# REMAINING UNITS COST

## 1.0 OVERVIEW

On November 13, 2015, OPG's Board of Directors approved the Release Quality Estimate ("RQE") for the Darlington Refurbishment Program ("DRP or the "Program"), which formed the basis of the OEB's approval in EB-2016-0152. The RQE was based on the best information available regarding the Program as at November 2015 and included cost estimates of sufficient quality based on industry standards in order to establish the four-unit, program-level control budget for the DRP. This exhibit briefly recaps the RQE.

Since November 2015, OPG has continued to refine its cost and schedule estimates for individual units' refurbishments and for the Program, through the completion of unit Execution Estimates ("EE"). Unit EEs were completed in advance of the refurbishment outages of Units 2 and 3, as follows:

1. For Unit 2, the Unit 2 EE ("U2EE") was completed in August 2016;[1]
2. For Unit 3, the Unit 3 EE ("U3EE") was finalized in August 2020 and reflects the impact of the COVID-19 pandemic on the start dates of the refurbishment outages of Units 3, 1, and 4 (the "Remaining Units").[2] See Section 2.3 below and Attachment 1.

OPG plans to develop Unit EEs for Units 1 and 4 as follows:

1. For Unit 1, the Unit 1 EE ("U1EE") is forecast to be completed in November 2021; and
2. For Unit 4, the Unit 4 EE ("U4EE") is forecast to be completed in May 2023.

While the focus of the unit EEs is on finalizing a cost and schedule baseline for the next unit to be refurbished, the estimate for the Program is also refreshed in order to verify the Program cost estimate. As a result, the U3EE is OPG's best estimate for the cost for each of the Remaining Units and, therefore, for completion of the Program.

[1] The Unit 2 Execution Estimate was filed in EB-2016-0152, Ex. L-4.3-1 Staff-055.
[2] Ex. D2-2-5, Section 3.1 and Ex. D2-2-5 Attachment 2.

This exhibit provides OPG's updated Program cost summaries. Based on the U3EE, forecast in-service amounts for the Remaining Units are also provided, as is further detail on the costs for each of the Major Work Bundles for the Remaining Units.

Consistent with the OEB's approval in EB-2016-0152, this exhibit reiterates that OPG's success should be measured at the total envelope level of the Remaining Units. Should OPG deliver the Remaining Units within the envelope amount of $6,604.2M, consisting of $6,444.4M[3] capital and $159.8M OM&A,[4] this would also mean that the overall Program would have been completed within the Program estimate of $12.8B set at the RQE, excluding the cost impacts of the COVID-19 pandemic.

OPG's planned approach for COVID-19 cost impacts is discussed further in Section 2.3.

## 2.0 PROGRAM BUDGETS

### 2.1 Release Quality Estimate

Completion of the RQE in November 2015 was a major milestone in planning for the Program and marked the end of the Definition Phase. In the RQE, OPG determined that the total estimated cost of refurbishing all four units at Darlington would be $12.8B, including contingency, capitalized interest and escalation.

The RQE, supported by the Execution Phase Business Case Summary,[5] was approved by OPG's Board of Directors in November 2015. The RQE was subsequently presented to the Minister of Energy who announced his endorsement of the DRP on January 11, 2016.[6] The RQE represents the baseline estimate or control budget for the entire DRP.[7]

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[3] Of the$6444.4M capital, $6442.6M is being requested in this application for the 2022-2026 rate period. Capital costs of $1.9M for an early-in-service project associated with Unit 3 are forecast to be placed in-service in 2021.

[4] Of the $159.8M of OM&A costs, $110.5M is being requested in this application for the 2022-2026 rate period. The remainder represents actual OM&A expenses in 2019 and forecast OM&A expenses in 2020 and 2021 on the Remaining Units.

[5] The Execution Phase Business Case Summary was filed in EB-2016-0152 (Ex. D2-02-08, Attachment 1).

[6] https://news.ontario.ca/en/release/35478/ontario-moving-forward-with-nuclear-refurbishment-at-darlington-and-pursuing-continued-operations-at.html

[7] EB-2016-0152, Ex. D2-2-8, p.3.

As discussed in the last application, contingency included in the RQE Program estimate of $12.8B did not include amounts to cover low probability, high consequence events, such as the COVID-19 pandemic.[8] OPG's proposed treatment of any ultimate impact of the COVID-19 pandemic on the Program is discussed in more detail in Section 2.3.

**2.2 Unit 2 Execution Estimate**

The U2EE was finalized in August 2016, two months prior to the Unit 2 refurbishment outage start date of October 2016, and ten months after completion of the RQE. The U2EE was an update of the forecast costs and schedule for the refurbishment of Unit 2. The U2EE also confirmed a total Program cost of $12.8B, as it was at the RQE. The U2EE was the basis upon which OPG's Board of Directors gave its August 2016 approval for the final release of funds to complete the execution of the Unit 2 refurbishment outage and served as the baseline against which performance on the Unit 2 refurbishment outage was measured. See Ex. D2-2-2 for a detailed discussion of how the U2EE was a more refined estimate as compared to the RQE.

**2.3 Unit 3 Execution Estimate**

Similarly, the U3EE represents refinements to the estimate for Unit 3 in particular, and the latest updated cost and schedule estimates for the Program. The U3EE was finalized in August 2020, in advance of the Unit 3 refurbishment outage start date of September 2020. A summary of the final U3EE is provided in Attachment 1.

As discussed in Ex. D2-2-3, the U3EE was refined and updated twice to reflect changes in Program schedule, experience from Unit 2 execution including Lessons Learned, implementation of Strategic Improvements, updated risk analyses with resultant updates to the contingency estimates, revised cost flows, and updates to interest and escalation.

Burns McDonnell/Modus Strategic Solutions ("BMcD/Modus"), the independent oversight consultant to OPG's Board of Directors, reviewed two iterations of the U3EE. Overall, BMcD/Modus found that:

[8] EB-2016-0152, Ex. D2-2-7, and Ex. D2-2-6, Section 2 in this application for more information.

> …the process for developing the estimate was consistent with the process the DR team has used to date on the DR project, starting with RQE. U3EE is based on estimates that have progressively matured, and as more is known, certainty around estimates increases. U3EE's increased base cost estimate and decreased contingency from the U3 Target Budget is a consequence of this ongoing building of project maturity.[9]

In its second report, BMcD/Modus also noted:

> Based on the maturity of the DR project, the Unit 3 estimate can be classified on the lower range of a Class 2 (+5% to +20%), and upper range of a Class 1 (+3% to +15%) as measured by the AACEi classification system[10] adopted by OPG for the DR project.[11] [12]

BMcD/Modus' two assessment reports are included as Attachments 2 and 3.

<u>COVID-19 Pandemic Impact on Program</u>

In response to the COVID-19 pandemic and the state of emergency declaration by the Province of Ontario on March 17, 2020, OPG immediately suspended all pre-requisite field work within the Darlington site on Unit 3, while continuing off-site field work and continuing planning and preparatory work for the Remaining Units, utilizing staff working from home. After assessment, OPG determined that return-to-service activities on Unit 2 could safely continue.

Based on a preliminary evaluation of the likely impacts of the pandemic on the Program, OPG Management determined that a deferral of the start date of the refurbishment outage of Unit 3, and correspondingly Units 1 and 4, by four months each, would be the most probable and feasible scenario.

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[9] Burns/Modus Report, Unit 3 Execution Estimate, Darlington Refurbishment Project, Burns McDonnell/Modus Strategic Solutions, March 5, 2019, p. 2. See Attachment 2.

[10] AACE International Recommended Practice No. 18R-97.

[11] Independent Oversight Team, Report on Darlington Unit 3 Execution Estimate, Burns McDonnell/Modus Strategic Solutions, November 11-12, 2019, p. 2. See Attachment 3.

[12] Class 2 estimate ranges are: Low: -5% to -15%; High: +5% to +20%; Class 1 estimate ranges are: Low: -3% to -10%; High: +3% to +15%.

The key factors which were considered in the analysis that resulted in the decision to defer the start dates of each of the Remaining Units by four months, included:

1. The safety of OPG's and contractors' employees;
2. Maintaining safe and reliable operation of OPG facilities, with particular emphasis on the impact on Darlington operations;
3. The impacts on the planning effort and resources required to re-plan for each of the Remaining Units;
4. Availability of critical resources for the refurbishment outages;
5. Fitness-for-Service assessments for each of the Remaining Units' systems and components;
6. Regulatory approvals required;
7. Feasibility of unit refurbishment outage overlaps; and,
8. Commercial impacts, including delay claims and warranties.

This change was subsequently approved by OPG's Board of Directors, resulting in the refurbishment of Unit 3 beginning in September 2020.

During the period of May to September 2020, OPG reviewed its evaluation of the impact of the COVID-19 pandemic on the Program, and resumed field work on Unit 3, with COVID-19 protocols in place. OPG's COVID-19 protocols have allowed work to safely continue to date; however, there continue to be significant uncertainties about the eventual impacts. OPG will continue to adjust its mitigation plans as needed in response to the pandemic, and will continue to manage the impacts on the DRP as best as possible.

OPG also prepared the final U3EE in August 2020 to formalize the changes to the Program as a result of the deferrals caused by the COVID-19 pandemic. The final U3EE included the following refinements:

1. The most up-to-date actual experience on Unit 2, including additional Lessons Learned and discovery issues – this allowed a small reduction in the working schedule duration for Unit 3.
2. Revised direct field labour productivity assumptions based on the Hybrid Schedule.

3. A strategic decision to transfer two key scope packages in the Turbine Generator Major Work Bundle (i.e., the centerline work and generator stator replacement) to General Electric, the Original Equipment Manufacturer ("OEM"), from CanAtom. This transfer of scope was coincident with the decision to perform the Unit 3 generator stator rewind in-situ rather than replacing the generator stator.
4. Revised cash flows and interest and escalation amounts, consistent with the revised schedule.

The final U3EE resulted in no changes to the overall Program estimate of $12.8B, to the individual estimates for each of the Remaining Units, or to the High Confidence schedule durations for each of the Remaining Units.

The final U3EE separately identifies, and OPG's 2020-2026 Business Plan includes, a preliminary estimate of the impact of the COVID-19 pandemic and of deferring the start dates of the Remaining Units' refurbishment outages on the Program of $150M. The ultimate impact of the pandemic on the Program remains inherently uncertain, cannot be forecasted and, as discussed in Ex. D2-2-6, is not included in the contingency. OPG will continue to monitor, assess and explore potential efficiencies during the execution of the Remaining Units' refurbishments in an effort to complete the Program inclusive of COVID-19 cost impacts within the $12.8B budget. OPG is not seeking approval of any COVID-19 pandemic-related costs in this application, and none are included in the in-service additions presented. Any ultimate variance to the $12.8B caused by the COVID-19 pandemic would be tracked separately and addressed through the Capacity Refurbishment Variance Account ("CRVA") in a future proceeding.

Chart 1 provides a comparison of the Program estimates as at the RQE, the U2EE and the final U3EE. The final U3EE forms the basis for the approval amounts requested for the Remaining Units in this application.

**Chart 1: Program Cost Breakdown at RQE, U2EE and U3EE (M$)**

| Bundle / Category | RQE Nov 2015 | % | U2EE Aug 2016 | % | U3EE Aug 2020 | % |
|---|---|---|---|---|---|---|
| Major Work Bundles | 6,992 | 55% | 6,983 | 55% | 8,021 | 63% |
| F&IP/ SIO* | 933 | 7% | 959 | 7% | 1,150 | 9% |
| OPG Functions | 2,869 | 22% | 2,852 | 22% | 2,975 | 23% |
| Contingency | 2,006 | 16% | 2,007 | 16% | 647 | 5% |
| **Total High Confidence Estimate** | **12,800** | **100%** | **12,800** | **100%** | **12,800** | **100%** |

Note that all numbers are in dollars of the year, i.e., including interest and escalation in each line item.
*F&IP/SIO refers to Facility and Infrastructure Projects / Safety Improvement Opportunities

Comparing the final U3EE and the U2EE, which were completed 48 months apart, the most noticeable change is the increase in the total forecast Program costs for the Major Work Bundles, offset by a reduction in the amount of contingency required to assure a high confidence forecast. The primary reasons for this change are that: (1) Unit 2 has now been completed and the contingency utilized on Unit 2 is now reflected in base estimates; and (2) based on Lessons Learned on Unit 2, base estimates have been updated for the Remaining Units to include Lessons Learned on Unit 2, including risks that have now become certainties and, therefore, included in base estimates. This concept of increasing “point” or “base” estimates, offset by a reduction in contingency requirements is explained in Ex. D2-2-6, Section 3. In summary, cost and schedule uncertainties and the number of discrete risks have decreased, as have the probabilities and consequences associated with the remaining risks, necessitating a lower amount of contingency to establish high confidence in forecasts costs.

## 3.0 IN-SERVICE AMOUNTS

In the EB-2016-0152 proceeding, the OEB granted envelope approval for OPG’s in-service amount request for Unit 2. In its EB-2016-0152 Decision and Order, the OEB stated:

> The OEB will not micromanage the DRP, but rather will hold OPG accountable to deliver the DRP on time and on budget. If OPG were to face CRVA scrutiny for each component part of the Unit 2 project, it may lead to unintended consequences and lessen the ability of OPG to deal with issues as they arise. As OPG argues convincingly in its reply submission, the refurbishment of Unit 2 is a single integrated project, not a web of independent projects. It must be managed on a holistic, dynamic basis, where "higher cost may be incurred in one area to address a risk or resolve an issue in another area, which, when taken as a whole, is to the benefit of ratepayers." At the end of the day, it is OPG's responsibility to deliver the Unit 2 project (and the campus plan projects) within the budget envelope approved in this proceeding ……. OPG should have some flexibility in doing so.[13]

Based on the final U3EE, and consistent with the OEB's approval for Unit 2 in EB-2016-0152, OPG is requesting total in-service additions of $6,442.6M over the IR term, consisting of (i) $1.4M in 2023 for an Early In-service Project associated with Unit 1, (ii) $2,505.5M in 2024 on completion of the Unit 3 refurbishment (this includes $1.6M for an Early-In-Service Project associated with Unit 4); (iii) $1,907.3M in 2025 on completion of the Unit 1 refurbishment; and, (iv) $2,028.3M in 2026 on completion of the Unit 4 refurbishment (see Ex. D2-2-9 for details). . Also consistent with the OEB's approval in EB-2016-0152, while the total high-confidence in-service amount for each of the Remaining Units may ultimately be different than the forecast amounts shown, OPG's success should be measured at the total envelope level of the Remaining Units.

As noted in Ex. D2-2-2, variances in nuclear revenue requirement resulting from variances in Program in-service additions (as well as DRP OM&A expenses) will be recorded in the CRVA. The balances in the CRVA, if any, will be brought forward for review and approval by the OEB in a future proceeding.

The breakdown of the Remaining Units in-service amounts is shown in Chart 2.

[13] Ontario Energy Board, *Decision and Order, EB-2016-0152, Ontario Power Generation Inc.*, December 28, 2017, p.41

**Chart 2: Breakdown of the Remaining Units In-service Additions ($M)**[14]

| # | Bundle / Category | Unit 3 2024 I/S | % | Unit 1 2025 I/S | % | Unit 4 2026 I/S | % |
|---|---|---|---|---|---|---|---|
| 1 | Retube and Feeder Replacement | 1,072.6 | 43% | 798.0 | 42% | 837.4 | 41% |
| 2 | Turbine Generators | 291.5 | 12% | 206.3 | 11% | 230.9 | 11% |
| 3 | Balance of Plant | 242.0 | 10% | 188.3 | 10% | 197.6 | 10% |
| 4 | Fuel Handling/Defuelling | 17.3 | 1% | 8.5 | 0% | 5.4 | 0% |
| 5 | Steam Generators | 43.3 | 2% | 42.8 | 2% | 46.2 | 2% |
| 6 | Subtotal Major Work Bundles | 1,666.7 | 67% | 1,243.9 | 65% | 1,317.5 | 65% |
| 7 | Project Execution | 70.4 | 3% | 49.7 | 3% | 47.5 | 2% |
| 8 | Contract Management | 11.9 | 0% | 7.8 | 0% | 10.9 | 1% |
| 9 | Engineering | 75.6 | 3% | 48.9 | 3% | 57.0 | 3% |
| 10 | Managed Systems Oversight | 2.8 | 0% | 1.9 | 0% | 2.2 | 0% |
| 11 | Planning and Controls | 25.6 | 1% | 20.9 | 1% | 26.0 | 1% |
| 12 | Nuclear Safety | 11.4 | 0% | 8.3 | 0% | 11.1 | 1% |
| 13 | Program Fees and Other Support | 73.3 | 3% | 56.1 | 3% | 65.9 | 3% |
| 14 | Supply Chain | 12.4 | 0% | 11.3 | 1% | 14.8 | 1% |
| 15 | Work Control | 30.7 | 1% | 27.1 | 1% | 33.2 | 2% |
| 16 | Operations and Maintenance | 285.0 | 11% | 218.0 | 11% | 249.8 | 12% |
| 17 | Subtotal OPG Functions | 599.1 | 24% | 449.9 | 24% | 518.4 | 26% |
| 18 | Contingency | 238.1 | 10% | 215.0 | 11% | 194.0 | 10% |
| **19** | **Total High Confidence Unit I/S Estimates** | **2,504.0** | **100%** | **1,908.8** | **100%** | **2,029.8** | **100%** |
| **20** | **Total Envelope In-Service Amount for Remaining Units** | **$6,442.6M** | | | | | |

[14] Inclusive of minor early in-service amounts totalling $3.0M as follows: (i) The Unit 1 amount of $1,908.8M includes $1.4M for an Early In-Service Project placed in-service in 2023; (ii) the Unit 4 amount of $2,029.8M includes $1.6M for an Early In-service Project placed in-service in 2024.

### 3.1 Unit 3 versus Unit 2

As provided in Ex. D2-2-2, the cost for Unit 2 only, i.e., excluding the Definition Phase costs, was $3,417M, of which $3,340.5M is the capital in-service amount. The Unit 3 capital in-service amount is forecast to be $2,504.0M. The primary contributors to the Unit 3 capital in-service amount being forecast to be approximately $840M lower than that for Unit 2 are:

- Scope: As mentioned in Ex. D2-2-3, scope differences between Units 2 and 3 include scope completed with Unit 2 that was of benefit to all four units because of the integrated four-unit configuration of the Darlington station, and scope not needing to be repeated because of the Darlington units being of the same design. These include Pre-requisite Engineering for Retube and Feeder Replacement ("RFR") and Defuelling, a large portion of the shutdown system work scope, breathing air and service air upgrades, and certain facilities, such as washrooms and trailers. The scope that will not be repeated on Unit 3 accounts for approximately $600M of the reduction in the in-service amount for Unit 3 compared to Unit 2. These reductions are partially offset by costs related to the Turbine Generator Controls and generator stator rewind scope on Unit 3 that was not performed on Unit 2 and in the investment in the Darlington 3 Innovations Project ("D3IP"), totalling approximately $200M.
- Lower Costs: Interest, contingency and fees are all forecast to be lower for Unit 3 than for Unit 2, resulting in a forecast cost reduction of $200M.
- Productivity Improvements: Based on industry experience and specific improvements to trades training programs and to radiation protection practices, the Unit 3 estimate reflects unit-over-unit productivity improvements of 18%.

### 3.2 Units 1 and 4 versus Unit 3

As shown in Chart 2, the forecasted in-service amounts for Units 1 and 4 are approximately $600M and $470M less than the forecasted in-service amount for Unit 3.

The primary contributors to the Unit 1 in-service amount being forecast to be approximately $600M lower than that for Unit 3 are:

- Scope: Scope differences between Units 3 and 1 include the cost of investment in D3IP tooling, which will be placed in service at the time of Unit 3 because it will be used, in full,

for Unit 3 refurbishment outage. As well, unlike Unit 3, Unit 1 does not include a generator stator rewind. Scope that will not be repeated on Unit 1 accounts for approximately $100M of the reduction.

- Lower Costs: Lower costs for Unit 1 compared to Unit 3 are attributed to: (1) engineering modification packages prepared for Unit 3 that will be applied to Unit 1, with only minor updates needed; (2) tooling procured for Unit 3 that will largely be repaired and re-used on Unit 1; and, (3) the overlapping of Unit 1 with both Units 3 and 4, combined with the planned Organizational Evolution Strategic Improvement (discussed in Ex. D2-2-3, Section 5.1.1 and expanded upon in Ex. D2-2-8, Section 2.2.1.1). Modest reductions in interest and contingency also contribute to the lower cost of Unit 1 compared to Unit 3. Lower costs are forecast to account for approximately $300M of the difference in costs between Units 1 and 3.
- Productivity Improvements: Further unit over unit productivity improvements are forecast, based on the improved training and radiation protection process improvements, resulting in a predicted shorter High Confidence Schedule (by two months) for Unit 1 than for Unit 3 and hence lower trades and Project Management Team ("PMT") costs. In addition, there are lower forecast training and re-training costs for Unit 1 as a result of the overlapping schedules, the lower risk of loss of trades, and the strategy of moving the PMT and trades from the prior unit to the subsequent unit refurbishment outage (see Ex. D2-2-8, Section 2.2.1.1). These productivity improvements are forecast to account for approximately $200M of the difference in costs between Units 1 and 3.

The comparison of Unit 4 to Unit 3 is similar to the above comparison of Unit 1 to Unit 3. However, the Unit 4 cost does not benefit as much as Unit 1 from the sharing of resources as a result of overlapping schedules. Higher PMT and closeout costs on Unit 4 than on Unit 1 are partially offset by lower costs, lower contingencies, and further productivity improvements expected from Unit 4 being the fourth unit to be executed, with the end result being a forecast cost increase over Unit 1 of approximately $120M.

### 3.3 Major Work Bundle Costs

As can be seen from Chart 2, the Major Work Bundles represent approximately two-thirds of each of the Remaining Units' refurbishment costs. The Major Work Bundle costs for Units 3, 1, and 4 are $1,668.6M, $1,243.9M, and $1,317.5M respectively or 67%, 65%, and 65% of the respective in-service amounts.

The cost estimates for all Major Work Bundles are based on the detailed scope, schedule, contingency and cost estimate development, as discussed in Ex. D2-2-3, Ex. D2-2-5, Ex. D2-2-6, and in this exhibit. As part of the development of the respective Unit EEs, each of the Major Work Bundles and functional cost estimates must progress through OPG's gated process (see Ex. D2-2-3, Attachment 1). The final gate, Gate 3, occurs prior to completion of the Unit EEs and submission of a request to the OPG Board of Directors for approval for a release of funds to proceed into the refurbishment outage of each unit. At Gate 3, the Major Work Bundle and functional estimates are challenged at gate review meetings with OPG's DRP executives.

The following sections present details on the cost estimates of the Major Work Bundles for each of the Remaining Units.

#### 3.3.1 Remaining Units Retube and Feeder Replacement

The RFR Major Work Bundle accounts for $1,072.6M, $798.0M, and $837.4M or approximately 43%, 42%, and 41% of the Units 3, 1, and 4 in-service amounts, respectively. As shown in Ex. D2-2-4, Attachment 2, since the RQE, the Unit Islanding scope of work has been moved from the Balance of Plant Major Work Bundle, to the RFR Major Work Bundle, as combining these scopes of work under one PMT is expected to improve performance. A breakdown of the RFR costs, which now include Unit Islanding, for Units 3, 1, and 4 is set out in Chart 3 below.

**Chart 3: Remaining Units RFR Bundle Costs**

| Description | Forecast Costs ($M) | | | | | |
|---|---|---|---|---|---|---|
| | **Unit 3 2024** | **%** | **Unit 1 2025** | **%** | **Unit 4 2026** | **%** |
| OPG Project Management | 35.2 | 3% | 39.6 | 5% | 48.1 | 6% |
| Execution Phase | 1,037.4 | 97% | 758.4 | 95% | 789.3 | 96% |
| **Total** | **1,072.6** | **100%** | **798.0** | **100%** | **837.4** | **100%** |
| Note that all numbers are in dollars of the year, i.e., including interest and escalation in each line item. | | | | | | |

As discussed in Ex. D2-2-4, OPG and CanAtom revised the RFR estimate for the Remaining Units, This revision was informed, as before, by steps and methods in the Comprehensive Work Packages ("CWP") and by performance on the mock-up, but had the added benefit of having actual task durations, resource utilization and other performance data from Unit 2. The RFR estimate has also been improved, compared to the RQE, through the incorporation of Lessons Learned into every CWP, including the assessment of delays experienced, and the elimination of "one-time" delays incurred on Unit 2.[15] The expected productivity improvements resulting from Strategic Improvements in Training, Radiation Protection and the use of the Hybrid Schedule have also been factored into the revised estimates.[16] In addition, the RFR cost estimate now includes the costs and benefits resulting from the implementation of the D3IP tooling improvements. The estimate also includes the impact of the Organizational Evolution Strategic Improvement, which comprises the implementation of the Project Centric Organization, Workstream Specialization and the One Team Approach.[17]

Differences in the scope of work for the Remaining Units is also a factor influencing the revised RFR estimates. For example, the number of Engineering Change packages required to be prepared for the RFR Major Work Bundle (excluding Unit Islanding) for Unit 3 was approximately 60% of those required for Unit 2, which was largely attributable to the decision not to employ bulkhead shielding in Unit 3. For Unit Islanding, the required number of

[15] Ex. D2-2-3 Section 4 for a discussion of the Lessons Learned process.
[16] Ex. D2-2-3 Section 5 for a discussion of Strategic Improvements.
[17] Ex. D2-2-3 Section 5.1.1 for a discussion of the Organizational Evolution Strategic Improvement.

engineering change packages for Unit 3 was 19% of the number required for Unit 2 because many of the Unit Islanding modifications did not need to be redone for Unit 3.

Similar to the process employed during the development of the RQE, OPG, working collaboratively with CanAtom, conducted a rigorous vetting process of the Unit 3 RFR estimate as part of the process leading up to the Gate 3 review. This process included challenge sessions with OPG's DRP executives where the RFR senior project managers would present and defend the estimate. All aspects of the estimate were reviewed and challenged, including direct field labour hours, PMT costs, subcontracts, support services and equipment, owner supplied materials, goods and fees.

### 3.3.2 Remaining Units Turbine Generators Costs

The Turbine Generators ("TG") Major Work Bundle accounts for $291.5M, $206.3M and $230.9M or approximately 12%, 11%, and 11% of Units 3, 1, and 4 in-service amounts, respectively. A breakdown of the Turbine Generator costs for Units 3, 1, and 4 is set out in Chart 4 below.

**Chart 4: Remaining Units Turbine Generator Bundle Costs**

| Description | Forecast Costs ($M) | | | | | |
|---|---|---|---|---|---|---|
| | **Unit 3 2024** | **%** | **Unit 1 2025** | **%** | **Unit 4 2026** | **%** |
| Turbine Generators - Engineering Services and Equipment Supply and Field Services (General Electric) | 172.8 | 59% | 120.1 | 58% | 151.8 | 66% |
| Turbine Generators - EPC (CanAtom) | 92.6 | 32% | 71.1 | 34% | 62.4 | 27% |
| OPG Executed Projects | 4.4 | 2% | 1.0 | 0% | 1.0 | 0% |
| OPG Project Management | 19.7 | 7% | 11.7 | 6% | 13.8 | 6% |
| OPG IRI* Support | 2.1 | 1% | 2.3 | 1% | 2.0 | 1% |
| **Total** | **291.5** | **100%** | **206.3** | **100%** | **230.9** | **100%** |
| Note that all numbers are in dollars of the year, i.e., including interest and escalation in each line item.<br>*IRI refers to OPG's Inspection and Reactor Innovation Division. | | | | | | |

As set out in Ex. D2-2-4, Section 3.3, the TG Major Work Bundle scope of work is divided into two contracts: (1) an Engineering Services and Equipment Supply and Field Services Agreement ("ESESFSA") between OPG and General Electric ("GE"), the OEM of the turbine generators; and, (2) an Engineering, Procurement and Construction ("EPC") contract between OPG and CanAtom. In Chart 4, the estimated costs of the ESESFSA with GE are shown in the first line and those of the EPC contract with CanAtom in the second line.

As also set out in Ex. D2-2-4, Section 3.3, leading up to the execution of Unit 3, OPG awarded additional execution scope to GE that had originally been assigned to CanAtom. Specifically, OPG decided to rewind the generator stators for Units 3 and 4 in-situ and to award this scope to GE, and also to award the centerline inspection and maintenance scope for the turbine generator set to GE. This decision was based on a favourable assessment of cost and schedule savings and on GE's deep experience in performing this type of work as the OEM. The estimated costs for the GE scope of work includes a fixed price component for the stator rewind and centerline inspection and maintenance, thereby providing cost certainty to OPG for this work.

The turbine generator EPC contract with CanAtom covers the majority of the fieldwork required to install the first-of-a-kind ("FOAK") turbine and generator excitation digital controls on Unit 3, and for inspection and repair of other equipment and components, such as the condenser on each unit. The estimates for this scope of work were derived from the original budget estimates at the RQE, factoring in Lessons Learned, mitigation of FOAK risks, eliminating "one-time" delays and including assumed productivity improvements. These estimates were reviewed in challenge sessions leading up to approval of the final U3EE.

3.3.3 Remaining Units Balance of Plant Costs

The Balance of Plant ("BOP") Major Work Bundle accounts for $242.0M, $188.3M and $197.6M or approximately 10%, 10%, and 10% of Units 3, 1, and 4 in-service amounts, respectively. A breakdown of the BOP costs for Units 3, 1, and 4 is set out in Chart 5 below.

**Chart 5: Remaining Units Balance of Plant Bundle Costs**

| Description | Forecast Costs ($M) | | | | | |
|---|---|---|---|---|---|---|
| | **Unit 3 2024** | **%** | **Unit 1 2025** | **%** | **Unit 4 2026** | **%** |
| Balance of Plant Work | 107.6 | 44% | 84.4 | 45% | 88.4 | 45% |
| Refurbishment Support Facilities | 6.9 | 3% | 0.0 | 0% | 2.8 | 1% |
| Shutdown, Layup and Services | 28.0 | 11% | 26.7 | 14% | 26.2 | 13% |
| Specialized Projects | 34.3 | 14% | 36.1 | 19% | 36.9 | 19% |
| Operations & Maintenance | 41.5 | 17% | 29.2 | 16% | 27.9 | 14% |
| OPG Project Management | 23.7 | 10% | 11.9 | 6% | 15.3 | 8% |
| **Total** | **242.0** | **100%** | **188.3** | **100%** | **197.6** | **100%** |
| Note that all numbers are in dollars of the year, i.e., including interest and escalation in each line item. | | | | | | |

The development of the BOP cost estimates for Units 3, 1, and 4 were derived from the Unit 2 actuals, and followed a similar process to that of the RFR project, incorporating Lessons Learned from Unit 2, eliminating "one-time" delays and factoring in productivity improvements. Where actual experience from Unit 2 was not available, the contractors developed a new estimate. Differences in the scope of work in the BOP Major Work Bundle for the Remaining

Units, compared to Unit 2, are as a result of OPG performing the engineering replication work, and of there being a lesser need for new refurbishment support facilities.

### 3.3.4 Remaining Units Fuel Handling and Defuelling Costs

The Fuel Handling and Defuelling Major Work Bundle accounts for $17.3M, $8.5M, and $5.4M or 0.7%, 0.5%, and 0.3 % of Units 3, 1, and 4 in-service amounts, respectively. A breakdown of the Fuel Handling and Defuelling costs for Units 3, 1, and 4 is set out in Chart 6 below.

**Chart 6: Remaining Units Fuel Handling and Defuelling Bundle Costs**

| Description | Forecast Costs ($M) | | | | | |
|---|---|---|---|---|---|---|
| | **Unit 3 2024** | **%** | **Unit 1 2025** | **%** | **Unit 4 2026** | **%** |
| Defuelling | 6.6 | 38% | 1.1 | 13% | 1.2 | 22% |
| Fuel Handling | 1.4 | 8% | 0.0 | 0% | 0.0 | 0% |
| OPG Project Management | 9.4 | 54% | 7.3 | 87% | 4.2 | 78% |
| **Total** | **17.3** | **100%** | **8.5** | **100%** | **5.4** | **100%** |
| Note that all numbers are in dollars of the year, i.e. including interest and escalation in each line item. | | | | | | |

The estimates for Units 3, 1, and 4, incorporate the Lessons Learned on this project.

### 3.3.5 Remaining Units Steam Generators Costs

The Steam Generators ("SG") Major Work Bundle accounts for $43.3M, $42.8M and $46.2M or approximately 2%, 2%, and 2% of Units 3, 1, and 4 in-service amounts, respectively. A breakdown of the SG costs for Units 3, 1, and 4 is set out in Chart 7 below.

**Chart 7: Remaining Units SG Bundle Costs**

| Description | Forecast Costs ($M) | | | | | |
|---|---|---|---|---|---|---|
| | **Unit 3 2024** | **%** | **Unit 1 2025** | **%** | **Unit 4 2026** | **%** |
| Steam Generators EPC (BWXT/CANDU)* | 31.0 | 71.6% | 30.8 | 72.0% | 33.1 | 71.7% |
| OPG Project Management | 3.2 | 7.4% | 2.6 | 6.1% | 3.2 | 7.0% |
| OPG IRI** Support | 9.1 | 21.0% | 9.4 | 21.9% | 9.8 | 21.3% |
| **Total** | **43.3** | **100%** | **42.8** | **100%** | **46.2** | **100%** |

Note that all numbers are in dollars of the year, i.e., including interest and escalation in each line item.
*BWXT/CANDU refers to the Babcock & Wilcox Canada Ltd. and Candu Energy Inc. Joint Venture
**IRI refers to OPG's Inspection and Reactor Innovation Division.

The majority of the scope of work of the SG Major Work Bundle is subject to fixed/firm pricing where tasks are highly defined and consistent with those performed at other nuclear facilities. The fixed price pricing model will provide OPG with greater cost certainty. A cost reimbursable target price model applies to the remainder of the scope of work. The estimates for Units 3, 1, and 4 incorporate the Lessons Learned on this project.

## ATTACHMENTS

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|---|---|
| Attachment 1: | Ontario Power Generation, Darlington Refurbishment – Final Unit 3 Execution Estimate, For Approval by Board of Directors, August 13, 2020 |
| Attachment 2: | Burns/Modus Report, Unit 3 Execution Estimate, Darlington Refurbishment Project, Burns McDonnell/Modus Strategic Solutions, March 5, 2019 |
| Attachment 3: | Independent Oversight Team, Report on Darlington Unit 3 Execution Estimate, Burns McDonnell/Modus Strategic Solutions, November 11-12, 2019 |