# Board Staff Interrogatory #76

**Issue Number: 4.4**
**Issue:** Are the proposed test period in-service additions for nuclear projects (excluding those for the Darlington Refurbishment Program) appropriate?

## Interrogatory

**Reference:**
Ref: Exh D2-1-3, Table 4

Please complete the following table with the requested information for Nuclear Operations in-service additions:

| Tier 2 and 1 projects | 2015 approved | 2015 actual | 2016 budget | Variance 2016 budget to 2105 actual |
|---|---|---|---|---|
| Project 1 | | | | |
| Project 2 | | | | |
| Etc. | | | | |
| Total for all other projects | | | | |
| Total | $120M+$66M = $186M | $181.8M | $466M | $284.4M |

Note: $66M is for the Operations Support Building and Auxiliary Heating System which were moved from DRP.

## Response

The following table details the 2015 Approved, 2015 Actual, 2016 Budget and the 2016 Budget Variance to 2015 Actual. The numbers may not add due to rounding.

| Tier 1 & 2 Project | 2015 Approved | 2015 Actual | 2016 Budget | Variance 2016 Budget to 2015 Actual |
|---|---|---|---|---|
| 25609 - Physical Barrier System | 0.0 | 0.0 | 0.5 | 0.5 |

Witness Panel: Nuclear Operations and Projects

| Tier 1 & 2 Project | 2015 Approved | 2015 Actual | 2016 Budget | Variance 2016 Budget to 2015 Actual |
|---|---|---|---|---|
| 25619 - DN Operations Support Building Refurbishment | 29.7 | 55.1 | 3.6 | (51.5) |
| 31412 - DN Class II Uninterruptible Power Supply Replacement | 3.8 | 0.0 | 7.0 | 7.0 |
| 31508 - DN Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment | 0.0 | 2.6 | 17.0 | 14.4 |
| 31518 - DN Restore Emergency Service Water and Firewater Margins | 0.0 | 0.0 | 1.9 | 1.9 |
| 31524 - DN Station Roofs Replacement | 0.0 | 0.0 | 10.7 | 10.7 |
| 31542 - DN Transformer Multi-Gas Analyzer Installation | 0.0 | 2.1 | 5.9 | 3.8 |
| 31552 - DN Condenser Cooling Water and Low Pressure Service Water Travelling Screens Replacement | 0.0 | 6.8 | 10.6 | 3.9 |
| 31710 - DN Shutdown Cooling Heat Exchanger Replacement | 0.0 | 0.0 | 15.8 | 15.8 |
| 31717 - DN Improve Maintenance Facilities at Darlington | 0.0 | 0.0 | 0.8 | 0.8 |
| 33621 - Air Conditioning Unit Replacement for Secondary Control Area | 0.0 | 0.0 | 10.3 | 10.3 |
| 33819 - DN Major Pump-sets Vibration Monitoring System Upgrades | 2.7 | 0.0 | 0.0 | 0.0 |
| 33955 - Shutdown System Computer Aging Management | 0.0 | 15.1 | 2.0 | (13.1) |
| 33973 - DN Standby Generator Controls Replacement | 0.0 | 4.1 | 17.9 | 13.8 |
| 33977 - DN Digital Control Computer Replacement / Refurbishment / Upgrades | 0.0 | 1.3 | 0.0 | (1.3) |
| 34000 - DN Auxiliary Heating System | 36.3 | 0.0 | 101.3 | 101.3 |
| 36001 - DN Purchase of Primary Heat Transport Pump Motor Capital Spares | 0.0 | 6.7 | 0.0 | (6.7) |
| 38948 - DN Zebra Mussel Mitigation Improvements | 0.0 | 0.0 | 18.9 | 18.9 |
| 40976 - PB Fuel Handling Reliability Modifications | 0.0 | 0.0 | 11.5 | 11.5 |
| 41023 - Unit 1 & 4 Fuel Channel East Pressure Tube Shift Tooling | 0.0 | 19.3 | 10.4 | (8.9) |
| 41027 - PN Fukushima Phase 2 Beyond | 0.0 | 0.0 | 7.3 | 7.3 |

| **Tier 1 & 2 Project** | **2015 Approved** | **2015 Actual** | **2016 Budget** | **Variance 2016 Budget to 2015 Actual** |
|---|---|---|---|---|
| Design Basis Event Emergency Mitigation Equipment | | | | |
| 46634 - PA Fuel Handling Single Point Vulnerability Equipment Reliability Improvement Project | 0.0 | 0.0 | 3.8 | 3.8 |
| 49109 - PB Standby Generator Governor Upgrade | 0.0 | 1.1 | 0.0 | (1.1) |
| 49158 - PB Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment | 8.1 | 5.6 | 14.4 | 8.9 |
| 49299 - PA Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment | 0.0 | 1.8 | 6.6 | 4.8 |
| 66600 - IMS Machine Delivered Scrape | 0.0 | 0.0 | 18.9 | 18.9 |
| 73566 - DN RS PHT Pump Motor Replacement | 0.0 | 0.0 | 8.8 | 8.8 |
| 73706 - DN Holt Road Interchange Upgrade | 0.0 | 0.0 | 22.4 | 22.4 |
| 80144 - DN Primary Heat Transport Pump Motor Overhaul | 0.0 | 0.0 | 6.0 | 6.0 |
| **Tier 1 Total** | **80.5** | **121.6** | **334.2** | **212.6** |
| 25918 – Security Project A | 0.0 | 0.0 | 8.8 | 8.8 |
| 31306 - DN Passive Auto-Catalytic Recombiners | 0.3 | 0.0 | 1.7 | 1.7 |
| 31403 - DN Active Liquid Waste System Upgrade | 0.0 | 0.0 | 1.5 | 1.5 |
| 31422 - DN Pressurizer Heaters & Controllers Replacement Project | 0.0 | 0.0 | 3.2 | 3.2 |
| 31426 - DN F/H Inverter Replacement | 0.0 | 0.0 | 2.6 | 2.6 |
| 31436 - DN Computer Upgrade for Heavy Water Management System (TRF/SUP) | 0.0 | 0.0 | 3.7 | 3.7 |
| 31520 - DN Replacement of Obsolete Online Chemistry Analysers | 0.0 | 0.0 | 4.3 | 4.3 |
| 31536 - DN T/G Lube Oil Purifier Replacement | 0.0 | 2.0 | 2.0 | 0.0 |
| 32202 - DN Fukushima Phase 2 Beyond Design Basis Event Emergency Mitigation Equipment | 0.0 | 0.0 | 6.9 | 6.9 |
| 33258 - DN Replacement of EPS | 0.0 | 1.4 | 1.7 | 0.4 |

| Tier 1 & 2 Project | 2015 Approved | 2015 Actual | 2016 Budget | Variance 2016 Budget to 2015 Actual |
|---|---|---|---|---|
| Uninterruptible Power Supply | | | | |
| 33509 - Replacement of Obsolete Computer Components | 0.0 | 0.0 | 0.4 | 0.4 |
| 33623 - DN Installation of partial discharge monitors | 0.0 | 0.0 | 0.1 | 0.1 |
| 33815 - FH Computer Replacement | 0.0 | 1.3 | 1.1 | (0.2) |
| 34006 - DN Suit and Maintenance Communication Replacement | 0.9 | 0.0 | 0.0 | 0.0 |
| 40680 - PB Main Generator Automatic Voltage Regulator and Protective Relay Upgrade | 2.4 | 6.2 | 0.1 | (6.1) |
| 40691 - PB Emergency Power Generator Protective Relays | 1.1 | 0.8 | 9.7 | 8.9 |
| 40972 - PA Standby Generator Reliability | 0.0 | 0.0 | 5.8 | 5.8 |
| 40983 - PB Machine Guarding Improvement on Low Risk Equipment | 0.0 | 1.3 | 0.9 | (0.3) |
| 40985 - PN Replacement of Obsolete Online Chemistry Analysers | 0.0 | 0.4 | 6.1 | 5.6 |
| 41043 - PN Emergency Power Generator Engine Replacement | 0.0 | 0.0 | 6.5 | 6.5 |
| 41044 - PA SG Protective Relay Upgrade | 0.0 | 0.0 | 4.2 | 4.2 |
| 46605 - PA Passive Auto-Catalytic Recombiners | 0.0 | 0.0 | 0.1 | 0.1 |
| 49116 - PB SG/EPG Fire Detection Upgrade and CO2 Suppression Removal | 0.0 | 0.4 | 1.2 | 0.8 |
| 49126 - PB Powerhouse Office Facilities (Capital) | 0.0 | 0.0 | 0.2 | 0.2 |
| 49132 - PB Reactor Building Service Water Dechlorination & MISA Cleanup | 0.0 | 0.0 | 13.5 | 13.5 |
| 49134 - PB Replacement of Containment Box-up Monitors | 0.0 | 0.6 | 0.2 | (0.4) |
| 49140 - PB Screenhouse Trash Bar Screen Replacement | 0.0 | 5.2 | 0.3 | (4.8) |
| 49146 - PN Fire Code Compliance for Relocatable Structures in Un-Zoned Area for Pickering Station | 0.0 | 0.7 | 12.4 | 11.8 |
| 49154 - PB Replacement of Obsolete Instrumentation and Control Equipment | 0.0 | 4.3 | 1.0 | (3.3) |

| Tier 1 & 2 Project | 2015 Approved | 2015 Actual | 2016 Budget | Variance 2016 Budget to 2015 Actual |
|---|---|---|---|---|
| 49247 - Unit 1 & 4 Fuel Channel East Pressure Tube Shift Tooling | 0.0 | 2.7 | 0.9 | (1.8) |
| 49267 - PN Standby Boiler Capacity Improvement | 0.0 | 2.5 | 0.1 | (2.4) |
| 49284 - PN Administration Building Rehab | 0.0 | 0.0 | 0.3 | 0.3 |
| 49296 - PA Class II Emergency Lighting | 0.2 | 2.3 | 0.1 | (2.2) |
| 49298 - PA Replacement of U1, U4 and IFB-A Stack Monitors | 0.0 | 0.0 | 4.5 | 4.5 |
| 66255 - OPGN Pressure Tube to Calandria Tube Gap | 0.0 | 0.3 | 0.0 | (0.3) |
| 66594 - IMS CIGAR Gap System and Drive Reliability | 0.7 | 0.8 | 4.5 | 3.7 |
| 73397 - DN Emergency Service Water Pipe and Component Replacement | 0.0 | 4.9 | 0.3 | (4.7) |
| 80027 - SES Station Personnel Emergency Accounting | 0.0 | 0.5 | 2.9 | 2.4 |
| 80069 - PA Firewater Buried Ring Header Replacement | 0.0 | 0.0 | 5.1 | 5.1 |
| 82949 - DN X-750 Spacer Retrieval | 0.0 | 0.0 | 5.5 | 5.5 |
| **Total – Tier 2 Projects** | **5.5** | **38.5** | **124.4** | **85.9** |
| **Total – Tier 3 Projects** | **0.9** | **21.7** | **54.9** | **33.2** |
| **Supplemental In-Service Forecast** | **99.1** | **0.0** | **(47.4)** | **(47.4)** |
| **Total** | **186.0** | **181.8** | **466.0** | **284.4** |

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# Board Staff Interrogatory #77

**Issue Number: 4.4**

**Issue:** Are the proposed test period in-service additions for nuclear projects (excluding those for the Darlington Refurbishment Program) appropriate?

## Interrogatory

**Reference:**
Ref: D2-1-3

For all Tier 1 projects for years 2014 and 2015, please provide the original approved project cost (as approved by the AISC), the actual cost, the projected in-service date provided and the actual in-service date.

## Response

The original approved project cost is the amount approved in the first full release business case. Project cost and schedule performance is then measured against the cost and schedule in the full release business case. Approval of business cases is described in Ex. A2-2-1, Attachment 4.

The interrogatory incorrectly assumes the original project cost is approved by AISC. As described at Ex. D2-1-1, p. 3, lines 2-4, "[t]he annual nuclear projects portfolio budget is administered by the AISC, which determines project prioritization and allocates portfolio funding to specific projects."

Following is the requested information for the Tier 1 projects that were declared in-service in 2014 and 2015:

| Project Name | Project Number | Original Approved Cost ($M) | Actual Cost ($M) | Projected In-Service Provided | Actual In-Service Date |
|---|---|---|---|---|---|
| DN Operations Support Building Refurbishment | 25619 | 53.0 | 62.0 | Oct-15 | Oct-15 |
| DN Shutdown System Computer Aging Management | 33955 | 17.2 | 20.4 | Nov-13 | Nov-15 |
| Primary Heat Transport Pump Motor Capital Spares | 36001 | 12.0 | 28.9 | Apr-12 | May-15 |
| PB Standby Generator Governor Upgrade | 49109 | 23.3 | 22.8 | Jun-08 | Jul-14 |

Witness Panel: Nuclear Operations and Projects

**CCC Interrogatory #21**

**Issue Number: 4.4**

**Issue:** Are the proposed test period in-service additions for nuclear projects (excluding those for the Darlington Refurbishment Program) appropriate?

## Interrogatory

**Reference:**
Reference: Ex. B1/T1/S1/p. 7 and B3/T2/S1/Table 1

Please explain, why in 2016, the nuclear asset retirement costs significantly decline relative to the historical period (2013-2015).

## Response

Nuclear asset retirement costs (ARC) decline in 2016 relative to the 2013-2015 historical period primarily due to a $417.5M decrease in ARC for the prescribed facilities, which was recorded on December 31, 2015 as a result of the December 31, 2015 change in the nuclear liabilities reflecting changes in nuclear station end-of-life dates.[1] The ratepayer credit associated with this reduction is being recorded in the Impact Resulting from Changes in Station End-of-Life Dates (December 31, 2015) Deferral Account established in EB-2015-0374. Further details on these changes in the nuclear liabilities and ARC, as well as associated revenue requirement impacts can be found in section 5.0 of Ex. C2-1-1.

[1] The December 31, 2015 ARC adjustment is excluded from the 2015 rate base as it was recorded at the end of the year and is reflected in rate base for the full year starting in 2016.

# SEC Interrogatory #42

**Issue Number: 4.3**
**Issue:** Are the proposed nuclear capital expenditures and/or financial commitments for the Darlington Refurbishment Program reasonable?

## Interrogatory

**Reference:**
[D2/2/10]
For each capital project that is related to a Darlington facility that will be rebased at the same time, please categorize the project into the following categories:

a. Required for the refurbishment of the Darlington units;

b. Being undertaken during the refurbishment period due to the difficulty or impossibility of undertaking the project on a fueled reactor;

c. Being undertaken during the refurbishment period for another reason. Please provide that reason.

## Response

For the following responses, "rebased" is interpreted to mean projects that are coming into service during the test period which are not Refurbishment scope, but are being done while the facility is in a Refurbishment outage.

a) The following capital projects are identified as part of the Darlington NGS Integrated Implementation Plan (see Ex. L-4.3-2 AMPCO-32) and are to be completed prior to the restart of the Unit 2 Refurbishment Outage. Projects are listed at Ex. D2-1-3 at the table references indicated below unless otherwise noted:

   i. DN Primary Heat Transport Liquid Relief Valve Modifications (Ex. F2-3-3 Table 1, line 1)[1]

   ii. DN Restore Emergency Service Water and Firewater Margins (Table 1, line 22)

   iii. DN Fire Hazard Assessment and Fire Safe Shutdown Analysis Modifications (Table 5a, line 8)

   iv. DN Class 1 Component Fatigue Monitoring (Table 5a, line 24)

[1] Project has been reclassified from project OM&A to capital with no change to the dollar amount.

b) The following projects are being undertaken during the Refurbishment period due to the difficulty or impossibility of undertaking the project on a fueled reactor:

   i. DN Shutdown Cooling Heat Exchanger Powerhouse Upper Level Service Water Piping Replacement (Table 1, line 29)

c) The following projects are being undertaken during the Refurbishment period for other reasons, as indicated below:

   i. DN Class II Uninterruptible Power Supply ("UPS") Replacement (Table 1, line 2): the current UPS's are obsolete and need to be replaced for reliable post-refurbishment operation. With the reactor defueled, all UPS's in Unit 2 can be replaced in the same outage without reactor safety concerns.

   ii. DN Primary Heat Transport Pump Motor Replacement (Table 1, line 37): consistent with such motor replacements taking place on the other units, all four motors are being replaced to ensure high reliability for re-commissioning and resumption of operations.

   iii. DN Phase 2 Battery Replacement (Ex. F2-3-3 Table 2b, line 24)[2]: replacement of the batteries is required at 17 to 20 years of service. Four out of eight banks of batteries will be replaced in Unit 2 to ensure the average age of the batteries in the unit is less than 18 years.

   iv. DN Condenser Circulating Water and Low Pressure Service Water Travelling Screens Replacement (Table 1, line 28): the last two low pressure service water travelling screens are to be replaced to complete replacements on Unit 2.

   v. DN Feeder Scanner Replacement (Table 2d, line 57): Installation of feeder scanner project in Unit 2 is required due to removal of feeders, guide tubes and detection equipment during Refurbishment activities. All other units are scheduled for completion by 2019 in planned outages. Remaining units cannot wait until their refurbishment outages due to on-going need for fuel defect monitoring.

   vi. DN Hydrogen Cooling Temperature Control Valve 20 Replacement (newly identified capital project, less than $20M): Earliest opportunity to install equipment to allow for reliable operation. All other units are scheduled for completion by 2019 in planned outages. Needed for reliable operation of Unit 2 post-refurbishment.

   vii. DN Pressurizer Heaters & Controllers Replacement (Table 2a, line 3): Pressurizer leaks represent one of the most significant impacts on unit Forced Loss Rate ("FLR") in 2015 and 2016. This project has been scoped into Unit 2

[2] Project has been reclassified from project OM&A to capital with no change to the dollar amount.

Refurbishment due to potential impact on FLR in the near-term. Project will be closed upon Unit 2 controller replacement.

# SEC Interrogatory #43

**Issue Number: 4.4**
**Issue:** Are the proposed test period in-service additions for nuclear projects (excluding those for the Darlington Refurbishment Program) appropriate?

## Interrogatory

**Reference:**
[D2/1/1, p.7]
Please provide further details regarding the following continuous improvement initiatives:

a. Centre of Excellence for project management

b. Collaborative Front End Planning

## Response

a) In late 2015, Nuclear initiated a Project Excellence initiative to implement consistent and streamlined project management practices for all projects executed in Nuclear. Since that time, a number of sub-initiatives have been implemented, including:
    a. Rollout of a common project delivery model/gated process in Nuclear. All new projects in 2016 are following this process. The process established standards related to risk, schedule, and costing at each project gate. As a project progresses from one phase of a project to the next, e.g., from Definition to Execution, the project is assessed against the criteria established in the gated process to confirm that it is ready to proceed.
    b. In support of the common project delivery model/gated process, central estimating and risk expertise was put in place to support each project.
    c. Standard portfolio metrics and reports have been developed.
    d. A project manager development program has been put in place and a number of project managers have attended a 5-day training session.

    In early 2016, senior OPG management initiated a Project Management Centre of Excellence with a goal to improve project outcomes across OPG. This initiative will leverage the work started in Nuclear.

    A working team has been established to develop and recommend to a Project Excellence Steering Committee, strategies for establishing across all of OPG:
    - A common, scalable project delivery model for all projects across all business units that focus on delivering projects safely, at the required quality, on time, and on budget, with all project goals achieved.

- A Project Management Centre of Excellence organization model where project management expertise, best practices, tools, processes, and lessons learned are available to all OPG projects.

Once the working team recommendations are accepted by the Project Excellence Steering Committee, an implementation plan will be developed. A Project Management Centre of Excellence is targeted to be fully operational in 2017.

b) Collaborative Front End Planning is the integration of OPG resources with contractor resources primarily in the engineering phase of a project to ensure OPG requirements are fully understood and to address contractor inquiries in a timely fashion. OPG has deployed its own resources in contractors' offices to work collaboratively on completing project designs and execution planning.

# SEC Interrogatory #44

**Issue Number: 4.4**
**Issue:** Are the proposed test period in-service additions for nuclear projects (excluding those for the Darlington Refurbishment Program) appropriate?

## Interrogatory

**Reference:**
[D2/1/1]
With respect to its continuous improvement initiatives:

a. For each year between 2017 and 2021, please provide the annual savings OPG expects from its continuous improvement initiatives. Please detail all assumptions made in its calculation.

b. What is the OM&A and/or capital cost for each continuous improvement initiative.

c. Please provide the business case for each continuous improvement initiative.

## Response

a) The continuous improvement initiatives are focused on improving project outcomes in terms of achieving the approved cost and schedule of each project. To the extent that these initiatives result in any individual project being completed at a lower cost, the available funds will be used to allow additional projects to be initiated or progressed by AISC. OPG does not expect savings that would lower the requested capital budgets.

b) The following are the cost impacts for the 5 initiatives:
   i. Centre of Excellence for project management initiative: costs are not currently defined as the project delivery model is under development and is targeted to be fully operational in 2017, as discussed in Ex. L-4.4-15 SEC-43 part (a).
   ii. Identification of appropriate contracting strategy: There are no incremental costs. Rather, this initiative applies lessons learned.
   iii. Implementing new approaches to improve ESMSA vendor project execution performance: There are annual incremental costs ($1M to $3M) associated with adding the third ESMSA vendor to improve contractor capacity and capability with an expected benefit of improving project schedule and cost adherence. There are no significant incremental costs associated with implementing collaborative front end planning.
   iv. Improving OPG's staff project management and oversight capabilities: There are no incremental costs.
   v. Improving project cost and schedule predictability: There are no incremental costs.

c) Business cases were not prepared for the continuous improvement initiatives.

# SEC Interrogatory #45

**Issue Number: 4.4**
**Issue:** Are the proposed test period in-service additions for nuclear projects (excluding those for the Darlington Refurbishment Program) appropriate?

## Interrogatory

**Reference:**

[D2/1/1, p.8]
With respect to OPG's plan to improve project cost and schedule predictability:

a. Please explain provide further details regarding the plan to implement "a revised approval process for the Nuclear Operations project portfolio".

b. Please provide any documents outlining this new approval process.

c. Regarding OPG's improved plan for estimating project cost and schedules. Please provide an illustrative example of how a project would have previously been estimated, and how it would be estimated based on the proposed changes.

d. How much better does OPG expect it will improve initial estimates based on its improved plan?

## Response

a) The Nuclear Operations project portfolio approval process is being supplemented by the implementation of a gated process. A gated process is a formal review of project readiness in terms of having completed sufficient project development to provide confidence in the project cost and schedule estimates for the next project phase of work.

b) See Ex. L-4.3-1 Staff-48 Attachment 20.

c) In the past, project initial cost estimates have been developed based on internal, third party, or contractor proposals with limited, if any, detailed engineering having been completed. These initial estimates lacked an understanding of engineering specific requirements and detailed stakeholder input which can significantly impact costs. With increased conceptual funding, more engineering work will be performed to develop the project scope and requirements that can be used as a basis for the initial project estimate. The use of updated estimating checklists and templates allows project lessons learned to be captured for future project managers developing project estimates.

d) Through the implementation of the gated process, the plan is expected to provide improved predictability and performance in the delivery of projects by providing more rigour in up-front planning including estimating, scheduling, and risk management. This up-front investment will increase the probability that projects are executed on plan against the full execution release BCS (in terms of both cost and schedule), safely, and at the required quality.

# SEC Interrogatory #46

**Issue Number: 4.4**

**Issue:** Are the proposed test period in-service additions for nuclear projects (excluding those for the Darlington Refurbishment Program) appropriate?

## Interrogatory

**Reference:**
[D2/1/2]
Please provide a table showing for each capital nuclear capital project (tier 1, 2 and 3) that will go in-service between 2014 and 2016, its forecasted cost and its actual cost. Please provide an explanation for all variances +/- 5% and why it is prudent. Please provide a copy of all Project Over-Variance Approval documents for those projects not already included in the pre-filed evidence.

## Response

Following is a table showing all Tier 1, 2 and 3 projects that have or are scheduled to go in-service between 2014 and 2016 as of October 15, 2016.

There are no projects with actual or forecasted costs that exceed approved costs (i.e. total project cost including contingency in the most recent BCS). Projects obtain approval for increased costs through over-variance approvals or superseding business cases before their approved amount is exceeded. No explanations are provided where the in-service amount is less than the approved cost of the project. An outcome where the final in-service amount will be less than the approved amount is not unexpected since the approved amount includes contingency, which may not be fully used in some projects.

| Projects | OEB Tier | Actual or Forecast In-Service Date | Actual or Forecast In-Service (M$) | Approved Cost (M$) | Variance (M$) |
|---|---|---|---|---|---|
| (a) | (b) | (c) | (d) | (e) | (f) |
| 25619 - DN OSB Refurbishment | 1 | Oct-15 | 60.6 | 62.7 | (2.1) |
| 33955 - Shutdown System Computer Aging Management | 1 | Nov-16 | 20.4 | 20.4 | 0.0 |
| 34000 - DN Auxiliary Heating System | 1 | Oct-17 | 98.7 | 107.1 | (8.4) |
| 41023 - Unit 1 & 4 Fuel Channel East Pressure Tube Shift Tooling (Capital) | 1 | Mar-16 | 27.8 | 29.7 | (1.9) |
| 73706 - DN Holt Road Interchange Upgrade | 1 | Aug-16 | 24.6 | 31.0 | (4.0) |

| Projects | OEB Tier | Actual or Forecast In-Service Date | Actual or Forecast In-Service (M$) | Approved Cost (M$) | Variance (M$) |
|---|---|---|---|---|---|
| (a) | (b) | (c) | (d) | (e) | (f) |
| 31306 - DN Passive Auto-Catalytic Recombiners | 2 | Jun-16 | 5.1 | 5.8 | (0.7) |
| 33623 - DN Installation of partial discharge monitors | 2 | Feb-14 | 5.6 | 7.1 | (1.5) |
| 36002 - DN MOT Capital Spares | 2 | Sep-16 | 8.1 | 8.3 | (0.2) |
| 40680 - PB Main Generator AVR and Protective Relay Upgrade | 2 | Jul-15 | 18.7 | 18.8 | (0.1) |
| 46605 - PA Passive Auto-Catalytic Recombiners | 2 | May-14 | 12.1 | 14.4 | (2.3) |
| 49116 - PB SG/EPG Fire Detection Upgrade and CO2 Suppression Removal | 2 | Jul-16 | 6.9 | 10.7 | (3.8) |
| 49126 - PB Powerhouse Office Facilities (Capital) | 2 | Dec-14 | 4.2 | 6.7 | (2.5) |
| 49132 - PB RBSW Dechlorination & MISA Cleanup | 2 | Dec-16 | 14.1 | 14.1 | (0.0) |
| 49134 - PB Replacement of Containment Box-up Monitors | 2 | Jul-15 | 6.9 | 8.8 | (1.9) |
| 49140 - PB Screenhouse Trash Bar Screen Replacement | 2 | Jul-15 | 6.8 | 7.7 | (0.9) |
| 49146 - PN Fire Code Compliance for Relocatable Structures in Un-Zoned Area for Pickering Station | 2 | Jul-16 | 17.1 | 18.8 | (1.7) |
| 49247 - Unit 1 & 4 Fuel Channel East Pressure Tube Shift Tooling (CMFA) | 2 | Mar-16 | 8.7 | 8.9 | (0.2) |
| 49267 - PN Standby Boiler Capacity Improvement | 2 | Nov-15 | 5.1 | 6.4 | (1.3) |
| 49284 - PN Administration Building Rehab | 2 | Dec-14 | 16.4 | 19.4 | (3.0) |
| 49296 - PA Class II Emergency Lighting | 2 | Aug-15 | 4.0 | 6.1 | (2.1) |
| 66255 - OPGN Pressure Tube to Calandria Tube Gap | 2 | Aug-15 | 16.8 | 17.5 | (0.7) |
| 66533 - Multiple Simultaneous Inspections for Feeders | 2 | Sep-14 | 0.4 | 0.5 | (0.0) |
| 73397 - DN ESW Pipe and Component Replacement | 2 | Jan-16 | 5.2 | 6.7 | (1.5) |
| 80027 - SES Station Personnel Emergency Accounting | 2 | Dec-16 | 0.2 | 3.3 | (3.2) |
| 25918 - Security Project A | 2 | Dec-16 | 9.9 | 9.9 | 0.0 |
| 31406 - DN SG Battery Rectifier upgrade | 3 | Mar-14 | 3.8 | 4.0 | (0.2) |

| Projects | OEB Tier | Actual or Forecast In-Service Date | Actual or Forecast In-Service (M$) | Approved Cost (M$) | Variance (M$) |
|---|---|---|---|---|---|
| (a) | (b) | (c) | (d) | (e) | (f) |
| (Capital) | | | | | |
| 31410 - DN TRF CRS Hydrogen Compressors Condition Monitoring System | 3 | May-16 | 6.6 | 6.6 | (0.0) |
| 31437 - DN F/H Service Area Bridge Mtce Platform | 3 | Dec-14 | 0.6 | 0.6 | (0.0) |
| 31530 - DN MOT/LIST/SST/10MVA Spare Transformer Storage Facility | 3 | Sep-16 | 5.1 | 5.6 | (0.5) |
| 31538 - DN RIH Instrumentation Upgrade | 3 | Dec-16 | 1.4 | 1.7 | (0.3) |
| 33214 - DN Building Heating Condensate Return Header Pipe Movement | 3 | Jan-16 | 2.8 | 2.8 | 0.0 |
| 33218 - DN Bleed Condenser Isolating Valve - Unit 1 | 3 | Jul-14 | 1.2 | 1.5 | (0.3) |
| 33220 - DN End Shield Cooling Button-up Valve Access Platform | 3 | Dec-14 | 0.8 | 0.8 | (0.0) |
| 33222 - DN FH IFB ESW Top-up Valve Access Platform | 3 | Apr-15 | 0.7 | 0.7 | (0.0) |
| 33904 - Plant Information System Addt'n in the MCR | 3 | Apr-14 | 4.6 | 4.8 | (0.2) |
| 36005 - DN Class IV 4kV 10MVA Transformer Capital Spare | 3 | Oct-16 | 0.5 | 0.5 | 0.0 |
| 36007 - DN UST Capital Spare | 3 | Oct-16 | 2.7 | 3.0 | (0.3) |
| 38946 - DN Domestic Waterline Replacement | 3 | Dec-15 | 3.4 | 3.9 | (0.5) |
| 40658 - PB Boiler Level Control Obsolescence | 3 | Feb-15 | 1.9 | 2.9 | (1.1) |
| 40692 - PB Turbine Supervisory Equipment (TSE) Obsolescence (Capital) | 3 | Dec-16 | 3.9 | 5.0 | (1.1) |
| 40708 - PB Bleed Condenser Bundle Replacement | 3 | Jan-16 | 3.9 | 4.4 | (0.5) |
| 40975 - PN N293-07 Fire Code Compliance Modifications | 3 | May-15 | 4.3 | 4.3 | 0.0 |
| 40978 - PN Fueling Machine Vault Camera Replacement | 3 | Dec-16 | 4.0 | 4.2 | (0.2) |
| 40982 - PA Enhancement of Pickering A Chlorination System (Capital) | 3 | Sep-15 | 3.1 | 3.4 | (0.3) |
| 40987 - PA Replacement of AIFB Supertool | 3 | Dec-16 | 3.1 | 3.4 | (0.3) |
| 40992 - PN Replacement of Auto Transfer Switch ATS1 & ATS2 | 3 | Aug-14 | 0.4 | 0.4 | (0.0) |
| 40993 - PA Bulk CO2 Tank Replacement | 3 | Aug-14 | 1.2 | 1.5 | (0.3) |
| 40994 - PA Fire Water Chlorination Skid | 3 | Sep-16 | 1.6 | 1.7 | (0.2) |

| Projects | OEB Tier | Actual or Forecast In-Service Date | Actual or Forecast In-Service (M$) | Approved Cost (M$) | Variance (M$) |
|---|---|---|---|---|---|
| (a) | (b) | (c) | (d) | (e) | (f) |
| 40998 - PA Generator Field Breaker Replacement | 3 | May-14 | 0.8 | 1.0 | (0.2) |
| 40999 - PA Generator Turbine Temperature Monitor Replacement | 3 | Apr-15 | 0.3 | 0.4 | (0.1) |
| 41005 - PA Reheat Drain Pumps Reliability Improvement | 3 | Dec-16 | 2.3 | 2.3 | 0.0 |
| 41006 - PN Comfo Washer Replacement | 3 | Nov-16 | 0.5 | 0.6 | (0.1) |
| 41008 - PN South Decontamination Shop Facility Upgrade | 3 | Feb-14 | 0.2 | 0.4 | (0.2) |
| 41009 - PA SRV Enclosure Ventilation Improvement | 3 | May-15 | 1.3 | 1.5 | (0.1) |
| 41011 - PN Upper Chamber Vacuum Pumps Replacement | 3 | Mar-14 | 0.3 | 1.0 | (0.7) |
| 41012 - PA 230 kV Disconnect Switches Replacement (DS138/DS142/DS154) | 3 | Apr-14 | 1.0 | 1.9 | (0.9) |
| 41033 - PN Whole Body Monitor Seismic Qualification | 3 | Feb-14 | 0.4 | 1.2 | (0.9) |
| 41034 - PA Fire Code Compliance (FSA Followup) | 3 | Jun-15 | 2.8 | 3.0 | (0.2) |
| 41040 - PN Permanent Power Supplies For Ontario Electrical Safety Code Compliance | 3 | Apr-14 | 0.8 | 0.9 | (0.1) |
| 41047 - PA Critical Pump and Motor Spares | 3 | Dec-15 | 0.5 | 2.9 | (2.4) |
| 49124 - PB Permanent Data Logger for Screenhouse | 3 | Sep-15 | 3.3 | 3.5 | (0.2) |
| 49142 - Pickering Site Engineering Services Bldg - 1 (ESB1) HVAC System Upgraders | 3 | Sep-14 | 4.2 | 4.4 | (0.2) |
| 49143 - PB Purchase of CEP Motor Capital Spares | 3 | Mar-16 | 0.3 | 0.3 | (0.0) |
| 49144 - PB Purchase of HPSW Motor Capital Spares | 3 | Mar-16 | 0.2 | 0.2 | 0.0 |
| 49163 - PA Fire Code Compliance for Relocatable Structures in Powerhouse | 3 | Dec-16 | 2.0 | 4.8 | (2.8) |
| 49289 - Pickering A - AVR Replacement for Standby Generators | 3 | Jul-16 | 4.8 | 4.8 | 0.0 |
| 49302 - PB Fire Code Compliance for Relocatable Structures in Powerhouse | 3 | Jan-16 | 2.9 | 4.6 | (1.6) |
| 62552 - Inspection Qualification | 3 | Dec-16 | 3.4 | 3.4 | (0.0) |
| 66599 - IMS Steam Generator Inspection | 3 | Dec-14 | 1.5 | 2.5 | (0.9) |

| Projects | OEB Tier | Actual or Forecast In-Service Date | Actual or Forecast In-Service (M$) | Approved Cost (M$) | Variance (M$) |
|---|---|---|---|---|---|
| (a) | (b) | (c) | (d) | (e) | (f) |
| Improvements | | | | | |
| 80020 - DN TRF Cold Box Vacuum System Obsolescence | 3 | May-16 | 3.7 | 4.9 | (1.3) |
| 80119 - PA Switchyard Air Blast Circuit Breaker Replacement | 3 | Apr-14 | 3.5 | 3.5 | 0.0 |
| 80149 - DN Sewage Lift Station Replacement | 3 | Feb-16 | 1.2 | 4.8 | (3.5) |

Attached are the Tier 1 Over-Variance Approval or Superseding Business Cases #33955 (Attachment 1) and #34000 (Attachment 2) that have received approval and have not been included in the pre-filed evidence or in response to other interrogatories. Attachment 2 includes confidential content as marked.

ONTARIO POWER GENERATION

Records File Information:
Final Security Classification of the completed form is determined below
00120.3 - P For Nuclear
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# Project Over-Variance Approval

Final Security Classification of the BCS: **Internal Use Only**

This form should not be used for over-variances in excess of 20% of cost or schedule or both. Submit this form with attachment of the latest approved Business Case Summary.

**Part A: Project Information**

| | | | | | |
|---|---|---|---|---|---|
| **Project #:** | 16-33955 | **Title:** | DN SDS Computers Aging Management | | |
| **Phase:** | Execution | **Class:** | Capital | **Records File:** | NK38-68000-T10 |

| | LTD | 2016 | 2017 | 2018 | Future | Total |
|---|---|---|---|---|---|---|
| Current Approval | 20,007 | 251 | | | | 20,258 |
| Amount Requested | - | 100 | | | | 100 |
| **New Total Release** | **20,007** | **351** | | | | **20,358** |

**Brief Description of the Project:**

The DN SDS Computers Aging Management Project (16-33955) is a capital project and includes the following items:
(a) Full replacement of the SDS1 and SDS2 Monitor Computers
(b) Eliminate need for a separate SSMC by incorporating functionality into the replacement Monitor Computers
(c) Full replacement of the SDS1 and SDS2 Display/Test Computer CRT monitors with modern display units
(d) Engineering required to enable use of higher density memory chips on SDS2 Trip Computer EPROM boards
(e) Preliminary engineering required to achieve a solution for replacing the SDS2 Trip Computer DEC boards

For items (a) and (b), everything has been completed except some closeout activities. Items (c), (d), and (e) have all been fully completed.

**Reason for Schedule Variance:**

The last Over-Variance approved in February 2015 included the following milestones:
1. SDS1/2 Monitor Computers – AFS Declaration – First Unit (February 2015)
2. SDS1/2 Monitor Computers – AFS Declaration – Final Unit (November 2015)
3. Project Closeout (May 2016)

Milestone 1 was not achieved until April 2015 due to technical issues with the Monitor Computer (MC) hardware and software.

Milestone 2 was achieved on schedule in November 2015.

Due to the additional time required to complete all the open items and closeout activities, Milestone 3 will have to be delayed until September 2016.

**Reason for Cost Variance:**

Since the last Over-Variance, field installations and AFS's of the SDS Monitor Computers on all Units have been carried out successfully, and closeout activities are substantially complete.

There are a number of reasons that the project has had to access the existing contingency funds of $652K and is requesting an additional $100K to complete the remaining closeout activities:

1. The AFS Declaration of the first Unit Monitor Computers was delayed from February 2015 to April 2015. The associated Report of Equipment in Service (REIS) form was submitted later in April, but delays in receiving signatures and processing the form resulted in the interest on the in-service amount of $15,141K not being stopped until late in June 2015. A release of $240K from contingency was required to fund these extra interest charges.

2. Some technical issues with both the Monitor Computer hardware and software came up during the first Unit installations. These are documented in SCRs D-2015-03302, D-2015-05776, D-2015-06077, D-2015-08587, and D-2015-08899. A Lessons Learned Report (D-LLD-68000-10002) has been prepared to more fully document these problems. A release of $296K from contingency was required to fund the extra effort to investigate these problems, revise the designs, and perform the required extra testing.

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## Project Over-Variance Approval

3. Some technical issues with the SDSPI Gateway modification to support the new Monitor Computers were discovered after the first Unit installations began in February 2015. The main issues are documented in SCRs D-2015-05915 and D-2015-07153. A release of $90K from contingency was required to fully fund this work.

4. The effort required to perform the closeout activities was underestimated chiefly due to the high volume of affected drawings (more than 700) and documents. A release of the final $26K of contingency and new funding of $70K will be required to complete the preparation, verification, and issuing of the drawings and documents.

5. Delays in submitting and processing of the final REIS form have resulted in approximately $30K in extra interest charges. New funding of $30K will be required for this.

In addition to the $100K of new funding being requested to close out the project as currently installed, SCR N-2016-10683 has been raised to document the underestimation of the drawing office costs and the delays in submitting and processing of the final REIS form.

**Options Considered to Mitigate Overruns:**

The project is now completing the AFS open items and mandatory ECC and project closeout activities. As a result the options to mitigate overruns are substantially reduced. The project team has been working with contributing organizations (Drawing Office, the System Engineers and Darlington Plant Design) to ensure costs and delays during the closeout phase are minimized.

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# Project Over-Variance Approval

| Part B: Variance Detail | | | | |
|---|---|---|---|---|
| **k$** | **Current Approval** | **Amount Requested** | **Variance** | **Comments** |
| **OPG Project Management** | 2,915 | 2,980 | 65 | Extra charges due to longer project duration |
| **OPG Engineering** | 4,622 | 5,032 | 410 | Extra charges to carry out the activities in the Reason for Cost Variance section. |
| **Permanent Materials** | 1,800 | 1,820 | 20 | Procurement of some extra spares. |
| **Design and Construction** | | | | Included in OPG Project Management, OPG Engineering, and Consultants. |
| **Consultants** | 7,487 | 7,527 | 40 | Extra charges to carry out the activities in the Reason for Cost Variance section. Includes Managed Task Services and Augmented Staff. (These costs were contained in the Engineering, Project Management, and Construction categories in the Full Release BCS.) |
| **Other Contracts/Costs** | 149 | 149 | 0 | Costs for Simulator group efforts in 2012 and 2013. |
| **Interest** | 2,633 | 2,850 | 217 | Extra charges due to schedule and cost over-runs. |
| **Subtotal** | **19,606** | **20,358** | **752** | |
| **Contingency** | 652 | 0 | (652) | The full contingency has been allocated as per the items described in the Reason for Cost Variance section. It is included in the amounts shown in the Variance column. |
| **Total** | **20,258** | **20,358** | **100** | |
| **Removal Costs Included** | | | | Included in Design and Construction originally |

| Part C: Review/Approvals | | | |
|---|---|---|---|
| | **Signature** | **Comments** | **Date** |
| **Recommended by:**<br>Glenn Jager<br>Project Sponsor | | | 2016-07-18<br>YYYY-MM-DD |
| **Finance Approval:**<br>Ken Hartwick<br>Position per OPG-STD-0076 | | | July 18, 2016<br>YYYY-MM-DD |
| **Approved by:**<br>Jeffrey Lyash<br>Per OAR Element 1.1, 1.2, or 1.3 | | | 2016-07-18<br>YYYY-MM-DD |

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# Project Over-Variance Approval

Final Security Classification of the BCS: **OPG Confidential**

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**Part A: Project Information**

| | | | | | |
|---|---|---|---|---|---|
| **Project #:** | 16-34000 | **Title:** | DN Auxiliary Heating System Facility | | |
| **Phase:** | Execution | **Class:** | Capital | **Records File:** | D-BCS-73110-10002 |

| | LTD | 2016 | 2017 | 2018 | Future | Total |
|---|---|---|---|---|---|---|
| Current Approval | 93,773 | 5,619 | 105 | 0 | 0 | 99,497 |
| Amount Requested | - | 2,067 | 4,910 | 675 | 0 | 7,652 |
| **New Total Release** | **93,773** | **7,686** | **5,015** | **675** | **0** | **107,149** |

**Brief Description of the Project:**

The existing Construction Boiler House (CBH) provides back-up heating steam to DNGS when all operating units are shutdown. The CBH is beyond it useful service life, and has a total capacity of supplying up to approximately 45,000 kg/hr steam, which does not meet the required 110,000 kg/hr required to maintain the Station temperature above 10 degrees Celsius as specified in the design requirements.

The business objective of this Regulatory project is to provide a source of reliable back-up steam to the DNGS main heating steam header to support irregular operating conditions in the event when all four turbine units are shut down in the winter to mitigate potential major equipment damage due to freezing. This will be achieved by replacing the existing CBH with a new Auxiliary Heating Steam (AHS) Facility. The scope of this project includes the disconnection and demolition of the existing CBH.

This Investment is part of Ontario Power Generation's (OPG) commitment to the Canadian Nuclear Safety Commission to resolve outstanding issues related to the CBH. This project is also categorized as an ongoing operational support project required for meeting the extended Darlington Station life.

**Project Status:**

Construction of the facility and connection to the Station has been completed. The contractor has completed testing of the AHS Facility up to 100% steam capacity with OPG as Owner Only. Transfer of the facility to OPG as Owner/Constructor for commissioning is in progress.

**Remaining Work:**

- Resolution of deficiencies by contractor (identified during construction completion declaration walkdown)
- OPG Commissioning
- Software Qualification to satisfy revised Software Categorization
- Available for Service Declaration
- Installation of additional security enhancements
- Engineering, procurement and construction for relocation of steam and condensate lines in Unit 4 reactor auxiliary bay (interference with station operation)
- Engineering, procurement and construction for steam bypass at Unit 3 steam header tie-in to limit steam release in event of steam break
- Cut and cap CBH connections to the Station and services
- Demolition of the CBH, and remediation of the site

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# Project Over-Variance Approval

Reason for Schedule Variance:

- Level 1 work protection violation documented under Station Condition Record D-2015-18210. Work was performed on equipment that was not guaranteed isolated. The event was categorized as C2, and a corrective action plan was issued. The key actions included improvement of contractor's process, training and OPG oversight. (10 weeks)
- Discovery and design issues that resulted in field changes and design changes (10 weeks)
- Procurement delays resulting from bill of materials revisions (design changes)
- Relocation of steam and condensate lines in Unit 4 reactor auxiliary bay (loading bay) rescheduled to the summer of 2017, due to availability of heating steam header outage.
- Old Construction Boiler House demolition rescheduled to later half of 2017, after the following: the operation of the new AHS Facility through initial warranty period and first heating season; and relocation of the steam and condensate lines in Unit 4.
- The following is a summary of the impact on milestones:

| Milestone | Existing Target Date | New Target Date |
|---|---|---|
| New AHS AFS | 2015-OCT-31 | 2016-JUN-30 |
| CBH Start of Demolition | 2016-JUN-15 | 2017-SEP-01 |
| CBH Demolition Final AFS | 2016-OCT-30 | 2018-FEB-28 |
| Project Closeout Complete | 2017-JUN-30 | 2019-FEB-28 |

Reason for **Cost** Variance:

- Interest incurred during the delay of project completion (October 2015 – April 2016) - $2,404k
- OPG Engineering oversight for the design changes and extended duration of construction - $1,142k
- The Burner Management System software has been re-categorized to account for personnel safety. OPG Engineering support for demonstrating compliance with the revised software categorization is estimated to be $110k.
- OPG Project Management and Supports for the design changes and extended duration of construction - $578k
- OPG Project Management and Supports for the extended duration of project - $260k
- There is an increase in the Engineer, Procure & Construct (EPC) contract cost. The contractor was behind schedule and over spent. The contractor did not account for updating OPG's valve packing database. The contract was re-negotiated from performance fee type to fixed price type. The fixed price contract is greater by [redacted]
- After the construction was substantially complete, due to the piping penetrations through the security fence, additional blind spots were identified, and new security camera(s) and lights will be required. This work will be contracted out to the EPC Contractor or other - [redacted]
- Around the clock security surveillance of the fence will be required until the additional camera(s) and lights are installed. - $1,051k
- A new bypass line will need to be installed in order to mitigate the nuclear safety risk of a steam line break. The existing line and valve are oversized, and will not limit the release of steam into the reactor auxiliary bay. This work will be contracted out to the EPC Contractor or other - [redacted]
- Increased contingency is required for the following risks
  - [redacted] general contingency for the remaining work - [redacted]
  - Delays in the field during steam line relocation in Unit 4 - [redacted]
  - Software qualification will need to be performed by a third party, instead of crediting the testing and commissioning work that already been completed, in order to satisfy the revised software categorization. - [redacted]
  - Risk of discovery issues (hazardous materials, contaminated soil, etc.) during CBH Demolition [redacted]

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# Project Over-Variance Approval

- The following table shows the contingency in the yearly cashflow ($k):

| Year | 2016 | 2017 | 2018 |
|---|---|---|---|
| Total Release without contingency | [redacted] | | |
| Contingency | | | |
| Total Release with contingency | 7,686 | 5,015 | 675 |

**Options Considered to Mitigate Overruns:**

- Converted the EPC contract from performance fee type to fixed price type for all remaining work.
- Where feasible, issue new requests for proposals to obtain competitive bids for outstanding scope.

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Records File Information:
Final Security Classification of the completed form is determined below
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# Project Over-Variance Approval

Part B: Variance Detail

| k$ | Current Approval | Amount Requested | Variance | Comments |
|---|---|---|---|---|
| OPG Project Management & Support | 5,812 | 7,701 | 1,889 | - Project Management for the design changes, software qualification, and extended duration of construction ($838k)<br>- Temporary security enhancements ($1,251k) |
| OPG Design & Engineering | 2,857 | 4,110 | 1,253 | - Engineering oversight for the design changes, extended duration of construction, and increased drawing office support ($1,142k)<br>- Demonstrate compliance to revised software categorization ($111k) |
| OPG Procured Materials | [redacted] | | | |
| Vendor Core Team | | | | |
| Design Contract (Historical) | | | | |
| EPC Contract | | | | |
| Interest | | | | |
| Subtotal | | | | |
| Contingency | | | | |
| **Total** | **99,497** | **107,149** | **7,652** | |
| Removal Costs Included | 4,354 | 4,354 | 0 | |

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Records File Information:
Final Security Classification of the completed form is determined below
00120.3 - P For Nuclear
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# Project Over-Variance Approval

| Part C: Review/Approvals | | | |
|---|---|---|---|
| | **Signature** | **Comments** | **Date** |
| **Recommended by:**<br>Glenn Jager<br>CNO<br>Project Sponsor | | | 3 MAY 2016 |
| **Finance Approval:**<br>Ken Hartwick<br>SVP Finance & CFO | | | May 11/16 |
| **Approved by:**<br>Jeff Lyash<br>President & CEO | | | May 12/16 |

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# SEC Interrogatory #47

**Issue Number: 4.4**
**Issue:** Are the proposed test period in-service additions for nuclear projects (excluding those for the Darlington Refurbishment Program) appropriate?

## Interrogatory

**Reference:**
[D2/1/3, p.16]
With respect to the Security Physical Barrier System (Project #25609):

a. Please provide further details regarding the claim made the subcontractor.

b. Please explain why OPG is responsible for costs of a settlement of a claim by a subcontractor to the EPC vendor?

## Response

a) and b)

OPG entered into an Engineering, Procurement and Construction Agreement for a Physical Barrier System ("PBS") around the protected zone at the Pickering and Darlington Stations (the "EPC Agreement"). The contractor entered into a subcontract for the design and installation of various aspects of the PBS, including the electrical equipment. The subcontractor asserted that in addition to its work under the EPC Agreement, it was requested to do additional work directly by OPG.

OPG accepted that it had instructed the subcontractor to design and construct an electrical distribution network, which was outside the scope of work set out in the EPC Agreement. The subcontractor successfully performed the design and construction of the electrical distribution network and OPG was responsible for paying the subcontractor for it.

# SEC Interrogatory #48

**Issue Number: 4.4**
**Issue:** Are the proposed test period in-service additions for nuclear projects (excluding those for the Darlington Refurbishment Program) appropriate?

## Interrogatory

**Reference:**
[D2/1/3, Attach 1, Tab 1]

With respect to the Operations Support Building Refurbishment project?

a. Who was the EPC contractor for the project?

b. Why was the contract not a fixed price?

c. Please provide the original Business Case Summary.

## Response

a) The EPC contractor for the project was Black & McDonald.

b) The Operations Support Building Refurbishment contract was issued following the request for proposals (RFP) and evaluation process. The RFP requested fixed price proposals. Through evaluation of the proposals submitted, OPG selected the alternative ES-MSA target price performance fee as providing best value as the fixed price proposals contained significant cost premiums.

c) See Attachment 1 which includes confidential content as marked.

The original Business Case Summary reflects the estimates in the first Execution Phase Business Case. Per OPG-STD-0017 Organizational Authority Register and OPG-STD-0076 Developing and Documenting Business Cases, OPG does not commit to the full estimated cost of a project until the first Execution Phase business case at which point most of the detailed engineering and planning is complete and procurement of engineered equipment is underway.

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Records File Information:
See Guidance Section

# Type 3 Business Case Summary

Final Security Classification of the BCS: **OPG Confidential**

To be used for investments/projects meeting Type 3 criteria in OPG-STD-0076.

## Executive Summary and Recommendations

| Project Information | | | |
|---|---|---|---|
| **Project #:** | 16-25619 | **Document #:** | D-BCS-28110-10004 |
| **Title:** | Operations Support Building (OSB) Refurbishment | | |
| **Class:** | Capital | **Investment Type:** | Sustaining |
| **Phase:** | Execution | **Release:** | Full |
| **Facility:** | Darlington | **Target In-Service or Completion Date:** | 30OCT2015 |

**Project Overview**

**We recommend the release of $30.4 M, [redacted]**

**The estimated total project cost is $53.0 M, [redacted]**

The quality of the estimate for this release is Class 2.

This release will fund the balance of the execution work which includes the following scope of work:

- Procurement of all remaining equipment and materials necessary to support construction.
- Construction and commissioning of all deliverables not already funded by the schedule critical contracts from the previous release.
- Design and project close-out.
- Perform owner's oversight, project controls, and reporting on the progress of the project

**Problem Statement/Business Need:**

The OSB was constructed in 1982 with the third floor added in 1988. It is an important facility that houses technical services essential to the business operations of Darlington (DNGS). These technical services include: site security systems, site information technology (IT) and telephone network hubs, quality assurance vault, station domestic water piping and radiological public domain access to the powerhouse via the bridge. The facility is 95,910 sq. ft. and houses approximately 375 Darlington employees who provide daily operations, maintenance and administrative support to station and control room staff.

An assessment performed by an external engineering firm found that many of the existing building systems are currently life expired or will be by 2015. Several systems need to be replaced such as the cladding and windows (currently leaking), roof membrane, heating/ventilation/air conditioning (HVAC) equipment and ducting, elevator, plumbing, electrical distribution, IT and telephone, cafeteria, furniture, interior furnishings including the carpet and ceiling tiles. There is no sprinkler system and interior lighting is insufficient throughout most of the office space. The continued degradation of the OSB will increase the likelihood of additional mould growth, worsened employee engagement and increased corrective maintenance to repair failing equipment, which will cause poor environmental conditions for the essential technical services and building occupants..

**The business objective of the project is:**

Provide a facility with an improved workplace environment for DNGS staff supporting the continued operations of the nuclear station post refurbishment while also providing for the following site essential services currently located in the OSB:

Security Equipment
IT and telephone hubs
Quality assurance vault
Domestic water main header

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# Type 3 Business Case Summary

Project #: 16-25619
Document #: D-BCS-28110-10004
Title: Operations Support Building (OSB) Refurbishment

Access to powerhouse bridge

**Summary of Preferred Alternative:**

The full-definition business case for this project confirmed that refurbishment of OSB is the preferred alternative. This was based on the results of an independent study completed by an external architectural firm. Completing the preferred alternative will ensure that the OSB remains operational to support the ongoing operations of DNGS post-refurbishment. The project engaged a separate architectural/engineering firm to develop the scope of modifications to be completed to achieve the business objectives. The project includes refurbishment or replacement of mechanical, electrical, controls and civil systems located on all floors of the building as well in the cafeteria, the roof and the exterior cladding and windows.

A full release of execution funds is required for remaining procurement and construction deliverables not already included in the schedule critical contracts from the previous release. The systems to be modified using this funding include HVAC, lighting, fire suppression, kitchen, IT/Telephone, plumbing and domestic water and interior architectural finishes.

**History of BCS releases and project cost estimates:**

The total project cost is now estimated at [redacted], compared to [redacted] in the previous release.

Overall, the execution-full BCS estimate class is considered Association for the Advancement of Cost Engineering (AACE) class 2 as the maturity level of project deliverables is within 75 to 90% of complete definition.

| Release Gate | ($M with contingency) | | Status of Major Scope Items |
|---|---|---|---|
| | Release amount per release | Total Project Estimate per Release | |
| Partial Definition | 1.0 | 9.2 | Building condition assessment complete. |
| Partial Definition | 1.4 | 40.6 | Third party estimate and project alternatives analysis complete. Preliminary design complete, including value engineering. |
| Full Definition | 2.0 | 46.8 | EPC Contract awarded; Detailed Design Started |
| Superseding Definition | 4.0 | 45.4 | Detailed design 75 to 90% complete. |
| Partial Execution | 14.3 | 47.8 | EPC Contractor mobilized to site, temporary construction modifications complete, demolition 35% complete, schedule-critical equipment procurement in progress |
| Full Execution | 30.4 | 53.0 | Funding as part of this release |

**History of scope and schedule changes:**

As part of detailed design, the following scope items were discovered and need to be incorporated into the project:

1) Addition of a new rooftop HVAC unit in order to meet the latest American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) standards, costing approximately $1.8M
2) As part of the Engineer, Procure, Construct (EPC) Contractor's original proposal, they did not budget for certain HVAC equipment that the detailed design has determined to be necessary. This has resulted in a cost increase of approximately $1M.
3) Changes to lighting system; conversion of existing fluorescent bulbs to light emitting diode (LED) lights plus the replacement of the entire motor control centre, costing approximately $580k. These changes will

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reduce/simplify construction and future maintenance required for these systems.

4) Removal/replacement of asbestos vinyl floor tiles throughout the building, costing $155k. This requirement was identified during pre-demolition testing activities by the Contractor.
5) Replacement of the existing gaseous fire suppression system with a water/nitrogen based system, eliminating the need to perform costly civil modifications in the equipment rooms containing this fire suppression system, which had inherent scope and cost risk, at an estimated cost of approximately $50k.

Additionally, the EPC Contractor's original proposal underestimated the amount of construction labour required to complete the project. After completing constructability reviews of the design packages, the Contractor has identified a cost increase of approximately $700k in additional construction trade labour.

The completion of the detailed design packages is behind schedule. The remaining design packages are currently targeted to be issued by June 5, 2014.

The EPC contractor has mobilized personnel and equipment to the OSB and has progressed with the setup of temporary construction power and ventilation as well as the removal of furniture and architectural systems such as ceiling tiles and carpet.

**Key Assumptions and Risks:**

The major risk to the project is the timely completion of the design packages by June 2014. These design packages are nearing completion and OPG design personnel have committed to provide a project oversight role to allow for a more integrated design review process to minimize delays that typically occur during the comment and disposition process. This collaborative approach to design reviews will reduce design review cycle times to achieve our design completion milestone. The remaining design packages are being released in stages to allow field work to progress as scheduled to maintain the originally committed Available for Service date.

As this is a building refurbishment project, there is a risk that issues may arise when commissioning building services that had not been refurbished due to integration issues with newly installed systems and/or components. The EPC Contractor and OPG field oversight are performing inspections throughout demolition to mitigate this risk.

**Project Cash Flows, NPV, and OAR Approval Amount**

| k$ | LTD | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Future | Total |
|---|---|---|---|---|---|---|---|---|---|
| Currently Released | 5,297 | 15,000 | 2,367 | | | | | | 22,664 |
| Requested Now | - | 14,668 | 14,825 | 874 | | | | | 30,367 |
| Future Required | - | | | | | | | | 0 |
| **Total Project Cost** | 5,297 | 29,668 | 17,192 | 874 | | | | | 53,030 |
| Ongoing Costs | - | 1,292 | 2,805 | 1,571 | | | | | 5,668 |
| **Grand Total** | 5,297 | 30,960 | 19,997 | 2,444 | | | | | 58,698 |

| | | | |
|---|---|---|---|
| **Estimate Class:** | Class 2 | **Estimate at Completion:** | [redacted] |
| **NPV:** | $19,308 k | **OAR Approval Amount:** | $58,698 k |

**Additional Information on Project Cash Flows:**

- The currently released $22,664k was used to complete the project conceptual work (building condition assessment, project alternatives analysis), scope development (value engineering, preliminary design, detailed design, installation planning), site mobilization, procurement of schedule critical equipment, demolition, management of building essential services, project management and contract administration
- The $30,367k requested now will provide full execution funding for the Engineer, Procure, Construction (EPC) contractor to complete the remaining procurement and construction portion of the contract ($19,861k), OPG project management and engineering [redacted], interest [redacted] and contingency [redacted].

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- The total capital project cost of $53,030k consists of [redacted] to complete detailed design, procurement and construction, which includes [redacted] to upgrade furniture and IT/telephone non-fixed assets, as well as [redacted] in OPG support costs and [redacted] in interest charges. The total requested project contingency is [redacted]
- The ongoing OM&A costs of $700k include employee office move costs in 2015, swing space lease and operating costs ($4,748k base OM&A) and swing space removal costs in 2016 ($220k base OM&A).
- The project only requires swing space until the end of 2015 however the swing space will need to be leased until mid-2016. As this would result in an early termination of the lease, termination fees are factored into the ongoing costs.

| Approvals | | | |
|---|---|---|---|
| **Project #:** | 16-25619 | **Document #:** | D-BCS-28110-10004 |
| **Title:** | Operations Support Building (OSB) Refurbishment | | |
| **Phase:** | Execution | **Release:** | Full |

| | Signature | Comments | Date |
|---|---|---|---|
| The recommended alternative, including the identified ongoing costs, if any, represents the best option to meet the validated business need. | | | |
| **Recommended by:**<br>Bill Robinson<br>Senior Vice President, Nuclear Projects<br>Project Sponsor | Bill Robinson | | 2014.05.01 |
| I concur with the business decision as documented in this BCS. | | | |
| **Finance Approval:**<br>Robin Heard<br>Interim Chief Financial Officer | | | 2014-05-05 |
| I confirm that this project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money. | | | |
| **Approved by:**<br>Tom Mitchell<br>President and Chief Executive Officer, per OAR 1.1 | | | 2014-05-06 |

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# Type 3 Business Case Summary

Project #: 16-25619
Document #: D-BCS-28110-10004
Title: Operations Support Building (OSB) Refurbishment

Final Security Classification of the BCS: OPG Confidential

## Business Case Summary

**Part A: Business Need**

The OSB was constructed in 1982 with the third floor having been added in 1988. It is an important facility at DNGS as it houses technical services that are essential to the business operations of DNGS. These technical services include: Security systems, site IT and telephone network hubs, quality assurance vault, station domestic water piping and radiological public domain access to the powerhouse via the bridge. This facility also provides office and conference room space for 375 employees and various speciality groups inside the DNGS protected area. The OSB is one of the site buildings included in the DNGS long term site accommodations strategy.

To ensure that the OSB will be operational post-refurbishment of the Darlington station, the following problems will need to be rectified:

- The leaks via the cladding and windows will need to be stopped. An attempt was made to re-caulk the joints however this work was stopped when it was determined that the deterioration of the components was too great.
- The roof is nearing the end of its service life and based on operational experience (OPEX) from other site buildings with identical room membranes, it needs to be replaced to prevent leaks in the future.
- When the third floor was added, the HVAC system was not upgraded to include the additional capacity and has been undersized ever since. In addition, the existing equipment is nearing its end of service life.
- A majority of the building does not have a sprinkler system, including the first, second and third floor office spaces. This does not meet the most recent building codes.
- Only a portion of the second floor has overhead fluorescent lighting. The remainder of the building has desk mounted lighting, which is not suitable for employee long term health or productivity.
- The building elevator, one of the busiest elevators on site, has frequently been out of service. It is near its end of service life.
- The electrical distribution system is at capacity in some locations and the equipment requires replacement due to age.
- A number of work groups that occupy the OSB require high data capacity from the IT network however the IT network cabling will not allow for greater network speeds. Future upgrades to computer technology will be restricted until the cabling is improved to the latest standards.
- The building furniture and interior components (carpet, ceiling tiles, paint, washrooms) are dated and require replacement due to age. The layout requires adjustments to meet building code as well as improve fire and emergency response capabilities.

The cafeteria requires HVAC and fire suppression upgrades as well as a replacement of equipment and an increase in cooking preparation space.

This picture is an aerial view of the OSB and surrounding grounds, including the protected area security fence, the radiological boundary fence, the powerhouse bridge and the overhead transmission lines.


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# Type 3 Business Case Summary

Project #: 16-25619
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Title: Operations Support Building (OSB) Refurbishment

**Part B: Preferred Alternative: Refurbish the Operations Support Building (OSB)**

**Description of Preferred Alternative**

This alternative provides for the refurbishment of the OSB while unoccupied. A temporary relocation of approximately 375 employees from the Darlington Engineering & Services Support Building (ESSB) to the an off-site leased facility is required to make space in the ESSB for the relocation out of the OSB of approximately 375 employees. This is considered the recommended alternative for the following reasons:

- Meets the needs of the DNGS long term employee accommodations plan
- Satisfies the business objectives while providing the best value for money
- Analysed to be the preferred alternative by external architectural firm from the list of alternatives provided by OPG
- Technical services essential to DNGS business operations are maintained in a cost effective manner (it would be costly to relocate these services outside of the building)
- Access to the station via the powerhouse bridge will remain available throughout construction
- Returns the building to operation in the shortest amount of time
- Provides office and conference room space within the radiological zone 1 portion of the protected area for approximately 375 employees

| Deliverables: | Associated Milestones (if any): | Target Date: |
|---|---|---|
| Building Turnover to OPG from EPC Contractor | | 30SEP2015 |
| Available for Service | Available for Service (AFS) | 30OCT2015 |
| Project close-out (once post occupancy commissioning complete) | Plan Complete Milestone (PCM) | 30OCT2016 |

**Part C: Other Alternatives**

Summarize all reasonable alternatives considered, including pros and cons, and associated risks. Other alternatives may include different means to meet the same business need, and a reduced or increased scope of work, etc.

**Base Case: Permanently relocate OSB employees to an off-site leased facility until 2062, refurbish first floor and basement and demolish second and third floors**

This alternative includes the *permanent* relocation of approximately 375 staff currently occupying the OSB to an offsite leased facility until the end of Darlington life (2062). This alternative also includes:

- The refurbishment of the first floor and basement, to maintain the operation of the essential technical services.
- Demolition of the second and third floors of the OSB instead of maintaining it in a non-refurbished configuration which would not be suitable for use over the long term.

The base case does not provide the best value for money and is not recommended for the following reasons:

a) Requires significant work to be completed to OSB in order to maintain the technical services and demolish unusable space
b) Subsequent loss of 54,000 sq.ft of useable office and conference room space within the protected area.
c) A long term lease at an off-site facility would be required to house employees who are typically located at Site.
d) Reduction in employee productivity due to additional travel to access site and the station powerhouse.

**Alternative 3: Refurbish basement and first floor, demolish second and third floor, construct a new off-site facility on OPG owned property**

This alternative includes:

- Refurbishment of the basement and first floor to maintain the essential technical services that currently exist in the OSB
- Demolition of the second and third floors of the OSB instead of maintaining it in a non-refurbished configuration which would not be suitable for use over the long term.
- Construction of a new *off-site* facility to house approximately 375 employees currently accommodated in the OSB

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Although this alternative satisfies the business objectives for this project, it is not recommended for the following reasons:

- Does not provide the best value for money
- Still requires significant work to be completed to OSB in order to maintain the technical services and demolish unusable space.
- Loss of valuable office and conference room space within the protected area
- Loss of productivity due to increased travel time for off-site staff requiring occasional or frequent access to the protected area
- Reduces space efficiency – functions currently housed in the OSB will be separated into two buildings

Two other locations were considered for the construction of a new facility. The locations included constructing a new facility inside the protected area, or constructing a new facility outside the protected area on the DNGS campus. Upon analysis of these locations, both of these locations provided less value for money than a new facility off-site. In addition, the DNGS campus plan does not indicate space available for this new facility.

**Alternative 4: Relocate OSB essential technical services, demolish OSB and construct a new facility in the same location**

This alternative includes the relocation of all essential technical services currently housed in the OSB to a new location on the Darlington campus, complete demolition of the OSB, and construction of a new building on the OSB site.

This alternative does not provide the best value for money and is not recommended for the following reasons:

- Significant operational and cost risks associated with the relocation of Darlington essential technical services
- Access to station via the powerhouse bridge will be significantly impacted by construction.
- Temporary loss of valuable office and conference space within the protected area and the subsequent loss of productivity due to increased travel time through security procedures into the protected area

Security and operational risks associated with moving the security, telephone and IT services outside of the protected area.

**Alternative 5: Refurbish basement and first floor, demolish second and third floor, employees in swing space and then utilize Refurbishment Project Office and R&FR Annex Buildings when DNGS Refurbishment Project complete**

This alternative includes:

- Refurbishment of the basement and first floor to maintain the essential technical services that currently exist in the OSB.
- Demolition of the second and third floors of the OSB instead of maintaining it in a non-refurbished configuration which would not be suitable for use over the long term.
- Housing Darlington employees in leased swing space until the DNGS refurbishment is complete at the end of 2025.
- Move employees into the following vacated buildings in 2026:
  - Refurbishment Project Office, which will be located just outside the site protected area on the west end of the site and will be radiological zone 1.
- Retube and Feeder Replacement Annex building, which will be located within the radiological unzoned area within the security protected area however its interior will be a radiological zone 1 environment.

Although this alternative satisfies the business objectives for this project, it is not recommended for the following reasons:

- Does not provide the best value for money due to the significant long term swing space lease costs until 2025.
- There is a high risk that available swing space won't be available beyond 2018.
- Still requires significant work to be completed to OSB in order to maintain the technical services and demolish unusable space.
- Loss of valuable office and conference room space within the protected area
- Loss of productivity due to increased travel time for off-site staff requiring occasional or frequent access to the protected area

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# Type 3 Business Case Summary

| Part D: Project Cash Flows, NPV, and OAR Approval Amount | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| k$ | LTD | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Future | Total |
| Currently Released | 5,297 | 15,000 | 2,367 | | | | | | 22,664 |
| Requested Now | - | 14,668 | 14,825 | 874 | | | | | 30,367 |
| Future Required | - | | | | | | | | 0 |
| **Total Project Cost** | 5,297 | 29,668 | 17,192 | 874 | | | | | 53,030 |
| Ongoing Costs | - | 1,292 | 2,805 | 1,571 | | | | | 5,668 |
| **Grand Total** | 5,297 | 30,960 | 19,997 | 2,444 | | | | | 58,698 |

| | | | |
|---|---|---|---|
| **Estimate Class:** | Class 2 | **Estimate at Completion:** | [redacted] |
| **NPV:** | $19,308 k | **OAR Approval Amount:** | $58,698 k |

**Additional Information on Project Cash Flows:**

- The currently released $22,664k was used to complete the project conceptual work (building condition assessment, project alternatives analysis), scope development (value engineering, preliminary design, detailed design, installation planning), site mobilization, procurement of schedule critical equipment, demolition, management of building essential services, project management and contract administration
- The $30,367k requested now will provide full execution funding for the Engineer, Procure, Construction (EPC) contractor to complete the remaining procurement and construction portion of the contract ([redacted]), OPG project management and engineering [redacted], interest [redacted] and contingency [redacted]
- The total capital project cost of $53,030k consists of [redacted] to complete detailed design, procurement and construction, which includes [redacted] to upgrade furniture and IT/telephone non-fixed assets, as well as [redacted] in OPG support costs and [redacted] in interest charges. The total requested project contingency is [redacted]
- The ongoing OM&A costs of $700k include employee office move costs in 2015, swing space lease and operating costs ($4,748k base OM&A) and swing space removal costs in 2016 ($220k base OM&A).
- The project only requires swing space until the end of 2015 however the swing space will need to be leased until mid-2016. As this would result in an early termination of the lease, termination fees are factored into the ongoing costs.

| Part E: Financial Evaluation | | | | | |
|---|---|---|---|---|---|
| k$ | Preferred Alternative | Base Case | Alternative 3 | Alternative 4 | Alternative 5 |
| **Project Cost** | [redacted] | (65,346) | (70,601) | (81,582) | (49,228) |
| **NPV** | | N/A | (5,255) | (16,236) | 16,119 |
| **Other (e.g., IRR)** | | | | | |

**Summary of Financial Model Key Assumptions or Key Findings:**

The financial model considers the following:

1) Capital costs to implement each alternative
2) Swing space lease and operating costs where required
3) Potential long-term improvement program costs
4) Incremental maintenance costs
5) Employee office move costs
6) Mileage costs

The costs were calculated until 2062 (assumed end of Darlington station life including safe storage activities).
The NPV is in 2014 dollars.

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**Part F: Qualitative Factors**

1. Maximizes the number of operations and maintenance support staff working in close proximity to the Darlington power house who frequently access the station.
2. Site infrastructure is already in place to support the refurbishment of the OSB and its continued operation
3. Essential technical services housed in the OSB will remain in place and be maintained throughout the construction period
4. Concerns over IT/LAN network performance, workstation ergonomics, task lighting, air quality, food services, and work place environment will be resolved as part of the refurbishment.
5. Resolution of issues raised in station condition records (SCR) will improve staff productivity and engagement

**Part G: Risk Assessment**

| Risk Class | Description of Risk | Risk Management Strategy | Post-Mitigation | |
|---|---|---|---|---|
| | | | Probability | Impact |
| Cost | There is a risk that unplanned entries by OPG personnel to the contractor's owner-only construction island, due to unplanned emergent activities requiring OPG to temporarily become the constructor, which is not in the EPC contract scope of work results in an increase in contract costs. | Project Manager to discuss opportunities for stakeholders to minimize the need to enter the construction island. [redacted] | Medium | Low |
| Schedule | As this is a building refurbishment, there is a risk that challenges will develop during commissioning since most of the mechanical/electrical systems in the OSB are being replaced and will be tied in to station systems, resulting in schedule delays prior to AFS. | EPC Contractor to involve OSB operations and maintenance staff (Nuclear East Facilities) during design and installation to help them become familiar with new equipment and building layout.<br>OPG project manager to ensure that building end users understand the importance of being an active stakeholder throughout this process. [redacted] | High | Medium |
| Scope | There is a risk that additional mould and/or other designated substances are discovered during demolition leading to additional demolition scope in the EPC contract. | The EPC contractor, in conjunction with OPG, will develop detailed work plans to manage these removal of these substances to ensure they are not negatively impacting the overall schedule. The response is to accept this risk. [redacted] | Medium | Medium |
| Other | There is a risk that a security system becomes disconnected or damaged by the EPC contractor causing the system to become unavailable, requiring OPG to file an S99 reportable event to the CNSC resulting in schedule delays. | EPC contractor to ensure that trades working within the security rooms understand the importance of maintaining distance from the security systems.<br>OPG to provide strategic oversight of work taking place within the security rooms. [redacted] | Medium | Medium |

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| | | | | |
|---|---|---|---|---|
| Cost and Schedule | As this is a building refurbishment, there is a risk that discovery work during installation can lead to additional scope and cost to the project. This may require future detailed design changes therefore impacting the installation schedule. | Constructability reviews and field walk downs by the construction team are occurring to identify potential discovery issues early. Team meetings during installation will challenge whether the discovery issues should become part of scope or not. [redacted] | High | Medium |
| Resources | The risk is that there is inadequate support from Nuclear East Facilities (NEF) for the project due to reallocation of NEF experienced technical and maintenance resources caused by the current OPG staff redeployment process, resulting in a negative impact to AFS. | OPG project manager to assess access to internal/external technical resources and provide timely resource request to OPG management. [redacted] | High | Medium |

**Additional Risk Analysis:**

As per N-GUID-0012-1003 Project Risk Management Guide, the Extensive Risk Management process was applied to this release. Risk workshops with stakeholders and other relevant groups were organized to indentify and determine risk exposures. In addition to the Most Likely costs for the risk impact estimates, the Minimum (optimistic) and Maximum (pessimistic) costs were identified. All risks were evaluated as documented in the Risk Register.

**Part H: Post Implementation Review (PIR) Plan**

☐ It is determined appropriate that only a Project Closure Report (PCR) is needed as the PIR for this project due to its straight forward deliverables, which do not require any measures other than confirmation of completion or delivery.

| Type of PIR Report | Target In-Service or Completion Date | Target PIR Completion Date |
|---|---|---|
| Comprehensive PIR Report | 30OCT2015 | 30OCT2016 |

| Measurable Parameter | Current Baseline | Target Result | How will it be measured? | Who will measure it? (person/group) |
|---|---|---|---|---|
| Successful completion of commissioning specifications based on building requirements (NK38-TS-28110-10001) and Modification Design Requirements (NK38-MDR-28110-10002). | OSB systems are at or near end of service life. Building Requirements (NK38-TS-28110-10001) document identifies required building improvements. | Building is occupied by employees and systems operate within building requirements. | OSB systems, structures and components are successfully commissioned and remain available for service throughout PIR period. | Nuclear East Facilities |

**Part I: Definitions and Acronyms**

1) AACE: Association for the Advancement of Cost Engineers
2) BOMA: Building Owners and Managers Association
3) Building Requirements document: The document prepared by an external architect/engineering firm that describes the modifications to be completed in each room of the building, along with the performance specifications of those modifications.
4) EPC: Engineering, Procure, Construct
5) Essential Technical Services: Important equipment located in the OSB that facilitates business operations across the site including security systems, information technology LAN servers, telephone network hub, station domestic water piping and radiological public domain access to the station via the bridge.
6) HVAC: Heating, Ventilation and Air Conditioning
7) OHSA: Occupational Health and Safety Act
8) OSB: Operations Support Building
9) Swing Space: Temporary office space for OSB employees while construction taking place.

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# Type 3 Business Case Summary

Project #: 16-25619
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Title: Operations Support Building (OSB) Refurbishment

| Appendix A: Summary of Estimate (Numbers may not add up due to rounding.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Project Number:** | 16-25619 | | | | | | | | | |
| **Title:** | Operations Support Building (OSB) Refurbishment Project | | | | | | | | | |
| **k$** | **LTD** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **Future** | **Total** | **%** |
| **OPG Project Management** | 1,865 | 816 | 1,115 | 503 | | | | | **4,298** | **8** |
| **OPG Engineering (including Design)** | 213 | 224 | 221 | 5 | | | | | **662** | **1** |
| **OPG Procured Non-Fixed Assets (IT/Telephone)** | | | 695 | | | | | | **695** | **1** |
| **OPG IT/Telephone Service Provider Installation Costs** | | | 470 | | | | | | **470** | **1** |
| **Design Contract(s)** | [redacted] | | | | | | | | | |
| **Construction Contract(s)** | | | | | | | | | | |
| **EPC Contract(s)** | | | | | | | | | | |
| **Consultants** | | | | | | | | | | |
| **EPC Procured Non-Fixed Assets (Furniture)** | | | | | | | | | | |
| **Interest** | | | | | | | | | | |
| **Subtotal** | | | | | | | | | | |
| **Contingency** | | | | | | | | | | |
| **Total** | **5,297** | **29,668** | **17,192** | **874** | **-** | **-** | **-** | **-** | **53,030** | |

| Notes | | | |
|---|---|---|---|
| **Project Start Date** | 09MAR2009 | **Definition Cost Included** (includes contingency only if spent) | $6.9 M |
| **Target In-Service (or AFS) Date** | 30OCT2015 | **Contingency Included in this Release** | [redacted] |
| **Target Completion Date** | 30MAY2016 | **Total-to-Date Contingency** | [redacted] |
| **Escalation Rate** | 2% | **Total-to-Date Released** (excluding contingency) | [redacted] |
| **Interest Rate** | 5% | **Total-to-Date Released** (including contingency) | $22.7 M |
| **Removal Costs** | $2540 k included in EPC Contracts | **Estimate at Completion** (includes contingency only if spent) | [redacted] |

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Project #: 16-25619

Document #: D-BCS-28110-10004

Title: Operations Support Building (OSB) Refurbishment

| Prepared by: | Approved by: |
|---|---|
| Chris Waugh<br>Section Manager, Design Projects<br>25 APR 2014<br>Date | Anthony Collela<br>Manager, Design Projects<br>2014-04-28<br>Date |

OPG-FORM-0070-R004

# Type 3 Business Case Summary

Project #: 16-25619

Document #: D-BCS-28110-10004

Title: Operations Support Building (OSB) Refurbishment

**Appendix B: Comparison of Total Project Estimates**

| Phase | Release | Date | Total Project Estimate in k$ (by year including contingency) | | | | | | Future | Total Project Estimate |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | | |
| Definition | Partial | 2009-MAR | 8996 | 200 | | | | | | 9,196 |
| Definition | Partial | 2010-NOV | 9625 | 28365 | 2187 | 404 | | | | 40,581 |
| Definition | Full | 2012-NOV | 6013 | 20869 | 18961 | 930 | | | | 46,773 |
| Definition | Superseding | 2013-OCT | 7019 | 27152 | 10676 | 579 | | | | 45,427 |
| Execution | Partial | 2013-NOV | 7021 | 28295 | 11778 | 642 | | | | 47,766 |
| Execution | Full | 2014-MAY | 5297 | 29668 | 17192 | 874 | | | | 53,030 |

**Project Variance Analysis**

| k$ | LTD | Total Project | | Variance | Comments |
|---|---|---|---|---|---|
| | | Last BCS | This BCS | | |
| **OPG Project Management** | 1,865 | 4,177 | 4,298 | 122 | Includes additional OPG project personnel to provide oversight of the Contractor's activities. |
| **OPG Engineering (including Design)** | 213 | 940 | 662 | (277) | Actual spending by internal engineering resources to date is under spent therefore the estimates for design resources were reviewed and adjusted accordingly. |
| **OPG Procured Non-Fixed Assets (IT/Telephone)** | - | 650 | 695 | 45 | Increase is a result of minor architectural changes to the building layout. |
| **OPG IT/Telephone Service Provider Installation Costs** | 0 | 310 | 470 | 160 | The installation effort required by the IT/Telephone service providers has increased due to additional audio/visual demands in conference rooms. |
| **Design Contract(s)** | [redacted] | | | | The project preliminary design contracts are now complete. No future design contracts other than the EPC contract are planned. |
| **Construction Contract(s)** | | | | | |
| **EPC Contract(s)** | | | | | The executive summary identifies the increase in costs, specifically, $2.7M in items discovered during detailed design as well as $1.7M in underestimated costs by the EPC contractor. The revised contractor estimate includes occasional premium time work where required. |
| **Consultants** | | | | | |
| **EPC Procured Non-Fixed Assets (Furniture)** | | | | | This amount has increased based on quotes received by the EPC contractor. |
| **Interest** | | | | | Interest was calculated based on revised project cash flows. |
| **Subtotal** | | | | | |
| **Contingency** | | | | | [redacted] |
| **Total** | **5,297** | **47,766** | **53,030** | **5,264** | |

# Type 3 Business Case Summary

Project #: 16-25619

Document #: D-BCS-28110-10004

Title: Operations Support Building (OSB) Refurbishment

| Appendix D: References |
| --- |
| 1) NK38-BCS-28110-10002 – Superseding Definition BCS<br>2) NK38-REP-28110-0322001 – Operations Support Building - Building Condition Assessment Report<br>3) NK38-REP-28110-0394044 – OSB Refurbishment Project Alternatives Analysis |

# Board Staff Interrogatory #78

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Ref: Exh: D2-2-10, page 16

The above reference states that the Heavy Water Facility was originally budgeted at $110M but the updated budget is now $381.1M. OPG states that the original EPC contractor's design was not adequate and the contractor has been replaced.

a) Please provide details of any recourse OPG was able to take due to the inadequacy of the contractor's work.

b) The over variance is 247%. What lessons learned have been applied to the work on the DRP?

## Response

a) At the time of termination of the ESMSA contractor on the Heavy Water Storage and Drum Handling Facility (Heavy Water Storage Facility) project, the parties were already in discussions regarding the recourse sought by both parties for commercial issues relating to various projects being performed by the contractor under the ESMSA, including those relating to the Heavy Water Storage Facility. The contractor's claims consisted of outstanding payments that had not yet been paid to the contractor and claims relating to the project, including performance incentives. After the termination, OPG added contractual damages arising from the inadequacy of the contractor's work on the Heavy Water Storage Facility to its list of claims. Ultimately, OPG and the contractor, including its main subcontractors, reached a global settlement for all of the claims between the parties. Through negotiation and verification of each party's claims, most of the claims advanced were reduced, eliminated or set off against each other.

   OPG reserved the right to make further claims to the contractor and its subcontractor with respect to any express or implied warranties relating to the quality of the goods or services that were supplied as part of their work on the Heavy Water Storage Facility, or any design deficiencies in the Heavy Water Storage Facility.

b) The Heavy Water Storage Facility is forecast to be 247% higher than its original estimate, however, the original estimate was prematurely established prior to the completion of the detailed engineering and with a performance specification that did not take into account

the space constraints and embedded and subsurface conditions that were to be encountered in the location where the project was to be constructed. The basis for the original estimate was determined before the start of construction and on a competitive basis with the other ESMSA contractors. The contractor that was initially selected was based on the lowest price submission and based on a review of the contractor pricing proposals.

OPG learned many lessons from the Heavy Water Storage Facility project. It is important to recognize that the construction of the Heavy Water Storage Facility is a first of kind type construction project and of significant magnitude. This type of work is not directly comparable to the type of work which will be conducted during the execution of the DRP, i.e., refurbishment of station systems and equipment, nor is it equivalent to the work that is normally done within the nuclear operations project portfolio.

Many of the issues that gave rise to lessons learned were specific to the construction of the new Heavy Water Storage Facility or to new facility and infrastructure projects, and are not directly applicable to the refurbishment of existing station equipment given the different nature of the projects. The issues discovered during the early phases of design and construction included:

- The relocation of existing emergency cooling water piping which interfered with the construction excavation. This interference was confirmed during the detailed design phase of the project and was unknown when the performance based specification was made.
- There was a requirement to move the new building seven metres to the west once the detailed design revealed that the original concept was unworkable due to interferences and concerns for the different seismic requirements that exist for new construction that is different from the existing structures.
- The requirement to have interconnecting process piping between the new facility and the existing Tritium Removal Facility run in a pipe tunnel below grade.
- Tritium levels that were discovered in the soil and groundwater during the excavation of the new building footprint that required the building of a special soil and groundwater management facility to treat soil and groundwater before it could be released from the excavation area (see also: Ex. D2-2-10, pp. 19-20).

Some of the lessons learned from the Heavy Water Facility project which have been applied to or otherwise re-confirmed for the DRP are:

- When the definition engineering has not been completed to a standard that will allow for confirmation of the design concept and performance, the Contractor's estimates should be appropriately classified to reflect this lack of engineering definition. Contractor's estimates should not be relied on until they are fully vetted and understood by the owner OPG. OPG had also previously used a separate third party estimating service to confirm the contractor estimate uncertainty. This estimating service is also subject to the level of engineering completed and the

uncertainty used in the case of the Heavy Water Management building was not appropriately factored to reflect the uncertainty of the design.

- Ensure that the contractor hired to do the work has the skills and experience related to the specific scope of work.
- Ensure project scope, including environmental and safety requirements, is well understood and is locked before construction begins.
- Complete detailed design engineering prior to beginning construction. OPG implemented the collaborative front-end planning process with contractors partly in response to this issue.
- OPG also made changes to its procurement approach to allow completion of detailed design engineering in advance of awarding the contract for the procurement and construction phases. In certain instances, where it made sense to separate the engineering from the procurement and construction, this was done.
- Early completion of detailed design engineering and early completion of assessing was also a lessons learned to mitigate the underestimation of material quantities. This included setting milestone to have all materials delivered before beginning construction.
- Tying-in new facilities to existing station systems is logistically complex and the effort and resources required to integrate with the station must take into consideration the detailed planning, integration coordination and oversight that is required to complete this type of work in operating plant equipment.
- Significantly more OPG oversight of the contractor may be required than initially estimated, particularly for large, first-of-a-kind projects. A detailed risk assessment, including an assessment of contingency for all risks, is required to be performed prior to establishing the project estimate.

# Board Staff Interrogatory #79

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Ref: Exh D2-2-10, page 20
Variances in the total cost of the Water & Sewer project (+6.9M) and the Upgrade to the Electrical System (+$3.9M) were both attributed in part to issues which appear to have been unforeseen, e.g. the soil conditions for the Water & Sewer project or the legacy equipment grounding for the Electrical Power Distribution Project.

a) Were these risks identified at the beginning of the projects? If so, was any mitigation put in place? If not, why not?
b) What has OPG done to eliminate these types of risk going forward with DRP projects?

## Response

a) Risks associated with buried services and soil conditions were identified early in the project planning phase for the Water & Sewer project. These risks were mitigated by reviewing drawings and by scanning underground for buried services as well as by the use of vacuum truck excavation techniques for the initial excavation. The soil conditions under the CN rail line proved more challenging than expected. Contingency budgets for these risks were identified but proved to be insufficient.

   Technical risks and unknown condition risks were identified for the Electrical Power Distribution Project early on. However, there were no reasonable means for the project team, at the planning stage, to identify the unknown specific risk associated with a legacy condition of the site electrical system grounding grid.

b) Upon completion of the Facilities and Infrastructure Projects and Safety Improvement Opportunities, the Darlington Refurbishment Program work will not involve any further ground excavations. Work is primarily on in-station equipment, with the majority of the scope being the Retube and Feeder Replacement. Unforeseen legacy conditions are mitigated through thorough planning including component condition assessments, inspections and system walkdowns during the design and pre-construction phases.

# AMPCO Interrogatory #105

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Ref: D2-2-10 Page 9

Preamble: OPG indicates that it has reviewed the cost classification of DRP projects that resulted in reclassification of certain projects from DRP to the Nuclear Operations Portfolio and certain OM&A costs to Nuclear Operations.

a) Please discuss the criteria OPG used to classify projects within and outside of the DRP.

b) How has the reclassification analysis of DRP projects changed since EB-2013-0321?

c) By year, please provide a complete reconciliation of all of the DRP reclassified costs (capital and OM&A) including a description of the costs and where they have been reclassified to.

## Response

a) Key principles included in the review include:

- The scope of the Darlington Refurbishment Program (DRP) is bounded and limited to the replacement of life limiting components, regulatory and safety improvement work, as well as approved balance of plan (BOP) components best performed in a defueled and dewatered state.
- DRP is a major capital project and as such should exclude OM&A work programs, but continue to include removal costs and low and intermediate level waste (L&ILW) waste costs.

Criteria for costs included in the DRP baseline include:

- Direct costs for DRP scope.
- Costs for resources that directly support DRP projects and program deliverables.
- Incremental facilities and infrastructure required to enable DRP to complete its approved scope.
- Pre-requisite activities if directly related to scope in the DRP execution window.

Criteria for costs excluded from the DRP cost baseline include:

- Costs of activities including operations, maintenance and engineering activities that will continue through the DRP outage period and would be performed even if the DRP project did not occur.
- Incremental costs by corporate or nuclear organizations that do not directly support DRP project and program deliverables.
- Maintaining Darlington's work force capabilities including training costs.
- Facilities and work programs funded by Nuclear Liabilities Waste Provision.

b) In support of the RQE process, Finance conducted an assessment of the RQE cost elements to ensure consistency with OPG's financial policies and governance in establishing the DRP cost baseline.

c) See Chart 1 below. Project costs were reclassified to the Nuclear Operations project portfolio as described in Ex. D2-2-10 p. 9. OM&A costs that were assessed not to be part of DRP were those identified consistent with the criteria for costs not included in DRP listed in part a) above. These costs form part of Darlington OM&A.

**Chart 1**

| | **2015 LTD** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** | **2026** | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OM&A | 12 | 32 | 62 | 48 | 44 | 54 | 63 | 73 | 70 | 49 | 27 | 0 | 533 |
| Capital | 200 | 20 | 31 | 15 | 12 | 14 | 35 | - | - | - | - | - | 327 |

# AMPCO Interrogatory #106

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Ref: D2-2-10 Page 17

a) With respect to the Heavy Water Storage and Drum Handling Facility (Project number 31555), please provide the amount paid to the initial contractor and provide the start and end dates of the contract.

b) Please advise if OPG paid a penalty in the termination of the contract for default.

c) Please provide the amount of the contract to SNC/AECON to complete the project.

d) Please advise if OPG paid a premium to have SNC/AECON complete the project.

e) Please confirm when the contract to SNC/AECON was awarded.

## Response

a) The initial contractor was paid $84.7M with a contract start date of June 3, 2012 for design. The purchase order under the initial contractor's Extended Services Master Services Agreement was terminated by OPG on October 15, 2014.

b) OPG did not pay a penalty in terminating the initial contract for default.

c) The contract value for the SNC/AECON Joint Venture to complete the project is $146.2M.

d) OPG has not paid a premium for the SNC/AECON Joint Venture to complete the project. The remainder of the project was competitively bid under the terms of the Extended Services Master Services Agreement. The target price to complete the project is subject to a performance fee incentive/disincentive.

e) OPG awarded the purchase order to the SNC/AECON Joint Venture on August 17, 2015.

# AMPCO Interrogatory #107

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Ref: D2-2-10 Page 22

Preamble: OPG provides a variance analysis comparing actual versus in-service amounts for the years 2013 to 2015.

a) Please advise of the lessons learned in analyzing the variances and how the lessons have been applied to the DRP.

## Response

OPG does not look specifically to variances in in-service amounts for lessons learned. These types of in-service variances often occur as a result of project schedule changes or delays. However, OPG does assess variances against project costs on a monthly basis, as well as at project closure.

For more information on lessons learned from OPG projects, please refer to;

- Ex. D2-2-4, p. 4 Chart 1
- Ex. D2-2-10 section 2.4.5
- Ex. L-04.3-1 Staff-053
- Ex. L-04.3-2 AMPCO-52
- Ex. L-04.3-15 SEC-20

# CCC Interrogatory #22

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Reference: Ex. D2/T2/S8/p. 1

On November 13, 2015 OPG's Board of Directors approved the Release Quality Estimate and Execution Phase Business Case Summary for the DRP. Please provide copies of all materials provided to the Board of Directors when seeking its approval of the DRP in November 2015.

## Response

Please see the memorandum attached that was provided to OPG's Board of Directors when approval of the Darlington Refurbishment Program Release Quality Estimate was sought in November 2015. The attachment contains confidential content as marked.

ONTARIO POWER GENERATION

**FOR APPROVAL by the Board of Directors**

**November 13, 2015**

# DARLINGTON REFURBISHMENT PROGRAM
# FINAL COST AND SCHEDULE ESTIMATE – FUNDING TO OCTOBER 2016

## DECISION REQUIRED

The purpose of this memo is to provide a summary of the Execution Phase business case for the Darlington Refurbishment Program ("DRP") and request approvals for the following:

- Approval of the 4-unit high confidence cost estimate;
- Approval of the 4-unit high confidence schedule; and
- Approval to transition from the Definition Phase to the Execution Phase including a release of funds for mobilization activities for the first unit, to October 2016.

## ISSUE

In 2009, the Board of Directors approved the Darlington Refurbishment Project Feasibility Business Case and provided funding to proceed to the Definition Phase of the project.

On October 1st, Management provided an update on the DRP, as referenced in Appendix 1. The update included the following:

- An overview of the history of the DRP and key decisions,
- A review of how the Levelized Unit Energy Cost (LUEC) compares to other Provincial options to supply 3,500 MW of baseload electricity,
- A review of project readiness and the preliminary 4-unit cost, schedule and business case,
- How oversight and assurance would be performed on the project,
- An overview of the risk management processes that support the DRP, and
- An update on Cost Recovery, Financing Strategy, Resourcing Strategy, and Communications.

Since that time, management has evaluated and prepared responses to the Board's key questions and has finalized the high confidence 4-unit cost and schedule estimate.

## ANALYSIS

**Management is providing, for information, responses to the following items raised at the October 1st meeting.**

**1. Resource-related risks have been assessed and preliminary mitigation strategies are in place.**

As a result of un-lapping Unit 2 and the reduction in resource requirements near the end of Unit 2, there is a risk that key resources may leave and not return to execute the refurbishment of Unit 3. This could result in schedule delays, increased cost, loss of lessons learned, loss of unit-over-unit performance improvements, and a potential loss of project momentum. This risk will be mitigated through:

- Re-alignment of Refurbishment work to the extent possible,
- Assigning certain resources to the Nuclear Project Portfolio and Station Life Extension work that will be purposely scheduled into this period, and
- Utilizing these resources to support fleet outage work.

In the unlikely event that this effort does not fully mitigate the issue, OPG has included $50 Million in the contingency estimate to retain select critical resources during this period.

There is a further risk of not having adequate resources when two units are overlapped (2021 to 2024). A resource-loaded project schedule has been developed for this period to allow for detailed analysis and assessment of exposure to this risk. The ability to secure, train, and deploy the resources (trades, supervision and knowledge workers) is currently being examined as a refurbishment key risk area, and tailored mitigation plans are in development. Similar to Unit 2, early integration and collaboration with vendors, trades unions and organizations such as Buildforce Canada will be a key component of mitigation.

OPG will continue to assess these risks and develop mitigation plans over the coming months as part of the Ready to Execute plan.

**2. Execution Phase contracts are in place.**

Agreement has been reached on the Execution Phase Target Price for the Re-tube & Feeder Replacement contract with the SNC Lavalin/Aecon joint venture. OPG will sign the final contract after shareholder approval is obtained for the DRP, and a mechanism that keeps the contract in effect in the event of a lengthy provincial approvals process is being implemented. Supporting details, including the final cost and schedule of the Re-tube Waste Processing Building and updates of procedures to align with the basis of estimate, are being finalized.

The total Engineer Procure Construct vendor estimate included within the projects high confidence estimate is $6.1 Billion, as shown in Table 1.

**Table 1: EPC Vendor Cost Estimate by Project**

| Project | EPC Vendor (s) | Definition Phase | Execution Phase | Total Estimate |
|---|---|---|---|---|
| Re-tube & Feeder Replacement | SNC Lavalin/Aecon JV | $0.7 | $2.8 | $3.5 |
| Turbine Generator | Alstom (Parts) and SNC Lavalin/Aecon JV (Execution) | 0.1 | 0.5 | 0.6 |
| Steam Generators | Babcock & Wilcox / CANDU Energy JV | < 0.1 | 0.1 | 0.1 |
| Fuel Handling and Defueling | General Electric / SNC Lavalin/Aecon JV / ES Fox | < 0.1 | 0.1 | 0.2 |
| Balance of Plant | ES Fox / Babcock & Wilcox / SNC Lavalin/Aecon JV | 0.2 | 0.7 | 0.8 |
| Facilities, Infrastructure, and Safety Improvement Projects | ES Fox / SNC Lavalin/Aecon JV | 0.6 | 0.3 | 0.9 |
| **Total EPC Vendor Contract Costs** *Note: Numbers may not add due to rounding.* | | **$1.6 Billion** | **$4.5 Billion** | **$6.1 Billion** |

**3. OPG's oversight requirement has been assessed and is deemed to be appropriately sized.**

Based on current operating experience, a further assessment of OPG's oversight requirements has been conducted, and additional resources have been added in the following areas:

- Field construction support and oversight;
- Quality surveillance;
- Source surveillance and vendor procurement; and
- Contract and claims management.

An overall histogram of OPG and vendor resources is shown in Appendix 3. Appendix 4 provides a further breakdown of OPG's project management, support, and oversight functions. Management believes that this is sufficient to effectively manage and oversee the work being performed.

**4. A detailed review of project risks and contingencies is now complete.**

Since the October Board meeting, Management has finalized its review of schedule and cost risks.

The final contingency was derived through a detailed analysis and modelling of cost and schedule estimate uncertainties, discrete risks, and contingent work across the entire program. The outcome of this analysis yielded that, at a high (90%) confidence, the estimate should include $1.7 Billion (2015$) of contingency, as summarized in Table 2.

**Table 2: 4-Unit Contingency Summaries**

| Project | Estimate Class | Project Contingency ($M) | Program Contingency ($M) | Total Contingency ($M) | % of Project Estimate to Complete |
|---|---|---|---|---|---|
| Re-tube & Feeder Replacement | Class 2 | 236 | 381 | **617** | **26%** |
| Turbine Generator | Class 2 – 3 | 195 | 23 | **218** | **50%** |
| Steam Generators | Class 2 | 20 | - | **20** | **20%** |
| Fuel Handling and Defueling | Class 3 | 25 | 38 | **63** | **52%** |
| Balance of Plant | Class 3 - 5 | 230 | - | **230** | **34%** |
| Facilities, Infrastructure, and Safety Improvement Projects | Class 1 – 3 | 42 | 34 | **76** | **35%** |
| Project Execution and Operations and Maintenance | Not Applicable | 58 | 222 | **280** | |
| Unallocated Program Contingency | Not Applicable | - | 202 | **202** | |
| **Total Contingency ($B)** | | **$0.8 Billion** | **$0.9 Billion** | **$1.7 Billion** | |

A contingency of $1.7 Billion represents 25% of the Execution Phase estimate ($6.7 Billion), or 38% of the external vendors' estimate ($4.5 Billion). With 90% of the estimates well defined at Class 3 or better, Management believes that the contingency amount is sufficient.

For a project of this size and duration, there are a number of low probability high consequence events that could impact the project and that are outside of the contingency determined for the project. Due to the low probabilities, these items would not contribute sufficiently to a probabilistic assessment used in establishing project contingency.

Management has compiled a list of such events that could occur, and are beyond the ability of the project to manage or mitigate. By their nature, these low probability events are hard to predict both in timing and magnitude, and typically have a very high impact on project costs and schedule should they occur. Examples of events may include force majeure, a significant labour disruption, changes in the political environment, an international nuclear accident (Fukushima-type event) or incident, and unforeseen changes to financial and other economic factors beyond those assumed in the project.

It is difficult to assess the impact of such events, however, Management's assessment concluded that these low probability events, if they did occur, may result in a project cost impact of up to $0.8 Billion and would cover each of the following potential scenarios:

- Anticipated interest and escalation rates each increase by 1% over the high confidence estimate assumption of 5% and 2%, respectively, for the entire duration of the project.
- An additional cumulative critical path extension of 1.7 years is endured (over and above the 1.2 years of schedule contingency funding included in the base estimate).
- An international nuclear event, or politically or regulatory driven mandate, results in a need to install new or modified upgrades. $800M is approximately three times the costs of the entire portfolio of Safety Improvement projects executed by Refurbishment.

If such an event were to occur, Management would evaluate the cost and schedule consequences of the event and provide a recommendation to the Board for approval on the appropriate response.

Additional information on the contingency analysis is included in Appendix 2.

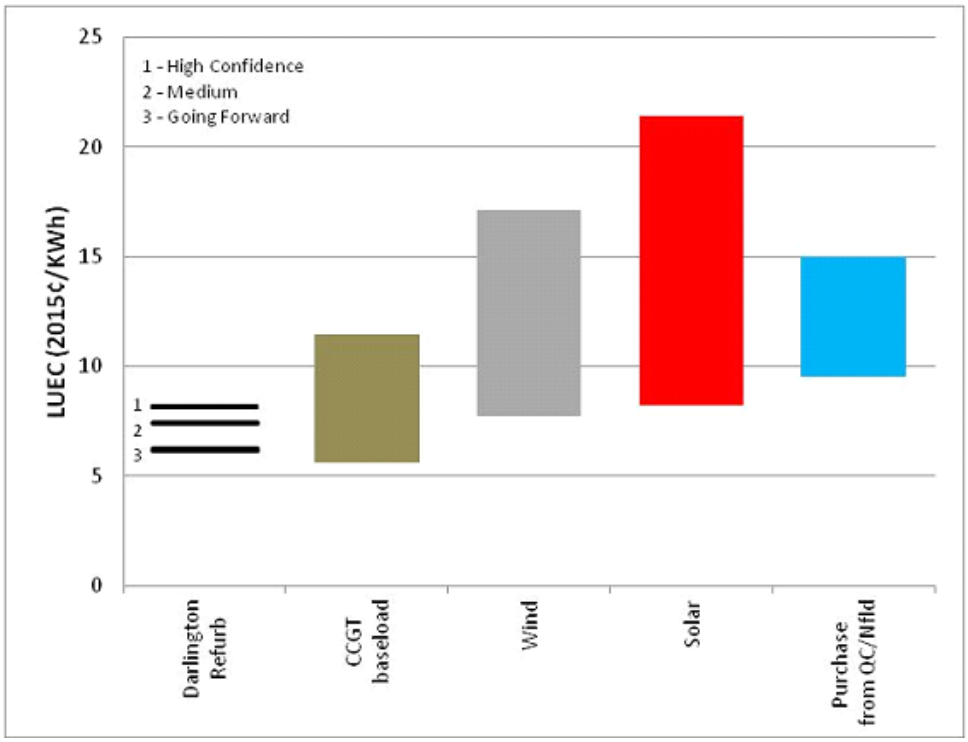
**5. The high confidence Levelized Unit Energy Cost of 8.1¢/kWh compares favourably to alternative sources.**

LUEC (Levelized Unit Energy Cost) is an economic measure used to facilitate consistent cost comparisons across generation options. As presented below in Figure 1, DRP compares favourably to all other Provincial options to supply 3,500 MW of baseload electricity.

The three point estimates presented for DRP are as follows:

- High Confidence 8.1¢/kWh – $12.8 Billion project cost; 88% capacity factor; $1.1 Billion annual OM&A costs over a 30 year life.
- Medium Confidence 7.2¢/kWh – $12.2 Billion project cost; 90% capacity factor; $1.0B annual OM&A costs over a 35 year life.
- Going Forward Medium Confidence (excludes sunk costs of $2.2 Billion) 6.4¢/kWh – $10.0 Billion project cost; 90% capacity factor; $1.0 Billion annual OM&A costs over a 35 year life.

**Figure 1: Levelized Unit Energy Cost Comparables**




A number of assumptions have been made to develop the ranges presented above. These assumptions are supported by external industry sources and supplemented by OPG's market intelligence. Further details on economic and operational characteristics of each of the options are provided in Appendix 2.

**Management is providing the following information to support the approval requests included in this memorandum.**

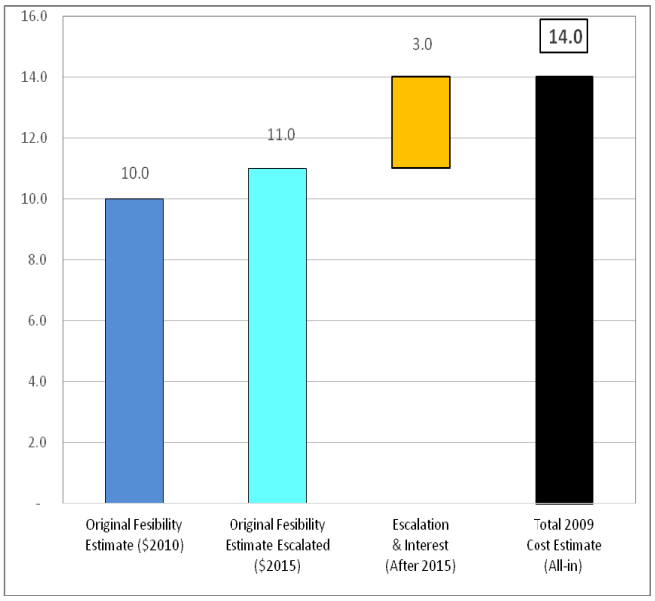
**1. The 4-Unit high confidence cost estimate has been established.**

In 2010, Management communicated that the high confidence DRP estimate would be less than $10.0 Billion. Including inflation and interest, this estimate would be less than $14.0 Billion.

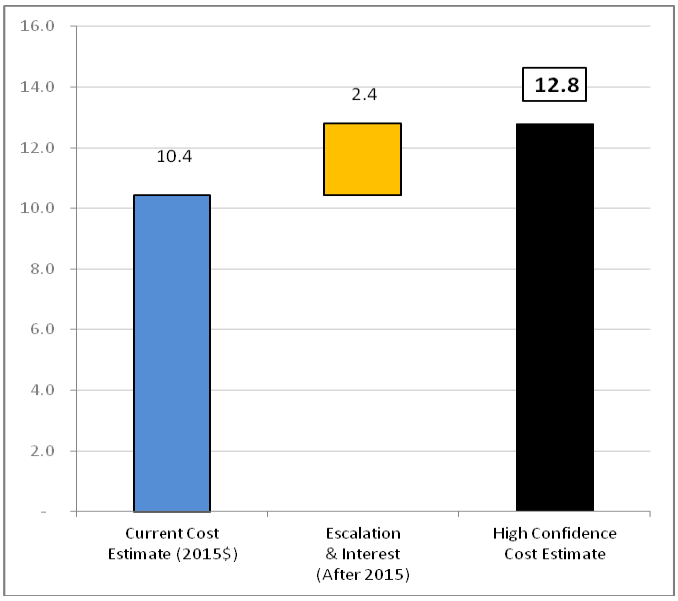
Management has completed Definition Phase planning and, has high confidence that the cost for refurbishing 4 units will be less than $12.8 Billion, including Definition Phase costs ($2.2 Billion), contingency ($1.7 Billion), inflation ($0.9 Billion), and interest ($1.3 Billion).

As shown in Figure 2, the current 4-unit estimate is $1.2 Billion lower than the original feasibility estimate communicated in 2010.

**Figure 2: Cost Comparison, 2010 vs. Current 4-Unit Cost Estimate**



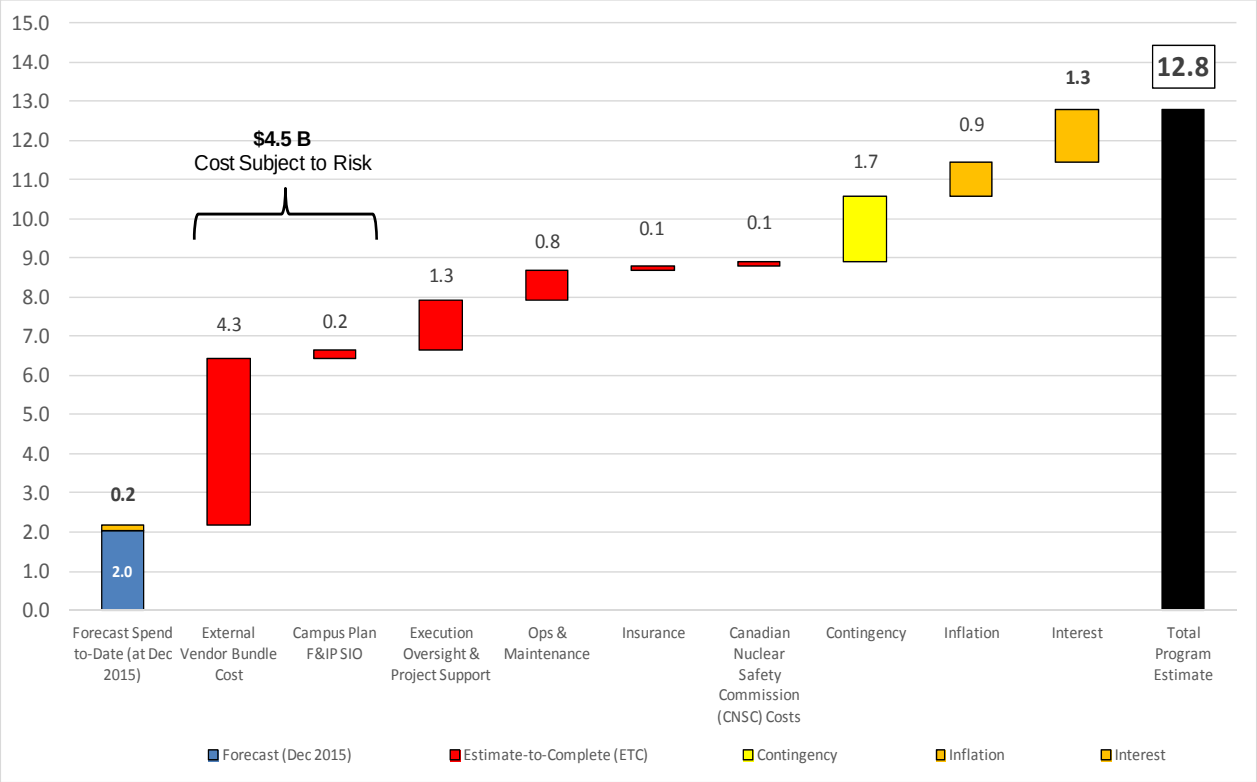

**Original Feasibility Estimate ($ Billion)**




**Current 4-Unit Cost Estimate ($ Billion)**

Figure 3 below, provides a summary of the build-up of the 4-unit high confidence cost estimate.

**Figure 3: 4-Unit Cost Estimate Build-up**




Appendix 2 provides a more detailed breakdown of the overall cost estimate including details on the 4-unit cash flow and release strategy.

**Management recommends Approval of the 4-unit high confidence cost estimate of $12.8 Billion, including $1.7 Billion of project contingency.**

**2. The 4-Unit high confidence schedule has been established.**

As part of the Definition Phase, OPG has integrated all vendor schedules, determined the critical path for the project and created a schedule provided in Appendix 4 for Unit 2 critical path. OPG evaluated risks for each segment of the schedule, determined the amount of contingency required to deliver the project, and produced a medium confidence (P50) and a high confidence (P90) schedule.

OPG will manage day-to-day project performance using the medium confidence schedule. The medium confidence schedule will also be used to determine contractor incentives and disincentives, where applicable, and will form the basis of project controlled schedule contingency. The 4-unit medium confidence schedule is shown in Table 3.

**Table 3: Refurbishment 4-Unit MEDIUM Confidence Project Schedule**

| Unit | Start[(1)] | Finish | Duration (Months) | Month when Unit Reaches 235,000 EFPH |
|---|---|---|---|---|
| Unit 2 | 15-Oct-16 | 15-Nov-19 | 37 | Feb-22 |
| Unit 3 | 15-Dec-19 | 15-Dec-22 | 36 | Dec-22 |
| Unit 1 | 15-Apr-21 | 15-Mar-24 | 35 | Sep-22 |
| Unit 4 | 15-Jan-23 | 15-Nov-25 | 34 | Sep-23 |
| **4 Units** | **15-Oct-16** | **15-Nov-25** | **109** | |

The high confidence schedule, as shown in Table 4, includes contingency for certain schedule risks that may be encountered during the execution of the refurbishment outages, and will form the basis of program controlled schedule contingency. This schedule will also be the basis for external communication and measurement. The high confidence duration for each unit is 37 to 40 months.

**Table 4: Refurbishment 4-Unit HIGH Confidence Project Schedule**

| Unit | Start[(1)] | Finish | Duration (Months) | Month when Unit Reaches 235,000 EFPH |
|---|---|---|---|---|
| Unit 2 | 15-Oct-16 | 15-Feb-20 | 40 | Feb-22 |
| Unit 3 | 15-Dec-19 | 15-Apr-23 | 40 | Dec-22 |
| Unit 1 | 15-Apr-21 | 15-Jun-24 | 38 | Sep-22 |
| Unit 4 | 15-Jan-23 | 15-Feb-26 | 37 | Sep-23 |
| **4 Units** | **15-Oct-16** | **15-Feb-26** | **112** | |

(1) Based on early start date, aligned with the Medium Confidence schedule duration and logic.

Based on the current high confidence that each of the 4 units will operate to 235,000 Effective Full Power Hours (EFPH), this schedule results in no idle time on operating units.

**Management recommends approval of the 4-unit high confidence schedule with a total duration of 40 months for Unit 2 and 112 months for all 4 units.**

**3. OPG is ready to transition to the Execution Phase and commence Unit 2 mobilization activities.**

With the Board's approval to proceed to the Execution Phase of the project, Management is expecting to spend $1,021 Million to October 15, 2016 (Unit 2 Breaker Open) for continued construction of the remaining Facility & Infrastructure and Safety Improvement projects and to commence Unit 2 mobilization, training, and installation of in-station support facilities. The release also includes some funding to commence long lead procurement for Unit 3 turbine control system and stator and Re-tube and Feeder Replacement engineering for subsequent units.

As of November 2014, $2,548 Million was released to the project with a forecast to spend $2,207 Million by the end of the Definition Phase. Incremental funding of $681 Million is required to complete these activities. A breakdown of the funding request is included in Appendix 6.

In August 2016, OPG will return to the Board with a request for funding to complete the refurbishment of Unit 2, commencing October 2016. Management will provide regular progress updates to the Board.

**Management recommends approval for the project team to transition from the Definition Phase to the Execution Phase including a release of funds in the amount of $681 Million for mobilization activities for the first unit, to October 2016.**

## RECOMMENDATION / RESOLUTION

Management is requesting that the Board of Directors approve the following items related to the DRP:

- Approval of the 4-unit high confidence cost estimate of $12.8 Billion, including $1.7 Billion of project contingency;
- Approval of the 4-unit high confidence schedule with a total duration of 40 months for Unit 2 and 112 months for all 4 units; and
- Approval to transition from the Definition Phase to the Execution Phase including a release of funds in the amount of $681 Million for mobilization activities for the first unit, to October 2016.

| **Recommended by:** | **Approved for submission to the Board of Directors by:** |
|---|---|
| _____ | _____ |
| Dietmar Reiner<br>Senior Vice President, Nuclear Projects | Jeff Lyash<br>President and CEO |

This Board memo was reviewed and approved for submission to the Board of Directors by the Darlington Refurbishment Committee at their meeting of November 12, 2015.

## APPENDICES

1. Board of Director's Annual Retreat and Strategy Session, October 1st, Darlington Nuclear Refurbishment Project
2. DRP 4-Unit Cost and Schedule Estimate and Economic Summary
3. DRP 4-Unit Total Resource Histogram
4. DRP 4-Unit OPG Owner's Resource Histogram
5. Unit 2 Critical Path Schedule Overview
6. Summary of Release amount for Unit 2 Mobilization Activities

ONTARIO POWER GENERATION

**FOR INFORMATION to the Board of Directors**

**October 1, 2015**

# Darlington Nuclear Refurbishment Project: Context and Rationale

## REASON FOR REPORT

Provide the Board a brief background on the history and context of Darlington Nuclear Refurbishment Project, as well as an understanding of the broader rationale for the project.

## HIGHLIGHTS

### 1. Project History and Context

In June 2006, the Ontario Government directed OPG to begin feasibility studies on refurbishing its existing nuclear plants. OPG commenced the Initiation Phase of the Darlington Refurbishment project, including an economic feasibility assessment, in late 2007. The objective of the Darlington Refurbishment Program is to extend the operating life of the station by approximately 30 years. The refurbishment involves an outage for replacement of life-limiting components, as well as maintenance or replacement of other components which are most effectively done during the refurbishment outage period.

In November 2009, based on the economics of the Program as documented in the preliminary business case, the OPG Board of Directors approved the overall timeline and release strategy for the refurbishment and released funds to complete preliminary planning within the Definition Phase of the Program and to commence development of the required infrastructure. The business case concluded that the economics of refurbishing the Darlington Station were more attractive than alternative generation options with a high confidence LUEC of <8 ¢/kWh (2009$).

The Minister of Energy concurred in February 2010 with OPG Board's decision relating to the refurbishment of Darlington and reinforced the importance of the nuclear fleet to the province's electricity supply in the future as the government continues to reduce greenhouse gas emissions. This message was reinforced by the government again in 2011 with the issuance of the Supply Mix Directive to the OPA which directed the OPA to plan for nuclear to continue to represent 50% of the generation mix and to plan for the refurbishment of Darlington and Bruce Power units. Since 2011, the Minister has continued to acknowledge our progress and encourage the progress of the project annually in the Business Plan concurrence letters.

In July 2011, OPG broke ground on the Darlington Energy Centre which would house the reactor mock-up, a key aspect of the planning process as it would allow tools and procedures to be tested and workers to rehearse in exact replica of the reactor face. This was a key lesson learned from previous refurbishments.

In December 2011, Management submitted the Environmental Assessment documents to the CNSC to commence the environmental approval process for refurbishment which would set key parameters that the project would need to meet in executing the refurbishment and continuing operations for a further 30 years.

In March 2012, OPG awarded the Retube and Feeder Replacement contract (R&FR) representing the first major contract under management's contracting strategy. The contract outlined a process to allow the contractor to develop tools and procedures early in planning and test those tools in the mock-up environment prior to committing to a cost and schedule estimate.

Reinforcing its commitment to nuclear refurbishment, the government issued the Long Term Energy Plan (LTEP) in December 2013 outlining the importance of refurbishing Darlington and Bruce Power units to the electricity system. The LTEP included key principles to utilize in planning the refurbishment projects. These principles were incorporated, to the extent already not utilized, into Management's planning and approach.

Based on a funding release strategy approved by the OPG Board in 2009, the Board approved annual funding releases each November between 2011-2014, based on a project updates including confirmation that the cost estimate and corresponding LUEC were still within the bounding estimates provided in 2009.

## 2. Rationale for Darlington Refurbishment

Darlington is one of the best performing CANDU nuclear plants in the world and was the first CANDU station to receive the highest WANO rating. It is the only CANDU plant in the world to receive the highest WANO rating in successive assessments. Over the past 5 years, Darlington has achieved an operating capacity factor of approximately 90%.

Baseload power generated by Darlington today needs to be replaced. Refurbishing Darlington is the best alternative compared to other forms of generation, considering LUEC[1] and other key factors, including greenhouse gas emissions, economic development in Ontario, local community support and feasibility of completing other potential options.

Supplying Needed Baseload Generation to Ontario

Darlington currently represents 13% of the Ontario's generating capacity and 20% of the energy consumed in the province. In accordance with the 2013 LTEP, the capacity that Darlington provides must be replaced one-for-one as conservation and efficiency standards will only offset demand growth and are not expected to reduce the existing demand. While the province has successfully developed significant wind and solar generation assets for the last few years, they do not represent reliable baseload generation, given their variability with atmospheric conditions. While CCGT's can play a role in baseload generation requirements, the Darlington refurbishment option also has the advantage of being an existing plant sited in a supportive community with existing transmission infrastructure.

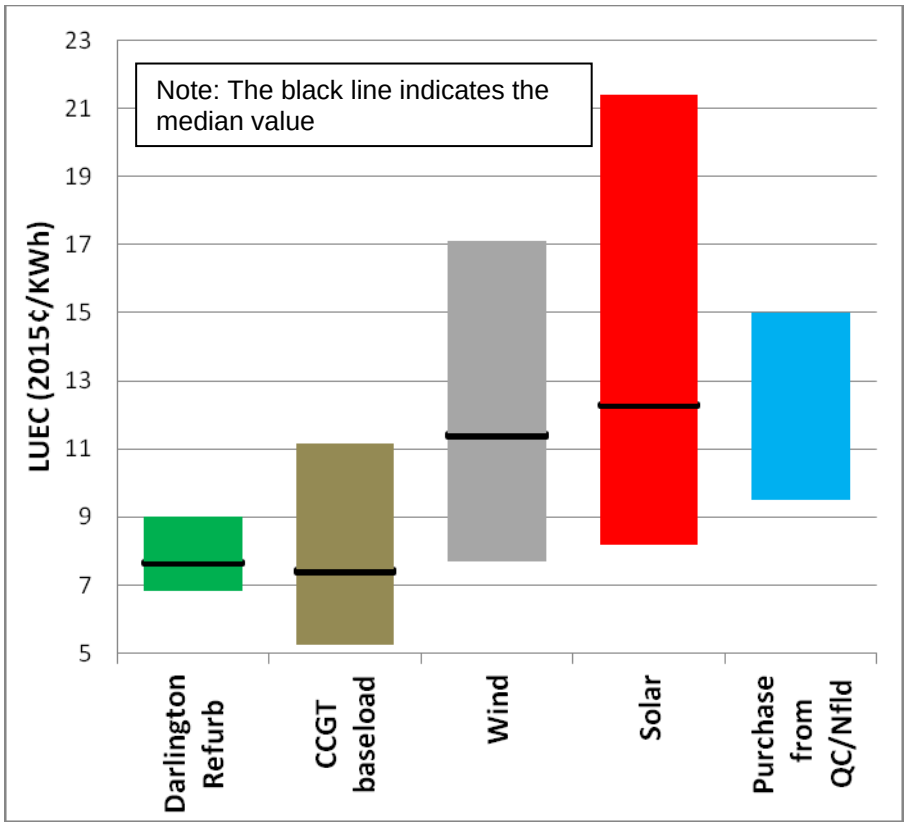
Economics of Darlington Comparable with Alternatives

The economics of refurbishing the Darlington Station are comparable with or better than other alternatives for Ontario, including the cost of gas-fired generation at median gas price forecasts and median values for carbon reduction. In 2010, OPG had publicly communicated that the economic LUEC would be less than 8 ¢/kWh in 2009$, which is equivalent to 9.0 ¢/kWh in 2015$. OPG's current estimate of the LUEC of 8.1 ¢/kWh (2015$) is well within the estimate OPG had publicly communicated in 2010.

Darlington's LUEC compares very favourably with alternatives such as imports from Quebec and Newfoundland, wind and solar. There is also considerable security of supply risk resulting from relying heavily on imports from Quebec or Newfoundland in the long term.

While CCGT's show a comparable LUEC at median to high long term gas prices and carbon prices, there is significant risk with the long term commodity prices inherent in the economics of a CCGT plant. In addition, the use of an existing generation site with a proven environmental record and a supportive host community avoids the additional costs to ratepayers of site selection, securing environmental approvals and development of host community support at multiple alternative sites.

[1] : Levelized Unit Energy Cost (LUEC) is an economic measure, often used as a screening tool to facilitate consistent cost comparisons across generation options that have similar applications (e.g. base-load); It provides a true comparator for the cost throughout the lifetime of the generation asset.




Enabling Greenhouse Gas Reductions

The refurbishment of Darlington supports the government's goal of reducing greenhouse gas emissions. The government has expended considerable effort over the last 10 years to reduce greenhouse gas from electricity generation including shutting down all coal-fired stations in the province. On a lifecycle basis, including construction and fabrication of equipment and building materials, GHG emissions from a nuclear power plant per MWh are comparable to those from wind generation. During operations, Darlington will produce effectively zero greenhouse gas emissions.

Refurbishing Ontario's nuclear fleet (Darlington and Bruce Power units) ensures that Ontario retains the benefits of reduced emissions that it gained in moving away from coal. If the nuclear fleet is not refurbished, Ontario would be at risk of returning to pre-coal era emissions levels, thereby negating the benefits achieved.

Substantial Economic Benefits to Municipality and Province of Refurbishment

Refurbishing the Darlington plant will increase Ontario's GDP by $14.6B[2] during the planning and refurbishment period.

There are substantial economic benefits of refurbishing the Darlington Station in terms of direct, indirect and induced job creation. OPG is the largest employer in the Municipality of Clarington, employing 2300 people at the Darlington site and an additional 500 are located at the Darlington Energy Complex. Closure of the Darlington station would result in significant job loss.

The project will boost employment by an average of 8,600 jobs during refurbishment, peaking in 2019 with 12,100 jobs. Over 50 companies have been engaged in the refurbishment project to date, 80% of which are based in Ontario. The geographic dispersion of these companies across southern Ontario brings jobs to many communities beyond the Durham region.

[2] Based on a draft Conference Board of Canada analysis. The final report is expected to be issued in November 2015.

Continued operation of the Darlington Station (post-refurbishment) will maintain the same level of employment as is currently associated with the Darlington Station for an additional 30 years. Economic impact studies indicate that post-refurbishment operations of the Darlington Station will result in approximately 5,700 resident jobs in Durham Region (direct, indirect and induced) for the additional 30 years.

In addition to job creation, OPG currently pays $4M in property taxes to both the Municipality of Clarington and the Province of Ontario. Beyond the taxes paid, OPG provides leadership and energy to community organizations across Durham and has contributed over $25M in community investment support in Durham Region since 1999.

Creating Value for Energy Sector

The Ontario government's LTEP established a mandate to export Ontario's home-grown nuclear industry expertise, products and services to international markets. With over 50 companies engaged to participate in the refurbishment project and over 80% of them located in Ontario, the project will build and strengthen Ontario's nuclear sector, in line with the LTEP goal. This will create opportunities to export resources and intellectual property globally for upcoming CANDU refurbishments and promote domestic and foreign investment opportunities in the nuclear space and adjacent sectors.

Capturing Benefits for Taxpayers and Ratepayers of Ontario

Refurbishing Darlington ensures that tax dollars are retained in Ontario, both from the taxes remitted during execution phase and net income and payments in lieu of taxes accruing to the Province during the 30 additional years of OPG operations.

In an independent report commissioned by the OPG Board in 2014, alternate ownership structures for completing the refurbishment were explored including:

- OPG on its own
- OPG partnering with a 3rd party
- A 3rd party on its own

The report concluded that OPG completing the project on its own was the best option for the ratepayers and taxpayers of Ontario, as it represented the most financially attractive option with the lowest rate impact to consumers and the greatest financial value and viability to OPG. One key driver of this value relates to OPG earning a regulated return as opposed to contracted return that includes construction risk premium.

In addition, this option provides flexibility for the Province to manage the velocity of electricity rate increases to the consumer through smoothing mechanisms at the OEB.

## 3. OPG's Strategic Approach to Refurbishment

OPG has focused on taking a long term, risk-informed approach to refurbishment. This approach is enabled by the regulatory structure that gives OPG reasonable certainty of recovering costs prudently incurred during the planning phase. As a result, OPG has been able to spend sufficient time and effort during the Definition Phase of the project to eliminate as much risk as possible prior to the decision to proceed with the first unit.

OPG has taken a holistic and long term approach to environmental and licensing approvals to understand, confirm and incorporate requirements into the planning phase to ensure Darlington has a 30 year life extension with reasonable licensing certainty.

Additionally, OPG's contracting strategy, including the use of the mockup facility, allows contractors enough time and provides the right tools to develop confidence in cost and schedule estimates. This ensures that certain risk contingencies can be removed from the estimates, not just transferred between the parties.

These upfront planning activities not only help ensure that OPG is adequately prepared for refurbishment but also increase the confidence in delivering the project on time and on budget.

[redacted]

[redacted]

## 4. OPG is Prepared for a Successful Execution of Darlington Refurbishment

OPG has captured operating experience and lessons from Darlington projects, past Candu refurbishments and other large projects. For each lesson learned identified (currently 120 lessons learned have been captured through the process), appropriate actions have been identified to apply the lesson learned to OPG's unique context and operating environment. OPG continues to gather lessons learned and collaborate with Bruce Power to share learnings during the overlapping refurbishments. In addition, OPG ensures that the contractors are incorporating lessons learned into their plans. Key lessons learned that were addressed in the planning phase include the construction of a full-scale reactor mock-up and the completion of the detailed design engineering in advance of finalizing the RQE.

OPG's approach to contracting has allowed contractors to be engaged in the early stage scoping and planning. The multi-contractor model enables reasonable risk transfer to the vendors while retaining OPG accountability for safety and quality. Having the contractors engaged early has provided them sufficient time and access to the mock-up facility. This allows the cost and schedule estimates to carry less contingency as the tools have been tested and execution times have been validated**.**

OPG's management team has significant experience working on major projects and Candu refurbishments. Strategies are being identified to allow for retention of key staff during the individual unit refurbishments, as well as succession planning and knowledge transfer for successive units.

## CONCLUSIONS

The Darlington refurbishment project is in the best interests of the ratepayers and taxpayers of Ontario and supports the government's environmental and economic development policies. It has been thoughtfully planned over a number of years to ensure OPG is ready to execute.

**Submitted by:**

*"Original signed by:"*

Glenn Jager
President, OPG Nuclear and
Chief Nuclear Officer

## APPENDICES

-None

# Darlington Nuclear Refurbishment Project:
# Context and Rationale

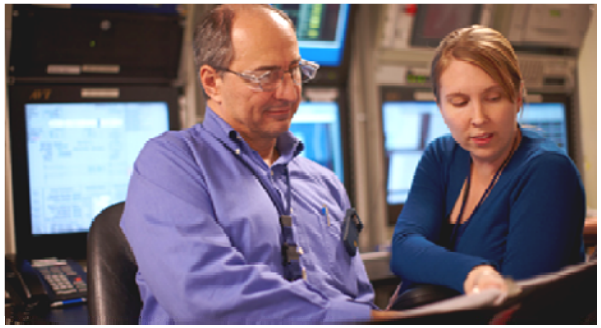
**OPG Board of Directors**
**October 1, 2015**

**Glenn Jager**
**President , OPG Nuclear and**
**Chief Nuclear Officer**

BEHAVIOURS

- Say It, Do It
- Simplify It
- Think Top and Bottom Line
- Integrate and Collaborate
- Tell It As It Is



VALUES ▪ SAFETY ▪ INTEGRITY ▪ EXCELLENCE ▪ PEOPLE & CITIZENSHIP ▪

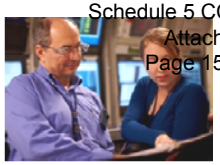
PEOPLE POWERING THE FUTURE OPG NUCLEAR



ONTARIO POWER GENERATION

# Objectives

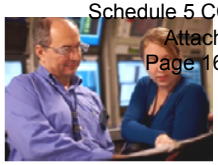




**The objective of this presentation is to provide an overview of the context and background of the Darlington Nuclear Refurbishment Project**

- History of DNP decision-making to-date
- Rationale for DNP compared to other generation alternatives and the benefits to Ontarian's from lower cost, reliable, and clean baseload generation
- OPG's strategic approach and why we are ready

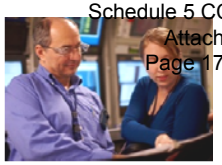




# THE HISTORY OF DNP DECISION-MAKING TO DATE

# Project History





## Since the Ontario Government directed OPG to begin DNP feasibility work in 2006, a series of informed decisions have been made to progress the program. Decision making has been guided by OPG business principles and the Ministry of Energy's principles for nuclear refurbishment in Ontario's LTEP

**June 2006**

OPG shareholder directive to **commence feasibility studies** on Darlington refurbishment

**February 2010**

Shareholder **confirms OPG decision** for DNP and continuing PNGS operations

Reinforces importance of nuclear to meeting demand while reducing emissions

**February 2011**

OPG shareholder issues **supply mix directive** to OPA; nuclear to represent 50% of generation mix

Includes notice to plan for upcoming DNGS and Bruce Power refurbishments

**December 2013**

**LTEP released**, confirming importance of nuclear generation and **outlining seven key principles** for refurbishment planning

**Legend**

- Shareholder communications
- Board approvals

Continual support from the Shareholder for Darlington Refurb

**November 2009**

Board **approval for DNP** timeline and release strategy with 8¢/kWh (2009$) LUEC, and funding release to continue Definition Phase

**May 2011**

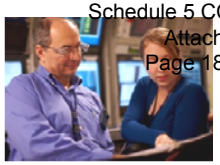
Board **approval for detailed planning within Definition phase**, including building the Darlington Energy Center

**November 2011** **November 2012** **November 2013** **November 2014**

Annual Board review of project status and funding release

# Major Project Decision Points





## Management decision making has been guided by shareholder and Board interactions; the Board has been informed of major decisions and milestones

**June 2006**

OPG shareholder directive to **commence feasibility studies** on Darlington refurbishment

**February 2010**

OPG publicly announces start of planning for DNP

**December 2011**

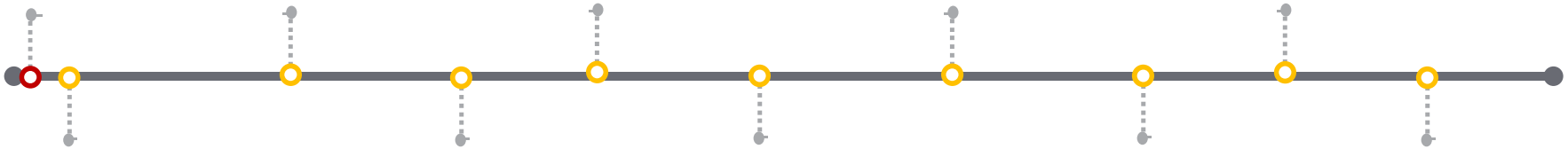
EA submitted to CNSC to commence environmental approval process

**March 2013**

CNSC issues EA approval for a 30 year duration, which creates long term predictability around generation profile

**December 2013**

Turbine generator contract awarded



**2008**

CEO approves the reference scope and schedule to set base planning assumptions for Definition phase work

**July 2011**

Groundbreaking ceremony for Darlington Energy Centre – allows reactor mock up to be built well in advance of execution to enable high-confidence cost and schedule planning

**March 2012**

R&FR contract awarded to allow for active vendor participation in scoping and planning

**June 2013**

Management recommends unlapping units to facilitate lessons learned and create incremental review points for Board

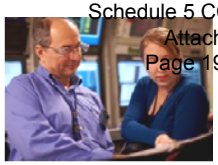
**November 2015**

Management to present RQE and schedule for final approval

**Legend**

- Shareholder communications
- Management decisions and project milestones

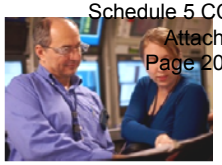




# THE RATIONALE FOR REFURBISHING DNGS IS CLEAR

# The Rationale for DNP





## In addition to the value DNP will provide to OPG, Darlington will benefit all Ontarians ensuring lower cost, reliable, clean baseload generation, as well as delivering substantial economic benefits to the province

### Value to Customers:

- Darlington refurbishment is the best option to provide required and reliable baseload generation for Ontario
- DNP offers a competitive economic alternative relative to other generation options
- Darlington's excellent material condition and status as a WANO 1 world class facility with an excellent operating track record makes it a strong candidate for refurbishment
- OPG can benefit ratepayers by taking a long-term, risk-informed approach to refurbishment

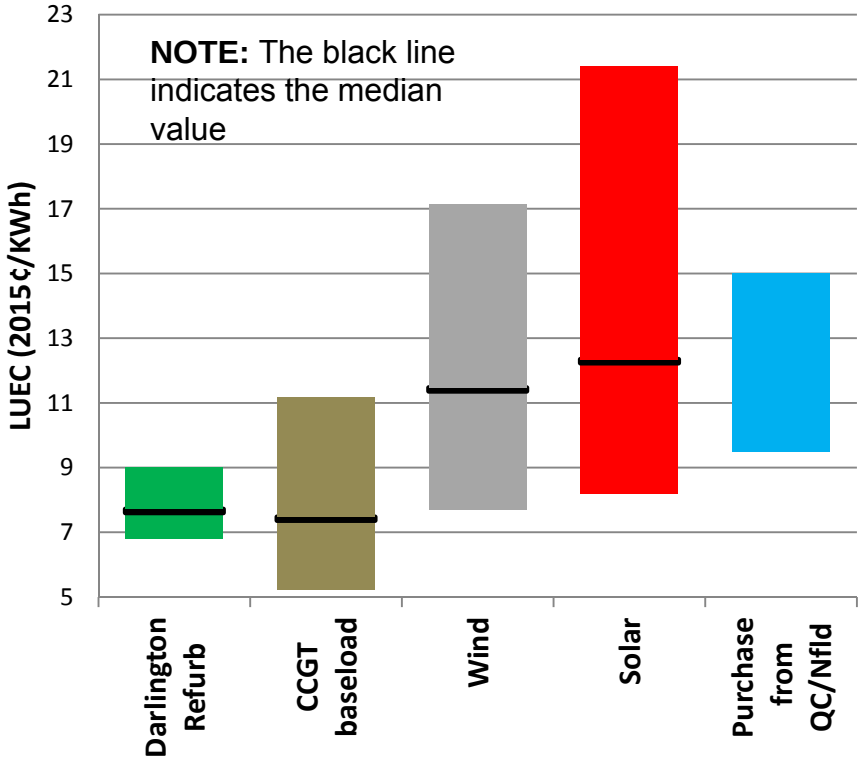
### Value to Shareholder:

- DNP will supply Ontario with clean, greenhouse emissions free energy allowing Ontario to retain the environmental benefits of coal closure
- DNP will create and maintain jobs, strengthen Ontario's nuclear sector, and retain taxpayer benefits (OPG net income and Payments in Lieu of Taxes) in Ontario

# Alternative Comparison

## In addition to qualitative benefits of DRNP over alternatives, DNP offers a comparable LUEC to CCGT and lower LUEC than other alternatives

### Generation LUEC Comparison




### Qualitative Benefits of DNP

- Negligible long term commodity cost risk compared to CCGT's
- Existing connection to the Provincial transmission system
- No carbon price risk
- Existing site with established host community acceptance
- Higher long term security of supply compared to importing power from QC or NFLD
- Baseload generation to meet market needs compared to intermittent wind and solar

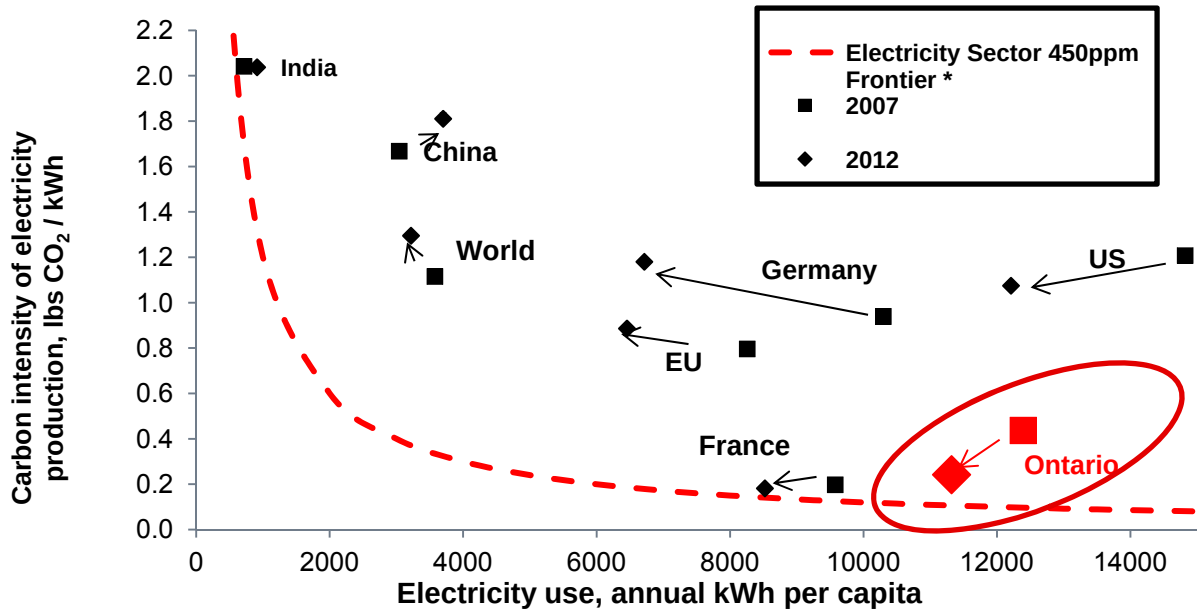
Note: LUEC is an economic measure, often used as a screening tool to facilitate consistent cost comparisons across generation options that have similar applications (e.g. base-load); It provides a true comparator for the cost throughout the lifetime of the generation asset..

# Significant GHG Reductions Achieved to Date

## Ontario has made significant progress in reducing its carbon intensity through elimination of coal generation.

### Carbon Intensity vs. Electricity Use

*2007 vs 2012*

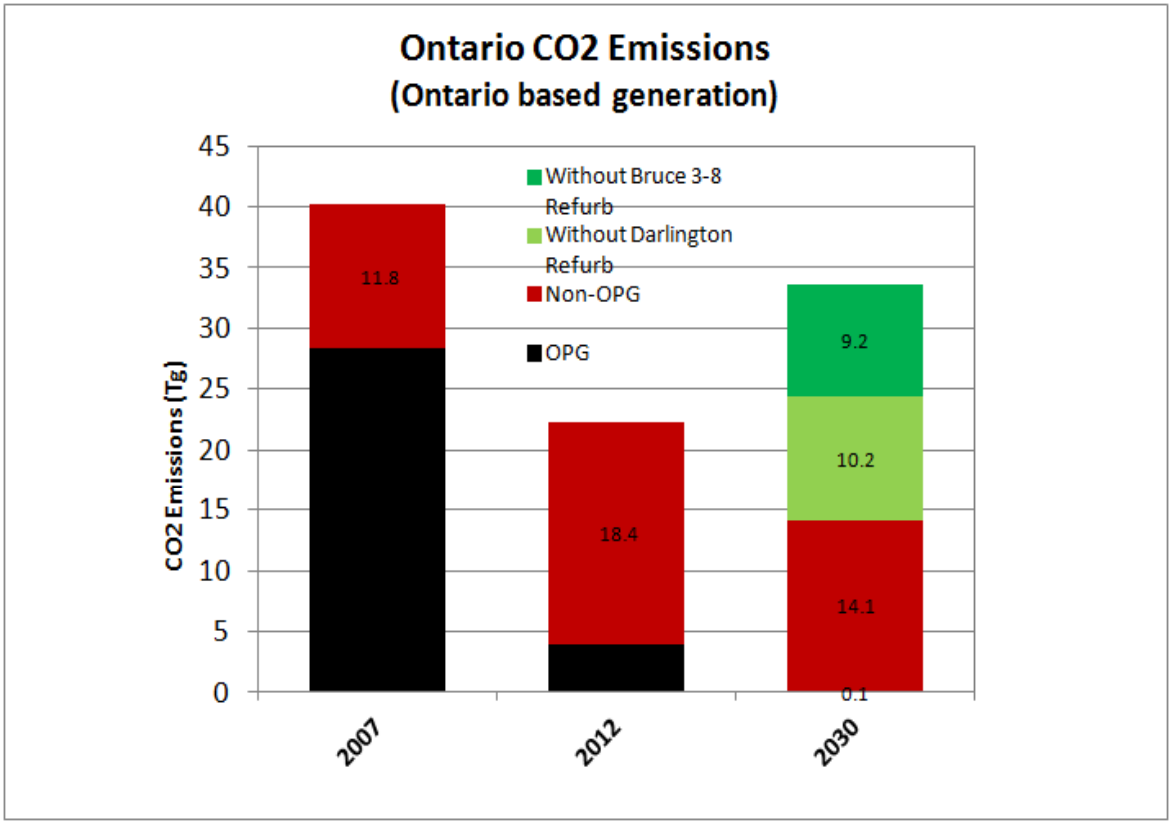



- Ontario's 2007 to 2012 decrease in emissions is due to the elimination of coal in Ontario
- Other jurisdictions, such as Germany, that have reduced nuclear generation have seen their carbon intensity increase.

Sources: IHS (2007 & 2012), OPG (2030)
•Electricity Sector 450ppm Frontier: Per capita electricity consumption and electricity production carbon intensities that produce a carbon footprint consistent with stabilizing greenhouse gases at the $CO_2$ equivalent of 450 ppm (threshold that climate scientists estimate limits the probability of a 2°C increase in global temperatures to 50%)
•**Nuclear Fleet Refurbishment of Darlington Units 1-4 & Bruce Units 3-8

# Delivering Emissions Free Energy

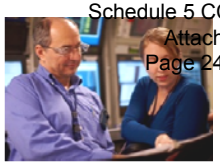
## Refurbishment of Ontario's nuclear fleet ensures that Ontario retains the benefits of reduced emissions resulting from eliminating coal




- Without refurbishment, Ontario would be at risk of returning to pre-coal era emissions levels
- DNP will avoid an increase in GHG emissions of ~200-300Tg over 20-30 years if replacement generation is natural gas fired

# Economic Benefits of DNP





## DNP will increase GDP for Ontario by $15B[1] throughout the duration of the project

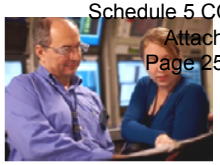
- As a major employer in Clarington and Durham, DNP will avoid the loss of jobs in the 2020's that would have resulted from closure
- The project will boost employment by an average of 8,600 jobs during refurbishment, peaking in 2019 with 12,100 jobs
  - As of August 2014, over 50 companies have been engaged to participate in DNP approximately 80% of which are located in Ontario
- OPG pays ~$4 million per year in property taxes to both the Municipality of Clarington and the Province of Ontario
- OPG contributes significantly to the Durham community, including $25M in community investment since 1999

### Ontario Companies Participating in DNP


[1] Based on draft results from Conference Board of Canada report. Final report will be issued in November 2015.

# Taxpayer and Ratepayer Benefits

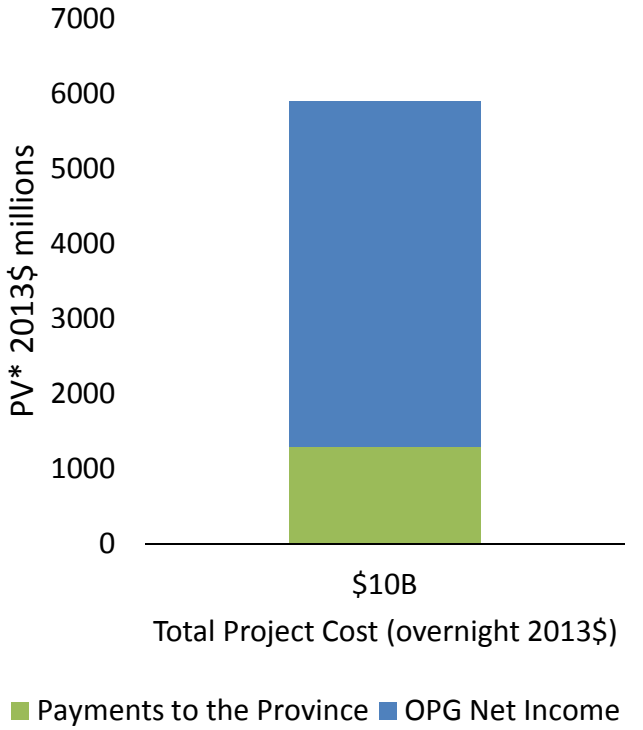




## DNP results in significant ratepayer and taxpayer benefits (OPG net income and payments in lieu of taxes) through DNP

- Darlington refurbishment ensures that tax dollars are retained in Ontario
- The OPG Board commissioned an independent report to confirm these benefits vs alternative ownership structures (a partnership or 3rd party completing the project)
  - Most financially attractive option given lowest rate impact to consumers and greatest financial value and viability to OPG
  - OPG would earn regulated return as opposed to contracted return that includes construction risk premium
- Refurbishing Darlington retains the province's ability to influence electricity rates for Ontarians

**Fiscal Implications of DNP**
*PV (2013), $M*



# OPG's Strategic Approach to Refurbishment

## OPG will benefit ratepayers by taking a long-term, risk informed approach to refurbishment

- Given its regulated structure, OPG is able to spend sufficient time and effort during the planning phases of DNP given a reasonable certainty of recovery of planning costs if prudently incurred. This allows OPG to eliminate as much risk as possible during the planning phases of DNP prior to approvals to proceed to the execution phase.
- The use of the mockup allows contractors sufficient time to develop confidence in their cost and schedule estimates such that risk can be removed and premiums eliminated, and not just transferred between parties.
- OPG has implemented a contracting strategy that transfers risks to the vendor, when appropriate, using a target or fixed price model while overall project and risk management is maintained by OPG.
- A long-term approach to environmental and licensing approvals to understand, confirm and incorporate requirements in the planning phase ensures the refurbished DNGS has a 30-year life with lengthy license durations.
- These upfront planning activities not only help ensure that OPG is adequately prepared for refurbishment but also increase confidence in on-time and on-budget completion.

# Best Choice for Ontario

## DNP provides the best overall value to the province of Ontario

- **Best economic alternative** for replacing the needed baseload generation
- Allows the province to **retain the greenhouse gas benefits** resulting from coal closure. Without refurbishment, Ontario would be at risk of returning to pre-coal era emission levels.
- **Increases Ontario's GDP by $15B** throughout the duration of the project.
- **Boosts employment** in Ontario by an average of 8,600 during the refurbishment period and retains the current level of employment for another 30 years of operations.
- Ensures the **dollars spent** on DNP and ongoing operations, tax dollars generated by the refurbishment and dividends paid on net income **stay in Ontario**.
- OPG only earns a **regulated return on capital dollars actually spent** avoiding a built-in risk premium
- Allows the Province to retain the **ability to influence electricity rates** for Ontarians

ONTARIO POWER GENERATION

**FOR INFORMATION to the Board of Directors**

**October 1, 2015**

# Darlington Refurbishment Program: Execution Phase Readiness and Business Case Summary

## REASON FOR REPORT

The purpose of this report is to provide the following:

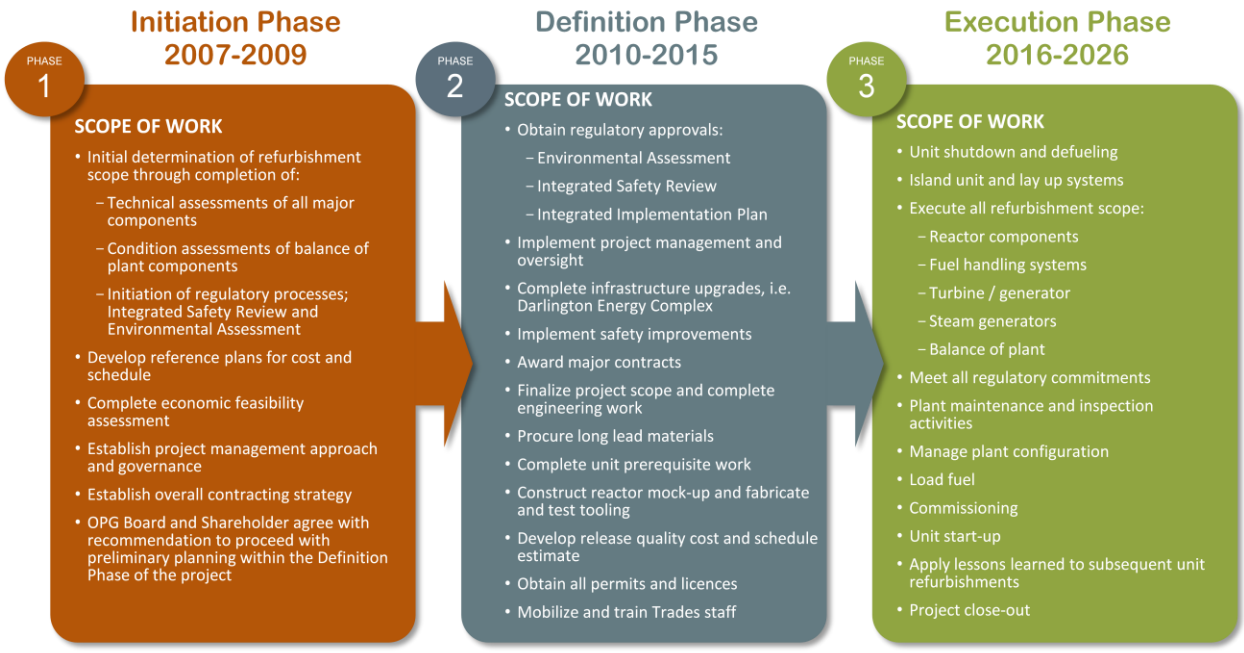
- An update on the status of the Darlington Refurbishment Program ("DRP") Definition Phase activities,
- An overview of the cost and schedule estimate for the execution phase to be presented in November with a recommendation on final contingencies and management reserve, and
- A summary of the business case including key OPG benefits and the expected energy cost from the refurbished Darlington station.

## HIGHLIGHTS

### Definition Phase Update

In 2009, the DRP identified three phases of project development as shown in Figure 1. The Initiation Phase, completed in 2009, concluded with the approval of a "Feasibility Business Case" allowing Management to proceed to the Definition Phase. In the past five years, the DRP has completed its planning deliverables including completion of the Canadian Nuclear Safety Commission's (CNSC) regulatory requirements related to the refurbishment and life extension of a nuclear plant, as identified in regulatory document RD-360. Management is now ready to proceed to the Execution Phase and have developed the overall 4-unit scope, cost, and schedule estimate including preparation of an execution phase business case, as outlined in this document.

**Figure 1: Darlington Refurbishment Phases of Project Development**



During the Definition Phase, management has taken sufficient time to plan and prepare for the successful execution of Darlington Refurbishment including incorporation of the following:

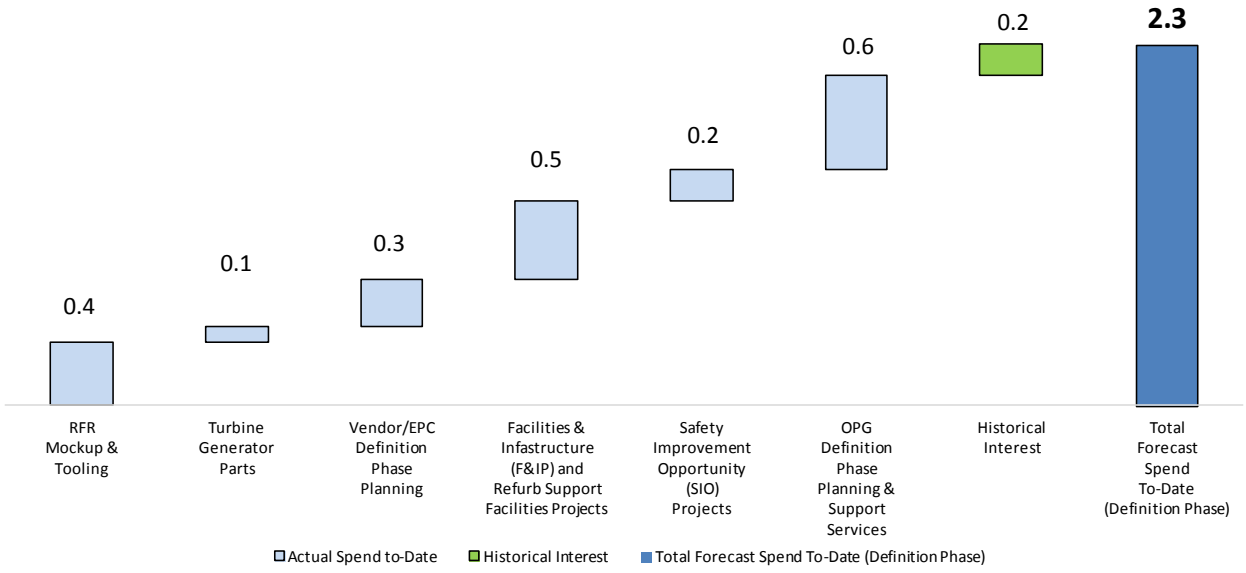
- OPG has captured operating experience and lessons from Darlington projects, past CANDU refurbishments and other large projects. For each of the 120 lessons identified, appropriate actions have been identified and applied to OPG's context and operating environment. OPG continues to gather lessons learned and collaborate with Bruce Power to share lessons learned during both companies' overlapping refurbishments. In addition, OPG ensures that the contractors are incorporating lessons learned into plans.
- OPG has invested $1 Billion in front end planning, including detailed scoping, and has completed detailed design more than a year before the start of construction. A full scale reactor mock-up was constructed and all Re-tube and Feeder Replacement tooling was tested. Test times were used to develop a reliable critical path schedule and comprehensive risk register. The mock-up will be used to train all workers, providing predictable execution phase performance. Estimates have been prepared for all scope with over 90% at Class 3 or better.
- OPG is the first Nuclear Operator to fully implement the CNSC's regulatory document RD-360 on the Refurbishment of Darlington; completing an Environmental Assessment, an Integrated Safety Report and Global Assessment, and an Integrated Implementation Plan. The Integrated Implementation Plan has been accepted by CNSC staff and is included in the Darlington license application. This provides OPG with certainty of regulatory scope and requirements to refurbish and restart the Darlington units.
- All of contracts for all bundles of work have been awarded. Engineering, Procurement, Construction ("EPC") vendors have engaged early in the planning activities to ensure a complete understanding of scope and full development of cost and schedule estimates. Contracts consider the appropriate level of risk transfer and provide both cost and schedule incentives and disincentives to encourage good performance.
- OPG's management team has significant experience working on major projects and CANDU refurbishments. Strategies are being identified to allow for retention of key staff during the individual unit refurbishments, as well as succession planning and knowledge transfer for successive units.

During the Definition Phase, OPG commenced construction and is nearing completion of many of the Facilities and Infrastructure and Safety Improvement Opportunity projects required to be in place prior to the start of the Refurbishment outage in October 2016. These activities include:

- The construction of a Refurbishment Project Office, a Re-tube and Feeder Replacement Island Support Annex, and required upgrades to roads, bridges, and parking lots; all with a goal of reducing the time that it takes to onboard contractors each and every day of the project.
- Safety Improvement Opportunity projects, including installation of a Third Emergency Power Generator and a Containment Filtered Venting System are also being constructed. A Heavy Water Storage facility is under construction to store the moderator water that must be drained from each unit prior to that unit's refurbishment.
- Facilities and Infrastructure and Safety Improvement Opportunity projects represent less than 8% of the total Program estimate. Funds released for these projects included contingencies to manage the associated risks. Although individual projects experienced cost growth and considering the contingency released, all of the projects are expected to be completed within the funding envelope approved by the Board. Lessons learned, as documented in Appendix 1, have been applied to the Execution Phase projects.

As of the end of the Definition Phase, as shown in Figure 2, over $2.3 Billion will have been spent to achieve both the planning deliverables, the pre-requisite Facilities and Infrastructure and Safety Improvement Opportunity project work, and delivery of the Re-tube and Feeder Replacement mock-up and tooling.

**Figure 2: Definition Phase Cost Summary**




## Execution Phase

In November, based on the successful completion of the Definition Phase, management will request approval to transition to the Execution Phase of the Project. As outlined in the DRP release strategy, Management's request will include funding to commence Unit 2 mobilization activities including the establishment of the Execution Phase organization, completion of Execution Phase unit specific planning and development of the final Unit 2 budget and execution ready schedule, and final construction and commissioning of all pre-requisite projects.

The following sections of this document provide insight into the Execution Phase cost and schedule and key risks, as well as a summary of the total DRP cost estimate and business case.

## Overall DRP Cost Estimate

In 2010, Management communicated that the high confidence estimate, including inflation and interest, would be less that $14 Billion.

Management has now completed Definition Phase planning and submits that the current high confidence estimate is $12.8 Billion, as reported in Table 1, to execute the refurbishment of the four Darlington units.

This estimate includes a preliminary contingency estimate of $1.9 Billion, however, excludes any amounts for additional Management reserve. Based on the current Levelized Unit Energy Cost (LUEC) of an estimated 8.1¢/kWh (approximately 0.9¢/kWh lower than the equivalent LUEC provided in 2009), there is ample opportunity for OPG to include sufficient Management reserve in the overall project estimate while maintaining an economically attractive project.

**Table 1: Refurbishment Current Estimate Compared to 2009 Estimate**

| Estimate | 2009 Estimate | Current Estimate | Variance |
|---|---|---|---|
| Overnight Estimate | $14.0 Billion(1,2) | $12.8 Billion(2) | $(1.2) Billion |

(1) The 2009 estimate was reported as $10 Billion in $2009, excluding interest and inflation. When interest and inflation is included, the estimate was $14 Billion.
(2) Estimate includes interest and inflation. Inflation is at 2% and interest in the current estimate is at approximately 5% to 2021 and 6% thereafter.

## Execution Phase Cost Estimate

OPG is nearing completion of the development of its Execution Phase cost estimate. Estimates have been received from all vendors and have been integrated into the overall cost estimate and a detailed risk register has been developed. A preliminary cost and schedule contingency analysis has also been performed; however, further reviews are underway and the estimate will be finalized by October 15th in advance of the November Board meeting. Management believes that the base project estimate and contingency amounts provided within this document are bounding and that any further refinement will reduce the overall project estimate, before Management Reserve is applied.

Figure 3 provides a summary of the cost build-up for the Execution Phase of the project. Of the $12.8 Billion estimate, $2.3 Billion has been spent in the Definition Phase and the Execution Phase estimate is $10.5 Billion. In addition to external vendor bundle costs to execute the major scopes of work, the project is carrying costs for vendor oversight, operations and maintenance and general project support. The project estimate also includes an estimate for CNSC fees and insurance.

OPG is responsible for providing the insurance coverage under an Owner Controlled Insurance Program, where the project owner places the construction insurance program rather than the contractor. This allows OPG to leverage the insurers on the corporate program for optimal terms and conditions. The Insurance estimate includes Course of Construction-Property, Wrap-Up Liability, Marine Cargo and Advance Loss of Profit, Nuclear Energy Physical Damage-Property, and Delayed Start-up insurance.

**Figure 3: Execution Phase Cost Estimate Build-up**

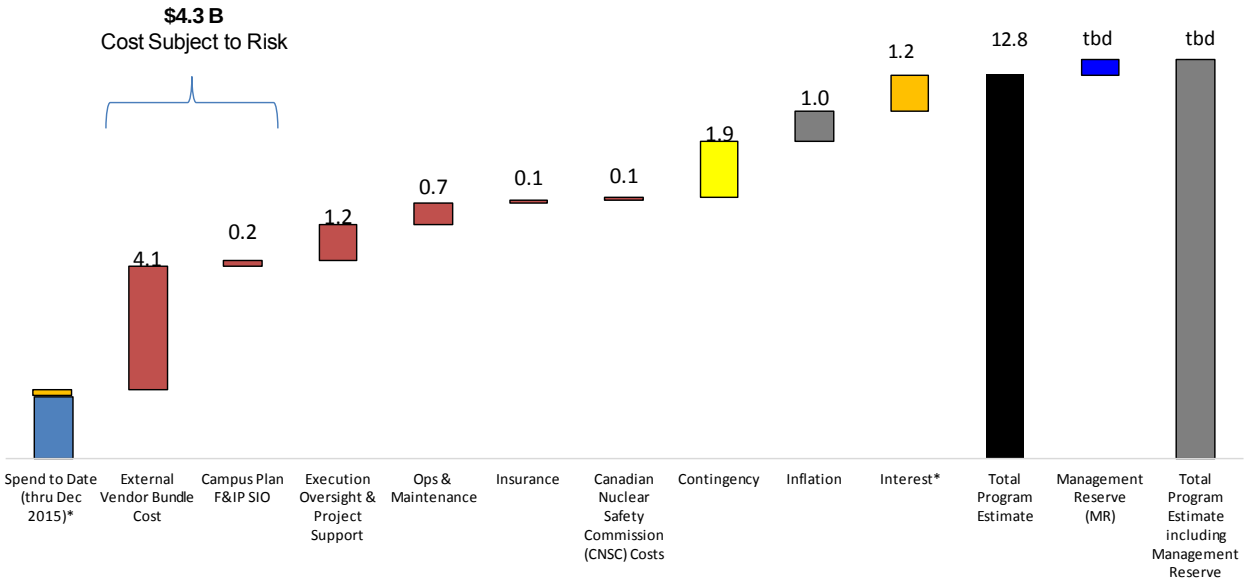
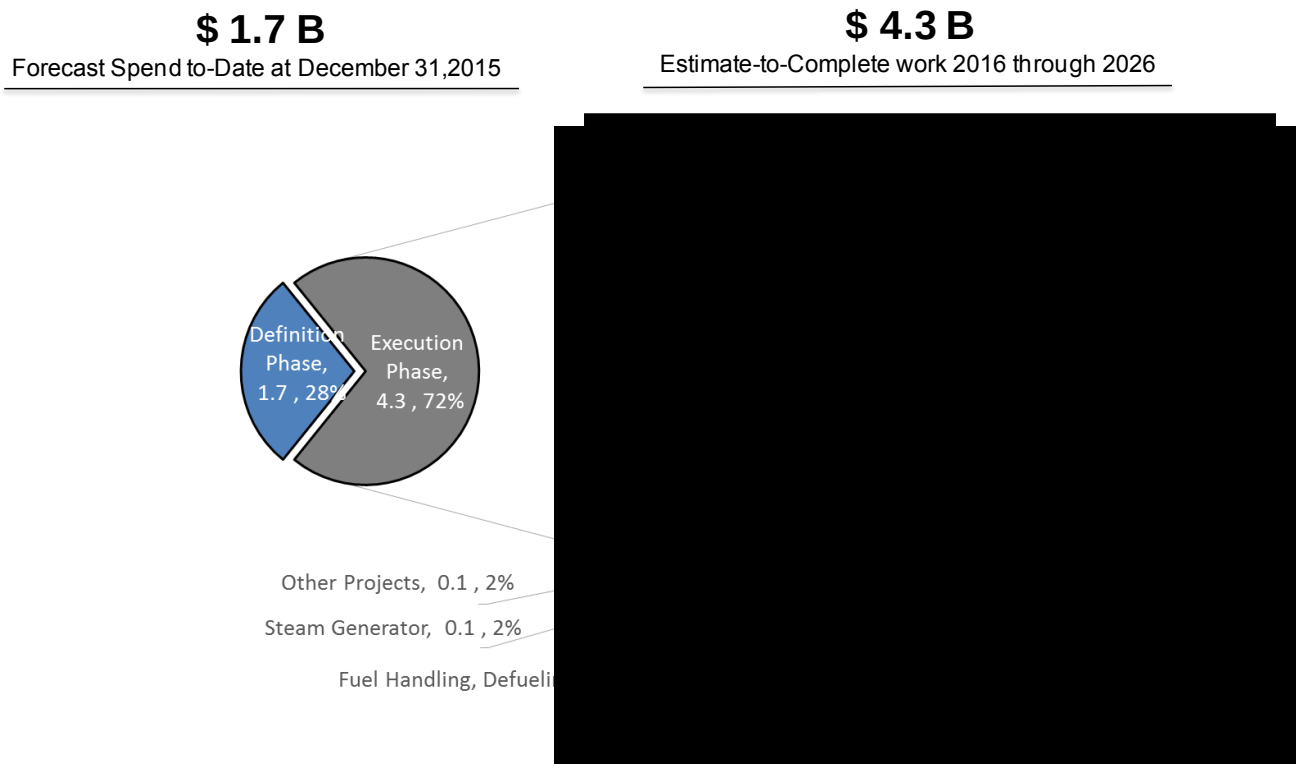



Figure 4 provides a breakout of external vendor bundle costs for EPC activities including those incurred in the Definition Phase and those to be incurred in the Execution Phase.

**Figure 4: EPC Vendor Project Costs**




As noted in the Definition Phase update, OPG has awarded contracts for all bundles of work. OPG's contracting strategy incorporates appropriate risk transfers and related cost and schedule incentives and disincentives:

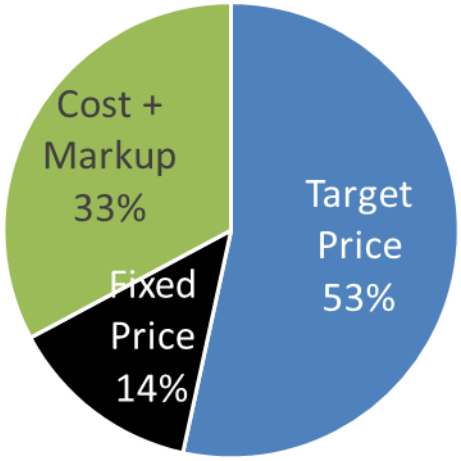
- The use of a combination of fixed and target pricing will result in appropriate risk premiums and a lower overall refurbishment cost. The contract structure for each bundle was based on the level of certainty in scope and on the ability for the contractor to control its own work.

- Projects where scope is certain and can be largely controlled by contractors are conducive to fixed price contracts including a premium for known risks that are transferred to the contractor.

- Projects where scope is not certain or where the contractor can't have full control, carry risks that can't be fully transferred to the contractor. In these cases, a cost plus or target price contract is conducive.

Figure 5 provides a breakdown of the contract structures in place for the DRP. OPG has fixed price contracts for Steam Generator work, Turbine Generator components, and Re-tube and Feeder Replacement tooling. OPG has target price contracts for Re-tube and Feeder replacement, turbine generator overhaul, and balance of plant work. Cost plus contracts are generally in place for some balance of plant work and for material purchases and contractor general expenses.

**Figure 5: Contract Structure of EPC Vendors**




## Project Schedule

As part of the Definition Phase, OPG has integrated all vendor schedules and, with the Re-tube and Feeder Replacement vendor, determined the critical path for the project. As a result, the high confidence duration for each unit is 38 to 39 months, as shown in Figure 6.

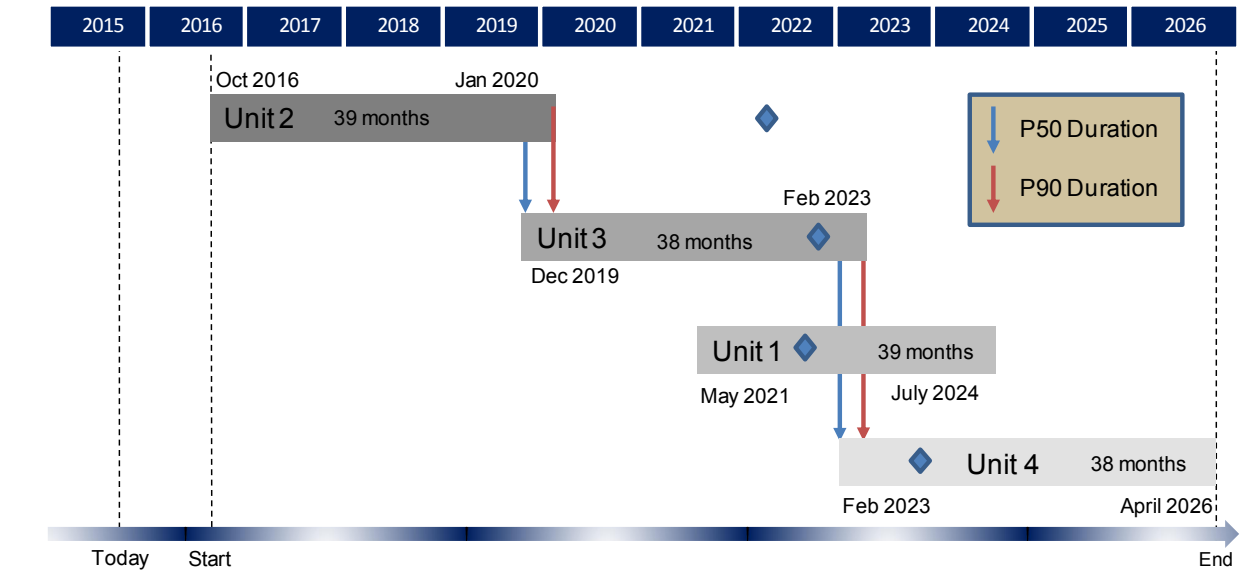
Based on the current high confidence that each of the Darlington units will operate to 235,000 Effective Full Power Hours (EFPH), this schedule results in no idle time on operating units.

A copy of the Unit 2 critical path Level 1 plan is included as Appendix 2.

Figure 6 shows both the P50 (50% probability of success) project duration and the P90 (90% probability of success) duration. OPG will internally focus on delivering the project within the P50 duration and as such, has logically tied subsequent units to the P50 dates. However, externally, Management recommends that the P90 dates be the basis for delivery of the project.

In November, Management will finalize its recommendation in this area and also consider whether additional Management Reserve should be included. Based on the current schedule, there are seven months of float between the start of Unit 4 and when the unit reaches 235,000 effective full power hours. This infers that the schedule could be delayed by up to seven months without resulting in any idle time (unit sitting idle waiting to be refurbished).

**Figure 6: Darlington Refurbishment Execution Phase Unit Schedule**



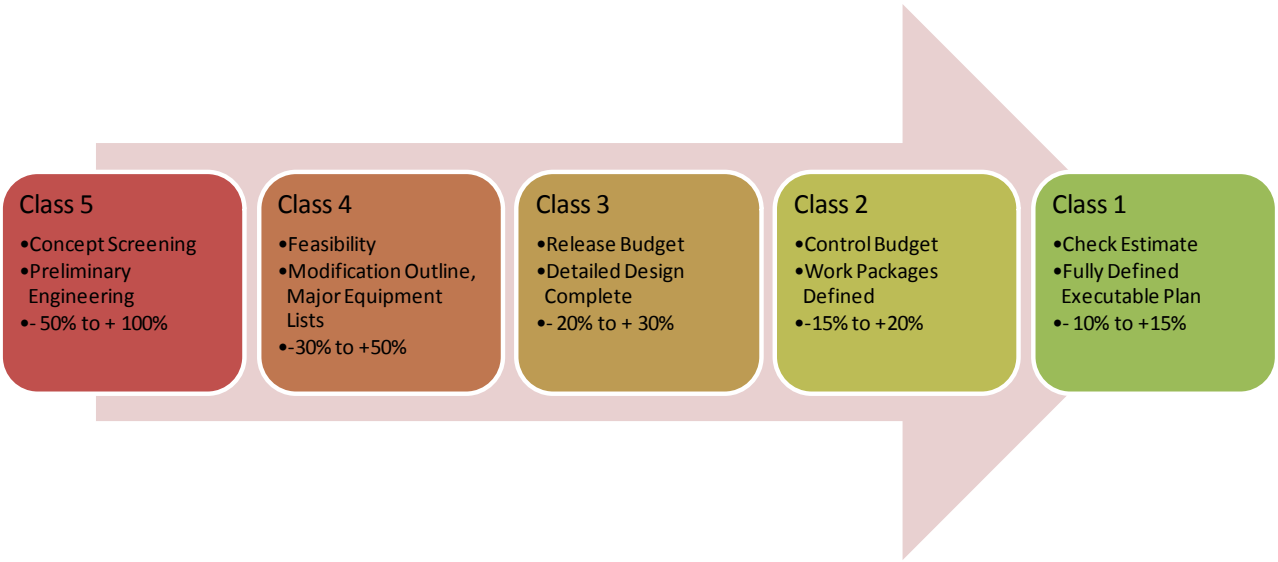

Date at which each unit reaches 235,000 EFPH

## Project Contingency

Included in the refurbishment estimate is an allowance for uncertainties in project scope, costs and schedule.

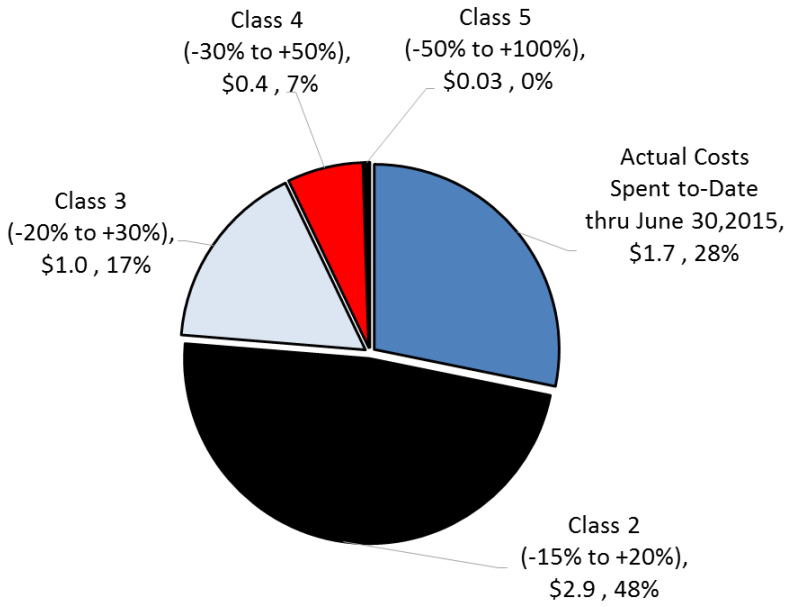
OPG developed the DRP project estimate in accordance with the Association for the Advancement of Cost Engineering (AACE) estimate classification recommended practice and integrated its standard approach to engineering and work planning within the AACE practice. Figure 7 provides an overview of the classification model and provides a reference to the general "type" of estimate, key deliverables, and the associated uncertainty band.

**Figure 7: AACE Estimate Progression and Classifications**




The current project estimate is better than Class 3 with large elements at Class 2 and 1, as shown in Figure 8 below:

**Figure 8: Estimate Classification Summary**




Contingency is derived through an evaluation of the remaining estimate uncertainty (cost and schedule) and the assessment of additional known discrete risks. Considering this, the $12.8 Billion estimate currently includes $1.9 Billion of contingency, as summarized in Table 3. The contingency analysis presented here is undergoing further review and this will be completed in advance of the November Board meeting. Also, this contingency amount is based on project and program risks only and excludes additional management reserve.

**Table 2: Contingency Summary**

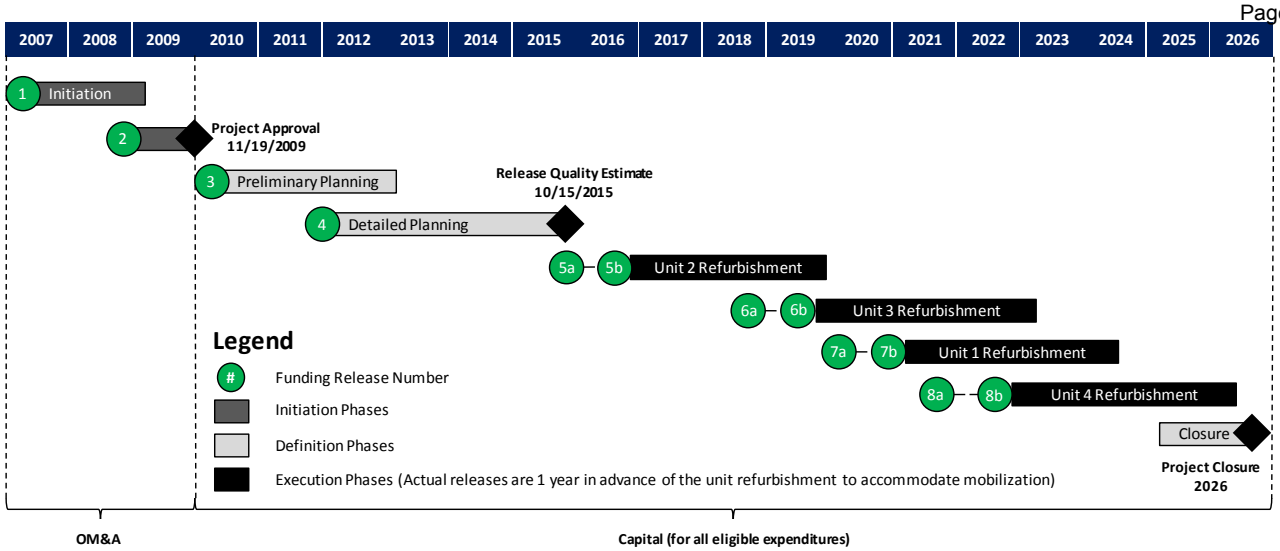
| Category | Contingency ($Billion) | % of Total Contingency |
|---|---|---|
| Project | 0.9 | 47% |
| Functions | 0.1 | 6% |
| Program | 0.9 | 47% |
| **Total** | **1.9** | **100%** |

The contingency amount further provides Management with additional confidence that the project can be executed within the $12.8 Billion project estimate. A contingency of $1.9 Billion represents 30% of the Execution Phase estimate of $6.4 Billion before contingency, or 45% of the external vendor's project costs of $4.3 Billion, as shown in Figure 3. Considering that the project estimates are largely at Class 3 or better, the level of definition is quite strong and the expected risks are well known. As such, Management believes that the contingency amount is sufficient.

## Release Strategy and Off Ramps

The project has established a release strategy that will further provide the Board of Directors with opportunities to review project performance prior to allowing the project to proceed to the next phase. While the project estimate totals $12.8 Billion, funding will be released on a unit by unit basis in accordance with the release strategy as shown in Figure 9. The release strategy is also aligned to the Provincial release strategy incorporated in the Long Term Energy Plan.

**Figure 9: Darlington Refurbishment Release Strategy**

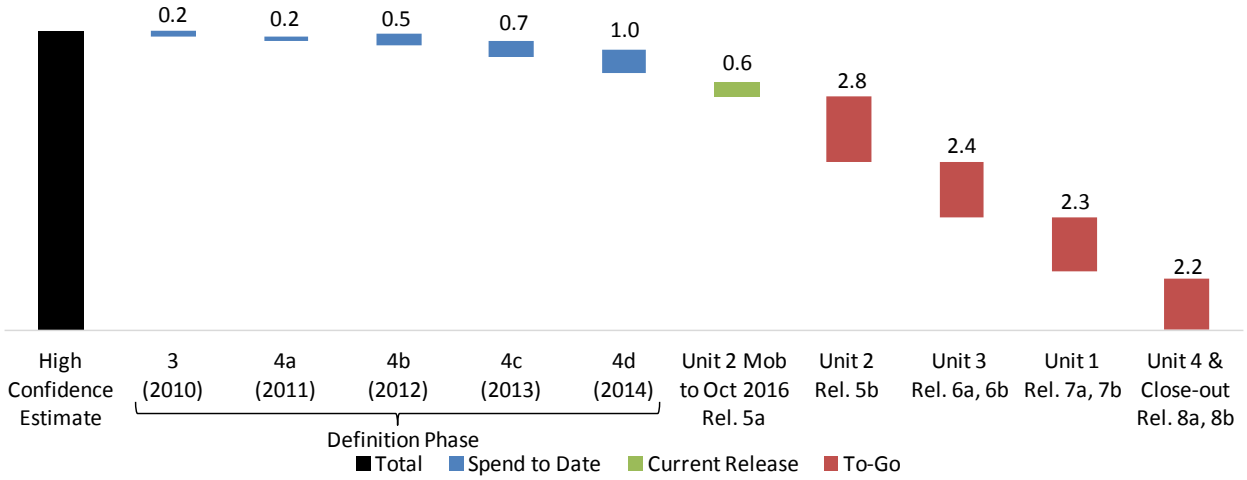



As shown in Figure 9, Management will release funds in advance of each unit's execution period to complete unit specific planning and mobilization activities including the preparation of a unit "check" estimate to confirm that the cost and schedule is bounded by the execution phase business case.

Due to the execution strategy, funds will be released for Unit 3 while Unit 2 is in the mid-part of its execution period. In the unit overlap period, funds will be released for Unit 4 at the same time that Units 3 and 1 are in the execution period.

Consistent with the above release strategy, Figure 10 provides a preliminary breakdown of the funding anticipated for each release to date and unit.

**Figure 10: Project Estimate by Release/Unit**




## Unit 2 Mobilization and Ready to Execute Plan

Upon approval of the execution phase business case, Management will request funding of approximately $0.6 Billion (Release 5a) to complete the construction and in-service of all of the pre-requisite projects and to commence Unit 2 mobilization, training, and installation of in-station support facilities.

During this period, Management is also executing a "ready to execute" plan. An overall strategy has been developed leading to Unit 2 breaker open to ensure all parts of the integrated execution organization are fully prepared. This strategy includes three streams:

- Completion of Definition Phase work including implementation of the Execution Organization,

- Preparation and execution of the ready to execute test period work and completion of the process testing and lessons learned implementation and process adjustments, and
- Completion of the balance of pre-requisite work and completion of the work documents, material procurement, and training and team building required to be field ready at breaker open, is to begin on Unit 2 in October 2016.

## Focus on Safety

OPG has a strong industry-recognized safety policy and program that covers all aspects of safety including conventional, nuclear, environmental, and radiological. OPG also recognizes that a positive and shared safety culture with the DRP vendors is critical to project success. OPG has clearly defined safety management responsibilities and expectations within each vendor contract. OPG expects that each vendor working on the Darlington site will have a safety program that is consistent with OPG's safety policies. All vendors are required to be pre-qualified in OPG's pre-qualification system prior to their mobilization to site. The DRP has assessed each of the vendor's safety programs and, where applicable, have identified gaps and opportunities for improvement, and corrective actions have been implemented.

The DRP Execution organization has a safety department that will perform ongoing oversight of the safety performance, for both vendors and OPG, and will identify any further corrective actions for improvement. The safety department will also interface with external parties such as the Ministry of Labour to ensure alignment with required labour laws.

Additionally, the DRP is establishing a dedicated Radiation Safety Department (RSD) for the refurbishment project. The RSD will operate within the Fleet Operations & Maintenance division to ensure a consistent approach to radiation safety within the Nuclear Fleet. The role of RSD is to provide high quality radiation protection services to ensure that all Refurbishment activities are completed in a safe and economic manner. RSD will be resourced with a combination of internal and augmented staff, as required, with the flexibility to draw on the fleet to meet the needs of the project.

In 2016, prior to the start of the refurbishment of Unit 2, Management will provide the Board with a full presentation on all aspects of the safety program being implemented by the DRP.

## Business Case Summary

In November 2009, based on the economics of the project as documented in the Economic Feasibility Assessment Business Case, the OPG Board of Directors approved the overall timeline and release strategy for the refurbishment and released funds for the project to complete preliminary planning within the Definition Phase. OPG's Board of Directors also released funding to commence detailed planning within the Definition Phase in November 2011, and to continue detailed planning annually in November 2012, 2013 and 2014.

Management had also revised the overall timeline and release strategy for Darlington Refurbishment, with the submission of the Release Quality Estimate (RQE) in October 2015, and a first unit refurbishment start date of October 2016.

An updated business case was produced in November 2013 to reflect the then current knowledge and understanding of the Darlington refurbishment project and to reflect additional experience from other refurbishment projects.

The November 2015 business case will reflect the RQE as well as the most up-to-date forecast of post refurbishment costs and performance of Darlington Station.

### Economic Impacts of Darlington Refurbishment

The successful completion of the Darlington refurbishment would put OPG in a stronger financial position and is estimated to generate in excess of $10 Billion in incremental net income to OPG based on the current rate regulation framework and nuclear rate smoothing assumptions. At the completion of the refurbishment project, the annual net income associated with the project will reach $0.7 Billion and then decline as the asset depreciates. The resulting cash inflows will be reinvested by OPG in new growth opportunities used to fund dividend payments to the Shareholder, and/or pay down debt.

The estimate of the DRP income benefits reflects returns on approximately $12 Billion of capital investment that would enter OPG's regulated rate base by 2026. It is expected the project will provide a regulated return on equity, which is currently 9.3%.

If the project does not move forward, the Darlington units would be permanently shut down in the early 2020s and OPG would cease nuclear operations. In addition to foregoing the return and income discussed above, cancellation of the project could result in a further net income reduction of approximately $5 Billion associated with the risk of not recovering the following impacts:

- $200 Million in currently committed costs, including demobilization;
- $1.8 Billion of the life-to-date capital expenditures which would be deemed to have no future benefit;
- [redacted]; and
- Past-service pension and other post employment benefit costs that would otherwise be recovered through OPG's post-refurbishment nuclear rates.

The closure of Darlington would occur at approximately the same time that Pickering reaches the end of commercial operations and OPG would, therefore, be ceasing all nuclear electricity production. OPG would effectively become a hydroelectric production company, while implementing a nuclear station safe storage and decommissioning project on 10 nuclear units simultaneously, challenging OPG's project management capacity.

The overall reduction in revenue would challenge OPG's ability to meet its future obligations with respect to nuclear waste, decommissioning, etc.

If these costs were to be recovered, they would add to OPG's nuclear rates into the early 2020s and would continue to have an approximate 20% impact on OPG's regulated hydroelectric rates after all Darlington and Pickering units are shut down.

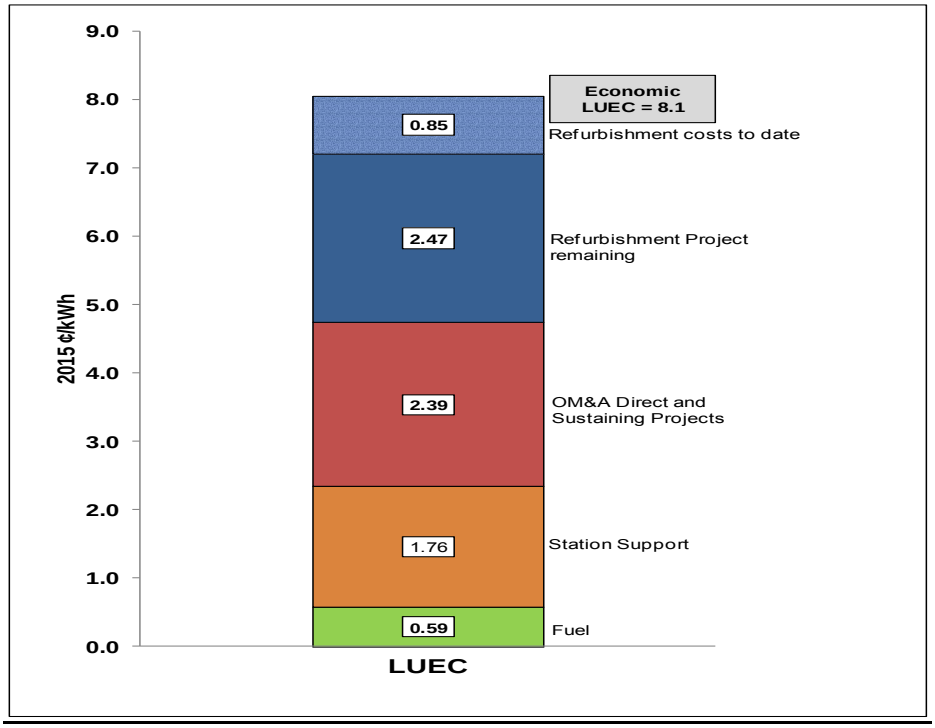
**Current Estimate of Darlington Refurbishment LUEC**

Utilizing the preliminary RQE of $12.8 Billion (including interest and inflation) and robust estimates of the future operating costs and performance of the station, the LUEC of Darlington Refurbishment is estimated at 8.1 ¢/kWh, making it a low cost, low emission, stably-priced generation option. In 2010, Management communicated that the LUEC for the DRP would be less than 8 ¢/kWh in 2009$, which is equivalent to 9.0 ¢/kWh in 2015$; therefore Management's current estimate is well within the LUEC estimate announced in 2010.

**Darlington Refurbishment LUEC**

Figure 10 shows the components which make up the current estimate of the DRP.

**Figure 11: Darlington Refurbishment LUEC Major Components**




The DRP contributes 3.3 ¢/kWh (2015$) (including 0.85 ¢/kWh for DRP costs to-date) to LUEC, and the post-refurbishment operations and support costs necessary to run the plant, including fuel, contribute to the remaining 4.8 ¢/kWh to the total LUEC of 8.1 ¢/kWh (2014$).

Post-Refurbishment operations costs include annual direct station and support costs of $570 Million and $460 Million, respectively. Post-refurbishment support costs are higher than in the current period, as OPG is forecasting losses of economies of scale following the shutdown of Pickering. Corporate-wide initiatives have begun to effect the transition to a smaller company (e.g. plans to streamline organizations and to implement different support services delivery models).

The LUEC is based on an assumed capability factor in the post-refurbishment period. An annual capability factor of 88% has been assumed, which compares to performance over the past 10 years of 89.4%.

Typically, economic LUEC estimates do not include sunk costs. However, OPG has chosen to include all costs incurred to the end of 2015 ($2.3B), to ensure that the complete cost picture of LUEC is provided. Excluding the 0.85 ¢/kWh associated with the DRP costs to-date, the going-forward LUEC would be 7.2 ¢/kWh.

LUEC is a point in time measure and is reflected in today's dollar. Over time, it will escalate with the consumer price index. At 2% CPI, the economic LUEC of 8.1 ¢/kWh in 2015$ would be 10.0 ¢/kWh in 2026$.

Management has also assessed the sensitivity of the LUEC to changes in specific inputs. The following is a summary of the impacts of changes to the key inputs:

i. A $500 million increase/decrease in DRP costs increases/reduces LUEC by approximately 0.15¢/kWh (2015$)

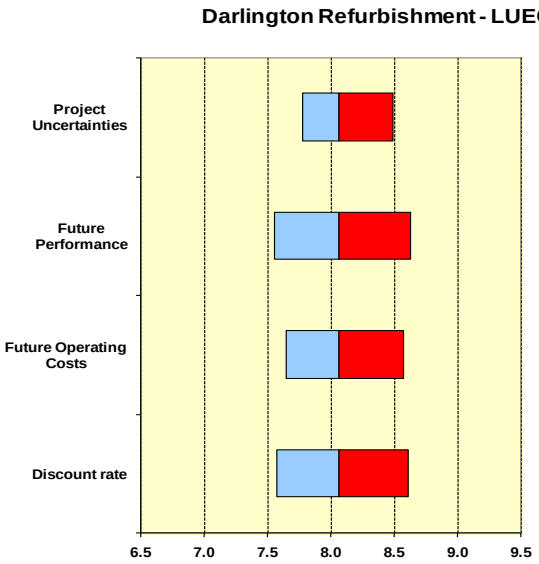
ii. An increase/decrease in schedule duration of six months would increase/decrease LUEC by approximately 0.06 ¢/kWh

iii. A 5% increase in the capability factor (from 88% to 93%) lowers LUEC by 0.35¢/kWh while a 5% decrease (from 88% to 83%) increases LUEC by 0.4¢/kWh (2015$)

iv. Each $100 million increase/decrease in post-refurbishment annual costs increases/decreases LUEC by 0.4¢/kWh (2015$)

Figure 12 shows the sensitivities of key inputs to deriving the LUEC. LUEC is the most sensitive to post refurbishment costs and performance of the units.

**Figure 12: Sensitivity of LUEC Inputs**




| Assumptions | Lower | Base | Upper |
|---|---|---|---|
| **Project Uncertainties** | | | |
| Refurb Cost* (2015$) | -10% | $10.4B | 15% |
| Refurb Duration (months) | -2 mths | 36 mths | +3 mths |
| **Future Performance** | | | |
| Annual Capacity Factor (%) | -5% | 88% | 5% |
| Life of Refurb Units (yrs) | +2 yrs | 30 yrs | -2 yrs |
| **Future Operating Costs** | | | |
| Base OM&A ($M) | -5% | 280 | 10% |
| Outage OM&A ($M) | -10% | 145 | 10% |
| Sustaining Projects ($M) | -10% | 145 | 10% |
| Nuclear Support ($M) | -5% | 220 | 15% |
| Corporate Support ($M) | -15% | 235 | 10% |
| Fuel ($/MWh) | -15% | 5 | 15% |
| **Discount Rate** | -1% | 7% | +1% |

*Refurb cost sensitivity applied only to going-forward costs excluding contingency

### Key Risks to the Business Case

Key Risks covering both the DRP and the post-refurbishment operations period are summarized below:

- DRP Costs and Schedule: There is a risk that, even with the contingency and management reserve, there could be cost and schedule overruns. Given OPG's investment of $2.3 Billion in Definition Phase and the level of contingency included in the RQE, Management believes that these risks are manageable within the current cost and schedule estimate. Insurance premiums of $116 Million are included in the estimate to purchase coverage to mitigate some of the financial risks; these cover Course of Construction-Property, Wrap-Up Liability, Marine Cargo and Advance Loss of Profit, Nuclear Energy Physical Damage-Property, and Delayed Start-Up.
- Post-Refurbishment Station Performance: An average station performance of 88% capability factor is assumed over the post-refurbishment life which is considered to be medium to high confidence as it is below the station's demonstrated performance over the past 10 years of 89.4%. Sustained past performance provides confidence that the post-refurbishment performance will be the same or better than the business case assumptions; however, execution of appropriate maintenance and life-cycle management programs during the life of the station to maintain the reliability, will be essential. The post-refurbishment costs include $4.4B Billion ($2015$) of ongoing sustaining investments to maintain the condition of the plant.
- Cost Recovery: There is a risk that OPG may not be able to fully recover its incurred costs. Given that the amount of DRP capital at risk continues to grow as the project proceeds to execution, the need for cost recovery assurance is increasing. Insufficient cost recovery would affect OPG's future rate base and revenue amounts, which reduces the value of OPG and return to the Shareholder.

### Qualitative Factors Supporting Executing the Refurbishment Program

- Decommissioning Fund Impacts: The decision to refurbish Darlington resulted in a decrease in the present value of the liability related to decommissioning. As of September 2015, the decommissioning fund was fully funded, partly as a result of the reduction in the present value of the liability caused by the assumption of Darlington refurbishment.

- $CO_2$ Reduction: Darlington refurbishment contributes to Provincial and Federal goals of reducing $CO_2$ emissions from electricity generation. Assuming efficient gas-fired plants would replace Darlington if it were not refurbished, the refurbishment of Darlington would avoid approximately 330 million tonnes of $CO_2$ emissions over the post-refurbishment life of the station.
- Employment Impacts: OPG is the largest employer in the Municipality of Clarington employing 2300 employees at the Darlington site, and 500 at the Darlington Energy Complex working on the DRP. Approximately 60% of Darlington's employees live in Durham Region. As of September 2015, over 800 employees are working at the Darlington site on Refurbishment preparations and 2,000 additional workers are expected at peak construction. Indirect and induced employment in Durham Region is expected to be 5,700 jobs.
- Municipal and Property Taxes: OPG pays approximately $4 Million per year in taxes to the Municipality of Clarington, shared with Durham Region and the school boards. OPG also pays an equivalent amount to the Provincial government for Darlington in the form of a "proxy tax".
- Citizenship and Community Involvement: OPG provides leadership to community organizations across Durham Region. In partnership with local communities and non-profit organizations, OPG delivers valuable programs for Durham families. OPG has contributed over $23 Million in community investment support in Durham Region between 1999 and 2011. In addition, OPG employees raise approximately $1 Million annually in Durham Region through the OPG Charity Campaign.

## CONCLUSIONS

Management has completed definition phase planning and Management's high confidence estimate to execute the refurbishment of the four Darlington units is $12.8 Billion.

Management has performed extensive planning and is ready to proceed to the execution phase. A detailed plan is in place to ensure readiness to execute the Unit 2 refurbishment starting in October 2016.

In November 2015, Management will request approval of the overall DRP business case through the Darlington Refurbishment Committee and the Board, including:

- Approval of the 4 unit cost estimate, including a recommendation for Management reserve;
- Approval of the 4 unit schedule;
- Approval to transition from the Definition Phase to the Execution Phase of the project; and
- Approval to release funds for mobilization activities for the first unit, to October 2016.

**Submitted by:**

_____
Dietmar Reiner
SVP, Nuclear Projects

## APPENDICES

1. Darlington Refurbishment Pre-Requisite Projects Key Lessons Learned Summary
2. Darlington Refurbishment Unit 2 Work Windows Schedule

## Appendix 1: Darlington Refurbishment Pre-Requisite Projects Key Lessons Learned Summary

During the Definition Phase of the Darlington Refurbishment Program, OPG will have constructed approximately $1 Billion of Facility and Infrastructure and Safety Improvement projects. These projects, which were performed in an expedited manner during the Definition Phase, provided a number of key lessons that have been applied to the Refurbishment project.

| Key Lessons | Refurbishment Application of Lesson |
|---|---|
| Collaborative Planning | Collaborative front end planning was put in place to complete engineering, procurement, and detailed work planning to ensure effective integration with the site. Detailed design is complete for Unit 2, over 12 months in advance of the first unit. |
| Scope Clarity and Control | Processes are being enhanced to align stakeholders on scope early in the process. Controls are put in place for effective management of scope changes. |
| Estimating | The DRP has centralized its estimating effort. OPG has completed detailed cost estimates for all scopes of work; over 90% of the Refurbishment scope is at Class 3 or better. |
| Scheduling | A detailed integrated schedule will be issued prior to the start of the first unit outage. Scheduling standards including work breakdown structure and earned value methods are in place an all vendors are preparing schedules in accordance with those standards. The Project Controls team validates that the schedule meets the required quality prior to acceptance. Work Management integrates the schedule to confirm that the work is doable within the timeframes provided. |
| Material Tracking | A material tracking database is now in place. Each Project Manager is developing a 'Playbook' that will outline the preparation milestones for Unit 2 Refurbishment. The Playbook dates will align with the Contract Milestones and ensure the Unit 2 Outage Director that work will be ready to execute for Unit 2, including identification of all materials. |
| Contractor/Construction Oversight | The amount of field oversight of contractor work was underestimated. Resources to perform construction oversight, clear barriers for contractors, and measure performance and progress, are included in the refurbishment plan. The existing Contractor Management Office (CMO) is being enhanced. |
| Field Engineers | Engineering to support construction activities in the field is built into refurbishment plans. |
| Sub-surface Risks | An underestimation of sub-surface issues due to incomplete drawings, buried construction debris, groundwater ingress and dewatering, and soil contamination. Additional ground surveys are planned and additional allowances to deal with the unknown sub-surface conditions have been built into project plans. For the Re-tube Waste Processing Building, additional geo-technical surveys as well as allowances to deal with these risks are incorporated into the plan. |
| Contract and Claims Management | The effort, capability, and timeliness required to monitor and control contract issues and related claims is being enhanced and integrated with project controls systems. |

DARLINGTON

# UNIT 2 Refurbishment Outage - DNRU2

**REV A7**
**Sept. 21, 2015**

OCT 2016 | NOV 2016 | DEC 2016 | JAN 2017 | FEB 2017 | MAR 2017 | APR 2017 | MAY 2017 | JUN 2017 | JUL 2017 | AUG 2017 | SEP 2017 | OCT 2017 | NOV 2017 | DEC 2017 | JAN 2018 | FEB 2018 | MAR 2018 | APR 2018 | MAY 2018 | JUN 2018 | JUL 2018 | AUG 2018 | SEP 2018 | OCT 2018 | NOV 2018 | DEC 2018 | JAN 2019 | FEB 2019 | MAR 2019 | APR 2019 | MAY 2019 | JUNE 2019 | JUL 2019 | AUG 2019

Outage Days: 0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740 760 780 800 820 840 860 880 900 920 940 960 980 1000 1020 1040

130 Lead In | 131 Removal | 132 Inspect & Install | Lead Out

U1 Outage 2017 | D2O Upgrader Outage | U3 Outage 2018 | Tritium Removal Facility Gas Outage | U4 Outage 2019

Conventional Side Lay up
002 Resource holdouts
Dec 1
100 TG and Condenser Work Phase 1
Condensate and
010 Feed Water Rehab
Nov 16 Resource holdouts
VVRS Mods and
Airlock Mtce & Testing
006
Vault Preparation Activities
013 PHT Bulk Drain
HTS Vac Dry 40d
Vac Dry (Cont'd)
to Moderator Drain
HTS Aux Vac Dry
SG Lay-Up Primary Side
to Tie-in for Moderator Vac Dry

BH Installed & D1711 Complete
052 Power Track 3,4 Replacement
Power Track 1/2 Replacement Window 1
To D1831
From D1831
Power Track 1/2 Replacement Window 2
To Start of D1831
D1711 Complete & Resource Holdout
061 Turbine Generator Major Overhaul
60% RFR Complete

HTS Aux Purge & Rehab
048 Outside Vault
HT Pump Motor Swaps
060
Note: Motors and Boilers cannot be done in parallel.(hoist way conflicts)
Reactor Area Crane not available during Class 4 Electrical Maintenance Window
To RCHP 4 HTS Fill

PT Install progressed to below row H
Primary Side SG Clean & Inspect
West Side SGs 064 | East Side SGs 070
Emergency Heat Sink
ACU4 replacement
RCHP 1
Temp Fission Chamber Install
Contingency HFD Replacements
Remove Mod Dry Equip & Reconnect Mod Pipework 078
Cold Testing & Establish GSS 081
079 Gross Air Leak Test
080 Fill Calandria

068 Vault Projects
HTS work (Cut & Cap, and Cyclical PMs); ESC STOP Mods; H2 Igniter Cables; LRV Mods; EP-LISS Bunker; EP 111elev N Side; MV 1 & 2; Bleed Cooler; Emergency Heat Sink

062 Vault ACU Replacements
West Side | East Side
Inspection Series
CTI Removal
CT Removal
CTI Release
Dummy FB Removal
Feeder Cabinet Removal
Feeder Removal
Bulk Interference Removals
Install Bulkhead
Defuel Reactor

Fuel Channel Removal Series
CT Install Series
Fuel Channel Install Series
Lower Feeder Install Series

Fuel Load
RCHP 2
084 RTP Removals, Bridge Replacement
Al Closed & Pressure Test 085
RCHP 3
Heat-up & Low Power Testing
Post-Req's
RCHP 5
Power Escalation
Run-up & Sync

| 113 days | 34 | 17 | 23 | 40 | 18 | 41 | 6 | 15 | 27 | 34 | 31 | 17 | 14 | 31 | 7 | 6 | 138 | 19 | 125 | 86 | 12 | 76 | 1 | 25 | 6 | 20 | 6 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | 4 | 3 | | | | | PT Sever | Sever Bellows | End Fitting Removal | PT Removal | | | | | | Trial CT Install | | Bellows Inspections | | | | 3 | | | | | |

S/D to GSS (1d)
015 Crane Maintenance
Install End Fitting Caps
RFR Prereq. Prior to containment isolation 008
Containment Pre-test, Achieve Dew pt. & Containment Test
-Final Commissioning/ VVRS Phase 1
-AL & TCD Logic Mods
-BU Logic Mods Ph 2
Install Shielding
RFR Prereq. post containment isolation
Remove FM Bridges & Install RTPs
19 days Upper Feeder Installation (180 days)
Nozzle Inspection & Weld Prep
073 HFD Replacements
Hold Out For Project Readiness
007 SDS1 & SDS2 Mods & Rehab
To Remove Mod Dry Equip.
Isolate Calandria From Main Pipework
Hookup Drying Equip. & Establish Calandria Purge Flow
038 Mod Drain & Flush
LISS Rehab 046
from HTS Vac Dry Complete
from HTS Auxiliaries Dry
Tie in HTS Vac Dry Skid to Mod Pipework
Vac Dry Moderator Pipework
122 Moderator Valve Rehab
To Post Feeder Vault Work
Pressurizer Power Supply Swap Over
SDC Rm Work (Purge, Maintenance Cooling System and SDC Valve work) 124
Remove Vac Dry Equip
Hold out to summer of 2018
Instrument Air Mtce
NPC Logic Restoration
Bulkhead Removal
ATC
096 High Power Testing & Turbine Testing
RCHP 6
RCHP 7
RCHP 8
RCHP 4
089 29 HTS Air Hold, Fill & Hydro Test
090 14 HTS Operational Testing

BU16 Maintenance
125
To VVRS Commissioning & Odd Electrical Outage
126 T9/T11 Maintenance
127 T10/T12 Maintenance
To TPDS & Odd Electrical Outage
(TPDS Tie-ins completed as pre-requisites)
HTS PM1 & PM3 Removal
Replace Adjuster Rods 021
028 Replace Vertical Flux Detector

Containment Boundary Established
EPS 005 MCC Rehab
Resource Tied to Class III Elec. Mtnce. Work
041 Class 3 Electrical Maintenance
Class 2 Elec. Maintenance
A 040 | B | C | DCC Mods & Mtce
To RCHP 1 Mod Fill
Hold out for system configuration
CL 4 Electrical Maintenance 051
032 LZCS Rehab
To RCHP 5
MOT/UST/IPB Rehab 004
To RCHP 7
To Turbine Testing
LPSW Outage 057
ESW Rehab 053
Winter of 2018 (Need cold water temps)
PULSW Outage 056
PULSW SDC Supply Line Replacement Outage
CCW Rehab 055
D1711 Complete & U2 defuel Complete & Cooldown After Vac. Dry(14d)
Secondary Side SG Layup
Secondary Side SG Clean & Install Access Ports 037

State 1 | State 2 | State 3a | State 3b | State 4a | State 4b | State 5

STOP State Transition Requires Approval to Proceed.
RCHP X Reactor Control Hold Point

| | |
|---|---|
| Drawn by: | Maurice Johnston<br>NR Execution |
| Prepared by: | Dennis Curley<br>NR Outage Manager |
| Reviewed by: | <br>NR Outage Director |
| Concurred by: | <br>NR Director Ops & Mtce |
| Approved by: | <br>VP Refurbishment Execution |

# Darlington Nuclear Refurbishment Project: Execution Phase Readiness and Business Case Summary

**OPG Board of Directors**
**October 1, 2015**

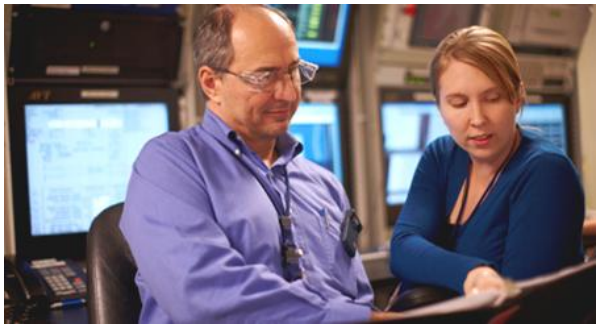
**Dietmar Reiner**
**SVP, Nuclear Projects**

**Beth Summers**
**Chief Financial Officer**

BEHAVIOURS

- Say It, Do It
- Simplify It
- Think Top and Bottom Line
- Integrate and Collaborate
- Tell It As It Is



# Purpose




**The purpose of this report is to provide the following:**

- An update on the status of the Darlington Refurbishment Definition Phase activities,
- An overview of the near final cost and schedule estimate, and
- A summary of the business case including key OPG benefits and the expected energy cost from the refurbished Darlington station.

**Management will request the following approvals from the Board of Directors in November 2015:**

- Approval of the 4 unit cost estimate,
- Approval of the 4 unit schedule,
- Approval to transition from the Definition Phase to the Execution Phase of the project, and
- Approval to release funds for mobilization activities for the first unit, to October 2016.

**Management will, in August 2016, seek Board approval to release the funding required for the execution of the refurbishment of Unit 2.**

# Darlington Nuclear Refurbishment Project:
# Execution Phase Readiness

**OPG Board of Directors**
**October 1, 2015**

**Dietmar Reiner**
**SVP, Nuclear Projects**

BEHAVIOURS

- Say It, Do It
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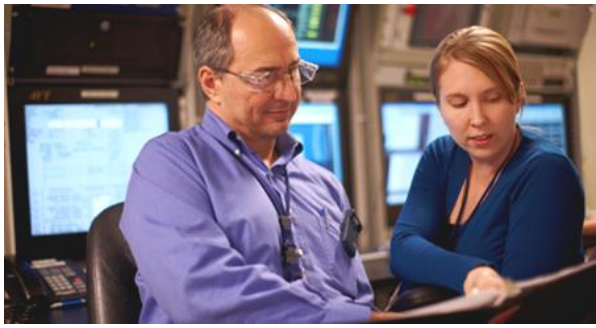
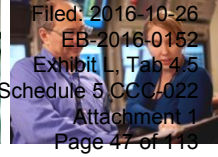
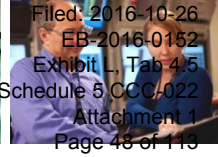


# Outline







# DEFINITION PHASE UPDATE

# Darlington Refurbishment: Phased Project Plan




**The Darlington Refurbishment Program (DRP) has now completed the Definition phase and is ready to proceed to the execution phase.**

## PHASE 1 — Initiation Phase 2007-2009

**SCOPE OF WORK**

- Initial determination of refurbishment scope through completion of:
  - Technical assessments of all major components
  - Condition assessments of balance of plant components
  - Initiation of regulatory processes; Integrated Safety Review and Environmental Assessment
- Develop reference plans for cost and schedule
- Complete economic feasibility assessment
- Establish project management approach and governance
- Establish overall contracting strategy
- OPG Board and Shareholder agree with recommendation to proceed with preliminary planning within the Definition Phase of the project

## PHASE 2 — Definition Phase 2010-2015

**SCOPE OF WORK**

- Obtain regulatory approvals:
  - Environmental Assessment
  - Integrated Safety Review
  - Integrated Implementation Plan
- Implement project management and oversight
- Complete infrastructure upgrades, i.e. Darlington Energy Complex
- Implement safety improvements
- Award major contracts
- Finalize project scope and complete engineering work
- Procure long lead materials
- Complete unit prerequisite work
- Construct reactor mock-up and fabricate and test tooling
- Develop release quality cost and schedule estimate
- Obtain all permits and licences
- Mobilize and train Trades staff

## PHASE 3 — Execution Phase 2016-2026

**SCOPE OF WORK**

- Unit shutdown and defueling
- Island unit and lay up systems
- Execute all refurbishment scope:
  - Reactor components
  - Fuel handling systems
  - Turbine / generator
  - Steam generators
  - Balance of plant
- Meet all regulatory commitments
- Plant maintenance and inspection activities
- Manage plant configuration
- Load fuel
- Commissioning
- Unit start-up
- Apply lessons learned to subsequent unit refurbishments
- Project close-out

# OPG's Preparation for Successful Execution of DRP




## OPG has taken steps to properly plan and prepare for the Execution Phase of the Refurbishment Program.

### Lessons Learned

OPG has incorporated lessons learned from past CANDU refurbishments and other large projects and is applying these lessons to ensure a successful outcome. Project management improvements are being implemented as a result of the experience with the Facility and Infrastructure and Safety Improvement projects.

### Front End Planning

OPG has expended significant effort in planning including detailed scoping, completion of Detailed Design , full development of a detailed cost and schedule estimate, and obtaining regulatory certainty.

### Management of Risk

OPG has implemented a framework with the appropriate controls that can effectively manage the risks associated with Refurbishment. Contracts ensure an appropriate allocation of risk.

### Right Team

OPG has the right team to successfully lead and execute DRP and are well integrated with the operating units.

# Application of Major Lessons Learned




## OPG has compiled lessons learned from DNGS, large projects, and past CANDU refurbishments to ensure a successful outcome.

- Lessons are tracked in a database and actioned to closure by management.

| Lesson | Actions Taken |
|---|---|
| **Management Team must be as Experienced and Qualified as possible, and hire third-party experts where appropriate** | • A high caliber team with significant major projects and refurbishment experience is in place |
| **Full scale Reactor Mock-up is necessary for training and tool development** | • Major tool development and testing are complete and staff training is underway<br>• The Contractors use of the mock-up has provided greater confidence in cost and schedule estimates |
| **Scope should be defined as early as possible** | • Detailed scope validation was conducted as part of the Release Quality Estimate process<br>• High percentage of scope defining station equipment inspections were complete with no significant additional work identified |
| **Select the right contract partners and contract models** | • Contractors were selected through a comprehensive bidding process with appropriate financial incentives and disincentives |
| **Implement a robust and independent program oversight function** | • Project Assurance and Project Controls functions have been established separate from the project execution team.<br>• Strong oversight and governance is in place |
| **Front End Collaborative Planning has been implemented including the completion of Engineering before commencing construction work** | • Collaborative Front End Planning has been used in the Engineering phase of the work and will be extended to the remaining phases to ensure highly predictable results<br>• Major engineering design work was completed prior to August 2015, well before breaker open |

# Application of Major Lessons Learned




**Project management improvements are being implemented as a result of the experience with the Facility and Infrastructure and Safety Improvement projects.**

- These projects represent < 8% of the total Program estimate. Although individual projects have experienced cost growth, all of the projects are expected to be completed within the funding envelope approved by the Board.

| Lesson | Actions Taken |
|---|---|
| **Collaborative Planning** | Collaborative front end planning was put in place to complete engineering, procurement, and detailed work planning to ensure effective integration with the site |
| **Scope Clarity and Control** | Processes are being enhanced to align stakeholders on scope early in the process. Controls are put in place for effective management of scope changes. |
| **Estimating** | The DRP has centralized its estimating effort and enhanced it's review and classification process. |
| **Scheduling** | Scheduling standards including work breakdown structure and earned value methods are in place an all vendors are preparing schedules in accordance with those standards. |
| **Material Tracking** | A material tracking database is now in place which provides metrics for each project. |
| **Contractor and Construction Oversight** | Resources to perform construction oversight, clear barriers for contractors, and measure performance and progress, are included in the refurbishment plan. Existing Contractor Management Office (CMO) is being enhanced. |
| **Field Engineers** | Engineering to support construction activities in the field is built into refurbishment plans. |
| **Sub-surface Risks** | Additional ground surveys are planned and additional allowances to deal with the unknown sub-surface conditions have been built into project plans. |
| **Contract Claims Management** | The effort, capability, and timeliness required to monitor and control contract issues and related claims is being enhanced and integrated with project controls systems. |

# Investment in Planning




**The budgeting process has been driven by public policy and has accordingly followed a phased approach, with significant investments being made in upfront, early planning.**

| | |
|---|---|
| Planning | • Province directed OPG to begin refurbishment feasibility study in 2006.<br>• OPG has completed detailed design prior to the start of construction. |
| Supporting Infrastructure | • Creation of full scale mock-up reactor to train staff, test tools, better anticipate project scope / cost / schedule.<br>• Other prerequisite projects either complete or underway to facilitate execution. |
| Contracting | • Contracts for all major work packages have been awarded.<br>• OPG has been working in close collaboration with contractors to improve accuracy of design / engineering / scoping / cost estimating / scheduling. |
| Budgeting | • Definition phase funding was put in place to select contractors early and fully define scope and develop a detailed cost and schedule baseline and risk register. |
| Resourcing | • OPG built a leadership team with extensive nuclear refurbishment and mega-project experience.<br>• Succession planning as well as initiatives to collaborate with Bruce Power on the overlap of refurbishment projects will ensure supply of resources through to the end of project life. |

# Scoping Process to Drive Planning




## OPG applied a robust scoping process to evaluate infrastructure investments.

**Scope Identification**

- Component Condition Assessments (2893)
- Life Cycle Management Plans
- Integrated Safety Review
- Environmental Assessment
- Regulatory Action Items
- Corrective Action Program
- Capital Modification Portfolio
- Operator Burden Program / Panel Deficiencies
- 40 Day Outage Improvements
- Hardened Elective Maintenance Backlog
- Cycle Outage Work
- Life Cycle Work
- Maintenance
- Engineering Inventory Backlog
- Unit Islanding
- Temporary Mods to Support Refurb
- Business Transformation Opportunities
- Beyond Design Basis Event Reviews
- OPEX from other plants
- Station Improvements
- Campus Plan / Facilities for Refurb
- Safety Improvements

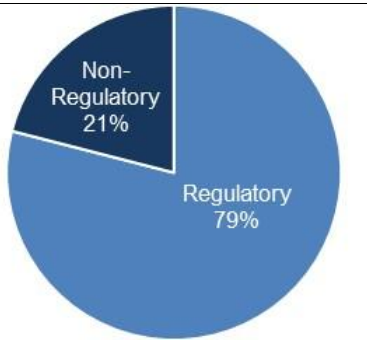
**Scope Assessment**

- Campus Plan
- Modifications
- Repair and Replace
- Engineering Studies
- Inspections

**Scope Execution (% of total scope)**

- Retubing & Feeder Replacement (RFR) - 61%
- Campus Plan (FIP SIO) 14%
- Turbine Generator (TG) 11%
- Fuel Handling (FH) 3%
- Steam Generator (SG) 2%
- Balance of Plant (BOP) 5%
- Shutdown, Layup and Services 4%
- Other (RSF, SP, UI) 1%

**Refurbishment Work Scope**
% of Estimated Cost



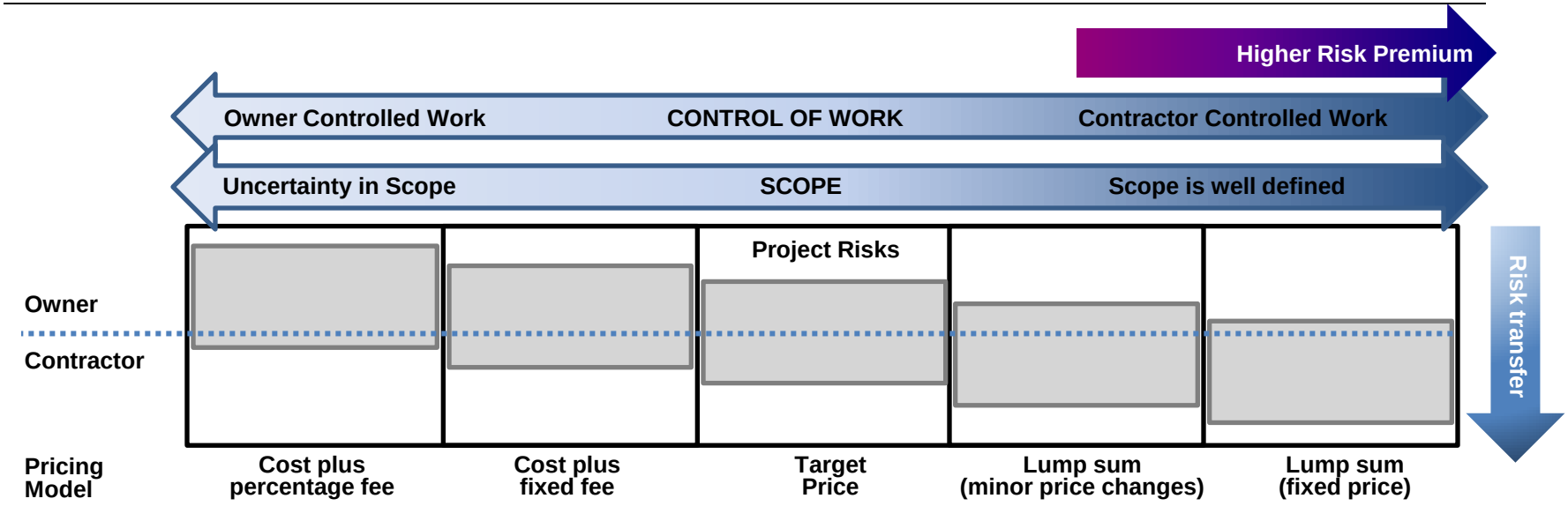
# Pricing Options for Specific Projects




## OPG's contracting strategy incorporates appropriate risk transfers and related cost and schedule incentives and disincentives.

- Use of a combination of fixed and target pricing will result in appropriate risk premiums and a lower overall refurbishment cost.
  - Projects where work is well defined and can be largely controlled by contractors are conducive to fixed price contracts including a premium for known risks that are transferred to the contractor. OPG has fixed price contracts for Steam Generator work, Turbine Generator components, and Re-tube and Feeder Tooling.
  - For Projects where scope is not certain or where the contractor cannot have full control, risks cannot be fully transferred to the contractor. In these cases, a cost plus or target price contract is conducive. OPG has target price contracts for Re-tube and Feeder replacement, Turbine Generator overhaul, and Balance of Plant work.

**Project Risk Allocation vs. Control of Work and Estimated Bid Prices across Contract Pricing Models**



# Target Pricing Model

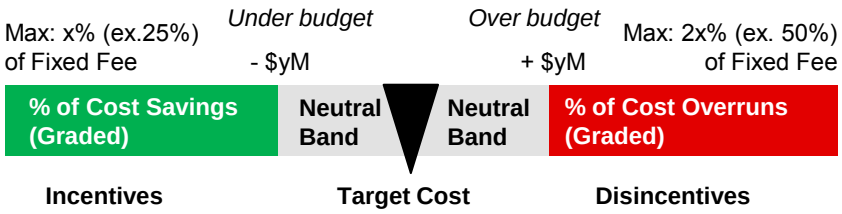



**The Target Pricing Model ensures that OPG obtains value for money in contracts where risks cannot be fully transferred to a contractor. OPG's approach includes both cost and schedule incentives/disincentives, with portions of the fee at risk.**

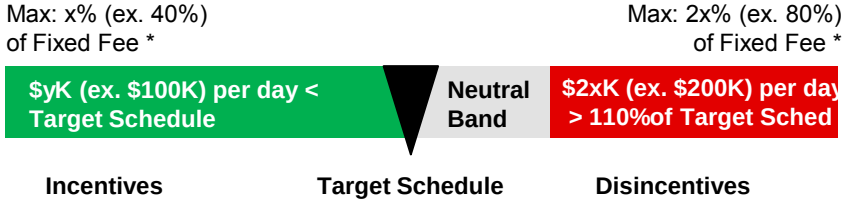
## Target Pricing Model

- **Common Model:** A common Target Pricing Model has been used by Refurbishment. OPG and the Contractor agree upon a Target Cost (excluding profit, risk and overhead) and Target Schedule. A Fixed Fee is agreed upon to compensate the Contractor for profit, risk and overhead and is paid based on milestones. The Target Cost and Schedule are the basis for the incentive/disincentive regime.
- **Target Cost:** "Allowed costs" and "disallowed costs" are agreed upon in advance; all disallowed costs are included in the Fixed Fee. OPG pays the Contractors allowed costs as they are incurred. If the total allowed costs paid are outside a neutral band, incentives/disincentives are incurred.
- **Target Schedule:** Schedule incentives/disincentives are payable if the work is completed before or after the Target Schedule (with neutral band before disincentives are payable, giving a strong incentive to finish early).
- **Fixed Fee:** If disincentives are payable, they reduce the Fixed Fee. A sufficient portion of the Fixed Fee is at risk that if the maximum disincentive amounts are payable, the Contractor will lose part of its overhead. Also, because it is a Fixed Fee, the contractor does not earn overheads on costs incurred beyond the Target Cost.

## Sample Cost Incentives / Disincentives




## Sample Schedule Incentives / Disincentives




* Less cost incentives / disincentives

# Contract Breakdown

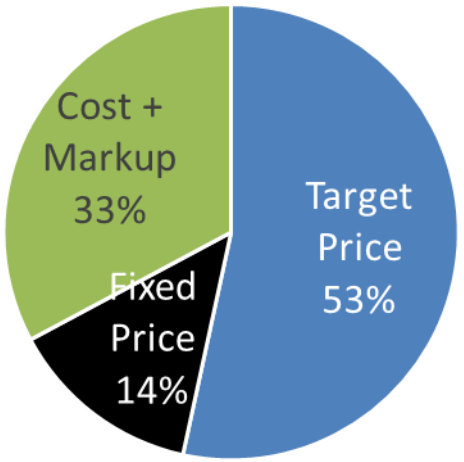



## The process for selecting experienced contract partners was extensive.

- Of the $12.8B high confidence estimate, $5.9B represents external vendor / EPC contracts which employ a combination of fixed / target / cost + markup pricing.
- Procurement started early to improve accuracy in planning - contractors have sufficient time / access to mock-up facility to develop confidence in estimates and reduce risk.
- Contracts are structured so that OPG has off ramps at the end of Definition Phase.

| Project | Contractor | Total EAC ($B) [1] |
|---|---|---|
| **RFR** | SNC Lavalin/Aecon JV | |
| **TG– Parts** | Alstom | |
| **TG- Execution** | SNC Lavalin/Aecon JV | |
| **SG** | Babcock & Wilcox / CANDU Energy JV | |
| **FH – Defueling & Refurb** | General Electric / SNC Lavalin/Aecon JV / ES Fox | |
| **BOP** | ES Fox / Babcock & Wilcox / Areva / AMEC / SWI | |
| **Shutdown & Layup** | ES Fox / SNC Lavalin/Aecon JV | |
| **Other Bundles – RSF, SP, UI** | ES Fox | |
| **Facilities, Infrastructure & Safety Improvement Projects** | Project & Mod's / ESFox / SNC Lavalin/Aecon JV | |
| | **Total Vendor / EPC Costs =** | **$5.9** |

**Percentage Breakdown of DRP Budget by Pricing Model[2]**

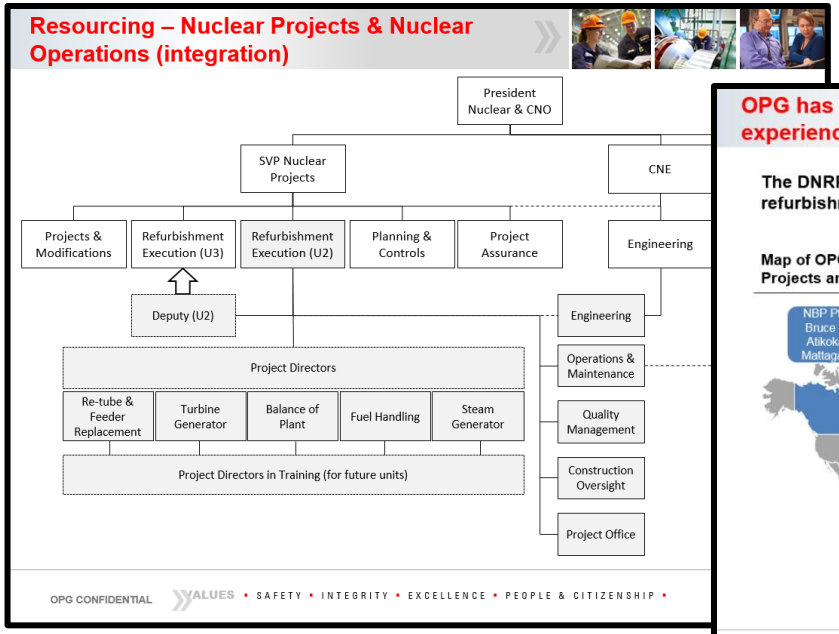



1. Costs exclude interest, and are before inflation

# DRP's Experienced Team


**OPG has the right leadership and succession plans in place to successfully deliver DRP and ensure continued operational excellence of the running Units[1].**

- The DRP leadership team has experience working on major projects and CANDU refurbishments and are incentivized to secure commitment to end of Unit 2.
- Succession planning and development is ongoing across Nuclear Projects and Nuclear Operations to ensure a continued supply of leadership and expertise.





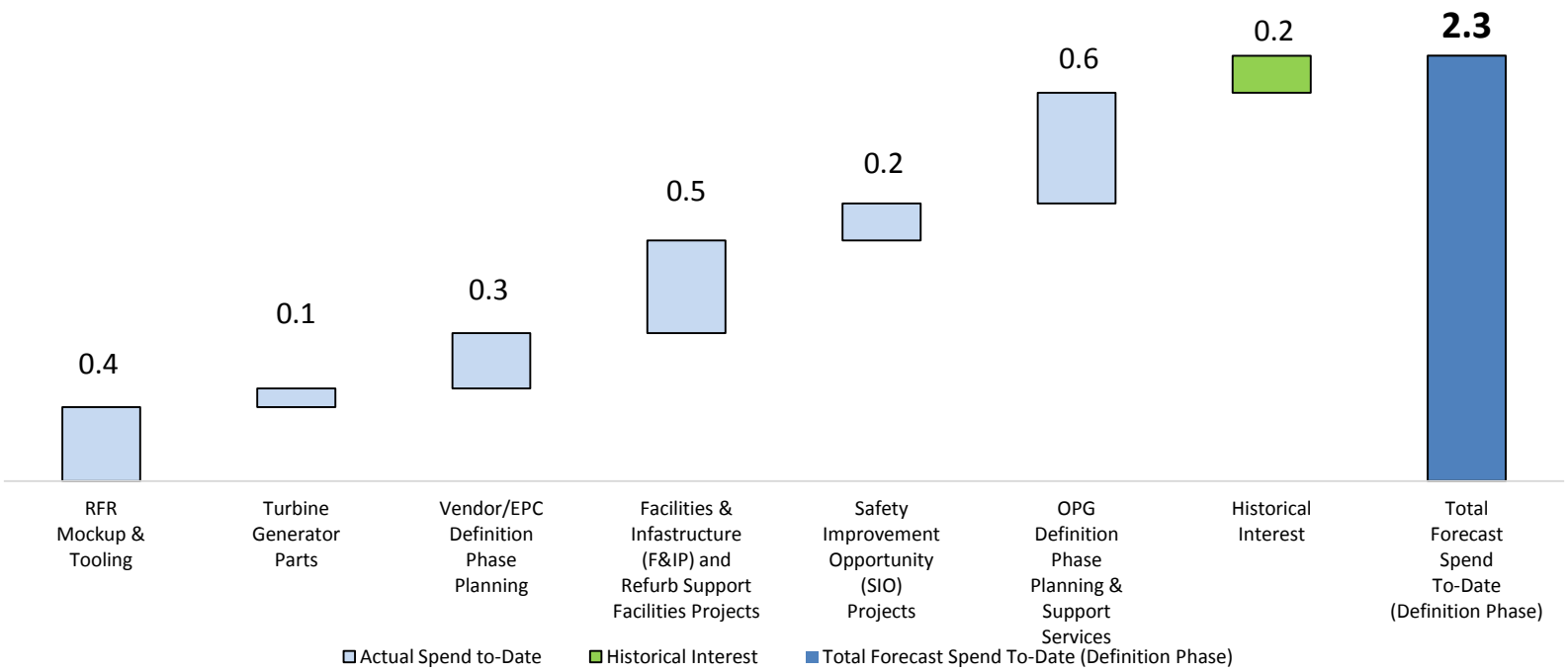
1. See Resourcing Module for further detail

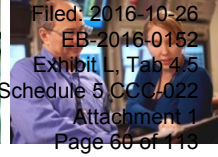
# Breakdown of the Spent to-Date




## The current "bottom-up" high confidence estimate, includes $2.3B of actual costs forecast to be Spent at December 31,2015.

**Build-up of the Forecast Spend To-Date**
*At December 31,2015 (2015$ Billions)*



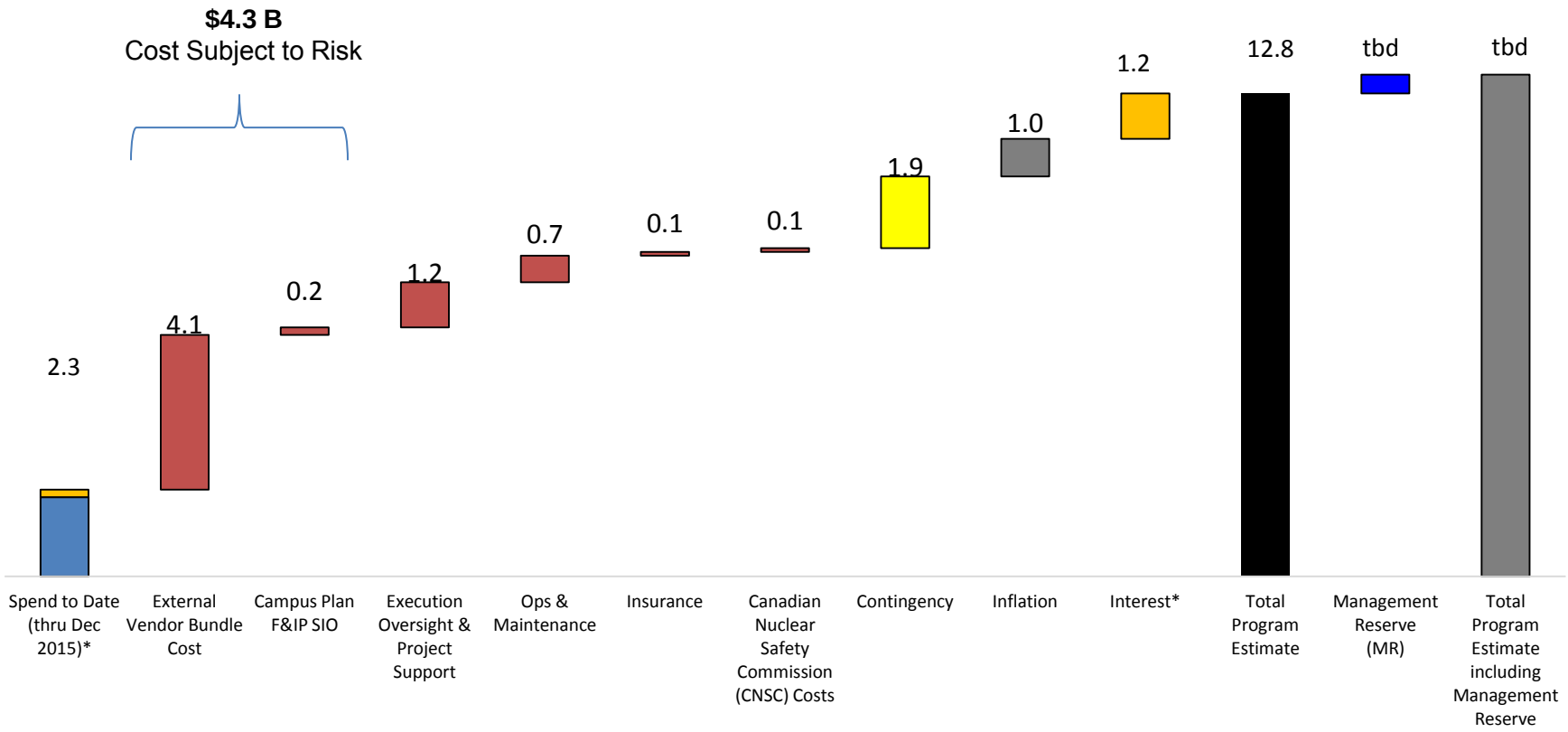


# DARLINGTON REFURBISHMENT EXECUTION PHASE COST AND SCHEDULE ESTIMATE

# Preliminary RQE Outputs


## The current "bottom-up" high confidence estimate, to refurbish 4 Darlington units is $12.8B.

**Build-up of the Preliminary Cost Estimate**
*As of September 12, 2015 (2015$ Billions)*

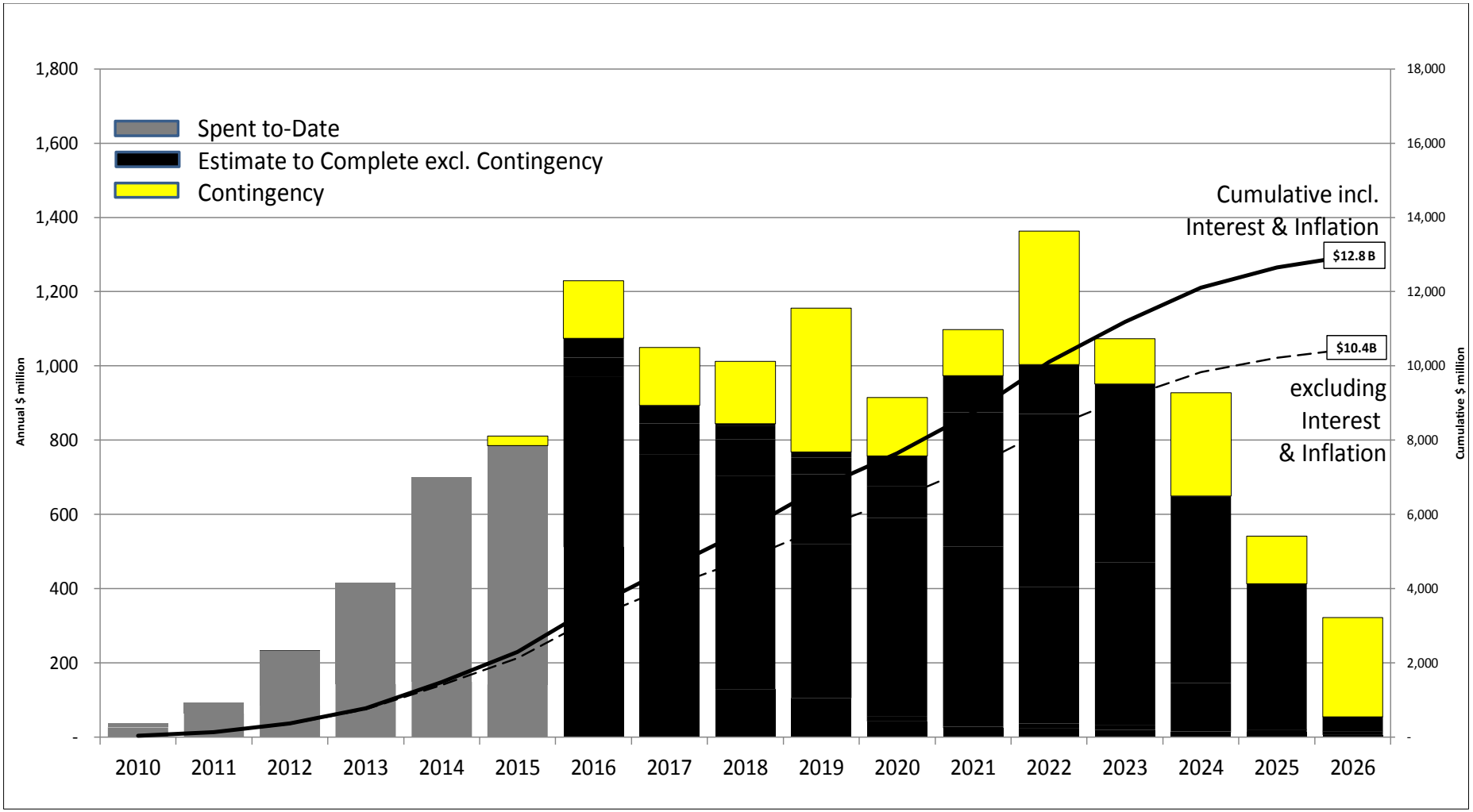



* Spend to date includes $0.2B of incurred interest.

# Overall Cash Flow




## The total $12.8 B DRP estimate is cost flowed over a 17 year life cycle from 2010 through 2026.



# EPC Estimate-to-Complete (By Value)



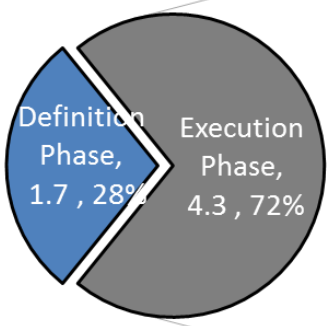

**Of the $6.0B of external vendor / EPC costs, $4.3B are Execution Costs to complete, with the majority related to Re-tube and Feeder Replacement.**

**$ 1.7 B**

Forecast Spend to-Date at December 31,2015

**$ 4.3 B**

Estimate-to-Complete work 2016 through 2026




[redacted]

Other Projects, 0.1 , 2%

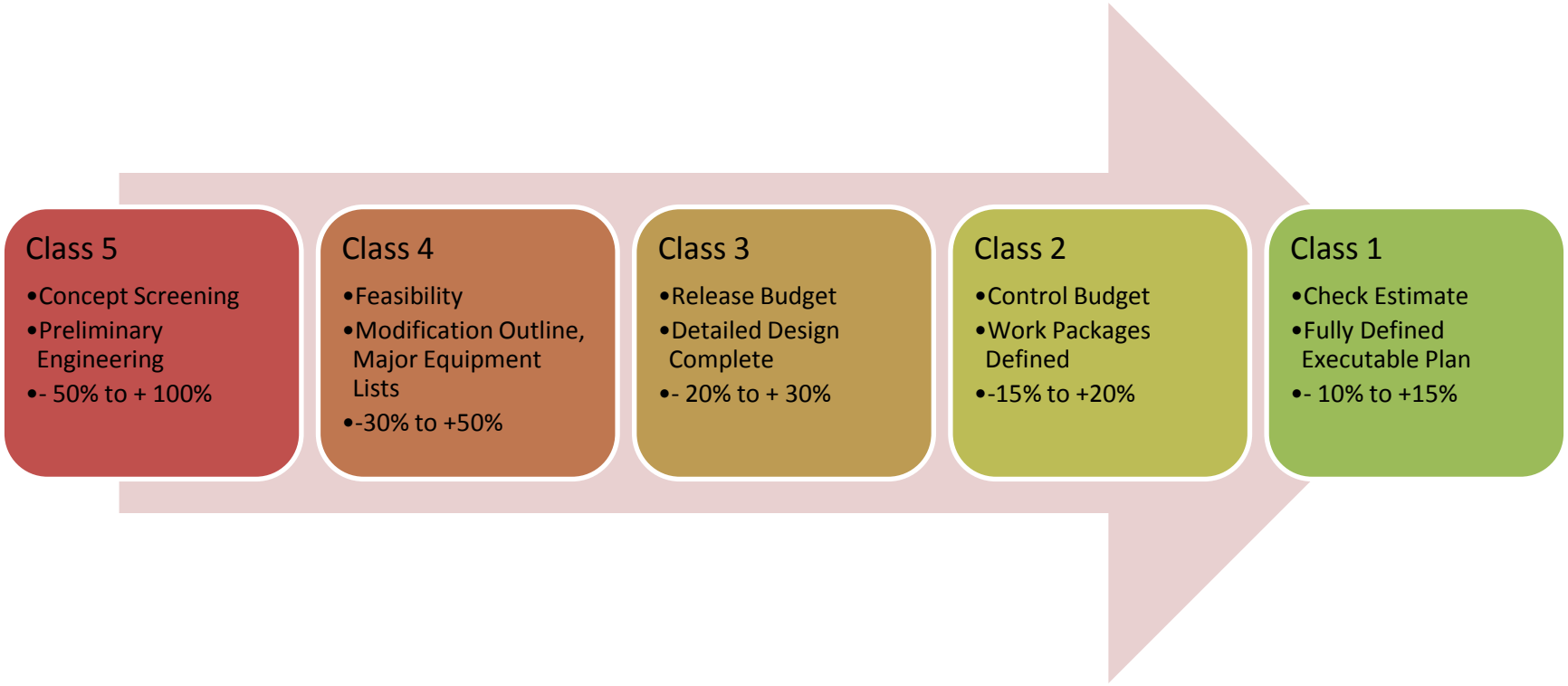
Steam Generator, 0.1 , 2%

Fuel Handling, Defueling,

# OPG Estimating Process




**OPG developed the DRP project estimate in accordance with the Association for the Advancement of Cost Engineering (AACE) estimating recommended practices as shown below.**

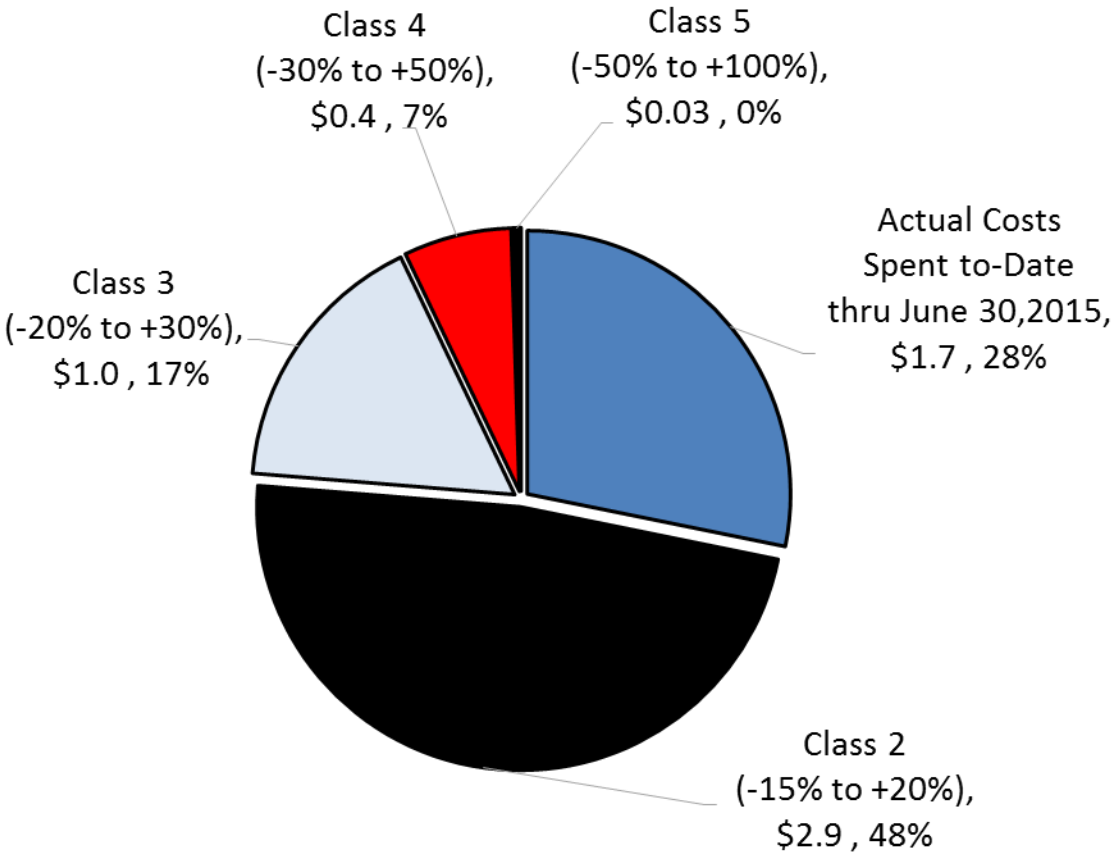



**OPG integrated it's approach to Engineering and Work planning with the AACE recommended practice.**

# EPC Estimate Classification




## Greater than 90% of the $6.0B of external vendor / EPC costs meets or or exceeds AACE Class 3




**Note:** Includes actual costs including interest to-date through June 30,2015 and Facility and Infrastructure and Safety Improvement projects currently in execution.

# Contingency Breakdown

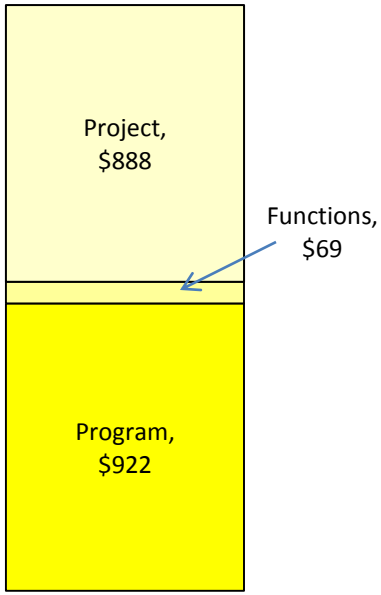



**The current contingency estimate is $1.9 Billion, which represents 30% of the $6.4 B estimated costs to complete.**

- This estimate is still under development and is based on project and program risks only, i.e. excludes any additional management reserve.

| Category | Bundle/Type | Contingency ($ millions) | % of Total Contingency |
|---|---|---|---|
| Project | Re-tube & Feeder Replacement | 317 | 17% |
| | Turbine Generator | 205 | 11% |
| | Balance of Plant | 166 | 9% |
| | Fuel Handling | 43 | 2% |
| | Steam Generator | 21 | 1% |
| | Shutdown, Layup and Services | 69 | 4% |
| | Other Projects | 67 | 4% |
| Functions | Total Functions | 69 | 4% |
| Program | Schedule Risk | 645 | 34% |
| | Discrete Program Risk | 211 | 11% |
| | Program Level Cost Uncertainty | 68 | 4% |
| | **Total Contingency** | **1,879** | **100%** |

**Contingency Breakdown**
*$millions, as at September 16, 2015*

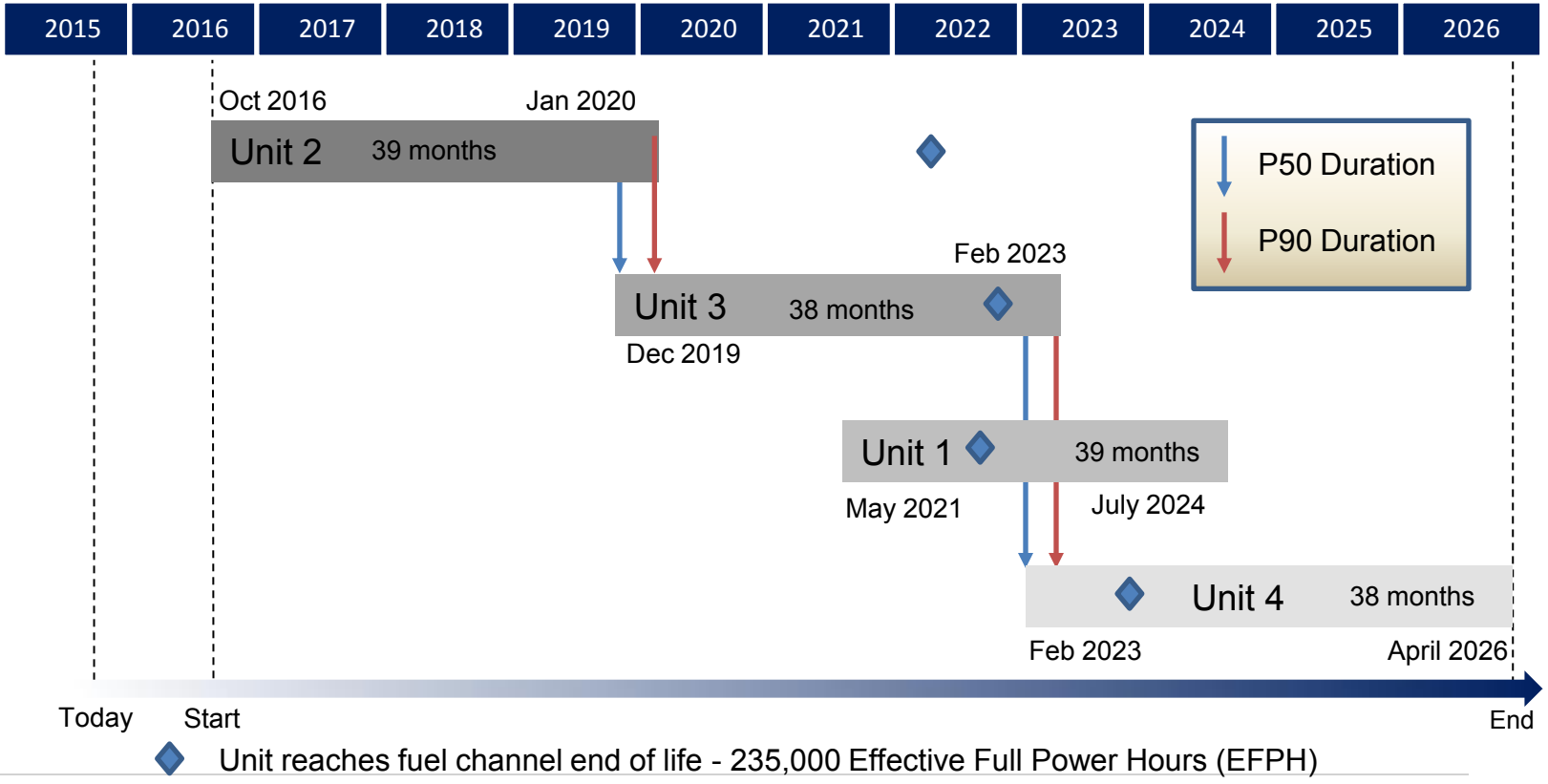


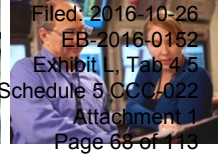
# Four Unit Schedule




**The high confidence schedule assumes the first unit's outage will commence in Oct. 2016 and each unit's scheduled duration is 38-39 months.**

- Based on the current high confidence that each of the Darlington units will operate to 235,000 Effective Full Power Hours (EFPH), this schedule results in no idle time on operating units.





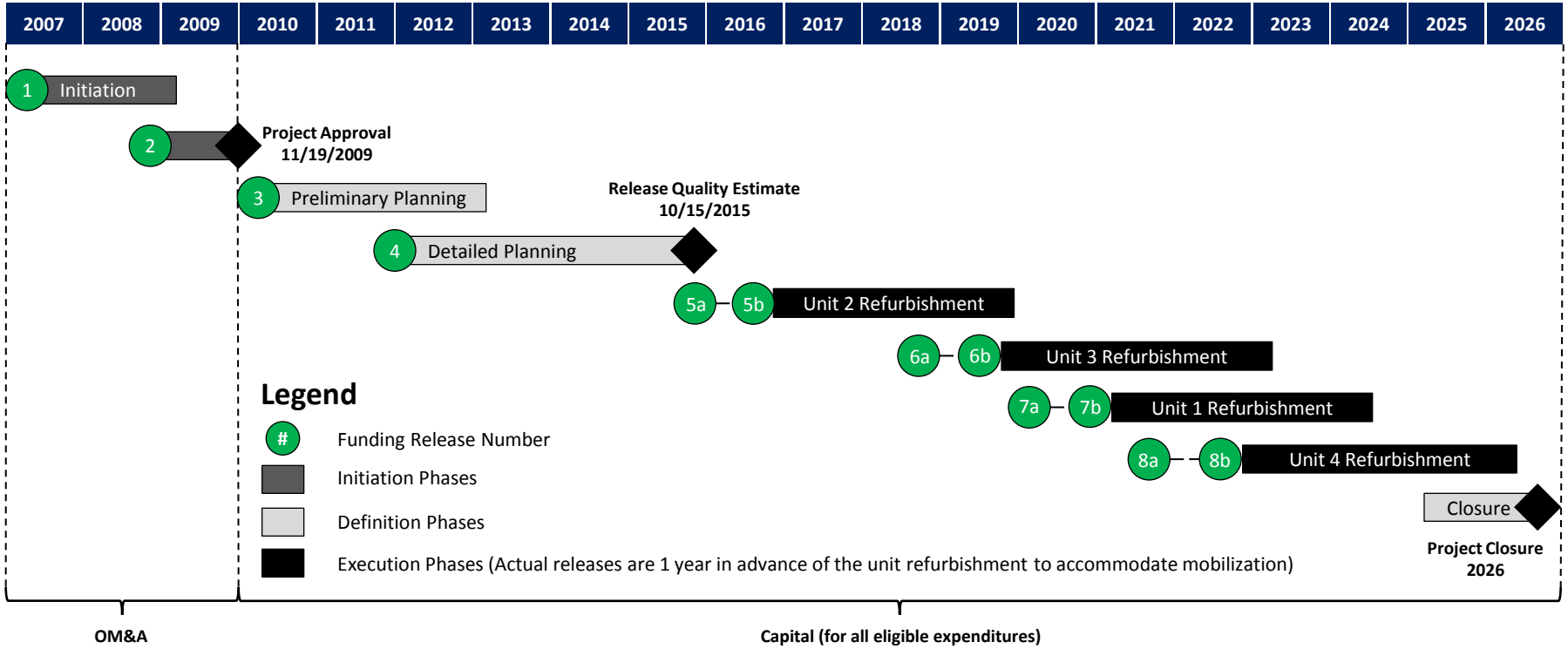
# DARLINGTON REFURBISHMENT PROGRAM RELEASE STRATEGY AND OFF RAMPS

# Release Strategy




**The Board of Directors will reconfirm the business case at structured intervals before each unit's funds are released, in accordance with the Release Strategy.**

- Funding for each unit will be released in two parts; a planning release 12 to 18 months prior to the start of the unit and a full release to execute the unit approximately 3 months before the commencement of the refurbishment of that unit.



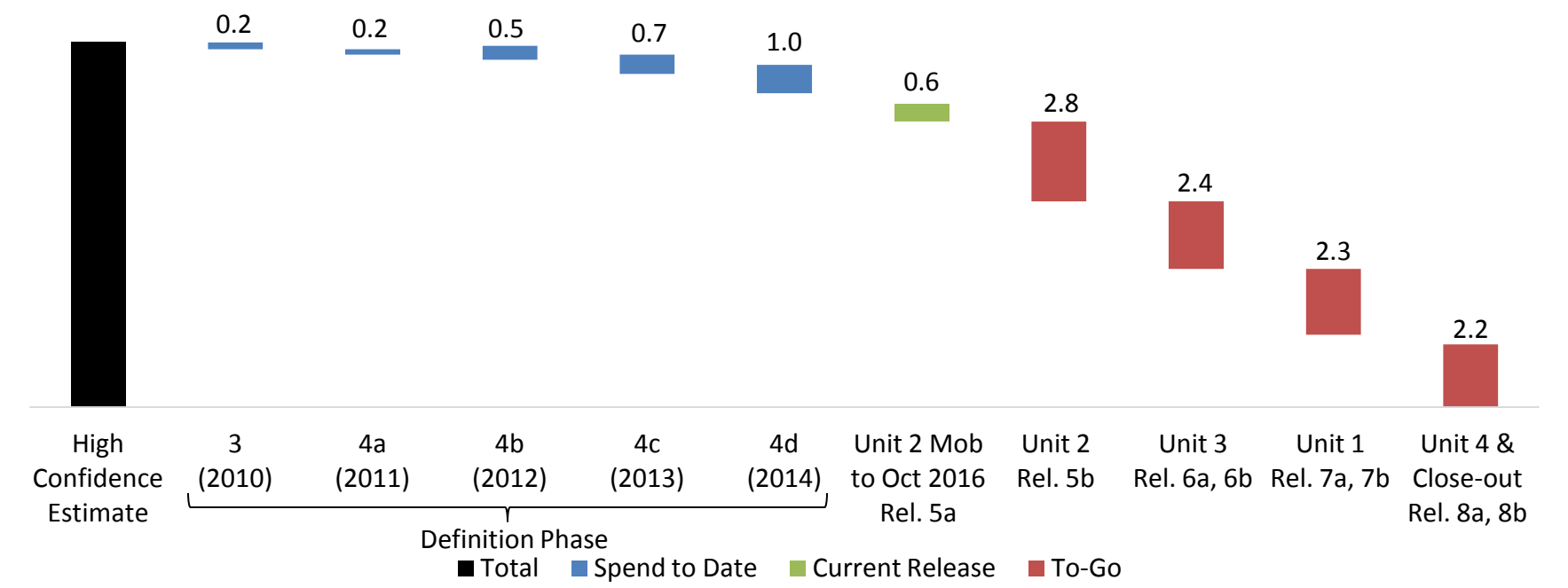
# Project Approvals and Off-Ramps




## While this is a $12.8B program, funds are structured for release unit by unit.

- The project release strategy will provide the Board with many opportunities to review project performance prior to allowing the project to proceed to the next phase.

**DRP Funding Releases**
*$ Billions*



# Darlington Nuclear Refurbishment Project:
# Business Case Summary

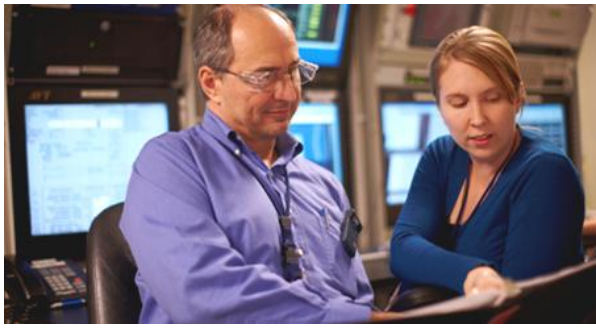
**OPG Board of Directors**
**October 1, 2015**

**Beth Summers**
**Chief Financial Officer**

BEHAVIOURS

- Say It, Do It
- Simplify It
- Think Top and Bottom Line
- Integrate and Collaborate
- Tell It As It Is





PEOPLE POWERING THE FUTURE OPG NUCLEAR



ONTARIO POWER GENERATION

# Economic Benefit of Refurbishing Darlington




**The successful execution of the DRP provides OPG with incremental net income in excess of $10 B**

- Income benefits driven by the addition of $12 B in capital investment to the regulated rate base by 2026.
- OPG expects to achieve the regulated rate of return of 9.3% on the project.
- Net income associated with the project will reach $0.7B at the end of the project and then decline
- Cash inflows will be reinvested by OPG in new growth opportunities, fund dividend payments and/or pay down debt
- [redacted]
- With a preliminary LUEC of 8.1 ¢/kWh, Darlington provides a stably-priced, low cost, low emissions generation option for Ontario, allowing OPG to maintain its status as the low cost, clean generator which moderates Ontario prices

# OPG and Provincial Benefits of Executing Darlington Refurbishment



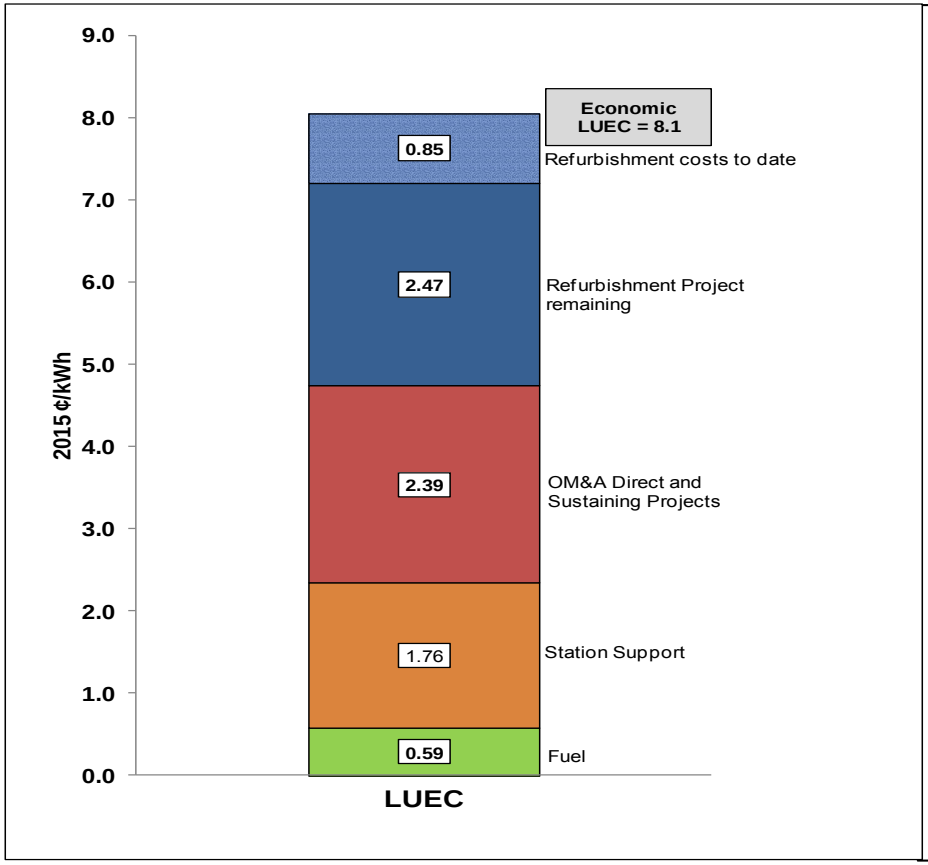

**In addition to incremental income in excess of $10B, refurbishment provides significant quantitative and qualitative benefits**

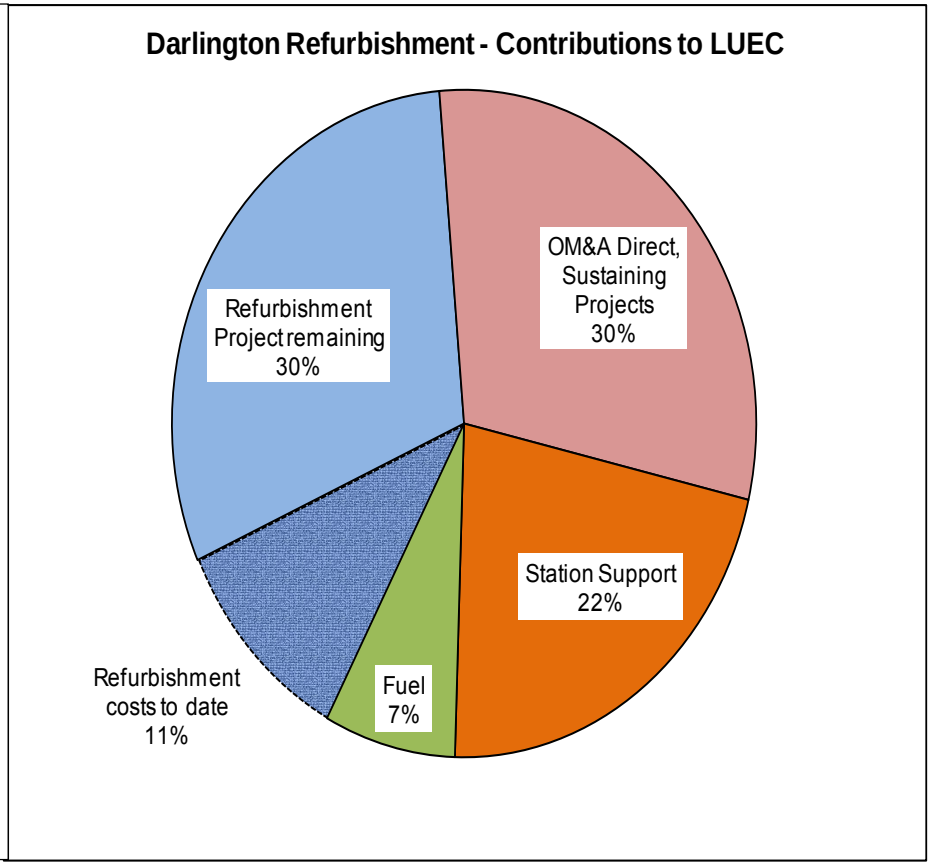
- [redacted] and provides opportunity for indirect employment
- [redacted]
- Avoids early decommissioning which would increase costs and mitigates the risk of having to safe store 10 nuclear units simultaneously
- Maintains OPG's nuclear footprint and is consistent with Ontario's Long-term Energy Plan
- Contributes to Provincial and Federal air emissions goals - avoids 330 million tonnes of $CO_2$ emissions compared to gas-fired generation over 30-year post-refurbishment life

# DRP LUEC Results




## The Total Economic LUEC of 8.1 ¢/kWh (2015$) is below the 2010 upper estimate of 9 ¢/kWh in 2015$ (8 ¢/kWh in 2009$)




- The Refurbishment Project contributes 3.3 ¢/kWh (including 0.85 ¢/kWh for project costs to date) or 41%.
- Post-refurbishment operations, support costs and fuel costs contribute the remaining 4.8 ¢/kWh or 59%.

# Post-Refurbishment Costs and Performance




- **The Post-Refurbishment Costs and Performance contribute 59% to the LUEC**

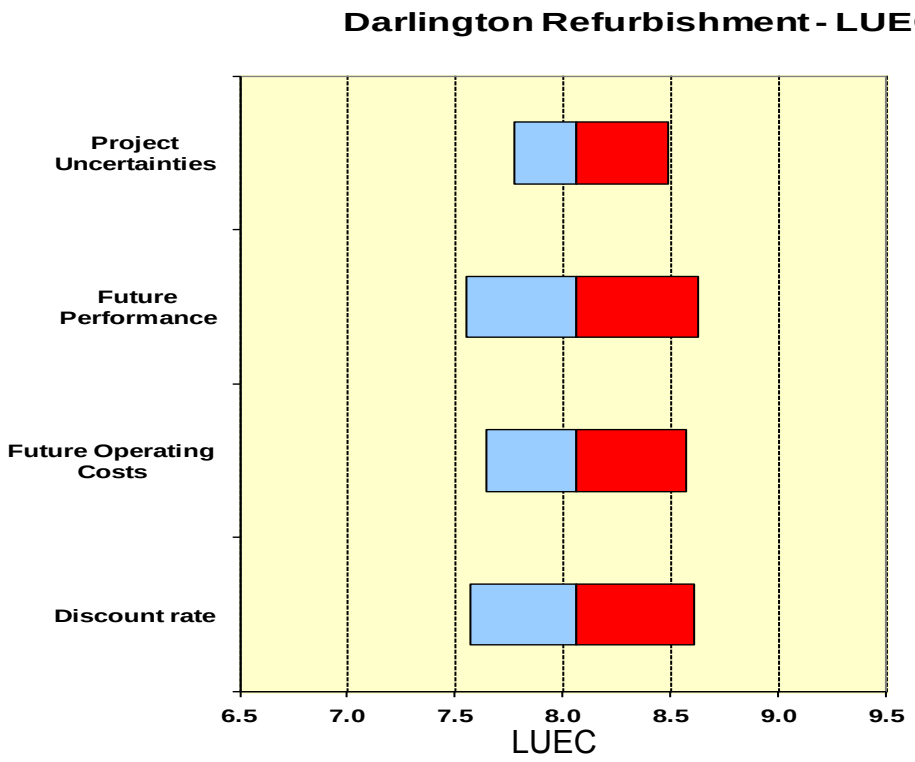
| Post Refurbishment Operations Estimates | Average Station Cost / Yr (2015$) | Comments |
|---|---|---|
| Annual Direct Station Costs Post-Refurbishment | 570 | Derived from the Long-Term Outlook, informed by historically achieved costs and detailed forecasts of station costs and sustaining projects |
| Annual Support Costs Post-Refurbishment | 460 | Derived from the Long-Term Outlook, are higher than the current BP period and reflects losses of economies of scale associated with the shutdown of Pickering |
| Plant Performance Post-Refurbishment (Capability Factor) | 88% | Range is 83% - 93%. Performance for the past 10 years has been 89.4%. |

- Costs are consistent with and based on the Long-term Outlook forecast.
- Post Performance is more conservative than internal operational targets and recent performance.

# Sensitivity of Darlington Refurbishment LUEC to Key Inputs




**Sensitivity of LUEC estimates to key cost and performance assumptions show risks and opportunities are less than 10%**




| Assumptions | Lower | Base | Upper |
|---|---|---|---|
| **Project Uncertainties** | | | |
| Refurb Cost* (2015$) | -10% | $10.4B | 15% |
| Refurb Duration (months) | -2 mths | 36 mths | +3 mths |
| **Future Performance** | | | |
| Annual Capacity Factor (%) | -5% | 88% | 5% |
| Life of Refurb Units (yrs) | +2 yrs | 30 yrs | -2 yrs |
| **Future Operating Costs** | | | |
| Base OM&A ($M) | -5% | 280 | 10% |
| Outage OM&A ($M) | -10% | 145 | 10% |
| Sustaining Projects ($M) | -10% | 150 | 10% |
| Nuclear Support ($M) | -5% | 220 | 15% |
| Corporate Support ($M) | -15% | 235 | 10% |
| Fuel ($/MWh) | -15% | 5 | 15% |
| **Discount Rate** | -1% | 7% | +1% |

*Refurb cost sensitivity applied only to going-forward costs excluding contingency

- Project uncertainties (costs and schedule) influence LUEC less than the post-refurbishment uncertainties.
- Discount rate sensitivities are also significant, showing the importance of ensuring financing at or below OPG's current weighted average cost of capital.

# Key Risks




**OPG has a structured approach to manage risks before, during and post-refurbishment**

| Risk | Risk Overview | Mitigating Strategies |
|---|---|---|
| Project Costs and Schedule | • Execution of a project of this magnitude and duration carries significant residual risk related to project cost and schedule uncertainties, even after significant investments in up-front planning | • Risk identification and analysis completed by the DRP. Specific project and program discrete risks evaluated. Insurance to be put in place to mitigate insurable risks.<br>• Significant contingency assessed and included in estimate; management assessment that it is adequate to cover cost and schedule risks |
| Post-Refurb Performance | • Post-refurbishment performance of the Darlington Station may not achieve the forecast in the Business Case | • Using 88% capability factor, considered to be a median to high confidence estimate as it is below actual performance over the past 10 years of 89.4%, but more than in-service performance of 84.8%<br>• Plan is to invest $4.4B in sustaining investments over 30 years. Maintenance and aging management programs will be maintained at or above the current high standards. |

# Key Risks (cont'd)



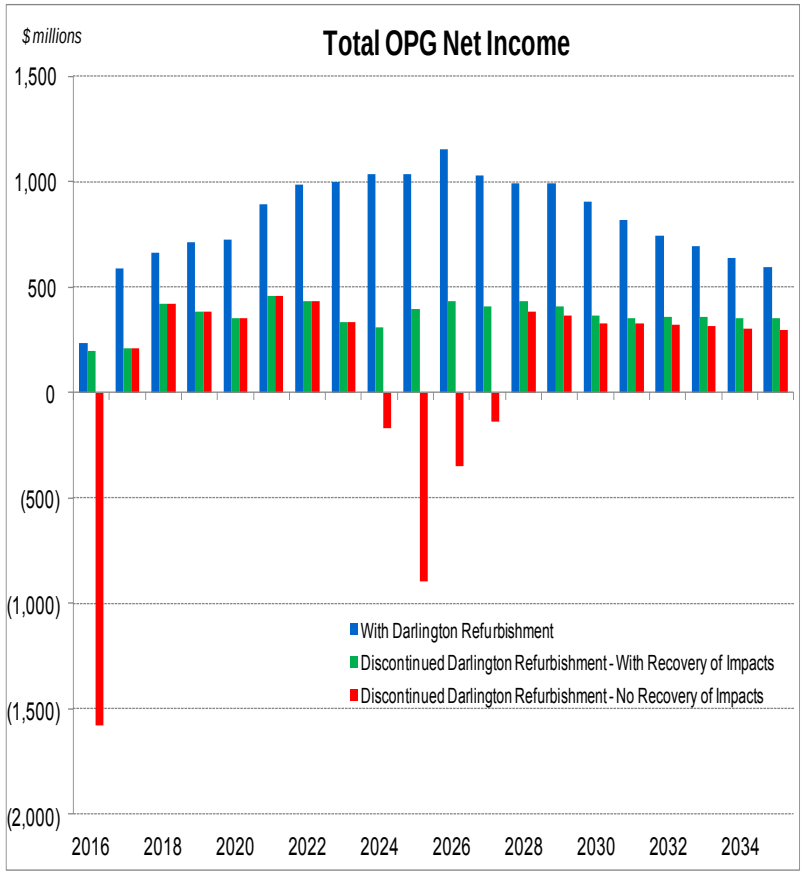

**OPG has a structured approach to manage cost recovery risks both during refurbishment and post-refurbishment.**

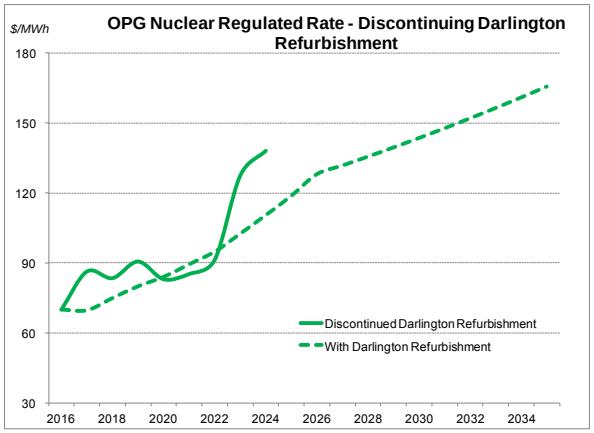
| Risk | Risk Description | Mitigating Strategies |
|---|---|---|
| Financing and Cost Recovery | • OPG may not be able to fully recover its incurred costs upon return to service of the units<br>• Amount of DRP capital at risk will grow as the project proceeds to execution, so the need for assurance of cost recovery is increasing | • OPG continues to discuss with the Province the need for regulatory support for nuclear rate smoothing and greater assurance of cost recovery. The MOE has posted a notice on August 13, 2015, "proposing to amend Ontario Regulation 53/05 to reduce volatility in OPG's regulated nuclear rates during and following the period of Darlington refurbishments, while permitting an orderly recovery of prudently incurred costs" |

# Directional Impacts of Discontinuing DRP

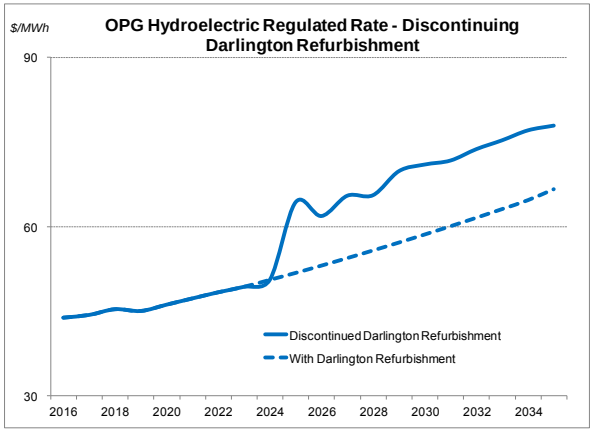



**If the DRP is discontinued, OPG will cease to be a nuclear generator, will forego net income in excess of $10 B and risk further income reduction of about $5 B if incurred costs are not recovered**

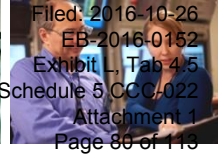



- **If cancellation costs are recovered, the Nuclear rate increases on average by ~$10/MWh into the mid-2020s when plants are shut down**




- **If cancellation costs are recovered, the Hydroelectric rate increases by ~20% post 2023 when Hydroelectric generation must bear the recovery of the remaining cancellation costs**



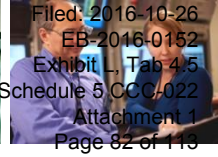
# NEXT STEPS

# Next Steps




**Going forward, OPG will continue to progress towards Unit 2 breaker open according to the Ready to Execute ("RTE") Strategy and prepare for ongoing Board decisions**

- Management will request the following approvals from the Board of Directors in November 2015:
  - Approval of the 4 unit cost estimate,
  - Approval of the 4 unit schedule,
  - Approval to transition from the Definition Phase to the Execution Phase of the project, and
  - Approval to release funds for mobilization activities for the first unit, to October 2016.
- OPG will also continue to progress against the RTE plan which has been develop to ensure that the organization is fully prepared to execute the first unit refurbishment by October 2016.
- Management will seek approval to release funding for the first unit refurbishment in August 2016.



# BACKUP

# ‘LUEC’ Backgrounder




## Levelized Unit Energy Cost (LUEC)

- LUEC is an economic measure, often used as a screening tool to facilitate consistent cost comparisons across generation options that have similar applications (e.g. base-load)
- LUEC is the electricity price (in ¢/kWh or $/MWh) that is required for an option to recover all its costs (including costs of capital) given the assumed option service life, operating pattern and incremental cost profile.
- LUEC is generally expressed in today’s dollars, and is a constant number that changes over time at the rate of inflation.
- For the purposes of economic comparisons, “Going Forward” (excluding sunk costs) LUECs are typically used.
- Price (LUEC) **x** Volume (ENERGY) = All costs of an option on a present value basis

# Report to Board of Directors

# Board Retreat

# October 1-2, 2015

## Darlington Nuclear Refurbishment Project

Burns & McDonnell
Modus Strategic Solutions

October 1-2, 2015

**This entirety of this report was filed at**

**L-4.3-1 Staff-072, Attachment 15**

# APPENDIX 2

# Darlington Refurbishment Program 4-Unit Cost and Schedule Estimate and Economic Update

**November 13, 2015**

# Table of Contents

# Introduction

The purpose of this report is to provide information to support the Darlington Refurbishment Program (DRP) execution phase 4-unit cost and schedule estimate as at the completion of the Definition Phase (RQE, or Release Quality Estimate).

In 2010, Management communicated that the estimate of the DRP would be less than $10.0 Billion in $2009, which is equivalent to $11.0 Billion in $2015, excluding interest and inflation and that the LUEC would be less than 8¢/kWh (2009$). At the 2010 OEB hearings, OPG communicated that the $10.0 Billion, including interest and inflation, is $14.0 Billion.

Management has now completed the definition phase. A number of key milestones were achieved in the year which provides Management with a 4-unit high confidence release quality estimate that the overall cost of the DRP, including interest and inflation, will be less than $12.8 Billion. Based on the 4-unit high confidence estimate of $12.8 Billion (including interest and inflation), the high confidence durations, and robust estimates of the future operating costs and performance of the station, the Levelized Unit Energy Cost (LUEC) of Darlington Refurbishment is estimated at 8.1 ¢/kWh, making it low cost, low emissions, stably-priced generation option.

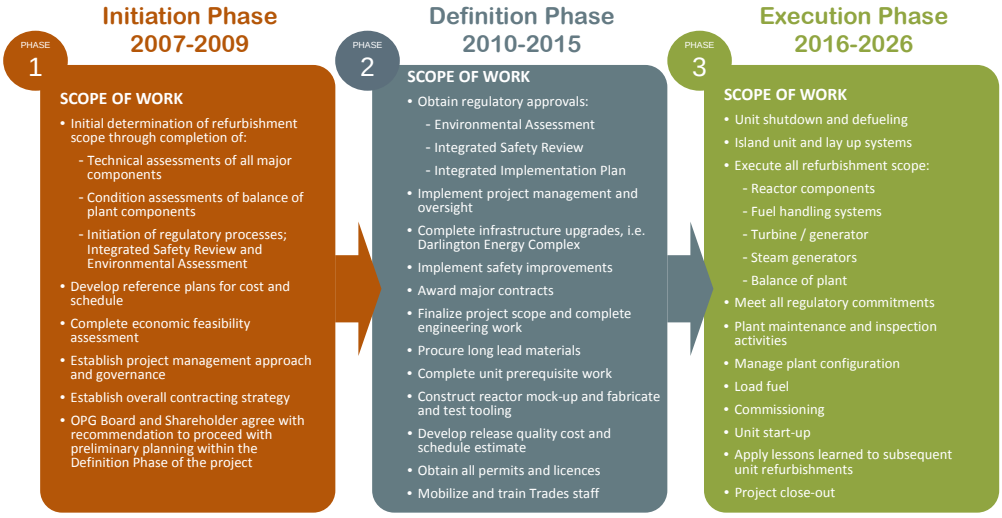
Management, in planning for the DRP, has negotiated contracts that limit OPG's exposure should a decision be made not to continue the DRP. Based on the amount of work currently in progress, should a decision be made not to continue the DRP, the currently committed cost to close the project, including demobilization of project staff and cancellation of existing contracts, material orders, etc., is estimated to be about $150 Million.

The balance of this report provides further details on accomplishments to date to complete the Definition Phase, a summary of the 4-unit cost and schedule estimate including details on contingency, and a review of the Levelized Unit Energy Cost (LUEC) included in the Business Case.

## Definition Phase Update

In 2009, the DRP identified three phases of project development as shown in Figure 1. The Initiation Phase, completed in 2009, concluded with the approval of a "Feasibility Business Case" allowing Management to proceed to the Definition Phase.

**Figure 1: Darlington Refurbishment Phases of Project Development**




During the Definition Phase, management has taken sufficient time to plan and prepare for the successful execution of Darlington Refurbishment including incorporation of the following:

- OPG has captured operating experience and lessons from Darlington projects, past CANDU refurbishments and other large projects. For each of the 120 lessons identified, appropriate actions have been identified and applied to OPG's context and operating environment. OPG continues to gather lessons learned and collaborate with Bruce Power to share lessons learned during both companies' overlapping refurbishments. In addition, OPG ensures that the contractors are incorporating lessons learned into plans.
- OPG has invested $1 Billion in front end planning, including detailed scoping, and has completed detailed design more than a year before the start of construction. A full scale reactor mock-up was constructed and all Re-tube and Feeder Replacement tooling was tested. Test times were used to develop a reliable critical path schedule and comprehensive risk register. The mock-up will be used to train all workers, providing predictable execution phase performance. Estimates have been prepared for all scope with 90% at Class 3 or better.
- OPG is the first Nuclear Operator to fully implement the CNSC's regulatory document RD-360 on the Refurbishment of Darlington; completing an Environmental Assessment, an Integrated Safety Review and Global Assessment, and an Integrated Implementation Plan. The Integrated Implementation Plan has been accepted by CNSC staff and is included in the Darlington license application. This provides OPG with certainty of regulatory scope and requirements to refurbish and restart the Darlington units.
- All of contracts for all bundles of work have been awarded. Engineering, Procurement, Construction ("EPC") vendors have engaged early in the planning activities to ensure a complete understanding of scope and full development of cost and schedule estimates. Contracts consider the appropriate level of risk transfer and provide both cost and schedule incentives and disincentives to encourage good performance.

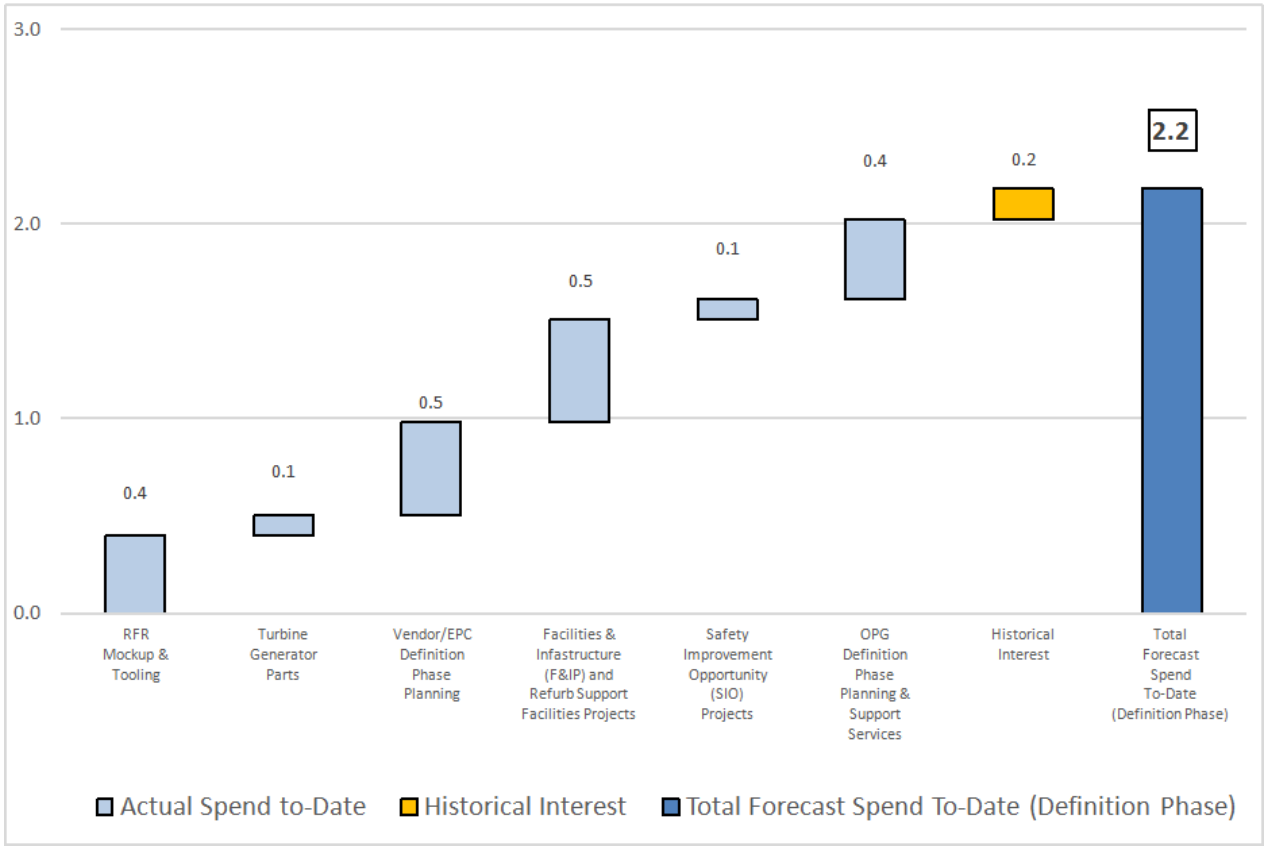
- OPG's management team has significant experience working on major projects and CANDU refurbishments. Strategies are being identified to allow for retention of key staff during the individual unit refurbishments, as well as succession planning and knowledge transfer for successive units.

During the Definition Phase, OPG commenced construction and is nearing completion of many of the Facilities and Infrastructure and Safety Improvement Opportunity projects required to be in place prior to the start of the Refurbishment outage in October 2016. These activities include:

- The construction of a Refurbishment Project Office, a Re-tube and Feeder Replacement Island Support Annex, and required upgrades to roads, bridges, and parking lots; all with a goal of reducing the time that it takes to on board contractors each and every day of the project.
- Safety Improvement Opportunity projects, including installation of a Third Emergency Power Generator and a Containment Filtered Venting System are also being constructed. A Heavy Water Storage facility is under construction to store the moderator water that must be drained from each unit prior to that unit's refurbishment.
- Facilities and Infrastructure and Safety Improvement Opportunity projects represent less than 8% of the total Program estimate. Funds released for these projects included contingencies to manage the associated risks. Although individual projects experienced cost growth and considering the contingency released, all of the projects are expected to be completed within the funding envelope approved by the Board. Lessons learned have been applied to the Execution Phase projects.

As of the end of the Definition Phase, as shown in Figure 2, over $2.2 Billion will have been spent to achieve both the planning deliverables, the pre-requisite Facilities and Infrastructure and Safety Improvement Opportunity project work, and delivery of the Re-tube and Feeder Replacement mock-up and tooling.

**Figure 2: Definition Phase Cost Summary**

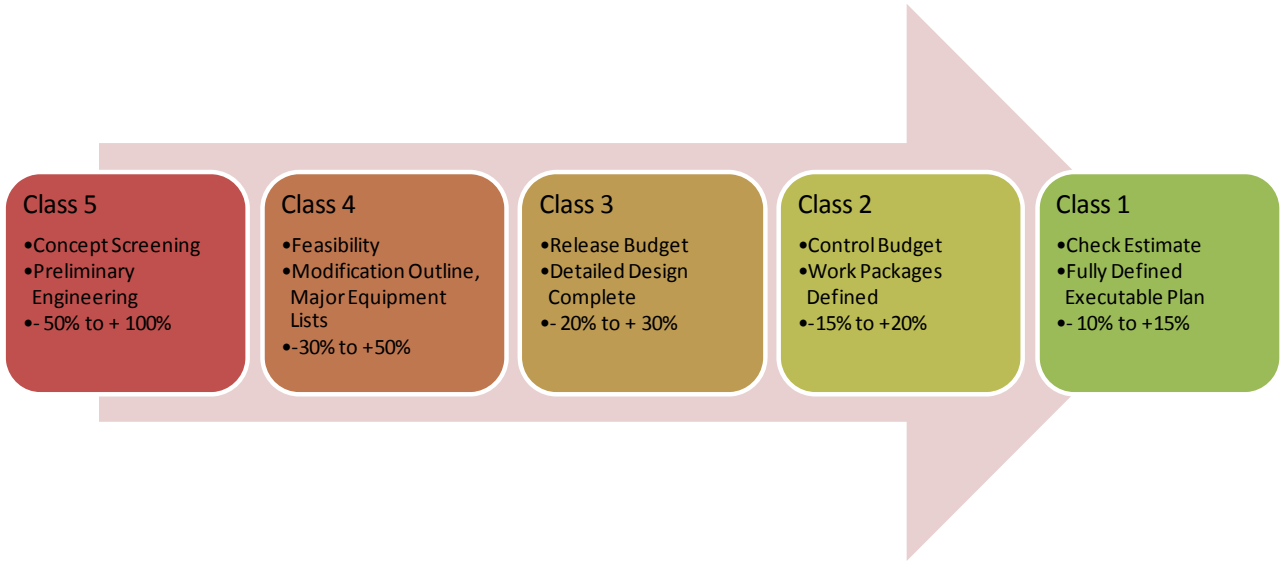


# Project Cost

## Project Estimate Backgrounder

OPG is developing the DRP project estimate in accordance with OPG practices and the Association for the Advancement of Cost Engineering (AACE) estimate classification model as shown below. Figure 3 provides an overview of the classification model and provides a reference to the general "type" of estimate and the associated uncertainty band.

**Figure 3: AACE Estimate Progression and Classifications**




In 2009, as part of the feasibility assessment and the preliminary Business Case, Management performed feasibility studies on major life-limiting components and initiated a component condition assessment for the balance of the station systems. Based on the level of planning, Management communicated a project estimate of less than $10 Billion ($2009) excluding interest and inflation. This estimate was considered Class 5 for known scope with additional contingency for discrete risks, regulatory uncertainty and unknown scope.

Since 2009, planning has significantly progressed; scope has been confirmed and clarified while detailed engineering was performed. As a result, Management's level of certainty has improved. As of October 2015, all detailed engineering and work planning is complete and 90% of the work is at Class 3 or better. It is for this reason that Management now has a high confidence in the overall project scope, cost, and schedule estimates and will implement this as a control budget upon Board approval.

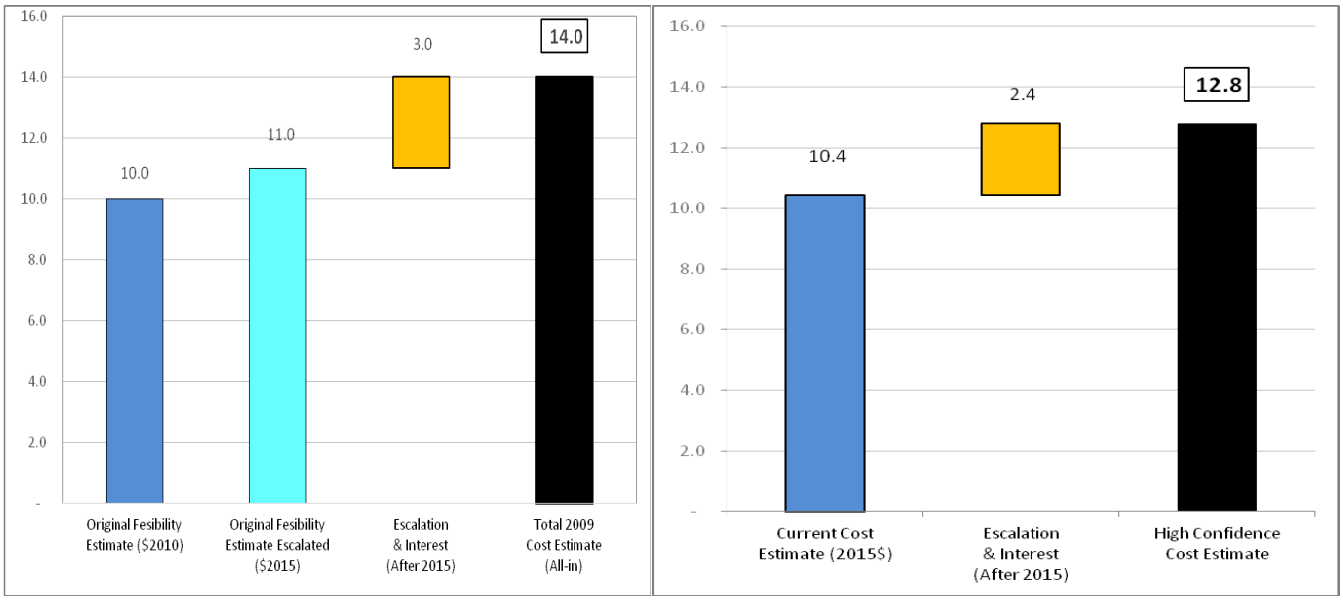
## Project Cost Estimate Summary

In 2010, Management communicated that the high confidence DRP estimate would be less than $10.0 Billion. Including inflation and interest, this estimate would be less than $14.0 Billion.

Management has completed Definition Phase planning and, has high confidence that the cost for refurbishing 4 units will be less than $12.8 Billion, including Definition Phase costs ($2.2 Billion), contingency ($1.7 Billion), inflation ($0.9 Billion), and interest ($1.3 Billion).

As shown in Figure 4 below, the current 4-unit estimate is $1.2 Billion lower than the original feasibility estimate communicated in 2010.

**Figure 4: Cost Comparison, 2010 vs. Current 4-Unit Cost Estimate**



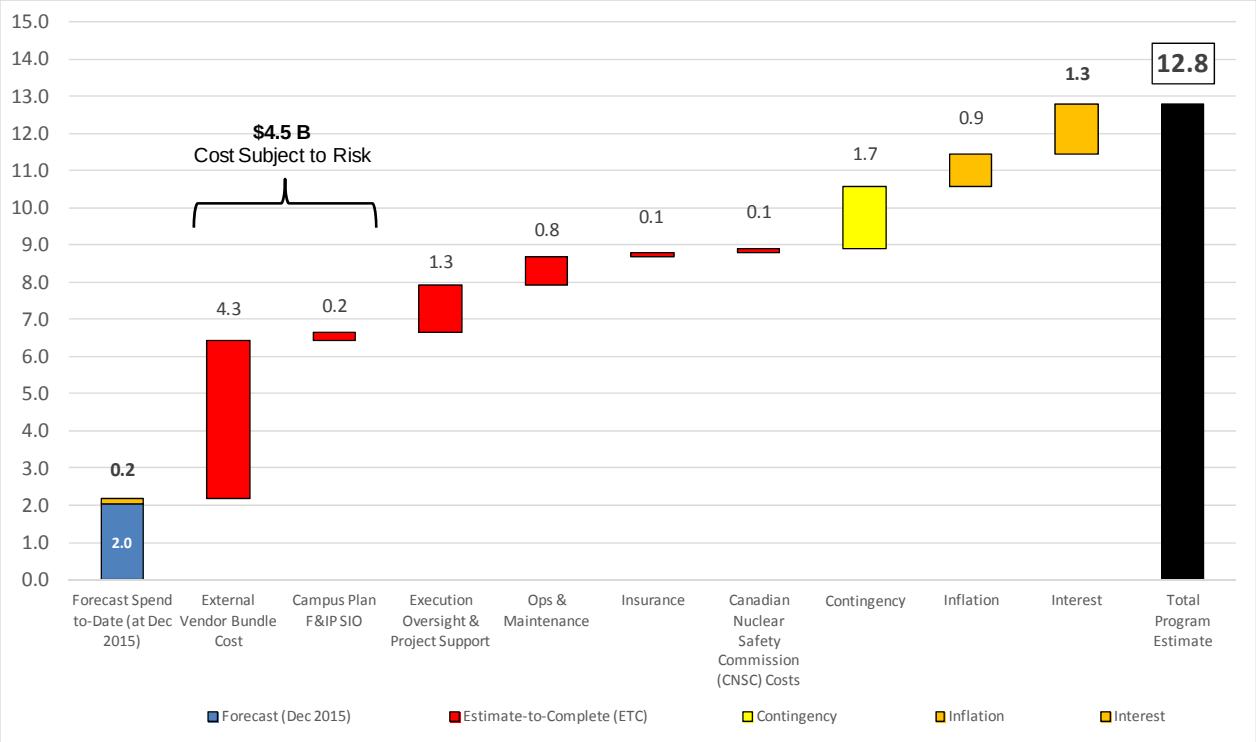

**Original Feasibility Estimate ($ Billion)**

**Current 4-Unit Cost Estimate ($ Billion)**

(1) The Original Feasibility Estimate was reported as $10 Billion in $2009, excluding interest and inflation. When interest and inflation is included, the estimate was $14 Billion as communicated in 2010.
(2) Estimate includes interest and inflation. Inflation is at 2% and interest in the current estimate is at approximately 5% to 2021 and 6% thereafter.

Figure 5 below, provides a summary of the estimate build-up for the Execution Phase of the project. Of the $12.8 Billion estimate, $2.2 Billion is forecast to be spent in the Definition Phase as at the end of 2015 and $10.6 Billion is to be spent in the Execution Phase. In addition to external vendor costs to execute the major scopes of work, the project is carrying costs for owner's oversight, operations and maintenance, regulatory fees and insurance, and general project support.

**Figure 5: Execution Phase Cost Estimate Build-up**




As indicated in Figure 2 and 5, the total Engineer Procure Construct (EPC) vendor estimates included within the projects high confidence estimate is $6.1 Billion, as summarized in Table 1.

**Table 1: EPC Vendor Cost Estimate by Project**

| Project | EPC Vendor (s) | Definition Phase | Execution Phase | Total Estimate |
|---|---|---|---|---|
| Re-tube & Feeder Replacement | SNC Lavalin/Aecon JV | $0.7 | $2.8 | $3.5 |
| Turbine Generator | Alstom (Parts) and SNC Lavalin/Aecon JV (Execution) | 0.1 | 0.5 | 0.6 |
| Steam Generators | Babcock & Wilcox / CANDU Energy JV | < 0.1 | 0.1 | 0.1 |
| Fuel Handling and Defueling | General Electric / SNC Lavalin/Aecon JV / ES Fox | < 0.1 | 0.1 | 0.2 |
| Balance of Plant | ES Fox / Babcock & Wilcox / SNC Lavalin/Aecon JV | 0.2 | 0.7 | 0.8 |
| Facilities, Infrastructure, and Safety Improvement Projects | ES Fox / SNC Lavalin/Aecon JV | 0.6 | 0.3 | 0.9 |
| **Total EPC Vendor Contract Costs** *Note: Numbers may not add due to rounding.* | | **$1.6 Billion** | **$4.5 Billion** | **$6.1 Billion** |

OPG's contracting strategy incorporates appropriate risk transfers and related cost and schedule incentives and disincentives:

- The use of a combination of fixed and target pricing will result in appropriate risk premiums and a lower overall refurbishment cost. The contract structure for each bundle was based on the level of certainty in scope and on the ability for the contractor to control its own work.

- Projects where scope is certain and can be largely controlled by contractors are conducive to fixed price contracts including a premium for known risks that are transferred to the contractor.

- Projects where scope is not certain or where the contractor can't have full control carry risks that can't be fully transferred to the contractor. In these cases, a cost plus or target price contract is conducive.

Figure 6 provides a breakdown of the contract structures in place for the DRP. OPG has fixed price contracts for Steam Generator work, Turbine Generator components, and Re-tube and Feeder Replacement tooling. OPG has target price contracts for Re-tube and Feeder Replacement and turbine generator execution phase work and balance of plant work. Cost plus contracts are generally in place for some balance of plant work and for material purchases and contractor general expenses.

**Figure 6: Contract Structure of EPC Vendors**

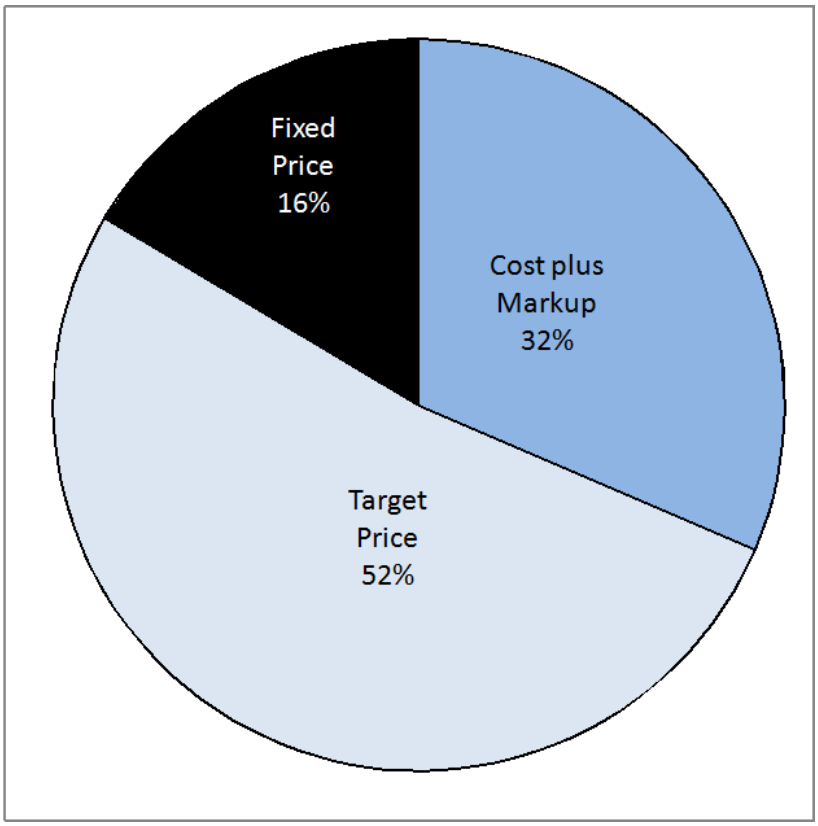



Table 2 below provides a break-out of all of the key components included in the 4-Unit cost estimate as summarized in Figure 4 on page 7.

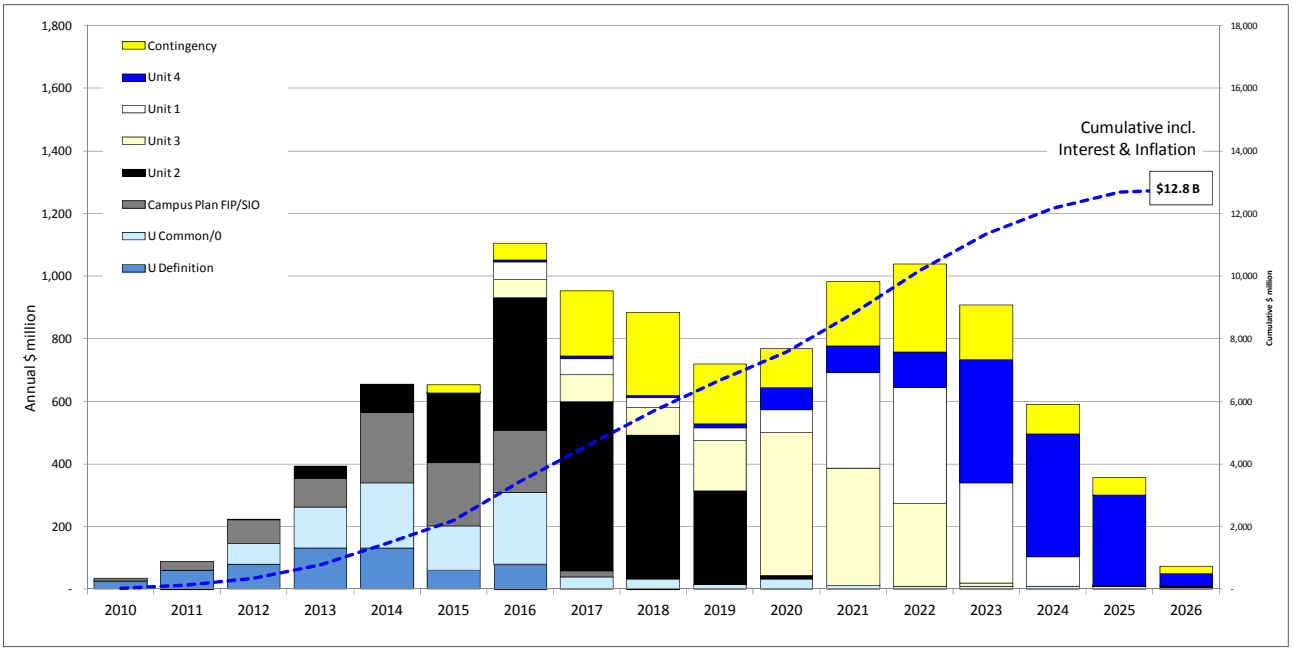
# Appendix 2 - Darlington Refurbishment Program 4-Unit Cost and Schedule Estimate and Economic Update

## Table 2: Darlington Refurbishment 4-Unit Cost Estimate

| | | RQE Total Cost | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Bundle Name | % of RQE by $ weight | Forecast Spend, Life-to-Date @Dec 2015 $ x 1000 | Estimate-to-Complete Vendor / EPC $ x 1000 | Estimate-to-Complete OPG O/S $ x 1000 | RQE Total Cost $ x 1000 | *Subtotals by Grouping* | | |
| 01 - RFR (Retube Feeder Replacement) | 35% | 651,651 | 2,839,288 | 107,283 | **3,598,222** | ***Bundles EPC + OPG O/S*** | | |
| 02 - TG (Turbine Generator) | 6% | 105,946 | 519,634 | 31,569 | **657,149** | | | |
| 03 - BOP (Balance of Plant) | 4% | 76,436 | 275,049 | 78,531 | **430,015** | | | |
| 04 - FH (Fuel Handling) | 2% | 13,811 | 120,183 | 24,558 | **158,553** | | | |
| 05 - DF (Defueling) | 0% | 28,983 | 2,487 | 8,116 | **39,586** | | | |
| 06 - SG (Steam Generator) | 1% | 13,990 | 98,844 | 9,745 | **122,579** | 1.0 | 4.6 | 5.5 |
| 07 - SP (Specialized Projects) | 1% | 22,365 | 78,732 | 6,812 | **107,909** | | | |
| 08 - SL (Shutdown Layup) | 2% | 21,203 | 185,511 | 11,303 | **218,017** | | | |
| 09 - RSF (Refub Support Facilities) | 1% | 16,721 | 50,286 | 11,363 | **78,370** | | | |
| 10 - IL (Unit Islanding) | 1% | 30,829 | 84,198 | 17,220 | **132,247** | | | |
| **Subtotal Bundles** | **53%** | **981,936** | **4,254,212** | **306,498** | **5,542,646** | ***Campus Plan*** | | |
| 11 - Campus Plan - F&IP | 6% | 484,045 | 155,765 | *incl* | **639,811** | | | |
| 12 - Campus Plan - SIO | 2% | 143,862 | 60,948 | *incl* | **204,810** | 0.6 | 0.2 | 0.8 |
| **Subtotal Campus Plan F&IP, SIO** | **8%** | **627,908** | **216,713** | - | **844,621** | | | |
| **Subtotal Bundles & Campus Plan** | | **1,609,844** | **4,470,925** | **306,498** | **6,387,267** | ***OPG Functional & Rel3+4 below*** | | |
| 13 - Functions (excl O&M) - Project Execution | 3% | 9,513 | 312,042 | - | 321,555 | | | |
| 14 - Functions (excl O&M) - Contract Management | 0% | 9,510 | 42,241 | - | 51,751 | | | |
| 15 - Functions (excl O&M) - Engineering | 3% | 76,046 | 206,460 | - | 282,506 | | | |
| 16 - Functions (excl O&M) - Managed Systems Oversight | 0% | 14,265 | 26,660 | - | 40,925 | | | |
| 17 - Functions (excl O&M) - Planning & Controls | 1% | 62,140 | 74,021 | - | 136,161 | 0.4 | 1.2 | 1.5 |
| 18 - Functions (excl O&M) - Nuclear Safety | 1% | 35,232 | 47,880 | - | 83,112 | | | |
| 19 - Functions (excl O&M) - Program Fees & Other Support | 3% | 21,178 | 319,597 | - | 340,775 | | | |
| 20 - Functions (excl O&M) - Supply Chain | 1% | 14,104 | 71,458 | - | 85,562 | | | |
| 21 - Functions (excl O&M) - Work Control | 1% | 8,617 | 70,890 | - | 79,507 | | | |
| **Subtotal Functions (excl O&M)** | **14%** | **250,605** | **1,171,247** | - | **1,421,852** | ***OPG Ops & Maintenance*** | | |
| 22 - Functions (O&M) - OMA Training Program | 0% | 10,981 | - | - | **10,981** | | | |
| 23 - Functions (O&M) - Waste Disposal | 0% | - | 38,054 | - | **38,054** | 0.3 | 0.8 | 0.8 |
| 24 - Functions (O&M) - Ops & Maintenance | 7% | 41,492 | 714,533 | - | **756,025** | | | |
| **Subtotal Functions - Ops & Mtce** | **8%** | **52,473** | **752,587** | - | **805,059** | ***Early Releases*** | | |
| 25 - Functional - Release 3 | 1% | 101,651 | - | - | **101,651** | | | |
| 26 - Functional - Advance Release 4 (incl Eng'g Reactor) | 0% | 7,467 | - | - | **7,467** | *included with Functions Subtotals* | | |
| **Subtotal Functions - Early Release Funds** | **1%** | **109,119** | - | - | **109,119** | | | |
| **Subtotal Before Contingency** | | **2,022,040** | **6,394,758** | **306,498** | **8,723,296** | ***Contingency*** | | |
| 27 - Project & Program Contingency | 21% | 26,182 | 1,679,976 | - | **1,706,158** | | | |
| **Subtotal Contingency** | **21%** | **26,182** | **1,679,976** | - | **1,706,158** | 0 | 1.7 | 1.7 |
| **Subtotal before Interest & Escalation** | **100%** | **2,048,222** | **8,074,735** | **306,498** | **10,429,454** | ***$2015 Base Cost*** | | |
| 28 - Interest | 14% | **159,000** | 1,313,844 | - | **1,472,844** | | | |
| 29 - Inflation / Escalation | 9% | - | 897,702 | - | **897,702** | **2.0** | **8.4** | **10.4** |
| **Subtotal Interest, Inflation / Escalation** | | **159,000** | **2,211,546** | - | **2,370,546** | ***$ DOY (incl Escalation & Interest)*** | | |
| **Total High Confidence Estimate ($DOY)** | | **2,207,222** | **10,286,281** | **306,498** | **12,800,000** | **2.2** | **10.6** | **12.8** |

Figure 7 provides a view of the overall cash flow.

**Figure 7: Current Darlington Refurbishment Summary Cost Estimate**




## Project Risk Assessment and Contingency

Included in the refurbishment high confidence estimate is contingency funding in the amount of $1.7 Billion for uncertainties in project scope, costs and schedule.

OPG developed the DRP project estimate in accordance with the Association for the Advancement of Cost Engineering (AACE) estimate classification recommended practice and integrated its standard approach to engineering and work planning within the AACE practice. Figure 3, shown earlier, provides an overview of the classification model and provides a reference to the general "type" of estimate, key deliverables, and the associated uncertainty band.

Contingency is derived through a detailed evaluation of the estimate uncertainties (cost and schedule), discrete risks (cost and schedule), and contingent work across each project and the entire DRP. These inputs were loaded into a fully integrated Monte Carlo simulation to assist in estimating contingency requirements in consideration of the risk and uncertainty profile presented. The outcome of this analysis yielded that, at a 90% high confidence, the estimate should include $1.7 Billion (2015$) of contingency, as summarized in Table 3 by project bundle.

**Table 3: 4-Unit Contingency Summaries**

| Project | Estimate Class | Project Contingency ($M) | Program Contingency ($M) | Total Contingency ($M) | % of Project Estimate to Complete |
|---|---|---|---|---|---|
| Re-tube & Feeder Replacement | Class 2 | 236 | 381 | **617** | **26%** |
| Turbine Generator | Class 2 - 3 | 195 | 23 | **218** | **50%** |
| Steam Generators | Class 2 | 20 | - | **20** | **20%** |
| Fuel Handling and 2Defueling | Class 3 | 25 | 38 | **63** | **52%** |
| Balance of Plant | Class 3 - 5 | 230 | - | **230** | **34%** |

# Appendix 2 - Darlington Refurbishment Program 4-Unit Cost and Schedule Estimate and Economic Update

| Project | Estimate Class | Project Contingency ($M) | Program Contingency ($M) | Total Contingency ($M) | % of Project Estimate to Complete |
|---|---|---|---|---|---|
| Facilities, Infrastructure, and Safety Improvement Projects | Class 1 - 3 | 42 | 34 | **76** | **35%** |
| Project Execution and Operations and Maintenance | Not Applicable | 58 | 222 | **280** | |
| Unallocated Program Contingency | Not Applicable | - | 202 | **202** | |
| **Total Contingency ($B)** | | **$0.8 Billion** | **$0.9 Billion** | **$1.7 Billion** | |

A contingency of $1.7 Billion represents 25% of the Execution Phase estimate ($6.7 Billion), or 38% of the external vendors' estimate ($4.5 Billion). With 90% of the estimates well defined at Class 3 or better, Management believes that the contingency amount is sufficient.

The following is a listing of some of the key risks that the above contingency provides for:

**Schedule Extension –** Contingency is provided to cover the risk of delay up to the high confidence schedule duration, totalling $503 Million. The high confidence duration and associated delay costs were derived based on a detailed analysis of risks and uncertainties associated with critical path activities. The process to execute this analysis was based on AACE Recommended Practice 57R-09, "Integrated Cost and Schedule Risk Analysis Using Monte Carlo Simulation of a CPM Model".

**Estimating Uncertainty** – Estimates are prepared and classified based on a level of project definition. Contingency is provided for the uncertainty in these estimates, i.e. the possibility that the actual cost to complete the project may be greater than the point estimate, exclusive of discrete risk impacts.

**Resource Management/Bridging Between Units -** Contingency is provided to retain critical trades and leadership resources between periods of specific resource demand. The risk is that due to the current un-lapped Unit 2 schedule, after the majority of the field work is complete on Unit 2, and prior to their requirement for Unit 3, key resources might leave OPG and not return to execute Unit 3. This could result in re-training of staff and reduced opportunity for performance improvement, as well as the potential loss of 'project momentum'. OPG will mitigate this by assigning certain critical resources to Nuclear Project portfolio work, Fleet Unit Outage work, or Darlington 'Life Extension' works during this period. In the unlikely event where this is not possible, OPG has included $50 Million in the contingency estimate to retain these resources. This risk is the focus of continual effort in order to minimize the impact on the project.

**Vendor Performance** – Contingency is provided to hire replacement contractors, re-train the resources, and even self-perform the work for a short period in the event that vendor performance becomes irrecoverable at any point.

For a project of this size and duration, there are a number of low probability high consequence events that could impact the project and that are outside of the contingency determined for the project. Due to the low probabilities, these items would not contribute sufficiently to a probabilistic assessment used in establishing project contingency.

Management has compiled a list of such events that could occur, and are beyond the ability of the project to manage or mitigate. By their nature, these low probability events are hard to predict both in timing and magnitude, and typically have a very high impact on project costs and schedule should they occur. Examples of events may include force majeure, a significant labour disruption, changes in the political environment, an international nuclear accident (Fukushima-type event) or incident, and unforeseen changes to financial and other economic factors beyond those assumed in the project.

It is difficult to assess the impact of such events; however, Management's assessment concluded that these low probability events, if they did occur, may result in a project cost impact of up to $0.8 Billion ($800 Million) and would cover each of the following potential scenarios:

- Anticipated interest and escalation rates each increase by 1% over the high confidence estimate assumption of 5% and 2%, respectively, for the entire duration of the project.
- An additional cumulative critical path extension of 1.7 years is endured (over and above the 1.2 years of schedule contingency funding included in the base estimate).
- An international nuclear event, or politically or regulatory driven mandate, results in a need to install new or modified upgrades. $800M is approximately three times the costs of the entire portfolio of Safety Improvement projects executed by Refurbishment.

If such an event were to occur, Management would evaluate the cost and schedule consequences of the event and provide a recommendation to the Board for approval on the appropriate response.

## Project Schedule

As part of the Definition Phase, OPG has integrated all vendor schedules, determined the critical path for the project and created a schedule provided in Appendix 4 for Unit 2 critical path. OPG evaluated risks for each segment of the schedule, determined the amount of contingency required to deliver the project, and produced a medium confidence (P50) and a high confidence (P90) schedule.

OPG will manage day-to-day project performance using the medium confidence schedule. The medium confidence schedule will also be used to determine contractor incentives and disincentives, where applicable, and will form the basis of project controlled schedule contingency. The 4-Unit medium confidence schedule is shown in Table 4.

**Table 4: Refurbishment 4-Unit MEDIUM Confidence Project Schedule**

| Unit | Start(1) | Finish | Duration (Months) | Month when Unit Reaches 235,000 EFPH |
|---|---|---|---|---|
| Unit 2 | 15-Oct-16 | 15-Nov-19 | 37 | Feb-22 |
| Unit 3 | 15-Dec-19 | 15-Dec-22 | 36 | Dec-22 |
| Unit 1 | 15-Apr-21 | 15-Mar-24 | 35 | Sep-22 |
| Unit 4 | 15-Jan-23 | 15-Nov-25 | 34 | Sep-23 |
| **4 Units** | **15-Oct-16** | **15-Nov-25** | **109** | |

The high confidence schedule, as shown in Table 5, includes contingency for certain schedule risks that may be encountered during the execution of the refurbishment outages, and will form the basis of program controlled schedule contingency. This schedule will also be the basis for external communication and measurement. The high confidence duration for each unit is 37 to 40 months.

**Table 5: Refurbishment 4-Unit HIGH Confidence Project Schedule**

| Unit | Start(1) | Finish | Duration (Months) | Month when Unit Reaches 235,000 EFPH |
|---|---|---|---|---|
| Unit 2 | 15-Oct-16 | 15-Feb-20 | 40 | Feb-22 |
| Unit 3 | 15-Dec-19 | 15-Apr-23 | 40 | Dec-22 |
| Unit 1 | 15-Apr-21 | 15-Jun-24 | 38 | Sep-22 |
| Unit 4 | 15-Jan-23 | 15-Feb-26 | 37 | Sep-23 |
| **4 Units** | **15-Oct-16** | **15-Feb-26** | **112** | |

(1) Based on early start date, aligned with the Medium Confidence schedule duration and logic.

Based on the current high confidence that each of the 4 units will operate to 235,000 Effective Full Power Hours (EFPH), this schedule results in no idle time on operating units.

## Planning Assumptions

Since 2008, OPG has been planning and defining the scope, cost, and schedule of the 4-unit refurbishment. This included major decisions on scope, unit sequencing, and timing of each refurbishment.

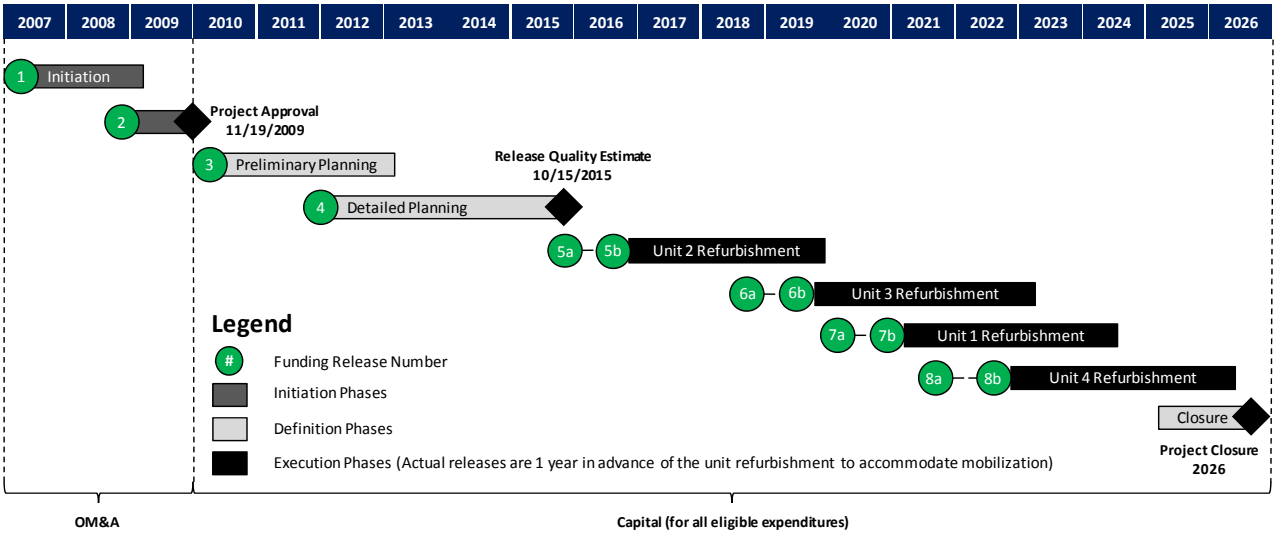
The following summarizes some of the key planning assumptions that have been incorporated into the 4-unit cost and schedule estimate.

- In 2008, after a detailed technical study on the condition of the Steam Generators that concluded that they have a high confidence of operating for the extended life, replacement of the SGs were excluded from the scope of the project. The scope of the project includes:
    - Construction of facilities and infrastructure required to support refurbishment activities
    - Replacement of reactor internals including pressure tubes, calandria tubes, and feeder piping
    - Refurbishment of life-limiting components, including Turbine/Generator sets, Steam Generators, as well as critical safety, process control, and nuclear process system components
    - Execution of Safety Improvement Opportunity projects, including Additional (3rd) Emergency Power Generator, Containment Filtered Venting System, Emergency Service Water Projects, Powerhouse Steam Venting System, and Shield Tank Overpressure Protection
- The scoping process considered a number of factors, including the results of the regulatory work programs which identified scope that must be performed to extend the life of the Darlington reactors, and, the appropriate timing of when scope would be executed; i.e. within the refurbishment project, or at another more appropriate time.
- In 2013, in alignment with the Long Term Energy Plan (LTEP), and to de-risk the delivery of the first unit, a decision was made to un-lap the first unit refurbishment with the remaining units being 50% overlapped to the previous unit.
- In 2014 the refurbishment sequence was revised to reflect the advancement of Unit 3 as the second unit to be refurbished. This resulted in the current sequencing reflected in Figure 8.
- In 2014 the Turbine/Generator controls replacement project was deferred out of the Unit 2 refurbishment scope and will be executed within a station outage after refurbishment.
- In 2015, the CNSC accepted the Integrated Implementation Plan (IIP), which defines the mandatory regulatory scope of the project.

## Program Release Strategy

The project has established a release strategy that will further provide the Board of Directors with opportunities to review project performance prior to allowing the project to proceed to the next phase. While the project 4-unit estimate totals $12.8 Billion, funding will be released on a unit by unit basis in accordance with the release strategy as shown in Figure 8 the release strategy is also aligned to the principles outlined in the Long Term Energy Plan (LTEP) published in December 2013.

**Figure 8: Darlington Refurbishment Release Strategy**

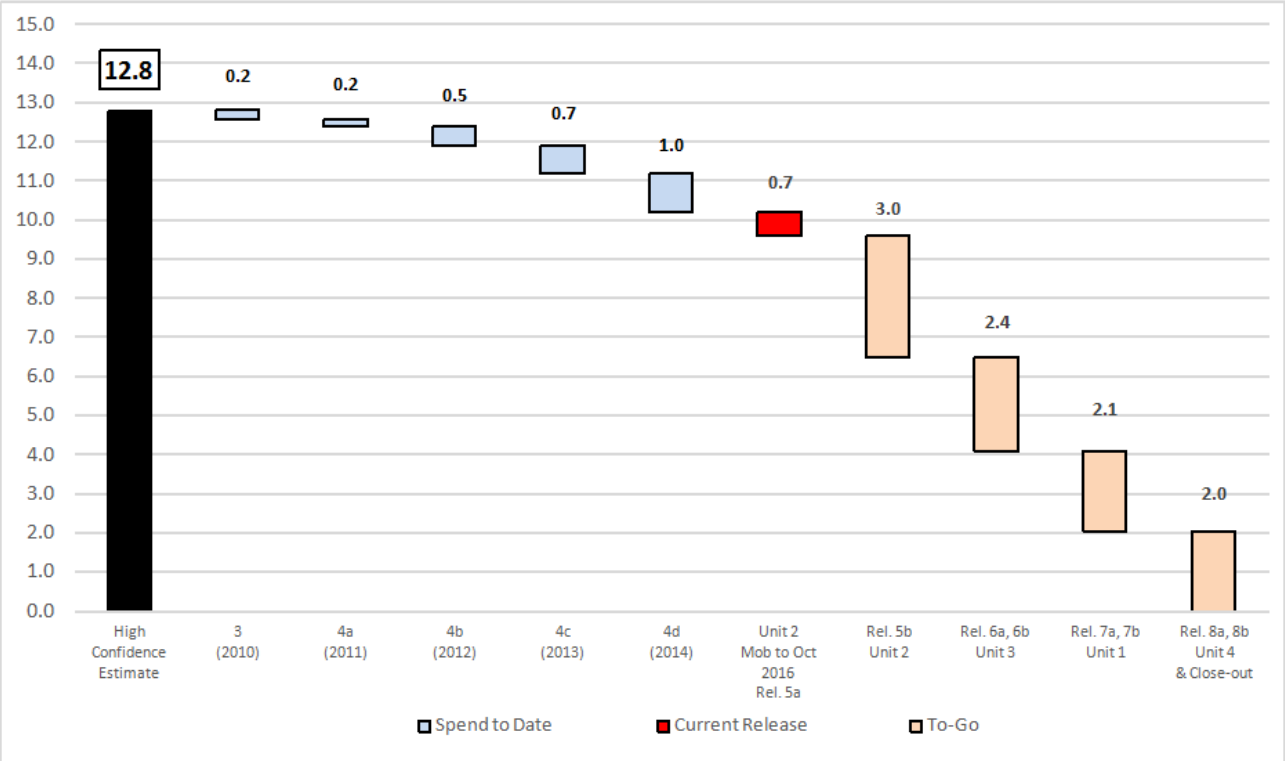



As shown in Figure 8, Management will request a release funds in advance of each unit's execution period to complete unit specific planning and mobilization activities including the preparation of a unit "check" estimate to confirm that the cost and schedule is bounded by the execution phase business case as provided within this document.

Due to the execution strategy, funds will be required to be released for Unit 3 while the Unit 2 is still being executed. In the unit overlap period, funds will be required to be released for Unit 4 at the same time that Units 3 and 1 are in their execution periods.

Consistent with the above release strategy, Figure 9 below provides a preliminary breakdown of the funding anticipated for each release, including those incurred in the definition phase.

**Figure 9: Project Estimate by Release/Unit**



# Project Economics

## Project Economics Background

In November 2009, based on the economics of the project as documented in the Economic Feasibility Assessment Business Case, the OPG Board of Directors approved the overall timeline and release strategy for the refurbishment and released funds for the project to complete preliminary planning within the Definition Phase. OPG's Board of Directors also released funding to commence detailed planning within the Definition Phase in November 2011, and to continue detailed planning annually in November 2012, 2013 and 2014.

Management had also revised the overall timeline and release strategy for Darlington Refurbishment, with the submission of the Release Quality Estimate (RQE) in November 2015, and a first unit refurbishment start date of October 2016.

An updated business case was produced in November 2013 to reflect the then current knowledge and understanding of the Darlington refurbishment project and to reflect additional experience from other refurbishment projects.

The November 2015 business case will reflect the RQE as well as the most up-to-date forecast of post refurbishment costs and performance of Darlington Station.

## Economic Impacts of Darlington Refurbishment

The successful completion of the Darlington refurbishment would put OPG in a stronger financial position and is estimated to generate in excess of $10 Billion in incremental net income to OPG based on the current rate regulation framework and nuclear rate smoothing assumptions. At the completion of the refurbishment project, the annual net income associated with the project will reach $0.7 Billion and then decline as the asset depreciates. The resulting cash inflows will be re-invested by OPG in new growth opportunities, used to fund dividend payments to the Shareholder, and/or pay down debt.

The estimate of the DRP income benefits reflects returns on approximately $12 Billion of capital investment that would enter OPG's regulated rate base by 2026. It is expected the project will provide a regulated return on equity, which is currently 9.3%.

If the project does not move forward, the Darlington units would be permanently shut down in the early 2020s and OPG would cease nuclear operations. In addition to foregoing the return and income discussed above, cancellation of the project could result in a further net income reduction of approximately $5 Billion associated with the risk of not recovering the following impacts:

- $200 Million in currently committed costs, including demobilization;
- $1.8 Billion of the life-to-date capital expenditures which would be deemed to have no future benefit;
- [redacted]; and
- Past-service pension and other post-employment benefit costs that would otherwise be recovered through OPG's post-refurbishment nuclear rates.

The closure of Darlington would occur at approximately the same time that Pickering reaches the end of commercial operations and OPG would, therefore, be ceasing all nuclear electricity production. OPG would effectively become a hydroelectric production company, while implementing a nuclear station safe storage and decommissioning project on 10 nuclear units simultaneously, challenging OPG's project management capacity.

The overall reduction in revenue would challenge OPG's ability to meet its future obligations with respect to nuclear waste, decommissioning, etc.

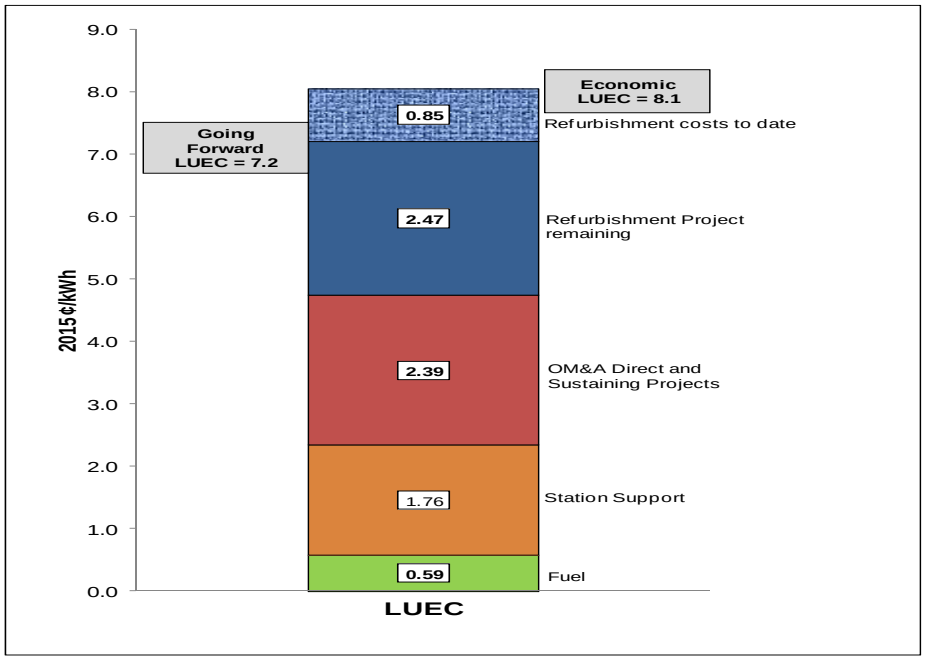
If these costs were to be recovered, they would add to OPG's nuclear rates into the early 2020s and would continue to have an approximate 20% impact on OPG's regulated hydroelectric rates after all Darlington and Pickering units are shut down.

## Current Estimate of Darlington Refurbishment LUEC

Utilizing the Release Quality Estimate of $12.8 Billion (including interest and inflation), the high confidence durations, and robust estimates of the future operating costs and performance of the station, the Levelized Unit Energy Cost (LUEC) of Darlington Refurbishment is estimated at 8.1 ¢/kWh, making it low cost, low emissions, stably-priced generation option. In 2010, Management communicated that the LUEC for the DRP would be less than 8 ¢/kWh in $2009, which is equivalent to 9.0 ¢/kWh in $2015; therefore Management's current estimate is well within the LUEC estimate announced in 2010.

Figure 10 shows the components which make up the current estimate of the DRP LUEC.

**Figure 10: Darlington Refurbishment LUEC Major Components**




The DRP contributes 3.3 ¢/kWh ($2015) (including 0.85 ¢/kWh for DRP costs to-date) to LUEC, and the post-refurbishment operations and support costs necessary to run the plant, including fuel, contribute to the remaining 4.8 ¢/kWh to the total LUEC of 8.1 ¢/kWh (2014$).

Post-Refurbishment operations costs include annual direct station and support costs of $570 Million and $460 Million, respectively. Post-refurbishment support costs are higher than in the current period, as OPG is forecasting losses of economies of scale following the shutdown of Pickering. Corporate-wide initiatives have begun to effect the transition to a smaller company (e.g. plans to streamline organizations and to implement different support services delivery models).

The LUEC is based on an assumed capability factor of 88% during the post-refurbishment period, which is comparable to performance over the past 10 years of 89.4%.

Typically, economic LUEC estimates do not include sunk costs. However, OPG has chosen to include all costs incurred to the end of 2015 ($2.2B), to ensure that the complete cost picture of LUEC is provided. Excluding the 0.85 ¢/kWh associated with the DRP costs to-date, the going-forward LUEC would be 7.2 ¢/kWh.

LUEC is a point in time measure and is reflected in today's dollars. Over time, it will escalate with the consumer price index. At 2% CPI, the economic LUEC of 8.1 ¢/kWh in 2015$ would be 10.0 ¢/kWh in $2026.

Management has also assessed the sensitivity of the LUEC to changes in specific inputs. The following is a summary of the impacts of changes to the key inputs:

i. A $500 million increase/decrease in DRP costs relative to the high confidence RQE would increase/reduce LUEC by approximately 0.15¢/kWh ($2015)

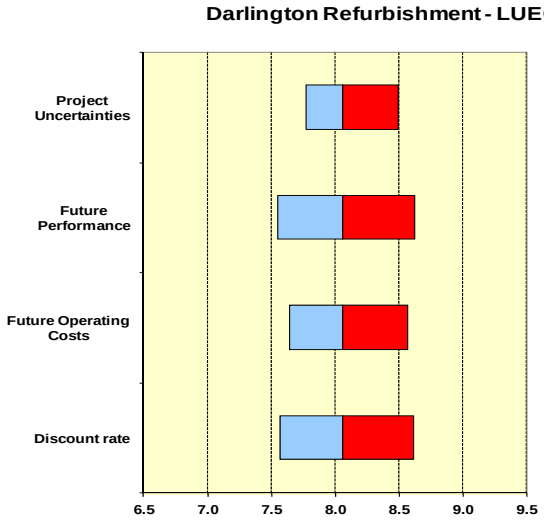
ii. An increase/decrease in overall schedule duration of six months relative to the high confidence duration (1.5 months per unit on average) would increase/decrease LUEC by approximately 0.12°¢/kWh

iii. A 5% increase in the capability factor (from 88% to 93%) lowers LUEC by 0.4°¢/kWh while a 5% decrease (from 88% to 83%) increases LUEC by 0.45°¢/kWh ($2015)

iv. Each $100 million increase/decrease in post-refurbishment annual costs increases/decreases LUEC by 0.4°¢/kWh ($2015)

Figure 11 shows the sensitivities of key inputs to deriving the LUEC. LUEC is the most sensitive to post refurbishment costs and performance of the units.

**Figure 11: Sensitivity of LUEC Inputs**




| Assumptions | Lower | Base | Upper |
|---|---|---|---|
| **Project Uncertainties** | | | |
| Refurb Cost* (2015$) | -10% | $10.4B | 15% |
| Avg. Refurb Duration (mths) | -2 mths | 39 mths | +3 mths |
| **Future Performance** | | | |
| Annual Capacity Factor (%) | +5% | 88% | -5% |
| Life of Refurb Units (yrs) | +2 yrs | 30 yrs | -2 yrs |
| **Future Operating Costs** | | | |
| Base OM&A ($M) | -5% | 280 | 10% |
| Outage OM&A ($M) | -10% | 220 | 10% |
| Sustaining Projects ($M) | -10% | 145 | 10% |
| Nuclear Support ($M) | -5% | 220 | 15% |
| Corporate Support ($M) | -15% | 235 | 10% |
| Fuel ($/MWh) | -15% | 5 | 15% |
| **Discount Rate** | -1% | 7% | +1% |

*Refurb cost sensitivity applied only to going-forward costs excluding contingency

## Key Risks to the Business Case

Key Risks covering both the DRP and the post-refurbishment operations period are summarized below:

- DRP Costs and Schedule: There is a risk that, even with the contingency, there could be cost and schedule overruns. Given OPG's investment of $2.2 Billion in Definition Phase and the level of contingency included in the RQE, Management believes that these risks are manageable within the current cost and schedule estimate. Insurance premiums of $116 Million are included in the estimate to purchase coverage to mitigate some of the financial risks; these cover Course of Construction-Property, Wrap-Up Liability, Marine Cargo and Advance Loss of Profit, Nuclear Energy Physical Damage-Property, and Delayed Start-Up.
- Post-Refurbishment Station Performance: An average station performance of 88% capability factor is assumed over the post-refurbishment life which is considered to be medium to high confidence as

it is below the station's demonstrated performance over the past 10 years of 89.4%. Sustained past performance provides confidence that the post-refurbishment performance will be the same or better than the business case assumptions; however, execution of appropriate maintenance and life-cycle management programs during the life of the station to maintain the reliability, will be essential. The post-refurbishment costs include $4.4B Billion ($2015) of ongoing sustaining investments to maintain the condition of the plant.

- Cost Recovery: There is a risk that OPG may not be able to fully recover its incurred costs. Given that the amount of DRP capital at risk continues to grow as the project proceeds to execution, the need for cost recovery assurance is increasing. Insufficient cost recovery would affect OPG's future rate base and revenue amounts, which reduces the value of OPG and return to the Shareholder.

## Qualitative Factors Supporting Executing the Refurbishment Program

- Decommissioning Fund Impacts: The decision to refurbish Darlington resulted in a decrease in the present value of the liability related to decommissioning. As of September 2015, the decommissioning fund was fully funded, partly as a result of the reduction in the present value of the liability caused by the assumption of Darlington refurbishment.
- $CO_2$ Reduction: Darlington refurbishment contributes to Provincial and Federal goals of reducing $CO_2$ emissions from electricity generation. Assuming efficient gas-fired plants would replace Darlington if it were not refurbished, the refurbishment of Darlington would avoid approximately 330 million tonnes of $CO_2$ emissions over the post-refurbishment life of the station.
- Employment Impacts: OPG is the largest employer in the Municipality of Clarington employing 2300 employees at the Darlington site, and 500 at the Darlington Energy Complex working on the DRP. Approximately 60% of Darlington's employees live in Durham Region. As of September 2015, over 800 employees are working at the Darlington site on Refurbishment preparations and 2,000 additional workers are expected at peak construction. Indirect and induced employment in Durham Region is expected to be 5,700 jobs.
- Municipal and Property Taxes: OPG pays approximately $4 Million per year in taxes to the Municipality of Clarington, shared with Durham Region and the school boards. OPG also pays an equivalent amount to the Provincial government for Darlington in the form of a "proxy tax".
- Citizenship and Community Involvement: OPG provides leadership to community organizations across Durham Region. In partnership with local communities and non-profit organizations, OPG delivers valuable programs for Durham families. OPG has contributed over $23 Million in community investment support in Durham Region between 1999 and 2011. In addition, OPG employees raise approximately $1 Million annually in Durham Region through the OPG Charity Campaign.

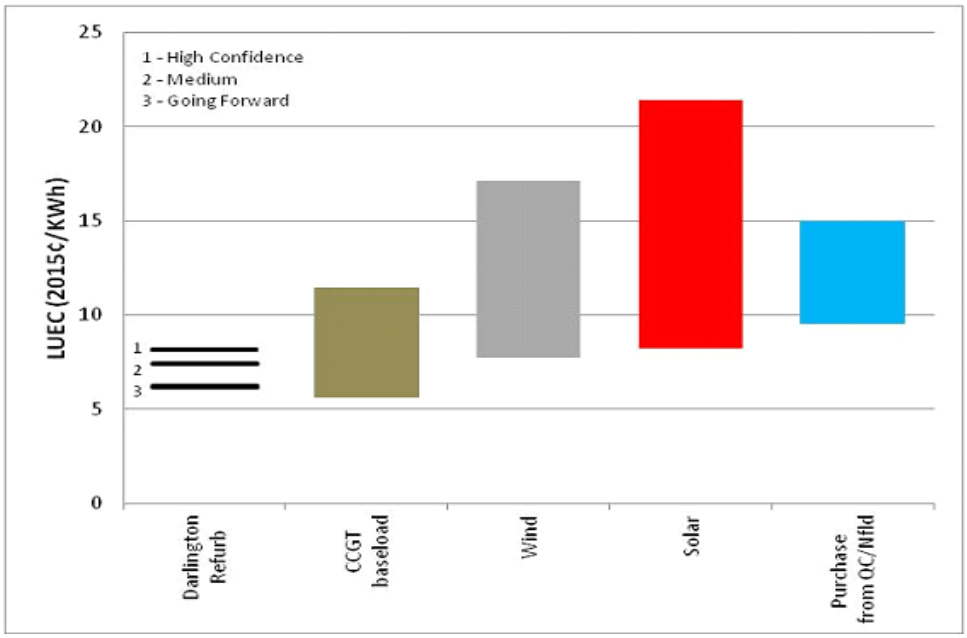
## Comparators to Other Alternatives

LUEC (Levelized Unit Energy Cost) is a standard approach used to compare across different energy generation options. As presented below in Figure 12, DRP compares favourably to all other Provincial options to supply 3,500 MW of baseload electricity.

The three point estimates presented for DRP are:

- High Confidence 8.1¢/kWh – $12.8 Billion project cost; 88% capacity factor; $1.1 Billion annual OM&A costs over a 30 year life.
- Medium Confidence 7.2¢/kWh – $12.2 Billion project cost; 90% capacity factor; $1.0B annual OM&A costs over a 35 year life.
- Going Forward Medium Confidence (excludes sunk costs of $2.2 Billion) 6.4¢/kWh – $10.0 Billion project cost; 90% capacity factor; $1.0 Billion annual OM&A costs over a 35 year life.

**Figure 12: Levelized Unit Energy Cost Comparables**




A number of assumptions have been made to develop the ranges presented above. These assumptions are supported by external industry sources, supplemented by OPG's market intelligence. Further details on economic and operational characteristics of each of the options are provided below.

***Combined Cycle Gas Option:***

The LUEC for baseload CCGT is most sensitive to assumptions for gas and carbon costs.

OPG's projected long term gas price range is CDN$4-$7.4/mmBtu at Henry Hub, which is within the range of long term forecasts issued by leading organizations:

- Several forecasts show generally higher forecast gas prices including EIA (US Energy Information Administration), PIRA Energy Group and Sproule (used by IESO);
- IHS shows a lower price forecast than OPG.

OPG's projected range for carbon cost is CDN$22-$88/tonne. The social cost of carbon is reflective of economic and environmental impacts of carbon, and is often used as a basis for decision making, not the price of carbon in carbon markets. For example, if Ontario Feed-in-Tariff prices for renewables were solely based on carbon reduction objectives, the implied cost of carbon would be well in excess of $100/tonne. Carbon market prices are influenced by specific rules within the market design that serve to reduce prices (e.g., excessive granting of allowances, protection for certain industries, etc.). OPG's projections are lower or within the range of a number of entities that publish the costs of carbon used for planning purposes:

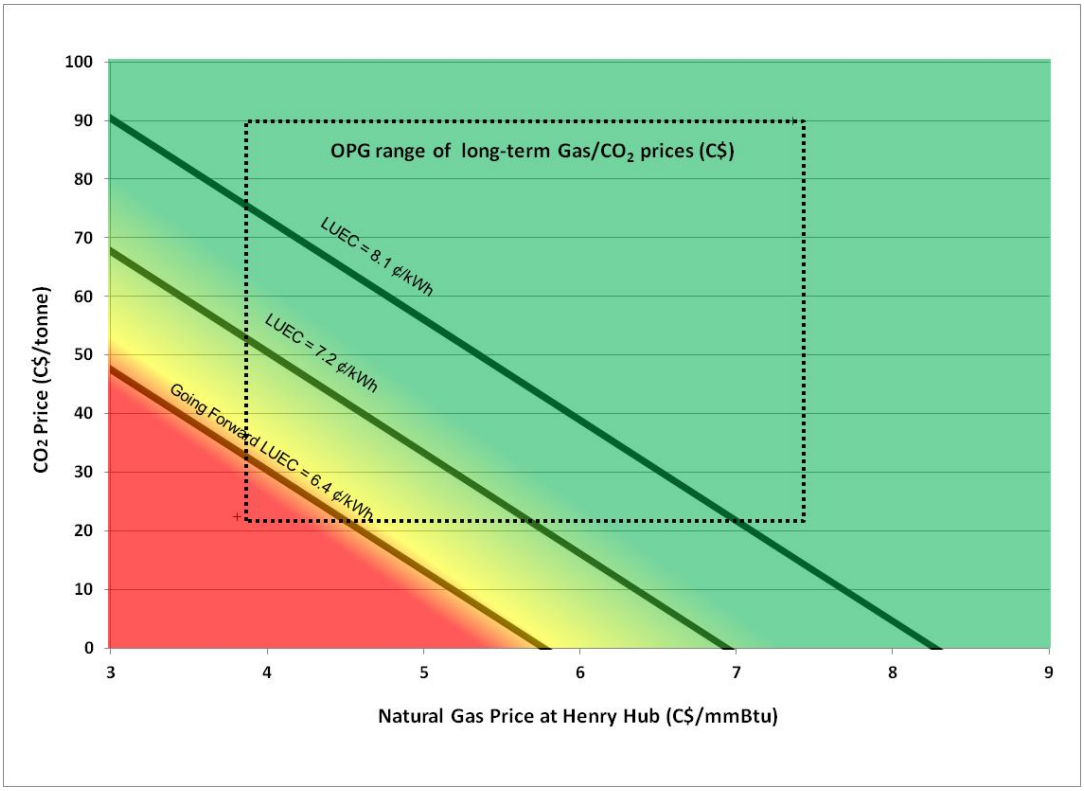
- US Environmental Protection Agency Social Cost of Carbon (higher than OPG)
- IHS Social Cost of Carbon (higher than OPG)
- Canadian Gazette Social Cost of Carbon (higher than OPG)
- Enbridge, Encana, Exxon Mobil, Statoil, Royal Dutch Shell (equal to or higher than OPG)
- ConocoPhillips, Cenovous, Suncor (slightly lower than OPG)

Figure 13 below illustrates how DRP compares to CCGT under different gas and carbon cost scenarios, holding all other assumptions at median values. The total range provided is CDN$3-$9/mmBtu at Henry Hub

for gas and CDN$0-$100/tonne for carbon. OPG's range of long term gas and carbon costs is depicted within the dotted line box. For any combination of carbon and gas costs on the upper right hand side of the DRP LUEC lines, DRP is the lower cost alternative. For any combination of carbon and gas costs on the lower left hand side of the DRP LUEC lines, CCGT is the lower cost alternative.

DRP is favourable or neutral to CCGT under most scenarios. It also offers the added benefit of not being exposed to significant uncertainties in future gas and carbon costs, costs for new gas and transmission infrastructure and difficulties in siting CCGT's in willing host communities.

**Figure 13: Levelized Unit Energy Cost Comparables**




***Wind and Solar Option:***

Wind (7.7 to 17.1 ¢/kWh) and solar (8.2 to 21.4 ¢/kWh) options will be higher cost than DRP. Because generation is intermittent, these options are unable to provide effective capacity to meet peaks in the summer and winter. The electricity produced from wind and solar is highly variable and cannot substitute for the baseload generation produced by a nuclear plant. To maintain system reliability additional storage or natural gas capacity and generation would be required with corresponding GHG emission and cost increases (not included in above cost estimates).

***Quebec and Newfoundland Purchases Option:***

Displacing Darlington's baseload generation with power purchases from Quebec or Newfoundland would require development of new, high cost, hydroelectric generation facilities and major transmission investment in both Quebec/Newfoundland and Ontario. The delivered cost of power to Ontario's major load centre (the Greater Toronto and Hamilton Area) would be expected to be in the 9 – 15 ¢/kWh range. Very long lead times, security of supply risks, upward cost pressures from competing sales to the northeast US and foregoing economic development in Ontario make DRP a superior alternative.

## Conclusion

Management has completed Definition Phase planning and Management's high confidence estimate to execute the refurbishment of the 4 units is $12.8 Billion.

At a cost of $12.8 Billion, the economic LUEC of the DRP is estimated at 8.1 ¢/kWh. Excluding sunk costs of $2.2 Billion to the end of 2015, the going forward LUEC would be 7.2 ¢/kWh.

Management has performed extensive planning and is ready to proceed to the Execution Phase. A detailed plan is in place to ensure readiness to execute the Unit 2 refurbishment starting in October 2016.

The DRP compares very favourably from a cost, GHG emission, economic development and risk perspective to all other Provincial options to supply 3,500 MW of baseload electricity:

- The conservative and high confidence Levelized Unit Energy Cost of 8.1¢/kWh compares favourably to alternative sources;
- Maintains the Province`s ability to assist in moderating Ontario`s Electricity Prices;
- Increases Ontario`s GDP by $15 Billion and boosts employment by 8,600 jobs during the project;
- Retains long-term jobs and provides a positive economic impact for an additional 30 years;
- Keeps tax dollars and net income in Ontario; and
- Avoids production of 330 million tonnes of greenhouse gases compared to replacement with natural gas, and maintains nuclear as an important element of clean and balanced approach to power generation.

The successful completion of the Darlington refurbishment would put OPG in a stronger financial position and is estimated to generate in excess of $10 Billion in incremental net income based on the current rate regulation framework and nuclear rate smoothing assumptions.

DARLINGTON REFURBISHMENT
Repowering Ontario

**Appendix 3: Darlington Nuclear Refubishment Program 4-Unit Resource Histogram**

**RQE - Release Quality Estimate**

ONTARIO POWER GENERATION

# Summary - Overall Program Staffing

[redacted]

DARLINGTON REFURBISHMENT
Repowering Ontario

**Appendix 4: Darlington Nuclear Refubishment Program 4-Unit OPG Owner's Resource Histogram**

**RQE - Release Quality Estimate**

ONTARIO POWER GENERATION

# OPG Labour: Functional + Ops & Maintenance Staffing

DARLINGTON

# UNIT 2 Refurbishment Outage - DNRU2

**REV A7**
**Sept. 21, 2015**

OCT 2016 | NOV 2016 | DEC 2016 | JAN 2017 | FEB 2017 | MAR 2017 | APR 2017 | MAY 2017 | JUN 2017 | JUL 2017 | AUG 2017 | SEP 2017 | OCT 2017 | NOV 2017 | DEC 2017 | JAN 2018 | FEB 2018 | MAR 2018 | APR 2018 | MAY 2018 | JUN 2018 | JUL 2018 | AUG 2018 | SEP 2018 | OCT 2018 | NOV 2018 | DEC 2018 | JAN 2019 | FEB 2019 | MAR 2019 | APR 2019 | MAY 2019 | JUNE 2019 | JUL 2019 | AUG 2019

Outage Days: 0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740 760 780 800 820 840 860 880 900 920 940 960 980 1000 1020 1040

130 Lead In | 131 Removal | 132 Inspect & Install | Lead Out

U1 Outage 2017 | D2O Upgrader Outage | U3 Outage 2018 | Tritium Removal Facility Gas Outage | U4 Outage 2019

Conventional Side Lay up
002 Resource holdouts
Dec 1
100 TG and Condenser Work Phase 1
Condensate and
010 Feed Water Rehab
Nov 16 Resource holdouts
VVRS Mods and
Airlock Mtce & Testing
006
Vault Preparation Activities
013 PHT Bulk Drain
HTS Vac Dry 40d
Vac Dry (Cont'd)
to Moderator Drain
HTS Aux Vac Dry
SG Lay-Up Primary Side
to Tie-in for Moderator Vac Dry

BH Installed & D1711 Complete
052 Power Track 3,4 Replacement
Power Track 1/2 Replacement Window 1
To D1831
From D1831
Power Track 1/2 Replacement Window 2
To Start of D1831
D1711 Complete & Resource Holdout
061 Turbine Generator Major Overhaul
60% RFR Complete

HTS Aux Purge & Rehab
048 Outside Vault
HT Pump Motor Swaps
060
Note: Motors and Boilers cannot be done in parallel.(hoist way conflicts)
Reactor Area Crane not available during Class 4 Electrical Maintenance Window
To RCHP 4 HTS Fill

PT Install progressed to below row H
Primary Side SG Clean & Inspect
West Side SGs 064 | East Side SGs 070
Emergency Heat Sink

ACU4 replacement
RCHP 1
Temp Fission Chamber Install
Contingency HFD Replacements
Remove Mod Dry Equip & Reconnect Mod Pipework 078
Cold Testing & Establish GSS 081
079 Gross Air Leak Test
080 Fill Calandria

068 Vault Projects
HTS work (Cut & Cap, and Cyclical PMs); ESC STOP Mods; H2 Igniter Cables; LRV Mods; EP-LISS Bunker; EP 111elev N Side; MV 1 & 2; Bleed Cooler; Emergency Heat Sink

062 Vault ACU Replacements
West Side | East Side

Fuel Load
RCHP 2
084 RTP Removals, Bridge Replacement
Al Closed & Pressure Test 085
RCHP 3
Heat-up & Low Power Testing
Post-Req's
RCHP 5
Power Escalation
Run-up & Sync

STOP Defuel Reactor 113 days
STOP Install Bulkhead 34
STOP 17 Install Shielding
23 Bulk Interference Removals
40 Feeder Cabinet Removal
18 Feeder Removal
41 Dummy FB Removal
6 | 15 Fuel Channel Removal Series
27 PT Sever
34 Sever Bellows
31 End Fitting Removal
17 PT Removal
14 CTI Release
31 CT Removal
7 | 6 Inspection Series
138 CT Install Series
19 Trial CT Install
125 Fuel Channel Install Series
86 Lower Feeder Install Series
12 | 76 | 1 | 25 | 6 | 20 | 6 | 4 | 9

S/D to GSS (1d)
015 Crane Maintenance
Install End Fitting Caps
RFR Prereq. Prior to containment isolation 008
Containment Pre-test, Achieve Dew pt. & Containment Test
-Final Commissioning/ VVRS Phase 1
-AL & TCD Logic Mods
-BU Logic Mods Ph 2
RFR Prereq. post containment isolation
Remove FM Bridges & Install RTPs
19 days Upper Feeder Installation (180 days)
PT Sever | Sever Bellows | End Fitting Removal | PT Removal | CTI Release | CT Removal | Trial CT Install | Bellows Inspections
Nozzle Inspection & Weld Prep
Isolate Calandria From Main Pipework
Hookup Drying Equip. & Establish Calandria Purge Flow
Hold Out For Project Readiness
073 HFD Replacements
007 SDS1 & SDS2 Mods & Rehab
To Remove Mod Dry Equip.
NPC Logic Restoration
Bulkhead Removal
ATC
RCHP 6
RCHP 7
RCHP 8
096 High Power Testing & Turbine Testing

from HTS Vac Dry Complete
038 Mod Drain & Flush
LISS Rehab 046
Hold out to summer of 2018
Instrument Air Mtce
from HTS Auxiliaries Dry
Tie in HTS Vac Dry Skid to Mod Pipework
Vac Dry Moderator Pipework
122 Moderator Valve Rehab
To Post Feeder Vault Work
Pressurizer Power Supply Swap Over
SDC Rm Work (Purge, Maintenance Cooling System and SDC Valve work) 124
Remove Vac Dry Equip

BU16 Maintenance 125
To VVRS Commissioning & Odd Electrical Outage
126 T9/T11 Maintenance
127 T10/T12 Maintenance
To TPDS & Odd Electrical Outage
(TPDS Tie-ins completed as pre-requisites)
HTS PM1 & PM3 Removal
Replace Adjuster Rods 021
028 Replace Vertical Flux Detector
RCHP 4
089 29 HTS Air Hold, Fill & Hydro Test
090 14 HTS Operational Testing

Containment Boundary Established
EPS 005 MCC Rehab
Resource Tied to Class III Elec. Mtnce. Work
041 Class 3 Electrical Maintenance
Class 2 Elec. Maintenance
A 040 | B | C | DCC Mods & Mtce
To RCHP 1 Mod Fill
Hold out for system configuration
CL 4 Electrical Maintenance 051
032 LZCS Rehab
To RCHP 5
MOT/UST/IPB Rehab 004
To RCHP 7
To Turbine Testing
LPSW Outage 057
ESW Rehab 053
Winter of 2018 (Need cold water temps)
PULSW Outage 056
PULSW SDC Supply Line Replacement Outage
CCW Rehab 055

D1711 Complete & U2 defuel Complete & Cooldown After Vac. Dry(14d)
Secondary Side Lay up
Secondary Side SG Clean & Install Access Ports 037

State 1 | State 2 | State 3a | State 3b | State 4a | State 4b | State 5

STOP State Transition Requires Approval to Proceed.
RCHP X Reactor Control Hold Point

| | |
|---|---|
| Drawn by: | Maurice Johnston<br>NR Execution |
| Prepared by: | Dennis Curley<br>NR Outage Manager |
| Reviewed by: | <br>NR Outage Director |
| Concurred by: | <br>NR Director Ops & Mtce |
| Approved by: | <br>VP Refurbishment Execution |

DARLINGTON REFURBISHMENT
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# Appendix 6: Darlington Nuclear Refurbishment Program
# Summary of Release Amount for Unit 2 Mobilization Activities
# Release Quality Estimate (RQE)

ONTARIO POWER GENERATION

| Bundle Name | Forecast Spend Jan 1 - Oct 15 (BO), 2016 Escalated | Key Activities<br>- Note all activities will include Oversight, Unit 2 planning, and Interest |
|---|---|---|
| 01 - RFR (Retube Feeder Replacement) | 385,347 | - Construction of Retube Waste Processing Building<br>- Procurement activities including Reactor Components for Unit 2,<br>- Mobilization and Rehearsal activities |
| 02 - TG (Turbine Generator) | 56,639 | - Turbine Hall Crane Overhaul<br>- Procurement activities<br>- Inspections |
| 03 - BOP (Balance of Plant) | 37,859 | - Inspections<br>- Execution of pre-breaker open work to support Refurb and IIP commitments (VVRS Containment |
| 04 - FH (Fuel Handling) | 12,276 | - Procurement of long lead materials for trolleys 3/4 and 1/2. |
| 05 - DF (Defueling) | 3,876 | - Procurement of 'Dummy Fuel Bundles (DFB)' and 'Flow Restricted Oriface Bundles (FROBs)'. |
| 06 - SG (Steam Generator) | 4,326 | - Manufacture of Access ports<br>- Procurement of tooling and tool validation |
| 07 - SP (Specialized Projects) | 20,018 | - Engineering and software development, system integration, qualification for Shutdown System computers.<br>- Procurement of long lead items for vault coolers. |
| 08 - SL (Shutdown Layup) | 41,263 | - Execution of pre-breaker open projects, including Breathing Air, Dry Air, Service Air, and Temporary Power. |
| 09 - RSF (Refurb Support Facilities) | 11,705 | - Installation of in-station facilities to support Refurbishment, including work control area, radiation and teledosimetry trailer, shops and storage areas. |
| 10 - IL (Unit Islanding) | 14,306 | - Procurement of bulkhead related materials and installation of Unit 2 barriers. |
| **Subtotal Bundles** | **587,613** | |
| 11 - Campus Plan - Facility and Infrastructure (F&IP) | 130,662 | - Continued Construction and in-service of F&IP and SIO projects. |
| 12 - Campus Plan - Safety Improvement Projects (SIO) | 56,321 | - In-service of EPG3, CFVS, RFRISA, etc; continued construction of Heavy Water Storage |
| **Subtotal Campus Plan F&IP, SIO** | **186,983** | |
| **Subtotal Bundles & Campus Plan** | **774,597** | |
| 13 - Functions (excl O&M) - Project Execution | 31,339 | Overall Planning Support of Projects and Readiness to execute Unit 2, including:<br>- Project Planning and Oversight of the pre-refurbishment and ready to execute plan (RTE),<br>- Establishment of the Construction organization and Comprehensive/Construction Work Package development and review,<br>- Engineering including Nuclear Safety studies on Restart Analysis,<br>- Installation of Execution Phase project controls/reporting tools,<br>- Unit 2 check estimate and Execution Phase integrated schedule development, and<br>- Procurement Activities. |
| 14 - Functions (excl O&M) - Contract Management | 4,781 | |
| 15 - Functions (excl O&M) - Engineering | 21,045 | |
| 16 - Functions (excl O&M) - Managed Systems Oversight | 3,273 | |
| 17 - Functions (excl O&M) - Planning & Controls | 20,211 | |
| 18 - Functions (excl O&M) - Nuclear Safety | 9,573 | |
| 19 - Functions (excl O&M) - Program Fees & Other Support | 35,946 | |
| 20 - Functions (excl O&M) - Supply Chain | 9,227 | |
| 21 - Functions (excl O&M) - Work Control | 5,633 | |
| **Subtotal Functions (excl O&M)** | **141,028** | |
| 22 - Functions (O&M) - OMA Training Program | - | Includes Operations programs to prepare the organization to commence Refurbishment, including:<br>- Support of pre-refurbishment projects,<br>- Permitry and radiation protection planning and readiness for Unit 2. |
| 23 - Functions (O&M) - Waste Disposal | 160 | |
| 24 - Functions (O&M) - Ops & Maintenance | 56,904 | |
| **Subtotal Functions - Ops & Mtce** | **57,064** | |
| 25 - Functional - Release 3 | 4,710 | - Completion and close-out activities related to the Integrated Implementation Plan. |
| 26 - Functional - Advance Release 4 (incl Engineering Reactor) | 342 | |
| **Subtotal Functions - Early Release Funds** | **5,052** | |
| **Subtotal Before Contingency** | **977,740** | |
| 27 - Project & Program Contingency | 43,311 | - Contingency for estimate variability and risks in above work. |
| **Subtotal Contingency** | **43,311** | |
| **Subtotal before Interest & Escalation** | **1,021,051** | |
| 28 - Interest | ***incl*** | - Included in above |
| 29 - Inflation / Escalation | *incl* | - Included in above |
| **Subtotal Interest, Inflation / Escalation** | **-** | |
| **Grand Total** | **1,021,051** | |

| | |
|---|---|
| - 2,547,700 | Current Release |
| 2,207,878 | Estimated Spend thru Dec 2015 |
| 1,021,051 | Forecast Spend in 2016 to Breaker Open (Oct 15,2016) |
| 681,229 | Calculation of Release 5a |

# CCC Interrogatory #23

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Reference: TC Presentation/September 23, 2016, p. 36

a. Please describe the role of the Darlington Refurbishment Committee and list each of its members;

b. Please describe the role of the Enterprise Leadership Team and list each of its members;

c. Please describe the role of the Refurbishment Construction Review Board and list each of its members.

## Response

a) Please see Ex. D2-2-9, p.12 and L-4.3-1 Staff-222 part a.

b) The Enterprise Leadership Team provides input on issues with business-wide impacts, communicates corporate direction and provides input to the strategic planning context underpinning OPG's Business Plan.

The current members of OPG's Enterprise Leadership Team are:

| | |
|---|---|
| Jeffrey J. Lyash | President and Chief Executive Officer |
| Glenn Jager | President, OPG Nuclear and Chief Nuclear Officer |
| Mike Martelli, B.A.Sc., P. Eng. | President, Renewable Generation and Power Marketing |
| Carlo Crozzoli, CPA, CA, | Senior Vice President, Corporate Business Development and Strategy |
| Christopher F. Ginther | Senior Vice President, Legal, Ethics and Compliance |
| Ken Hartwick, CPA | Senior Vice President, Finance, Risk and Strategy, and Chief Financial Officer |

Witness Panel: Darlington Refurbishment Program

| | |
|---|---|
| Barb Keenan | Senior Vice President, People, Culture and Communications |
| Scott Martin | Senior Vice President, Business and Administrative Services |
| Dietmar Reiner, B.A.Sc., P.Eng. | Senior Vice President, Nuclear Projects |
| Catriona King | Vice President, Corporate Secretary and Executive Office Operations |

c) Please see Ex. D2-2-11, p. 11, lines 21 to 30 and L-4.3-1 Staff-222 part c.

# EP Interrogatory #20

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Exhibit D2, Tab 2, Schedule 10, page 17

Can you provide a final cost estimate for the Heavy Water Facility project.

## Response

The forecast total cost estimate for the Heavy Water Facility project is $381.1M, as noted in Ex. D2-2-10, p. 16. It represents the superseding full release estimate shown in Ex. D2-2-10, Table 2.

# ED Interrogatory #6

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Reference: "For the purpose of OPG's request for approval of in-service additions, $4,800.2M is forecast to come into service in 2020 for the Unit 2 refurbishment." Ex. D2, Tab 2, Schedule 1, Page 5

Please provide OPG's forecast of its cumulative capital expenditures and interest costs with respect to the Unit 2 refurbishment, at the end of each quarter, starting with the first quarter in 2017 and ending with the 4th quarter in 2020. Please include contingency amounts. Please base the quarterly estimates based on the $4,800.2M high confidence budget. Presumably the cumulative capital expenditures for the 4th quarter of 2020 will equal approximately $4,800.2 million, but if that is not the case please explain why not.

## Response

The cumulative Unit 2 capital expenditures including contingency and interest costs based on the RQE high confidence schedule are shown below. The total adds up to $4,800.2M, noted in Ex. D2-2-1, p. 5, at the end of 2020.

| M$ | LTD 2016 FCST | 2017 Q1 | 2017 Q2 | 2017 Q3 | 2017 Q4 | 2018 Annual | 2019 Annual | 2020 Annual |
|---|---|---|---|---|---|---|---|---|
| Capital including contingency | 2,065 | 193 | 188 | 205 | 191 | 782 | 328 | 70 |
| Interest | 215 | 29 | 31 | 34 | 37 | 178 | 214 | 40 |
| **Total Capital Costs** | **2,280** | **221** | **220** | **239** | **228** | **959** | **542** | **110** |
| **Cumulative Total Capital Costs** | 2,280 | 2,502 | 2,722 | 2,961 | 3,189 | 4,148 | 4,690 | 4,800 |

Note: numbers may not add due to rounding.

As part of the RQE development, annual flows are available for the estimates from 2018 onwards.

Witness Panel: Darlington Refurbishment Program

# ED Interrogatory #7

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Reference: "For the purpose of OPG's request for approval of in-service additions, $4,800.2M is forecast to come into service in 2020 for the Unit 2 refurbishment." Ex. D2, Tab 2, Schedule 1, Page 5

Please provide OPG's estimate of the probability that the cost of the Unit 2 refurbishment will exceed $4,800.2 M.

## Response

OPG does not estimate the probability associated with in-service additions. In-service additions are not analogous to cost estimates. For example, the timing of in-service amounts is governed by accounting rules.

# ED Interrogatory #8

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Reference: "For the purpose of OPG's request for approval of in-service additions, $4,800.2M is forecast to come into service in 2020 for the Unit 2 refurbishment." Ex. D2, Tab 2, Schedule 1, Page 5

Please provide OPG's estimate of the probability that the cost of the Unit 2 refurbishment will exceed $4,800.2 M by 10% or greater.

## Response

Please see response to L-4.5-7 ED-7.

Witness Panel: Darlington Refurbishment Program

# GEC Interrogatory #4

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Exhibit D2-2-11 Attachment 3 Page 9 of 122
"It is typical for megaprograms, such as the DRP, to be managed on a planned duration that is less time than reflected in the high-confidence schedule."

And at p. 10 "The Facilities and Infrastructure Projects (F&IP) and Safety Improvement Opportunities (SIO) were not necessarily completed per the initial planned schedule and estimate…"

a) Please provide details of the various percentage schedule delays and percentage cost overruns in the F&IP and SIO projects relative to the high confidence schedule and estimate and the planned schedule and estimate.

b) Please provide an analysis of the degree of adherence to date to the high confidence and the panned schedules for each major work component of the DRP. Please do so with reference to the highest level schedule (as described at page 31 of the Pegasus evidence) that existed at the time of OPG's prior OEB application and with respect to the initial version of the level 5 schedule.

c) Please provide a complete history of the DRP's expected unit completion dates and outage duration schedules showing initial assumptions and changes to date.

## Response

a) The F&IP and SIO projects were not planned in the same manner as the Unit 2 refurbishment outage, with planned (target) and high confidence schedules and estimates. OPG is therefore unable to provide the analysis requested. Variance explanations for F&IP projects greater than $20M, where the project cost variance was greater than 10% are provided in Ex. D2-2-10, pp. 11-22.

b) As OPG has just begun to execute the refurbishment outage on Unit 2 (Breaker Open was on October 15, 2016), this analysis is not possible.

Witness Panel: Darlington Refurbishment Program

c) Please refer to L-4.3-8 GEC-10.

# GEC Interrogatory #6

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**

Please confirm that OPG in effect seeks a prudency ruling in advance on the $4.8B in DRP costs included in this application as coming into service by 2020 such that only variances there from will be subject to subsequent Board review.

## Response

The determinations that OPG is seeking with regard to Darlington Refurbishment Program costs are clearly stated in its evidence (Ex. A1-2-2, pp. 4-5 and Ex. D2-2-1, p. 6) as follows:

i. In-service additions to rate base of: (i) $350.4M in the 2016 Bridge Year; and (ii) for the test period, $374.4M in 2017, $8.9M in 2018, $4,809.2M in 2020, and $0.4M in 2021 on a forecast basis. These amounts reflect the addition to rate base of $4,800.2M related to Unit 2 in-service addition in 2020 and 2021, as well as $743.1M related to Unit Refurbishment Early In-Service Projects, Safety Improvement Opportunities, and Facilities & Infrastructure Projects. If actual additions to rate base are different from forecast amounts, the cost impact of the difference will be recorded in the Capacity Refurbishment Variance Account (CRVA) and any amounts greater than the forecast amounts added to rate base will be subject to a prudence review in a future proceeding; and

ii. OM&A expenditures of $41.5M in 2017, $13.8M in 2018, $3.5M in 2019, $48.4M in 2020, and $19.7M in 2021 (Ex. F2-7-1).

# GEC Interrogatory #13

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**

If not already filed, please provide copies of all of the quarterly oversight reports from Burns & McDonnell Canada and Modus Strategic Solutions Canada since 2014.

## Response

Please see Ex. L-4.3-1 Staff-72, part a.

Please see also the first Burns & McDonnel Canada/Modus Strategic Solutions Canada report for the Execution Phase attached.

BURNS McDONNELL

# Report to Darlington Review Committee of OPG Board of Directors

MODUS STRATEGIC SOLUTIONS

## *Executive Summary*

OPG Management's August 11, 2016 report to the DRC affirms the DR Project remains within the overall RQE control budget of $12.8 billion and that the Project's overall P90 schedule duration has not changed. Based on our review, the Independent External Oversight Team (EO Team) found OPG Management's report to the DRC adequately reflects and is generally focused on the DR Project's current key status points and risks. The process OPG used for developing the Execution Phase schedule has followed accepted industry practices and once complete should provide a good baseline for the Project. We have also reviewed recent output from OPG's assurance programs and find them to be effective.

OPG has accomplished most of its planned readiness activities and, at this time, there are no known imminent threats to Unit 2 breaker open; however, there are issues that require attention that could have a significant downstream impact on the Project if they are not addressed:

- Schedule performance and adherence is an ongoing concern;
- While the technical tools are now in place, cost and schedule trending and forecasting are not mature;
- Aspects of key vendors' readiness for execution are a concern; and
- The Risk Management Program has not been fully embraced as an essential day-to-day management tool.

## *Evaluation of DR Project Status*

The EO Team has identified the following key status points that should be considered for purposes of evaluating the DR Project's health as a whole and for the Board of Directors' approval of management's Unit 2 budget and schedule.

| Key DR Project Status Indicators | |
|---|---|
| **Schedule Performance** | OPG identified the DR Project's current SPI of 0.91 which equates to being approximately 9-10% behind the Project's P50 schedule (though should not impact the P90 range). The impacts of these delays include late finalization of the Unit 2 Execution Phase schedule, procurement and field preparation that will need to be recovered or mitigated prior to field need dates. The vendors' ability to meet their procurement schedules is a concern. OPG has increased visibility and management attention to resolving outstanding vendor and internal issues. |
| **Cost Performance** | Based on all of the available information, the overall Project control budget of $12.8 Billion has been maintained, though the EO Team identifies three caveats:<br>❖ The final Unit 2 Execution Phase schedule will be completed in mid-September. Until that schedule is completed, issues can materialize that could impact the final Unit 2 budget. OPG Management has reserved the possibility of making changes to the Unit 2 budget until the schedule is closed-out.<br>❖ Since RQE, $61M of contingency has been drawn and allocated, which translates to a rate of approximately $10 Million/month. While we believe this is largely due to finalizing and updating the Unit 2 cost estimate, this velocity of change would be a concern if it continues past the locking-down of the Unit 2 budget.<br>❖ Risk and contingency calculations for Unit 2 may change as a result of recent additions to the DR Project's risk register. For example, within the last month, certain technical risks have materialized that could have significantly impacted the Project's critical path. While these issues |

| | |
|---|---|
| | were resolved without additions to the base schedule. This underscores the potential for discovery of changes while a project undertakes a detailed baseline schedule review. |
| **Vendor Performance** | [redacted] |
| **Risk Management** | Since RQE, OPG has identified a number of new program and project risks. Many of these new risks appear to have been added without benefit of the rigor established during RQE and required Management attention. Key technical risks were identified or revised during the Execution Phase schedule preparation, which are under consideration for Unit 2 contingency calculations. |
| **Safety and Quality** | OPG's assurance activities have included identifying adverse safety or quality trends and have been adequate to date. |

## *Project and Program Assurance*

The EO Team believes the activities performed by the Project and Program assurance teams have been appropriate and their findings have positively influenced behaviors. The DR Team's Performance Assurance Group (PAG), Enterprise Risk Management and OPG Internal Audit have developed and are executing robust plans for assurance activities. The DR Project's quality and safety trends are being reviewed, tracked and monitored and the Project Team has identified and pursued course corrections.

## *Effectiveness of OPG Project Team*

OPG's Project leadership is displaying its commitment to identifying issues and increasing accountability across all work groups. The OPG Execution Team has revised processes based on the Readiness to Execute and its own OPEX that, on paper, should be effective but must be proven. Ensuring that the vendor and OPG commitments are kept and lines of authority are maintained will be a key contributor to success for the Project.

## *Strategic Considerations*

Based on our independent review of the current DR Project's status, the EO Team offers the following analysis of certain forward-looking risks and strategic considerations as the Project advances to Unit 2's Execution Phase. As a part of our analysis, the EO Team has reviewed and assessed OPG's assurance activities to identify any potential gaps. The risks described below have the potential to challenge the DR Project's ability to maintain the P90 schedule and/or cost.

| Risk Area | EO Team Observations |
|---|---|
| **Cost and Change Management** | OPG's Internal Audit verified that the DR Team has put into place the tools needed to maintain and analyze cost trends; it is now the Project Team's responsibility to properly use these tools. The Project Team has not been utilizing a consistent process for forecasting the impacts caused by deviations from the plan to overall cost and schedule of any particular project. Moreover, critical information needed from the vendors to prepare accurate forecasts has been suspect or missing.<br><br>As an example, the DR Team has identified mitigation plans for the late finishing F&IP Projects (D2O Storage Facility, EPG3, CFVS and STOP). Analyzing the full impact of these delays requires the vendors |

| | |
|---|---|
| | to provide accurate information and for OPG to validate that information for its cost and schedule forecasts. The current documented status of these projects suggests a high likelihood that OPG will need further draws against contingency due to extended costs and/or recovery of delays, though the vendors' information (or lack thereof) makes accurate analysis of the extent of delays more difficult.<br><br>Without robust forecasting, projects have limited ability to estimate the impact of current progress on future completion and, thus, no basis for timely or effective corrective action. On a large and complex project like Refurbishment, this could have a significant impact on the cost and schedule. Going forward, improving the accuracy of cost and schedule forecasts will depend upon the Project Team's use of the available tools, verification of the work in the field and ensuring it is receiving timely and accurate data from the vendors. |
| **Risk Management** | Since RQE, the EO Team has seen a broad range of risks added by the Project Team to the risk register. The program and structure is well established and functional. Discrete risks have been clearly identified and represent significant aggregate exposure which must be addressed. However, the Project Team's focus should be aimed at building effective mitigation strategies that can be successfully tracked and executed. The EO Team acknowledges that the OPG assurance teams have identified a number of concerns regarding the Project Team's use of the risk program as a management tool. However, the fact this issue continues to come up is evidence that the Project Team has not fully embraced the Risk Management Program as an essential day-to-day working tool. In our opinion, risk management is just as important to project success as methods used to control cost and schedule. |
| **Vendor Capability and Readiness** | To date, the vendors have struggled performing the F&IP projects and in meeting some of their commitments during the Refurbishment Project's Definition Phase. This raises several concerns with respect to the Refurbishment Project, [redacted] Based on our review of the vendor's performance over time, we have made the following observations that could have a significant impact on cost and schedule:<br><br>❖ The OPG Project Team has a tendency to "help" the contractors resolve issues in a manner that imposes unanticipated demands on OPG staff. Care must be taken to ensure that the contractors do not unnecessarily rely on OPG and shift contractual responsibilities.<br><br>❖ OPG's ability to effectively manage the vendors and anticipate issues depends largely on the quality of the data the contractors provide to OPG. As an example, OPG has not consistently compelled the contractors to provide performance data for its second and third-tier contractors or contractor actual hours, also known as their "burn rates." Such data is critical for assessing the contractor's true performance, assessing productivity and finding troubled areas.<br><br>❖ OPG has allowed the contractors to re-sequence their projects, which is generally an indicator of either poor performance or poor baseline scheduling. Accountability suffers when a project loses sight of its original baseline. OPG needs to ensure that the contractors are meeting schedule commitments as the Project moves into the Execution Phase and hold them accountable when the schedule slips. Changing a baseline schedule also makes forecasting much more difficult.<br><br>❖ OPG has requested changes to the key vendors' project management teams which the vendors have honored. It will be important to monitor these changes for their effectiveness.<br><br>OPG's commercial management team is currently understaffed. OPG is in the process of finalizing an RFP process to retain an outside vendor to assist in this regard, to keep pace with the volume of potential commercial issues, which it anticipates will increase after breaker open. |

# VECC Interrogatory #1

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Reference: D2/T2/S10/pg.8

a) What is meant by "partially placed in service in November 2015" for the Retube and Feeder Replacement Island Support Annex? Specifically what part and what amount was placed in- service? Is the $40.7 million shown in Chart 1 the entire project or the amount put into service?

## Response

a) "Partially placed in service" means that a portion of the Retube and Feeder Replacement Island Support Annex project was placed in service and is used or useful in advance of completion of the entire project. In November 2015, 10% of the project engineering changes, namely, the fire water and domestic water tie-in systems were installed, became useful, and were placed in-service for an amount of $1.7M. The total project cost is $40.7M, as noted in Ex. D2-2-10, p. 10, Chart 1.

# VECC Interrogatory #2

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Reference: D2/T2/S10/pg.16-

a) With respect to the Heavy Water Facility please provide the initial entire budget ($110.0m), the updated budget ($278m in EB-2013-0321) and the final budget ($381.m).

b) Please explain the statement "*While cited as a Class 2 estimate, this was not the case*". Specifically who cited what budget as a class 2 estimate?

c) What contracting penalty provisions were invoked due this overrun and termination of the initial contract?

d) Is this contractor in question currently employed as part of the DRP?

e) Is the current-in-service date for this project still May 2017?

## Response

a) The approved initial budget of $108.1M was provided in the business case summary filed in EB-2013-0321 at Ex. D2-2-1, Attachment 8-03. The superseding business case summary with an approved estimate of $381.1M was filed at Ex. D2-2-10, Attachment 1, Tab 1. During EB-2013-0321, a $287M estimate (not $278M) was discussed; however, this was a preliminary estimate that was generated early in the preparation of the final budget approved in the superseding BCS, and was not an approved estimate.

b) The project manager, in presenting the business case for approval, incorrectly cited Class 2 in the Full Release BCS. A Class 2 estimate requires engineering to be complete, which was not the case at that time of the business case.

c) OPG invoked the termination for default provision and a negotiated settlement was reached with the contractor. Please see L-4.3-1 Staff-78 for more information.

d) The contactor continues to provide services to OPG but OPG has adjusted its approach to awarding new First of a Kind (FOAK) projects to the contractor in consideration of the lessons learned on the Heavy Water Facility project. DRP scope for the subject

contractor is minimal and tailored to their proven capabilities as demonstrated on past projects.

e) The forecast date for the Heavy Water Facility remains May 2017.

# VECC Interrogatory #16

**Issue Number: 4.5**
**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

## Interrogatory

**Reference:**
Reference: D2/T2/S8Chart 4 & D2/T2/S7

a) Using Chart 4 please provide the AACE class estimate for the 4.8B refurbishment of unit 2.

b) Please explain how the contingency of 14% is consistent with the AACE class estimate for this project.

## Response

a) A Class of Estimate cannot be applied to an in-service amount. Please refer to L-4.5-7 ED-7.

b) Please see Ex. L-4.3-1 Staff-75, where OPG discusses the difference between Class of Estimate and contingency. Please note also that the in-service amount for Unit 2 includes amounts already expended in the Definition Phase which will be placed in service with Unit 2. Therefore, where OPG states, in Ex. D2-2-7, p. 7, that contingency to be placed in-service with Unit 2 in-service amount represents 14.4% of the Unit 2 in-service amount, it was not intended to imply that this is the percentage contingency on the Unit 2 cost estimate.