable in light of off-ramp;
- 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 to pass onto ratepayers given that it includes significant up-front planning that was intended for a 4-unit refurbishment project; and

- A possible write-off of increased costs of operating a one-unit station vs. a 4-unit station (i.e., due to loss of economies of scale), if, through a future prudence review, the OEB determines that it is not reasonable to pass the higher operating cost onto ratepayers.

In addition, cancellation of the remaining three Darlington units would reduce OPG's contribution to Government's income (ongoing net income and income tax PILs), as a result of foregone net income from capital investment (i.e., return on equity invested in the 3 foregone refurbishments):

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Darlington "Write-offs"	-3,700	-1,360	-780	-160	-	-	-	-	-	-
Ongoing Net Income & PIL's	-	-	-	-280	-350	-450	-560	-680	-820	-870

Note: Ongoing Net Income and PIL's reductions reflect: (i) foregone cost of capital recovery due to a lower asset base, and (ii) the compounding interest effects from lower cash receipts. While the impact of (i) generally declines over time, the effect of (ii) increases and more than offsets (i). Cost of capital is based on a deemed capital structure of 49% equity / 51% debt, return on equity of ~9% and debt rate of ~5%. PIL's are based on a 25% tax rate.

Overall, OPG projects that the foregone capital investment and possible write-offs due to non-recovery of costs from OEB would result in a reduction of OPG's contribution to government's income (net income and income tax PILs) of \$1,100 to \$1,400 million per year, on average, or \$43 to \$55 billion over Darlington's life.

APPENDIX F: SUPPLEMENTAL ANALYSIS

The Ministry has provided additional analysis to its signed submission that provides a more detailed rationale for its recommendation that the Darlington Refurbishment Project should proceed as planned and no off-ramp is required prior to the next Darlington unit refurbishment – Unit 3. Below is an overview:

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.

- OPG requires government approval before proceeding with each remaining unit refurbishment. These decision points act as “off-ramps” for the project.

Rationale for taking an “off-ramp” before the start of Unit 3:

- 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 the Darlington off-ramps were triggered for Units 1, 3 and 4, new capacity would be required. This new capacity would also be required to produce a large amount of energy to replace the baseload production from Darlington. 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
- Renewable energy generation via wind

Nuclear and natural gas plants are able to provide large amounts of firm capacity, as their availability is typically greater than 90% during peak periods. Wind generation has an availability at peak of only about 10%, meaning additional firm generation must be procured in order to back up the 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.

- From 2017 FAO report – *“The 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 leads to the prospect of large scale imports from Quebec not being competitive with nuclear generation.**”*

Three replacement scenarios are being considered to address the future capacity needs (Analysis focused on *total system cost, GHG impact, economic impact and fiscal impact* of pursuing any of the three replacement scenarios to address the future capacity needs should a Darlington refurbishment off-ramp be taken):

Scenario 1 – 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 to meet total system needs (i.e., 17 new units),
- Decreased exports and increased imports (including from emitting jurisdictions).

Scenario 2 – Non-Hydro Renewable Capacity Replacement

- Renewable capacity (i.e., wind) is built to replace the capacity lost from the Darlington off-ramp on a MW-per-MW basis
- 3,000 MW of natural gas-fired capacity (15 new units) is also required in order to provide firm capacity, ensure system reliability, and meet total system needs. Natural gas continues

operating primarily as a peaking resource in this scenario, and to back up intermittent wind generation.

- Decreased exports and increased imports (including from emitting jurisdictions)

Scenario 3 – Non-Hydro Renewable Energy Replacement

- Renewable energy (i.e., wind) is built to replace the energy lost from the Darlington off-ramp;
- 2,600 MW of natural gas-fired capacity (13 new units) is also required in order to provide firm capacity, ensure system reliability, and meet total system needs. Natural gas continues operating primarily as a peaking resource in this scenario, and to back up intermittent wind generation.
- Decreased exports and increased imports (including from emitting jurisdictions)

Commented [JS1]: Energy, what is the difference between capacity (Scenario 2) and energy in Scenario 3?

Findings – System Cost:

Scenario 1: Replacing off-ramped Darlington units with gas-fired generation results in similar cost outcomes, however the risk profiles of the three scenarios are very different.

- The primary risk for natural gas is operating cost, as the plants are exposed to natural gas and carbon price volatility. This is very difficult to forecast over a 20-year plant life, and will increase end-user electricity price volatility.
- Conversely, the primary risk for nuclear refurbishment is capital cost, with very little variability in operating costs. The Darlington refurbishment is currently within its approved capital budget.

Scenario 2: Replacing Darlington with renewables would substantially increase electricity costs as a large renewable build-out would be required (i.e., \$1.4 billion - \$8.1 billion). The build out in the energy replacement scenario is significantly larger. In both cases a large amount of new peaking gas-fired generators are still required to provide system reliability.

Commented [JS2]: Energy, why such a large range.

Scenario 3: Siting renewable projects that satisfy the three primary criteria listed below would likely be difficult:

- Wind regime – developments are currently saturated at optimal locations;
- Transmission connections – transmission congestion limits the amount of low-cost connection points; and
- Municipal, regional, and community support – the pool of supportive host communities is limited.

Even with all units of Darlington refurbished, new generating capacity will be required in the mid-2020s, primarily as a result of the retirement of the Pickering Nuclear Generating Station. For analysis purposes, this capacity is assumed to be provided by natural gas.

Scenario	New Gas-Fired Units Built			New Gas-Fired Capacity
	2023	2025	2030	MW
Baseline	4	2	0	1,200
Gas-Fired Generation replacement	4	12	1	3,400
Renewable capacity replacement	3	11	1	3,000
Renewable energy replacement	1	11	1	2,600

	NPV (\$2015 CAD)	Commentary
Baseline	\$238.58	Does not include Transmission Cost
Gas Fired Generation – Low Forecast	\$238.05	Based on ENERGY Model assumptions
Gas Fired Generation – High Forecast	\$240.43	Deloitte Natural Gas forecast and LTEP2017 Carbon Price
Renewable Capacity Replacement – Low Forecast	\$240.00	Based on PPA* of \$86/MWh, baseline Natural Gas and Carbon Price forecast
Renewable Capacity Replacement – High Forecast	\$244.52	Based on PPA of \$135/MWh, Deloitte Natural Gas forecast, and LTEP2017 Carbon Price forecast
Renewable Energy Replacement – Low Forecast	\$241.50	Based on PPA* of \$86/MWh and baseline Natural Gas and Carbon Price forecast
Replacement Energy Replacement – High Forecast	\$246.64	Based on PPA* of \$135/MWh, Deloitte Natural Gas forecast, and LTEP2017 Carbon Price forecast

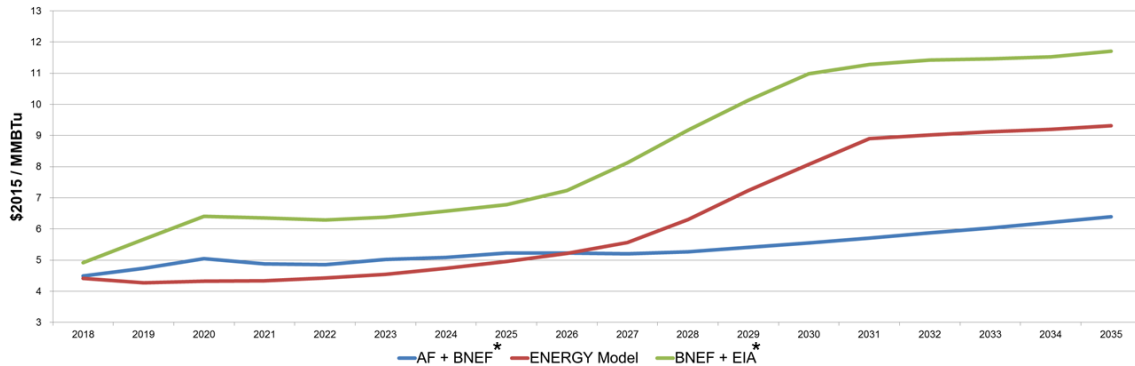
Commented [JS3]: TBS, Centre of Excellence was asked to look at the supplemental analysis and will likely be contacting ENERGY.

Commented [JS4]: ENERGY, provide more info on the wind range \$86 to \$135. Are these recent PPAs or older PPAs? Are there lower estimates?

How do the wind #s in this table relate to the graphic on slide 37 of the Appendix – 2013 LTEP Relative cost of Electricity (\$2015/MWh)

PPA – Power Purchase Agreements

Natural gas and carbon price forecast models cover a wide range. Nuclear power provides a hedge against potential price fluctuations.



Findings – GHG Emissions:

Scenario 1 – Replacing off-ramped Darlington units with gas-fired generation results in an increase in greenhouse gas (GHG) emissions (i.e., about 5 - 6 Mt annually starting in 2026).

Scenario 2 – Replacing off-ramped Darlington units on a capacity 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 due to increased use of natural gas.

Scenario 3 – Replacing off-ramped Darlington units on a energy basis with wind produce GHG emissions slightly above 2017 LTEP starting in 2025 and is significantly lower than on a capacity basis. Replacing off-ramped Darlington units with other generating sources makes it difficult to meet the electricity sector GHG emissions outlooks in the 2017 LTEP.

In 2017, approximately 96 per cent of the electricity generated in Ontario was free of greenhouse gas (GHG) emissions. Nuclear currently provides approximately 60 per cent of Ontario's power.

- Ontario's electricity sector is forecast to account for only about two per cent of Ontario's total GHG emissions in 2017 and the emissions are forecast to be more than 80 per cent below 1990 levels. Emissions are expected to remain well below historical levels and to be relatively flat over the planning period (2017-2035).

Findings – Economic Impacts:

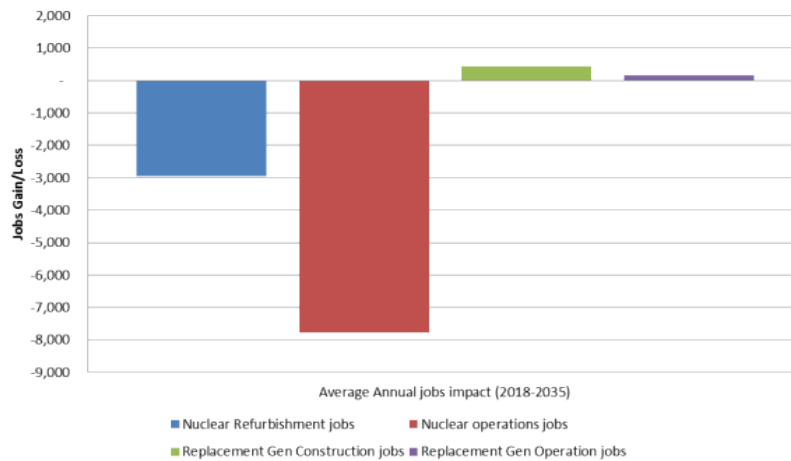
The Ministry's economic impact analysis estimates the jobs impact of triggering an off-ramp after refurbishing Darlington unit 2 – with the remaining units operating to their unrefurbished end of life and decommissioned – and replaced with the generation resource mix under the 3 scenarios.

Overall, thousands of jobs will be lost from the economy following the off-ramp over the long-term, as the direct and indirect jobs gain from the construction and operation of replacement sources of generation in each of the scenarios is not sufficient to offset the jobs lost as a result of forgoing the refurbishment and operation of 3 Darlington units.

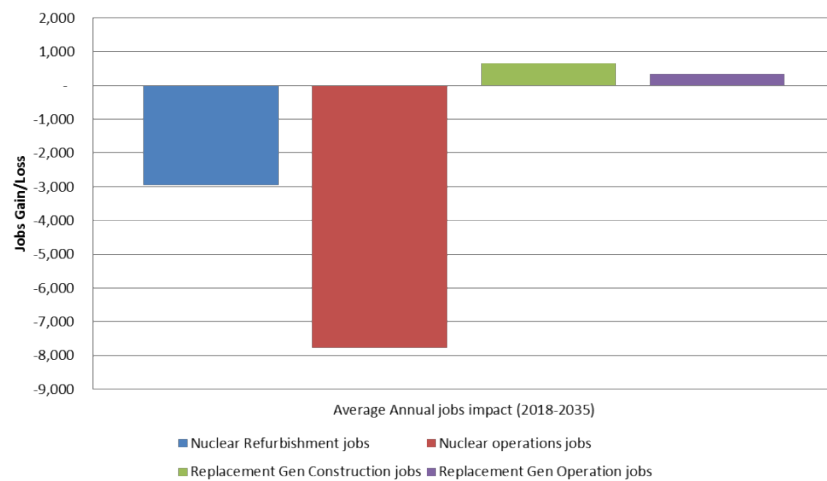
- Key reasons for significantly higher number of jobs generated from nuclear refurbishment and continued operation when compared to the alternatives under the 3 scenarios include:
 - Highly capital- and labour-intensive nature of nuclear refurbishment and operation when compared to the construction and operation of gas-fired generators and wind turbines
 - Ontario is home to Canada's mature nuclear supply chain that includes more than 200 companies and supports 60,000 Ontario jobs

- Darlington Refurbishment is a made-in-Ontario project, with 96 per cent of the project's budget invested in this province, supporting hundreds of Ontario companies

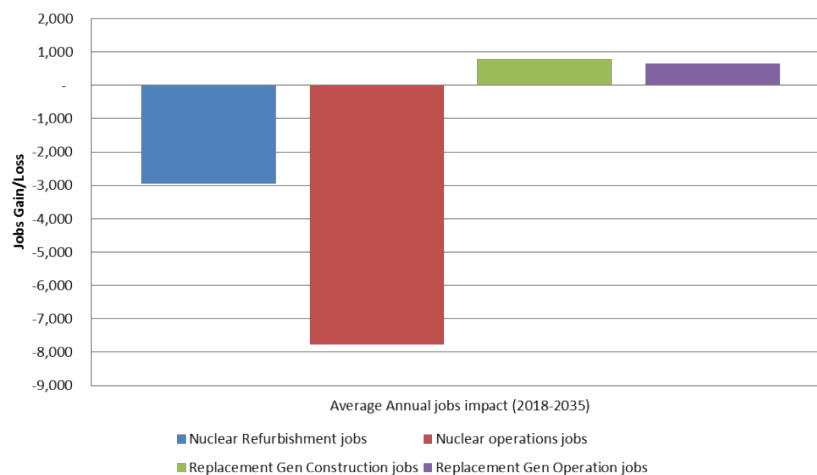
Gas-fired Generation replacement - Jobs Impact



Renewable Capacity (Wind) Replacement - Jobs Impact



Renewable Energy (Wind) Replacement - Jobs Impact

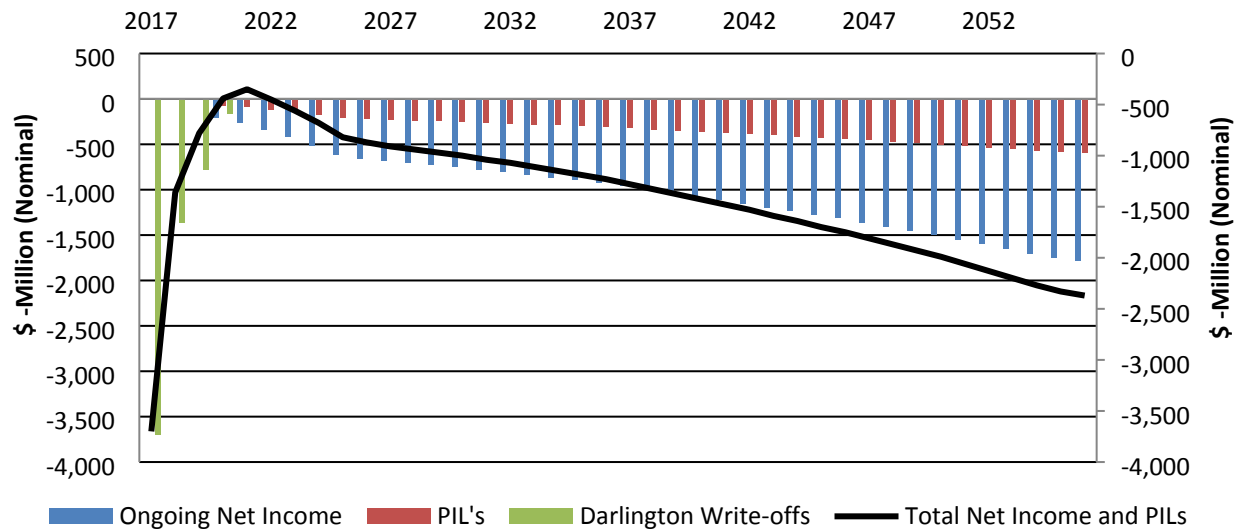


Findings – Fiscal Impact (Long-Term Outlook):

Ontario Power Generation may incur up to \$6 billion in total “write-offs” as result of cost disallowances by the Ontario Energy Board (OEB) following the off-ramp.

Overall, OPG projects that the foregone capital investment and possible write-offs due to non-recovery of costs from OEB would result in a reduction of OPG’s contribution to government revenues (net income and income tax PILs) of \$1,100 to \$1,400 million per year, on average, or \$43 to \$55 billion over Darlington’s life.

Darlington Off-ramp After Unit 2 - Foregone Fiscal Benefit



APPENDIX G: OEB RATE-SETTING SEQUENCE (INCLUDING OEB DECISIONS)

- **2017-2021 Rate Application Period:**

- OPG submitted the 5-year rate application with forecast nuclear revenue requirement and forecast nuclear production over the 5-year period, including a forecast of Darlington Unit 2 refurbishment.
- OEB will determine OPG's appropriate revenue requirement and forecast nuclear production for the 5-year period as well as the amount of nuclear revenue requirement to be deferred until after Darlington refurbishments are complete and accordingly set OPG's "smoothed" nuclear rates for the 5-year period.
 - OEB Decision (EB-2016-0152) (December 28, 2017) – Approval of OPG's application relating to the Darlington Refurbishment Program (DRP), including the addition of \$4,800 million to rate base in 2020 when the first of the four units to be refurbished is expected to come back online.
 - TBS staff note OPG's application (approval of in-service additions to rate base) was updated for removal of the Heavy Water Storage Facility (HWSF) project, which has experienced delays and cost overruns. Any OEB review of HWSF cost overruns would take place as part of OPG's next 5-year rate application to the OEB to be submitted in 2021.
 - OEB decision pending on a follow-up OPG submission outlining proposed smoothed payment amounts in accordance with regulatory requirement to defer the collection of some the revenue from ratepayers. Only then will customer bill impacts be known.

- **2022-2026 Rate Application Period:**

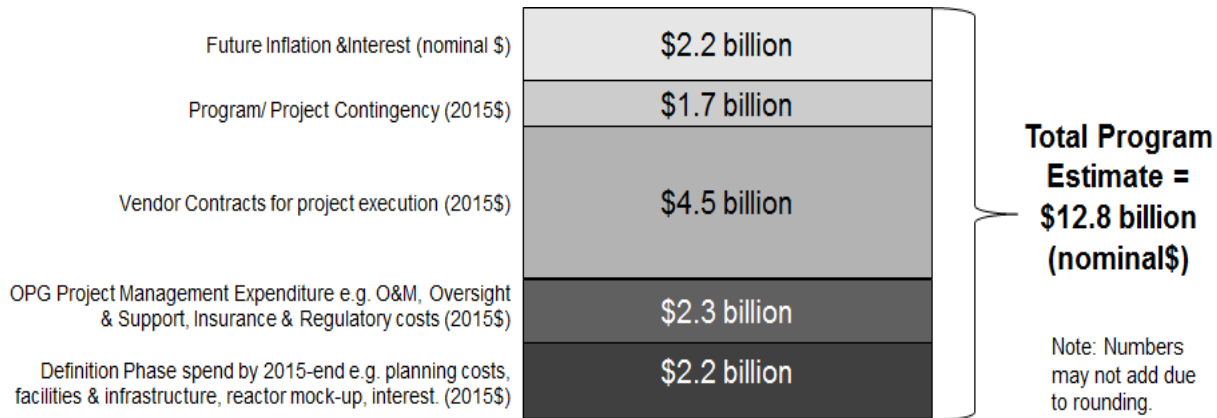
- OPG will submit a 5-year rate application with forecast nuclear revenue requirement and forecast nuclear production over the 5-year period. OPG's revenue requirement would be informed by the actual refurbishment cost for Unit 2 which is expected to be complete by 2019 and a forecast of the remaining unit refurbishments.
- Similar to the 2017-2021 period, OEB will set smoothed rates for the 2022-2026 period while taking into account the actual refurbishment costs incurred to date, including undertaking a prudence review of the unit's refurbishment costs.

- **Rate Applications beyond 2027:**

- The Darlington Refurbishment Project is expected to be complete and all units in-service.
- OEB to conduct prudence review of Darlington refurbishment costs in setting rates.
- The rate setting period will be determined by OEB.
- OEB will ensure draw-down of prudently incurred costs in the rate-smoothing deferral account in no more than 10 years, on a straight-line basis.

APPENDIX F: PROJECT BACKGROUND

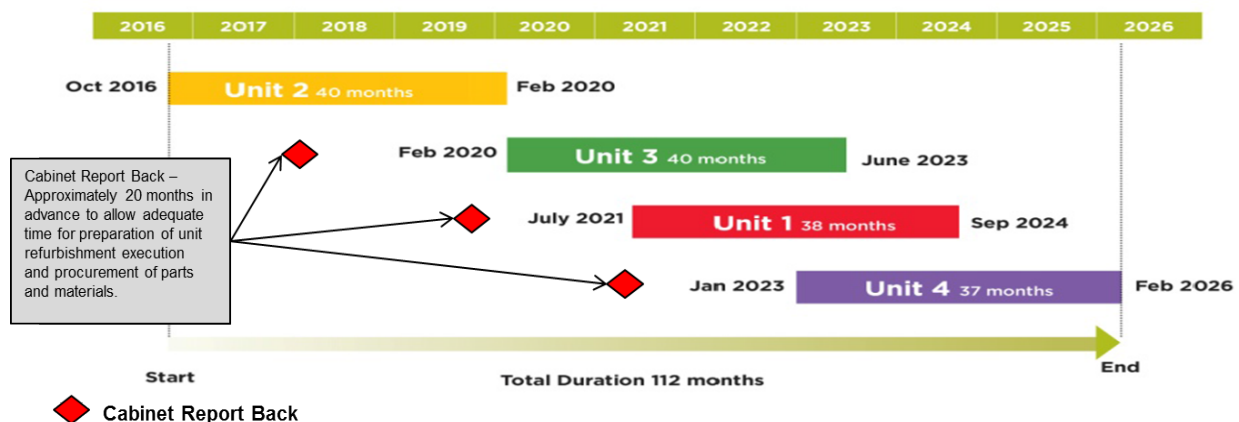
In December 2015, following more than five years of detailed project planning and preparation, Cabinet approved OPG's total budget of \$12.8 billion to refurbish the four nuclear units at Darlington (see chart below).



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



APPENDIX H: TIMELINE AND NEXT STEPS

