EB-2016-0152

ONTARIO ENERGY BOARD

IN THE MATTER OF an application by Ontario Power Generation Inc. pursuant to section 78.1 of the *Ontario Energy Board Act, 1998* for an Order or Orders determining payment amounts for the output of certain generation facilities.

Cross-Examination Compendium of

Association of Major Power Consumers in Ontario (AMPCO)

OPG Panel 1B

March 7, 2017

UNDERTAKING J2.4

Undertaking

To advise precisely where in the evidence there is an expert that says P90 is an appropriate allocation.

Response

The below references are derived from the Testimony of Dr. Patricia D. Galloway, located at Ex. D2-2-11, Attachment 3.

On page 8:

> "OPG's selection of a P90 confidence level for the Unit 2 schedule is reasonable and in accordance with the robust risk analyses that were performed."

On page 14:

> "By performing a detailed cost estimate and schedule based on a thorough and robust probabilistic risk assessment of the Program, *OPG has established a P90 confidence level of the cost to complete the Program and established an appropriate level of contingency, which in my opinion, is a reasonable cost estimate.*" *(emphasis added).*

On page 54:

> "Q. Did you assess whether the amount of contingency included in the RQE by OPG was reasonable given the nature of the DRP?
>
> A. *Yes. In review of the DRP documentation and through interviews with OPG personnel, I have determined that OPG's $1.7B of contingency for the DRP is reasonable*. I base this finding on my understanding of the robust method in which OPG determined its contingency amount, which included a comprehensive risk assessment, Monte Carlo simulations, vetting by internal and external parties, and the decision to use a P90 confidence level." *(emphasis added).*

On page 55:

"Q. Is it appropriate to use the P90 confidence level to determine the amount of contingency?

A. Yes. Although no specific confidence level is considered a best practice, using a P90 confidence level provides OPG with a high probability that the Program will be completed within the budget. Using a lower confidence level, such as a P50 confidence level, may not adequately address the complexities and risks inherent with the execution of a megaprogram (particularly the extended duration of execution as compared to a typical project), thus increasing the risk of a cost overrun."

On page 56:

"Q. Did you reach any overall opinions concerning the RQE $12.8B estimate for the DRP?

A. Yes. From my review and evaluation of the contemporaneous documentation and the interviews of OPG management, at the time the RQE cost estimate was completed, OPG had ample reason to feel confident in the accuracy of RQE estimate. I found the methodologies employed by OPG to develop the RQE estimate to be world-class. A review of all the relevant documentation and interviews with OPG project personnel confirmed the fact that the methodologies employed met all accepted industry standards and guidelines as promulgated by AACE. As I discussed earlier in my testimony, *the use of a P90 confidence level, along with the detailed estimate development process, provides OPG with appropriate assurances that the DRP can be completed within the $12.8B estimate.*" (*emphasis added*).

On page 62:

"Q. Do you believe it is reasonable to use the high-confidence P90 schedule for execution of Unit 2?

A. While there is no prescribed standard for use of a particular confidence schedule over another, OPG, by selecting the P90 schedule for Unit 2, has demonstrated its risk tolerance preference for a high-confidence schedule (aligning with its use of a P90 estimate) to limit the likelihood of schedule overruns. *I find OPG's selection of a P90 confidence level for the Unit 2 schedule to be reasonable and in accordance with the robust risk analyses that were performed.*" *(emphasis added).*

In part b of M1-4.3 AMPCO-009 regarding Schiff Hardin's assessment of whether a P50 versus a P90 contingency or another contingency probability is the industry standard, Schiff Hardin stated:

> "The P50 is an estimate of the project cost based on a 50% probability that the cost will not be exceeded. Stated another way, the P50 estimate is one with equal chance of project overruns or underruns. *The P90 is an estimate of the project cost based on a 90% probability that the cost will not be exceeded. Some project participants prefer to have less exposure to increases in capital budgets and often look for a P90 figure.* The P90 contingency means that the contingency allowance on top of the base estimate is sufficient to ensure that there is a 90% chance that the amount will not be exceeded. Budget determinations and the confidence level for projects/programs vary by the contracting strategy, schedule, and other project/program factors." *(emphasis added).*

UNDERTAKING J2.2

Undertaking

To provide P-level associated with the working schedule and cost level associated with the working schedule.

Response

The duration of the working schedule for Unit 2 is 35 months, as provided in L 4.3-2 AMPCO-066, p. 2, Chart 1. This working schedule duration is equivalent to a confidence level of P37 or 37%.

Completion of Unit 2 on the working schedule of 35 months, i.e. a return-to-service in mid-September 2019, would result in a reduction in the use of schedule contingency. OPG has approximated the reduction in the use of schedule contingency, based on the difference in durations between the P90 and the working schedule and an appropriate average daily rate.

OPG's estimates that the in-service amount associated Unit 2 based on the working schedule would be reduced by $144M, i.e. to approximately $4656M.

The working schedule is intended to be aggressive. OPG is managing the work to this schedule to allow early identification of risks so that mitigating action can be taken promptly.

UNDERTAKING J3.5

Undertaking

To provide the methodology to get to the Unit 2 in-service amounts at an alternate P level, if there is one. If not, advise that there is no methodology.

Response

The methodology used in OPG's response to Ex. L-4.3-5 CCC-018, part b) to prorate the contingency amount for Unit 2 by the ratio of the P50 contingency amount to the P90 contingency amount for the overall DRP, can also be used to estimate the revised in-service amount for Unit 2 at other confidence levels, e.g. P70.

This methodology, while providing a reasonable approximation of a revised in-service amount at any particular revised confidence level, would not yield an accurate in-service amount. An accurate in-service amount can only be generated by determining the contingency cash flow at the revised confidence level, apply it over the base estimate, and re-doing the detailed escalation and interest calculations.

CCC Interrogatory #18

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

Interrogatory

Reference:
Reference: Ex. D2/T2/S11 Attachment 3 p. 8
This testimony from Dr. Patricia D. Galloway asserts at several places that OPG used a "p90" confidence level when setting the contingency amount for the DRP of $1.7B.

a) What is the level of contingency that would result from utilizing a p50 confidence level?

b) Please provide a table that illustrates, for the test period, both the "as filed" in service additions for the DRP and the reduced in service additions for the DRP during the test period based on the lower contingency amount that results from using a p50 confidence level. Please estimate the reduced revenue requirement for each of the test years in relation to the p50 scenario.

c) Please list and describe all of the risks that OPG considered may contribute to increased costs for the DRP where the nature of the risk is such that if manifested the added cost would not be appropriately recovered from either OPG's contractors or from OPG's ratepayers, but rather absorbed by OPG directly.

Response

a) The level of contingency that would result from using a P50 confidence level is $1.4B (2015$) excluding interest and escalation. Please see L-4.3-2 AMPCO-70.

b) The total contingency for Unit 2 is $694.1M (Ex. D2-2-7, p. 7) which includes interest and escalation. This amount is included in the in-service amount of $4.8B for Unit 2 in 2020. As noted in part a), the amount of contingency for the four unit refurbishment at the P50 confidence level is $1.4B (2015$). The contingency amount for Unit 2 at the P50 confidence level is estimated by prorating the P50 and the P90 contingency estimates in the RQE and is therefore estimated to be $578M ($694.1M X ($1.4B/$1.7B)), including interest and escalation. Thus, the estimated revised in-service amount for Unit 2 in 2020 would be reduced by $116M ($694M-$578M) to $4,693M.

Please refer to the chart below for the revised in-service amounts:

Witness Panel: Darlington Refurbishment Program

Chart 1

	2017 ($M)	2018 ($M)	2019 ($M)	2020 ($M)	2021 ($M)
Filed Evidence – In-Service Additions [(1)]	374.4	8.9	0.0	4,809.2	0.4
Estimated In-Service Additions with Unit 2 P50 Contingency	374.4	8.9	0.0	4,693	0.4

Note (1) – Please see Ex. D2-2-10, Table 5.

OPG estimates that in-service additions of $4,693M in 2020 and associated reductions in capital expenditures leading up to that point would reduce the 2017-2021 revenue requirement by approximately $18M, as follows: $2M increase in 2019, $9M decrease in 2020 and $11M decrease in 2021. These estimated amounts were derived in the manner shown in L-04.3-2 AMPCO-77.

c) There are no risks that OPG considered at the program or project level that would not appropriately be recoverable through the CRVA.

AMPCO Interrogatory #70

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

Interrogatory

Reference:
Ref: Exhibit D2-2-7 Page 5-6

Preamble: OPG indicates that its Monte Carlo simulation provides decision makers with a range of possible outcomes and the probabilities that those outcomes will occur to certain confidence levels.

a) Please provide the confidence levels tested and the contingency amounts at these confidence levels.

b) Were P10, P50 and P70 confidence levels tested? If not, please provide the total cost of the four units and the average cost per unit at low confidence (10%), medium confidence (50%), medium high confidence (70%) and high confidence (90%).

Response

a) The Monte Carlo Simulation generated a cumulative distribution from P0 to P99.9. Select high probability risks were added to contingency during final reviews by Management. Please refer to Ex. L-04.3-15 SEC-027 for calculated contingency amounts in 5% increments ranging from 70% to 95% and also the contingency amount at 99%.

b) Please refer to the chart below. Contingency amounts are in $2015 and exclude interest and escalation. Total costs for the Darlington Refurbishment Program include interest and escalation. Simplifying assumptions were made in order to generate the total DRP costs.

Chart 1

Reference Confidence Level (%)	Total DRP Contingency Estimate At Reference Confidence Level (2015$B)	Total Project Cost [(1)] $B
P10	1.2	12.1
P50	1.4	12.4
P70	1.5	12.6

Witness Panel: Darlington Refurbishment Program

P90	1.7	12.8

(1) A factor has been applied to approximate the impact of reduced escalation and interest resulting from reduced contingency expenditures

Board Staff Interrogatory #55

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

Interrogatory

Reference:
Ref: Exh D2-2-8, Attachment 1 page 2

The DRP BCS states that "[t]he current target date to start the Refurbishment outage on Unit 2 is October 2016, prior to which management will complete a Unit 2 Execution estimate and seek further authorization and funding approval from the Board."

a) Please provide an update on the current start date for Unit 2

b) On page 23 of Attachment 1 to Ex. D2-2-8, the overview identifies that funding release 5b is scheduled for mid-2016. Was the Unit 2 Execution estimate completed and approved by the Board (Release 5b)? If so, please provide a copy.

Response

a) The current start date for Unit 2 remains October 15, 2016.

b) The Unit 2 Execution Estimate was completed and approved by the Board of Directors in August 2016. Please see Attachment 1 (Attachment 1 is marked confidential but OPG has determined it is non-confidential in its entirety).

August 12, 2016

DARLINGTON REFURBISHMENT - UNIT 2 EXECUTION

DECISION REQUIRED

The purpose of this memo is to provide a summary of the Darlington Refurbishment Program (DRP) Unit 2 cost and schedule estimates and key risks, and request approval for:

- Commencement of Unit 2 refurbishment in October 2016;
- The Unit 2 budget and schedule; and
- Release of additional funds in the amount of $2,876 Million, which includes $635 Million of contingency to execute the Unit 2 refurbishment.

ISSUE

In November 2015, OPG's Board of Directors approved the Release Quality Estimate (RQE), representing the overall 4-unit high confidence budget, schedule and release strategy to refurbish the four Darlington units.

Since that time, as management continued with the detailed planning and preparations for execution of the Unit 2 refurbishment, management has further developed the Unit 2 cost estimate and schedule and performed an updated risk analyses. Consistent with the approved funding strategy, Management is now requesting Board approval to proceed with the refurbishment of Unit 2 starting in October 2016 and to release the required funding to complete the refurbishment of Unit 2.

ANALYSIS

The current Unit 2 Execution Estimate (U2EE) is an update to RQE, which takes into consideration additional planning and work executed over the past 8 months, and incorporates the following:

- Revised estimates for scope that has progressed from a Class V or IV estimate to a Class III and II.
- Updated base cost estimates to reflect the development of comprehensive execution work packages and an enhanced understanding of the cost to perform the work, which is a direct outcome of estimate development and actual field work.
- Updated risk profile, and resultant contingency required for residual risks.
- Assessment of the actual costs to date and the estimate-to-complete (ETC) for all work packages.
- Review of the cash flow, including interest and escalation requirements, against the current schedule.

All of these items have been compiled into the current U2EE, as well as a review of the 4-unit overall cost estimate. The following sections summarize this analysis.

1. Management is adequately prepared and ready to proceed with the execution of Unit 2.

Management has provided an update on the status of the DRP to the Darlington Refurbishment Committee (DRC) at its August 11, 2016 meeting. In the report, Management indicates that the DRP remains on track to commence the execution and refurbishment of Unit 2 in October 2016.

Management is executing all pre-requisite projects in order to be ready to commence the refurbishment of Unit 2. Some of these projects are currently behind schedule; however, all critical projects required to enable the start of refurbishment are expected to be complete prior to their need date.

Management is focused on applying lessons learned from the Ready to Execute (RTE) test period, where processes for managing in-plant execution of work were tested and refined, to increase the productivity and schedule compliance of all work being performed in the field. Although many of the pre-requisite projects are not required for the start of refurbishment, management remains focused on the delivery of these projects as quickly as reasonably feasible while managing safety, quality, and cost.

2. Unit 2 scope has been clearly specified, engineering is complete, and comprehensive work plans are in place.

Since RQE, there have been no major scope changes to the DRP.

Detailed design engineering is substantially complete for all field work to be executed during Unit 2.

Management has focused on the completion of Phase 1 Comprehensive Work Packages (CWPs) that describe the details of the work to be executed in the field. The CWPs for all the project bundles are now essentially complete with a few minor exceptions. Completion of the CWPs took an additional month beyond what was planned due primarily to station interfaces for the Re-tube & Feeder Replacement (RFR) project not being fully understood by the vendor; however, they have been completed with quality, and provide the necessary information to complete field execution of all project work.

3. Regulatory certainty has been achieved.

The Integrated Implementation Plan (IIP) identifies the regulatory scope required to be completed during the refurbishment period, including work being done by the station.

The 51 Integrated Implementation Plan (IIP) tasks that have been committed to the Canadian Nuclear Safety Commission (CNSC) for completion in 2016 are on track. To date, 17 items are complete and field work for an additional 10 is complete with document closeout underway.

OPG has received all remaining regulatory approvals from the CNSC required to support the start of Unit 2 refurbishment. No additional approvals are required to commence refurbishment of Unit 2.

OPG has committed in the IIP to have the 3rd Emergency Power Generator (EPG) and Containment Filtered Venting System (CFVS) in-service prior to the start of the Unit 2 refurbishment, and continues to demonstrate to the CNSC that completion of these projects is a high priority. The CNSC is being kept informed of the project complexities, including commissioning and site integration of the 3rd EPG, and is aware of the potential risk to the in-service date. In the event that the IIP commitment cannot be achieved, the IIP Change Control Process will be initiated.

The regulatory hold-points for returning the units to service, after refurbishment, have been agreed to with the CNSC. Development of a decision and escalation protocol with the CNSC, to ensure scope and schedule commitments are effectively managed, is being considered.

4. The Unit 2 high confidence schedule duration, consistent with RQE, remains at 40 months; the 4-unit schedule remains at 112 months.

The Unit 2 high confidence schedule duration of 40 months remains consistent with RQE.

The only significant change to the high confidence 4-unit schedule since RQE was the de-lapping of Unit 3 from Unit 2, to be consistent with the Province's Long Term Energy Plan (LTEP) requirement to complete Unit 2 prior to commencing any subsequent units.

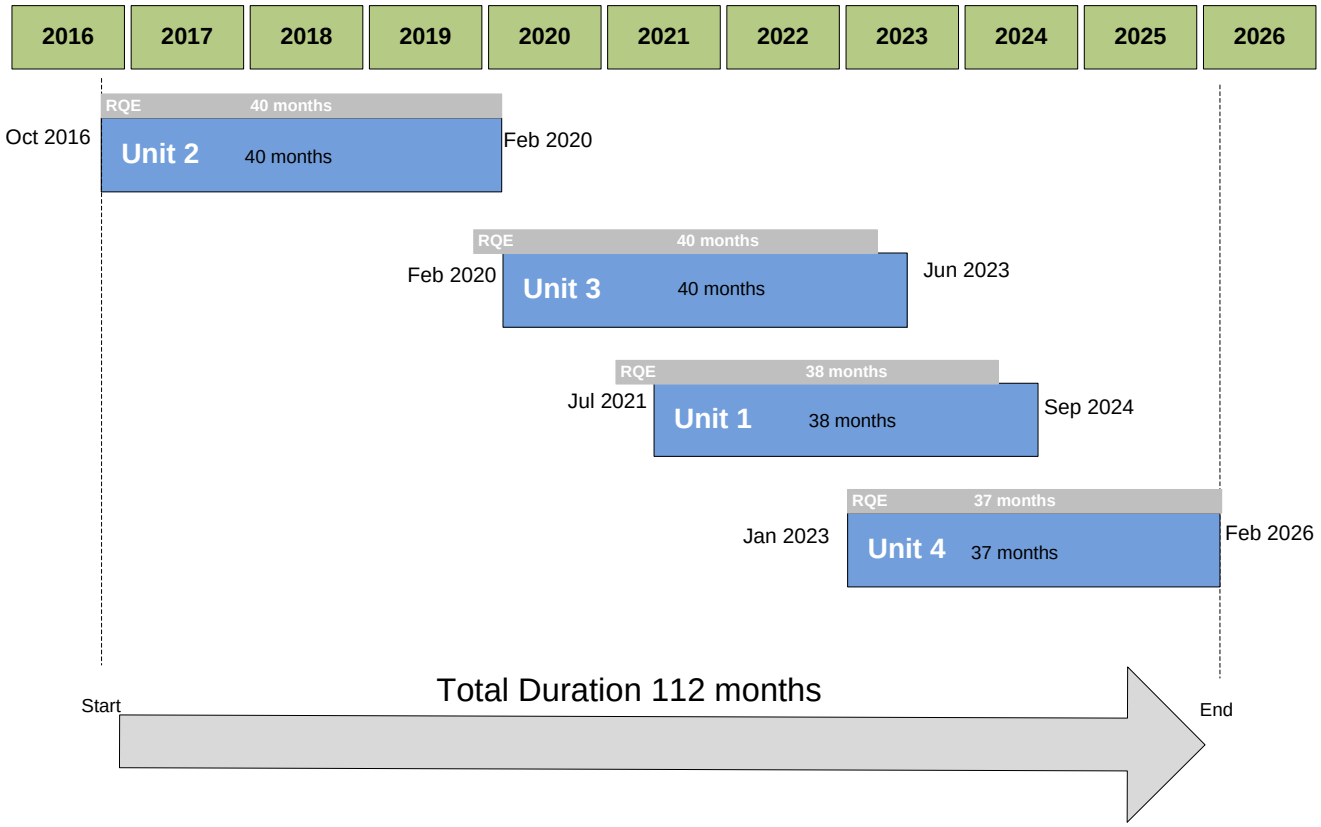
The overall 4-unit high confidence schedule duration remains at 112 months per Table 1 below:

Table 1: Comparison of 4-Unit High Confidence Schedule (RQE vs. U2EE)

Unit	High Confidence at RQE			High Confidence (U2EE)			Variance From RQE
	Start	Finish	Duration (Months)	Start	Finish	Duration (Months)	
Unit 2	15-Oct-16	15-Feb-20	40	15-Oct-16	15-Feb-20	40	0
Unit 3	15-Dec-19	15-Apr-23	40	15-Feb-20	15-June-23	40	0
Unit 1	15-Apr-21	15-Jun-24	38	15-Jul-21	15-Sep-24	38	0
Unit 4	15-Jan-23	15-Feb-26	37	15-Jan-23	15-Feb-26	37	0
4 Units	**15-Oct-16**	**15-Feb-26**	**112**	**15-Oct-16**	**15-Feb-26**	**112**	

The U2EE High Confidence schedule and comparison to RQE as noted above in Table 2, is illustrated in the following Figure A:

Figure A: Refurbishment 4-Unit High Confidence Project Schedule



High Confidence durations are shown above. Unit 2 project performance will however get managed against an aggressive planned outage duration (working schedule) of 35 months. Since RQE, detailed schedules have been further developed, and have resulted in a minor 10 day increase for activities within the removal and installation series. A copy of the Level 1 schedule is included as Appendix 1.

The planned outage duration is based on a detailed evaluation of the schedule risks for each segment of the critical path, including discrete technical risks such as a Primary Heat Transport pump motor failure during defueling and requirements for Primary Heat Transport system flush and Hot Conditioning on unit startup. Management is, and will continue to, look for opportunities to reduce schedule durations.

The high confidence schedule is the basis for the Release Quality Estimate, which is the program level control budget and this schedule is the schedule from which project success will be assessed. Management will report on the performance of the DRP to the DRC on a quarterly basis, against both the Unit 2 working schedule and the high confidence schedule, with clear indications of project status and contingency utilization.

Final detailed schedule reviews are now underway in order to ensure all potential interferences between vendors are eliminated and labour resources are effectively balanced. The final baseline Unit 2 working schedule will be issued in mid September. This schedule will contain over 75,000 tasks for OPG and the vendors.

5. A detailed review of Unit 2 execution phase risks and contingencies is now complete.

Management has finalized its review of schedule and cost risks. Since the RQE analysis in October, a reduction in cost estimating uncertainty contingency requirements has been observed, which reflects the progression of project estimates and the integration of lessons learned from the Ready to Execute test period.

As shown in Figure B, the percentage of project costs where the estimate is at Class III or better has increased since RQE from 94% to 98%. For those projects not yet at Class III, adequate contingency has been carried to reflect the remaining uncertainty with these projects.

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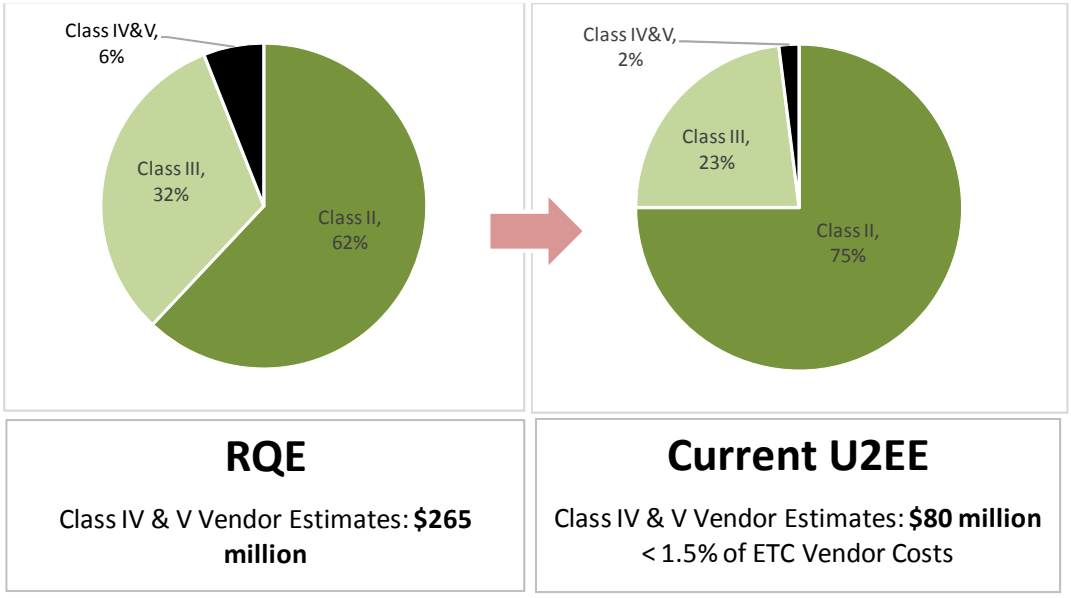
Figure B: Estimate Classification Summary



(1) Figures above represent 4-Unit estimates. Actions are already underway to finalize these estimates to Class III or II prior to work release and execution.

The contingency analysis summarized in Table 2 was derived through a detailed analysis and modeling of the current risk profile across the entire program. The assessed contingency is based on the residual risks contained within the DRP and excludes the $61 Million of contingency allocated since RQE. In addition to the continuous monitoring of contingency draw-downs, a thorough assessment of the risk profile and impact on contingency will be performed quarterly.

The outcome of Management's contingency analysis yielded that, at a high confidence, the estimate should include $2,006 Million of contingency for the DRP, including $677 Million for Unit 2.

There is no significant change to the anticipated contingency calculated at RQE. For clarity, RQE consisted of $1,706 Million of contingency in 2015 dollars, plus $300 Million of inflation and interest,

which totals $2,006 Million. Contingency on Unit 3 has increased due to a shift of risks from Unit 2 to Unit 3 related to the Turbine Controls installation on Unit 3.

Below, in Table 3, is a breakdown of the $2,006 Million of contingency, by unit and contingency type.

Table 2: 4-Unit Contingency Summary

Unit	RQE ($M)	Current U2EE ($M)	Changes since RQE ($M)
Campus Plan Program Total, *plus $41mil of add'l contingency included with projects	32	18	-14
Unit 2 Total	690	677	-13
Unit 3 Total	516	557	41
Unit 1 Total	419	409	-10
Unit 4 Total	350	345	-5
4-Unit Contingency ($M)	**2,006**	**2,006**	**0**

Table 3: 4-Unit Contingency Summary by Type

Level	Contingency Type	Updated 4-Unit Contingency ($M)	Facility and SIO Projects ($M)	U2 ($M)	U3 ($M)	U1 ($M)	U4 ($M)
PROJECT	**Project Discrete Risks** - Specific to Bundles	658	18	216	177	135	112
	Project Level Estimating Uncertainty - Project Bundles and Resources	192	-	67	54	38	33
	Critical Path Schedule Contingency - for the Working Schedule Duration	438	-	149	122	91	76
	Critical Path Schedule Contingency - to High Confidence Duration	192	-	66	55	38	33
PROGRAM	**Program Discrete Risks** - Functional Risks	458	-	153	129	95	81
	Program Level Estimating Uncertainty - Functional Resources	68	-	26	20	12	10
	Total Contingency $M	**2,006**	**18**	**677**	**557**	**409**	**345**

The contingency of $2,006 Million represents 23% of the Execution Phase Estimate-to-Complete cost of $8,300 Million, or 32% of the external vendors' estimate of $6,000 Million. With 98% of vendor cost estimates well defined at Class III or better, Management believes that the contingency amount is sufficient.

4.0 CONTINGENCY AMOUNTS

4.1 DRP Contingency Amounts

The detailed evaluation of cost and schedule uncertainties and discrete risks, as well as contingent work across each project and the entire DRP, enabled OPG to determine the appropriate amount of contingency to include in the RQE. The outcome of this analysis yielded that, at a high confidence level, the RQE should include $1.7B (2015$) of contingency, which is comprised of project contingency and program contingency amounts.

Project contingency is derived from the individual discrete risks and cost uncertainties managed by project directors. Project risks have a localized project impact if they occur. *Program contingency* is derived from overarching Program risks managed at the executive level that could influence the overall Program's objectives, may require Program-wide response and may have a global impact on the Program.

For a project of the size and duration of the DRP, there are a number of low probability high consequence events that could impact the Program and that are outside of the contingency determined for the Program. Due to the low probability, these items would not contribute sufficiently to a probabilistic assessment used in establishing contingency. Management has compiled a list of such events that could occur, and are beyond the ability of the project to manage or mitigate. 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 Program. 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.

A breakdown of the DRP contingency amounts is set out below in Chart 1.

Chart 1

Unit Project and Program Contingency

Project	Estimate Class[4]	Project Contingency ($M)	Program Contingency ($M)	Total Contingency ($M)
RFR	2	236	381	617
Turbine Generator	2-3	195	23	218
Steam Generators	2	20	0	20
Fuel Handling and Defueling	3	25	38	63
Balance of Plant	3-5	230	0	230
F&IP and SIO	1-3	42	34	76
Project Execution and Operations and Maintenance	N/A	58	222	280
Unallocated Program Contingency	N/A	0	202	202
Total Contingency ($B)	**-**	**$0.8B**	**$0.9B**	**$1.7B**

Authorization of the use of contingency funds is strictly controlled through the Change Control Board ("CCB"), which requires an explanation of the risk or uncertainty element that has been realized and a robust approval model that requires escalation for use of any contingency funds. Additional information regarding the CCB is found under Ex. D2-2-9, Attachment 1.

4.2 Unit 2 Contingency Amounts

Of the total $1.7B of DRP contingency, $694.1M is attributed specifically to the Unit 2 refurbishment and forms part of the forecast cost of Unit 2 refurbishment. This includes $339.0M of project level contingency and $355.1M of Program level contingency, which together represent 14.4 per cent (7.0 per cent and 7.4 per cent respectively) of the total Unit 2 in-service additions for 2020.

Allocation of the total contingency across the four units was based on 'risk exposure windows', which refers to the anticipated timing for when the risks or uncertainties would be realized and associated contingency costs would be incurred. In allocating contingency to

[4] See section 2 of Ex. D2-2-8 for further information on estimate classification.

Unit 2, OPG assumed, based on industry experience, that the first unit will realize more risks than subsequent units and that lessons learned will be incorporated for subsequent units to avoid recurrence. Accordingly, approximately 40 per cent of the total DRP contingency amount was allocated to Unit 2, with the expectation that the amount of contingency required for each subsequent unit would be less than the one prior to it. A breakdown of the specific components of the $694.1M of contingency for Unit 2 is provided in Chart 2, below.

Chart 2

Breakdown of Unit 2 Contingency Amounts

Program Element	**Contingency ($M)**
RFR	117.9
Turbine Generator	81.7
Fuel Handling/Defueling	10.5
Steam Generator	8.2
Balance of Plant	96.6
Subtotal Major Work Bundles	**314.9**
Project Execution	3.6
Contract Management	0.6
Engineering	2.7
Managed System Oversight	0.4
Planning and Controls	0.8
Nuclear Safety	-
Program Fees and Other Supports	6.1
Supply Chain	0.9
Work Control	1.0
Operations and Maintenance	7.9
Subtotal Functions	**24.1**
Subtotal Project Contingency	**339.0**
Program Contingency	355.1
Total Contingency	**694.1**

As set out in section 5.6 of Ex. H1-1-1, OPG proposes that the variance between actual costs and firm financial commitments and those forecast costs and firm financial commitments underpinning the 2017-2021 annual nuclear revenue requirement approved by the OEB in this proceeding be recorded in the Capacity Refurbishment Variance Account ("CRVA"). The nuclear revenue requirement includes DRP in-service additions. In the event of any unallocated contingency at the point of in-service, the favourable revenue requirement amount will be recorded in the CRVA and returned to ratepayers in a future test period.

4.0 UNIT 2 COST BREAKDOWN

Based on the RQE, OPG is requesting an in-service addition of $4,799.8M in 2020 for the return to service of a refurbished Unit 2. A detailed breakdown of the components of this estimate is provided in Chart 4 and Figure 1, below. While actual costs may ultimately be different than forecast for individual line items shown in Figure 1, OPG will complete the Unit 2 refurbishment and return Unit 2 to service within the total envelope budgeted for this purpose, being approximately $4.8B. To the extent of any deviations, the overall DRP will still be completed within the four unit estimate of $12.8B. As such, with respect to cost, OPG's success on refurbishing and returning Unit 2 to service should be measured at the total envelope level. It is also important to recognize that the total cost of refurbishing and returning all four units to service will not be a simple multiple of the Unit 2 refurbishment cost. Rather, there are additional costs associated with Unit 2 being the first unit to be refurbished, which will not be incurred in refurbishing the remaining units. In particular, the Unit 2 refurbishment cost includes all Definition Phase costs and common costs[4] (unless such costs are only attributable to units other than Unit 2). In addition, the Unit 2 refurbishment Execution Phase includes more scope than refurbishment execution for each of the remaining units.

As set out in section 5.6 of Ex. H1-1-1, in accordance with O. Reg. 53/05 the variance between actual costs and firm financial commitments and those forecast costs and firm financial commitments underpinning the 2017-2021 annual nuclear revenue requirements approved by the OEB in this proceeding will be recorded in the CRVA. The nuclear revenue requirement includes the revenue requirement impact of DRP in-service additions. Variances in nuclear revenue requirement resulting from variances in DRP in-service additions (as well as DRP OM&A expenses) will be recorded in the CRVA. The balances in the CRVA will be brought forward for review and approval by the OEB in a future proceeding.

[4] Common costs are costs of completing 'common' work that is required for two or more units.

Chart 4

Breakdown of the 2020 $4.8B in service additions ($M)

Bundle / Category	2020 I/S	%
Retube & Feeder Replacement	1,834.8	38%
Turbine Generator	258.6	5%
Fuel Handling / Defueling	132.6	3%
Steam Generator	56.3	1%
Balance of Plant	480.9	10%
Subtotal Bundles [1]	**2,763.2**	**58%**
Project Execution	165.4	3%
Contract Management	31.0	1%
Engineering	163.6	3%
Managed Systems Oversight	31.6	1%
Planning & Controls	133.3	3%
Nuclear Safety	70.2	1%
Program Fees & Other Support	163.8	3%
Supply Chain	55.2	1%
Work Control	36.1	1%
Operations & Maintenance	336.9	7%
Subtotal Functions	**1,187.1**	**25%**
Early Release 3	144.9	3%
Early Release 4	10.5	0%
Subtotal Early Release Funds [2]	**155.4**	**3%**
Subtotal Before Contingency	**4,105.7**	**86%**
Contingency	694.1	14%
Grand Total	**4,799.8**	**100%**

Notes:

(1) U2 in-service additions include minor close-out activities up to August 2020.

(2) There is an additional $0.4M in-service addition in 2021.

Footnotes:

[1] Escalation and interest are included in the bundle/category in-service amounts.

[2] Early release funds are costs that were associated with the preliminary planning phase of the Definition Phase. During preliminary planning, the DRP program structure was not yet in place and this early work was not associated with major work bundles or OPG functional support.

REDACTED
PUBLIC

ONTARIO ENERGY BOARD

FILE NO.:	**EB-2016-0152**	**Ontario Power Generation Inc.**
VOLUME:	**2**	**REDACTED - PUBLIC**
DATE:	**February 28, 2017**	
BEFORE:	**Christine Long**	**Presiding Member and Vice-Chair**
	Ellen Fry	**Member**
	Cathy Spoel	**Member**

back, the D20 facility had a budget with a contingency?

MR. REINER: Yes.

MR. MONDROW: And some portion, perhaps all the D20's facilities costs were actually allocated to unit 2 for the purposes of this application?

MR. REINER: No. Those costs -- so the 4.8 billion is a unit 2 cost, and then initially in the application, there was a cost identified for the early in-service, the facility and infrastructure and SAO projects, and it's in that number.

MR. MONDROW: Okay. And the contingency amount, I think it was 1.7 million overall for the project, 40 percent of which was included in this application.

MR. REINER: Yes.

MR. MONDROW: I think I asked you the wrong question. Thank you for your clarification. So the $677.5 million of contingency, that is the current contingency amount before this Hearing Panel. That's -- is that just a unit 2 contingency, or is that -- that's just a unit 2 --

MR. REINER: That is a unit 2 contingency, yes.

MR. MONDROW: So there is additional contingency before this Hearing Panel for approval other than the 677.5 because of the early in-service projects that haven't closed to rate base yet that you're going to close at the same time as unit 2?

MR. REINER: Yes. So whatever the actual costs are for those projects when they close, that will determine how much of that program-level contingency was actually

consumed for those projects.

MR. MONDROW: So if I look at the updated -- and we're going to do this at the end of my questions -- at the updated approvals requested, you have got revenue-requirement numbers for each year. Those numbers are net of the removal of the D20 facility from this application. Is that right?

MR. REINER: Yes.

MR. MONDROW: Those are the final numbers as of today that you're asking for approval?

MR. REINER: They are the final numbers as of today, yes.

MR. MONDROW: And "as of today" means after taking D20 out?

MR. REINER: After removing D20 storage from the application, yes.

MR. MONDROW: Good enough. Thank you.

Mr. Reiner, I think the evidence now reveals that, in respect of the early in-service projects, there has been some schedule delay on some of the projects.

MR. REINER: Yes.

MR. MONDROW: We'll get into details with panel 1B, but that is correct; right?

MR. REINER: That is correct.

MR. MONDROW: Okay. And do any of those projects impact the critical path for the unit 2 refurbishment?

MR. REINER: Those projects do not. There were commitments that were made in our integrated implementation

UNDERTAKING J3.1

Undertaking

To provide the 2017 Corporate Scorecard.

Response

The 2017 Corporate Scorecard was approved by the OPG board of directors on November 10, 2016, and communicated internally January 2017. The witness indicated in error that it had not yet been approved by the board of directors.

A copy of the 2017 Corporate Scorecard is provided in Attachment 1.

Corporate 2017 Balanced Scorecard				
	Key Performance Indicators	**Threshold**	**Business Plan**	**Stretch Target**
10%	**Social Licence** - Through building and maintaining public trust, positive indigenous relations and an engaged workforce			
10%	**AIR**: All Injury rate	0.49	0.37	0.31
	Safety focus areas: o Continuing to develop and implement materials, initiatives and model behaviours that will progress and imbed the iCare Enough to Act for Safety culture o Enhance field oversight to monitor compliance to our safety initiatives and programs including contractors, with a focus on the Darlington Refurbishment Project o Continue to advance the Total Health culture in OPG through the implementation and execution of initiatives that will promote employee attendance, mental health and the adoption of healthy behaviours and lifestyles	As determined by CEO		
	No significant events that impact OPG's reputation			
35%	**Financial Strength** - Through regulated asset revenue and expansion of our core business, risk management, commercial focus and financial flexibility			
20%	**EBT**, excl. nuclear waste management segment ($M)	675	875	1075
15%	**Operating OM&A Expenses** – Total OPG ($M)	2675	2550	2425
15%	**Operational Excellence** - Through efficiencies and optimized asset management in a safe and environmentally responsible manner			
15%	**Production** – Total OPG adjusted for SBG (TWh)	70.3	72.4	74.6
40%	**Project Excellence** - Through delivering project results on time and on budget and industry leading project management			
10%	**Refurbishment Project Cost** – 2017 actual expenditures ($M) as a percentage of approved 2017 budget	100%	97.5%	95%
5%	**Refurbishment Unit 2 Critical Path Execution** – Commencement of Feeder cabinet removal (Milestone #A1012)	5-Aug-17	26-Jul-17	28-Jun-17
10%	**Refurbishment Unit 2 Critical Path Execution** - Progress of critical path on December 31, 2017	All Bellows Severed (Milestone #A1127)	50% of End Fittings Removed (Milestone #A1056)	400 Pressure Tubes Removed (Milestone #A1058)
5%	**Pump Generating Station** In-Service and within budget	1-Jun-17	1-Apr-17	1-Mar-17
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
5%	**Total In-service Capital -** not including major projects otherwise on scorecard (DRP, [redacted] and PGS)	$578 +/-10% to +/-15%	$578 +/- 3% to +/-10%	$578 to +/- 3%
100%				

These measures form the basis on which our overall Corporate performance will be assessed, but the scores against these measures and overall Corporate Score are not absolute. The Board and President reserve the right to determine the Corporate Score. In exercising their discretion, the Board and President may choose to make adjustments to the Corporate Score or individual scorecard items.

AMPCO Interrogatory #44

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

Interrogatory

Reference:
Ref: D2-2-3 Attachment 1 Page 2

Preamble: The Summary of EPC Contract for RFR with SNC/Aecon JV states that the contractor and OPG developed an execution phase plan that included a cost estimate, schedules and a risk register for the execution phase. The evidence states "The cost and schedule estimates developed by the contractor were subject to a P50 analysis and the P50 analysis was the basis for establishing the target cost and target schedule under the agreement".

a) Please provide the risk register.

b) Please explain why a P50 analysis was selected.

c) Were higher confidence levels tested? If yes, please provide the results. If not, why not?

d) Please explain how the contractor's fixed fee was calculated based on the target cost.

Response

a) Please see Ex. D2-2-3 Attachment 6, the Retube and Feeder Replacement (RFR) contract; the risk register used for the purposes of developing the execution phase plan is Exhibit 3.5(g) to the contract.

b) P50 means that, all other things being equal, there is an equal probability of the final result being better than or worse than the calculated outcome. It would not be appropriate, when negotiating a contract, for either party to aim for higher than P50, as that would imply that one party was attempting to achieve greater certainty at the expense of the other party taking on more risks. P50 is also a standard analysis based on AACE International Recommended Practice No. 18R-97. A P50 analysis was established by OPG prior to the RFP process and agreed to by the contractor during the RFR negotiations.

c) Yes, higher confidence levels were tested, particularly for schedule confidence. The results, as expected, were that the target price would have increased, as higher confidence would have required the contractor to take accountability for a greater number

of risks, some of which they were not in the best position to manage. Please see Attachment 1, Darlington RFR Class II Estimate Monte Carlo Model Report, for more information.

d) Please see Attachment 1, Appendix I.

Darlington RFR Class II Estimate
Monte Carlo Model Report

NK38-REP-09701-10320-R000
2015-10-02

Order Number: N/A
Other Reference Number:

OPG Confidential

Prepared By: Steve Wong Oct. 2, 2015
Steve Wong Date
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Darlington RFR

Prepared By: For: Adam Cziraky. John Wannamaker October 2, 2015
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SLN-Aecon J.V.

Approved By: Oct 5/15
Roy Brown Date
Senior Director
Darlington RFR

Table of Contents

Executive Summary

As part of the Darlington RFR Class II estimate, the SLN-AECON Joint Venture (JV) is developing the Execution Phase base schedule estimate, cost estimate and risk register. OPG is developing the contingency duration and cost in a Monte Carlo Model using an integrated cost and schedule approach. In parallel with the OPG Monte Carlo Model, a similar model has been developed by JV. OPG contingency model is based on Section 3.5 of the RFR contract to determine the cost and schedule contingency amounts.

This report describes the contingency development work done by OPG. Model Inputs, Processing and Outputs are described and analyzed. The Monte Carlo Model calculations are performed using a Monte Carlo simulation method and Oracle's Primavera Risk Analysis software tool.

Model inputs consist of uncertainties and risks associated with project cost and schedule. The inputs were developed as part of the RFR Class II Estimate JV/OPG collaborative process by JV and OPG subject matter experts. Cost and Schedule uncertainty ranges are input to the model as 3-point estimates and risks are entered with probability and consequence values which are used in the Monte Carlo simulation to calculate project contingency at a P50 level. Identified schedule risks are separated into global risks, which affect multiple tasks or the entire unit, and mapped risks, which are linked to specific tasks.

The final P50 model results for cost and schedule are presented in the following table:

	Base ($M)	Rework ($M)	Contingency (adj.) ($M)	Execution Phase Target Cost ($M)	Fixed Fee ($M)	Target Cost + Fixed Fee* ($M)	Contingency Duration [Days]
Unit 2	[redacted]						
Unit 3							
Unit 1							
Unit 4							

Note: * Escalation not included.

The Cost Contingency has an adjustment of the Schedule Driven Rework Cost per individual unit, as results of the Rework Schedule Risks (A La Carte Rework Risks).

There are several project factors which result in reduced calculated contingency values. These include:

- Significant front-end planning completed in the definition phase
- Contractual arrangements for internal JV and OPG risks not included in the risk model
- Contract allowances for rework, spot OT and cost escalation not included in the risk model

1.0 INTRODUCTION

The RFR contractor, SNC-LAVALIN NUCLEAR INC. and AECON CONSTRUCTION GROUP INC. acting jointly and doing business as a contractual joint venture known as the "SLN-AECON Joint Venture" (JV), is responsible for the development of an AACE standard Class II estimate for the execution of RFR work during the Darlington nuclear generating station (DNGS) refurbishment.

Exhibit 3.5 Section 16 of the Agreement between JV and OPG specifies that the schedule contingency amount (in durations) will be developed in a Monte Carlo model that will be managed by OPG's authorized representative or an independent third party, and the output will be reviewed and agreed by JV and OPG to establish the required contingency for a 50% confidence level in achieving completion of the work within the relevant Execution Phase Schedule.

Exhibit 3.5 Section 17 of the Agreement between JV and OPG also specifies that the cost contingency amount (in dollar values) will be developed in a Monte Carlo model that will be managed by OPG's authorized representative or an independent third party, and the output will be reviewed and agreed by JV and OPG to establish the required contingency for a 50% confidence level in achieving completion of the work within the relevant Execution Phase Cost Estimate.

OPG has developed a Monte Carlo Model with Primavera Risk Analysis software which uses an integrated cost and schedule approach to determine the required contingency for schedule and the required contingency for cost. See 3.0 below.

In parallel with OPG, JV has developed the JV Risk Models as a reference for comparison purpose. The JV Risk Model is using Acumen Risk and @Risk software applications to develop the schedule risk model and the cost risk model respectively, according to JV's Risk Management Plan [5].

Both JV Risk Models and OPG Monte Carlo Model are following Exhibit 3.5 to determine the cost and schedule contingency amounts using a Monte Carlo sampling method.

2.0 SCOPE

The scope of this report is to describe the Inputs, Processing and Outputs of the OPG Monte Carlo Model (hereinafter Monte Carlo Model). Results are presented for cost and schedule, including probabilistic cash flow. These results are then analyzed and compared to other relevant projects.

3.0 SOFTWARE

Oracle's Primavera Risk Analysis software (previously known as Pertmaster) is a tool that helps model risks and performs analysis of cost and schedule impacts. By

- Opportunities are identified and analyzed with a goal to implement enhancement actions, once they have been approved to improve the chance of success of the project.

- Finally, the risks in the Risk Register and the schedule uncertainties and cost uncertainties have been confirmed and validated that they are included in the Monte Carlo simulation to derive the Contingency for Schedule and Cost of the Project.

7.2 Indirect Cost vs Direct Cost

The following table shows calculated Ratios of Indirect Cost vs Direct Cost in the Base and the P50 Cost. The results confirm that the risks and uncertainties have higher impacts on Direct Cost as on Indirect Cost.

Table 5 - Indirect / Direct Cost Ratios

	Base Indirect/Direct Cost Ratio	P50 Indirect/Direct Cost Ratio
Unit 2	[redacted]	
Unit 3		
Unit 1		
Unit 4		

7.3 P90

When examining the Schedule Duration output, it is observed that the P90 Schedule Duration is very close to P50 (average difference of approximately 35 days per unit, that is a 3% of the P50 durations, Figure 1). This indicates that the spread is very narrow, meaning the worst case durations may be overly aggressive, or overly optimistic, and the consequences and probabilities may be too narrow.

However, due to contractual arrangements, risks are transferred to OPG internal or transferred to JV internal. For example, Excusable Delay is a risk in OPG Risk Register, and Defective Work is a risk in JV Internal Risk Register. Some of these excluded risks may have the extreme worst case impacts which will not be shown in the Monte Carlo Model.

Figure 1 - Comparison of Base, P50 and P90 Schedule Duration

7.4 Uncertainty/Risk Split

The following table shows calculated Uncertainty/Risk Contingency ratios for each unit. On average the Uncertainty to Risk ratio is approximately 2.05 for cost and 2.4 for schedule.

Table 6 - Cost and Schedule Duration Uncertainty/Risk Ratios

	Cost Uncertainty/Risk Ratio	Schedule Uncertainty/Risk Ratio
Unit 2		
Unit 3		
Unit 1		
Unit 4		
Overall		

The Uncertainty component of the contingency calculation is significantly higher than the risk component. This is because the Best Case is used as Base, therefore the uncertainty makes up a higher portion when compared to risk, as the portion from Best Case to Most Likely is included as part of the uncertainty contingency. As the requirement of the Class 2 Estimate and Contingency Determination, JV and

OPG SMEs took multiple steps to ensure that no rework and no contingency were embedded in the Base.

7.5 Schedule Driven Rework Cost

The 3% Rework Cost is not included in the Monte Carlo Model. It is calculated separately with the Base Cost of the Labour portion (All items in 1, 2, and 3) from the Class 2 Estimate, as per the Cost Summary Table (Table 7) of the Class II Milestone Report [2], with the exception of items 1.2, 1.5, 1.6, 1.7, 3.5.

Rework Schedule Risks (also known as A La Carte Rework Risks) were clearly identified and marked by SMEs and management. The schedule risks were mapped to individual tasks in the risk models. To avoid double counting, the contingency value will have to be adjusted to remove the cost impact of the Rework Schedule Risks.

The following formula shows how the Contingency Amount is adjusted:

$$Adj.\,Cost\ Contingency = P50\ Contingency - \sum Schedule\ Driven\ Rework\ Cost$$

The schedule driven rework cost is calculated using two versions of the risk models - a prime version without schedule driven rework risks and a version with rework risks included. The difference in P50 cost between these two models is the schedule driven rework cost. This cost is shown in Table 7.

Table 7 - Cost Impact of Schedule Driven Rework

	Schedule Driven Rework Cost [$ Millions]	P50 Contingency (Cost) [$ Millions]	Adjusted Cost Contingency [$ Millions]
Unit 2	[redacted]		
Unit 3			
Unit 1			
Unit 4			
Overall			

Table 8 – Target Cost & Fixed Fees

[$ Millions]	Base	Rework	Contingency (adjusted)	Execution Phase Target Cost	Fixed Fee	Subtotal*
Unit 2	[redacted]					
Unit 3						
Unit 1						
Unit 4						

Note: * Escalation not included.

7.6 Risks Excluded From Risk Registers

As per the Agreement, certain risks are not allowed in the Risk Registers as input to the Monte Carlo Model. Due to contractual arrangements, risks are transferred to OPG internal or transferred to JV internal. For example, Excusable Delay is a risk in OPG Risk Register, and Defective Work is a risk in JV Internal Risk Register. These two risks are examples of risks not included in the Monte Carlo Model.

This implies that less contingency will be shown in this Monte Carlo Model, as part of the contingency shall reside with OPG and part remain with the JV. To assess overall contingency, all OPG and JV contingency needs to be considered.

7.7 Impact of Separate Unit Risk Models

The Monte Carlo Model has the 4 units run independently. As some of the units undergoing refurbishment at the same time (overlap) and some of units planned to be refurbished in series, it may appear that these separate risk models do not simulate the big picture. However, the Monte Carlo Model of independent runs is based on the assumption that OPG will make the informed decisions to optimize the breaker open dates for the Subsequent Units. With this assumption, the Monte Carlo Model is portraying the big picture with the contingency profiles of the individual units, .

UNDERTAKING J2.7

Undertaking

Reference: Ex. D2-2-2, Attachment 2, p.21

To provide the major scope changes from when scope was finalized to present and any associated cost from these changes.

Response

There have been no major scope changes since the finalization of the approval of the Release Quality Estimate in November 2015 to the end of January 2017. Please refer to Ex. L-4.3-2 AMPCO-060 which indicates that since RQE to August 1, 2016, the number of Darlington Scope Requests had increased from 340 to 344, with no material impacts on cost and schedule. OPG confirms that since August 1, 2016, there have been no further material changes in scope and the number of DSRs remains at 344.

AMPCO Interrogatory #30

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

Interrogatory

Reference:
Ref: D2-2-1 Page 3, Chart 1 & D2-2-8 Page 7, Chart 3

Preamble: OPG provides a cost breakdown of the total Darlington Refurbishment Program (DRP) Release Quality Estimate (RQE) showing the Program components.

a) Please confirm that the RQE provides the baseline cost estimate for each major program component that OPG will compare all future costs to until 2026.

b) Please add a column to Chart 1 to reflect the component costs approved by OPG's Board of Directors in November 2013.

c) Based on OPG's review of other nuclear refurbishment projects and other megaprojects please compare OPG's Contingency of 16.4% of the RQE (excluding interest & escalation) to the Contingency % of these other projects.

d) Based on OPG's review of other nuclear refurbishment projects megaprojects, please compare OPG's Functional Costs of 21.3% of the RQE (excluding interest & escalation) to the % of Functional Costs of these other projects.

e) Please provide the original and current (revised) Safety Improvement Opportunities and Facilities & Infrastructure Projects budgets and show the % of costs for each that have been reclassified to date.

Response

a) OPG will compare future costs to the baseline established by the RQE on a total program basis. As indicated at Ex. D2-2-8 p. 8, while actual costs may ultimately be different than forecast for individual major program components, OPG's success on refurbishing and returning Unit 2 to service and the Program as a whole, should be measured at the total envelope level.

b) In November 2013, OPG's Board of Directors did not approve any costs equivalent to the costs shown in Ex. D2-2-1 p. 3. The Board of Directors' approval was limited to a release of $680M to continue the Definition Phase of the Darlington Refurbishment Program (DRP) and complete planned 2014 deliverables. The life cycle estimate prepared in

November 2013 in support of the release was a preliminary estimate and is not directly comparable to the RQE, as the scope of work was yet to be finalized. However, an approximation of the comparison is identified below:

Chart 1

	Ex. D-2-2-1 p.3 Chart 1		Nov. 2013 Total Cost Est (Release 4C)		
Program Component	**RQE Total Cost ($2015B)[1]**	**RQE Total Cost (%)**	**Total Cost Estimate Converted to 2015$[1]**	**Total Cost (%)**	**Total Cost Estimate (2013$)[2]**
Major Work Bundles	5.54	43	4.35	38	4.18
Safety Improvement Opportunities	0.20	2	0.11	1	0.11
Facilities & Infrastructure Projects	0.64	5	0.57	5	0.55
OPG Functional Support	2.23	17	2.16	19	2.08
Early Release Funds	0.11	1	0.12	1	0.12
Contingency	1.71	13	2.16	19	2.08
Interest & Escalation($B) [3]	2.37	19	1.97	17	2.20
Total Cost Estimate ($B) [3]	**12.8**	**100**	**11.32**	100	**11.32**

(1) All numbers are in 2015$ except for Interest and Escalation and the Total Cost Estimate
(2) All numbers are in 2013$ except for Interest and Escalation and the Total Cost Estimate
(3) Interest and Escalation and the Total Cost Estimate are in nominal dollars, i.e. a sum of the dollars of the year in which they are expended

c) OPG does not have enough detailed information on the costs estimates developed for such projects and the percentage of contingency in those estimates to do the comparison requested.

d) Please see Ex. L 4.3-1 Staff-45, part c).

e) The requested information for Facilities & Infrastructure Projects is shown in the following chart:

Witness Panel: Darlington Refurbishment Program

Chart 2

Project Title	Total Project Cost (M$)		% of costs Reclassified
	Original Full Release	EB-2016-0152	
Darlington OSB Refurbishment	53.0	62.7	100
DN Auxiliary Heating System	99.5	99.5	100
D2O Storage Facility	110.0	381.1	0
Water & Sewer Project	40.6	57.7	0
Darlington Energy Complex	105.4	105.4	0
R&FR Island Support Annex	40.7	40.7	0
Refurbishment Project Office	99.9	99.9	0
Electrical Power Distribution System	16.9	20.8	0
GM Office Facility	9.3	9.3	0
Vehicle Screening Facility	3.0	6.6	0

The requested information for the Safety Improvement Opportunities (SIO) projects is shown in the following chart. No SIO projects have been reclassified.

Chart 3

Project Title	Total Project Cost (M$)		% of costs Reclassified
	Original Release	EB-2016-0152	
Third Emergency Power Generator	88.2	120.4	0
Containment Filtered Venting System	80.6	80.3	0
Powerhouse Steam Venting System	5.6	5.6	0
Shield Tank Overpressure Protection	13.5	13.5	0
Emergency Service Water Buried Services	7.9	14.6	0

Note: The original release amounts for the SIO projects are based on the first approved Gate Progression Form or Change Control Form for Execution Phase.

Witness Panel: Darlington Refurbishment Program

UNDERTAKING JT1.19

Undertaking

FOR D2, 28, ATTACHMENT NUMBER 1, PAGE 29, TO PROVIDE A UNIT BREAKOUT OF THE CUMULATIVE SPEND

Response

Life-to-date costs to September 2016 are $2,900 million. The unit breakout is as follows:

Unit/Category	LTD Cost ($M)	Comments
Unit 2	1,881	Includes Definition Phase costs
Unit 3	26	Primarily Engineering for the T/G controls
Unit 1	0	
Unit 4	0	
Early In Service Projects	972	Including FIP/SIO
Project OM&A	20	
Total Life-to-Date	**2,900**	**To September 2016**

UNDERTAKING J2.1

Undertaking

To advise how much of the $2.2 billion has already been approved by the Ontario Energy Board for recovery.

Response

Chart 1 presents the amounts for the Definition Phase of DRP that have been approved by the OEB. Years 2010 – 2014 are actuals that were approved through payment amounts applications EB-2010-0008 and EB-2013-0321 and trued-up through clearance of the Capacity Refurbishment Variance Account (CRVA) in EB-2012-0002 and EB-2014-0370. The amounts for 2015 are the amounts approved on a forecast basis in EB-2013-0321. OPG has proposed to clear amounts recorded in the CRVA in 2015 in this Application[1].

Chart 1 - Amounts for Definition Phase DRP Approved by the OEB

($M)	2010	2011	2012	2013	2014	2015
OM&A	3.2	2.2	2.8	6.3	6.3	18.2
Capital In-service	0	0	5.0	99.2	43.5	143.4[2]

[1] For 2015 amounts to be cleared in the CRVA, see Ex. H1-1-1 Table 11.
[2] Does not includes amounts for the Darlington Operations Support Building and Darlington Auxiliary Heating System projects that were approved and subsequently reclassified to the Nuclear Operations portfolio. As discussed in Ex. L-9.1-1 Staff-210 p. 3, lines 21-27, the revenue requirement of these forecast amounts was effectively credited back to customers through the CRVA, as a result of their reclassification.

UNDERTAKING J2.6

Undertaking

For Ex. D2-2-10, Tables 2 and Table 3, to provide updated final in service and cost information, and to provide 2016 actuals for projects that are in-service.

Response

Attachments 1 and 2 provide the actual or current forecast in-service date and cost information for the projects in Ex. D2-2-10 Tables 2 and 3, together with the Final In-Service Date and Total Project Cost information as originally filed.

Numbers may not add due to rounding.

Attachment 1
Updated Ex. D2-2-10 Table 2 per J2.6
Projects ≥ $20M Total Project Cost [1]

Line No.	Facility	Project Name	Project Number	Category	Start Date	Final In-Service Date (As Filed)	Forecast/Actual In-Service Date[4] (Updated)	Total Project Cost (As Filed) ($M)	Forecast/Actual In-Service Amount ($M)[4] (Updated)	Forecast/Actual OM&A Amount ($M)[4] (Updated)	Forecast/Actual Total Project Cost ($M)[4] (Updated)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k) = (i) + (j)
		ONGOING PROJECTS FROM EB-2013-0321									
1	DN	Darlington Refurbishment - Unit Refurbishment - Unit 2	Various	Unit Refurb - Unit 2	2010	Feb-20	Feb-20 (F)	4,800.2	4800.2 (F)	0.0 (F)	4800.2 (F)
2	DN	R&FR - Tooling for Removal Activities	73112	Unit Refurb - Early In-service	Feb-12	May-16	Jun-16 (A)	87.0	88.1 (A)	0.0 (A)	88.1 (A)
3	DN	Heavy Water Storage Facility [2]	31555	F&IP	Nov-06	May-17	TBD	381.1	TBD	TBD	TBD
4	DN	Water & Sewer Project [2]	73802	F&IP	Jun-10	Nov-15	Oct-14 (A)	57.7	44.8 (A)	3.3 (A)	48.1 (A)
5	DN	Darlington Energy Complex [2]	73803	F&IP	Mar-10	Jul-13	Jun-13 (A)	105.4	83.0 (A)	0.0 (A)	83.0 (A)
6	DN	Retube Feeder Replacement Island Support Annex [2]	73810	F&IP	Sep-11	Oct-15	Mar-16 (A)	40.7	45.3 (A)	0.4 (A)	45.7 (A)
7	DN	Refurbishment Project Office [2]	73815	F&IP	Sep-11	Jan-16	Sep-15 (A)	99.9	104.8 (A)	0.0 (A)	104.8 (A)
8	DN	Electrical Power Distribution System [2]	73821	F&IP	Nov-10	Oct-15	Jul-15 (A)	20.8	20.1 (A)	0.2 (A)	20.3 (A)
9	DN	Third Emergency Power Generator [3]	73360	SIO	Apr-12	Oct-16	Mar-17 (F)	120.4	139.6 (F)	0.4 (A)	140.0 (F)
10	DN	Containment Filtered Venting System [3]	73365	SIO	Aug-13	Aug-16	Mar-17 (F)	80.3	101.0 (F)	0.0 (F)	101.0 (F)

Notes:
1 Projects with expenditures during Test Period OR In-Service Amounts in Bridge or Test Period.
2 For F&IP, columns (f) and (h) reflect approved Business Case Summary.
3 For SIO, columns (f) and (h) reflect approved Gate Progression Form or Change Control Form.
4 Forecast (F) and Actual (A) as at December 31, 2016 as noted in columns (g), (i), (j) and (k).

Numbers may not add due to rounding.

Attachment 2
Updated Ex. D2-2-10 Table 3 per J2.6
Projects $5M - $20M Total Project Cost [1]

Line No.	Facility	Project Name	Project Number	Category	Project Description	Start Date	Final In-Service Date (As Filed)	Forecast/Actual In-Service Date[4] (Updated)	Total Project Cost (As Filed) ($M)	Forecast/Actual In-Service Amount ($M)[4] (Updated)	Forecast/Actual OM&A Amount ($M)[4] (Updated)	Forecast/Actual Total Project Cost ($M)[4] (Updated)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l) = (j) + (k)
		ONGOING PROJECTS FROM EB-2013-0321										
1	DN	Fuel Handling - IFB Heat Exchanger Plate Replacement	73164	Unit Refurb - Early In-service	Replace the plate packs for all 8 heat exchangers of the irradiated fuel bay system to restore cooling capacity and mitigate margin management issue	Mar-14	Jul-15	Jul-15 (A)	6.4	6.3 (A)	0.0 (A)	6.3 (A)
2	DN	Balance of Plant - Negative Pressure Containment	73471	Unit Refurb - Early In-service	Provide a redundant monitoring capability in Unit 3 for negative pressure containment parameters used in three safety related systems	Apr-12	Oct-16	Nov-16 (A)	5.1	5.7 (A)	0.0 (A)	5.7 (A)
3	DN	Balance of Plant - Heavy Water Islanding Modifications	73472	Unit Refurb - Early In-service	Provide isolation valves and a redundant pressure relief path for the headers used to transfer moderator and primary heat transport heavy water between units and the heavy water processing facility	Apr-12	Aug-16	Oct-16 (A)	5.6	10.6 (A)	0.0 (A)	10.6 (A)
4	DN	Balance of Plant - Low Pressure Service Water	73514	Unit Refurb - Unit 2	Re-orient a valve to allow a hose connection to be attached as part of the low pressure service water temporary modifications during Unit 2 refurbishment	Oct-14	Feb-18	Feb-20 (F)	6.4	5.3 (F)	0.0 (F)	5.3 (F)
5	DN	GM Facility Interim Office Leasehold Improvements [2]	73806 / 73814	F&IP	Make leasehold improvements for the Nuclear Refurbishment Interim Office Facility at 1908 Colonel Sam Drive "GM Facility" that will accommodate the Nuclear Refurbishment organization and some delegated support staff for the period between the fall of 2010 until the fall of 2013 when the Darlington Energy Complex is ready for use	Mar-10	Feb-20	Feb-20 (F)	9.3	10.2 (F)	0.0 (F)	10.2 (F)
6	DN	Vehicle Screening Facility [2]	73817	F&IP	Build an extension to the vehicle screening infrastructure at the DNGS Sally Port to increase throughput of vehicles entering/exiting the Darlington Protected Area at the Sally Port from the refurbishment and Campus Plan projects	Jun-13	Oct-14	Oct-14 (A)	6.6	6.5 (A)	0.1 (A)	0.1 (A)
7	DN	Powerhouse Steam Venting System Improvements [3]	73370	SIO	Increase nuclear safety margins by the addition of a second redundant control loop in the Powerhouse Steam Venting System initiation logic	Oct-12	Oct-15	Nov-15 (A)	5.6	5.7 (A)	0.0 (A)	5.7 (A)
8	DN	Shield Tank Overpressure Protection [3]	73380	SIO	Install relief devices to the Shield Tank Cooling System in each Darlington Unit to prevent shield tank failure from over-pressureization under Beyond Design Basis Accidents	Jan-13	Jul-17	Sep-17 (F)	13.5	32.7 (F)	0.0 (F)	32.7 (F)
9	DN	Emergency Service Water Buried Services [3]	73398	SIO	Replace the buried Emergency Service Water Piping L6 due to extensive corrosive pitting observed during inspection	Jul-13	Nov-15	Oct-15 (A)	14.6	13.9 (A)	0.0 (A)	13.9 (A)

Notes:
1 Projects with expenditures during Test Period OR In-Service Amounts in Bridge or Test Period.
2 For F&IP, columns (g) and (i) reflect approved Business Case Summary.
3 For SIO, columns (g) and (i) reflect approved Gate Progression Form or Change Control Form.
4 Forecast (F) and Actual (A) as at December 31, 2016 as noted in columns (h), (j), (k) and (l).

DARLINGTON REFURBISHMENT PROGRAM
OVERVIEW

1.0 PROGRAM SUMMARY

The Darlington Refurbishment Program (the "Program" or "DRP") is a multi-year, multi-phase mega-project that will enable the Darlington Generating Station ("Darlington") to continue safe and reliable operation until approximately 2055. The Program includes the replacement of life-limiting critical components, the completion of upgrades to meet applicable regulatory requirements, and the rehabilitation of components at Darlington's four units. The Program is comprised of individual projects of various scales and sizes that will be executed during multi-year outages.

In this application, OPG provides an update on the progress of the DRP and evidence to support its request for approval of in-service additions through 2021, including the in-service additions related to Unit 2 refurbishment. More specifically, OPG's pre-filed evidence demonstrates that:

- OPG has successfully performed the detailed planning that is necessary to determine Program scope and to establish high-confidence schedule ("schedule") and cost estimates for safely completing the Unit 2 refurbishment by February 2020 and refurbishment of the other three units thereafter; and
- OPG has in place the resources, organization and processes necessary to execute the refurbishment of Unit 2, and the Program in its entirety, safely, on time, on budget, and to the required quality level.

As part of the work completed during the Definition Phase of the Program, all major contracts required to execute the scope of the DRP have been awarded. The detailed planning conducted by OPG and its contractors during the Definition Phase has enabled the development of a four-unit budget and schedule for the successful execution of the DRP. Critical to OPG's planning efforts during this phase have been the construction of a full scale reactor mock-up and other training facilities which have been brought into service in this phase, as well as the Retube and Feeder Replacement tooling development and testing in

the mock-up. Equally important has been the completion of the Unit 2 detailed engineering for each design modification package for all committed scope that is part of the DRP. Based upon this work, OPG prepared a detailed four-unit budget and schedule (the "Release Quality Estimate" or "RQE"), which was finalized in November 2015 (as discussed in Ex. D2-2-8).

Refurbishment of all four Darlington units will take place over a total span of 112 months (October 2016 to February 2026), including 40 months for Unit 2 from October 2016 to February 2020. Based on the significant effort that went into developing the RQE, which was approved by OPG's Board of Directors on November 13, 2015, OPG has a high level of confidence in the DRP cost estimate of $12.8B, which includes contingency, capitalized interest and escalation. The RQE establishes a four-unit, program-level control budget that serves as the baseline against which the success of the DRP will be measured. Subsequent to receiving approval from OPG's Board of Directors, the RQE was provided to the Minister of Energy, who announced the Province's endorsement of the DRP on January 11, 2016.[1]

A simplified breakdown showing the Program components included in RQE and their budget is provided in Chart 1, below, followed by brief descriptions of the listed components. Life to date expenditures (to the end of 2015) are $2.2B, inclusive of interest and escalation.

[1] See: https://news.ontario.ca/mei/en/2016/01/ontario-moving-forward-with-nuclear-refurbishment-at-darlington-and-pursuing-continued-operations-at.html.

Chart 1

Simplified Breakdown of Total DRP Release Quality Estimate[2]

Program Component	RQE Total Cost (Billion $)	RQE Total Cost (%)
Major Work Bundles	5.54	43
Safety Improvement Opportunities	0.20	2
Facilities & Infrastructure Projects	0.64	5
OPG Functional Support	2.23	17
Early Release Funds	0.11	1
Contingency	1.71	13
Interest & Escalation	2.37	19
Total Cost Estimate	**12.8**	**100**

Major Work Bundles are logical groupings of work scope, each consisting of a number of individual projects, defined by OPG for purposes of effectively contracting work to outside contractors and assigning project management accountabilities. The work to be undertaken through the major work bundles consists of the replacement and rehabilitation of components, inspections and the completion of upgrades directly related to unit refurbishment. The major work bundles are (1) Retube and Feeder Replacement ("RFR"), (2) Turbines, Generators and Auxiliaries ("Turbine Generator"), (3) Fuel Handling and Defueling, (4) Steam Generators, and (5) Balance of Plant.

Safety Improvement Opportunities ("SIO") are initiatives which OPG committed to in the Environmental Assessment ("EA") for the DRP, primarily to address beyond-design basis or four-unit events. The need for this work was established through the EA, which was filed with the Canadian Nuclear Safety Commission ("CNSC"). To meet required in-service dates, OPG commenced execution of SIO work early in the Definition Phase of the Program. The SIO are useful to OPG's current and future nuclear operations independent of whether the DRP is completed.

[2] The vast majority of these amounts are capital, but included in these amounts are some amounts (e.g. removal costs) that are expensed as OM&A. OM&A costs associated with the DRP are set out in Ex. F2-7-1.

Facilities and Infrastructure Projects ("F&IP") are projects that do not involve the refurbishment of units but which are necessary to enable execution of the unit refurbishments. A number of the F&IP involve upgrades to Darlington site infrastructure to ensure it can effectively support continued operations for 30 or more years. Other F&IP involve facilities that are needed to support DRP activities during the life of the Program. To meet required in-service dates, OPG commenced the F&IP work early in the Definition Phase of the Program. The F&IP are expected to remain useful to OPG's current and future nuclear operations independent of whether the DRP is completed.

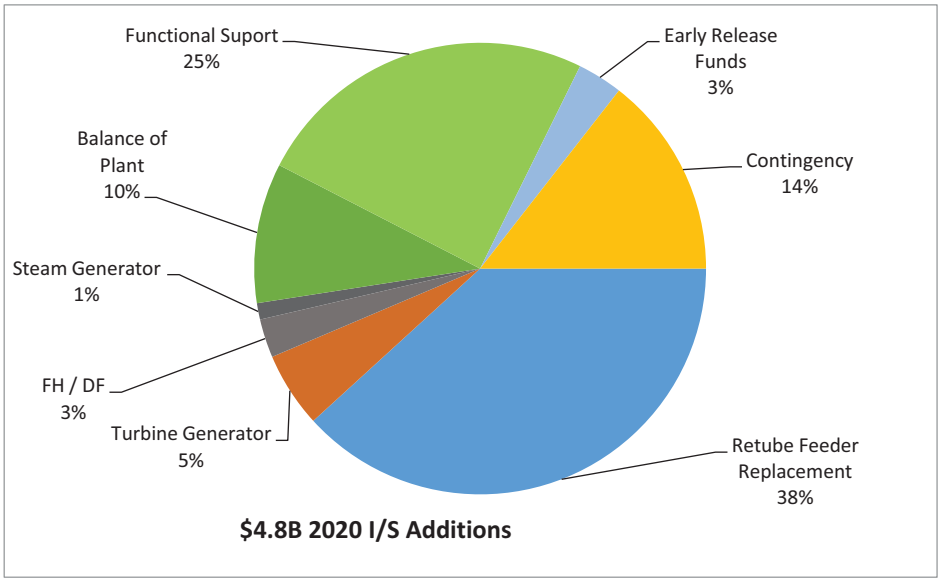
OPG Functional Support refers to work carried out by groups (referred to as "Functions") within OPG's DRP organization. The Functions provide a broad range of support that is critical for the success of the major work bundles and the Program as a whole, including oversight, coordination and integration among the various contractors and ongoing station operations. The largest of the groups, the Operations and Maintenance Function, is distinct from the others because it is both a functional and execution organization in that it provides functional support to the major work bundles and also directly carries out work at the station, particularly for the purpose of ensuring that refurbishment activities do not adversely impact Darlington's other operating units. It is largely through the Functions that OPG performs its vital role as the Program owner, with overall responsibility for Program management, deliverables, costs and schedule, as well as full integration with the operating units in order to comply with all CNSC regulations and safe work practices, including permits and work control, radiation protection, chemistry and environmental controls.

The remaining Program components consist of: (i) *Early Release Funds*, which are costs incurred during the Preliminary Planning Phase, such as with respect to EA and CNSC approvals work, that cannot be attributed to particular major work bundles or Functions; (ii) *Contingency*, which is an element of the cost estimate that is allocated to manage uncertainty and risk throughout the life of the Program, and which is expected to be spent based on OPG's in-depth assessment of the DRP risks and uncertainties that cannot be avoided or fully mitigated; and (iii) *Interest and Escalation*, which are included in the RQE to reflect costs associated with the passage of time during the life of the Program.

As noted above, the total four-unit budget to refurbish the four Darlington units is $12.8B. Within the 2017-2021 period, all of the F&IP and SIO will be placed in service and the Unit 2 refurbishment will be completed and placed in service. 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. A simplified breakdown showing the components of the Unit 2 amount is provided in Figure 1, below. While actual costs for particular components shown in Figure 1 may ultimately be higher or lower than forecast, OPG will complete the Unit 2 refurbishment within the total envelope budgeted for Unit 2 and OPG's performance with respect to cost should be considered on this basis.

Figure 1

Simplified Breakdown of Unit 2 In-Service Amounts[3]



OPG plans to issue annual status reports to the public for the duration of the Program. This reporting will include a range of measures, including construction completion, cost performance, schedule performance and safety performance, and is described in greater detail in section 7 of Ex. D2-2-9.

[3] Interest and escalation for in-service amounts are included in major work bundle costs.

PROGRAM SCOPE

1.0 OVERVIEW

OPG has engaged in an extensive planning process for the Darlington Refurbishment Program ("DRP"), the foundation of which has been OPG's thorough, methodical and disciplined process for identifying and defining the scope of the work that is to be undertaken as part of the DRP. This section describes (1) the steps taken by OPG during the Definition Phase to identify and define the scope of the DRP, including in particular the work to be performed for Unit 2, (2) completion of the detailed design and engineering work, and (3) the resulting scope of work identified for each of the major work bundles.

2.0 SIGNIFICANCE OF SCOPING TO PROGRAM SUCCESS

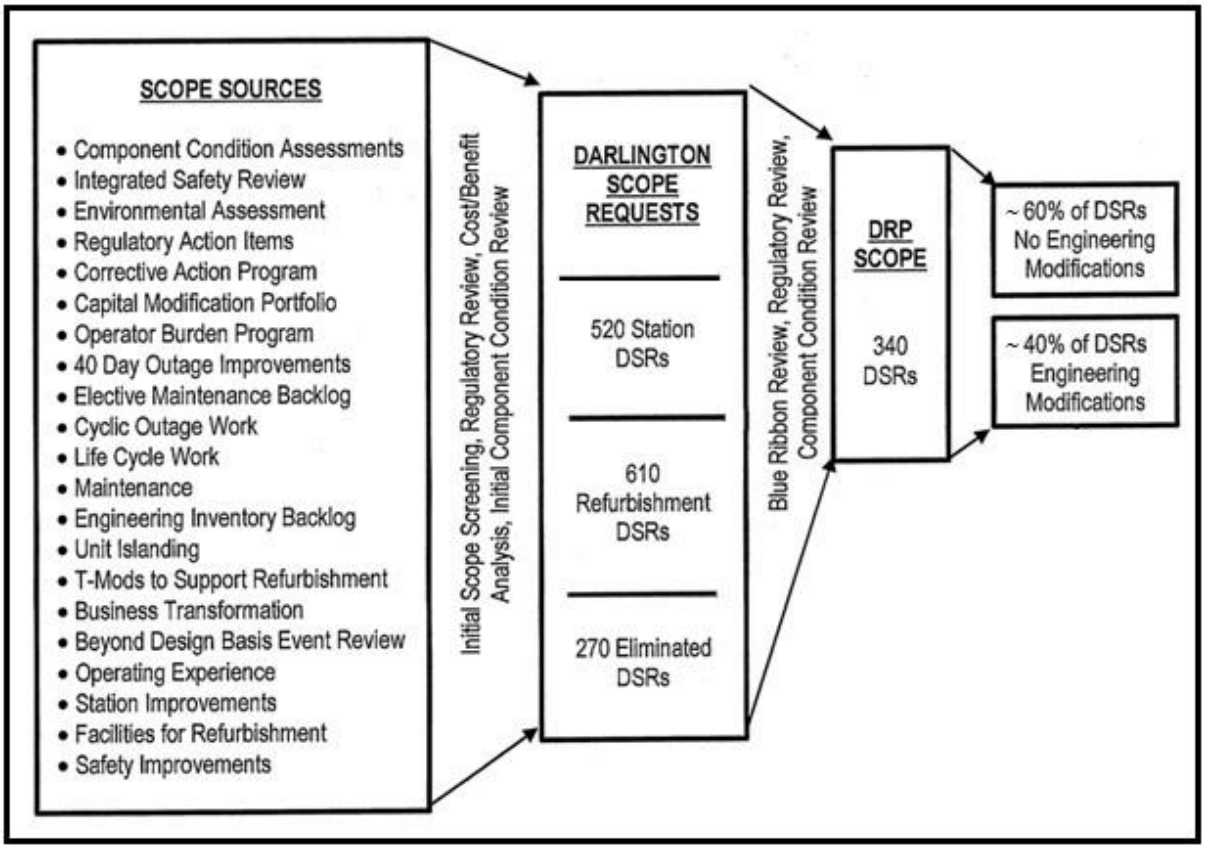
A failure to adequately define scope, in advance of setting the budget and schedule for a project, will substantially increase the likelihood of project failure. For the DRP, OPG has established a clear, well-defined program scope, which provides the proper basis for establishing high confidence estimates of the budget and schedule. OPG has also implemented a change control process to control scope growth. This process addresses operating experience from each of the Pickering 'A' Return to Service project, the Pt. Lepreau refurbishment and various Bruce Power restart projects, where cost and schedule overruns were significantly driven by scope growth.

Having a detailed understanding of scope enables the development of a schedule that is inclusive of all work. Moreover, because of the interrelated nature of the work being executed, changes to scope made during execution could potentially result in cascading impacts and cost and schedule consequences. By investing in scope definition prior to execution, OPG is minimizing the risk of such costs and schedule consequences. In addition, having a detailed definition of scope enables OPG and its contractors to take the necessary steps to ensure completion of all corresponding engineering in advance of unit execution, and to secure necessary materials, parts, tools, labour and craft resources to support the schedule.

3.0 APPROACH TO WORK SCOPE DEFINITION

The work scope definition process for DRP commenced in 2008 with a number of scope assessments for the major components within the nuclear plant, including the reactor components, steam generators, and turbine generator sets and other nuclear and conventional components. In 2011, OPG performed nearly 3,000 component condition assessments and reviewed numerous other sources in order to determine the potential scope to be executed on the DRP, as depicted in Figure 1.

Figure 1 - Scope Definition Process Overview



Based on consideration of these sources, OPG identified and documented, in the form of Darlington Scope Requests ("Scope Requests"), specific proposals for work that might be included as part of the DRP. Each Scope Request included a description of the particular work being proposed, the units to which the work would apply, whether and how the work

responds to regulatory requirements, as well as various means of classifying the work based on its objectives and relationship to other work. This process generated a total of 1,400 Scope Requests.

OPG established a Project Scope Review Board ("PSRB") to review and approve (or reject) proposed Program scope. The PSRB is a senior, cross-functional board with representation from the Darlington site and supporting business units, and is chaired by the Refurbishment Planning and Project Controls Function. The PSRB decided on whether proposed scope should be included or not, and how it should be categorized. In making these decisions, the PSRB was primarily concerned with whether the proposed scope needed to be included in the DRP or could be performed through normal station work processes (or was required at all). Based on this initial screening process, the PSRB in 2013 determined that 610 of the 1400 Scope Requests were within the scope of the DRP. The remainder were found to be either capable of being performed as part of normal station work or were not required.

Following this initial scope rationalization process, three further steps were taken. First, OPG undertook a detailed review of the component condition assessments which were found to have prompted many of the Scope Requests. Second, OPG worked with CNSC staff to finalize the regulatory requirements for extending the life of Darlington (see section 4 of Ex. D2-2-1 for discussion of regulatory requirements). Third, OPG formed a Darlington Nuclear Refurbishment Scope Review Panel (also referred to as the "Blue Ribbon Task Force")[1] in late 2013 to perform a detailed review of all Scope Requests that the PSRB intended (based on its initial screening) to include in the DRP. The primary considerations for the Blue Ribbon Task Force, in determining which scope should be included in the DRP, were:

- whether the work to be executed required defueled and dewatered conditions;
- whether the work to be executed required a unit outage that would be significantly longer than a standard unit outage; and/or

[1] The Blue Ribbon Task Force was comprised of senior representatives from Darlington and the refurbishment organization, including the Senior Manager of Plant Design, Director of Fleet Operations, the Senior Vice President, and the Director of Nuclear Safety. Its objective was to ensure that only Scope Requests required to support the refurbishment of Darlington units are included in the approved DRP scope.

- whether the work could be completed in a manner that is substantially safer, results in a lower radiation dose and/or is easier to complete if accomplished during the refurbishment outage rather than during operation or a normal maintenance outage.

Based on the Blue Ribbon Task Force's review and recommendations, the DRP scope was reduced to 340 Scope Requests. The scope of the DRP, which was fixed as of June 1, 2015, is based upon these 340 Scope Requests. Any proposed changes are subject to OPG's scope change process, which includes the need for PSRB approval. OPG's scope change process is described in section 3 of Ex. D2-2-9.

3.1 Engineering Modifications

Scope Requests specify whether engineering modifications or changes are needed. These are changes to final design documents that affect a system, structure, component, software or engineered tool. They also include modifications that affect or alter the design, function or method of performing a particular function, such as the removal, abandonment or retirement of equipment that is currently installed. Changes may be required temporarily for purposes of refurbishing a unit or on a permanent basis. Of the 340 Scope Requests within DRP scope, approximately 40% include engineering modifications, with Unit 2 requiring approximately 340 engineering changes that are permanent plant modifications for the extended life of the station. The completion of engineering for the DRP is further discussed in section 2.1.2 of Ex. D2-2-4.

3.2 Regulatory Scope

OPG has determined that approximately 80% of the DRP scope is driven directly by regulatory requirements, with the remainder being related to non-nuclear systems and/or scope that is required to be in place to support the refurbishment (e.g., refurbishment project office). OPG's Global Assessment Report and Integrated Implementation Plan ("IIP") were accepted by the CNSC in December 2015, thereby confirming the regulatory scope for DRP.

3.3 Work Bundles

For each Scope Request that was approved as part of the DRP scope, the corresponding work was then assigned to one of the five major work bundles that are described in Ex. D2-2-3 or to the functional support groups described in section 3.2 of Ex. D2-2-2.

After the Scope Requests were assigned to specific work bundles, the corresponding project teams, through studies or preliminary engineering, further defined the particular scopes of work to be performed in connection with each Scope Request. Not all scopes need to be completed for each unit.

When applied to the four units, the result is approximately 560 specific projects to be completed over the life of the DRP. Of these, a large portion, more than for any other unit, will need to be completed directly for Unit 2. In addition, there are projects that involve work that is common to two or more of the units, projects completed during the Definition Phase that are not part of any outage, as well as Safety Improvement Opportunities ("SIO") and Facility and Infrastructure Projects ("F&IP"). Some examples of projects completed during the Unit 2 outage that are not completed for other units include:

- the Irradiated Fuel Bay Heat Exchanger Plate Replacement project is a common system scope that is executed as a pre-requisite to the Unit 2 outage (see section 4.3.4, and section 2.2.2 of Ex. D2-2-10 for more information);
- engineering and procurement for Defueling (Defueling execution work is the same for all units, but there will be no additional engineering scope for the remainder of the units);
- the Work Control Area project is required for all four units, but will be executed during Unit 2 outage;
- the Service Air Capacity Enhancement project will be executed during the Unit 2 outage, which consists of an engineering modification that will enhance the capacity of service air;
- as part of the Retube and Feeder Replacement ("RFR") work package, calandria tube sheet boring polishing validation is required for Unit 2 but will not be performed for any other unit; and

- as part of the Steam Generators work package, a bleed cooler inspection/repair is only required for Unit 2.

Because the scope is not the same for each unit, the cost will not be the same for each unit. Unit 2 is expected to be the most costly unit to refurbish because it includes more scope than the subsequent units and, due to station configuration and various requirements that are common across the station, many engineering changes and other supporting scope is only required for Unit 2 (as they would already be in place for the remaining units). Costs are discussed in Ex. D2-2-8.

4.0 SCOPE FOR MAJOR WORK BUNDLES

For each major work bundle, OPG has appropriately and to a high level of specificity defined the relevant work, as well as effectively planned and integrated the work into the Program and Unit 2 schedules. The scope of work associated with each of the major work bundles for Unit 2 refurbishment is as follows.

4.1 Retube and Feeder Replacement

The RFR major work bundle is comprised of three broad areas of scope, consisting of (1) RFR Definition Phase work, (2) Retube Waste Processing Building, and (3) RFR Execution Phase work.

4.1.1 RFR Definition Phase Work

(a) *Mock-up.* The full-scale reactor mock-up was completed and went into service at the Darlington Energy Complex on budget and ahead of schedule on March 31, 2014. The successful installation of the mock-up facility included the design, manufacture and installation of the reactor face and all components, fueling machine bridge and two retube tooling platforms. The mock-up has been, and will continue to be used to train workers, providing predictable Execution Phase performance and minimizing the need for workers to overcome any learning curves while performing work during the refurbishment outage.