COST

1.0 OVERVIEW

On November 13, 2015, OPG's Board of Directors approved the Release Quality Estimate ("RQE") and Execution Phase Business Case Summary for the Darlington Refurbishment Program ("DRP"). A copy of the Execution Phase Business Case Summary is provided in Attachment 1. The RQE provides a high confidence estimate of the cost of the DRP based on the costs spent to date and estimated costs to completion, as derived from detailed planning that has been undertaken. The RQE is supported by the Execution Phase Business Case Summary, which includes descriptions of program status, program schedule, updated program economics, as well as funding requirements. This section describes the costs of the DRP, including the specific cost of Unit 2 refurbishment and the costs of the major work bundles, as determined in the RQE.

In the RQE, OPG determined that the total estimated cost of refurbishing all four units at Darlington would be $12.8B, including capitalized interest and escalation. This is approximately $1.2B lower than the top of the range originally expected, which was $14B including capitalized interest and escalation, as communicated by management to OPG's Board of Directors in 2009.

In approving the RQE and Execution Phase Business Case Summary, OPG's Board of Directors also approved the release of $681M to complete 2016 deliverables relating to preparation for Unit 2 execution and further planning for subsequent units. This release brings the total cumulative funds released for the DRP to $3,228M.

The RQE and Execution Phase Business Case Summary, as approved by OPG's Board of Directors, were subsequently presented to the Minister of Energy. On January 11, 2016, the Minister announced his endorsement of the DRP.

2.0 RELEASE QUALITY ESTIMATE

At a high level, the process of cost estimating involves (1) identifying the scope of work, constraints and assumptions, (2) completing engineering and determining resource and material requirements, (3) quantifying the resources required, including both labour and non-labour resources, (4) applying costs to the resources, and (5) adjusting or factoring the pricing based on the project environment. Importantly, the quality of an estimate is directly related to how well the project scope has been defined – the greater the detail with which scope has been defined, the more accurate the estimate.

Cost estimating is a process that is repeated and refined at different stages of a program or project, particularly for purposes of a project progressing through its project life-cycle. With each iteration, a cost estimate is expected to become more accurate. For purposes of classifying its cost estimates, OPG relies upon the estimate accuracy classification standards established by the Association for the Advancement of Cost Engineering ("AACE"). AACE's estimate classification framework is broadly accepted and relied upon in the industry as a recommended practice.

Specifically, OPG has developed and classified the RQE in accordance with AACE's Recommended Practice No. 18R-97, which defines classes of cost estimates based on the level of engineering and scope definition completed. The estimate classes range from Class 5 (most conceptual with the widest range of potential variability) to Class 1 (most mature with the narrowest range of potential variability). In applying this recommended practice, OPG aligned its engineering change control process and its respective deliverables with the AACE estimate classification matrix as provided in Chart 1 below.

Chart 1

Generic Cost Estimate Matrix - AACE Recommended Practice No. 18R-97

	Primary Characteristic	*Secondary Characteristic*		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

The RQE is a Class 3 estimate and is being used as the control budget for the Program. Ninety per cent of the estimated costs of completion meet or exceed the level of estimate accuracy corresponding to Class 3. The largest component of the work bundle estimate, the Retube and Feeder Replacement ("RFR") estimate, is a Class 2 estimate. Chart 2 provides the estimate class for each of the major work bundles.

Chart 2

Class of Estimate for the Major Work Bundles

Project	Estimate Class
RFR	Class 2
Turbine Generator	Class 2 - 3
Steam Generators	Class 2
Fuel Handling and Defueling	Class 3
Balance of Plant	Class 3 - 5
Facilities & Infrastructure Projects and Safety Improvement Opportunities	Class 1 - 3

As a Class 3 estimate, the RQE has an expected accuracy range of [-10 to -20% / +10 to +30%]. In their final oversight report to the OPG Board of Directors (Attachment 2), Burns & McDonnell Canada Ltd. and Modus Strategic Solutions Canada Company ("BMcD/Modus") conclude:

> Based on our nearly three years of oversight of the DR Project's planning, BMcD/Modus believes the process used for developing the control budget and critical path schedule that form the basis for RQE meets or exceeds industry thresholds. The control budget is based, most notably, on well-defined scope and detailed engineering, which has sufficiently matured to allow classification using the AACE International guidelines in the manner OPG intended for RQE. In addition, the level of detail in the RQE control budget is in line with our experience for projects of this nature and should form the basis for a robust project controls regime that will be used to track progress.

OPG engaged KPMG to provide an independent review of the governance and processes used to develop the RQE. KPMG's review consisted of (1) a governance and process assessment, and (2) a cross-cutting vertical slice review of the estimates. KPMG's final report arising from this review is provided in Attachment 3.

With respect to its governance and process assessment, KPMG assessed OPG's estimating governance and management processes associated with RQE development against relevant

AACE guidelines for estimate development, classification, review, validation, document management and risk management. KPMG found that OPG has demonstrated knowledge of the AACE guidelines and has generally interpreted and correctly applied those guidelines to the DRP. KPMG also found that OPG's estimating governance and processes for developing the RQE have been particularly strong with respect to: (1) their alignment with AACE's estimate classification system, (2) integration and consideration of historical knowledge of risks, opportunities and lessons learned from other projects, (3) the risk management framework that has been developed and implemented using best practice tools, and (4) design and implementation of processes for challenging and performing quality reviews of vendor estimates in alignment with AACE guidelines and best estimating practices.

With respect to its cross-cutting vertical slice review of the estimates, KPMG reviewed estimate documentation using three vertical slices from the DRP and reported on overall traceability, data integrity and level of detail. The slices selected by KPMG were RFR, Balance of Plant, and Operations and Maintenance. KPMG found that the vertical slices it reviewed were generally well organized, complete, and traceable to estimate detail and source data. KPMG also found that the level of detail in the estimate packages is generally acceptable and sufficient when compared to other similar projects and best industry practices.

As part of its review, KPMG also analyzed the RQE against the AACE guidelines. Out of 186 items of the RQE analyzed, KPMG's report identified no items that it classified as Category A (critical) gaps, and 33 items that it classified as Category B (non-critical or procedural) gaps. The 33 Category B gaps are quality issues related to governance documentation that can be improved to further substantiate and support the estimate. According to KPMG's report, this number of Category B gaps is considered normal and could reasonably be expected for a capital program of this size. The fact that KPMG identified no Category A gaps is a reflection of the effort deployed by OPG, and the quality of the processes and governance implemented to arrive at the RQE. In response to KMPG's assessment, OPG has put a process in place to address the recommendations from KPMG and is tracking all actions to completion.

Additional oversight for the RQE development process has been provided by BMcD/Modus. The RQE oversight provided by BMcD/Modus has been carried out as part of its broader role in providing DRP oversight. In particular, BMcD/Modus assessed the process used for developing RQE, with a particular focus on the development of detailed cost estimates that are of sufficient quality and basis in order to establish a four-unit, program level control budget for DRP. In addition to considering OPG's processes relative to its governance and industry guidance, particularly from AACE, BMcD/Modus considered whether the RQE process was sufficiently thorough and robust, whether contingency was developed in a manner consistent with industry practices and whether RQE was appropriately documented to permit vetting by senior management. A copy of the resulting BMcD/Modus report is provided in Attachment 2.

Based on its three years of DRP oversight, including one year with a particular focus on RQE, BMcD/Modus found that the processes used to develop RQE and the critical path schedule that forms the basis for RQE meets or exceeds industry thresholds. It found the RQE to be based on well-defined scope and detailed engineering, which was sufficiently mature to allow the intended classification based on AACE guidelines. The RQE was also found to be based on a level of detail in line with that seen for other projects of a similar nature, which will support a robust project controls regime to track progress. However, they also identified some risks associated with certain components of the RQE that, if not corrected before the Unit 2 full execution release in Q3 2016, could impact the Unit 2 estimate. OPG has therefore put a process in place to address the recommendations from BMcD/Modus and is tracking all actions to completion within this timeframe.

3.0 DRP COST BREAKDOWN

Chart 3 below provides a detailed cost breakdown of the RQE components.

Chart 3

DRP RQE Breakdown (M$)

#	Bundle / Category	RQE Total Cost	%
1	Retube & Feeder Replacement	3,598	28

#	Bundle / Category	RQE Total Cost	%
2	Turbine Generators	657	5
3	Balance of Plant	967	8
4	Fuel Handling/Defueling	198	2
5	Steam Generators	123	1
6	Subtotal Major Work Bundles	5,543	43
7	Facility and Infrastructure Projects	640	5
8	Safety Improvement Opportunities	205	2
9	Subtotal F&IP/ SIO	845	7
10	Project Execution	322	3
11	Contract Management	52	0
12	Engineering	283	2
13	Managed Systems Oversight	41	0
14	Planning & Controls	136	1
15	Nuclear Safety	83	1
16	Program Fees & Other Support	341	3
17	Supply Chain	86	1
18	Work Control	80	1
19	Operations & Maintenance	805	6
20	Early Release 3[1]	102	1
21	Early Release 4[1]	7	0
22	Subtotal OPG Functions	2,336	18
23	Contingency	1,706	13
24	Subtotal Before Interest & Escalation	10,429	81
25	Interest[2]	1,473	12
26	Escalation[3]	898	7
27	Subtotal Interest & Escalation	2,371	19
28	Total High Confidence Estimate	12,800	100

[1] Early Releases 3 and 4 are costs that were incurred during the preliminary planning phase of the Definition Phase before the DRP organization was in place. As a result, they cannot be attributed to the work bundles or functions. These costs are primarily related to EA, ISR and early planning work.

[2] Interest is applied monthly to cumulative capital expenditures in the previous months at a rate of 5 per cent until 2021, consistent with OPG's business planning assumptions and 6% thereafter.

[3] Escalation is set at 2 per cent on a per annum basis.

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.

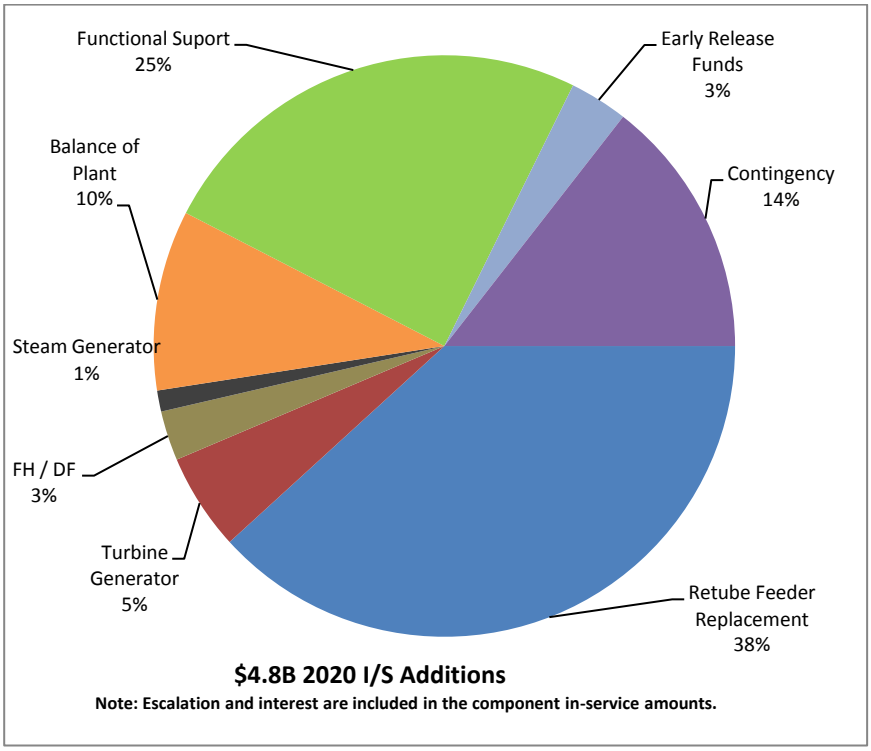
Footnotes:

[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.

Figure 1

Breakdown of the 2020 In-Service Additions for Unit 2



4.1 Major Work Bundle Costs

The major work bundles represent a very substantial portion of the Unit 2 refurbishment costs. The major work bundle costs for Unit 2 are $2,763.2M or 58 per cent of this Unit 2 in-service amount. As illustrated in Figure 1 above, the RFR major work bundle alone accounts for $1,834.8M or 38 per cent of the Unit 2 in-service amount, with Balance of Plant accounting for 10 per cent, Turbine Generator accounting for 5 per cent, Fuel Handling and Defueling accounting for 3 per cent, and Steam Generators accounting for 1 per cent. These amounts do not include project contingency. Contingency is considered in Ex. D2-2-9. The cost estimates for all major work bundles are based on the detailed scheduling, scoping and contingency development as discussed in Ex. D2-2-5, Ex. D2-2-6 and Ex. D2-2-7. The degree of rigor applied to such planning efforts has been proportionate to the level of cost and risk associated with each particular bundle. Cost estimation processes similar to that which is described for RFR, below, were employed for the remaining major work bundles.

4.1.1 Retube and Feeder Replacement

The RFR major work bundle accounts for $1834.8M of the forecast Unit 2 in-service amount. A breakdown of the costs of the RFR scope for Unit 2 is set out in Chart 5 below.

Chart 5

Unit 2 RFR Bundle Cost

Description	**Amount ($M)**	**%**
Definition Phase – Mock-up	38.2	2
Definition Phase - Tooling	274.2	15
Definition Phase – Target Cost & Fixed Fee (including OSM)	382.9	21
Retube Waste Processing Building ("RWPB") (EPC only)	163.1	9
Execution Phase – Retubing (including OSM)	574.6	31
OPG Project Management (includes RWPB oversight)	108.4	6
Interest and Escalation	293.3	16
Total	**1,834.8**	**100%**

The Unit 2 RFR major work bundle costs are based upon a Class 2 estimate established through a detailed estimating of all tasks involved. Based on AACE classification, a Class 2 estimate has an expected accuracy range of +20/-15 per cent. OPG has estimated RFR costs to a Class 2 accuracy level because RFR is on the critical path and the largest component of program costs, and OPG benefitted from the use of the mock-up in estimating the required work resources. This estimating accuracy is an indicator of OPG's significant investment in planning for this key aspect of the DRP.

The RFR cost estimate was developed by the SNC/AECON JV. The target price and target schedule for the Execution Phase were not established at contract award. Instead, the target price and target schedule were developed in collaboration with OPG over the course of the Definition Phase.

The Class 2 Estimate is based on a deterministic methodology. The basis of estimate is derived from the Comprehensive Work Packages, which incorporate the steps and methods for how the work for each set of tasks on the schedule will be performed. The durations of these tasks, where related, are based on the results of actual tool performance data obtained at the mock-up facility. The total duration was then compared with actual results of prior refurbishments for benchmarking purposes. This combination of documented steps and methods, combined with actual durations from the testing of tools, benchmarked with other refurbishments, provides OPG with confidence in the estimated durations and cost estimate for the RFR work bundle. In addition, productivity gains are contemplated in the RFR contract (see page 5 of Attachment 1 to Ex. D2-2-3).

OPG, working together and collaboratively with the RFR contractor, conducted a rigorous vetting process to establish the Class 2 estimate for RFR. The process included detailed review of the elements of the estimate by the project management team, and a strategy to (i) validate elements of the estimate, and (ii) assess the gaps OPG identified in the original estimate submission as well as in comparisons to benchmarks. This process is considered in the BMcD/Modus RQE assessment report (Attachment 3) which concludes:

> Overall, the vetting process resulted in a reduction of over 3M work hours and more than $390M in direct cost from the May Class 2 submission to the final September submission. Together with the reduction in associated Fixed Fee ($120M) and Contingency ($105M), the overall Class 2 estimate was reduced from May to September 2015 by over $600M. These cost reductions identified in the estimate review process displayed the effectiveness of the progressive reviews, and in particular the detailed vetting that occurred between SNC/Aecon Rev. 0 and Rev 1 submissions. This process resulted in the maturation of SNC/Aecon's estimate and an improved confidence level.

OPG and the RFR contractor, the SNC/AECON JV, jointly engaged an expert review panel comprised of four individuals with previous retube and feeder replacement experience at senior levels in primary contractor and customer organizations. The panel was engaged to conduct an independent review of the SNC/AECON JV submission that formed a basis for the RFR cost estimate. The outcome of the panel's review was a report, provided as Attachment 4, page 3, confirming compliance with good industry practices, while offering observations and recommendations for potential improvements. The report concludes:

> The Panel concludes that the JV Class 2 Estimate followed the AACE requirements for preparing a Class 2 Estimate. The integrity of the Class 2 process was maintained during the evolution of the estimate from Class 2 R0 to Class 2 R1.

OPG has established a process to address the recommendations made by the panel and will track all recommendations to completion.

4.1.2 Turbine Generators

The Turbine Generators major work bundle accounts for $258.6M of the forecast Unit 2 in-service amount. A breakdown of the costs of the Turbine Generator scope for Unit 2 is set out in Chart 6.

The process for preparing the Class 2-3 estimate for the Turbine Generators Unit 2 scope of work was similar to the RFR bundle in terms of gaining a full understanding of the effort required to complete the work. That effort, in addition to OPG's operational experience, was used to determine the expected hours, durations and rates in the estimate.

As set out in section 3.3 of Ex. D2-2-3, for the Turbine Generator major work bundle, OPG has engaged Alstom, the OEM through a series of corporate mergers and acquisitions of the turbine generator sets through an Engineering Services and Equipment Supply contract, as well as the SNC/AECON JV through an Engineering, Procurement and Construction contract. Alstom will also provide technical services to the SNC/AECON JV performing the field work. A Memorandum of Understanding among OPG, Alstom and the SNC/AECON JV is in place to ensure the three parties work closely together to mitigate technical and operational risks

The SNC/AECON JV, in completing their EPC estimate, reviewed OPG operational experience to validate effort and durations. Where work had never been performed by OPG, the SNC/AECON JV relied upon engineering products provided by Alstom for the basis of their estimate.

Chart 6

Unit 2 Turbine Generator Bundle Costs

Description	Amount ($M)	%
Turbine Generators – Engineering Services & Equipment Supply (Alstom)	115.4	45
Turbine Generators – EPC (JV)	69.2	27
OPG Project Management	25.0	10
OPG IMS Inspection Support	4.5	2
Interest	44.5	17
Total	**258.6**	**100%**

4.1.3 Fuel Handling and Defueling

The Fuel Handling and Defueling major work bundle accounts for $132.6M of the forecast Unit 2 in-service amount. A breakdown of the costs of Fuel Handing and Defueling scope for Unit 2 is set out in Chart 7.

Chart 7

Unit 2 Fuel Handling and Defueling Bundle Costs

Description	Amount ($M)	%
Defueling	23.3	18
Fuel Handling	57.8	44
OPG Project Management	31.2	24
Interest	20.3	15
Total	**132.6**	**100%**

4.1.4 Steam Generators

The Steam Generators major work bundle accounts for $56.3M of the forecast Unit 2 in-service amount. A breakdown of the costs of the Steam Generators scope for Unit 2 is set out in Chart 8. A large portion of this work bundle is fixed price as the contractor, the BWXT/CANDU JV, has experience performing this work at other nuclear locations, therefore

allowing tasks to be highly definable. The fixed price pricing model will provide OPG with greater cost certainty.

Chart 8

Unit 2 Steam Generators Bundle Costs

Description	**Amount ($M)**	**%**
Steam Generators EPC (BWXT/CANDU)	34.9	62
OPG Project Management	6.5	12
OPG IMS Support	7.5	13
Interest	7.4	13
Total	**56.3**	**100%**

4.1.5 Balance of Plant

The Balance of Plant major work bundle accounts for $480.9M of the forecast Unit 2 in-service amount. This major work bundle is comprised of approximately two dozen projects with a diverse range of work. The cost estimates were derived from completed engineering packages and are based upon a list of required materials and expected hours.

The ESMSA contractor's estimating teams were responsible for preparing the estimate. OPG's estimating and project management teams reviewed and challenged the contractor's submissions and, subsequently, the estimates were revised by the contractor prior to final acceptance by OPG. As some of the estimates did not achieve Class 3 at the time of RQE, a higher contingency amount for estimating uncertainty was included. A breakdown of the costs of Balance of Plant scope for Unit 2 is set out in Chart 9.

Chart 9

Unit 2 Balance of Plant Bundle Costs[5]

Description	Amount ($M)	%
Balance of Plant Work	204.6	43
Unit Islanding	57.0	12
Refurbishment Support Facilities	40.3	8
Shutdown, Layup and Services	100.6	21
Specialized Projects	78.4	16
Total	**480.9**	**100%**

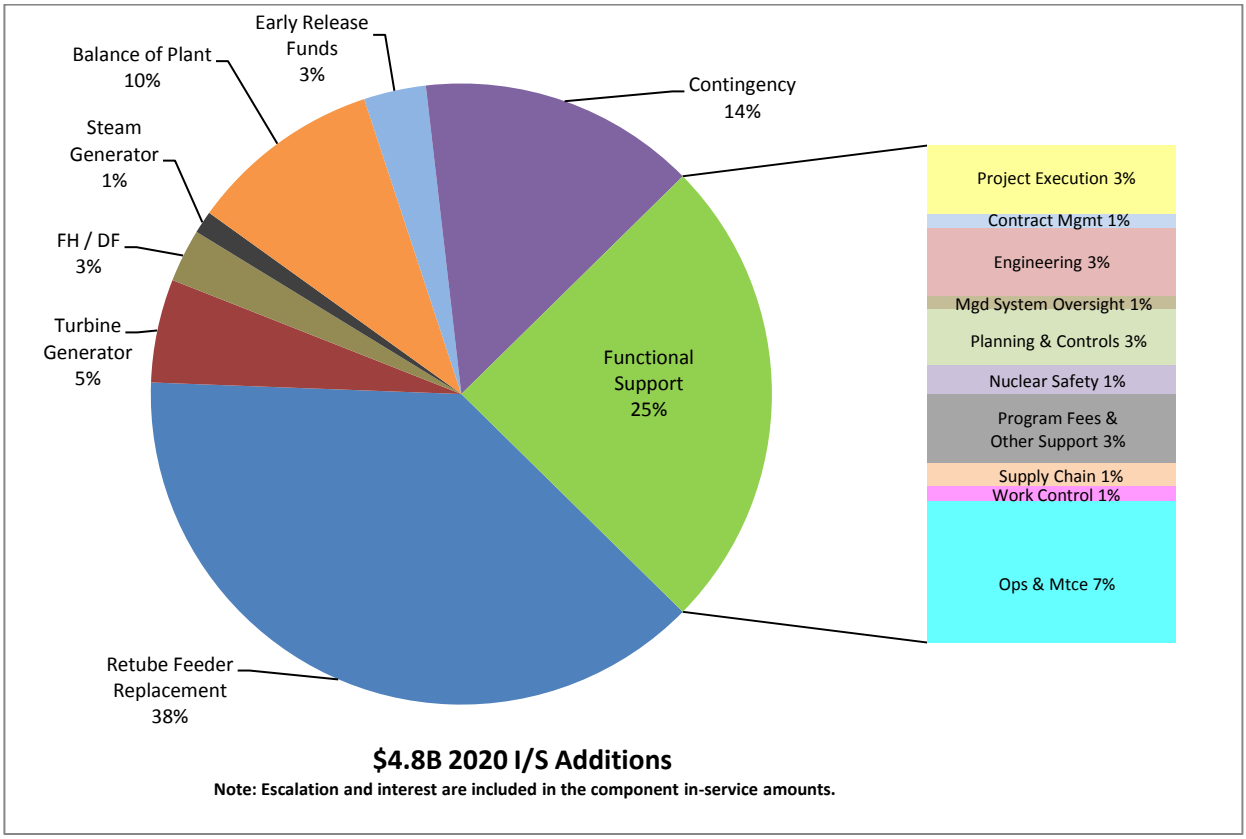
4.2 Functional Cost

Figure 2 below presents the breakdown of the functional costs in the Unit 2 in-service amounts. The role of the Functions and their key deliverables are described in section 3 of Ex. D2-2-2.

[5] Inclusive of OPG project management and interest costs.

Figure 2

Breakdown of the Function Costs in the Unit 2 In-service Amount



ATTACHMENTS

Attachment 1:	Execution Phase Business Case Summary
Attachment 2:	BMcD/Modus Report on RQE
Attachment 3:	KPMG Report on RQE
Attachment 4:	Expert Review Panel Report on RFR

ONTARIO POWER GENERATION

File No: N-REP-00120.3-10001-R000

Project ID - 16-27959

Darlington Refurbishment

Execution Phase

Business Case Summary

November 13, 2015

OPG Confidential & Commercially Sensitive

Contents

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY

1. RECOMMENDATION:

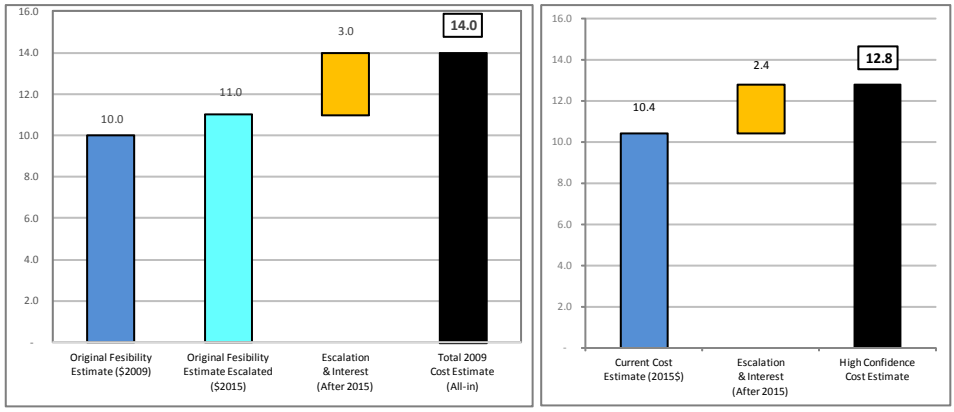
In 2009, OPG's Board of Directors (the Board) approved the Economic Feasibility Assessment and the Business Case Summary (BCS) related to the refurbishment of the Darlington Nuclear Generating Station. The Board approved the project and released funds to commence preliminary planning within the Definition Phase in accordance with the Darlington Refurbishment Program's (DRP) release strategy. The Board also approved the release of funds in November 2011, November 2012, November 2013 and November 2014 to complete detailed planning activities within the Definition Phase.

The purpose of this Release Quality Estimate BCS is to provide: a) a 4-Unit cost and schedule estimate (the "RQE"); b) an update on the status of the DRP; c) an update on the economics of the DRP; and (d) to request funding to complete preparation of execution activities on Unit 2, and other critical 2016 planned deliverables related to subsequent units. The 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.

In 2009, management communicated to the Board that the project cost would be less than $10B in 2009$ which is equivalent to $11.0B in 2015$ excluding capitalized interest and inflation. Including capitalized interest and inflation, the 2009 estimate is $14B.

Management has completed the Definition Phase has high confident that the 4-unit cost estimate is $10.4B (2015$). The $10.4B (2015$) estimate is $12.8B including capitalized interest and future inflation. Life to date expenditures (to the end of December 2015) are forecast at $2.2B (including interest and inflation), leaving $10.6B remaining to be expended on the project. Figure 1 below provides a comparison of the RQE compared to the bounding estimate communicated in 2009.

Figure 1: Refurbishment RQE Compared to 2009 Promise of Less Than $10B 2009$



Original Feasibility Estimate
($ Billion)

4-Unit Cost Estimate
($ Billion)

At a cost of $10.4B (2015$), the Levelized Unit Energy Cost ("LUEC") of refurbishing and continuing to operate the Darlington units for a further 30 years is estimated to be 8.1 ¢/kWh (2015$). This LUEC is based on the RQE of the DRP (which is a high confidence estimate) and high confidence estimates of the post-refurbishment operating costs and performance. In 2010, OPG publicly communicated that the economic LUEC would be less than 8 ¢/kWh in 2009$, which is equivalent to 9.0 ¢/kWh in 2015$. Thus, OPG's current LUEC estimate of 8.1 ¢/kWh (2015$) for the DRP is well within the bounding estimate, publicly communicated by OPG in 2010.

The LUEC of refurbishing the Darlington Station indicates that Darlington would provide a stably-priced, low cost generation option for Ontario for the future 30 to 35 years.

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY

Other considerations which contribute to and support the favourable economic assessment for refurbishing the Darlington Station include:

- The use of an existing generation site, with a proven environmental record and a supportive host community, avoids the additional costs to OPG (and ratepayers) of site selection, securing environmental approvals and development of host community support at an unproven greenfield or brownfield site. It also avoids the additional costs to ratepayers of establishing new transmission infrastructure.
- Economic benefits of refurbishing the Darlington Station, in terms of direct, indirect and induced job creation. Between 2016 and 2025, the Conference Board of Canada estimates that the DRP's construction phase alone is expected to generate $14.7B in economic benefits to Ontario. At its peak, the DRP will create 11,700 jobs per year, with an average of 8,700 annually between 2014 and 2013. It will also increase household revenues in Ontario by $8.5B and government revenues by $5.5B.

As a result of OPG's improving confidence in the life of critical components at the Darlington Station and the resulting opportunity created to maximize the value of the asset and smooth the overall rate impact while mitigating execution risk of the DRP, management recommended the removal of the overlap of the first and second refurbishment units in June, 2013. This recommendation effectively delays the beginning of the refurbishment outages on the 2nd, 3rd and 4th units nominally, by 18 months each. This schedule change was approved by the Chief Executive Officer ("CEO") and formed the base schedule planning assumption for this BCS. With the RQE and schedule, it remains that OPG will execute the refurbishment of the 4 Darlington Units with no overlap of the first two units, but with approximately 50% overlap of the remaining 3 units. Management will continue to explore opportunities to optimize the schedule based on remaining station life and economics.

Management is seeking a partial release in the amount of $681M to prepare for the execution of Unit 2 in 2016 (Release #5a) and to complete other critical 2016 planned deliverables related to subsequent units. The total cumulative funds released to the project, including this release, will total $3,228M including capitalized interest, inflation, and contingencies.

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

Key activities, as defined in Appendix D, to be completed in 2016 include:

- Procurement activities including the fabrication and delivery of reactor components for Unit 2
- Progression of refurbishment pre-requisite work including construction of facilities and infrastructure projects, safety improvement projects (e.g. 3rd Emergency Power Generator, Containment Filtered Venting System) and other pre-requisite work such as the Re-tube Waste Processing Building
- Execution of pre-breaker open work to support Refurbishment and Integrated Improvement Plan (IIP) commitments (e.g. unit islanding modifications, service modifications such as breathing air and temporary power, and turbine crane overhaul)
- Overall planning support to the projects including establishment of the construction organization, work instruction development and review, and permitry and radiation protection planning

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY

2. SIGNATURES

Submitted By:

Dietmar Reiner
Senior Vice President, Nuclear Projects

Finance Approval:

Beth Summers
Chief Financial Officer

Recommended By:

Glenn Jager
President OPG Nuclear and
Chief Nuclear Officer

Approval per OAR Element 1.3.

Jeff Lyash
President and Chief Executive Officer

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY

3. BACKGROUND AND ISSUES:

In June 2006, the Ontario Government directed OPG to begin feasibility studies on refurbishing its existing nuclear plants. The need for refurbishment of nuclear plants was also addressed in the Ontario Power Authority's Integrated Power System Plan I (IPSP I) issued in 2007, the Ontario Government's Long-term Energy Plan issued in November 2010, the Government's Supply Mix Directive issued to the Ontario Power Authority in February 2011 and in the Long Term Energy Plan II (known as LTEP II) issued in December 2013.

OPG commenced the Initiation Phase of the DRP, including an economic feasibility assessment in late 2007. The objective of the DRP is to extend the operating life of the station by approximately 30 to 35 years. The refurbishment involves an outage for replacement of life-limiting components, as well as maintenance or replacement of other components which are most effectively done during the refurbishment outage period.

The Initiation Phase concluded on December 31, 2009 with the Board's approval of management's recommendation to proceed with refurbishing the 4 Darlington units. In November 2009, concurrent with approval to proceed with the project, the Board released $240.7M for preliminary planning within the Definition Phase of the project. Funding included $102.5M for preliminary planning, as well as $138.2M for the design and construction of facilities and infrastructure projects required prior to refurbishment of the units and/or to support the post-refurbishment operations period.

On November 17, 2011, the Board approved the revised overall project timeline (the updated "Program Release Strategy"), incorporating an October 2015 RQE (revised from October 2014 in order to incorporate tool testing results from the R&FR project), and management's recommendation to move to the Detailed Planning Phase including a partial release of $436M.

In November 2012, the Board approved a further partial release of funds, for 2013 deliverables, in the amount of $492M for a cumulative project release of $928M.

In November 2013, the Board approved a further partial release of funds for 2014 deliverables, in the amount of $680M, for a cumulate project release of $1,608M.

In November 2014, the Board approved a further partial release of funds for 2015 deliverables, for a cumulate project release of $2,548M. This reflects the assignment of $184M of project work to the Nuclear Operations portfolio identified to the Board in January 2015.

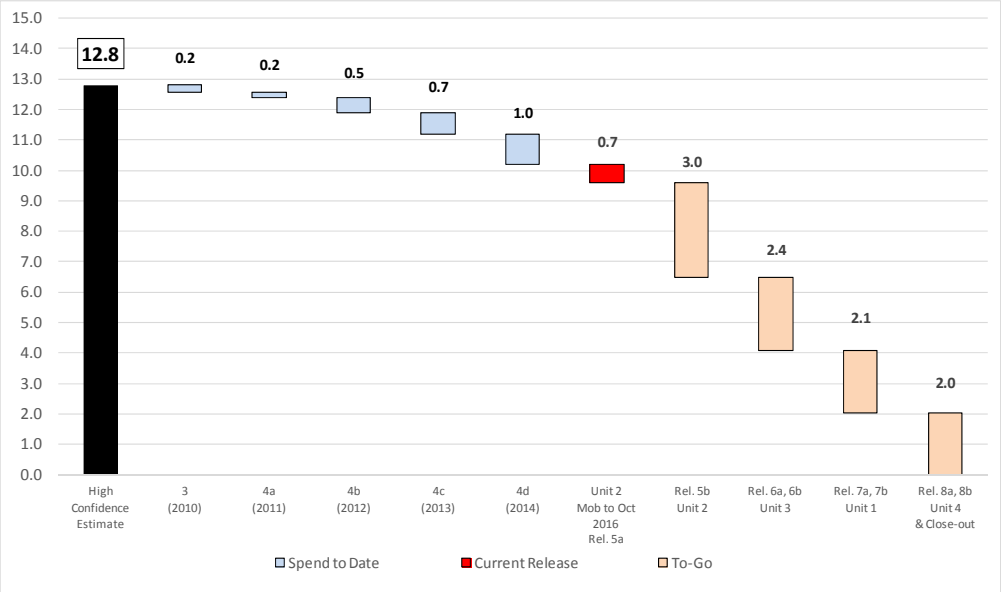
Total releases to date are $2,548M for the Definition Phase preliminary planning and detailed planning phases of the Definition Phase. OPG is requesting an additional $681M to complete 2015 deliverables for preparation of the Execution Phase of the project for a cumulative release of $3,228M.

The detailed 4-Unit cost and schedule and RQE was completed on plan in October 2015 and is the basis for this BCS. The planned start of execution of the first unit's refurbishment outage remains in mid-October 2016.

Figure 2 below provides a summary of the above releases as well as a projection of the amounts of future releases.

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY

Figure 2: Darlington Refurbishment Program – Release Summary



Status of Work:

The status of work is reported to the Darlington Refurbishment Committee on a quarterly basis. The latest report, as of September 30, 2015, provides a status of the Detailed Planning Phase.

The following is a summary of the major planning activities.

a. **Project Planning**

Project Management

Using a "strong project matrix" model for the Definition Phase of the DRP, the Project Management organization was put in place. Key roles on the project team include Engineering, Execution, Supply Chain, Oversight, Operations & Maintenance and Project Planning & Controls. The Senior Vice President of Nuclear Projects has the overall accountability to deliver the DRP.

Management is currently developing the organization model and supporting strategies, including professional staffing and labour strategies, for the Execution Phase of the DRP.

Project Governance

Project controls governance and supporting information technologies, including scope management, cost management, scheduling, estimating, risk management, change management, and document and records management, have been implemented.

Project Planning

At the time of the initial economic feasibility assessment in 2007, the Darlington Station units were predicted to reach their nominal end-of-service lives between 2019 and 2020, based on a nominal fuel channel life expectancy of 210,000 Effective Full Power Hours (EFPH). End-of-service life predictions are continually reviewed as new inspection information and knowledge of possible degradation mechanisms becomes available and forecast production levels are updated. On June 12, 2008, the CEO approved the initial planning assumptions and reference schedule for the DRP, based on the expectation of nominal end-of-service lives for the Darlington Station units. At that time, the planning assumptions were based on a first unit refurbishment start date of October, 2016. Each unit's refurbishment was to last 25 months, and, with a four month

overlap of unit outages, the overall duration (elapsed time) of the refurbishment outage window would be 88 months for the 4 units with 100 actual outage months.

In 2009, based on the completion of the technical studies, consideration of operating experience (OPEX) from Bruce Power and Pt. Lepreau, the planning assumptions were modified. The most likely critical path duration of each unit refurbishment was determined to be 36 months. Management subsequently endorsed a schedule of nominal 36 month outages, with the first unit beginning its outage in October 2016, and with a 16 or 19 month overlap to ensure that only two units are in a refurbishment state at any point in time, resulting in a total refurbishment outage window of 88 months for the 4 units with 144 actual outage months.

OPG has pursued increased fuel channel life for both Pickering and Darlington through the Fuel Channel Life Management Project with the aim of developing high confidence in the fuel channel service lives. CNSC approval has been sought during Darlington's licence renewal to extend the lives of the fuel channels beyond the nominal life of 210,000 EFPH to 235,000 EFPH. The CNSC is expected to approve the fuel channel life extension in conjunction with the Darlington licence, by the end of 2015.

In June 2013, based on improving confidence in the life of critical components at Darlington and the expectation of positive results from the FCLE project, management recommended the removal of the overlap of the first and second refurbishment units. This resulted in an opportunity to maximize the value of the asset and to smooth overall rate impact while mitigating execution risk of the DRP. This was approved by the CEO and forms the base planning assumption for this Business Case.

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

The high confidence schedule, as shown in Table 1 below, includes contingency for certain schedule risks that may be encountered during the execution of the refurbishment outages, and will form the basis of program controlled schedule contingency. The high confidence duration for each unit is 37 to 40 months.

Table 1: Refurbishment 4-Unit HIGH Confidence Project Schedule

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

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

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

Scoping

A Program Scope Review Board (PSRB) with supporting governance was put in place to approve the scope of the DRP. The technical scope for the DRP was initially confirmed in May 2012. Since that time, as a result of engineering studies and analysis, results of planned inspections, and completion

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of regulatory submittals including the Integrated Safety Review (ISR) and the Environmental Assessment (EA), scope has been finalized. A Change Control Board (CCB) with supporting governance has been established to manage cost, schedule and scope changes against approved baselines. If there is significant new or changed scope, approval will be required through the PSRB.

Contracting

A contracting strategy is the means for successful implementation of the project delivery approach for the major project work packages that make up the DRP. Each contracting strategy is free standing and takes into account factors such as the nature and scope of the work, the vendor marketplace, and any potential long term commercial arrangements. Each contracting strategy results in a recommendation on the most suitable sourcing approach, contract structure and pricing mechanism for that specific work package.

The DRP is a multi-phase project made up of individual projects of various sizes. As part of the Definition Phase, OPG developed an overall commercial strategy (the "Commercial Strategy") and separate contracting strategies for all major project work packages.

The Commercial Strategy sets out an overall commercial framework with guiding principles for establishing and maintaining commercial relationships with third parties to support the DRP.

The Commercial Strategy is a multi-prime contractor model in which there is more than one prime contractor working on the DRP. The owner has a separate contract with each prime contractor. Each prime contractor is responsible for the completion of the work under its particular contract, but not for the entire DRP. The owner is the integrator between the prime contractors and is responsible for the entire DRP. Under this model OPG retains project management responsibility and design authority for the DRP.

To execute the work, OPG retains a number of contractors who are responsible for major project work packages. To guide OPG in project oversight and contracting activities, OPG has engaged external technical and project management experts to assist with the overall project management.

The benefits of this model are that OPG retains control over the entire DRP, including the deliverables, costs and schedule. Retaining control by OPG is important given the scale, technical complexity and integrated nature of the DRP. OPG will also be able to assign risks to the party that is best able to manage the risk and mitigate its impact on the DRP. This will provide OPG with a better balance between the transfer of risk and the costs of the contractor services.

OPG considered a number of alternative commercial strategies, including multi-prime contractors, partnering, a lump-sum turnkey agreement and a project management organization arrangement.

Partnering typically contemplates a single agreement with a number of service providers (organized in the forming of a joint venture). However, OPG did not find this viable because of alignment issues between service providers, a loss of control related to the service providers and an unwillingness of service providers engage in this structure.

OPG found that although there was price certainty in a lump sum turnkey strategy, it came at a cost including loss of control of design, schedule and management of key aspects. Additionally, the risk premium was out of proportion to the corresponding transfer of risk since various exclusions or force majeure provisions diminished the transfer of risk.

Under the project management model, one firm would be responsible for planning the project, negotiating requirements and managing the work packages. Although this provides the owner with project management experience, there can be lack of alignment between the project manager, owner and contractors, particularly if the project manager was also participating in completing an aspect of the project. There would also be a risk premium factored into the arrangement.

In examining the alternatives, OPG took into consideration lessons learned from other nuclear refurbishment projects such as the consequences of schedule slippage and replacement power where a lump sum turnkey agreement was used. Another lesson learned is a mid-project

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commercial strategy change (i.e. the abandonment of the project management model and the adoption of the multi-prime model).

Engineering

From 2008 to 2011, Engineering completed a detailed set of component condition assessments (CCA's) in order to determine preliminary scope for the project. Since that time, some CCA's have been further developed, and engineering studies have been completed in order to finalize DRP scope.

By mid 2014, over 180 owner-specified modification design packages (MDP's) had been prepared. These MDP's define the scope requirements and are provided to the major project contractors in order to perform detailed engineering. As of September 30, 2015, detailed engineering was completed on over 200 engineering change (EC) modification packages by the major project contractors. Owner Engineering, as the Design Authority, is working collaboratively with the contractors to ensure requirements are understood, while providing oversight of all engineering deliverables being prepared by each contractor working on the DRP.

Substantial completion of detailed engineering 14 months in advance of the start of unit 2 refurbishment was central in the development of the high confidence RQE, and supports downstream procurement and work planning activities that are occurring during the preparation for Execution Phase.

Cost Recovery and Financing

Cost recovery and financing confirmation is underway; however, is not currently in place. OPG will recover prudently incurred costs via the Ontario Energy Board (OEB) rate approval process (O. Reg. 53/05) once the units are refurbished and returned to service. The risk is that there is no assurance that all costs are recoverable through this process.

OPG continues to discuss with the Province the need for greater assurance of cost recovery and has suggested regulatory changes to facilitate this. The Province continues to support the DRP which has also been endorsed by the Long Term Energy Plan .

b. **Major Projects**

Re-tube & Feeder Replacement

The R&FR work package determines the DRP's critical path. This work package includes the removal and replacement of each reactor's 480 pressure tubes and calandria tubes, and the removal and replacement of the 960 feeder pipes in each reactor.

OPG initiated the R&FR contracting process in 2010 by issuing a request for expressions of interest. OPG received submissions from seven potential contractors. Based on the responses received, pre-qualification of the potential contractors, and the subsequent partnering by potential contractors, OPG issued a Request for Proposal (RFP) in March 2011. Responses to the RFP were received on June 26, 2011. OPG continued negotiations with two proponents in an effort to reach acceptable commercial terms. OPG then required each proponent to submit their final proposals based on the negotiated terms. The SNC/AECON consortium was selected and OPG executed a final agreement with the consortium on March 1, 2012.

The contracting strategy selected by OPG for the R&FR work package includes an Engineering, Procurement and Construction (EPC) arrangement that combines fixed/firm pricing for known or highly definable tasks and a target price for the remaining scope of the R&FR work package where work is less definable. The work is phased with a project schedule comprised of a definition phase, an execution phase and a commissioning phase.

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During the definition phase, OPG and its selected contractor completed the detailed design of the project, procured long lead materials, fabricated long lead components and tools, tested the specialized tooling and completed final planning activities. At the conclusion of the definition phase, a 4 unit cost and schedule was developed and the Execution Phase target price to complete the execution phase work with upper and lower cost sharing bands was achieved. Financial incentives also exist for early completion of each unit outage, and financial penalties exist for failure to complete unit outages within the agreed upon schedule.

Since the contract award, the R&FR work program has progressed in three main areas:

1) R&FR Mock-ups

   A full scale reactor mock-up is in-service at the Darlington Energy Complex. 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 re-tube tooling platforms. The mock-up will be used to train workers, providing predictable execution phase performance.

2) R&FR Tooling

   The manufacturing of all prototype tools is complete and all tooling has been tested. Test times were used to develop a reliable critical path schedule and comprehensive risk register. Tool testing in the reactor mock-up has resulted in costs being avoided if the issues experienced in the mock-up occurred during actual field execution. The total estimated improvement over other refurbishment projects which did not have a reactor mock-up is expected to be in excess of $100M while providing both cost and schedule predictability. Manufacturing of the production tools is in progress with all tool sets scheduled for delivery mid 2016.

3) Execution Phase Planning

   Detailed Engineering for station modifications required to execute the R&FR work program is complete. All long lead material including pressure tubes, Calandria tubes, fuel channel end fitting assemblies, feeders and re-tube waste containers is either in production or complete for Unit 2.

Turbine Generator

The Turbine Generator Project consists of (i) inspections, repairs and replacement of specific components of the four Turbine Generator sets and their auxiliaries; and (ii) upgrades to the steam turbine control and generator excitation systems from analog to a digital platform. The turbine generator sets are highly specialized machines designed and manufactured to order specifically for Darlington by BBC Brown Boveri Canada Inc. A series of corporate mergers and acquisitions resulted in Alstom Power & Transport Canada Inc. (Alstom) becoming the Original Equipment Manufacturer (OEM).

This work package was divided into two contracts. The first contract for Engineering Services and Equipment Supply was awarded as a single source contract to Alstom on March 27, 2013. Since the original design was specifically for Darlington and given the technical complexity of the work, the single source strategy was selected to ensure that no technical or operational risks were introduced as a result of component replacements and converting from analog to digital turbine and excitation control systems. Operating experience across other major refurbishments has shown that the OEM is the only provider capable of ensuring the compatibility of the new systems to existing equipment. A complete steam path retrofit is not being undertaken since the Turbine Generator sets are in excellent condition and have performed extremely well over the years, and replacement is not required. As a result, the OEM provides the consistency needed to ensure compatibility.

To date, all design packages for the Turbine Generator control system upgrade, as well as other mechanical upgrades, are complete.

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A contract for the scope of the work required in the field for installations, repairs and replacement of equipment and components, and engineering integration of the OEM equipment with the OPG Engineering Change Control process, was awarded to SNC-Aecon Joint Venture on February 6, 2014.

Procurement of OEM material and completion of comprehensive work packages is in progress and execution for pre-requisite work has commenced.

Fuel Handling

The Fuel Handling work package has two distinct areas of work: (i) defueling of the reactor core; and (ii) refurbishment of the fuel handling equipment.

Defueling is a critical path element for each unit's refurbishment as it involves the removal of all irradiated fuel from each reactor prior to each refurbishment outage. No other refurbishment work can occur until the unit is defueled. The defueling work will include field and non-field work. All defueling field work will be done by OPG. Defueling non-field work involving engineering, manufacturing and technical support will be done by a third party.

The Darlington fuel handling system was designed and manufactured by GE-Hitachi Nuclear Energy Canada Inc (GEH-C). GEH-C, as the OEM, has provided OPG with fuel handling related equipment, components and services including test facilities, systems engineering, and materials and troubleshooting support for over 30 years. Engaging a supplier other than the OEM would introduce integration, compatibility, operational and nuclear safety risks. The contracting strategy selected to mitigate these risks was to single source the supply component and equipment related to defueling, along with the technical experts required to support OPG during the defueling operations, to the OEM.

The non-field related work is being performed under an Engineering Services and Equipment Supply contract which was issued to GEH-C on May 17, 2013. The contract is made up of firm/fixed price for components and equipment and a cost reimbursable element for technical support during the defueling operation.

To date defueling prototypes, including the Universal Carrier, New Fuel Transfer Equipment, Flow Restrictive Outlet Bundles, and Dummy Fuel bundles have been designed, developed, manufactured and tested. Simulations were conducted to demonstrate that the new components met the design intent .

All commissioning of the Defueling equipment at the Darlington Fuel Handling Rehearsal Facility was completed in September 2015. The tool trials were successful and on-reactor trials are scheduled for spring 2016.

A defueling readiness plan has been developed which outlines all the required activities that need to be completed to ensure the project team and the equipment are ready to defuel at the start of the Refurbishment outage.

The second work area of Fuel Handling is refurbishment of the Fuel Handling systems. The work for the Fuel Handling System has been divided into 6 work packages. As part of the 2013 Darlington Scope Review, a portion of the scope has been transferred to the Darlington Station to be performed as part of the stations Fuel Handling Reliability project.

The Fuel Handling project includes the refurbishment of the Powertrack, replacement of all Irradiated Fuel Bay Heat Exchangers and replacement of the reactor area bridge and carriage. To date the Fuel Bay Heat Exchanges are complete and work planning for the Powertrack is in progress.

Steam Generators

The Steam Generator work package consists of major inspections and maintenance work to extend the life of the Steam Generators for an additional 30 years. There are a number of aspects including chemical cleaning of the inside of the Steam Generator tubes, augmented inspection and repairs, leakage measurements, and water lancing each steam generator.

After evaluating the work and other contracting considerations, OPG decided to bundle all of the Steam Generator Work into one work package to be competitively bid. OPG considered various contracting models and determined that the Steam Generator work package fit well into an EPC contract. As a result, an EPC contract was awarded to the joint venture of Babcock & Wilcox Canada and Candu Energy Inc. on December 17, 2013.

All detailed design for the primary side cleaning is complete and full mock-up testing on the primary side cleaning optimization has been conducted.

Balance of Plant

Balance of Plant work represents the remaining work to be performed by the DRP that is not included in one of the above major packages. It includes work required to isolate the refurbishment unit from the remaining operating units, shutdown and layup unit systems to maintain protected environment, provide services to support field work during execution, and the remaining modification and repair work that is not included in the major packages above.

As a result of the Darlington Scope Review, the Balance of Plant project scope has gone through extensive challenges to ensure that the correct work is being performed during refurbishment.

Detailed design is essentially complete for the Balance of Plant project, and execution phase planning is underway.

c. **Prerequisite Projects**

Darlington Energy Complex

Lessons learned in previous refurbishments and other nuclear projects have shown that the use of equipment mock-ups, replicas and models for training is effective for the successful execution of complex projects. Accordingly, a decision was made to design and build multiple mock-up models in preparation for the refurbishment of the Darlington reactors. The Darlington Energy Complex (DEC) houses a full-scale reactor mock-up, other key mock-ups, and a training center for both the DRP and the Nuclear Operations organization. Workers will be trained on the mock-ups and tested on new tooling in the DEC prior to working on the reactor face. Additionally, the DEC includes office space and a warehouse for the storage of tooling and materials to be used in the training center. The project was placed in-service in June 2013.

Darlington Water and Sewer

The Water and Sewer project will ensure adequate and reliable domestic and fire water supply and sanitary sewer system capacity in support of the new Refurbishment support facilities, as well as continued operation of the station for an additional 25 to 30 years.

Execution of the west pumping station and installation of related water/sewer distribution lines to support Refurbishment facilities is complete. Demolition of the existing Sewage Treatment Plant is underway and the water/sewer main is now in service.

Heavy Water Storage and Drum Handling Facility

The Heavy Water (D2O) Storage and Drum Handling Facility project will provide heavy water storage capacity during refurbishment and support ongoing station operations. This storage capacity is needed for the heavy water removed from the reactors being refurbished (approximately 1,500 m3, per unit) and to facilitate flushing and other support operations associated with the preparation of the Darlington units for refurbishment work. The project will also implement improvements for heavy water management at the Tritium Removal Facility (TRF) including increasing operational storage; adding D2O drum handling, cleaning, testing, and storage capability; and offices for TRF staff.

The project is currently in the construction phase. Excavation is complete and concrete placement is underway.

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Darlington Operations Support Building Refurbishment

The purpose of this project is to extend the life of the Operations Support Building (OSB) to support the continued operations of the Darlington station. The OSB houses technical services that are essential to the operations of Darlington including security systems, site IT and telephone network hubs, quality assurance vault, station domestic water piping and safe access to the powerhouse via the bridge. This facility also provides office and conference room space for 375 station employees and various specialty groups inside the Darlington protected area.

The structure is now complete and in service.

Refurbishment Project Office

This facility acts as a secure entry point for Refurbishment workers and provides office space, a lunchroom, change room and parking space.

The full occupancy permit has been received, and move-in plans are being prepared for occupancy by year end 2015.

Electrical Power Distribution System

Electrical power from the grid is supplied to Darlington site facilities and buildings located outside the protected area by a feeder line from Hydro One's Wilson Transformer Station. This system was designed and installed 25 to 30 years ago, and had reached the end of its operational life. Capacity in the old system had diminished due to growth in electricity demand resulting from the addition of several new buildings on site. The performance and reliability of old system had gradually degraded over time and was not capable of supplying power to the new buildings needed to support Darlington Refurbishment and operations.

The site power distribution system was upgraded to meet the incremental demands of the new building/facilities, as well as to facilitate the supply of reliable electrical power to the existing and new buildings at the Darlington station. The upgrades included refurbishment/overhaul of the two old power distribution substations and construction of a new power distribution substation and associated distribution system.

The project is now complete and in service.

Re-tube & Feeder Replacement Island Support Annex

To provide office and meeting space for R&FR Contractor Management and OPG oversight teams, a facility is being constructed that will include shop space for contractors to perform pre-RFR fabrication and preparatory work activities.

Construction of the facility is nearing completion and is expected to be in-service in November 2015.

Vehicle Screening Facility

A facility was constructed to expedite vehicle traffic through security into the plant to enable higher priority vehicles to bypass traffic queues on the access road during periods of high construction traffic volume.

This project is complete and in service.

Re-tube Waste Processing Building

This facility is required to process waste in support of the R&FR project. Construction activities are underway and the facility is expected to be in service in December 2016.

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d. **Regulatory Projects**

Environmental Assessment

The EA Screening Report for the project was submitted to the CNSC on December 1, 2011. The CNSC released its decision on the EA on March 14, 2013. The overall finding of the CNSC is that the project will not result in any significant adverse environmental effects given the proposed mitigations.

Integrated Safety Review

The Integrated Safety Review (ISR), which assesses and documents key safety factors against modern codes and standards, was submitted to the CNSC on October 27, 2011. The CNSC issued their assessment of the ISR on July 5, 2013. The assessment concluded that the ISR meets applicable regulatory requirements.

Integrated Implementation Plan and Global Assessment Report

OPG has prepared the Global Assessment Report and Integrated Implementation Plan (IIP). The IIP revision was submitted to the CNSC in March 2014 has been accepted. This is included in the licensing application for the DRP. The licence renewal hearings were completed in November 2015, with approvals expected by year end. The new licence will allow OPG to execute the refurbishment and continue to operate DNGS for an additional 30 years assuming all licence conditions and regulatory obligations are met.

e. **Safety Improvement Projects**

Powerhouse Steam Venting System

This safety improvement project is a DRP EA commitment to the CNSC and is to be in-service prior to the first unit refurbishment. The project will improve the reliability of powerhouse venting and preclude vulnerability to common mode failures. Secondary side piping failures (e.g., steam, feed water, condensate and heating system piping breaks) may result in harsh environmental conditions that may impact safety-related systems, structures and components.

Commissioning of Units 1, 2 and 4 are now complete and in-service. Unit 3 installation is in progress and completion is expected by the end of 2015.

Containment Filtered Venting System (CFVS)

This project includes the installation of a new, manually initiated, filtered, containment venting system for Beyond Design Basis events of containment boundary. The system is designed in combination with the Shield Tank Overpressure Protection project to protect containment boundary from overpressure and to filter any releases from containment boundary.

The project is currently in the construction phase and is expected to be complete in August 2016.

Fire Water and Emergency Cooling

In order to meet fire water and emergency cooling requirements of the EA, Line 60 (part of emergency service water lines) was replaced. This project is now complete and in-service.

3rd Emergency Power Generator

This safety improvement project is a DRP EA commitment to the CNSC and is required to improve availability and reliability of the Emergency Power System.

The project involves installation of a third Emergency Power Generator (EPG) that can withstand a higher level seismic event than the Design Basis Earthquake to which the existing two EPGs are designed, and that can operate following a severe site flood. It will also address availability in cases where either one of the EPGs fail or where one of the two EPGs requires maintenance and the second EPG fails.

In addition, the third EPG is one of a suite of modifications required to support safe plant operation during Darlington Refurbishment. These modifications will allow for the removal of support services as needed to perform refurbishment activities.

The project is currently in the construction phase. Placement of the basement wall concrete is underway and the foundation to support generator placement is expected to be complete in December 2015. The third EPG is expected to be placed in-service in 2016.

Shield Tank Overpressure Protection

A requirement of the EA is the installation of a Shield Tank Overpressure Protection device to control pressurization of the shield tank during a beyond design basis accident. The Project will be installed on Units 1, 3 and 4 during planned unit outages and on Unit 2 during Refurbishment.

4. ALTERNATIVES AND ECONOMIC ANALYSIS

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

Management had also revised the overall timeline and release strategy for the DRP, with the submission of the RQE in November 2015, and a first unit refurbishment start date of October 2016.

An updated BCS was produced in November 2013 to reflect the then current knowledge and understanding of the DRP and to reflect additional experience from other refurbishment projects. In the 2013 BCS, management reviewed the economics of several alternatives, including:

Alternative 1: Approve the strategic schedule to refurbish Darlington units starting in October 2016, with the first and second unit execution overlaps removed – RECOMMENDED.

Alternative 2: Retain the original schedule of refurbishing the Darlington units starting in October 2016, with all 4 units overlapped as before – NOT RECOMMENDED.

Alternative 3: Delay the approval of continued work in the Definition Phase of the DRP by one or more years – NOT RECOMMENDED.

Alternative 4: Abandon the DRP and do not Plan to Refurbish Darlington – NOT RECOMMENDED

Management recommended Alternative 1. An economic assessment showed that this alternative would be more economical to the Ontario system than the previous overlapped alternative provided that the Darlington units could be operated to 235,000 EFPH, thereby limiting the risk that any one of the units would incur “idle time” prior to the start of its refurbishment outage. Since 2013, management has worked to establish contracts, develop the RQE and in place the required infrastructure to enable only this alternative. Through regular briefings, management has kept the Board and the Ministry of Energy informed regarding progress on this alternative. Therefore, management does not propose to analyse other alternative schedule options in this BCS.

Pursuit of the recommended alternative has positioned OPG to be ready to execute a successful refurbishment of the first Darlington unit starting in October 2016, by ensuring that the Definition Phase of the DRP was focused primarily on readiness of the first unit, by applying operating experience/lessons learned of other refurbishments, lowering overall execution phase risk on the first unit and providing opportunities to apply lessons learned on the first unit to subsequent units.

The execution schedule for this alternative is described in Section 3.0 of this BCS. To enable this alternative, the Fuel Channel Life Extension Project was implemented with a goal to achieve high confidence in fitness-for-service of the fuel channels to 235,000 EFPH. In June, 2015, the CNSC concurred with OPG’s assessment that OPG’s programs, including its life management plan and plans for continued inspection, surveillance examination and testing, on-going research and development, and

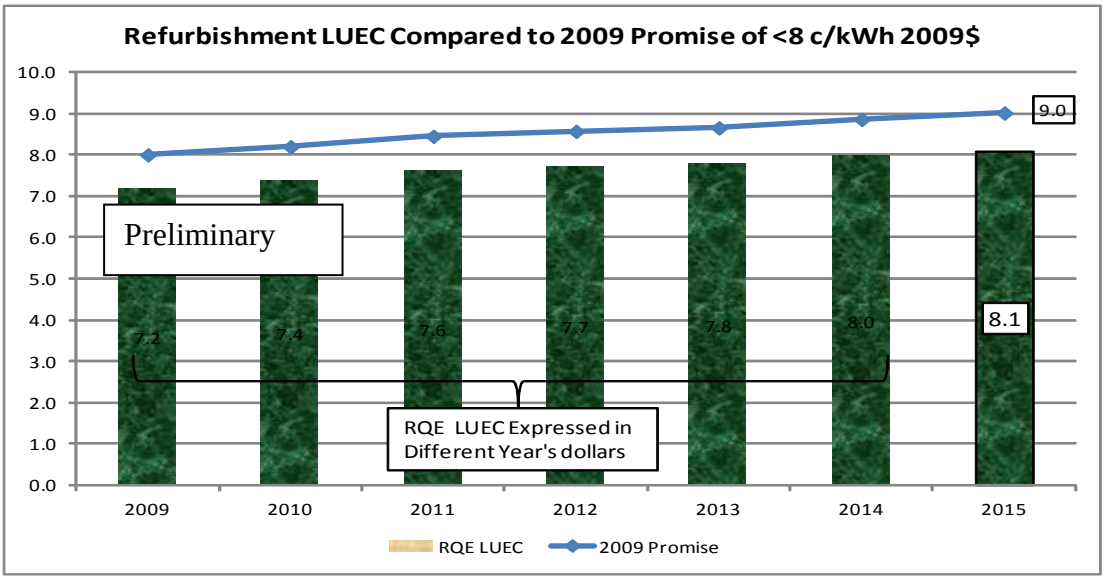
mitigation options in place, were adequate to support the safe operation of fuel channels for the pre-refurbishment life of Darlington of 235,000 EFPH.

Updated LUEC Estimate

The economic assessment has been updated to reflect the RQE of $10.4B for DRP or $12.8B including capitalized interest and future inflation.

At a cost of $10.4B (2015$), the LUEC of refurbishing and continuing to operate the Darlington units for a further 30 years is estimated to be 8.1 ¢/kWh (2015$), based on a high-confidence estimate of the DRP and of the post-refurbishment operating costs and performance. In 2010, OPG had publicly communicated that the economic LUEC would be less than 8 ¢/kWh in 2009$, which is equivalent to 9.0 ¢/kWh in 2015$. Thus OPG's current LUEC estimate for Darlington is well within the bounding LUEC estimate which OPG had publicly communicated in 2010. Figure 3 below illustrates.the comparisons that the current 2015 LUEC estimate is well below the target LUEC announced in 2010 adjusted for inflation.

Figure 3: RQE LUEC Compared to 2010 Target of Less Than 8 ¢/kWh 2009$



Other considerations which contribute to and support the favourable economic assessment for refurbishing the Darlington Station include:

- The use of an existing generation site with a proven environmental record and a supportive host community avoids the additional costs to OPG (and ratepayers) of site selection, securing environmental approvals and development of host community support at an unproven green or brown field site. It also avoids the additional costs to ratepayers of establishing a new transmission infrastructure.

- It is estimated that approximately 2,000 direct jobs are created during the Program Definition and Execution Phases. Continued Operation of the Darlington Station (post-refurbishment) will maintain the same level of employment as is currently associated with the Darlington Station for an additional 30 years. Economic impact studies indicate that post-refurbishment operations of the Darlington Station will result in approximately 5,700 resident jobs in Durham Region (direct, indirect and induced).

The future operating costs and performance of Darlington are a significant aspect of the economic assessment. An updated analysis has been completed of past performance in order to forecast the

expected capability factor for the Darlington units in the post-refurbishment period. An average capability factor of 88% continues to be used in this economic assessment with a range of 83% to 93%. Given the historical performance and detailed analysis of likely future performance, there is high confidence in achieving this average capability factor over the post-refurbishment life of the station. This average performance includes allowances for a "break-in" period immediately following the refurbishment outages on each unit and an allowance for aging as the units approach the end of the post-refurbishment lives.

Table 2 below summarizes the key post-refurbishment costs and performance assumptions used in the economic assessment.

Table 2: Darlington Post-Refurbishment Costs and Performance Forecasts

Post-Refurbishment Operations Estimates	Average Station Cost / Yr (2015 $M)	Comments
Annual Direct Station Costs Post-Refurbishment(1)	575	Developed from the long-term forecasts, informed by historically achieved costs and detailed forecasts of station and sustaining projects costs, including allowances for increased maintenance with age
Annual Support Costs Post-Refurbishment (2)	475	Derived from the Long-Term Outlook and reflects losses of economies of scale associated with the shutdown of Pickering
Plant Performance Post Refurbishment (Capacity Factor)	88%	Range is 83%-93%. Performance has been 89.4% for the past 10 years; and 89.5% over the past 5 years. The station's performance since in-service has been 84.8%.

(1) Major costs only. Excludes fuel and fuel-related cost, Minor Fixed Assets, Property Taxes, etc. However, these costs are included in the development of the LUEC estimate.

(2) Annual Support Costs shown exclude past-service Pension and OPEB costs which are not related to the economic LUEC of the Darlington station.

Figure 4 below shows the components which make up the current estimate of the LUEC in 2015 ¢/kWh, utilizing the RQE of $10.4B (2015$) and the assumptions regarding post-refurbishment operations costs shown in Table 2. The DRP contributes 3.3 ¢/kWh ($2015), including 0.85 ¢/kWh for DRP costs to-date, to the LUEC estimate, and the post-refurbishment operations and support costs necessary to run the plant, including fuel, contribute to the remaining 4.8 ¢/kWh to the total LUEC of 8.1 ¢/kWh (2015$).

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

Typically, an economic LUEC includes only costs that are "not committed", i.e. can be avoided if the DRP were not undertaken. It should, therefore, not include any "sunk" costs. However, OPG has chosen to include the "sunk" refurbishment costs to the end of 2015 ($2.2B), which contribute 0.85 ¢/kWh, in order to ensure that the complete cost picture of LUEC is provided.

The "going forward" LUEC of 7.2 ¢/kWh (2015$), represents an economic LUEC at the current time, as this LUEC estimate includes only the incremental costs which would be incurred from 2016 onwards as the project proceeds.

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY

Figure 4: Darlington Refurbishment LUEC Components

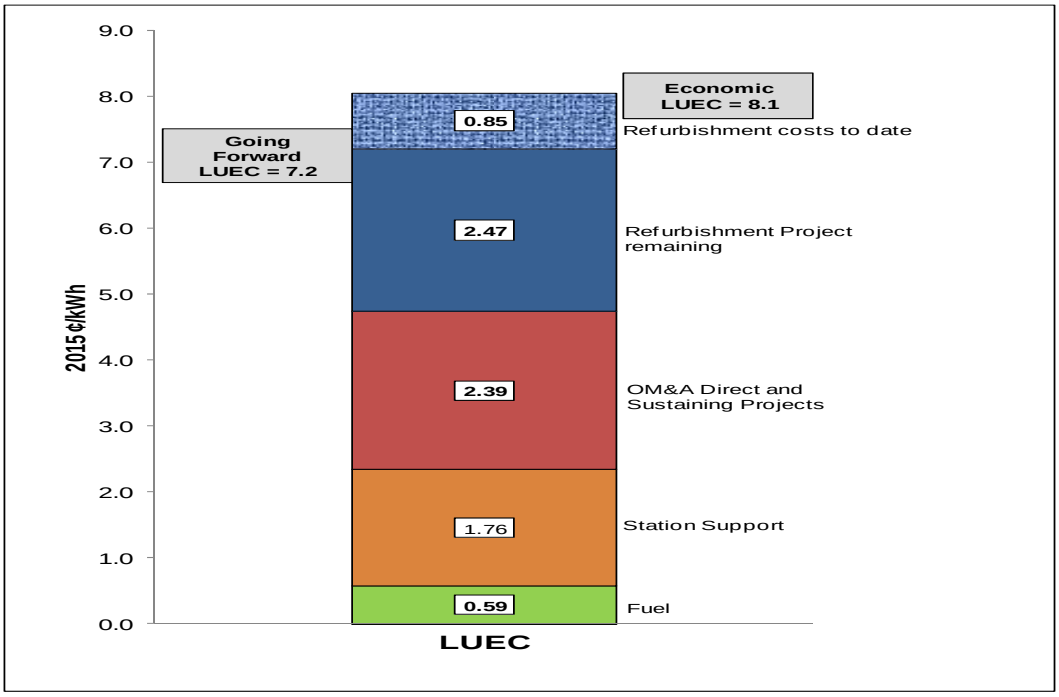
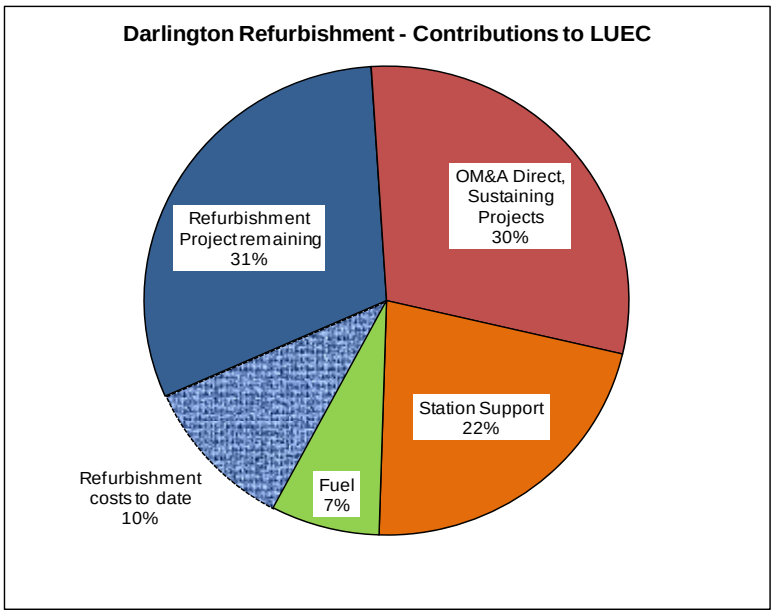


Figure 5 shows the percentage contributions of each of the cost components to the LUEC. The DRP makes up 40% of the LUEC, direct Station OM&A, sustaining projects and station support make up 53% of the LUEC, and fuel costs make up 7% of the LUEC.

Figure 5: Darlington Refurbishment Levelized Unit Energy Cost – Major Components



DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY

Figure 5 highlights the importance of ensuring that, in addition to delivering the DRP on time and on budget, it is critically important for OPG to ensure that post-refurbishment, the station performs to a high level and that the direct and support costs are contained within forecast amounts.

On the basis of the updated economic analysis which continues to show the DRP as economic, management recommends proceeding with the expenditures in the preparation for Execution Phase of Unit 2 in 2016, leading up to a Unit 2 execution estimate in June 2016, and Board approval to begin the Unit 2 refurbishment outage in October 2016.

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY

5. THE PROPOSAL

Approve the continuation of the DRP, and the transition from the Definition Phase to the Execution Phase. This includes a release of funds for mobilization activities for the first unit until October 2016, and to complete other critical 2016 planned deliverables related to subsequent units.

Key deliverables to be completed in the Preparation for Execution Phase include:

- Procurement activities including the fabrication and delivery of reactor components for Unit 2
- Progression of refurbishment pre-requisite work including construction of facilities and infrastructure projects, safety improvement projects (e.g. 3rd Emergency Power Generator, Containment Filtered Venting System) and other pre-requisite work such as the Re-tube Waste Processing Building
- Execution of pre-breaker open work to support Refurbishment and Integrated Improvement Plan (IIP) commitments (e.g. unit islanding modifications, service modifications such as breathing air and temporary power, and turbine crane overhaul)
- Overall planning support to the projects including establishment of the construction organization, work instruction development and review, and permitry and radiation protection planning

Table 3 below, provides a summary of the key milestones leading to the Execution Phase.

Table 3: Overview of the DRP Key Milestones Leading to the Execution Phase

Key Milestone	Milestone Date
Detailed Engineering Complete	COMPLETE
Long Lead Material Identified	COMPLETE
Pre-requisite Work Scheduled	Nov 21, 2015
Work Protection Plan Complete	Dec 15, 2015
Integrated Implementation Plan Approval	Dec 31, 2015
Radiation Dose Plans Submitted	Mar 1, 2016
Field Constructability Reviews Complete	Mar 15, 2016
Work Assessment Complete	Apr 15, 2016
Work Permits Prepared – Segment 1	Jul 15, 2016
Schedule Revision 0 Issued	Jul 15, 2016
Construction Readiness Assessments Complete – Segment 1	Jul 15, 2016
Execution Phase Metrics Prepared	Jul 15, 2016
Unit 2 Execution Estimate Approved	Aug 12, 2016
Unit 2 Breaker Open	Oct 15, 2016

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY

6. QUALITATIVE FACTORS OR FACTORS NOT FULLY QUANTIFIED

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

- **CO2 Reduction**: Darlington refurbishment contributes to Provincial and Federal goals of reducing CO2 emissions from electricity generation. Assuming efficient gas-fired plants would replace Darlington if it were not refurbished, the refurbishment of Darlington would avoid approximately 330 million tonnes of CO2 emissions over the post-refurbishment life of the station.

- **Employment Impacts**: OPG is the largest employer in the Municipality of Clarington employing 2300 employees at the Darlington site, and 500 at the Darlington Energy Complex working on the DRP. Approximately 60% of Darlington's employees live in Durham Region. As of September 2015, over 800 employees are working at the Darlington site on Refurbishment preparations and 2,000 additional workers are expected at peak construction. Indirect and induced employment in Durham Region is expected to be 5,700 jobs.

- **Municipal and Property Taxes**: OPG pays approximately $4M per year in taxes to the Municipality of Clarington, shared with Durham Region and the school boards. OPG also pays an equivalent amount to the Provincial government for Darlington in the form of a "proxy tax".

- **Citizenship and Community Involvement**: OPG provides leadership to community organizations across Durham Region. In partnership with local communities and non-profit organizations, OPG delivers valuable programs for Durham families. OPG has contributed over $23M in community investment support in Durham Region between 1999 and 2011. In addition, OPG employees raise approximately $1M annually in Durham Region through the OPG Charity Campaign.

7. RISKS

A detailed risk register and a Risk Management Plan has been developed and issued for the DRP. Risks at both the project and program level are identified and mitigating actions are prepared to ensure that each risk is appropriately managed.

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

- **DRP Costs and Schedule:** There is a risk that, even with the contingency, there could be cost and schedule overruns. Given OPG's investment of $2.2B in Definition Phase and the level of contingency included in the RQE, Management believes that these risks are manageable within the current cost and schedule estimate. Insurance premiums of $116M are included in the estimate to purchase coverage to mitigate some of the financial risks; these cover Course of Construction-Property, Wrap-Up Liability, Marine Cargo and Advance Loss of Profit, Nuclear Energy Physical Damage-Property, and Delayed Start-Up.

- **Post-Refurbishment Station Performance:** An average station performance of 88% capability factor is assumed over the post-refurbishment life which is considered to be medium to high confidence as it is below the station's demonstrated performance over the past 10 years of 89.4%. Sustained past performance provides confidence that the post-refurbishment performance will be the same or better than the business case assumptions; however, execution of appropriate maintenance and life-cycle management programs during the life of the station to maintain the reliability, will be essential. The post-refurbishment costs include $4.4B ($2015) of ongoing sustaining investments to maintain the condition of the plant.

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

8. POST IMPLEMENTATION REVIEW (PIR) PLAN

Comprehensive Post Implementation Review (PIR) shall be carried out by an independent team prior to the commencement of the execution of the Unit 2 refurbishment. The independent team will be appointed and will include the independent oversight organizations as well as key OPG staff independent of the DRP. The PIR will review and confirm the following

1. Verify that the stated targets, milestones, and deliverables were achieved and confirm readiness to proceed to the execution of unit 2,

2. Make recommendations for the unit 2 execution, and,

3. Document the lessons learned for use in the subsequent stages of the project

The PIR should complete an independent and systematic evaluation of the work completed in the Unit 2 mobilization phase including the following:

- Review the completeness of the planning and readiness to execute activities that have been undertaken in the Unit 2 mobilization phase including the detailed Unit 2 schedule and estimate,
- Evaluate and report on the changes in the Unit 2 estimate against those documented in RQE, and assess impact on future units,
- Completion of Infrastructure required to be in place to support the unit 2 execution, including pre-requisite Facility and Safety Improvement projects as well as in-station facilities.
- Confirm the readiness of the organization to execute the refurbishment, including station support staff including the fuel handling organization,
- Review and confirmation of the regulatory strategy for the unit execution, and,
- Finalization of all reporting and metrics required to monitor the Unit 2 execution.

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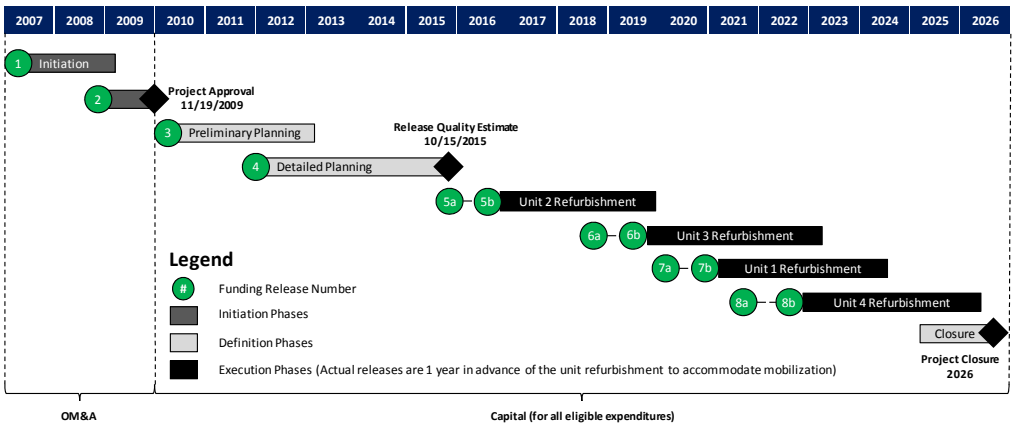
DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX A – RELEASE STRATEGY AND DESCRIPTION OF WORK PHASES

1. Overview of Release Strategy

Funding for the DRP will be released in phases using a gating methodology, i.e. the project cannot proceed from one phase to the next without completing certain deliverables.

The overall release strategy is described in Figure A1 below.

Figure A1: Overview of the Darlington Refurbishment Release Strategy



This release strategy is based on an October 2016 1st unit outage and incorporates an October 2015, 2015 RQE date in order to incorporate the results of R&FR tooling production test results into the overall baseline schedule in order to increase Management's confidence in the projects scope, cost, and schedule estimate at RQE.

For the Detailed Planning Phase of the project, the releases were sub-divided into annual release amounts, i.e. Release 4a for 2012, Release 4b for 2013, Release 4c for 2014, and Release 4d for 2015.

For the Execution Phase of the project, funding will be requested and released one year in advance of each individual unit outage to provide funding for mobilization of staff and to perform unit specific preparation including development of comprehensive work packages, unit specific planning and engineering, unit isolation and barriers preparation, and procurement of unit specific materials.

The sections below document the key deliverables for each release of the project. As the project progresses through the Planning Phase, further definition on deliverables and risks, may result in changes to timing and/or deliverables within each release, however, the phase-based gating methodology will be adhered to throughout the Darlington Refurbishment Project.

2. Project Phases

As described in Figure A1 above, the project has been divided into phases. A description of the deliverables for each phase has been provided.

Initiation Phase – Releases 1 to 2

The initiation phase included the following activities:

- Determine preliminary project scope through the completion of a Plant Condition Assessment (PCA) with a special focus on the life-limiting components, such as feeders and fuel channels.

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX A – RELEASE STRATEGY AND DESCRIPTION OF WORK PHASES

Studies were also conducted to assess the condition of all major station components, and methods and timing for carrying out the required refurbishment scope would be proposed.

- Planning for the ISR, including a review of modern codes and standards, and an EA.
- Assessed the various execution options (e.g., contracting, project management, work management, governance) for the Definition and Execution Phases of the Refurbishment Project, and recommended an execution strategy.
- Identification of an initial project organization for the Definition and Execution Phases.
- Developed a communication plan to ensure stakeholders are informed of OPG's Refurbishment Project and obtain their support for the decision.
- Developed Project Management support such as Project Controls, performance measures, schedules, risk and contingency processes, project metrics and reports.
- Developed a preliminary schedule and cost estimate for the refurbishment outages, and a Refurbishment Outage Preparation Plan that included both key and supporting scope (organization, infrastructure, oversight, plant and programmatic work, risk contingencies and allowances). Construction Islanding is a key study to determine the supporting scope.
- Prepared a recommendation with respect to proceeding to refurbish the Darlington station to OPG Senior Management, OPG's Board of Directors and Shareholders. Supported this recommendation through the completion of a BCS.

Definition Phase - Preliminary Planning – Release 3

The following key deliverables in the Preliminary Planning Phase have been completed.

- The project Management organization for the Definition Phase of the project has been put in place. The key roles on the project team include Engineering, Execution, Supply Chain, Contract Management, Managed Systems Oversight, and Project Planning and Controls. All positions report to the Senior Vice President of Nuclear Refurbishment who has the overall accountability to deliver the project.
- An overall contract strategy document has been developed and approved for the project. Additionally, contract strategy documents for each major work component, i.e. R&FR, Fuel Handling, Turbine Generators, Steam Generators, and Balance of Plant has been developed.
- The ISR final report, a required regulatory document that assesses and documents key safety factors against modern codes and standards, was submitted to the CNSC in October 2011. The CNSC issued their assessment of the ISR on July 5, 2013. The assessment concluded that the ISR meets applicable regulatory requirements.
- The EA Screening Report was submitted to the CNSC December 1, 2011. The CNSC released its decision on the EA on March 14, 2013. The overall finding of the CNSC is that the project will not result in any significant adverse environmental effects given the proposed mitigations. Both the Integrated Safety Report and EA are precursors for the CNSC approval of the Integrated Improvement Plan which will allow the project to proceed and the Darlington Station to be operated for an additional 30 years post refurbishment.
- Project controls governance and supporting tools, including cost management, scheduling, estimating, risk management, and change management have been implemented. Governance has been put in place, establishing the review and approval process for all major program scope and funding through the SRB and the Gate Review Board (GRB). The technical scope for the refurbishment project was finalized in 2011 and the SRB will continue to review and approve

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX A – RELEASE STRATEGY AND DESCRIPTION OF WORK PHASES

scope deletions and/or additions due to plant configuration, regulatory or code changes, on a reduced frequency for the duration of the project. Funds are released by the GRB, as projects proceed through each phase of the gate process.

- Labour strategies have been developed for the project with labour agreements in placed with Society. Additionally, in July 2011, OPG declared the Darlington Refurbishment Project a "Rehabilitation" project which invoked the Chestnut Park Accord Agreement. Subsequently, the committee has reviewed and assigned approximately 90% of the craft work to the Building Trades Union (BTU) with approximately 5% assigned to the Power Worker's Union and another 5% to be determined.
- An organizational "strong project matrix" model has been deployed for the Refurbishment Project. The model is in the process of being implemented. Staffing guidelines recognizing the model and the fact that OPG will be performing oversight of Engineer, Procure, Construct (EPC) contractors have been established.
- The project economics and the BCS have been updated based on the latest known information.

Definition Phase - Detailed Planning – Releases 4a to 4d

The Definition Phase - Detailed Planning work program includes the following activities:

- Completion of all Outage preparation plans and unit pre-requisite work, including infrastructure and facilities required to execute the Refurbishment as well as unit modifications to enable unit islanding and isolation.
- Finalization of all project scope and progression of engineering.
- OPG has prepared the Global Assessment Report and Integrated Implementation Plan (IIP). The IIP revision was submitted to the CNSC in March 2014 has been accepted. This is included in the licensing application for the DRP. The licence renewal hearings were completed in November 2015, with approvals expected by year end. The new licence will allow OPG to execute the refurbishment and continue to operate DNGS for an additional 30 years assuming all licence conditions and regulatory obligations are met.
- Orders for long lead items issued and delivery dates confirmed, where required.
- Contracts for Engineering, Detailed Planning and pre-execution outage work (i.e., development of mock-up and tooling for re-tube, awarded or partially released to key vendors).
- Establishment of an independent oversight process and assurance model.
- Update of the Program Business Case, with a full project cost estimate, and presented to Senior Management, the Board of Directors and Shareholder, with a project execution strategy recommendation, for approval.

Field Execution and Closeout Phase – Releases 5 to 8

The Field Execution and Closeout Phase will involve completion of all planned aspects of refurbishment and associated re-commissioning and re-licensing tasks.

Releases for subsequent units will be developed and approved throughout this phase.

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX A – RELEASE STRATEGY AND DESCRIPTION OF WORK PHASES

A Full Release BCS will be prepared for each of the subsequent units (2nd, 3rd, and 4th Units), including any updates to cost and schedule estimates, for each of these subsequent releases. Release 8, for the 4th and final unit, will include project closure costs.

Operations Phase

The Operations phase is the return to service of the units, starting around 2019, when the first unit refurbishment is complete.

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX B – SUMMARY OF ESTIMATE

ONTARIO POWER GENERATION	**PROJECT** **Summary of Estimate**	Date	November 14, 2013
		Project #	27959 (OM&A) 73010 & 73011 (Capital)

Facility Name:	Darlington Nuclear Station	
Project Title:	**Darlington Refurbishment Program** Release Quality Estimate	

Estimated Cost in M$

#	Bundle / Division	Forecast Spend, Life-to-Date @Dec 2015	Estimate-to-Complete	RQE Total Cost	%
1	Retube Feeder Replacement	652	2,947	3,598	23%
2	Turbine Generator	106	551	657	4%
3	Balance of Plant (1)	168	799	967	6%
4	Fuel Handling & Defueling	43	155	198	1%
5	Steam Generator	14	109	123	1%
6	**Subtotal Project Bundles (2)**	**982**	**4,561**	**5,543**	**36%**
7	Campus Plan - F&IP + SIO Projects (5)	628	217	845	2%
8	**Subtotal External Vendor**	**1,610**	**4,777**	**6,387**	**50%**
9	OPG Oversight & Project Support (3)	360	1,171	1,531	9%
10	OPG Operations & Maintenance	52	753	805	6%
11	**Subtotal OPG**	**412**	**1,924**	**2,336**	**18%**
12	**SubTotal before Contingency**	**2,022**	**6,701**	**8,723**	**68%**
13	Project & Program Contingency	26	1,680	1,706	13%
14	**Subtotal before Interest & Inflation**	**2,048**	**8,381**	**10,429**	**81%**
15	Interest (4)	159	1,314	1,473	12%
16	Inflation (4)	-	898	898	7%
17	**Subtotal Interest & Inflation**	**159**	**2,212**	**2,371**	**19%**
18	**Total High Confidence Estimate ($DOY)**	**2,207**	**10,593**	**12,800**	**100%**

Notes:
(1) Balance of Plant also includes Shutdown Layup, Specialized Projects, Refurbishment Support Facilities and Unit Islanding
(2) Bundle Projects include OPG Project Management
(3) OPG Oversight & Project Support includes Early Releases 3/4
(4) Interest & Inflation rates are based on current allocation rates provided by Finance
(5) F&IP = Facilities & Infrastructure Projects, SIO = Safety Improvement Opportunity Projects

Prepared by:	**Approved by:**
G. Rose Director, Planning and Control Nuclear Refurbishment	**D. Reiner** SVP, Nuclear Refurbishment

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX C – SUMMARY OF LUEC ASSESSMENT

1.0 Assessing the LEUC of the DRP and Continued Operations

In order to assess the LUEC of the DRP and continued operation of Darlington, the following key factors must be considered:

- Refurbishment Scope, Cost, Duration and Timing
- Expected Life of each unit post-refurbishment
- Forecast annual operating costs post-refurbishment, including Operation, Maintenance and Administration costs, On-going Sustaining Project (Capital & OM&A) costs, Outage costs, Fuel costs, Nuclear Waste Management and Decommissioning (Provisions) costs and Nuclear and Corporate Support costs.
- Forecast Performance post-refurbishment (annual capacity factor/capability factor).
- Economic Indices (e.g. labour and material inflation rates, appropriate discount rate)

The above factors can be used to determine the LUEC of the refurbished plant. There are other potential incremental costs or opportunities associated with a decision to go or not to go ahead, such as changes to the present value of the decommissioning liability or incremental transmission costs, which are applicable if one were to take a societal view of the costs and benefits of the project, which may also influence the ultimate decision.

The above items are discussed in more detail in the following sections.

1.1. Refurbishment Scope, Cost and Reference Schedule

1.1.1. Refurbishment Scope

As noted, the main scope of work during the refurbishment of each Darlington unit is the replacement of fuel channels (pressure tubes and calandria tubes) and feeder pipes (up to the feeder header). The refurbishment scope does not include replacement of the steam generators. The scope also includes provisions for outage support work (unit islanding, facilities, construction island barriers, heavy water management, and radioactive waste management). Given the detailed discussion of scope in the body of the BCS, no further discussion of scope is warranted in this Appendix.

1.1.2. Refurbishment Costs

In conjunction with scope development and definition, cost estimates for the DRP have now been completed to a RQE. As well, benchmarking has continued against publicly available costs of other CANDU refurbishment projects at Pt. Lepreau and the Bruce 1 & 2 Units and lessons learned from these projects have been incorporated into the DRP cost estimate.

The establishment of contracts for the major project bundles, such as F&FR, Fuel Handling, Defueling, Turbine Generator and Steam Generator has resulted in increased cost certainty. Updated estimates of Functional Groups have also been completed.

The Refurbishment Project costs and the cost flows which were utilized in the LUEC estimate are shown in Table C1 below.

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX C – SUMMARY OF LUEC ASSESSMENT

Table C1: Darlington Refurbishment 4-Unit Cost Estimate

		RQE Total Cost						
Bundle Name	% of Total Cost	Forecast Spend, Life-to-Date @Dec 2015 $ x 1000	Estimate-to-Complete Vendor / EPC $ x 1000	Estimate-to-Complete OPG O/S $ x 1000	RQE Total Cost $ x 1000	*Subtotals by Grouping*		
01 - RFR (Retube Feeder Replacement)	28%	651,651	2,839,288	107,283	**3,598,222**	***Bundles EPC + OPG O/S***		
02 - TG (Turbine Generator)	5%	105,946	519,634	31,569	**657,149**			
03 - BOP (Balance of Plant)	3%	76,436	275,049	78,531	**430,015**			
04 - FH (Fuel Handling)	1%	13,811	120,183	24,558	**158,553**			
05 - DF (Defueling)	0%	28,983	2,487	8,116	**39,586**			
06 - SG (Steam Generator)	1%	13,990	98,844	9,745	**122,579**	1.0	4.6	5.5
07 - SP (Specialized Projects)	1%	22,365	78,732	6,812	**107,909**			
08 - SL (Shutdown Layup)	2%	21,203	185,511	11,303	**218,017**			
09 - RSF (Refub Support Facilities)	1%	16,721	50,286	11,363	**78,370**			
10 - IL (Unit Islanding)	1%	30,829	84,198	17,220	**132,247**			
Subtotal Bundles	**43%**	**981,936**	**4,254,212**	**306,498**	**5,542,646**	***Campus Plan***		
11 - Campus Plan - F&IP	5%	484,045	155,765	*incl*	**639,811**			
12 - Campus Plan - SIO	2%	143,862	60,948	*incl*	**204,810**	0.6	0.2	0.8
Subtotal Campus Plan F&IP, SIO	**7%**	**627,908**	**216,713**	**-**	**844,621**			
Subtotal Bundles & Campus Plan	**50%**	**1,609,844**	**4,470,925**	**306,498**	**6,387,267**	***OPG Functional & Rel3+4 below***		
13 - Functions (excl O&M) - Project Execution	3%	9,513		312,042	321,555			
14 - Functions (excl O&M) - Contract Management	0%	9,510		42,241	51,751			
15 - Functions (excl O&M) - Engineering	2%	76,046		206,460	282,506			
16 - Functions (excl O&M) - Managed Systems Oversight	0%	14,265		26,660	40,925			
17 - Functions (excl O&M) - Planning & Controls	1%	62,140		74,021	136,161	0.4	1.2	1.5
18 - Functions (excl O&M) - Nuclear Safety	1%	35,232		47,880	83,112			
19 - Functions (excl O&M) - Program Fees & Other Supp	3%	21,178		319,597	340,775			
20 - Functions (excl O&M) - Supply Chain	1%	14,104		71,458	85,562			
21 - Functions (excl O&M) - Work Control	1%	8,617		70,890	79,507			
Subtotal Functions (excl O&M)	**11%**	**250,605**		**1,171,247**	**1,421,852**	***OPG Ops & Maintenance***		
22 - Functions (O&M) - OMA Training Program	0%	10,981		-	**10,981**			
23 - Functions (O&M) - Waste Disposal	0%	-		38,054	**38,054**	0.3	0.8	0.8
24 - Functions (O&M) - Ops & Maintenance	6%	41,492		714,533	**756,025**			
Subtotal Functions - Ops & Mtce	**6%**	**52,473**		**752,587**	**805,059**	***Early Releases***		
25 - Functional - Release 3	1%	101,651	-	-	**101,651**			
26 - Functional - Advance Release 4 (incl Eng'g Reactor)	0%	7,467	-	-	**7,467**	*included with Functions Subtotals*		
Subtotal Functions - Early Release Funds	**1%**	**109,119**	**-**	**-**	**109,119**			
Subtotal Before Contingency	**68%**	**2,022,040**	**4,470,925**	**2,230,332**	**8,723,296**	***Contingency***		
27 - Project & Program Contingency	13%	26,182	1,679,976	<-- incl	**1,706,158**	0	1.7	1.7
Subtotal Contingency	**13%**	**26,182**	**1,679,976**	**-**	**1,706,158**			
Subtotal before Interest & Inflation	**81%**	**2,048,222**	**6,150,901**	**2,230,332**	**10,429,454**	***$2015 Base Cost***		
28 - Interest	12%	**159,000**	1,313,844	<-- incl	**1,472,844**	**2.0**	**8.4**	**10.4**
29 - Inflation	7%	-	897,702	<-- incl	**897,702**			
Subtotal Interest & Inflation	**19%**	**159,000**	**2,211,546**	**-**	**2,370,546**	***Total $ (incl Inflation & Interest)***		
Total Cost Estimate (Expressed as Nominal $)	**100%**	**2,207,222**	**8,362,447**	**2,230,332**	**12,800,000**	**2.2**	**10.6**	**12.8**

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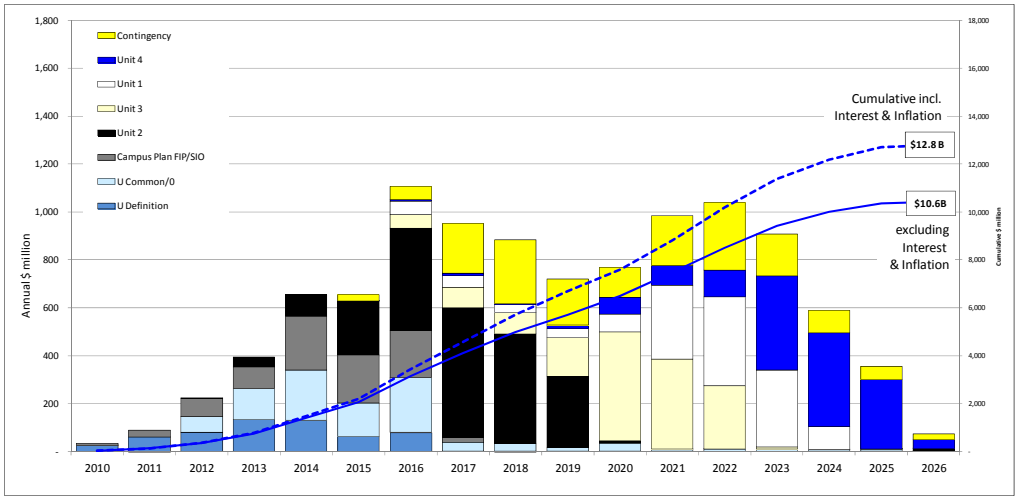
Figure C1 provides the anticipated cash flows for the DRP, based on the RQE in Table C1.

Figure C1: Darlington Refurbishment Program Anticipated Cash Flow



1.1.3. Project Risk Assessment and Contingency

OPG developed the DRP project estimate in accordance with the Association for the Advancement of Cost Engineering (AACE) estimate classification recommended practice and integrated its standard approach to engineering and work planning within the AACE practice.

Contingency is derived through a detailed evaluation of the estimate uncertainties (cost and schedule), discrete risks (cost and schedule), and contingent work across each project and the entire DRP. These inputs were loaded into a simulation model to assist in estimating contingency requirements in consideration of the risk and uncertainty profile presented. The outcome of this analysis yielded that, at 90% confidence, the estimate should include $1.7B (2015$) of contingency, as summarized in Table C2 below, by project bundle.

Table C2: 4-Unit Contingency Summary

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

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

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

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

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

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

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

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

1.1.4. Refurbishment Timing and Schedule

Timing of Unit Refurbishment Outages:

Several criteria are used to assess the optimum start dates for a Darlington refurbishment outage, including the life of major components (e.g. pressure tubes and feeders), lead times for key decisions (EA, ISR), lead times for critical path procurement activities (e.g. R&FR tooling), project preparation and planning efficiency and project execution efficiency. The overall assessment indicated that the optimum start date for the first Darlington refurbishment outage was 2016.

The refurbishment schedule considers a range of factors. Key considerations included minimizing refurbishment planning and execution risks while maximising the value of the asset to the Ontario electricity system prior to refurbishment, bearing in mind the expected operational lives of the units. If readiness to refurbish could not be achieved (e.g. lead time constraints have prevented the acquisition of necessary materials or tooling) before a unit reaches its operational end-of-life, there is a risk of idle time being incurred on the unit. On the other hand, operational life is forsaken when units are shutdown for refurbishment before they reach the limiting component end-of-life. Because the end-of-life dates of the

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four Darlington units would occur within approximately a 1- 2 year span, it is necessary to stagger the start dates of the refurbishments, thereby incurring some forsaken life on the earlier units to be refurbished), in order to minimize the risk of idle time.

OPG has pursued increased fuel channel life for both Pickering and Darlington through the Fuel Channel Life Management Project and Fuel Channel Life Extension Project with the aim of developing high confidence in the fuel channel service lives. The Fuel Channel Life Extension (FCLE) project included the objective of achievement of high confidence in 235,000 EFPH on the fuel channels at Darlington. As noted, in June 2013, based on improving confidence in the life of critical components at Darlington and the expectation of positive results from the FCLE project and the resulting opportunity this created to maximize the value of the asset and to smooth overall rate impact while mitigating execution risk of the DRP, management recommended and received CEO approval to remove the overlap of the first and second refurbishment units. In June, 2015, the CNSC concurred with OPG's assessment that its programs, including its life management plan and plans for continued inspection, surveillance examination and testing, on-going research and development, and mitigation options in place, are adequate to support the safe operation of fuel channels for the pre-refurbishment life of Darlington NGS of 235,000 EFPH.

Refurbishment Schedule

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

The high confidence schedule, as shown in Table C3 below, includes contingency for certain schedule risks that may be encountered during the execution of the refurbishment outages, and will form the basis of program controlled schedule contingency. This schedule will also be the basis for external communication and measurement. The high confidence duration for each unit is 37 to 40 months.

Table C3: Refurbishment 4-Unit HIGH Confidence Project Schedule

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

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

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

1.2. Post-Refurbishment Assumptions

To assess the LUEC estimate for the DRP and Continued Operation of Darlington, all future expected costs of operating the facility over its post-refurbishment life, as well as the expected operating performance of the plant and expected unit life must be forecasted.

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1.2.1. Unit Life

Since the Darlington units would have been in service for nominally 60 years by the end of their post-refurbishment lives, OPG has prudently utilized a conservative assumption of 30 calendar years for unit lives in the assessment of the economic LUEC estimate. This post-refurbishment calendar life took into consideration that based on the knowledge gained on pressure tube degradation mechanisms, future pressure tubes will be designed and operated to achieve longer service lives. Thirty calendar years, with an assumed 88% capability factor translates into a pressure tube life of approximately approx. 231,000 EFPH, which is well within the target OPG expects to achieve within the pre-refurbishment life, i.e. 235,000 EFPH.
This conservative life estimate mitigates the risk that unforeseen equipment issues could emerge which could bring about an earlier than expected end of post-refurbishment life.

1.2.2. Annual Station Operating, Maintenance & Projects Costs

Annual OM&A levels were derived based on levels in the current long-term outlook forecast, factoring in changes to work programs and approaches expected over the life of the units.

The post-refurbishment outage costs were developed based on expected work programs and outage templates as well as the long-term outlook forecast. Outage durations and costs were adjusted during the last 10 years of post-refurbishment life to reflect potential equipment aging-related driven need longer outage windows. Outage costs and durations include allowances for periodic 4-unit shutdowns for Vacuum Building Inspections.

On-going sustaining project expenditures (both capital and OM&A) were estimated based on the projected requirements given knowledge and age of the equipment as well as historical investment levels. The forecast also relied heavily on benchmarking Darlington's required investment against those of peer nuclear plants in the U.S (similar vintage, similar size). Given the level of investment during the refurbishment project on each unit, it was assumed that capital project investments, in the first year post-refurbishment, would be 50% of the "typical' annual capital investment level and would ramp up to 100% by the 6^{th} year. In the final 5 years of each unit's life, capital project investments are assumed to ramp down from 100% to 0%. Annual OM&A project investment levels are kept at the typical level throughout the life of each unit.

Table C4 below provides details on the assumptions used for these factors in the analysis.

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Table C4: Annual OM&A, Outages & Projects Costs Used in the LUEC estimate

Cost Factor	Post-Refurbishment Forecast Avg. ($M/yr; 2015$)
Station Base OM&A (1)	290
Outages OM&A (1)	140
Capital Projects & OM&A) (2)	110
OM&A Projects (2)	35
Annual Direct Station Costs (3)	575

Notes:
Costs are rounded to the nearest $5M.
1. Base and outage post-refurbishment forecasts are based on the long-term outlook, and include all Vacuum Building Outages and cost and scope adjustments as the units age. The Vacuum Building Outage Costs were normalized to reflect a planned VBO every 12 years.
2. Capital & OM&A project forecasts are based on the long-term outlook and include adjustments for losses of economies of scale upon the shutdown of Pickering and are informed by benchmarking against peer plants. Periodic major projects (e.g. facilities, security) are factored into the long-term projects forecast.
3. Major costs only. Excludes fuel and fuel-related costs, Minor Fixed Assets, Property Taxes, etc. However, these costs are included in the development of the LUEC estimate.

1.2.3. Annual Support Costs

Costs associated with direct and allocated support services are divided into Nuclear and Corporate Support. Examples of nuclear support include Nuclear Engineering, Fleet Operations and Maintenance and Inspection and Maintenance Services. Examples of Corporate Support costs include Finance, People and Culture, Business and Administrative Services, Legal Support and Commercial Operations and Environment, which includes Regulatory Affairs. In addition, there are centrally held costs, such as insurance premiums, pandemic provisions, past-service obligations for pensions and Other Post-Employment Benefits (OPEB) which are allocated to the Darlington station. Note that past service obligations for pensions and OPEB are costs to the ratepayer regardless of whether the Darlington station is refurbished or not, and, therefore, these costs are not considered in deriving the economic LUEC for Darlington Refurbishment.

Based on the following premises: a) that there are economies of scale in the provision of Nuclear and Corporate Support to a large fleet of stations; b) that there are some "centrally held costs" allocated by Corporate to each station that are purely "fixed", i.e. are not affected by a decision to continue or not continue to operate a station, it has been observed that, as the OPG nuclear fleet shrinks, losses of economies of scale result in an effective increase in the cost of providing Nuclear & Corporate support services to the remaining stations. Because it is assumed that the Pickering units will have already been shutdown by the time that the Darlington Station will be in its post-refurbishment period, Darlington's share of the Nuclear Support Costs and Corporate Support costs will come under upward pressure due to losses of economies of scale. This is evident when OPG's long-term outlook forecast is analysed.

The analysis of Darlington's LUEC estimate, therefore, reflects the expected losses of economies of scale in providing Nuclear and Corporate Support services following the shutdown of Pickering. Table C5 shows the support costs which were assumed in the assessment of the LUEC estimate.

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Table C5: Nuclear & Corporate Support Costs Used in the LUEC estimate Assessment

Cost Factor	Incremental M$/Yr, 2015$
Nuclear Support	**230** (1)
Corporate Support & Adjustments	**245** (1)
Total	**475** (1)

Note 1: Costs are rounded to the nearest $5M.

The overall post-refurbishment costs assumed, including the amounts in Tables C4 and C5, plus costs for Minor Fixed Assets and Property Taxes, but excluding fuel and fuel related costs, averages $1,070M (2015$) per year, or approximately $1.1B (2015$). This is the figure used on OPG's high confidence economic LUEC estimate.

1.2.4. Station Performance Assumptions

Over several years, OPG has developed and refined its estimate of the performance of the Darlington units in the post-refurbishment period. Numerous factors were considered including performance since in-service of the Darlington plant, specific contributors to incapability in the past and known improvements to maintenance and life cycle management programs. Recent (5-yr and 10-yr average) performance has been excellent, in the 85%-94% range, with the low year of 85% in 2009 coinciding with the periodic planned station shutdown for the vacuum building outage. Recent planned outage performance and forced loss rates (FLR) have also been very good. Darlington is a consistently a top-rated plant in peer reviews.

Factors considered in forecasting post-refurbishment performance include the following:

- Lifetime performance of the Darlington station has been 84.8% capability factor; last 10 years' performance has averaged 89.4% and last 5 years' performance has averaged 89.5%. Most recent year (2014) capability factor achieved was 91.4%.
- As part of the assessment for refurbishment, detailed plant condition assessments (PCAs) were completed. These PCAs have been reviewed and plans put in place to address findings, either pre-refurbishment, during refurbishment or post-refurbishment.
- Technical knowledge of equipment reliability issues, including component degradation mechanisms in CANDU reactors and the balance of plant, has improved dramatically over the past 5 decades of the CANDU program, leading to high confidence that there are fewer unexpected degradation mechanisms to be uncovered in the future.

These issues were discussed in meetings, including senior station personnel and members of the Nuclear Executive Team. The consensus was to assume a reference annual capacity factor of 88% but to analyze over a broad range as shown in Table C6 below.

Table C6: Performance Assumptions Used in the Updated LUEC estimate Assessment

Performance Factor	High Confidence	Medium Confidence	Low Confidence
Gross Capability Factor (%)	83%	**88%**	93%

The 88% capability factor is lower than Darlington's average performance for last 10 years, which was 89.4%, as well as past 5 year's performance of 89.5%. It is considered a high confidence estimate, given

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APPENDIX C – SUMMARY OF LUEC ASSESSMENT

the station's performance of over the last 10 years. The low end performance of 83% (which is 1.8% lower than the station's since-in-service performance of 84.8%) is a very high confidence estimate, but could result, for example, from a failure to effectively maintain the Integrated Aging Management Program (IAMP) and/or an inability to maintain the current 3-year outage cycle, both considered very low probability outcomes, given OPG's robust management system. An 83% capability factor would also allow for large outages for unforeseen major equipment maintenance during the post-refurbishment period, if necessary. The high end performance of 93% could be achieved if Darlington were to sustain 1st or 2nd quartile INPO performance, funding levels are maintained, the IAMP is effective, and the Management System and currently high Human Performance levels are maintained.

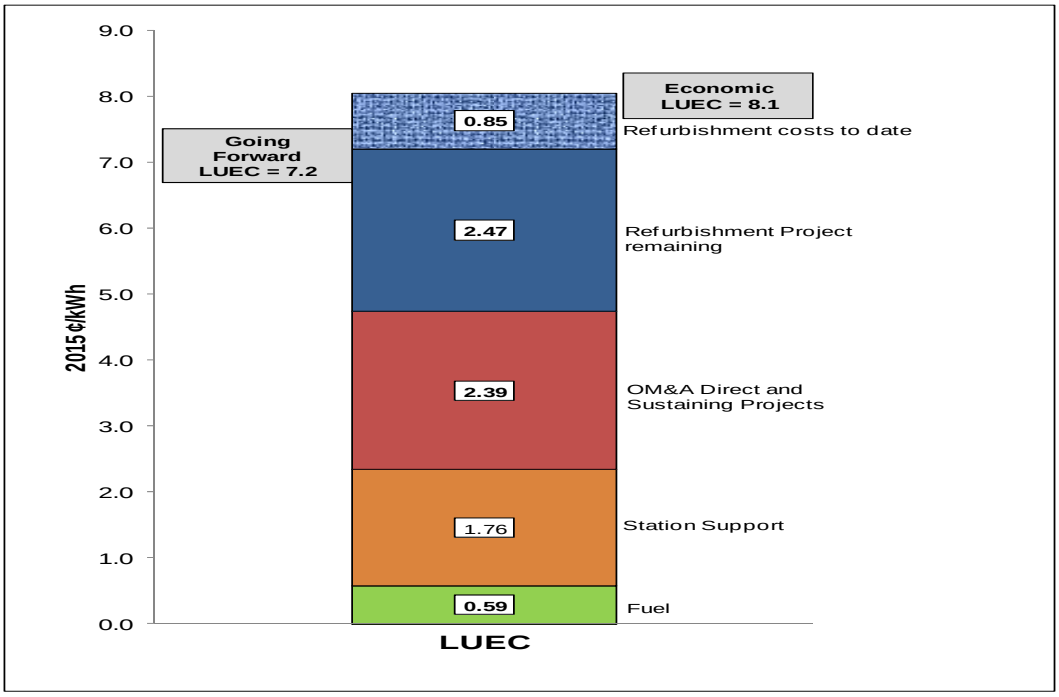
2.0 Results

The high confidence LUEC was calculated using the above assumptions and alternative scenarios and sensitivity analyses were run on lower/higher (more pessimistic/more optimistic) assumptions in order to assess the sensitivity of the results to the various input variables. These results are presented below.

2.1. Levelized Unit Energy Costs

Figure C2 shows the components which make up the current estimate of the LUEC in 2015 ¢/kWh, utilizing the RQE of $10.4B (2015$) and the assumptions regarding post-refurbishment operations costs shown in Table 2. The DRP contributes 3.3 ¢/kWh ($2015), including 0.85 ¢/kWh for DRP costs to-date, to the LUEC estimate, and the post-refurbishment operations and support costs necessary to run the plant, including fuel, contribute to the remaining 4.8 ¢/kWh to the total LUEC of 8.1 ¢/kWh (2015$).

Figure C2: Darlington Refurbishment LUEC Components



Typically an economic LUEC includes only costs that are "not committed", i.e. can be avoided if Darlington Refurbishment were not undertaken. It should, therefore, not include any "sunk" costs. However, OPG has chosen to include the "sunk" refurbishment costs to the end of 2015 ($2.2B), which contribute 0.85 ¢/kWh, in order to ensure that the complete cost picture of LUEC is provided.

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APPENDIX C – SUMMARY OF LUEC ASSESSMENT

The "going forward" LUEC of 7.2 ¢/kWh (2015$), represents an economic LUEC at the current time, as this LUEC estimate includes only the incremental costs which would be incurred from 2016 onwards as the project proceeds.

Figure C3 shows the percentage contributions of each of the cost components to the LUEC. The Refurbishment Project makes up 40% of the LUEC, Direct Station OM&A, Sustaining Projects and Station Support make up 53% of the LUEC, and Fuel costs make up 7% of the LUEC.

Figure C3: Darlington Refurbishment Levelized Unit Energy Cost – Major Components

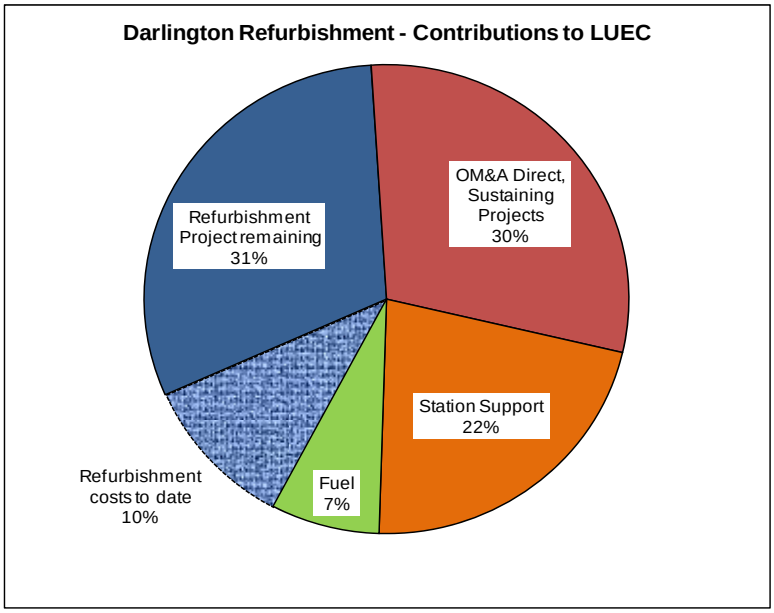


Figure C3 highlights the importance of ensuring that, in addition to delivering the Refurbishment Program on time and on budget, it is critically important for OPG to ensure that post-refurbishment, the station performs to a high level and that the direct and support costs are contained within forecast amounts.

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

2.2. Sensitivity of Results to Changes in Input Assumptions

As documented in Section 1, this assessment includes a large number of assumptions regarding refurbishment costs and durations, going forward operating and sustaining investment costs and operating performance. For each of these factors, ranges were developed and sensitivity analyses were performed at the low and high ends of these ranges for each of the key input factors. Figure C4 below shows the results of the sensitivity analysis. The following helps to understand the impacts of specific changes in underlying assumptions on the magnitude of the Darlington Refurbishment LUEC.

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

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

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX C – SUMMARY OF LUEC ASSESSMENT

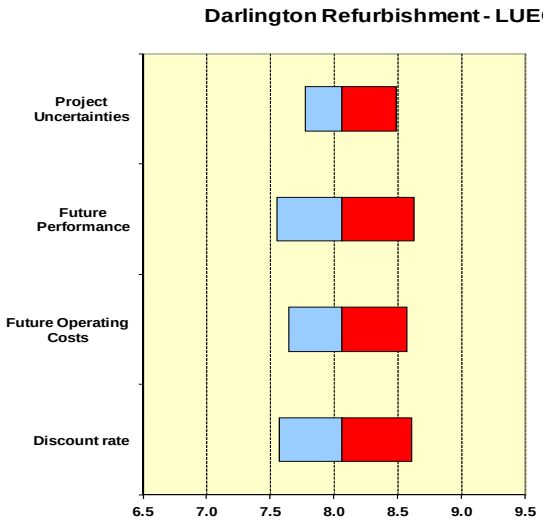
ii. An increase/decrease in overall schedule duration of six months relative to the high confidence duration (1.5 months per unit on average) would increase/decrease LUEC by approximately 0.1 ¢/kWh

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

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

These impacts on LUEC highlight the importance of managing the DRP within its current high confidence cost and schedule and of addressing the key risks to costs and performance post-refurbishment.

Figure C4: Sensitivity Analysis – Darlington LUEC



Assumptions	Lower	Base	Upper
Project Uncertainties			
Refurb Cost* (2015$)	-10%	$10.4B	15%
Avg Refurb Duration (mths)	-2 mths	39 mths	+3 mths
Future Performance			
Annual Capacity Factor (%)	+5%	88%	-5%
Life of Refurb Units (yrs)	+2 yrs	30 yrs	-2 yrs
Future Operating Costs			
Base OM&A ($M)	-5%	290	10%
Outage OM&A ($M)	-10%	140	10%
Sustaining Projects ($M)	-10%	145	10%
Nuclear Support ($M)	-5%	230	15%
Corporate Support ($M)	-15%	245	10%
Fuel ($/MWh)	-15%	5	15%
Discount Rate	-1%	7%	+1%

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

There are other considerations which contribute to and support the favourable economic assessment for refurbishing the Darlington Station. These include:

- The use of an existing generation site with a proven environmental record and a supportive host community avoids the additional costs to OPG (and ratepayers) of site selection, securing environmental approvals and development of host community support at an unproven green or brown field site. It also avoids the additional costs to ratepayers of establishing a new transmission infrastructure.
- The economic benefits of refurbishing the Darlington Station, in terms of direct, indirect and induced job creation. It is estimated that approximately 2,000 direct jobs are created during the Program Definition and Execution Phases. Continued Operation of the Darlington Station (post-refurbishment) will maintain the same level of employment as is currently associated with the Darlington Station for an additional 30 years. Economic impact studies indicate that post-refurbishment operations of the Darlington Station will result in approximately 5,700 resident jobs in Durham Region (direct, indirect and induced).

In summary, the DRP's high confidence LUEC estimate is approximately 8.1 ¢/kWh, and the going-forward LUEC is approximately 7.2 ¢/kWh. Therefore, Darlington provides a low-cost, stably-priced generation option for Ontario for the future.

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APPENDIX D – SUMMARY OF RELEASE 5A EXPENDITURES

1.0 Summary of Release 5a Expenditures

The expected spend of $1,021M in 2016 includes $681M of new Release 5a funding plus a carry forward of $340M underspent from previous releases. The total cumulative funds released to the project, including this release, will total $3,228M including capitalized interest, inflation, and contingencies.

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APPENDIX D – SUMMARY OF RELEASE 5A EXPENDITURES

Bundle Name	Forecast Spend Jan 1 - Oct 15 (BO), 2016 Escalated	Key Activities - Note all activities will include Oversight, Unit 2 planning, and Interest
01 - RFR (Retube Feeder Replacement)	385,347	- Construction of Retube Waste Processing Building - Procurement activities including Reactor Components for Unit 2, - Mobilization and Rehearsal activities
02 - TG (Turbine Generator)	56,639	- Turbine Hall Crane Overhaul - Procurement activities - Inspections
03 - BOP (Balance of Plant)	37,859	- Inspections - Execution of pre-breaker open work to support Refurb and IIP commitments (VVRS
04 - FH (Fuel Handling)	12,276	- Procurement of long lead materials for trolleys 3/4 and 1/2.
05 - DF (Defueling)	3,876	- Procurement of 'Dummy Fuel Bundles (DFB)' and 'Flow Restricted Oriface Bundles (FROBs)'.
06 - SG (Steam Generator)	4,326	- Manufacture of Access ports - Procurement of tooling and tool validation
07 - SP (Specialized Projects)	20,018	- Engineering and software development, system integration, qualification for Shutdown System computers. - Procurement of long lead items for vault coolers.
08 - SL (Shutdown Layup)	41,263	- Execution of pre-breaker open projects, including Breathing Air, Dry Air, Service Air, and Temporary Power.
09 - RSF (Refurb Support Facilities)	11,705	- Installation of in-station facilities to support Refurbishment, including work control area, radiation and teledosimetry trailer, shops and storage areas.
10 - IL (Unit Islanding)	14,306	- Procurement of bulkhead related materials and installation of Unit 2 barriers.
Subtotal Bundles	**587,613**	
11 - Campus Plan - Facility and Infrastructure (F&IP)	130,662	- Continued Construction and in-service of F&IP and SIO projects. - In-service of EPG3, CFVS, RFRISA, etc; continued construction of Heavy Water Storage
12 - Campus Plan - Safety Improvement Projects (SIO)	56,321	
Subtotal Campus Plan F&IP, SIO	**186,983**	
Subtotal Bundles & Campus Plan	**774,597**	
13 - Functions (excl O&M) - Project Execution	31,339	Overall Planning Support of Projects and Readiness to execute Unit 2, including: - Project Planning and Oversight of the pre-refurbishment and ready to execute plan (RTE), - Establishment of the Construction organization and Comprehensive/Construction Work Package development and review, - Engineering including Nuclear Safety studies on Restart Analysis, - Installation of Execution Phase project controls/reporting tools, - Unit 2 check estimate and Execution Phase integrated schedule development, and - Procurement Activities.
14 - Functions (excl O&M) - Contract Management	4,781	
15 - Functions (excl O&M) - Engineering	21,045	
16 - Functions (excl O&M) - Managed Systems Oversight	3,273	
17 - Functions (excl O&M) - Planning & Controls	20,211	
18 - Functions (excl O&M) - Nuclear Safety	9,573	
19 - Functions (excl O&M) - Program Fees & Other Support	35,946	
20 - Functions (excl O&M) - Supply Chain	9,227	
21 - Functions (excl O&M) - Work Control	5,633	
Subtotal Functions (excl O&M)	**141,028**	
22 - Functions (O&M) - OMA Training Program	-	Includes Operations programs to prepare the organization to commence Refurbishment, including: - Support of pre-refurbishment projects, - Permitry and radiation protection planning and readiness for Unit 2.
23 - Functions (O&M) - Waste Disposal	160	
24 - Functions (O&M) - Ops & Maintenance	56,904	
Subtotal Functions - Ops & Mtce	**57,064**	
25 - Functional - Release 3	4,710	- Completion and close-out activities related to the Integrated Implementation Plan.
26 - Functional - Advance Release 4 (incl Engineering Reactor)	342	
Subtotal Functions - Early Release Funds	**5,052**	
Subtotal Before Contingency	**977,740**	
27 - Project & Program Contingency	43,311	- Contingency for estimate variability and risks in above work.
Subtotal Contingency	**43,311**	
Subtotal before Interest & Escalation	**1,021,051**	
28 - Interest	***incl***	- Included in above
29 - Inflation / Escalation	*incl*	- Included in above
Subtotal Interest, Inflation / Escalation	**-**	
Grand Total	**1,021,051**	**<---- Plus Additional Est. Spend Oct 15-Dec 30 2016**
	- 2,547,700	Current Release
	2,207,222	Estimated Spend thru Dec 2015
	1,021,051	Forecast Spend in 2016 to Breaker Open (Oct 15,2016)
	680,573	Calculation of Release 5a (to Oct 15, 2016)
	3,228,273	Cumulative Release through 25% of the entire Program

Nuclear External Oversight Assessment Report of DR Team's Process for Developing the RQE Estimate

OBJECTIVE AND SCOPE

Burns & McDonnell Canada Ltd. and Modus Strategic Solutions Canada Company ("BMcD/Modus") have assessed the DR Team's process for developing the Release Quality Estimate ("RQE") which OPG and the DR Team have been developing since 2009. The DR Team's major focus over this time period has been the development of detailed cost estimates of sufficient quality and basis in order to establish a four-unit, program level ***control budget*** for the DR Project. In order to develop the control budget, the DR Team was required to mature its planning to the point where the cost estimates were of substance and able to be relied upon. In keeping with OPG's funding release strategy, the DR Team will continue to refine the unitized estimates for each of the four units in order to make specific funding requests through the established gating process. However, the RQE control budget will be the baseline against which both the stakeholder confidence and public trust will be measured for the life of the DR Project. In order to plan and develop the RQE, OPG developed its governance and adopted industry accepted guidelines with respect to cost estimating to facilitate the efforts of its project teams and vendors.

This report addresses the following issues related to RQE and the processes the DR Team used in developing its multiple sub-components:

- Has OPG properly developed and supported its control budget for the DR Project in conformance with OPG's governance and applicable industry guidance, in particular those of the Association for the Advancement of Cost Engineers International ("AACE International")?
- Was the process used for RQE reasonably robust and thorough in regard to the development of the DR Project's control budget?
- Was OPG's process for developing the control budget for RQE successful in advancing the overall maturity of the effort and characterizing its project estimates?
- Did OPG develop contingency in a manner reasonably consistent with prevailing industry practices and its adopted Governance?
- Did OPG properly document the RQE Basis of its Estimate ("BOE") in a manner that allowed for reasonable vetting by Senior Management?

In the foregoing, BMcD/Modus focused on the manner in which the DR Team developed, vetted, iterated and finalized the major elements of RQE, including:

- Base or direct cost estimates for the multiple sub-projects, or "bundles", which were largely developed by OPG's vendors and vetted by OPG for purposes of establishing commercial agreements with the contractors;
- Functional costs for OPG's project management team, which were prepared by OPG;
- Project and program contingency, which was developed by OPG.

It should be noted that this assessment's entire focus has been on the process the DR Team used for developing the RQE. BMcD/Modus has not evaluated whether the particular quantum of any of the costs estimates in part or in whole are sufficient for performing the work. We have not performed independent estimates or Monte Carlo simulations. We do not express an opinion whether the DR Project can be successfully performed within the funding envelop that RQE's control budget provides, nor do we have an opinion regarding whether the amount of contingency is sufficient for covering the DR Project's risks. We have not assessed in any manner OPG's projections used for RQE for escalation or foreign exchange rates. Rather, we have only evaluated whether the major processes that the DR Team used for formulating the control budget were reasonable, sufficiently robust and thorough, and in general conformance with what is commonly done in the industry on similar large capital projects.

In addition to assessing the development and status of the RQE, BMcD/Modus provides recommendations for addressing potential improvements, in particular for future cost estimating updates for each of the DR Project's four units. Some of the goals that the DR Team had for RQE were not met, including the maturation of all of the Project bundles to AACE International Class 3 cost estimate or better along with the completion of an integrated baseline project schedule. While the DR Team mitigated the uneven maturity level represented by the cost estimates and schedules prepared for RQE, it will still need to close the gap or the DR Project could be subjected to unanticipated risk cost and schedule overruns. Hence, while BMcD/Modus believes that OPG has substantially met the goals for RQE, the DR Team will have considerable work to complete prior to Unit 2's breaker open in October 2016.

PERIOD OF ASSESSMENT

November, 2014 through November, 2015.

OVERALL ASSESSMENT RISK SCORE:

The overall risk score for RQE is **Low to Medium.** However, we have identified some significant risks associated with certain items of RQE which the Project Team intends to address, though if not corrected for the Unit 2 Estimate, could have a medium- to-high impact on the Unit 2 Estimate and thereafter.

BACKGROUND AND METHODOLOGY

From the outset of our engagement, BMcD/Modus has been focused on the DR Team's progressive development of RQE. Our team has monitored and evaluated the processes developed and utilized by the DR Team as they have evolved through the budget development process. We have issued two prior assessments that focused on RQE inputs, our Initial Assessment in August 2013, which discussed the then-current status of budget development, and our Observations of the 4d Cost Estimate in November 2014. Throughout our engagement, BMcD/Modus has been partially embedded in the development of the DR Team's and the EPC contractors' development of direct cost, project bundle estimate development, the DR Team's development of the functional estimates and project contingency. We have issued more than 200 separate recommendations, most of which have had direct or tangential relationships to elements in RQE. The DR Team has dispositioned all but nine of these recommendations to date.

In monitoring the development of the project bundle estimates from a process perspective, we have actively participated in (on a selective basis) detailed vetting sessions for each of the bundles, with specific emphasis on the Retube and Feeder Replacement ("RFR"), Turbine Generator upgrades, Balance of Plant ("BOP"), Shut-down/Lay-up ("SDLU") and Refurbishment Support Facilities ("RSF").

Together, these bundles represent approximately 90% of the RQE direct field work costs. We have performed detailed review of each of SNC/Aecon's RFR successive estimate submissions and provided the DR Team with our comments regarding the process used and components of the estimate, specific cost quantum excluded. As part of the RFR Class 2 review, we provided the DR Team with in excess of 200 comments and participated in multiple weeks of review and vetting sessions. We have also participated in executive steering committee meetings with SNC/Aecon and OPG at which the commercial aspects of the RFR, Turbine Generator and D2O Storage Facility projects have been discussed.

With respect to the functional costs, we have monitored the DR Team's development of functional management plans, cost estimates and challenge sessions and issued multiple specific recommendations regarding the development of roles and responsibilities for the DR Team. We note herein that the DR Team did not fully define roles and responsibilities of the functional groups, thus the specifics of the functional area cost estimates will require significant additional work prior to the start of Unit 2.

Recognizing the critical importance of risk management and contingency development, BMcD/Modus has closely followed the risk management and contingency programs since early 2013. We closely monitored the development of the Risk Program for OPG activities and for contractor activities, especially related to SNC/Aecon's RFR project performance. In February 2014, BMcD/Modus issued an Assessment Report on the DR Risk Program and worked with the DR Risk Team to address and close the assessment's recommendations. From a process perspective, BMcD/Modus has maintained constructive and close interface with the DR risk group throughout the Definition Phase, and the DR Team has been receptive to our comments. BMcD/Modus also performed periodic process reviews of the SNC/Aecon and DR Project risk registers and relevant procedures, with resulting comments provided to appropriate DR Project's project managers.

The BMcD/Modus team also participated in numerous risk and contingency coordination meetings between management and subject matter experts of SNC/Aecon and the DR Team. The DR Risk Team conducted risk vetting sessions for each project bundle's estimate, each function's estimates and, ultimately, the finalization of contingency for RQE.

Our team attended the periodic Risk Oversight Committee ("ROC") meetings and provided process feedback and recommendations to the DR Risk Team. We engaged in periodic interface discussions with the OPG corporate risk management personnel, as well.

As detailed RQE contingency development proceeded, BMcD/Modus attended contingency workshops and management review sessions, providing detailed observations and recommendations to the DR management and the risk team with respect to process issues. We performed detailed reviews of contingency input documents and provided feedback to the DR risk team.

Finally, BMcD/Modus participated in the DR Team's RQE vetting sessions, during which each Project Team presented its proposed cost estimates and schedules for NPET review. BMcD/Modus further participated in the NPET's vetting of final RQE contingency analysis, from a process perspective.

INTERVIEWS AND DISCUSSIONS WITH THE FOLLOWING INDIVIDUALS:

Mike Allen, VP Refurbishment Execution	Roy Brown, Senior Director, RFR Project
Art Rob, VP Projects & Modifications	Perrrik LeDreff, Manager, RFR Project
Meg Timberg, VP	Sorrin Marinescu, Project Director, Fuel Handling/Defueling/ Specialized Projects

Gary Rose, Director, Project Controls Karen Fritz, Director, Outage Management Ryan Smith, Manager, Risk Management Andy Elliott, Manager, Project Controls Leo Saagi, Director, Controllership Steve Wiacek, Manager, Finance Carlos Barrios, Planning & Controls Ian Sansom, Planning & Controls Rob Obertreis, Manager, Estimating Nader Rahmaty, Sr. Planning & Reporting John Haight, Estimating Michael McNeill, Planning & Controls David White, Estimating	Scott Guthrie, Project Director, BOP Todd Josifovski, Project Director, Turbine Generator Tracy Leung, Project Controls Manager, SDLU Peter Moore, Manager, Turbine Generator Sudhaker Pulagam, Project Controls Manager, RFR Julian Read, Section Manager, Projects & Modifications Al Arnott, Director, P&M Norton Thomas, Senior Manager, Enterprise Risk Management

ATTENDED THE FOLLOWING MEETINGS:

A sampling of the meetings BMcD/Modus attended in preparation of this Assessment include but not limited to the following:

- Quarterly Risk Oversight Committee Meetings
- Project and Function Contingency Workshops
- NPET RQE and Contingency Review Meetings
- RFR Class 2 Estimate Vetting Sessions with SNC/Aecon and OPG
- Executive Steering Committee Meetings with OPG and contractor management teams
- RFR DR & JV SME Risk and Uncertainty Alignment Meetings
- RFR Risk and Uncertainty DR & JV Management Review Sessions
- RFR Class 2 Estimate Monte Carlo Report Review
- Numerous one-on-one sessions with Risk Team and Project/Function Managers

REVIEWED THE FOLLOWING DOCUMENTS:

The documents BMcD/Modus reviewed in preparation of this assessment are too voluminous to comprehensively list. The following comprise the more significant documents or categories of documents that were utilized in the preparation of this assessment, as it relates to OPG's process:

- RQE Roadmap, multiple iterations from January to September 2015
- NK38-PLAN-09701-10235-R000 RQE Cost Estimate Plan dated March 9, 2015
- NK38-PLAN-09701-10004RQE Project Management Plan, dated November 20, 2014
- N-MAN-00120-10001-RISK-04-R002 - Nuclear Refurbishment Risk Management & Contingency Development Guide
- N-REP-09701-055662 RQE Contingency Development Report, dated August 20, 2015
- NK38-NR-PLAN-09701-10006 RQE Contingency Development Plan

- 509407-0000-00000-33RA-0172-00 – DNGS RFR Project - Class 2 – Contingency Target Cost and Target Schedule Development
- N-MAN-00120-10001 Sheet PC-12 – Nuclear Refurbishment Change Management
- N-MAN-00120-10001-RISK – Nuclear Projects Risk Management
- SNC/Aecon Class 2 Estimate (Rev.0 and Rev.1) for RFR and Turbine Generator Projects
- RQE Estimating file site June to September 2015, including ES Fox contractor estimates, comments and disposition forms, estimate checklists and declarations.
- RQE Release Consolidation files, including bundle files, function files, master consolidated file, snapshot 1 dashboards, source data for final cash dashboards, source data for August 18, 2015 point estimates
- NK38-REP-09701-0568870 – RQE Total Cost Summary, 4 vFinal, dated October 30, 2015
- NK38-REP-09701-0568872 – RQE Total Cost Overview NPET Final Package
- NK38-REP-09701-0548257 – Program BOE Report
- RQE Release bundle and function estimate files, including fully populated templates, for April, May, June, and September 2015 updates
- RQE NPET cost, schedule and scope reports for all bundles and functions, various drafts and final packages, and documentation for final closeout
- Weekly/monthly status updates from each project bundle
- Functional management plans for each DR Project function
- NK38-REP-09071 – RQE Quality Assessment Report (Draft)

OVERALL ASSESSMENT:

Overview

On November 12, 2015, the DR Team issued the RQE to its Board of Directors in the total amount of $12,800,000,000 including contingency, interest and escalation. A high-level breakdown is attached as Appendix A. Based on our nearly three years of oversight involvement of the DR Project's planning, BMcD/Modus believes the process used for developing the DR Project control budget and the associated critical path schedule[1] that form the basis for RQE meets general industry thresholds. The control budget is based, most notably, on well-defined scope and detailed engineering, which has sufficiently matured to allow classification using the AACE International guidelines in the manner OPG intended for RQE. In addition, the general level of detail in the RQE control budget is in line with that seen on other projects of similar nature and should provide the foundation for a robust project controls regime that will be used to track progress against the control budget. From a process perspective, the Team performed a reasonable amount of vetting of the risks in finalizing RQE.

While there is still considerable work ahead for the DR Team to further refine its cost estimates, schedule and execution planning for each of the Project's units, the DR Team has substantially met the goals it set forth in 2009 at the DR Project's inception for its Definition Phase and has completed the necessary work to establish a control budget for the Program. Moreover, the DR Team's confidence level with the control budget does not appear to be inappropriately characterized, in that the team is aware of both the strengths and weaknesses in the current Program.

[1] The development of the critical path schedule is the subject of a separate BMcD/Modus assessment issued simultaneously with this assessment.

Project Bundle Costs

The Basis of Estimates ("BOE's") for the DR Project's project bundle costs range from quite detailed (for RFR and Turbine Generator in particular) to developmental/conceptual (for approximately half of the BOP and SDLU packages). The process that the DR Project used to characterize the estimates reasonably conforms to AACE International guidelines. We have confidence that process has been reasonably robust and achieved a level of accuracy commensurate with the assessed classification. Overall, 90% of the direct cost estimates are Class 3 level or better. Nonetheless, improving the accuracy and confidence level for the bundles that have not matured to at least AACE International Class 3 level presents a challenge for the DR Team in development of its Unit 2 Estimate. These estimates are mostly being developed by a contractor that has struggled with estimating inaccuracies in regard to OPG's Campus Plan Projects under the terms of the same commercial agreement. For purposes of the control budget, OPG chose to accept that 45% of these estimates were in large part no more mature than AACE International Class 4/5 level and carried substantial contingency to account for potential estimating inaccuracy and performance issues related to the ESMSA contractors. However, in light of that contractor's track record, there is an inherent risk that this level of contingency will not fully account for the risks. Refurbishment is utilizing the lessons learned from the Campus Plan Projects and has taken actions intended to mitigate these issues, as discussed herein.

In addition, while the RFR, Turbine Generator, Defueling and Fuel Handling bundles each have reasonably mature (Class 3 or better) estimates, there was still remaining work for each to further refine its estimates for Unit 2, including resolving the size of the vendors' project management teams for execution, final application of shift premiums, wage rate discrepancies and other costs needing refinement. In addition, the DR Team is considering shifting some work to different contractors to achieve efficiency and potential economies of scale, which could result in some cost differences. Thus we have rated the risk associated with the Project Bundle costs as low-to-medium, though this could rise depending on the DR Team's work in the upcoming 1Q of 2016.

Functional Costs

The DR Team's efforts to assess and monetize its internal functional costs has taken many different turns and still is not complete, with additional work remaining to capture roles and responsibilities that may ultimately impact cost. From 4d to RQE, the total functional budget held to approximately $2.3B (excluding contingency), which is 22% of RQE. During this period, $232M of Operations & Maintenance cost was apportioned to the station, while the remaining functions actually grew by $253M, or 20%, offsetting these reductions.

The DR Team's goal for RQE was to define the extent of the funding envelope for the functions and work to comprehensively define the team's roles and responsibilities during the Readiness to Execute period. Moreover, the DR Team's staffing plan for RQE calls for immediate increases in staffing that may not be achievable. From a process perspective, while we do not have a strong concern that the DR Team will maintain the functional costs within the budget, BMcD/Modus remains concerned that the DR Team has not fully worked out the roles and responsibilities for its execution organization and the associated risk has potential consequences that extend far beyond the cost of the team itself, including potential confusion over direction given to the Project's contractors. Thus, we rate the risk associated with the functions to be medium-to-high, and the delineation of roles within the DR Team will require significant focus.

Contingency

During the Definition Phase, considerable effort was expended on the RFR project, which is the largest and possibly highest risk component of the Refurbishment. OPG and SNC/Aecon spent considerable effort identifying discrete risks, developing response plans (e.g. mitigation), and quantifying the impacts of post-mitigated risks. Assessments of the RFR discrete risk and schedule impact have been reviewed and challenged in considerable detail by OPG management, SNC/Aecon management and subject matter experts (SMEs) from both parties. In the course of developing the remaining RQE contingency, a well-defined process was developed and all project and function managers increased their focus on contingency input matters to ensure that risks were identified; response plans were established; and occurrence probabilities and impact quantification were developed. Challenges and reviews of the input parameters occurred at various levels of the organization.

In addition to this effort, a comprehensive Monte Carlo model was initially constructed and run for Release 4d, which provided lessons learned and an excellent base for creating a very robust RQE model.

While, risk management and contingency development has many subjective aspects, the DR process has been reasonably well constructed and executed. It is perhaps in the upper percentile of comparable project practices. Nonetheless, because of uncertainties and unknowns, contingency values do not enjoy perfection, but the DR process likely contributes to a reasonably reliable and defensible RQE quantum, all from a process perspective.

EVALUATION OF OPG'S GOVERNANCE PROCESS AND ADHERENCE TO AACE INTERNATIONAL GUIDANCE

In order to aid itself in its development and characterization of the RQE estimate, OPG appropriately chose to utilize AACE International's Cost Estimate Classification System[2], which explains the importance of these guidelines and the intent of their general use:

> *An intent of the guidelines is to improve communication among all of the stakeholders involved with preparing, evaluating, and using project cost estimates. The various parties that use project cost estimates often misinterpret the quality and value of the information available to prepare cost estimates, the various methods employed during the estimating process, the accuracy level expected from estimates, and the level of risk associated with estimates,… improving communications about estimate classifications reduces business costs and project cycle times by avoiding inappropriate business and financial decisions, actions, delays or disputes caused by misunderstandings of cost estimates and what they are expected to represent.*

As a recommended practice of AACE, the *Cost Estimate Classification System* provides guidelines for applying the general principles of estimate classification which typically range from Class 5 to Class 1, the criterion for which is primarily based on the maturity level of project definition deliverables. Typical Class 5 estimates are based upon a low-level of project scope definition and therefore these estimates have the highest amount of uncertainty and the lowest level of expected accuracy range

[2] See AACE's Recommended Practice No. 17R-97, Cost Estimate Classification System (November 29, 2011) and Recommended Practice No. 18R-97 Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries (November 29, 2011)

values after application of contingency. In contrast, the typical Class 1 estimate should have reduced uncertainty and higher expected accuracy range values after application of contingency. The actual accuracy range is determined through the risk analysis of the specific project. As noted in our past assessments of the DR Team's prior cost estimates (4c and 4d), this approach is appropriate and allows for better understanding of the cost estimates underpinning RQE.

Pursuant to the Nuclear Refurbishment Project RQE Cost Estimate Plan (NK38-PLAN-09701-10235):

> *The target classification of the RQE cost submission is AACE Class 3 with an expected 50% level of confidence on the point estimate and accuracy range, exclusive of applying escalation, interest and management reserve, within:*

Class 3	*Level of Project Definition: 10% to 40%*	*Budget authorization or control*	*Accuracy Range:* *L: -10% to -20%* *H: +10% to +30%*

> *An assessment of the class of estimate achieved by each project bundle will be performed by the NR Estimating Team based upon AACE Recommended Practices and the nature of the project scope of work.*

As stated above, AACE International's guidelines use maturity level of project definition deliverables as the primary characteristic for classifying estimates. In its governance, OPG listed the specific deliverables unique to the nuclear industry that would need to be developed in order to sufficiently advance the Project to support an RQE within the target Class 3 classification.

BMcD/Modus concurs that the DR Team has sufficiently matured the work in these areas in order to support RQE as a Class 3 estimate and establish a control budget, from a process perspective. Attached as Appendices B and C are evaluations BMcD/Modus performed of the DR Team's conformance to its governance. The most significant remaining gaps as noted are: (1) some project bundles lack Class 3-level maturity (i.e. BOP and SDLU/RSF); (2) the functional costs need further refinement and definition; (3) the US Cost database was not fully utilized, as the method the DR Team used for compiling costs was largely via Excel, which introduces potential human error.

Differences in maturity are not unusual for projects of this complexity and size, and the DR Team appears to have a reasonably full understanding of those parts of the work that need enhanced definition. In the detailed sections of this assessment, we provide our analysis of the remaining gaps and risks to the DR Project.

During the Definition Phase, the DR Project's scope was substantially developed and supported with detailed engineering packages. With some exceptions, the detailed engineering packages were prepared in sufficient time for that scope to be adequately assessed and estimated by the DR Project's EPC vendors. Additionally, as we noted in our 3Q 2015 report to the DRC, the process the DR Team used for validating and vetting the cost estimates for the Project's bundles has followed the approved DR Project RQE Cost Estimate Plan, and the result of this process was as intended – the vendors' estimates for project cost have been classified so that management understands the underlying quality, accuracy range and reasonableness. This knowledge aided management in identifying potential risks in performance, gaps in the vendors' planned approaches, and areas to shore up for the future unit-specific cost estimates.

Moreover, with this effort complete for the control budget, the DR Team is better positioned to execute its remaining cost estimating work, which will be considerable during the Project's lifecycle. The Unit

2 Estimate the DR Team intends to deliver in the 3Q of 2016 to the Board of Directors will support that unit's execution. The team is committed to performing a similar quality estimate prior to each unit's execution. In addition, projects of this type must have ongoing cost estimate support for evaluating potential change orders, claims and cost overruns. The process the DR Team has used for RQE coupled with the lessons learned from that effort should be adaptable for each of these future needs, given aggressive management. The DR Team should consider the benefit of employing permanent estimating staff to meet these demands.

In addition, with the development of the control budget, the DR Team has advanced its understanding of the Project's estimated costs such that it should no longer need to depend upon AACE International's cost estimate classification. The DR Team has now established its own measuring stick. With the exception of those projects (BOP, Shut-Down/Lay-up and Refurb Support Facilities) that have not advanced to Class 3 designation and which still need to reach appropriate level of maturity of project definition deliverables, OPG should henceforth measure its progress against the control budget without further regard to AACE International classification.

In summary, BMcD/Modus found that OPG has substantially conformed to the governance it put in place for RQE and the guidance from AACE International on which that governance was based.

COMPARISON OF PROCESSES - 4D COST ESTIMATE TO RQE

In November 2014, BMcD/Modus prepared a Supplemental Report to the Board of Directors Nuclear Oversight Committee regarding our Observations of the 4d Cost Estimate (4d Cost Estimate Assessment). The main purposes of our 4d Cost Estimate Assessment were to: (1) document the process the DR Team used for the 4d Cost Estimate; and, (2) provide recommendations for RQE based on the lessons the team learned from 4d. In this section of this assessment, we discuss the extent to which the DR Team followed our recommendations from the 4d Cost Estimate Assessment.

- **Estimate Maturity**: The DR Team reasonably met its goal for maturing the project bundle estimates for RQE to Class 3 estimates or better. As of the 4d Cost Estimate, approximately 64% of the project bundle derived cost estimate was at the Class 3 level, while other portions were less defined. With the maturation of the project estimates, as illustrated in Figure 1[3], 90% of the project estimates in RQE were assessed at Class 2 (64%) and Class 3 (26%).

  Another measure of RQE is the granularity of the vetting performed by the DR Team in OPG's estimate review process. The following Table 1 illustrates the average value of detailed estimate line items OPG examined in its vetting of the bundle estimates.

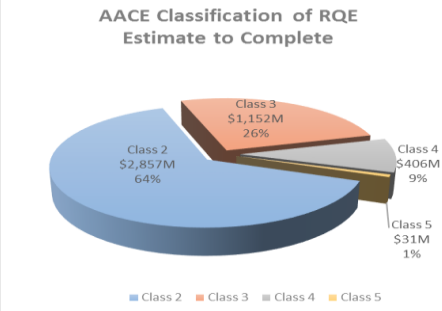


Figure 1: Data Source – RQE Total Cost Summary

[3] The estimates in Figure 1 exclude interest, escalation, inflation, contingency and functional costs.

Table 1 – Summary of Line Items Reviewed per Bundle Cost Estimate			
Project Bundle	**Estimate Lines Reviewed**	**EPC Estimate ($K) Cost 2016-2026 (excl. fees)**	**$ per Line of Estimate Reviewed**
RFR	165,880	$2,327,288	$14,030
Turbine Generator	39,917	$438,317	$10,981
SDLU	19,607	$196,814	$10,038
BOP	17,813	$353,380	$19,838
Refurbishment Facilities	4,099	$50,286	$12,268
Islanding	1,921	$84,198	$43,830
Steam Generator	1,209	$98,844	$81,757
Specialized Projects	1,152	$78,732	$68,344
Fuel Handling	428	$120,183	$280,801
Defueling	-	$2,487	
Grand Total	**252,026**	**$3,660,895**	$14,526

The OPG estimating team vetted 100% of the direct field labour line items, while indirect and PMT costs in contractors' estimates were vetted on the basis of standard percentages compared to direct labour cost. Overall, the process resulted in an aggregate average cost of $14,526 per estimate line item. As with 4d, estimates for the largest cost components – the RFR and Turbine Generator bundles – were the most mature, though the Fuel Handling/Defueling/Specialized Project bundle has matured to the expected Class 3 level. The lagging bundles continue to be BOP, SDLU, and RSF. For the most part, Design Engineering is substantially complete with some select packages (approximately 3-4%) requiring additional time to complete.

In the following sections, we evaluate the extent to which the DR Team advanced the cost estimating process from 4d to RQE.

- **Commercial Strategy as a Key Driver to RQE**: The 4d Cost Estimate had embedded assumptions regarding the expected outcome of future commercial negotiations with key vendors that needed to transpire before RQE. In particular, the DR Team management allocated in excess of $700M in potential savings relative to SNC/Aecon's Class 3 estimate and negotiating the final terms of the RFR and TG contracts with SNC/Aecon. In fact, the final RFR target price of $2.706B is $63.7M less than SNC/Aecon's $2.77B Class 3 estimate and more than $600M less than SNC/Aecon's initial Class 2 estimate submission. However, the final RQE value, when compared to what was carried in 4d, is more than $600M higher, offsetting the majority of the presumed $700M savings included in 4d. Although some of the $700M in savings included in 4d was achieved through the Class 2 development process, the value of other scope changes and the final negotiated Fixed Fee and Contingency exceeded the 4d assumptions.

  Nonetheless, the final resolution of SNC/Aecon's target price represented significant work by the parties to narrow the direct cost elements of the RFR work. As illustrated in Table 1a below, SNC/Aecon's estimate increased significantly from its June 2014 Class 3 estimate to the initial Rev.0 submission of its Class 2 in May 2015, and then was reduced through the vetting of the final estimate.

Table 1A – Comparison of RFR Estimates from Class 3 to Class 2					
Category	**Class 3 - June 2014**	**CL 2 Rev 0 - May 2015**	**CL 2 Rev 01 - Sept 2015**	**CL 2 Reduction Rev 0 to Rev 1**	**Total Reduction - CL 3 to CL 2 Rev 01**
Base Cost	$ 2,084,800	$ 2,199,648	$ 1,807,008	$ (392,640)	$ (277,792)
Fixed Fee	$ 451,319	$ 651,143	$ 530,609	$ (120,534)	$ 79,290
Contingency	$ 233,568	$ 473,255	$ 368,400	$ (104,855)	$ 134,832
Total	$ 2,769,687	$ 3,324,046	$ 2,706,017	$ (618,029)	$ (63,670)

The reductions realized from vetting of the direct base cost work were considerable – from Class 3 to Class 2, these reductions totaled $277.8M. The final negotiated Fixed Fee and Contingency exceeded the 4d assumptions and nearly consumed the direct cost savings. OPG and SNC/Aecon accomplished this target price without having to make significant changes to the contract; thus OPG has maintained significant provisions regarding change order thresholds[redacted] and disincentives to SNC/Aecon's work while achieving over $63.7M in overall savings from Class 3. While not achieving the original projected level of savings, this nonetheless is a major accomplishment.

- **Functional Costs**: As noted, from the 4d cost estimate to RQE, the DR Team's functional costs were essentially unchanged in aggregate, though there was 20% growth among the non-Operations & Maintenance and Engineering groups. We noted in our 4d Cost Estimate Assessment the need for additional work by the DR Team, including the need for more realistic planning assumptions and greater identification of roles and responsibilities of the staff. For RQE, the DR Team has advanced the definition of the functions to an extent, though has not completed the task of fully defining the Execution Phase organization. The DR Team is committed to finalizing a Division of Responsibility ("DOR") matrix in 1Q 2016 that will further define the roles and responsibilities within the organization, and will "live-test" the team's ability to respond during the Readiness to Execute period. BMcD/Modus is concerned that until the DOR is in place and the functions have been properly aligned and tested prior to Execution, the functions may not be adequately defined. If not addressed, this could lead to duplication, coverage gaps, and confusion in the field during the Execution Phase. Nonetheless, from a budgetary standpoint, the result for RQE can be used as a control budget for managing the entirety of the DR Team.

- **Campus Plan Project Risks**: In our 4d Cost Estimate Assessment, we noted the risks presented by the remaining Campus Plan Projects, which include both Facilities & Infrastructure and SIO Projects. As of November 2014, the path for D20 Storage in particular was very uncertain, as OPG had just terminated Black & McDonald from D20 Storage, and [redacted] The overall picture has improved as some of the work has completed. There are currently six remaining Campus Plan Projects with substantive remaining field work – D20 Storage, EPG 3, CFVS, STOP, Refurbishment Project Office and RFRISA. Of these, D20 Storage and EPG 3 present the greatest risk to the control budget while CFVS and STOP have remaining technical challenges that could impact their completion dates. Although the Campus Plan Projects do not necessarily have a significant monetary impact to RQE, the performance of D2O Storage Facility Storage, CFVS and EPG 3 in particular remain a risk to breaker open of Unit 2. These projects' completion dates have shifted over time and further delays could result in a schedule delay for the Unit 2 outage. Overall, the entire portfolio of Campus Plan Projects experienced

$76.3M in base cost growth from 4d to RQE, an increase of 9%[4], which resulted in contingency drawdowns from the allocated budget amount set in 4d. P&M is currently forecasting an Estimate to Complete ("ETC") for all remaining Campus Plan and SIO work of $216,713,000.

Based on the history of these projects, the velocity of change orders and the volume of remaining work, a stepped-up, more aggressive approach to managing these projects is in order. In addition, the $75.5 million in remaining contingency needs to be rigorously managed and closely tracked to ensure all draws are necessary and there is enough contingency to cover any remaining cost issues with completing these projects. In particular, D20 and EPG3 pose the greatest risk to the remaining Campus Plan contingency, and EPG 3's final cost estimate has not been fully vetted and approved. P&M's change control process needs to be monitored so that the use of contingency is readily identified and so there are sufficient funds going forward.

- **Contingency and Risk Management**: From the 4d Cost Estimate to RQE, the DR Team reduced contingency from 20% to 16% of the overall budget. The process used for deriving project and program level contingency significantly matured over the intervening year. We provide a detailed description of the DR Team's contingency effort herein.

- **Estimating Process**: From the 4d Cost Estimate to RQE, we saw a need for the DR Team to step-up its estimating process for developing a high confidence RQE. At that time, the process the team used for vetting the estimate was in its infancy. The post-4d estimating review process that was rolled-out in March 2015 and used for vetting the project bundle costs was a significant improvement. The RQE Cost Estimate Plan (NK38-PLAN-09701-10235-R000) along with the RQE Project Management Plan (NK38-PLAN-09701—10004) formed OPG's governance documents for preparation of the RQE. For the most part the process set forth in these plans were followed. Appendices B and C are assessment checklists prepared by BMcD/Modus showing the extent to which the team followed and achieved the objectives and project deliverables in these plans.

  However, one recommendation we previously made – for the DR Team to prepare a detailed schedule of RQE activities – was not strictly followed. This led to uncertainty regarding performance status and hampered the DR Team's ability to effectively identify and correct problems in a timely manner. The resulting process was less efficient as a result. We have additional recommendations regarding the organization of the team for the Unit 2 Estimate effort.

- **Quality Assurance Should Be Increased and Embedded**: BMcD/Modus identified and underscored a gap in the 4d Cost Estimate's effort with quality assurance. We noted that within the industry, owners of mega-projects typically invest considerable sums in quality assurance in the development of estimates to combat potential double-counting, errors in spreadsheets and ensuring the documentation backing-up the estimate is complete; we urged OPG to follow suit. We also advocated the DR Team fully implement the US Cost system it had implemented for the RQE effort and which allows, among other things, establishing a common and comparable platform for evaluating costs across different bundles or work groups. For RQE, the DR Team addressed some, but not all of these concerns. US Cost was implemented for the bundle estimates, though was not used for the remainder of the estimate. Quality assurance checks were in many instances incorporated after-the-fact, and not in an efficient manner. The DR Team developed a RQE Quality Assessment Report (NK38-REP-09071-05645969) that was an after-the-fact comparison of the methodology used

[4] Excluding the Auxiliary Heat System Building.

for RQE to develop and document the results of the DR Team's cost estimating work. However, this report identified (rather than addressed) the need for contemporaneous quality assurance checks for future estimates while essentially finding many of the same issues with RQE as we highlight in this report. We have recommended the team take another "quality sweep" through the RQE well in advance of the Unit 2 Estimate, which we understand is currently underway.

- **Documentation of Assumptions for the Basis of Estimates**: Development of the planning assumptions for the 4d Cost Estimate development were largely abandoned as the different groups used varying ways to develop the collateral information (i.e. analysis, management plans, organization charts) supporting the cost estimate. However, for RQE, the team successfully recorded all assumptions in a database and the Outage Management team took the lead to produce project-specific packages that clearly identified the basis of the estimate, scope and other key assumptions. This effort was very successful and made the review cycle much more effective. The team has some remaining work to fully populate the Project's database so that the information used for RQE is properly organized and available for future use. We have recommended that OPG audit the documentation to identify whether there are any gaps.

- **Vetting of the Estimate by Senior Management**: In our 4d Cost Estimate Assessment, BMcD/Modus recommended to the DR Team that the RQE effort should be organized with multiple weigh points for senior management to test the development and maturation of the Project's costs. We recommended that the schedule of RQE reflect the needs for senior management to appropriately and adequately inform the Board, the Shareholder and other key external stakeholders. In general, the DR Team followed this recommendation, though at one point the time for RQE preparation was cut by 6-weeks which would have significantly compromised the process. Ultimately, the original duration for RQE preparation was restored. Overall, the DR Team largely addressed our recommendations for improving upon the 4d Cost Estimate for RQE.

The process OPG used for RQE was a substantial improvement over past estimating efforts and was appropriate for establishing the DR Project's control budget. The DR Team addressed the majority of the issues BMcD/Modus identified in the 4d Cost Estimate. However, the remaining issues – the full definition of the Project's functions and completing the bundle estimates for BOP and SDLU – need to be closed for the Unit 2 Estimate to be accurate and an appropriate tool for managing the Unit 2 work.

SUMMARIES OF RQE MAJOR COST ELEMENTS

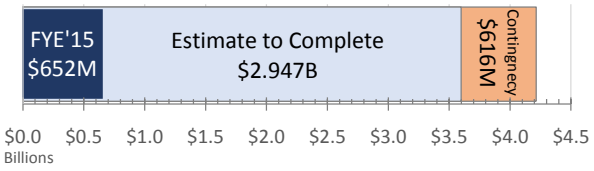
The following is a summary of the basis for each Project Bundle cost, OPG functions and contingency.

RETUBE AND FEEDER REPLACEMENT (RFR)

Retube and Feeder Replacement Project Summary

Control Budget:	$4,214,626,000
RQE Base Cost:	$3,598,222,000
Estimate to Complete:	$2,946,571,000
Project + Program Allocated Cont.:	$616,404,000
Percent of ETC	(21%)
Estimate Class:	Class 2 (95%) Class 3 (5%)
Percent of RQE:	33%

Control Budget
$4.215B



Risk Perspective

1. RFR BASIS OF ESTIMATE

RFR is the single largest element of the RQE and its budget reflects the overall importance of this work to the DR Project. The RFR cost estimate was developed over the past three years by SNC/Aecon, the project's EPC contractor, under the terms of the contract executed between the parties on February 8, 2012. SNC/Aecon prepared four separate estimate submittals, each intended to be a further refinement of the prior estimate.

The most critical phase for SNC/Aecon's estimate was from Class 4 to Class 3, during which time SNC/Aecon refined its estimate from an "Optimistic OPEX based" and conceptual estimate to a Darlington specific, "Deterministic" estimate based on the work required for the DR Project. SNC/Aecon issued its Class 2 Estimating Plan on November 6, 2014 (509407-0000-00000-33IM-0001, Rev. 9) that detailed the strategy for further refinement of the Deterministic estimate. SNC/Aecon provided an overview of the estimating process and the goals for the final, Class 2 estimate:

> The Estimate Plan is addressing the fact that the Target Price and Target Schedule for the Execution Phase were not established at contract award. Instead, the Agreement contains a mechanism whereby the Target Price and Target Schedule are developed in collaboration with OPG over the course of the four (4) year Definition Phase with OPG. As Execution Phase work activities become better defined and are finalized, the estimate and schedule become more detailed and uncertainties and risks are mitigated and addressed. SNC/Aecon has submitted successive estimates, Class 5, 4 and 3, each presenting a progress update of the estimate and schedule to OPG.
>
> The Class 2 Estimate, Level 5 Schedule and Risk Register will be the fourth in a series of these annual updates. These are submitted in support of OPG's RFR Project estimate development gating process. A data input freeze date will be implemented to permit timely completion and for the finalization of the Class 2 Estimate (Please refer to the Class 2 deliverables Schedule updated regularly). At this stage, risks and uncertainties captured in the Risk Registry will be quantified for potential schedule and cost implications in accordance with the Risk Management Plan.

The Class 3 Estimate is the starting baseline for the Class 2 Estimate/ Level 5 Schedule and Risk Register development, building upon the established WBS and utilizing the estimating and schedule database coding framework implemented in collaboration with OPG.

Similarly to Class 3, the Class 2 Estimate will be based on deterministic methodology, DNGS-specific work packages, which differs from the Class 5 and 4 Estimates, submitted in 2012 and 2013 respectively, which were based on a top-down OPEX-based estimate. The Class 2 Estimate is a substantial improvement over the previous Class 3 Estimate in that the basis of estimate will be derived from the Stage 3 Comprehensive Work Packages and the Tool Performance Guarantee details updated based on the results of actual Tool Performance data obtained at the DEC.

After receiving SNC/Aecon's Class 3 estimate in June 2014, OPG worked collaboratively with SNC/Aecon to plan the next phase so that its Class 2 estimate would be, when delivered, reasonable and achievable. This collaborative review process was intended to ensure that SNC/Aecon's estimate accounted for OPEX from past refurbishments, improvements to the tool set for Darlington and the value of the planning effort to date, including the full-scale mock-up at the Darlington Energy Centre ("DEC"). The collaborative review process spanned much of the year between the delivery of the Class 3 estimate in June 2014 to mid-April 2015, [redacted] On May 8th, 2015, after several changes to the agreed to delivery date[5], SNC/Aecon presented its first draft of the Class 2 Rev 0 estimate to OPG.

From an initial reading, it was immediately apparent that SNC/Aecon's Class 2 submission was based on a substantially longer duration and higher cost than OPG anticipated. OPG expected SNC/Aecon's estimate to reflect the favorable results from testing in the mock-up. In fact, the base duration in SNC/Aecon's Rev. 0 exceeded the scaled-up duration of Wolsong (which is a smaller unit), and the reasonably achievable duration was in excess of Bruce Unit 1, both of which had problems during execution that SNC/Aecon and OPG had strived to eliminate for the DR Project.

Simultaneous to OPG's review, the parties jointly engaged an expert panel (including individuals selected by OPG and SNC/Aecon) who have played significant roles in virtually every CANDU refurbishment to date. The expert panel reviewed SNC/Aecon's submission and generally agreed with OPG's conclusions regarding the excessive schedule, cost, size of the labour force and risk monetization. BMcD/Modus also provided input from our review of the submission, focusing largely on inconsistencies in the information presented and areas lacking in appropriate back-up and rigor, all process in nature. Areas we highlighted to OPG at that time were as follows:

- Overall quality was insufficient to support a Class 2 submission;
- Contingency was improperly built into the base estimate and schedule;
- Subsequent unit estimates were assumed to be a replication of Unit 2, with overlapping schedules, and did not consider discrete risks from the overlaps and changes in the execution model;

[5] The SNC/Aecon contract specifies that the Class 2 Estimate would be delivered by May 15th, 2015. By mutual agreement, SNC/Aecon's Class 2 estimate was accelerated for delivery by April 10th, 2015, though SNC/Aecon was unable to meet this deadline. OPG ultimately provided SNC/Aecon with an extension to May 8th, 2015 to ensure SNC/Aecon was providing an estimate package of requisite quality.

- OPEX was not utilized in a meaningful manner for establishing the basis of the estimate or testing reasonability;
- Resource leveling was questionable and resultant resource curves are not achievable;
- Based on comparable metrics, the PMT was oversized and is not presented as a well-integrated organization;
- [redacted]

Overall, the expert panel and BMcD/Modus produced over 300 comments regarding the Rev. 0 estimate's quality.

Following SNC/Aecon's delivery of its Rev. 0 Class 2 estimate, OPG's project management team (including members of the Estimating, Scheduling, and RFR organizations) commenced detailed reviews, ultimately producing over 2,000 comments regarding various noted deficiencies. Beginning in mid-May, 2015, the OPG team developed a "war room" strategy that included: (1) daily internal and external meetings with SNC/Aecon team to analyze, set-up and vet the elements of the estimate; (2) focused meetings on elements of the estimate to vet and assess the gaps OPG saw within the Rev 0 submission. In accordance with the RQE Estimating Plan, OPG began bottom-up estimate vetting exercises consisting of "deep dives" and "vertical slices" through the estimate documentation. The deep dives generally addressed specific items of cost such as tool management, support services, direct field labor, performance adjustment factors, and the like. The "vertical slices" evaluated SNC/Aecon's estimate at different key points in time, testing the veracity of SNC/Aecon's planning, resourcing, and constructability; in particular, areas of high complexity such as peak man-power staffing, unit over unit overlaps, and waste processing logistics were carefully analyzed. The results of the early vetting revealed problems with SNC/Aecon's submission that needed to be corrected for OPG to accept the estimate and utilize it as the basis of the Project's target price.

Based on the DR Team's initial reviews and input from third parties, [redacted] and resolving the multitude of issues would require substantially more time and effort than originally planned. The resultant estimate vetting process ultimately extended 3 months past the initial mid-June 2015 target date for approving SNC/Aecon's Class 2 estimate. Starting in June, OPG and SNC/Aecon proceeded down parallel paths to resolve the then current estimate issues:

- Project executive level working sessions, intent on establishing a set of baseline cost and schedule objectives and addressing potential risks and barriers to performance that caused SNC/Aecon to take an excessively conservative approach to the estimate;
- Continued bottoms-up vetting of the detailed estimate and schedule, with subject matter experts ("SMEs") from OPG and SNC/Aecon working shoulder-to-shoulder to resolve OPG's comments and challenges.

Based on a working agreement reached at the project executive level, the combined OPG and SNC/Aecon teams were given targets for schedule and cost (a P50 schedule of 1,100 days and a target cost of ~$2.6B including contingency). These targets were provided for context only, as the direction given by both management teams was to focus on coming to agreement on a realistic and achievable estimate supported by workable plans, concrete data, and OPEX, rather than meeting top-down targets.

SNC/Aecon's final estimate was updated and finalized on September 18, 2015 and forms the basis of the target price contract the parties finalized prior to the November 12, 2015 Board of Directors

meeting[6]. Through detailed vetting, OPG's estimating team confirmed SNC/Aecon's representation that the underlying quality of this estimate is Class 2 level. The most significant supporting facts for this classification include:

- The final Execution Phase target price value of $2.750 B (2015$) has been fully negotiated and is based on mutually agreed upon project durations and schedule contingency, and encompasses 12.9M work hours, project management, supporting tasks, fee and all other costs;
- SNC/Aecon has designed and procured the specialized tools needed for the work. Some of the schedule task durations used in the estimate basis are derived from actually using the tools on the Mock-Up reactor and timing the results;
- All detailed engineering for Unit 2 is complete;
- Construction Work Packages ("CWP's") have been prepared and submitted as a part of the estimate;
- All 53,000 pages of SNC/Aecon's submission were vetted by OPG's subject-matter experts; ~165,000 estimate line items were reviewed/vetted by the estimating team;
- Both OPG and SNC/Aecon have teams with considerable experience on prior CANDU refurbishment projects and much of that experience has been incorporated into the estimate;
- Tool design has been significantly improved over those used in prior refurbishments, increasing reliability and making the tools easier to use;
- Training on the full-scale Mock-Up, which has never been done on prior refurbishments, should significantly increase the trades' performance in the field;
- Risk identification and contingency planning have been thoroughly performed and known risks are incorporated into SNC/Aecon's base schedule durations and work planning efforts.

Overall, the vetting process resulted in a reduction of over 3M work hours and more than $390M in direct cost from the May Class 2 submission to the final September submission.[7] Together with the reduction in associated Fixed Fee ($120M) and Contingency ($105M), the overall Class 2 estimate was reduced from May to September 2015 by over $600M. These cost reductions identified in the estimate review process displayed the effectiveness of the progressive reviews, and in particular the detailed vetting that occurred between SNC/Aecon Rev. 0 and Rev 1 submissions. This process resulted in the maturation of SNC/Aecon's estimate and an improved confidence level.

2. VETTING AND CHARACTERIZATION OF ESTIMATE

As described above, after the delivery of Revision 0 of the Class 2 Estimate, OPG engaged SNC/Aecon in a detailed vetting process aimed at reducing the overall cost estimate, providing substantive basis for SNC/Aecon's portion of the critical path, and challenging the nature of SNC/Aecon's stated risks and contingency. The OPG and SNC/Aecon teams established a review

[6] Final negotiations should result in some changes to the price. To ensure that the amount OPG has captured in RQE is all-encompassing, it has included in RQE a value of $2.83B for SNC/Aecon's target price and will true-up the control budget based on the final award as it becomes available.

[7] SNC/Aecon's Class 3 estimate submission excluded, by contract, contingency and fixed fee. These amounts were estimated by OPG to complete the Class 3 estimate included in release 4d. The Class 2 estimate included contingency and fixed fee at a significantly higher value than estimated by OPG in release 4d, and therefore, the total cost variance from Class 3 to Class 2 actually only decreased by ~$64M. However, when these elements are not considered, the direct cost variance from Class 3 to Class 2 is actually a decrease of $278M.

and vetting process that was driven by OPG and SNC/Aecon subject-matter experts with specific experience in prior CANDU refurbishments. This process was extremely successful at achieving consensus between the subject-matter experts, who objectively agreed with the underlying schedule durations in most instances. As we noted in our October 2015 Report to the Board of Directors, the process utilized to reach these final estimates was extremely detailed and rigorous, which should provide confidence in the results of the vetting process.

The OPG Estimating group delivered its Class 2 estimate report for the RFR project in November and declared the estimate acceptable, appropriately documented, and within conformance to the AACE International Class 2 criteria. There were several outstanding areas for improvement noted, summarized below, that will be addressed as part of the Unit 2 estimate process. These areas for improvement include:

- Savings of $47M related to “late changes” that were not included in the Revision 01 estimate;
- Savings of approximately $10M related to aligning General Foreman rates to the contract agreement and exhibits;
- Reconciling trades labor rates that changed (increased) from Revision 00 to Revision 01 to the contract agreement and exhibits;
- Reconciling Owner Supplied Material (“OSM”) and Goods supporting details with the estimate summary report;
- Refining the resource leveling, manpower loading, and labor optimization approaches;
- Providing additional detail for differences in subsequent units’ costs and Execution Phase work prior to breaker open;
- Providing additional detail regarding commissioning and return to service scope, risk, and cost estimates;
- Providing additional detail regarding close out activities including engineering closeout, demobilization, decommissioning, and demobilization.

Closing out these items will be a priority for the RFR team prior to the Unit 2 Estimate.

3. CONTINGENCY

Contingency related to the RFR work is split between the following major buckets:

- The contract includes a contingency amount that can be utilized by SNC/Aecon as an allowance to resolve issues without impact on the target price. The basis and monetization of this contractually required contingency was heavily vetted by the subject-matter experts and senior management. The resulting 13.5% contingency (totaling $368M) is largely based on a deterministic analysis of the potential duration for work task performance and other discrete risks that could impact the work, as monetized with the use of Monte Carlo simulation. The DR Team has assumed for purposes of the control budget that this contingency will be utilized.
- OPG is holding $236M of contingency at the project level which includes discrete risks not carried under the contract. These discrete risks were developed by the OPG Project Team based on its own vetting process regarding the risks from the RFR work that OPG should own and control.
- OPG is also holding $381M for schedule uncertainty which, due to the RFR project’s significant critical path duration, is based on the modeled difference in impact to the critical

path between SNC/Aecon's "medium confidence" (or P50) schedule and OPG's "high confidence" (or P90).

In total, OPG is carrying $617M in contingency for RFR or RFR-related risks over and above the contingency that is built into the contract. With a remaining EPC contractor base cost for RFR of $2.33B (excluding contractor fees), this equates to 26%. Taking into account the level of planning and engineering performed to date, offset by the track record of prior CANDU refurbishments, the work performed to identify performance risks and the overall importance of RFR to the work, this level of contingency appears, at this stage, to be appropriate all from a process perspective.

4. SUMMARY AND REMAINING ISSUES

BMcD/Modus closely monitored the development of SNC/Aecon's cost estimate and OPG's vetting of same, and believes the process the parties used to develop the cost estimate was reasonably robust, producing an estimate with significant detail. Moreover, we have witnessed the relationship between the parties substantially improve at every level, which will be important as issues arise. Based on the initial commercial goals the parties set forth, the contract and the resultant cost and schedule estimating process appears to have thus far driven appropriate behaviours and a beneficial result.

With the Class 2 Estimate and target price agreement in place, the RFR team's attention is now turning to execution. The major near-term focus will be on the following:

- Recovery of procurement dates for some components: SNC/Aecon's procurement is generally lagging behind, though some of this lag is driven by aggressive contract milestones, not actual needs for the material. This is currently being addressed by the joint SNC/Aecon and OPG RFR team who have established a "war room" similar to that exercised for the Class 2 estimate development. In addition, SNC/Aecon's procurement system is not compatible with the system OPG has put in place, which could lead to misunderstandings regarding the status of SNC/Aecon's efforts. A work-around that allows OPG transparent review of SNC/Aecon's status needs to be implemented.
- Retube Waste Processing Building ("RWPB") estimate, schedule and performance: the work on RWPB continues while the estimate and schedule preparation continues. The $167M estimate included in RQE was presented as an upper limit estimate, though SNC/Aecon's final estimate and execution plan needs to be fleshed out before that can be definitively stated.
- Logistics need further refinement: SNC/Aecon needs to devote further attention to its supporting activities for material and tooling logistics during the Execution Phase and take full advantage of the currently available time leading up to breaker open to test and implement its logistics plan.
- SNC/Aecon's construction organization needs to be built, the importance of which cannot be overstated.
- Execution Phase schedule needs additional work and must align with the Project's work breakdown structure so that metrics for reporting progress can achieve needed fidelity. Moreover, SNC/Aecon's reporting of earned value status needs to follow OPG's requirements and eliminate level of effort activities that dilute the basis of earned value.
- SNC/Aecon needs to remobilize in the DEC and make full and beneficial use of the Mock-Up to practice tasks and train workers (this work commenced at the end of October 2015).

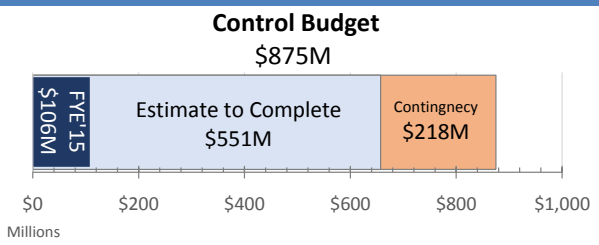
Each of these elements will provide necessary information regarding cost, schedule, risk and overall confidence as the DR Project advances that can be rolled into the Unit 2 Estimate.

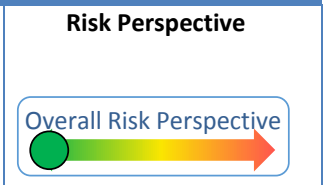
MODUS STRATEGIC SOLUTIONS

BURNS McDONNELL

TURBINE GENERATOR (TG)

Turbine Generator Project Summary	
Control Budget:	$875,025,000
RQE Base Cost:	$657,149,000
Estimate to Complete:	$551,203,000
Contingency	$217,876,000
(as % of Estimate to Complete):	(40%)
Estimate Class:	Class 3 (85%) Class 2 (15%)
Percent of RQE:	7%





1. TURBINE GENERATOR BASIS OF ESTIMATE

The Project's Turbine Generator work consists of two significant scopes: (1) maintenance work; and (2) digital controls change-out for Unit 3, Unit 1 and Unit 4. In 2014, the DR Team decided to postpone the controls change-out for Unit 2 until the conclusion of the DR Project in order to reduce the risk of the Unit 2 work. Thus, the risk profile for the Project changes significantly with Unit 3, which will be the first of three units that will have a full replacement of the original TG controls during Refurbishment. The digital controls upgrade will be a first time evolution for OPG and will require significantly more planning than the limited maintenance scope for Unit 2. The risk profile of the subsequent units has been developed with this in mind. Based on the risk profile of similar controls replacements, the decision to delay Unit 2 appears to have been prudent.

Unit 3 will also be the first replacement of the generator mid-section and stator rewind. A new stator will be installed for Unit 3, and the existing Unit 3 stator will be rewound and installed in Unit 4. This work has been planned sufficiently in advance that it should not be a threat to the schedule of the later units.

OPG has accepted SNC/Aecon's Class 2 Estimate for the Turbine Generator for Unit 2, and Alstom has completed its detailed design. SNC/Aecon and Alstom have submitted their full estimates for the subsequent units, which are characterized as Class 3 in nature. These estimates are expected to be fully accepted before the Board of Directors meeting.

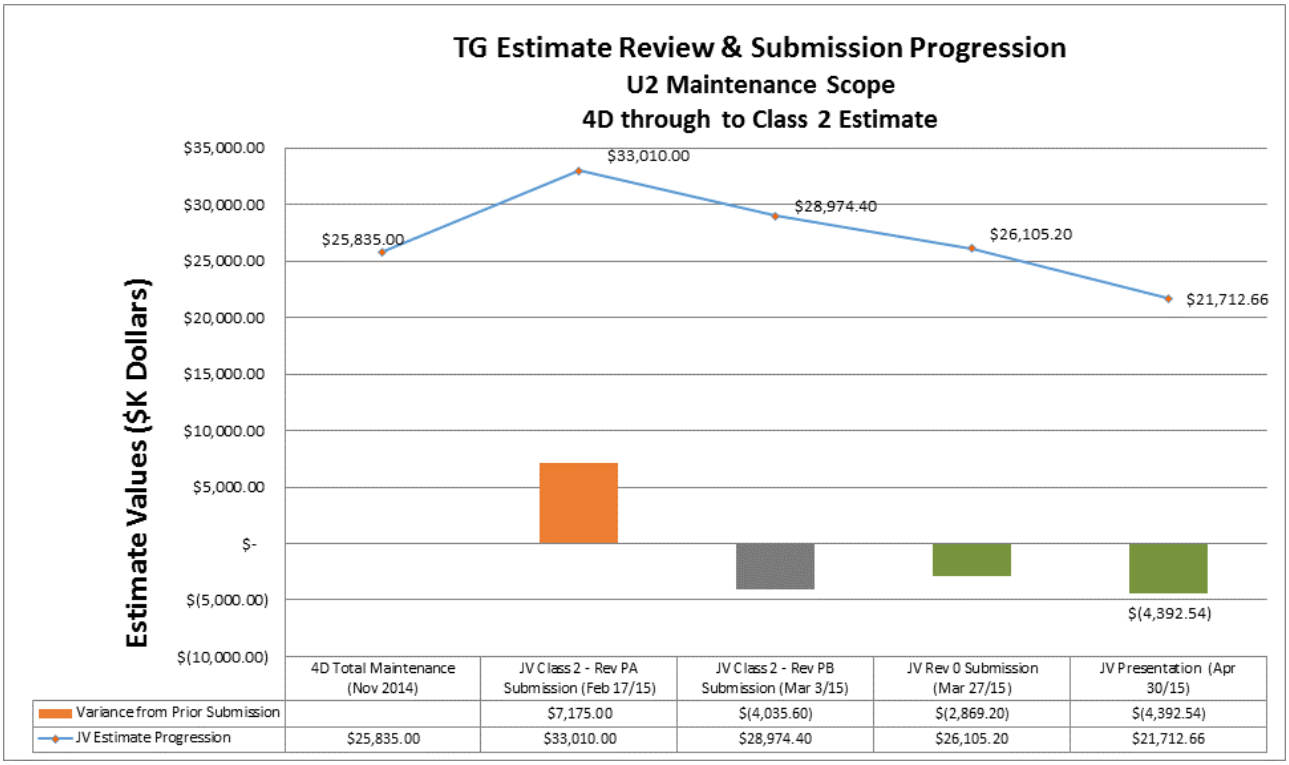
2. VETTING AND CHARACTERIZING THE ESTIMATE

Vetting of the Turbine Generator Project estimates came in two phases. Alstom, the original equipment manufacturer ("OEM"), is supplying parts and engineering per a fixed price. That contract was assigned to SNC/Aecon for management after its team was awarded the labour portion of the work. SNC/Aecon's estimate followed much of the same structure as its RFR effort, including successive iterations of the estimate from Class 5 to Class 2. The final Class 2 estimate that forms the basis of the target price with SNC/Aecon was the test case for utilizing OPG's vetting process of contractor's estimates and laid the groundwork for RFR and the remaining project bundles..

The TG RQE estimate has three main cost components: (1) the Alstom engineering and procurement contract, which represents approximately 50% of the total at RQE; (2) SNC/Aecon's construction estimate for performance of the work (40% of the RQE line item); and, (3) OPG's project management cost estimate, which makes up the remaining 10% and includes OPG's expenses, such as oversight and inspection maintenance services. As with RFR, the Turbine Generator ("TG") estimate has significantly matured since the 4d Cost estimate, from $576.6M to $657.2M, a 12% increase from the Class 3 to the Class 2 estimate.

Over a period of four months, OPG's estimating team vetted 100% of the estimate comprising approximately 40,000 line items and issued over 300 comments that SNC/Aecon had to disposition. The collaborative approach taken between SNC/Aecon and OPG teams resulted in constructive exchanges on the completeness, quality and reasonability of the estimate for issues such as labor productivity factors, crew size/rates/composition and overtime factors. SNC/Aecon was responsive to feedback and dispositioned all comments, resulting in the refinement and increased quality of the Class 2 estimate.

For example, as a comparison of the base scope for the maintenance portion of refurbishment work, the graph below presents the results of the teams working through successive reviews, multiple challenge sessions, and negotiations.



	4D Total Maintenance (Nov 2014)	JV Class 2 - Rev PA Submission (Feb 17/15)	JV Class 2 - Rev PB Submission (Mar 3/15)	JV Rev 0 Submission (Mar 27/15)	JV Presentation (Apr 30/15)
Variance from Prior Submission		$7,175.00	$(4,035.60)	$(2,869.20)	$(4,392.54)
JV Estimate Progression	$25,835.00	$33,010.00	$28,974.40	$26,105.20	$21,712.66

The reduction of SNC/Aecon's estimate by ~25% from its initial submission provided an example of the potential results that can be achieved through an iterative and collaborative vetting process for the other project bundles.

3. CONTINGENCY

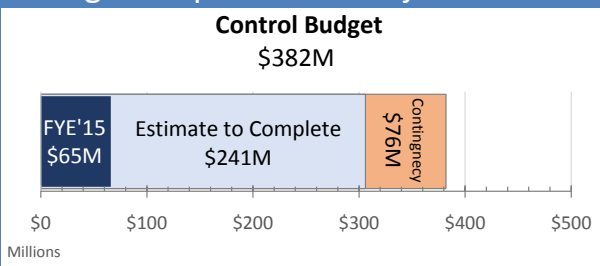
OPG has designated both project-level and program-level contingency for this project totalling $218M ($194.8M project-level and $23M program-level contingency). The $195M in project-level contingency broken down as follows: (1) $27.9M for cost uncertainty; (2) $49.9M for discrete risks identified by the Project Team; and (3) $117M for potential component replacement based on the results of concealed condition assessments on each unit's turbine generator. The DR Team set aside $23M in program-level contingency for schedule uncertainty. This project's contingency bucket was vetted and classified using the OPG estimating process. The team has fully examined the potential schedule impact of discovery work and believes it has reserved sufficient non-critical path time for major component procurement and replacement in the event such work is required.

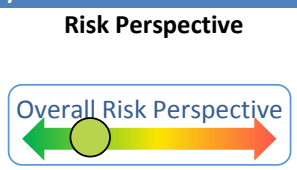
4. SUMMARY AND REMAINING ISSUES

BMcD/Modus monitored the process used for vetting the TG estimates, and we believe this effort was reasonably robust and resulted in further maturation of the estimate. SNC/Aecon's plan for execution was fully explored and significant cost reductions were realized for RQE. As stated above, the Unit 2 work is essentially routine maintenance, though the performance of that work will allow for improved understanding and efficiency for the future units. The controls change-out for Unit 3 needs to be further examined so that the team is assured the labour hours are properly estimated and risks from schedule impacts are mitigated. It is also important to establish and execute a very well planned and rigorous control system test program prior to turbine roll. These will be issues for future unit estimates.

FUEL HANDLING, DEFUELING AND SPECIALIZED PROJECTS (FH, DF, SP)

Fuel Handling, Defueling and Specialized Projects Summary	
Control Budget:	$381,947,000
RQE Base Cost:	$306,048,000
Estimate to Complete:	$240,888,000
Contingency	$75,866,000
(as % of Estimate to Complete):	(31%)
Estimate Class:	Class 3
Percent of RQE:	3%





1. FUEL HANDLING, DEFUELING AND SPECIALIZED PROJECTS BASES OF ESTIMATES

In summary, the scope of these project bundles includes: (1) Defueling each of the reactors to begin refurbishment, which is the first major work on the critical path and fully in OPG's control; (2) Fuel Handling equipment replacement to increase the likelihood of the power track maintaining operation through the Refurbishment outages; and (3) Specialized Projects to replace out of-date components to the Darlington Shutdown System computers, and replacement of the vault coolers that have reached the end of their useful lives. The work for these sub-bundles is directed by OPG, with the DR Team and the Darlington Station working cooperatively, with vendors supplying engineering, parts and labour for portions of the work. OPG decided to minimize the number of engineering changes to these critical components by calling for "like-for-like" replacements and thus limited the potential risk of execution.

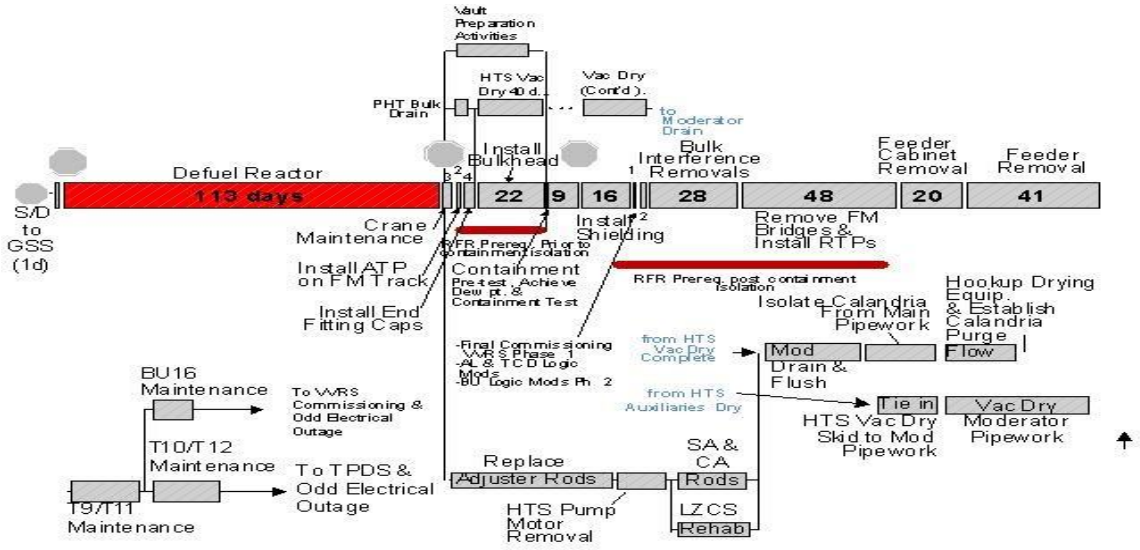
While the total cost estimate for Fuel Handling/Defueling/Specialized Projects constitutes only about 3% of the total cost of the DR Project, each of these projects could affect the critical path. Defueling the Unit 2 reactor is the first critical path activity in the Unit 2 outage, and this is a first time defuel for Darlington. Ensuring the Fuel Handling components work throughout the DR Project is OPG's responsibility, as OPG will seek to maintain the operation of the running units during each defueling period of each unit's refurbishment. For these reasons, the planning, scheduling and risk mitigation of this work is extremely important. The DR Team has been focused on evaluating the past defueling OPEX at other CANDU plants and scrubbing the planned durations to the extent possible.

2. VETTING AND CHARACTERIZING THE ESTIMATE

The process for vetting the estimates for these sub-projects was robust and included a team drawn from the station and the project. The process involved an assessment of reasonable performance in light of past CANDU refurbishment execution, station and vendor performance, and the first-of-a-kind nature of some of this work. It was the latter that drove the estimated Class 3 designation, as the Defueling/Fuel Handling team needed at least one unit's performance before committing to tighter cost estimates.

The current assessment from the Defueling team shows the best case for defueling is 90 days, the medium confidence schedule (i.e. P50) is 113 days, and the 90% high confidence level duration is 134 days. Figure 3 below depicts the defueling duration's criticality at the beginning of Unit 2.

Figure 3 – Unit 2 Critical Path through Feeder Removal



The Defueling Project Team believes these same durations should be utilized for all four units, as the learning curve for performing defuel will have limited value in improving performance over time. The team believes the 90 day best case is strictly a function of core hydraulics and cannot be improved, while the worst case is based largely on the potential for equipment failure. In the course of deriving these point durations, the Defueling team has dispositioned OPEX from Bruce Power and Pickering and has consulted with its vendor, GE/Hitachi. The due diligence performed by the Defueling team has greatly improved the DR Team's understanding of this critical duration.

3. CONTINGENCY

Each of the sub-bundles within this Project is carrying contingency that was assigned on the basis of the work's approximated risk. The following depicts the level of contingency assigned to each:

Table 3 – Contingency Summary – Fuel Handling, Defueling and Specialized Projects

Bundle	Base Cost Estimate (in $M)	Est. to Complete (in $M)	Project Contingency (in $M)	Program Schedule Contingency	% Contingency on ETC
Defueling	$39.6	$10.6	$5.4	$38.0	51%
Fuel Handling	$158.6	$144.7	$19.6		
Specialized Projects	$107.9	$85.5	$12.8		15%
Total	$306.1	$240.8	$37.8	$38.0	31.4%

From a process perspective in regard to both project and program-level contingency ($75.8M total), the contingency for the Fuel Handling, Specialized Projects and Defueling bundles appear to be

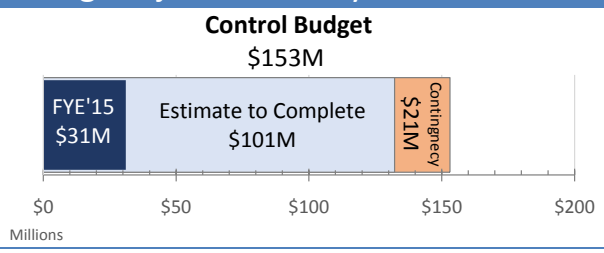
appropriate. The Specialized Projects and Fuel Handling are lower-risk based on the "like-for-like" nature of the work, and a significant amount of schedule contingency has been applied to the Defueling due to the potential risk of delaying the critical path. The discrete risks identified for this work appear to be schedule-focused, which seems appropriate.

4. SUMMARY AND REMAINING ISSUES

The Defueling/Fuel Handling teams have identified the risks and mitigation approaches. The commissioning of the test fuel handling equipment is complete and the team accelerated the schedule to maximize the amount of practice the teams can perform in advance of breaker open. OPG's performance of these projects will be under tremendous scrutiny going forward, so practice and proving-out processes for documenting progress will be important during the Readiness to Execute phase.

ISLANDING (IL)

Islanding Project Summary	
Control Budget:	$153,104,000
RQE Base Cost:	$132,247,000
Estimate to Complete:	$101,418,000
Contingency	$20,857,000
(as % of Estimate to Complete):	(21%)
Estimate Class:	Class 3
Percent of RQE:	1%



1. ISLANDING BASIS OF ESTIMATE

The various islanding projects are relatively small in cost but significant to the DR Project's success. The design of the Darlington plant, in particular the fueling bay that runs below the reactors, makes isolating a single unit for refurbishment a challenge. These projects include: (1) Installing a bulkhead that isolates the Refurbishment unit reactor vault from station containment, once the irradiated fuel has been removed from the core, which will allow both airlock doors to be opened to facilitate worker and material transfer into/out of the vault, thus significantly improving RFR worker efficiency[8]; (2) Establishing barriers and access control around the Refurbishment Island to keep the Refurb station staff from entering operating unit areas and to keep Station workers from entering Refurbishment work areas; and (3) Establishing terminal points on station systems to allow them to be isolated from the operating units to the maximum extent possible.

2. VETTING AND CLASSIFICATION

The majority of the cost for the Islanding work is being carried under SNC/Aecon's contract and was estimated by SNC/Aecon using essentially the same vetting process for RFR.

3. CONTINGENCY

The total contingency of $20.86M equals 25% of the remaining costs. The largest and most significant driver of contingency is the potential impact on the DR Project's schedule from potential delays installing the bulkhead. The risk register for Islanding appears to be appropriate for its current state of maturity.

4. SUMMARY AND REMAINING ISSUES

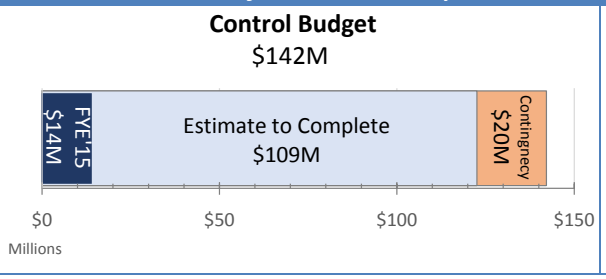
The DR Team has performed extensive reviews of plant conditions and OPEX, particularly from Bruce

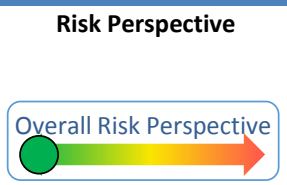
[8] Bulkhead installation is the single largest element of the Islanding Project and its performance will be by SNC/Aecon

Power, and its efforts appear to have isolated and mitigated the risks to the extent possible. There will be some Islanding work during the Readiness to Execute phase that will allow the team to test its processes and metrics for the larger, more important scopes after breaker open, including schedule and earned value tracking.

STEAM GENERATOR (SG)

Steam Generator Project Summary	
Control Budget:	$142,171,000
RQE Base Cost:	$122,579,000
Estimate to Complete:	$108,589,000
Contingency (as % of Estimate to Complete):	$19,592,000 (18%)
Estimate Class:	Class 2 (72%) Class 3 (28%)
Percent of RQE:	1%





1. STEAM GENERATOR BASIS OF ESTIMATE

The scope of the Steam Generator Bundle comprises maintenance work, including the following: (1) Primary side cleaning; (2) Secondary side cleaning (Tubesheet Water Lancing); (3) Access Port installations (modification); (4) Inspection and Repair (Primary and Secondary Side); (5) Divider Plate Inspections, Boiler Open/Close & Inspection Support; (6) Lay-up work, and; (7) Bleed Cooler Inspection. All of the work has been executed in other plants. The contract for the work was let to a joint venture of B&W and CANDU Energy, a subsidiary of SNC Lavalin.

2. VETTING AND CLASSIFICATION OF THE ESTIMATE

The SG work is classified as Class 2 due to the nature of the work and the fixed-price contract.

3. CONTINGENCY

The project is carrying $19.6M in contingency (18% of remaining cost) which is largely driven by the potential for discovery work, and coordination issues with RFR and OPG's Inspection Maintenance Services.

4. SUMMARY AND REMAINING ISSUES

The development of the SG project has proceeded well and the work planning is underway. The risks discussed above with coordination and the Project's schedule appear to be the most important factors for the team to consider. The performance of the Primary Side Cleaning is currently planned to be the only work other than RFR to extend past the 60% window designated for non-critical path work.

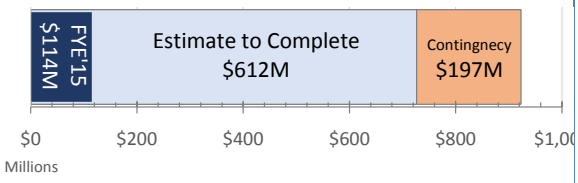
MODUS STRATEGIC SOLUTIONS

BURNS McDONNELL

BALANCE OF PLANT, SHUT DOWN LAY-UP AND REFURB. SUPPORT FACILITIES (BOP, SDLU, RSF)

BOP, SDLU, and RSF Project Summary	
Control Budget:	$922,940,000
RQE Base Cost:	$726,402,000
Estimate to Complete:	$612,043,000
Contingency	$196,538,000
(as % of Estimate to Complete):	(32%)
Estimate Class:	Class 2 (1%) Class 3 (53%) Class 4 (39%) Class 5 (6%)
Percent of RQE:	7%

Control Budget
$923M



Risk Perspective

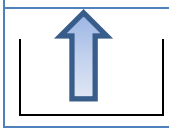
1. BOP, SDLU AND RSF BASIS OF ESTIMATE

This work scope includes a number of smaller to medium-sized project bundles. Approximately two-thirds of the work is based on design modifications, while the rest of the work is like-for-like replacement of aging components. The DR Team completed detailed engineering for the modification projects in time for the August 15, 2015 milestone, with some minor exceptions. The BOP work currently includes seventeen unique sub-projects that range in value from approximately $700K to $66M, and the scope includes replacement of components, electrical cable, and inspect and repair/replacement of valves. SDLU consists of twenty-eight different sub-projects and includes a number of prerequisites for construction, including breathing air for workers in the vault and barriers, as well as lay-up of plant systems for the unit being refurbished. RSF consists of building, improving and maintaining shops and other facilities for use during construction. The majority of this work has been released to ES Fox under the terms of the ESMSA contract.

The majority of the BOP work will be performed during the first 50-60% of each unit's refurbishment schedule, with the goal of keeping BOP work off the critical path. Much of the SDLU and RSF work will precede breaker open, but maintenance of the lay-up of systems will stretch throughout the length of the Project.

The BOP, SDLU and RSF bundle estimates for RQE have matured considerably since the 4d Cost Estimate. As of 4d, these bundles were at Classes 4 and 5. Now, a little more than half of the estimates conform to Class 3 and all estimates are expected to be Class 3 by the Gate 3 release, which is expected by 1Q 2016. The following table illustrates the progression from 4d to RQE and future progression to BOP/SDLU Gate 3:

Table 3a – Changes in BOP/SDLU/RSF Classification

Maturity	Class	4d	RQE	Gate 3
	3	0%	53%	100%
	4	68%	39%	0%
	5	32%	6%	0%

As the estimates for the work have matured, the cost estimates have, in aggregate, increased by 22% as represented in the table below.

Table 3b – Comparison of BOP, SDLU and RSF Bundles from 4d to RQE				
Bundle	4d	RQE	Variance	
BOP	$379,410,000	$430,098,000	$ 50,688,000	13%
SDLU	$125,196,000	$218,051,000	$ 92,855,000	74%
RSF	$ 91,845,000	$ 78,404,000	$(13,441,000)	(15%)
TOTAL	$596,451,000	$726,553,000	$130,102,000	22%

The EPC vendors for these bundles are ES Fox, B&W, Areva, and AMEC.

2. VETTING AND CHARACTERIZING THE ESTIMATES

The vetting process of the BOP and SDLU/RSF estimates for RQE was fundamentally the same as was used on other projects. However, because the contractor ES Fox has had documented issues with the accuracy of its cost estimates on DR Project work, a further enhanced "seven step" collaborative process was added prior to the vetting effort to expedite the submittal/feedback loop between owner and contractor.

This process employed focused multi-discipline planning, information development on plant conditions and execution sequencing, direct technical input, and incorporation of past OPEX. OPG SME's were embedded within ES Fox's organization and worked side by side with ES Fox in a "war room" environment to quickly identify and resolve issues as they arose.

Upon finalization of detailed estimate reviews, the review cycle was closed out with a joint reasonability review to establish support for the review results and completion of the estimate classification, and an estimate final report was collated and signed off by the estimating and project management teams. This process and additional level of effort expended by OPG in reviews and refinements resulted in many of the projects achieving a higher level of detail within their submissions.

These project bundles are the least mature in the Refurbishment scope, which is reflected by their respective estimate classifications; 1% is Class 2, 53% is Class 3, 39% is Class 4, and 6% is Class 5. The BOP, SDLU and RSF bundle estimates comprised approximately 42,000 estimate line items and the estimating team reviewed 100% of the field labor related items Based on our observations, the vetting process was sufficient given the maturity level of project definition and characterizations of the estimates appear to be appropriate and generally aligned with AACE recommended guidelines.

3. CONTINGENCY

These bundles' contingency is broken down as follows:

Table 4 – BOP, SDLU and RSF Remaining Contingency				
Bundle	**Base Cost Estimate (in $Ms)**	**Est. to Complete (in $Ms)**	**Contingency (in $Ms)**	**% Contingency on ETC**
Balance of Plant	$430.0	$353.6	$125.3	35%
Shut-Down/Lay-up	$218.0	$196.8	$53.1	27%
Refurbishment Support Facilities	$78.4	$61.6	$18.1	29%
Total	$726.4	$612.0	$196.5	32%

The drivers for contingency include: (1) cost uncertainty due to the maturity level of the packages and the recent completion of supporting detailed engineering; (2) potential upfront delays to Refurbishment causing early schedule issues; (3) past performance of ES Fox on the Campus Plan

Projects; and (4) potential for discovery work.

ES Fox's performance on the Campus Plan Projects and the recently completed Vacuum Building Outage (VBP) provides vital OPEX that the team has considered in identifying risk for these projects. The DR Team is aware of the issues [redacted] and are attempting to mitigate those issues. The completion of engineering and the nature of the work in the plant [redacted] The OPG scheduling team has recognized these shortcomings and worked with ES Fox to improve the deliverables. Overall, 45% of the BOP and Shut-Down/Lay-Up work estimates are in the Class 4 or 5 range, which increases the risk of estimating uncertainty for these projects. The BOP and Shut-Down/Lay-Up project teams have identified discrete risks related to vendor performance. Additionally, OPG has included some program-level contingency due to the past track record of these vendors in the event performance issues resurface during Refurbishment.

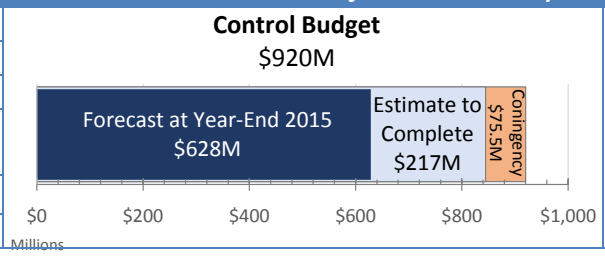
4. SUMMARY AND REMAINING ISSUES

BOP and Shut-Down/Lay-Up will be under significant scrutiny once the DR Team's focus shifts to the Readiness to Execute plan. ES Fox must continue its planning work with more detailed and mature estimates, execution schedules and development of Construction Work Packages. The DR Team's goal of having all of the BOP projects proceed to their respective Gate 3 between late November 2015 and January 2016 will require a determined effort. To meet this goal, ES Fox will need to complete the detailed level 3 execution schedules, Class 2/3 estimates and Construction Work Packages to support these gates. The BOP team has set interim milestone dates with ES Fox for these deliverables which may be too aggressive for the DR Team to receive quality work product.

CAMPUS PLAN PROJECTS (CP – F&IP AND SIO)

Campus Plan Projects – F&IP and SIO Project Summary

Control Budget:	$920,079,000
RQE Base Cost:	$844,621,000
Estimate to Complete:	$216,713,000
(Project + Program Allocated Cont.):	$75,458,000
(as a Percent of ETC):	(35%)
Estimate Class:	Not Applicable
Percent of RQE:	8%



1. BUDGET STATUS

As of this assessment, there are six active Campus Plan Projects in execution. There are two other pre-requisite projects, the Auxiliary Heat System ("AHS") which for budgetary purposes was, after a review by Finance, classified as a Station project, though P&M is still managing the work. The costs for AHS are carried as part of the Nuclear Asset Investment Portfolio. Another pre-requisite project, the Refurbishment Waste Processing Building ("RWPB") is being performed by SNC/Aecon under the RFR Definition Phase contract and is not part of P&M's reporting.

We have noted in past reports that while the remaining cost involved in completing the Campus Plan Projects should not necessarily have a significant monetary impact to RQE, though certain of the projects, most notably D20 Storage and EPG 3, remain a risk to breaker open of Unit 2. These projects' completion dates have shifted over time and further delays risk drawing attention away from the Readiness to Execute plan. As noted, the entire portfolio of Campus Plan Projects experienced

$76.3M in base cost growth from 4d to RQE, an increase of 9%, which resulted in contingency drawdowns from the allocated budget amount set in 4d. P&M is currently forecasting an Estimate to Complete ("ETC") for all remaining Campus Plan and SIO work of $216,713,000.

2. CONTINGENCY

Based on the history of these projects, the velocity of change and the volume of remaining work, the $75.5 million in contingency needs to be closely tracked to ensure it is enough to cover any remaining cost issues with completing these projects. OPG currently anticipates that it will spend $26.2 million of this contingency leaving only $49.3M for the remaining work. In particular, D20 and EPG3 pose the greatest risk to the remaining Campus Plan Contingency, and EPG 3's final cost estimate has not been fully vetted and approved. P&M's change control process needs to be monitored so that the use of contingency is readily identified and so there are sufficient funds going forward.

FUNCTIONS

The total control budget for the OPG functions is $2.6B ($2015), or 20% of the overall RQE. The summary costs for the functional groups is as follows:

Functional Group	LTD (@ DEC 2015) x $1,000	Total Base Cost Excl. Contingency (x 1,000)	Project Contingency (Discrete Risks)	Program Contingency (Schedule/ Functions/ General)	Total Contingency P90	Total RQE (Incl. Contingency) (@P90)
O&M	$ 41,492	$ 756,025	$ 19,290	$ 33,822	$ 53,112	$ 809,137
Program Support	$ 21,178	$ 340,775	$ 14,343	$ 17,752	$ 32,095	$ 372,870
Execution OH	$ 9,513	$ 321,555	$ 8,506	$ 158,021	$ 166,527	$ 488,082
Engineering Services	$ 76,046	$ 282,506	$ 6,467	$ 5,148	$ 11,615	$ 294,121
Contract Management	$ 9,510	$ 51,751	$ 1,507	$ 1,819	$ 3,326	$ 55,077
Managed System Oversight	$ 14,265	$ 40,925	$ 1,035	$ 1,685	$ 2,720	$ 43,645
Planning and Controls	$ 62,140	$ 136,161	$ 1,950	$ 3,387	$ 5,337	$ 141,498
Nuclear Safety	$ 35,232	$ 83,112			$ -	$ 83,112
Supply Chain	$ 14,104	$ 85,562	$ 2,222		$ 2,222	$ 87,784
Work Control	$ 8,617	$ 79,507	$ 2,336		$ 2,336	$ 81,843
OMA Training Prog.	$ 10,981	$ 10,981			$ -	$ 10,981
Waste Disposal		$ 38,054			$ -	$ 38,054
Functions - Rel. 3	$ 101,651	$ 101,651			$ -	$ 101,651
Adv Rel. 4	$ 7,467	$ 7,467			$ -	$ 7,467
Total	**$ 412,196**	**$ 2,336,032**	**$ 57,656**	**$ 221,634**	**$ 279,290**	**$ 2,615,322**

With the exception of Operations & Maintenance, the remaining functional groups that compose the DR Team has increased in size from 4d to RQE. The non-Operations & Maintenance groups' cost estimates increased by 20% in aggregate, from $1.28B (2015$) to $1.53B. The largest gain was for the Project Execution Organization ($243M to $488M, or 51%), as a reflection of lessons learned from the early approach to the Campus Plan Projects. Operations & Maintenance's budget decreased by from $1.1B (2015$) at 4d to $756M for RQE, a reduction of 31%. This reduction was due primarily to identification and removal from the DR Project of certain non-Refurbishment Operations & Maintenance costs.

The DR Team nonetheless has high confidence in the extent of the estimates it has prepared for RQE and are all-inclusive of what could reasonably be identified for staffing at this time. We believe that there is some risk that OPG will not meet its proposed plan in this area as the job functions and specific roles within the functional groups are not as defined as they could be. Additionally, the pace of the proposed ramp-up of the DR Team's staff over the next several months is very aggressive and will be very difficult to meet. In order to meet the plan, the DR Team would have to increase from 770 to just over 900 (17%) staff in less than 3 months. Moreover, the DR Team's projections for 2016 show a planned functional expenditure of $120M, excluding Operations & Maintenance and Engineering, which would equate to nearly 70% of the cost of these functions for the last 5+ years. The DR Team has been chronically under-spent during the Definition Phase, and missing these major ramp-up dates will further impact the accuracy of the team's staffing forecasts and potentially the

status of preparatory work for breaker open.

The commitment from the NPET to further rationalize and organize the functions on the basis of a division of responsibility matrix ("DOR") has been held over to the Readiness to Execute phase. The DR Team committed to putting a DOR in place that defines each function's accountability and responsibility by early 1Q 2016, which in turn should result in optimizing the organization. This DOR is intended to also define roles and integration responsibilities between the DR Team, the contractors and the Station. Such an undertaking will certainly require some shake-out, which the team intends to do during the Readiness to Execute phase.

While the DR Team's goal for RQE was to identify the outer cost limit for the functions, BMcD/Modus is more concerned that the DR Team operate efficiently, have highly qualified and skilled resources, and actively manage the field work during the Execution Phase. One of the primary complaints from OPG's contractors is the company's track record of having too many decision-makers involved, particularly when problems arise. Thus, the risk to the Project's cost from a poorly defined functional team extend well beyond the cost of the team itself.

In particular, the DR Team should sharpen its focus on commercial management of the contractors work in the field, which will entail a team effort between the commercial managers, project managers and field execution team. The DR Team intends to focus on these functions during the Readiness to Execute period, and their seamless integration will be essential to avoid claims and commercial disputes that can negatively impact work if allowed to fester.

The team has considerable work ahead to meet these goals, and we rate the current risk level in this area that the DR Team will not meet its plan as medium-high if the DR Team does not dedicate time and resources in this area in the short term.

RISK AND CONTINGENCY

1. CONTINGENCY PROGRAM OVERVIEW

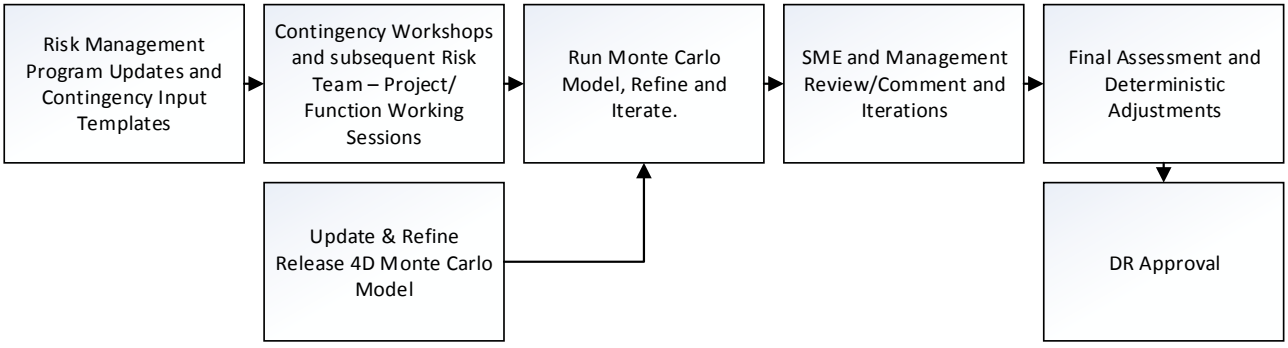
RQE contains $1.7B in contingency that is allocated among the various bundles and functions based upon OPG's risk management program and the RQE Contingency Development Plan NK38-NR-PLAN-09701-10006 prepared and approved by the DR Team in Q1 2015. OPG has established a fairly robust approach for developing the RQE contingency. The breakdown of the contingency is as follows:

	Name	Project Contingency (Discrete Risks)	Program Contingency	Total Contingency P90
Bundles	RFR	$ 235,820	$ 380,584	$ 616,404
	F&IP/SIO	$ 41,525	$ 33,933	$ 75,458
	TG	$ 194,855	$ 23,021	$ 217,876
	SG	$ 19,592		$ 19,592
	BOP	$ 125,318		$ 125,318
	SL	$ 53,064		$ 53,064
	RSF	$ 18,156		$ 18,156
	Fuel Handling	$ 19,625	$ 38,057	$ 57,682
	Defueling	$ 5,398		$ 5,398
	SP	$ 12,819		$ 12,819
	Islanding	$ 20,857		$ 20,857
		Total Contingency Bundles x $1,000		**$ 1,222,624**
Functions	O&M	$ 19,290	$ 33,822	$ 53,112
	Program Support	$ 14,343	$ 17,752	$ 32,095
	Execution OH	$ 8,506	$ 158,021	$ 166,527
	Engineering Services	$ 6,467	$ 5,148	$ 11,615
	Contract Management	$ 1,507	$ 1,819	$ 3,326
	Managed System Oversight	$ 1,035	$ 1,685	$ 2,720
	Planning and Controls	$ 1,950	$ 3,387	$ 5,337
	Nuclear Safety			$ -
	Supply Chain	$ 2,222		$ 2,222
	Work Control	$ 2,336		$ 2,336
	OMA Training Prog.			$ -
	Waste Disposal			$ -
	Functions - Rel. 3			$ -
	Adv Rel. 4			$ -
		Total Contingency Functions x $1,000		**$ 279,290**
Unallocated Contingency				$ -
	Program/Function		$ 107,906	$ 107,906
	Program Reserve		$ 96,340	$ 96,340
		Total Unallocated Contingency x $1,000		**$ 204,246**
	Total Contingency	**$ 804,684**	**$ 901,474**	**$ 1,706,158**

The Plan established a contingency process utilizing a number of AACE recommended practices for contingency development. It appropriately states that the practices will be supplemented with the expert opinion and judgment of the NPET (Nuclear Projects Executive Team) to ensure there is confidence that the contingency estimate is robust and sufficient to deal with the risks and uncertainties characterized at the time of RQE.

The DR Contingency development process is rigorous and reasonably conforms to good industry practices. Figure 4 below details that process.

Figure 4 - Simplified View of the RQE Contingency Development Process



Five basic components were addressed in developing the RQE contingency:

I. Cost Estimating Uncertainty - The project managers and function leads provided three point estimate uncertainty ranges for application to the base estimate cost elements.

II. Schedule Uncertainty – Uncertainty range estimates for critical path durations were provided to the risk team by the project managers. Schedule cost impact was determined by applying a daily "burn rate" to any schedule impacts. Allocation of schedule contingency between the affected project and the overall program critical path was carefully addressed.

III. Discrete Risks - Discrete risks from the project, program and function Risk Registers were reviewed and post mitigation probability of occurrence values were finalized. Quantitative cost & schedule impact values were developed with associated three point ranges as model input. In addition, provision for risk event recurrence over the four units was established for model input.

IV. Campus Plan/F&IP – The nature of Campus Plan risk registers, estimates and schedules required that contingency be established through a combination of stochastic, deterministic and expert judgment means. Probabilities and impact ranges for the discrete risks were updated. Cost elements were assigned uncertainty ranges. The results of the risk probabilities and impact quantification with three point ranging, along with estimate uncertainty ranges were then submitted for Monte Carlo analysis. The Monte Carlo contingency values were assessed by P&M's management and deterministic adjustments were made for RQE. The stochastic and deterministic numbers were then compared and justifiable adjustments were made. In addition, program contingency was added to reflect the historic performance issues associated with Campus Plan projects.

V. Insurance Uncertainty – A premium cost point estimate and pessimistic/optimistic uncertainty range was provided by the Finance department and factored into the contingency calculation.

OPG's risk team developed the contingency input templates which defined the required data and the format for input from projects and functions. The risk team led vetting of the results in workshops that followed a structured process. Instructions were provided to the respective managers, who then the presented draft data in twelve contingency workshops, where subject matter experts challenged, critiqued and provided constructive feedback. Many issues associated with the initial input were addressed in these workshops, including justifications, inconsistencies, and clarifications. There were good discussions and informative challenges regarding the risk scores and three point ranges. This dialog likely helped the project/function personnel refine and finalize contingency input.

After the workshops, members of the OPG risk team met with the respective managers and their teams to guide the template refining and updating. The updated data was entered into the Monte Carlo model and preliminary results were obtained. Those results were analyzed, changes were made to the model, and input data was refined. To monetize schedule impact, the finance department reviewed cash flow projections and developed a point estimate for daily burn rate and an associated uncertainty range. That approach is considered reasonable and consistent with industry practice.

Extensive review and iteration by the risk team and by DR management were conducted to ensure the contingency was reasonable and defensible. There were twelve NPET Bundle Challenge Review Meetings and three RQE Summary Snapshot Reports were reviewed. These were rigorous and effective in creating defensible and reasonable contingency, which is presented in Final Snapshot 4.

OPG first developed a Monte Carlo model to determine Release 4D contingency. This was valuable for creating an effective RQE input and review process and a robust model for RQE contingency

calculation. The 4D contingency model was reviewed by a modeling expert from the Palisade Corporation[9]. In general, Palisade found that the 4D documentation and methodology complied with quantitative risk management best practices. In their 4D report, Palisade identified 35 recommendations for improving the execution of the model and increasing the result accuracy. All recommendations but a few (considered "nice-to-have") were implemented for the RQE contingency model. When interviewed by BMcD/Modus, the Palisade expert indicated that the DR RQE model is well constructed and operated; and is in the upper range of size and complexity. He also confirmed that large models frequently apply correlation factors based of informed qualitative rationale and risk appetite, rather than tediously mapping correlation factors to individual risks.

In their final report, which focused on the RQE contingency process, Palisade stated that the DR model contains all the elements of risk management's best practices and contains well-defined methodology as its foundation. Palisade also cited the collaboration of risk experts interfacing with project/functional managers and SMEs.

The RQE Monte Carlo model is extremely robust and comprehensive. All four units are addressed in an integrated fashion. The model consists of over 2600 three point estimates which were used to model outcome (maximizing use of 3 point range estimating contributes to the veracity of the input by allowing the source to avoid conservative single value "plug-in" numbers). Over 470 discrete risks were analyzed, and 273 of those were included in the contingency calculation. Of the 273, 55 were program/function related and 218 were from projects. Close to 800 estimate uncertainties were analyzed and 128 schedule activities were assessed across the 4 Units.

A schedule correlation factor of 70% is included in the contingency model, reflecting interdependence of schedule activities. In addition, because DR is a multiple unit project, provisions to address risk recurrence are incorporated based on project and functional manager input.

CONCLUSION

In summary, BMcD/Modus finds that OPG has substantially met the goals set out in 2009 for development of RQE, and in particular, the control budget that OPG will use for measuring performance of the DR Project. Our findings, as substantiated in this assessment, are:

- OPG properly developed and reasonably supported its control budget for the DR Project in conformance with its governance and AACE International guidance. Attachments B and C summarize our assessment of OPG's conformance to the governance.
- OPG's processes for RQE were reasonably robust and thorough in the development of the DR Project's control budget. The process used for developing the majority of the DR Project's bundles was reasonably thorough, as was the development of the Project's contingency.
- OPG's process for developing the control budget for RQE was generally successful in advancing the maturity of the work, and was consistent in characterizing its project estimates. As noted, approximately 90% of the project estimates achieved sufficient maturity to be characterized as a Class 2 or Class 3 estimate.
- OPG's process for developing contingency was reasonably effective and thorough.

[9] Palisade Corporation provides widely accepted @RISK software system to a global base of customers and consults on the process for developing stochastic tools for understanding and quantifying risks and uncertainties.

- OPG addressed certain concerns from the 4d Cost Estimate and appropriately documented the RQE Basis of its Estimate ("BOE") in a manner that allowed for appropriate vetting by Senior Management.

Although there are some exceptions noted in Attachments B and C, as we have stated above, the majority of the requirements in the DR Project's governance were satisfactorily met and commitments and plans to close remaining gaps are largely in place. Attachment D is BMcD/Modus' forward-looking recommendations for OPG to address remaining gaps in the DR Program prior to the Unit 2 Estimate, which is expected to be delivered to the Board of Directors in August 2016.

Signatures:

Prepared by: _____ Date: November 12, 2015

Prepared by: _____

Prepared by: _____

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APPENDIX A
SUMMMARY OF RQE CONTROL BUDGET

	Name	LTD (@ DEC 2015)	Estimate To Complete OPG Oversight Costs	ETC Contractor Fees	ETC (EPC Contractor Costs Excluding Fixed Fees and OPG Oversight)	Total Base Cost Excl. Contingency (x 1,000)	Project Contingency (Discrete Risks)	Program Contingency (Schedule/ Functions/ General)	Total Contingency P90	% Contingency of ETC	Total RQE (Incl. Contingency) (@P90)	Total % of RQE
Bundles	RFR	$ 651,651	$ 107,283	$ 512,000	$ 2,327,288	$ 3,598,222	$ 235,820	$ 380,584	$ 616,404	21%	$ 4,214,626	33%
	F&IP/SIO	$ 627,908			$ 216,713	$ 844,621	$ 41,525	$ 33,933	$ 75,458	35%	$ 920,079	7%
	TG	$ 105,946	$ 31,569	$ 81,317	$ 438,317	$ 657,149	$ 194,855	$ 23,021	$ 217,876	40%	$ 875,025	7%
	SG	$ 13,990	$ 9,745		$ 98,844	$ 122,579	$ 19,592		$ 19,592	18%	$ 142,171	1%
	BOP	$ 76,436	$ 78,531		$ 275,049	$ 430,015	$ 125,318		$ 125,318	35%	$ 555,333	4%
	SL	$ 21,203	$ 11,303		$ 185,511	$ 218,017	$ 53,064		$ 53,064	27%	$ 271,081	2%
	RSF	$ 16,721	$ 11,363		$ 50,286	$ 78,370	$ 18,156		$ 18,156	29%	$ 96,526	1%
	Fuel Handling	$ 13,811	$ 24,558		$ 120,183	$ 158,553	$ 19,625	$ 38,057	$ 57,682	40%	$ 216,235	2%
	Defueling	$ 28,983	$ 8,116		$ 2,487	$ 39,586	$ 5,398		$ 5,398	51%	$ 44,984	0%
	SP	$ 22,365	$ 6,812		$ 78,732	$ 107,909	$ 12,819		$ 12,819	15%	$ 120,728	1%
	Islanding	$ 30,829	$ 17,220		$ 84,198	$ 132,247	$ 20,857		$ 20,857	21%	$ 153,104	1%
									$ -			
Functions	O&M	$ 41,492			$ 714,533	$ 756,025	$ 19,290	$ 33,822	$ 53,112	7%	$ 809,137	6%
	Program Support	$ 21,178			$ 319,597	$ 340,775	$ 14,343	$ 17,752	$ 32,095	10%	$ 372,870	3%
	Execution OH	$ 9,513			$ 312,042	$ 321,555	$ 8,506	$ 158,021	$ 166,527	53%	$ 488,082	4%
	Engineering Services	$ 76,046			$ 206,460	$ 282,506	$ 6,467	$ 5,148	$ 11,615	6%	$ 294,121	2%
	Contract Management	$ 9,510			$ 42,241	$ 51,751	$ 1,507	$ 1,819	$ 3,326	8%	$ 55,077	0%
	Managed System Oversight	$ 14,265			$ 26,660	$ 40,925	$ 1,035	$ 1,685	$ 2,720	10%	$ 43,645	0%
	Planning and Controls	$ 62,140			$ 74,021	$ 136,161	$ 1,950	$ 3,387	$ 5,337	7%	$ 141,498	1%
	Nuclear Safety	$ 35,232			$ 47,880	$ 83,112			$ -		$ 83,112	1%
	Supply Chain	$ 14,104			$ 71,458	$ 85,562	$ 2,222		$ 2,222	3%	$ 87,784	1%
	Work Control	$ 8,617			$ 70,890	$ 79,507	$ 2,336		$ 2,336	3%	$ 81,843	1%
	OMA Training Prog.	$ 10,981				$ 10,981			$ -		$ 10,981	0%
	Waste Disposal				$ 38,054	$ 38,054			$ -		$ 38,054	0%
	Functions - Rel. 3	$ 101,651				$ 101,651			$ -		$ 101,651	1%
	Adv Rel. 4	$ 7,467				$ 7,467			$ -		$ 7,467	0%
Unallocated Contingency												
	Program/Function							$ 107,906	$ 107,906		$ 107,906	1%
	Program Reserve							$ 96,340	$ 96,340		$ 96,340	1%
	Project Bundles/CP	$ 26,182							$ -		$ -	
	Total	$ 2,048,221			$ 5,801,444	$ 8,723,300	$ 804,684	$ 901,474	$ 1,706,158		$ 10,429,458	81%
	Interest	$ 159,000			$ 1,313,844	$ 1,472,844					$ 1,472,844	12%
	Inflation/Escalation					$ 897,702					$ 897,702	7%
	Total Program Cost	$ 2,207,221	$ 306,500	$ 593,317	$ 7,115,288	$ 897,702	$ 804,684	$ 901,474		TOTAL RQE	$ 12,800,004	100%

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APPENDIX B BMcD/Modus Assessment of RQE Compliance to Nuclear Refurbishment Project RQE Cost Estimate Plan NK38-PLAN-09701-10235			
RQE CEP Page	**Topic, Milestone, Deliverable, Requirement**	**Description of Requirements**	**Disposition: Item Met or Achieved?**
8	Purpose	The cost estimate, in support of the RQE RL030 Program milestone, is developed to seek full approval from the Board to execute the DNRP, and specifically, the Unit 2 Execution of refurbishment scope.	✓
8	Purpose	The cost estimate will form the first cost control baseline from which actual costs will be collected and resources monitored to establish performance measurement against the program execution plan.	✓
8	Purpose	The target classification of the RQE cost submission is AACE Class 3 with an expected 50% level of confidence on the point estimate and accuracy range, exclusive of applying escalation, interest and management reserve.	✓
8	Purpose	An assessment of the class of estimate achieved by each project bundle will be performed by the NR Estimating Team based upon AACE Recommended Practices and the nature of the project scope of work. The intent of AACE will be applied “fit-for-purpose” to the nature of a refurbishment program whereby standard outage work management practices and OPEX are leveraged in the execution planning of the work.	✓
9	Cost Estimate Plan Baseline	Key Milestone: Detailed plan to achieve compilation, review, validation and issuance of the RQE. Review and acceptance of plan. Roadmap approved.	✓

9, 16, 36 (App. B)	RQE Basis Inputs Defined	Key Milestone: All data items used to form Release 4D and required as input to developing the RQE. Design, Cost, Planning, Program. 4D Proliance Integration. 4D Basis of Estimate Finalized. OP2015	✓
20, 21 41-47 (App. B)	Progressive Estimate Reviews and Validations	EPC estimate deliverables will be progressively reviewed and vetted by the OPG project and estimating teams to ensure the opportunity for a timely collaborative "review and fix" approach. Basis (cost, schedule, risk), scope and COMS, estimate line items, drivers, labor rates, resources, quantities, productivity, assumptions, exclusions, benchmarking.	✓, except for OPG PMT, functional estimates and discrete risks
21, 48, 49 (App. B)	Estimate Reviews and Validations: Bundles, functions	Report on progressive reviews, overall review, cold eyes review. Estimate presentation, technical review, estimating team review, project team review with estimate validations.	✓, except for OPG PMT, functional estimates and discrete risks
9, 18, 38 (App. B)	Scope & Assumptions Review All Units	Key Milestone: Final Basis review of U2 scope and assumptions. Review of remaining units' scope and assumptions to confirm variances from U2. Unit 2 Initial work assessment. Assumptions updated and plan for disposition finalized. OP2075	✓
9	Program Estimate Data Freeze	Key Milestone: All data submissions for estimates and schedules completed. Gate Package data complete. All estimates submitted. CCFs incorporated.	✓, Data frozen incrementally
18, 39 (App. B)	Estimate Integration	Estimates loaded into database (US Cost), resources loaded into P6, review process to align US Cost and P6	✓, Estimates loaded into excel

9, 22	First Manpower and Cash flow Reports	Key Milestone: Integrated estimate and schedule at the work package level (Level 3 for U2 and L2 for remaining units) to produce manpower and cash flow histogram reports. Estimate/Schedule Integration Complete	Estimates loaded into excel, BOP SDLU at G2X
9	All Projects Gate 3	Key Milestone: All projects successfully completed Gate 3 Review Board. GRB complete for each project. RP300	✓, except for BOP, SDLU
9, 22	Total Cost Estimate Snapshot #1	Key Milestone: Draft total cost estimate report for use in management reviews. First draft contingency analysis performed. Estimate review and validations complete. Draft program integrated schedule.	✓
23	Senior Management Reviews	The review process builds upon the progressive EPC deliverables reviews, project and bundle reviews and the program scope & assumptions review in order to achieve management review and full understanding of the estimate, estimate refinement, finalized closure on gaps, assumptions and outstanding issues requiring management attention and disposition, and input into the contingency analysis, and assessment of the management reserve.	✓
9, 23	Total Cost Estimate Snapshot #2	Key Milestone: Final draft total cost estimate report with final contingency analysis and incorporate of review comments/changes. Senior Management reviews complete. Assumptions, gaps, issues closure. Final program integrated schedule.	✓
9, 23	Final RQE Cost Estimate Report	Key Milestone: Final Report issuance for executive management approvals Financial review complete. Final contingency. Finance review.	✓, gaps to be resolved U2 RTE
9, 23	Total Cost Estimate File & Integrated Data Set Complete	Key Milestone: Integrated data set resides in estimate systems and folders with verifications performed. Database and electronic files submission. Benchmark analysis complete. RL030	✓, gaps to be closed U2 RTE
7, App. A, Roadmap	Basis of Estimate	The implementing details of the estimating process form the basis of estimate (BOE) that evolves during the development process and is finalized upon completion of the final estimate report.	✓, BOE complies with AACE 34R-05

10	RQE Progression	RQE, referred as Release 5, will establish a progression from prior releases to a program class 3 cost estimate and level 3 execution schedule that will be utilized as the program control budget. The estimate progression is defined below within the estimate requirements and summarized in the enclosed process details, Appendix B CE.1.010 (A).	✓
30	RQE Progression	All project bundles progressed through Gate 3 with approved cost estimates, schedules, risks and contingency analyses.	✓, gaps to be closed U2 RTE
30	RQE Progression	Functional costs defined with functional management plans, organization structure and outputs aligned to release 4D cost estimates	✓
30	RQE Progression	All assumptions reconciled from 4D to RQE with inclusion to project plans, basis document or disposition of final assumption within Final Log	✓
30	RQE Progression	Schedules aligned to program level plan and based on approved planning assumptions incorporated into execution plan	✓, gaps to be closed U2 RTE
30	RQE Progression	Unit 2 schedule defined to level 3 and construction work package level with remaining units defined to program level 2 control account level	✓, gaps to be closed U2 RTE
30	RQE Progression	All estimates achieved to a minimum class 3	✓, gaps to be closed U2 RTE
30	RQE Progression	Integrated cost, schedule and risk model to support financial analysis	✓

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APPENDIX C BMcD/Modus Assessment of RQE Compliance to RQE Project Management Plan NK38-NR-PLAN-09701-10004			
RQE PMP Page	**Topic, Milestone, Deliverable, Requirement**	**Description of Requirements**	**Disposition: Generally Met or Achieved?**
5	Objective	Provide details regarding the strategic processes and methodology to be used by the RQE Project to fulfill NK38-REF-09701-10005 "RQE Project Terms of Reference" (TOR) and successfully complete the RL030 milestone deliverables. The strategic processes and methodology defined by this plan will incorporate industry best practice approaches and activities.	✓
5	Objective	Describe and detail expectations regarding the RQE Project deliverables; The RQE Package Components and the data and process assurance requirements for RQE Project Management Review.	✓
5	Objective	Describe and detail expectations regarding the inputs and input streams required to build the RQE Package and perform Program level RQE analysis.	✓
5	Objective	Describe the RQE Project Team activities, and management plan deliverables required to facilitate the objectives of the Management Plan.	✓
5	Objective	Define the roles and accountabilities.	✓

5	Objective: Note	THIS MANAGEMENT PLAN (MP) IS A LIVING DOCUMENT AND WILL BE REVISED TO REFLECT UPDATED INFORMATION AS REQUIRED. AREAS WHERE KNOWN REVISIONS WILL BE REQUIRED AT A FUTURE DATE ARE NOTED IN THE RELEVANT SECTIONS.	No revision of MP was found.
6	Required Deliverables	COMMUNICATION PLAN: OUTLINED IN NK38-PLAN-09701-0502946, "RQE COMMUNICATIONS PLAN". THIS DOCUMENT CONTAINS A SUMMARY OF PLANNED COMMUNICATION EVENTS TO ENSURE STAKEHOLDERS RECEIVE INFORMATION IN REGARD TO RQE AS APPROPRIATE.	✓
6	Required Deliverables	Timeline and Schedule: Scheduled work activities associated with the RQE Project will reside in Project Integrated Master Schedule (PIMS) and the RQE Schedule will be managed within Primavera P6. Bundle and Functional deliverables required to successfully complete production of the RQE Package and meet the RL030 milestone must also be documented in the Program Integrated schedule reflected in P6. The RQE Milestone Roadmap (Appendix B) reflects key RQE milestones and milestones that could affect the success of RL030	✓, Appendix B, RQE Milestone Roadmap not attached to Controlled Document
6	Required Deliverables	RQE Performance Reporting: The RQE Project Manager & Support will produce RQE Project performance reports against scheduled activities and provide updates to management quad charts on progress to RL030 completion and overall DNRP Readiness. Selected Reporting processes and tools will be created for RQE Project Team to report on the Program and Project/Functional level progress and cost elements. Work stream level reporting will be required and performed on a monthly basis at a minimum. Metrics and status updates produced by Work stream Leads will provide sufficient level of detail regarding the status of work stream inputs and progression to RQE Package requirements such that the RQE Project Team can assess the status of the Refurbishment Program design basis, planning basis, cost basis and risk basis inputs and processes at the lowest available granularity, if required.	✓

9	Figure 2: Execution Phase Unit Release Strategy	All Projects at Gate 3 (4 units Class 3 Estimate.)	Except BOP/SDLU and RSF.
11	RQE Package	The RQE Project's main output is the production and management of the RQE Package. The RQE Package becomes the basis of Program validation that all key deliverables associated with the current funding release strategy, as based on the October 2016 First Unit Outage schedule proposed in the November 2013 Darlington Refurbishment Business Case Summary (BCS, Doc # N-REP-00120.3-10000, Rev 1 OPG Confidential), have been completed within the detail planning phase. The Package consists of the following:	✓
11	RQE Package Components	Plan over plan variance analysis performed against the baseline package based on the characterization of the 4D Closeout package. The 4D baseline has a nominal milestone TCD of 15JAN2015 and will be utilized for the progression review of the Program BOE point estimate and final RQE Package range estimate.	✓
11	RQE Package Components	The Program Basis of Estimate (BOE). This is a point estimate for the first unit of execution and remaining Program life cycle funding requirements as defined by the requirements in RL030. This point estimate will be aligned to the estimate characteristics as defined by AACE, and translated into the OPG organizational framework and terminology. The BOE will be applicable to all 4 units and products produced by the whole of the Refurbishment Program under Gate 3.	✓, except BOP and SDLU to achieve G3 after RQE and before U2 RTE
11	RQE Package Components	The additionally identified graded, risk based oversight deliverables which support OPG investment Management Program Objectives and are listed in the Milestone Definition	✓

		Statements of the RQE lead up milestones, and support the key deliverables and RQE specific completion assumptions defined in the Darlington Refurbishment BCS.	
11, 19	RQE Package Components, Section 7.2.1	The Third party independent estimate review report with all recommendations and findings dispositioned.	Not achieved
11	RQE Package Components	The updated BCS as a result of project characterization based upon the maturity given items 1 - 4 above, associated analysis of related contingency values and consolidated confidence evaluation.	✓
11	RQE Package Components	An overall recommendation regarding execution phase funding release to OPG Board of Directors based on Program Readiness; and RQE Management review and analysis.	✓
14	Methodology	Program BOE input to the RQE Package and related BOE Plan will be part of the accountabilities of the Estimating Manager.	Except Inputs for bundle PMT, Functions and Discrete Risks.
22	Section 9.2 Quality Assurance and Verification	The Quality Review by the RQE Project Manager will represent an alignment verification review of Program delivery against the Overall Program Cost Basis. RQE related execution activities and frameworks will be validated against the classified Program BOE point estimate to ensure they support the cost basis defined by the BOE as well as the additional requirements defined in RL030. This will be conducted using an RQE verification form, (See Note Below). This form will provide auditable documentation that management reviews of the RL030 design basis, planning basis, cost basis, risk basis and overall Program delivery; conform to the production requirements dictated by OPG governance, and result in products which align to a BOE characterized to the right level of confidence for the RQE range estimate.	See Modus Comments to RQE Cost Estimate Plan re Quality Assessment Report (QAR)
33	Appendix B	RQE Milestone Roadmap	Not Attached to Ctrl. Doc.

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APPENDIX D

OBSERVATIONS/FINDINGS

#	Observations/Findings	Risk Rating (Prior to MR)	Recommendations	Management Response
1	Substantial effort will be required by ES Fox to complete the Construction Work Packages (CWP's) for BOP, SDLU & RSF in order to mature the estimates to a Class 3 level to achieve Gate 3, and support Unit 2 RTE estimate development by April 2016. OPG has received assurances from ES Fox that it will commit the necessary resources to complete the estimates, CWPs and schedules for these projects. Senior management and the PMs will need to weekly monitor Fox's efforts to securing adequate resources to complete the CWP's and Class 3 estimates and achieve the schedule for Gate 3 presentation. ES Fox has posited that performance of Campus Plan Projects can be distinguished from future performance of Refurbishment work is that the Refurbishment work is more similar	MEDIUM	ES Fox's preparation of estimates, schedules and CWPs needs to be tracked by the OPG team from multiple perspectives: • Schedule adherence to the Rev B schedule to ensure the packages are being prepared in a timely manner; • Quality reviews (both objective and subjective) need to occur by OPG and tracked for timing of ES Fox's responses • Resources via planned and actual work hours need to be tracked to ensure level of effort is being provided; • RFIs or other issues impacting the quality of estimates need to be tracked and answered as quickly as possible; • OPG needs to confirm it has the resources on the receiving end to review and comment on all ES Fox submittals. • ES Fox should be compelled to provide comparative and referenceable details from its past experience in plant maintenance work to substantiate its estimates for Refurbishment • The core team estimates need to be vetted to ensure the common functions	

#	Observations/Findings	Risk Rating (Prior to MR)	Recommendations	Management Response
	to the work it has previously performed in plant outages Moreover, BOP, SDLU and RSF projects contracted to ES FOX are being estimated as standalone projects per supply chain requirements. As a result, duplication of costs exists in certain cost elements such as PMT and supplies (i.e. scaffolding).		are not overestimated	
2	With RQE's completion, the DR Team must now focus its attention on ensuring the documentation needed to substantiate its decisions during development of the RQE is properly archived and available for future needs, including the unit-specific estimates and future regulatory proceedings. OPG intends to use the BOE for RQE as the central document for identifying, indexing and locating materials	LOW	OPG's archiving of the documents should consider: • The complete RQE package should include the source documentation necessary for the traceability of all cost numbers. • Once prepared, the sufficiency of OPG's system for document maintenance needs to be tested through audit/assessment. • All documents that support the RQE should be identified with a document number that is consistent with applicable OPG NR governance (i.e. NK38-NR….). The documents should be well organized in a controlled environment.	
3	Personnel, accountabilities and responsibilities appeared to be changed during development of the	MEDIUM	In conjunction with the roll-out of the Division of Responsibilities ("DOR"), the DR Team should ensure that its members understand their	

#	Observations/Findings	Risk Rating (Prior to MR)	Recommendations	Management Response
	RQE without written communications clearly explaining changing roles and responsibilities of team members. This resulted in confusion over roles and responsibilities.		individual roles and responsibilities. Roll-out of organizational changes should follow commonly used practices for organizational changes: • Agreement on a common vision for change -- no competing initiatives. • Strong executive leadership to communicate the vision and sell the business case for change. • A strategy for educating employees about how their day-to-day work will change. • A concrete plan for how to measure whether or not the change is a success -- and follow-up plans for both successful and unsuccessful results. • Rewards, both monetary and social, that encourage individuals and groups to take ownership for their new roles and responsibilities.	
4	The DR Team did not complete all of the deliverables or reach the maturity level for all aspects of the control budget that were planned. With the completion of the RQE, the team should consider using lessons learned from the RQE effort to develop a comprehensive Plan for	LOW	The DR Team's Unit 2 Estimating plan should clearly identify assignments and accountabilities across the full organization.	

#	Observations/Findings	Risk Rating (Prior to MR)	Recommendations	Management Response
	estimating Unit 2.			
5	The RQE cost data resides in the Master Consolidated File (MCF), which is a series of excel spreadsheets with few controls around the data and its traceability from point A to point B during development of the RQE. It also appears the spreadsheets were not password protected during data assembly. Our understanding is US Cost is being modified for the purpose of centralizing inputs to the Unit 2 estimate.	LOW TO MEDIUM	For the Unit 2 estimate, OPG should consider a standardized cost system platform that deters use of manual intervention and has data security controls and version controls in place.	
7	The ramp-up of qualified estimators for RQE resulted in acquiring estimators from multiple companies who were unfamiliar with OPG procedures and standards. By relying on outside resources with varying skill sets, the learning curve for outsiders was much steeper than it should have been. Moreover, OPG will need to maintain the estimating function through the Unit 2 Execution Phase and prepare for subsequent units. Continuity will be more critical for future estimating efforts.	MEDIUM	For the Unit 2 estimate and subsequent unit estimates, OPG should consider cost estimating a function worthy of permanent staffing and consider long-term retention of resources. The work of the estimating team could reasonably expand to evaluating the results and lessons from Unit 2 for subsequent unit estimates.	

#	Observations/Findings	Risk Rating (Prior to MR)	Recommendations	Management Response
8	The schedule for senior management review (NPET) of the RQE was significantly compressed from the original plan. Often reviews of parts of RQE proceeded without sufficient time for the NPET members to reasonably consider the materials presented.	LOW TO MEDIUM	Establishing reasonable time tables for multiple review/challenge sessions for the Unit 2 estimate would enhance the process. The schedule for reviews and NPET involvement should be worked out well in advance with the goal for all deliverables to be provided (minimum) 3 days ahead of time). Time, location and extent of reviews should consider the engagement needed from senior management. NPET should also provide feedback to the Project Controls team regarding the materials used for the NPET presentations and any future changes that could improve the future review cycle.	
9	The RQE Quality Assessment Report (QAR) was not defined prior to RQE and the information in the QAR was not aggregated to support the development of the cost estimates at the time they were being prepared. The QAR lacks reference to a RQE Assurance Plan, established prior to RQE, or to any systemic monitoring of QA during preparation of the RQE.	LOW	The QAR should mirror the sections of the Basis of Estimate (BOE) and provide an assessment of the underlying data in coordination with the BOE. Recommend that the Quality Assessor meet with the Estimator Manager to jointly prepare the QAR.	
10	Quantitative cost impacts of discrete risks have been generated by project and functional teams and managers. Many were developed	LOW	As a minimum, OPG should consider performing independent spot checks of discrete risk cost impacts to determine their	

#	Observations/Findings	Risk Rating (Prior to MR)	Recommendations	Management Response
	in the accelerated process of creating contingency input for RQE. Because of time constraints, inputs may not have received a rigorous independent review. The effect of this on the contingency results may not be material. However, it represents an inconsistency in the overall process		acceptability. Further probing should be considered if the initial checks indicate the potential for material changes to the contingency result. This would be appropriate during the Unit 2 estimate process.	
11	The Risk Management program is well-structured and the RMO tool facilitates effective program participation and management. Nonetheless, considerable last minute effort was spent updating and refining Risk Registers to support RQE. That process should have been occurring on a frequent basis throughout the Definition Phase to avoid inefficient last-minute cramming that may be prone to errors and omissions. Considering the multiple unit aspect of the Darlington refurbishment, very strong risk [and internal OPEX] identification and management performance can have a significant influence on overall refurbishment success.	LOW	The DR Team should consider: • Conduct information/training sessions with all DR personnel to highlight the importance of rigorously identifying and managing risks within the established program on a day-to-day basis. Focus on the relevance and value in developing the RQE contingency and in actual risk impact reduction. Consider that most individuals may not appreciate the purpose and application of risk management and contingency development. These sessions can have most effect if performed soon, while the significance and value of risk management is elevated due to the RQE contingency effort. The effect can be heightened if such sessions were offered by senior management. • Consider increasing senior management visibility and risk program advocacy throughout the organization.	
12	The RQE process has been a rigorous effort. Often in such	MEDIUM	• Establish simple criteria for documenting the	

#	Observations/Findings	Risk Rating (Prior to MR)	Recommendations	Management Response
	situations, the bases and justifications for decisions are not well documented. Impact estimate values and ranges can play a role in future budget management matters and in dealing with challenges from external (and internal) sources. Individually, the bases for such numbers may not be important. However, the overall quality of the program may be challenged if justifications for input values are weak or non-existent.		bases for input values such as quantitative risk impact values and ranges. Review the Contingency input sheets to assess the quality of reasonableness and defensibility of justifications; and address inadequate basis documentation where appropriate. This must be accomplished while the personal source of the input is available. • Ensure that justification is well documented for applying correlation, calculating burn rates, and other similar matters.	
12	During the review of RQE components, the DR Team performed significant work to study the "Day in the Life" of the project. This effort yielded a number of good inputs. However, the impact of that effort on the cost estimates was not clearly drawn. The Readiness to Execute effort will further many of these initiatives and should be used to inform the Unit 2 Estimate and associated contingency	MEDIUM	• The DR Team needs to establish a formal process for capturing the information that emanates from RTE activities for integration into the Unit 2 Estimate, either as direct cost or risk.	
13	The DR Team has chosen to utilize a new cost management platform supplied by EcoSys.	HIGH	The DR Team needs to have a detailed plan for implementation of the new system that is mindful of: • The reasonable amount of time	

#	Observations/Findings	Risk Rating (Prior to MR)	Recommendations	Management Response
			implementing the new system will require; • The need to maintain parallel systems until the new system is functioning; • Changes in metrics and reporting that are likely to occur.	

KPMG

cutting through complexity

Ontario Power Generation

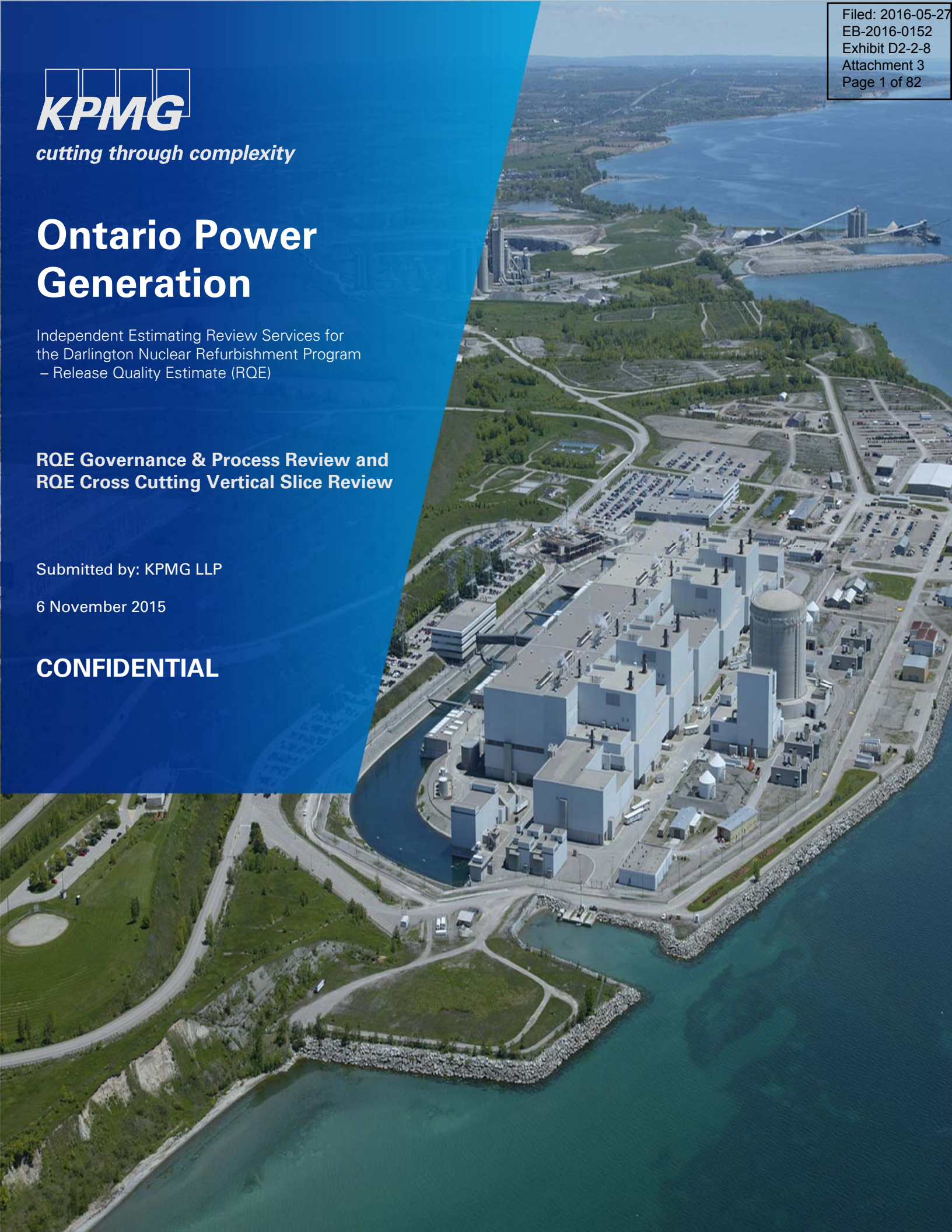
Independent Estimating Review Services for the Darlington Nuclear Refurbishment Program – Release Quality Estimate (RQE)

RQE Governance & Process Review and RQE Cross Cutting Vertical Slice Review

Submitted by: KPMG LLP

6 November 2015

CONFIDENTIAL



Contents

1. RQE Independent Review Executive Summary

1.1 Scope of the Review

KPMG LLP ("KPMG") was engaged by Ontario Power Generation ("OPG") to provide an independent review of their governance and processes to develop a Release Quality Estimate ("RQE") for the Darlington Nuclear Refurbishment Program ("DNRP" or the "Program").

KPMG's independent review of the DNRP RQE processes and estimates consists of the following two focus areas:

1) Governance and Process Assessment ("Work Stream 1"), and
2) Cross Cutting Vertical Slice Review of the estimates ("Work Stream 2")

The KPMG scope does not include the validation or assessment of the quantities, figures, or calculations performed to arrive at the final RQE cost figure.

The draft report for Work Stream 1 was delivered to OPG in May 2015. The draft report for Work Stream 2 was delivered to OPG on September 2015. Since then, both reports have been progressively updated based on OPG's feedback and documentation provided by OPG to help address or close the gaps and findings.

1.2 Work Stream 1 – Governance and Process Assessment

The objective of Work Steam 1 is to assess OPG's estimating governance and management processes for developing the RQE against the following AACE[1] guidelines:

- Development of Estimate Plan Process (AACE No. 36R-08);
- Development of Estimate Plan Content (AACE No. 36R-08);
- Basis of Estimate (AACE No. 34R-05);
- Estimate Classification System (AACE No. 18R-97);
- Estimate Review, Validation, and Documentation (AACE No. 31R-03); and
- Developing a Project Risk Management Plan (AACE No. 72R-12)

OPG have demonstrated knowledge of the AACE guidelines and have generally interpreted and correctly applied them to the DNRP program.

KPMG also noted that OPG's estimating governance and processes for the DNRP RQE are strong in the following areas:

1. The **estimate classification system** has been developed in direct alignment with AACE guidelines and tailored to fit the nuclear industry. The estimating team has strong knowledge of the terminology and significance of the AACE concepts with regards to cost classification and levels of maturity and project definition.
2. **Historical knowledge** of risks, opportunities and lessons learned from other projects have been well integrated and considered across most project bundles.
3. The RQE **risk management framework** has been developed and implemented following a

[1] The Association for the Advancement of Cost Engineering ("AACE") is a non-profit organization recognized throughout the construction industry for publishing a set of guidelines for the effective application of professional and technical expertise to plan and control resources, costs, profitability, and risk.

thorough process and utilizing best practice tools at the corporate and project level.

4. OPG have designed and implemented processes for challenging and performing **quality reviews of vendor estimates**. Such processes are tailored to the nuclear projects environment, and therefore are in alignment with AACE guidelines and best estimating practices.

As would be normal for a program of this size, KPMG has identified some procedural (non-critical) gaps from recommended AACE guidelines and industry leading practices. For context, gaps are classified under two categories of priority:

Table 1: Explanation of Risk Categories for Work Stream 1

Category	Definition
A	Category A: Items that could potentially impact the level of confidence in final RQE value and could be considered a priority.
B	Category B: Items that will have less of an impact than Category A items on the level of confidence in final RQE value, but will impact the quality of the final estimate produced and should be addressed in 2016 (prior to the execution stage) as part of the check estimate process.

KPMG has completed the analysis of 186 items of RQE against the AACE guidelines. Out of 186 items analyzed, KPMG's current classification of the gaps is:

- 0 items as category A (critical) gaps
- 33 items as category B (non-critical or procedural) gaps

The 33 category B gaps are quality issues related to governance documentation that can be improved to further substantiate and support the estimate. This number of category B gaps is considered normal and could reasonably be expected for a capital program of this size. The process for developing the RQE is a significant undertaking to consolidate, update, validate and summarize information for 538 project numbers (bundle costs) and functional cost estimates. The fact that there are no category A gaps in our assessment is a reflection of the effort deployed by the OPG team, and the quality of the processes and governance implemented to arrive at the RQE which is in general alignment with AACE guidelines.

It is expected that the 33 remaining category B gaps will be actioned and addressed by the OPG team throughout 2016 to support the "check estimate" process, allowing for a robust estimating basis and baseline for execution.

Detailed tables with descriptions of the gaps and findings in Work Stream 1 are provided in the final report.

1.3 Work Stream 2 - Cross Cutting Vertical Slice Review

The objective of Work Stream 2 is to perform a cross cutting review of estimate documentation, utilizing three vertical slices of the DNRP, and provide a report on overall traceability, data integrity, and level of detail in the preparation of the RQE.

The three vertical slices selected by KPMG are:

- Re-tube and Feeder Replacement ("RFR");

- Balance of Plant ("BOP"); and
- Operations and Maintenance ("O&M").

KPMG found that the vertical slices reviewed are generally well organized, complete, and traceable to estimate detail and source data. KPMG also found that the level of detail in the estimate packages is generally acceptable and sufficient when compared to other similar projects and best industry practices.

As would be normal and expected for a program of this size and complexity, the 'estimate slices' reviewed by KPMG contained some non-critical gaps/quality issues (i.e., referred to in this report as Category B and C issues). OPG is working collaboratively with its vendors to reduce the number of quality issues in the estimates.

Table 2: Explanation of Risk Categories for Work Stream 2

Category	Definition
A	Category A: Items that could potentially impact the level of confidence in final RQE value and could be considered a priority.
B	Category B: Items that will have less of an impact than Category A items on the level of confidence in final RQE value, but will impact the quality of the final estimate produced and should be addressed in 2016 (prior to the execution stage) as part of the check estimate process.
C	Category C: Items that likely will not materially impact the level of confidence in the final RQE, but could have an impact on the quality of the final estimate or expose OPG to commercial risk and should be addressed in 2016 as part of the check estimate process.

Out of 554 items analyzed, KPMG's current classification of the gaps for Work Stream 2 is:

	Open (as of November 6, 2015)			
Category	RFR	BOP	O&M	Total
A	0	0	0	**0**
B	9	27	4	**40**
C	8	29	7	**44**
Total:	**17**	**56**	**11**	**84**

As of the submission date of this report 0 higher risk (i.e., Category A) gaps remain open.

There are 84 Category B and C issues that remain to be actioned and closed. For a program of this size and complexity this number of non-critical issues is considered reasonable and would normally be expected.

OPG's Darlington Nuclear Refurbishment Program is a program of massive scope and performing a comprehensive cost review represents an enormous undertaking.

To ensure a thorough review is completed, KPMG has utilized a systematic review structure to examine the RFR, BOP and O&M vertical slices. These slices represent a substantive portion of the

RQE (36% or $4.6B of the total $12.8B RQE cost). This structure includes the use of existence and traceability checks for each cost category. Our approach, for example, was applied to the review of the RFR vertical slice, which represents $3.6B or 28% of the RQE, and is the largest and most significant portion of RQE. The review of the RFR vertical slice involved 364 individual checks which covered approximately 60% of all RFR costs across the four units. Of these 364 checks, our results produced 42 identifiable issues in the initial RFR estimate draft (Rev. 0) which included 1 Category A, 33 Category B, and 8 Category C issues. With the latest RFR estimate (Rev. 1), the number of issues have now declined by 60% to 17 issues, which include 0 Category A, 9 Category B and 8 Category C issues.

KPMG believes this is reasonable low number of issues for a project of this scale, and have determined the issues are not critical for the purposes of RQE.

It is anticipated that these quality issues (combined with OPG's own checklist of quality issues) will provide a comprehensive 'checklist' for closing gaps when the estimates undergo the final 'check estimate' in 2016 and we consider that OPG have ample time to work with vendors in addressing these gaps prior to execution. This process should be started as soon as possible.

The themes below are the primary generators of the 84 gaps. These quality issues are listed in their respective 'estimate slice' section of the final report for reference purposes.

Key Themes of remaining Category B and C gaps:

1) Basis for labour rates in the estimates not always clearly specified in the estimate package or documented in the BOE.
2) Some bundle estimates do not adequately identify strategies or assumptions that were made with regard to the workweek schedule (hours worked per day, days worked per week, shifts worked per day, etc.) and planned use of overtime.
3) Some estimates have not adequately defined its resource strategy such as its approach to resource levelling and allocation of the PMT and indirect costs across multiple projects.
4) The project assumptions/exclusions are not in all cases clearly reflected in the estimate package for some project bundles (Basis of Estimate) and not clearly linked to the estimate workbooks.
5) Project schedules within the BOP project bundle have certain negative characteristics with respect to logic and integrity that degrade their ability to provide accurate analysis and forecasting. OPG's scheduling team have identified the same issues as KPMG, and are currently working with the BOP vendor to improve the schedules and address the findings. Currently, when measured against industry recommended standards, the quality level of their construct /configuration does not indicate a reasonable level of confidence or reliability in their usefulness as a forecasting tool.
6) Data integrity issues with numerous hard coded numbers (i.e., hours and dollars) in the estimate without explanation, Excel worksheets with broken links to other missing worksheets, etc.
7) There are examples of "plug pricing" for major equipment with no unit cost basis (i.e., source, year).

It should be noted that the issues identified by KPMG (or issues of a similar nature) should be addressed throughout the DNRP estimate, not just in the three vertical slices that were the focus of the final report.

Detailed tables with descriptions of the gaps and findings in Work Stream 2 are provided in the final report.

2. Introduction

The objectives and scope of service, including deliverables, are summarized below.

2.1 Objective

The objective of an Independent Estimating Review ("IER") engagement is a comprehensive review, at a particular point in time, of the design of a project's governance and management processes over project establishment, implementation and oversight. For each vertical slice, the IER focused on:

- Identifying whether the estimate files provide the required information regarding the design basis, planning basis, cost basis, and risk basis of the estimate to meet industry best practices;
- Evaluating the ability of every cost in the estimate summary to trace back to the estimate detail, scope of work, and basis of estimation;
- Assessing whether the estimate incorporates the appropriate work breakdown and code of account structure; and
- Determining whether the Cost estimate reflects the project strategy, objectives, scope and risk.

Our engagement team worked closely with OPG personnel (the "Project Team") to identify and focus on the areas of greatest risk for the DRP.

2.2 Scope and Deliverables

The scope of this engagement includes performing an Independent Estimating Review ("IER") for the DRP to ensure the program cost estimate is both internally and externally validated for quality and reliability. KPMG's scope for Work Stream 1 consists of evaluating the existing OPG governance, estimate plan, process and execution requirements, and assessing the extent it meets the AACE International Recommended Practice ("AACE IRP") and KPMG's best practice MPA Methodology (refer to section 4.3), to ensure they are aligned to industry standards and best practices. KPMG's scope Work Stream 2 consists of performing a cross cutting review of estimate basis documentation, utilising three vertical slices of the DNRP, and providing a report on overall DNRP preparedness and data integrity in the preparation of the RQE.

Questions considered while administering this assessment for governance and process review were:

- Is OPG governance related to the RQE plan, process and deliverables in line with expectations and requirements of industry best standards for producing an "estimate in alignment with AACE recommended practices, and with classification requirements as defined in the RL030 definition statement"?;
- Is OPG governance adequately incorporated into the RQE plan?;
- Is OPG adequately adhering to the plan and process for RQE deliverable production, management and monitoring?;
- Is there adequate traceability through the plan and process to governance from RQE deliverable?; and
- Are there any exceptions to the RQE plan or processes which may affect the quality of the final RQE estimate number?

Selected items or categories of items in the RQE estimate that are likely to have the most significant cost effect if estimated incorrectly were examined in detail. Areas of concern have been highlighted and recommendations offered to address exceptions or deficiencies as identified during the review and assessment of the estimating files, basis documentation, schedules, execution plans, risk items and contingency calculations which:

- May negatively affect DNRP's ability to have a high level of confidence in the final RQE; and
- May negatively impact the quality of the final estimate produced.

The methodology used to perform the Cross Cutting Vertical Slice Review has been outlined in Approach and Methodology section and includes:

- Review of the estimates and related documentation. This includes documents such as OPG estimate governance, OPG Risk Management governance, OPG Scopes of Work, Estimate workbooks, Oracle Primavera P6 schedules;
- A series of interviews were conducted with key OPG staff involved in the DNRP to clarify questions concerning the documentation reviewed, in order to better understand the estimate development and review process, and to understand the responsibilities of the various team members and the external Vendors involved in the production of the estimates; and
- Benchmarking the budgetary estimates submitted by Vendors against OPG requirements of industry best standards for producing an estimate.

The estimate must establish a realistic budget and provide accurate information required to allow for scheduling, cost monitoring, and progress measurement of the project during execution. It will become the basis of Program validation that all key deliverables associated with the current funding release strategy, as based on the October 2016 1st Unit Outage schedule.

2.3 Program Background

The objective of the DNRP, a 10-year program (execution phase) involving the mid-life refurbishment of four nuclear reactors at the Darlington Nuclear station, is to extend the operating life of the station by approximately 30 years.

The refurbishment will involve an outage period, allowing for the replacement of life-limiting components, as well as maintenance or replacement of other components. The DNRP primarily consists of five Major projects, namely the Re-tube and Feeder Replacement ("RFR"), Turbine Generator, Fuel Handling, the Balance of Plant projects and the Steam Generators project. There are other projects in the DNRP that are related to changing regulations, safety improvements, and facilities and infrastructure projects.

2.3.1 Program Timeline

DNRP is divided into 3 major phases: the Initiation Phase, Definition Phase, and Field Execution and Close-out phase, followed by the Operations phase. As further described below, the estimated overall timeline for the DNRP from the Initiation Phase to project close out is from 2007 - 2026.

2.3.1.1 Initiation Phase (2007 – 2009)

In June 2006, the Ontario Government directed OPG to begin feasibility studies on refurbishing its existing nuclear power plants. In late 2007, OPG commenced the Initiation Phase of the DNRP, including an economic feasibility assessment. In the Initiation Phase, a preliminary scope was determined through a Plant Condition Assessment ("PCA"), and the preliminary program schedule and cost estimate were developed. The Initiation Phase of the DNRP concluded with the OPG Board approval of OPG management's recommendation to proceed with the refurbishment of the Darlington units.

Other major activities performed during this phase include:

- Planning for the Integrated Safety Review ("ISR"), including a review of modern codes and standards, and an Economic Assessment ("EA");
- Assessment of the various execution options (i.e., contracting, project management, work management, governance) for the Definition and Execution Phases of the Refurbishment Project, and the recommended execution strategy;
- Identification of an initial project organization for the Definition and Execution Phases;
- Developing a communication plan to ensure stakeholders are informed of OPG's Refurbishment Project and obtaining their support for the decision;
- Developing Project Management support such as Project Controls, performance measures, schedules, risk and contingency processes, project metrics and reports; and
- A Business Case Summary ("BCS") which was provided as supporting documentation for the recommendation to proceed with the refurbishment of the Darlington station.

2.3.1.2 Definition Phase (2010 – 2015)

The Definition Phase comprises two sub-phases: the Preliminary Planning Phase and the Detailed Planning Phase. The Preliminary Planning Phase generally involved setting up the project management organization and developing project controls governance and supporting tools, as well as developing labour and contracting strategies, completing a required regulatory document in the form of the ISR report, and then finally updating project economics and the BCS based on the latest information.

OPG is currently in the Detailed Planning Phase which involves the following major activities:

- Completing all Outage preparation plans and unit pre-requisite work;
- Finalizing all project scope and progression of engineering;
- Submitting an Integrated Implementation Plan and Global Assessment report to the CNSC;
- Ordering long lead items and confirming their delivery;
- Awarding or partially releasing contracts to key vendors; and
- Establishing an independent oversight process and assurance model.

In addition, the Program's preliminary cost estimate which was developed in the Initiation Phase, is being fine-tuned in the Detailed Planning Phase and will be finalized in the form of a RQE containing detailed cost estimates and a detailed execution phase schedule based on approved scope. The purpose of the RQE is to serve as the Program Level bounding cost and schedule estimate. The RQE Milestone, RL030, represents an OPG Management decision gate for the DNRP, and signifies the completion of the Detailed Planning Phase. It also establishes a program level scope, cost and schedule baseline for the DNRP.

This phase will also be used to enable Execution Phase funding for Unit 2 and will conclude with the update of the Program Business Case, including a full project cost estimate and will be followed by a presentation of the recommended execution strategy to senior management, and the Board of Directors.

2.3.1.3 Field Execution and Close-Out Phase (2016 – 2026)

The Field Execution and Close-Out Phase will involve completion of all planned aspects of refurbishment and associated re-commissioning and re-licensing tasks. The execution of the first unit's refurbishment outage is planned to start in October 2016, and the funding releases for subsequent units will be developed and approved throughout this phase. A Full Release BCS will be prepared for each of the subsequent units including any updates to cost and schedule estimates.

2.3.1.4 Operations Phase (2019 – 2055)

The Operations phase overlaps with the Field Execution and Close-Out Phase, and involves returning the units to service when refurbishment is complete, starting with the first unit in 2019.

2.3.1.5 Review of the RQE

OPG has engaged KPMG to perform an Independent Estimating Review ("IER") of the RQE. As part of the independent review, KPMG is assessing the RQE for alignment with Association for the Advancement of Cost Engineering ("AACE") guidelines, other leading industry standards and leading practices such as KPMG's MPA standards.

2.4 Report Objective

The overall objective of Work Stream 2 was to assess and review the budget estimates related to the refurbishment program and highlight key gap areas for OPG. The estimates provided by various contractors associated with various work packages were reviewed to determine the level of robustness and accuracy.

The primary objectives of Work Stream 2 are to answer the following:

- Are the estimate file documents well organized and complete? Do the estimate files provide the required information regarding the design basis, planning basis, cost basis, and risk basis of the estimate? Do they clearly define the project scope and all potential critical activities? ;
- Is every cost appearing on the estimate summary traceable to the estimate detail and other estimate backup? ;
- Is the level of detail in the estimate sufficient for the purpose of the estimate? ;
- Were parts of the project difficult to estimate and why? ;
- Was the estimate prepared using the appropriate work breakdown and code of account structure? ; and
- Does the Cost estimate reflect the project strategy, objectives, scope and risk? ;

3. Approach and Methodology

The independent review of the DRP RQE cost estimate consists of two (2) main Work Streams:

- Work Stream 1 – Governance and Process review; and
- Work Stream 2 – Cross Cutting Vertical Slice Review

This section of the report describes the approach and methodology for executing the work associated with Work Stream 1 - the review of OPG's governance and processes in relation to the RQE.

3.1 Objective

The overall objective of Work Stream 1 was to assess the OPG governance and processes required for the production, monitoring and management of the RQE cost estimating plans, processes and deliverables against industry standards and best practices. AACE guidelines, supplemented with KPMG's MPA methodology, were used as reference points for industry standards and best practice to enable this assessment.

3.2 Approach

In general, the 5-Step approach undertaken to review and assess OPG's RQE governance and processes was as follows:

Figure 1: 5 step approach to Governance and Process Review

Step 1: Documentation Review

Review of OPG governance required for the production, monitoring and management of the RQE cost estimating plans, processes and deliverables. This includes documents such as manuals, standards, plans, business cases, and memos.

Step 2: Interviews

A series of interviews were conducted with key OPG staff involved in the DRP to clarify questions concerning the documentation reviewed in order to better understand the processes followed in the production of the RQE, and to understand the responsibilities of the various team members and the external firms involved in the production of the RQE.

Step 3: Benchmarking

Reviewing, assessing and benchmarking the OPG RQE governance and processes against expectations and requirements of industry best standards for producing an estimate (i.e., the AACE recommended practices and other industry standards).

The RQE governance and management processes were rated following MPA methodology using a scale that measured the maturity of the MPA Project Control Categories ("PCCs") / Process Control Elements ("PCEs"). The rating methodology and scale are covered in detail in section 5.1.

Step 4: Risk / Gap Identification

Identify gaps or deficiencies where the OPG governance and processes are not aligned with industry standards and best practice.

Step 5: Opportunities for Improvement

Highlight recommendations to address gaps identified during the review and assessment which may negatively impact the quality of the final estimate produced.

In general, the 6-Step approach undertaken to perform the cross cutting vertical slice review was as follows:

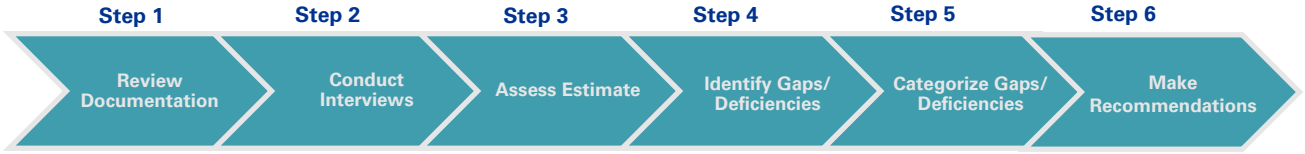


Figure 2: 6-Step approach to Cross Cutting Vertical Slice Review

Step 1: Review Documentation

Review of the estimates and related documentation. This includes documents such as OPG estimate governance, OPG Risk Management governance, OPG Scopes of Work, Estimate workbooks, Oracle Primavera P6 schedules.

Step 2: Conduct Interviews

A series of interviews were conducted with key OPG staff involved in the DNRP to clarify questions concerning the documentation reviewed, in order to better understand the estimate development and review process, and to understand the responsibilities of the various team members and the external Vendors involved in the production of the estimates.

Step 3: Assess Estimate

Assess the current state of the cost estimate based on information obtained in the documentation review and interviews.

The review comprised two main areas:

- Existence/Alignment – Determined whether the elements of the cost estimate met the established criteria; and the degree to which they were appropriate. Attempted to answer:
- Are the estimate file documents well organized and complete? ;
- Do the estimate files provide the required information regarding the design basis, planning basis, cost basis, and risk basis of the estimate? ;
- Do they clearly define the project scope and all potential critical activities? ;
- Is the level of detail in the estimate sufficient for the purpose of the estimate? ;
- Were parts of the project difficult to estimate and why? ;
- Was the estimate prepared using the appropriate work breakdown and code of account structure? ;
- Does the cost estimate reflect the project strategy, objectives, scope and risk? ;

- Traceability – Determined whether the numbers presented in the cost estimate were traceable back to source documents, and whether the numbers were internally consistent. Attempted to answer ; and
- Is every cost appearing on the estimate summary traceable to the estimate detail and other estimate backup?

Step 4: Identify Gaps and Deficiencies

Identify gaps or deficiencies where the OPG governance and processes are not aligned with industry standards and best practice. For the risk/gap identification process, KPMG has developed a tool (refer to section 2.4.2) to identify the gap areas.

Step 5: Categorize Gaps and Deficiencies

Categorize gaps and deficiencies into common themes and risk categories. Issues were assigned a risk rating based on the potential impact on the cost estimate as explained in the following table.

Table 3: Explanation of Risk Categories

Category	Definition
A	Category A: Items that could potentially impact the level of confidence in final RQE value and could be considered a priority.
B	Category B: Items that will have less of an impact than Category A items on the level of confidence in final RQE value, but will impact the quality of the final estimate produced and should be addressed in 2016 (prior to Unit 2 outage) as part of the check estimate process.
C	Category C: Items that likely will not materially impact the level of confidence in the final RQE, but could have an impact on the quality of the final estimate or expose OPG to commercial risk and should be addressed in 2016 as part of the check estimate process.

Step 6: Make Recommendations

Highlight recommendations to address gaps identified during the review and assessment which may negatively impact the quality of the final estimate produced.

3.3 Methodology

3.3.1 Work Stream 1: KPMG Assessment Tool

The KPMG Assessment Tool was used as a 'benchmarking tool' to assess compliance with industry standards and identify potential risks and highlight opportunities to address exceptions or deficiencies as they relate to the **RQE cost estimating plans, processes and deliverables**.

The KPMG Assessment Tool comprises 6 PCCs that are fundamentally based on the 5 AACE guidelines identified below, and the KPMG Major Projects Advisory (MPA) recommended practices for assessing fundamental governance and control processes applied to successful capital construction projects or programs under a set of Project Control Categories. The 6 PCCs and the AACE guidelines that that they are based on are summarized below:

- PCC #1: Development of Estimate Plan Process (AACE No. 36R-08);
- PCC #2: Development of Estimate Plan Content (AACE No. 36R-08);
- PCC #3: Basis of Estimate (AACE No. 34R-05);
- PCC #4: Estimate Classification System (AACE No. 18R-97);
- PCC #5: Estimate Review, Validation, and Documentation (AACE No. 31R-03); and
- PCC #6: Developing a Project Risk Management Plan (AACE No. 72R-12).

As will be explained in greater detail in the 'AACE Guidelines' section (refer to section 4.5), each of the PCCs break down further into sub-elements of the major categories called PCEs (mirroring the breakdown of the AACE guideline). The content for each of the PCEs was based on the applicable AACE guidelines and supplemented by the KPMG Major Projects Advisory (MPA) recommended practices.[2]

3.3.1.1 Development of the KPMG Assessment Tool

KPMG Assessment Tool was developed by assessing each of the PCEs according to the following steps:

- Identifying the relevant OPG document references and sources of information;
- Evaluating the relevant OPG document references and sources against the AACE guidelines/MPA standards;
- Assessing whether OPG has met the intent of the AACE guidelines/MPA standards and presenting findings based on professional opinion;
- Identifying gaps and deficiencies in the reference documents reviewed (if applicable);
- Providing recommendations and opportunities for improvements to mitigate identified risks (if applicable); and
- Rating the assessed PCC/PCE in terms of maturity.

KPMG's assessment was also supported by a series of interviews with key OPG staff to better understand the OPG reference documents being reviewed, the processes and governance procedures employed, and key member roles and responsibilities.

3.3.1.2 AACE Guidelines

PCC #1: Development of Estimate Plan Process (AACE No.36R-08)

PCC #1 defines the development of cost estimate preparation plans for engineering, procurement and construction ("EPC") projects and is sub-divided into two main areas: (1) planning process and (2) estimate plan content. This PCC focuses on the planning process; that is, the main planning steps and the issues to be considered when preparing an estimate plan.

This PCC #1 is further broken down into PCE as illustrated below:

PCC #1
Inputs to Estimate Plan Development

[2] While the AACE guidelines provided the industry standards and approach to developing an estimate, the KPMG Major Projects Advisory framework provided general industry knowledge of leading practices around governance, estimating, planning, scheduling, performance metrics, and project controls.

Prepare Draft Estimate Plan
Estimate Plan Reviews
Estimate Plan Approval
Revision Process

The purpose of a cost estimate preparation plan ("estimate plan") is to establish and communicate how the preparation, development, review and approval of the estimate will be completed.

Some key principles this AACE guideline recommends include:

- Preparing an estimate plan that helps to ensure successful estimate completion in an effective and timely manner;
- Engaging key stakeholders in the estimate planning process prior to the start of the estimate development process, improves the likelihood of meeting estimate objectives;
- An estimate plan that defines what information is required from who and when; and
- An approved estimate plan that provides a duly authorized basis to proceed with the estimating effort, clarifies requirements and responsibilities.

PCC #2: Development of Estimate Plan Content (AACE No.36R-08)

PCC #2 defines the development of cost estimate preparation plans for engineering, procurement and construction (EPC) projects and is sub-divided into two main areas: (1) planning process and (2) estimate plan content. This PCC focuses on the estimate plan content; that is, the recommended format and content for a cost estimate plan.

This PCC #2 is further broken down into PCEs as illustrated below:

PCC #2					
Purpose of Estimate	Process Equipment Pricing	Freight	Clarifications, Qualifications and Assumptions	Purpose of Estimate	Process Equipment Pricing
Construction Labour Productivity	Exclusions	Project Scope and Execution Plan Summary	Non-Process Equipment Pricing	Construction Work Week and Overtime	Owner Costs
Construction, Fabrication, and Operating Parameters	Vendor Representative	Construction Labour Wage rates	Late Changes	Project Execution Schedule Basis	Bulk Commodity Material Quantities
Construction Subcontracts	Escalation	Estimating Methodology	Bulk Material Quantity Take-Off Allowances	Construction Indirect Costs	Risk Analysis and Recommended Contingency
Estimating Software	Bulk Material Construction Waste Allowances	General Demolition	Benchmarking	Coding and Formatting	Bulk Commodity Material Pricing

Commissioning and Start-up	Cash Flow / Cost Flow	Filing Structure	Offsite Fabrication	Engineering and Home Office Hours	Estimate Development Schedule (EDS)
Units of measure	Offsite Module Assembly	Engineering and Home Office Costs	Estimate Responsibility Matrix	Currency and Exchange Rate	

PCC #3: Basis of Estimate (AACE No.34R-05)

PCC #3 defines a basis of estimate (BOE) document as a required component of a cost estimate. This PCC #3 is further broken down for the structure and content of a cost basis of an estimate into PCEs as illustrated below:

PCC #3					
Purpose	Estimate Classification	Cost Basis	Exceptions	Contingencies	Benchmarking
Project Scope Description	Design Basis	Allowances	Risks and Opportunities	Management Reserve	Estimate Quality Assurance
BOE Methodology	Planning Basis	Exclusions	Containments	Reconciliation	Estimating Team

The BOE defines the scope of the project, and ultimately becomes the basis for change management. The intent is that any person with capital project experience can use the BOE to understand and assess the estimate, independent of any other supporting documentation. A well-written BOE achieves these goals by clearly and concisely stating the purpose of the estimate being prepared (i.e. cost study, project options, funding, etc.), the project scope, pricing basis, allowances, assumptions, exclusions, cost risks and opportunities, and any deviations from standard practices.

In addition the BOE is a documented record of pertinent communications that have occurred and agreements that have been made between the estimator and other project stakeholders.

As per this AACE guideline, a well prepared basis of estimate will:

- Document the overall project scope;
- Communicate the estimator's knowledge of the project by demonstrating an understanding of scope and schedule as it relates to cost;
- Alert the project team to potential cost risks and opportunities;
- Provide a record of key communications made during estimate preparation;
- Provide a record of all documents used to prepare the estimate;
- Act as a source of support during dispute resolutions;
- Establish the initial baseline for scope, quantities and cost for use in cost trending throughout the project;
- Provide the historical relationships between estimates throughout the project lifecycle; and
- Facilitate the review and validation of the cost estimate.

PCC #4: Cost Estimate Classification System (AACE No.18R-97)

PCC #4 defines the general principles of estimate classification to project cost estimates (i.e. cost estimates that are used to evaluate, approve, and/or fund projects).

The intent of this guideline is to improve communications among all of the stakeholders involved with preparing, evaluating, and using project cost estimates. This PCC #4 is further broken down into PCEs as illustrated below:

PCC #4					
Project Scope Description	Block Flow Diagrams	Electrical One-Line Drawings	Plant Production/ Facility Capacity	Plot Plans	Specifications & Datasheets
Plant Location	Process Flow Diagrams (PFDs)	General Equipment Arrangement Drawings	Soils & Hydrology	Utility Flow Diagrams (UFDs)	Spare Parts Listings
Integrated Project Plan	Piping & Instrument Diagrams	Mechanical Discipline Drawings	Project Master Schedule	Heat & Material Balances	Electrical Discipline Drawings
Escalation Strategy	Process Equipment List	Instrumentation/ Control System Discipline Drawings	Work Breakdown Structure	Utility Equipment List	Civil/ Structural/ Site Discipline Drawings
Project Code of Accounts	Contracting Strategy				

This guideline provides a definition deliverable maturity matrix for each 'class' of estimate which maps the extent and maturity of estimate deliverables (i.e., master project schedule, work breakdown structure, engineering drawings, etc.) against the 5 classifications.

Depending on the aggregate maturity of the various estimating deliverables, the estimate can then be classified as follows:

	Class 1	Class 2	Class 3	Class 4	Class 5
Maturity level of project definition deliverables	0% to 2%	1% to 15%	10% to 40%	35% to 75%	65% to 100%

PCC #5: Reviewing, Validating and Documenting the Estimate (AACE No.31R-03)

PCC #5 defines the basic elements and broad guidelines of the review process which is divided into three main areas (estimate review, validation and documentation process), and further broken down into several PCEs as illustrated below:

PCC #5					
Plan for Estimate review	Estimate Team review	Reviewing estimate prepared by others	Project Manager review	Scope review	Management review

The estimate "review" is typically qualitative in nature and focuses on ensuring that the estimate technically meets requirements (i.e., it serves as a quality assurance and control function). This quality review determines if the estimate:

- Was developed using contractually or procedurally required practices, tools and data;
- Covers the entire project scope;
- Is free from errors and omissions (at a macro level; the validation step should reveal any errors or omissions from the specific details); and

- Is structured and presented in the expected format.

Alternatively, the estimate 'validation' is typically quantitative in nature and focuses on ensuring that the estimate meets project expectations and requirements in regards to its appropriateness, competitiveness, and identification of improvement opportunities; some estimates are not only for "design/build" but could be for the complete life cycle.

The estimate is typically benchmarked against, or compared to, various cost metrics and/or cost targets where valid comparators are available, including third party published data from the public domain (desired), similar completed projects from company's historical data (acceptable), or past detailed estimates (not recommended but acceptable).

Estimate 'validation' examines the estimate from a different perspective using different metrics than are used in estimate preparation.

Finally, the estimate 'documentation' element is an assessment of whether:

- The estimate is documented clearly;
- The estimate summary and detail pages are well organized, and presented at an appropriate level of detail; and
- The costs appearing on the estimate summary are traceable to the estimate detail and other estimate backup.

PCC #6: Developing a Project Risk Management Plan (AACE No.72R-12)

PCC #6 defines practices for developing and implementing a risk management plan for any type of project for any project phase. A risk management plan defines how the project team intends to implement its applicable risk management process.

This PCC #6 is further broken down into PCEs as illustrated below:

PCC #6				
Scope	Strategy and Objectives	Definitions	Roles and Responsibilities	Qualitative Risk Assessment
Quantitative Risk Assessment	Risk Management Schedule	Key Performance Indicators (KPI)	Communications	Reporting
Closeout and Lessons Learned	Reference Documents	Software	Risk Management Plan Revision Control	

In general, the risk management plan model includes:

- Ensuring risk management objectives are addressed for all stakeholder and project requirements;
- Implementing an integrated set of work processes, procedures, and applications to plan, identify, analyze, evaluate, treat, and monitor risks specific to the life of the project;
- Implementing an organization's integrated suite of risk management applications (tools and systems);
- Identifying organizational roles, responsibilities, and accountabilities with respect to risk management;
- Producing, updating, and controlling the risk management deliverables;
- Communicating risk management information and deliverables;

- Initiating the risk management process; and
- Capturing and disseminating learnings for future risk management planning.

3.3.2 Work Stream 2: KPMG Assessment Tool

KPMG utilized an assessment tool to determine the completeness and review the details presented in the budgetary estimate. The assessment tool incorporates the objectives of the review (i.e., identified in the scope of work) by comparing the budgetary estimate against industry standards (i.e. AACE) and best practice, identifying any areas where there could potentially be gaps. For example, the assessment can be grouped together in the following categories:

1) Review of cost structure and baseline information

- Determine whether the cost estimate reflects the project strategies, objectives and scope of work;
- Review the level of detail in the estimate packages, and whether every cost component in the estimate summary can be traced back to the estimate details and estimate backups;
- Review the master schedule to determine whether it integrates all schedules and project cost;
- Determine whether all the engineering deliverables used in developing the estimate have been identified;
- Review the robustness and accuracy of work breakdown and code of account structure and the way it is utilized and mapped in the estimating process; and
- Whether the work breakdown structure is practical from a technical perspective (specifically from a construction schedule and project control perspective) for the purposes of using it as a contracting (by work package) and control budget.

2) Review of Direct and Indirect Cost Estimates

- Establish the linkage between the total cost and per unit original costs for labour, materials and equipment;
- Review whether the unit costs for labour are reflective of the existing applicable collective agreements and/or contractor bid prices;
- Review the material costs to analyse whether the unit costs for major materials and equipment are reflective of applicable market range prices and/or contractor bid prices;
- To identify whether the escalation item is adequately supported and forecasted with all underlying assumptions stated (indexes utilized, wage and material increases and other statistical data from Statistics Canada and global sources);
- Determine whether the Indirect Costs in the summary sheets can be traced back to original unit costs for staff, offices, vehicles, insurances, bonds, and general installations and equipment;
- Existence of detailed risk register in line with risk register structure leading practices that contains probabilities and cost estimates for risks (both at strategic and tactical levels); and
- Analyse whether the most probable risks have been incorporated into the estimate, either as direct cost items, indirect cost items, or as contingency items.

3.3.2.1 Traceability

The Traceability analysis is focused on reviewing the cost estimate model for robustness of data integrity and accuracy of calculations. The main objective of this exercise is to assess the following characteristics:

- The workbook generally contains strong definition, mirroring the Scope of Work and Basis of Estimate hierarchy outlined in the documentation;

- All the worksheets are properly linked to each other;
- The summary sheet summarizes the cost calculations done in respective sheets;
- There is no hardcoding embedded in the calculations formulas and all the assumptions can be traced to either assumption sheet or BoE;
- Back-up or reference has been provided for all the unit costs such as material rates, labour rates, etc.;
- All the cells have been properly referred and there is easing of navigation while reviewing the model; and
- There is no off-sheet reference or reference to other worksheets not linked to model.

Revising an estimate requires that the data it draws from have a certain level of integrity, in order to ensure that assumptions, exclusions, risks, escalation, and various inputs are followed through into the final estimate values. The challenges that are associated with a data source that does not possess strong linkages (i.e., inputs (labour rates) linked to outputs (total direct field labour for a CWP) are material, and left untreated, could potentially hinder OPG's ability to have a high level of confidence in the RQE.

3.3.2.2 Schedule

The schedule analysis involved a comparison of existing schedules for RFR and BOP. Schedule assessment looked at potential areas of concern and sought to make recommendations to address any issues that arose.

Wherever possible, schedule quality analysis focused on reviewing the schedules' technical quality in relation to industry benchmarks.

The schedule analysis is restricted to RFR and BOP as no integrated master schedule for DNRP was reviewed.

4. Work Stream 1: AACE Gap Analysis

4.1 Summary of AACE Gap Analysis

This analysis outlines the gaps and potential risks in the DRP governance and estimating processes after a thorough comparison of AACE guidelines against the available documentation supplied by OPG.

After performing a gap analysis, major gap themes were identified and grouped into the following gap categories:

	PCC #1	PCC #2	PCC #3	PCC #4	PCC #5	PCC #6	
Gap Category	**Estimate Plan Process**	**Estimate Plan Content**	**Basis of Estimate**	**Estimate Class**	**Estimate Review**	**Project Risk Mgmt.**	**Total**
Minor departure from AACE guideline. Missing required element for AACE guideline.	1	8	4	0	0	2	**15**
Minor departure from AACE guideline. Missing required element is found in alternative document.	1	4	23	0	1	0	**9**
Minor departure from AACE guideline, end product appears to be met but process / activities needed to produce the output is not provided.	0	2	7	0	0	0	**10**
No document identified to address the AACE guideline at either the project or program level.	0	0	0	0	0	0	**0**
Total Gaps	**2**	**14**	**14**	**0**	**1**	**2**	**33**
Closed gaps	2	13	1	0	1	4	**21**
No departure from AACE guideline identified.	14	68	6	9	11	24	**132**
Total Items Analyzed	**18**	**95**	**21**	**9**	**13**	**30**	**186**

From the chart above, 33 gaps currently fall under three categories:

- Minor departure from AACE guideline. Missing required element for AACE guideline ;
- Minor departure from AACE guideline. Missing required element is found in alternative document ; and
- Minor departure from AACE guideline, end product appears to be met but process / activities needed to produce the output is not provided.

These items have subsequently been classified as category B gaps, which are not expected to materially impact OPG's level of confidence in RQE, but could impact the quality of the final estimate produced and should be addressed subsequent to RQE as part of the 2016 check estimate process.

The aggregate sum of the remaining 33 risks indicates that 18% of the total items analysed have some form of departure and are category B gaps. Since this initial assessment, the OPG team have been working with KPMG to produce supporting documentation and processes to close or reduce all of the t category a gaps. The recommended next step actions and current status of each of the identified AACE gaps is provided in section 8.

4.1.1 Tier Assessment Rating

For completeness, the project governance and management processes established to develop, monitor and execute the program were rated using a scale that measured the maturity of the PCCs/PCEs analysed within the assessment tool. The PCCs/PCEs were rated based on their development and documentation, the degree to which they have been implemented and utilized and finally their functionality compared to the industry and peers.

For reference the tier rating system has been presented below:

Rating	Symbol	Rating Summary	Rating Description
Tier 4	4	**Optimized**	Leading practice integrated processes have been designed and are adequately documented, with real time monitoring being completed and continuous improvement efforts underway to refine the process framework.
Tier 3	3	**Monitored**	Strong process design and documentation for standardized use across the program. Some periodic testing is completed to report to management on the effective design and operation of the processes.
Tier 2	2	**Standardized**	Processes have been designed and are adequately documented, but the documentation may have missing elements from best practice standards. Established monitoring activities are not in place to test and improve the process framework.
Tier 1	1	**Unreliable/Informal**	Process and/or control documentation is not designed or in place, and therefore monitoring or improvement activities are not occurring. Some processes may have been designed but are not adequately documented, monitored, or refined.

4.2 Development of Estimate Plans Process (36R-08)

Overall Risk Rating: 3

AACE International Recommended Practice No. 36R-08 serves as a guideline for the development of cost estimate preparation plans for engineering, procurement and construction ("EPC") projects. Cost estimate preparation plans establish and communicate how the preparation, development, review and approval of the estimate will be completed.

AACE guideline 36R-08 is divided into two components: (1) the Estimate Plan Process and (2) the Estimate Plan Content. The Estimate Development Plan Process defines the main steps and discusses issues to be considered in preparing an estimate plan. The Estimate Development Plan Content is analysed in section 5.3.

Initial Gap Analysis

Based on our initial review of pertinent program documents and interviews conducted with the Project Team, the following table summarizes the key gaps that were identified under this guideline:

Summary of Gaps Found in the Initial Assessment:
1 The critical process of **integrating and reviewing the project level estimates and schedules** with the overall program schedule should be clearly defined and tested to ensure the integration process as planned will be achievable.
2 The overall RQE Management Plan should clearly outline or make reference to the relevant documents that define the **process and key timelines for review and approval of the estimate**.

Current Summary of Tier Ratings for each PCC:

This section summarizes the assessed Tier Rating for each PCC with an outline of the findings in the respective PCC based on documentation and support provided to date:

Estimate Plan Process					
	Inputs to Estimate Plan Development	**Estimate and Schedule Integration**	**Estimate Plan Reviews**	**Estimate Plan Approval**	**Revision Process**
Risk Rating	2	3	2	3	3

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Inputs to Estimate Plan Development	2	**Opportunities:** ■ Most input requirements have been well documented in the RQE Management Plan. **Gaps and Risks:** ■ There is no reference to the timing of reviews/approvals by management of contractor submissions. This information is identified in the Roadmap document, which provides the timing for the review / approval process for RQE, and NK38-PLAN-09701-10235-001 RQE Cost Estimate Development Roadmap provides specific dates for each bundle and progression into the review process. These schedule requirements are missing in the document that covers the objectives, and therefore should be attached as an appendix or referenced directly in the RQE Management Plan.
Standardized Estimate and Schedule Integration Process	3	**Observations:** ■ Documentation has been provided with respect to the process for drafting scope, engineering design basis, schedule; responsibility matrix, risk analysis and execution planning. ■ Within the primary RQE Cost Estimate Plan document, there is a note that "Primavera P6 has been selected as the major scheduling software for Nuclear Projects" within the Nuclear Projects Schedule Management document (N-MAN-00120-10001). The RQE Management Plan also identifies P6 for schedule; ■ OPG have recently developed a new estimate-schedule integration process, where information flows from vendor estimates and P6 Schedules into US Cost tool; ■ In addition, OPG have implemented an internal QA review process to ensure that estimate summaries flowing from the integration of vendor schedules and estimates are consistent and free of large errors; and ■ Documenting and communicating the integration process has been completed by OPG at the time of writing.
Estimate Plan Reviews	2	**Observations:** ■ Within the primary RQE Cost Estimate Plan document, Appendix B covers an Estimating Review and Validation Framework, and also outlines the benefits of establishing the review schedule and plan within section 11.6 Program Estimate Review Plan; and ■ G3-2 Schedule QA Review Checklist separately covers a checklist on how to review the schedule, but there is no indication of how this process will be conducted. **Gaps and Risks:**

PCC	Risk Rating	Observations, and Potential Gaps and Risks
		■ Key stakeholders are not identified (only references "senior management"), and review process and expected meeting date deadlines are not currently being followed; and ■ The scheduling process is being followed through the high level governance covered under N-MAN-00120-10001, and a desktop level Job Aid. In the next revision of the Gate Review Process, OPG will explicitly add the reference to the scheduling job aid and the specific plan N-MAN-00120-10001-SCH-11.
Estimate Plan Approval	3	**Observations:** ■ RQE Cost Estimate Plan outlines the approval process as part of the estimate submissions. Functional and project managers, as estimate owners, are accountable for the review and vetting/validation of estimates to ensure completeness, quality and reasonability. The NR Estimating Manager is responsible to assess estimates for quality, coordinate the review process to ensure completeness and reasonability is achieved, and provide the assignment of the estimate classification achieved.
Revision Process	3	**Observations:** ■ It is outlined that estimates shall be revised to reflect approved major changes (scope, government policies, working conditions, etc.) per project requirement or Refurbishment Program requirement and direction; and ■ Estimates shall be revised when the project or Refurbishment program proceeds to the next gate in accordance with Nuclear Projects - Gated Process (N-MAN-00120-10001-GRB).

4.3 Development of Estimate Plan Content (36R-08)

Overall Risk Rating: 3

The Estimate Plan Format and Content provides a suggested format for an estimate plan along with annotations. It is designed to allow practitioners to use and modify it as needed for their specific situation.

Initial Gap Analysis

Based on our initial review of pertinent program documents and interviews conducted with the Project Team, the following table summarizes the key gaps that were identified under this guideline:

Summary of Gaps Found in the Initial Assessment:	
1	Lack of a clearly defined and developed program level execution plan (PEP) which can support RQE as a whole.
2	Development of a strategy is required for the execution, commissioning and start-up of DRP.
3	Direct sources of benchmark data should be identified, listed and consolidated to support and validate the estimate review.
4	The WBS in which the Program Estimate has been presented to date (4C or 4D) is not consistent with best practice for tracking construction (execution) performance and measuring cost variances in terms of the level of detail or the duration or size of the activities defined.

Current Summary of Tier Ratings for each PCC:

This section summarizes the assessed Tier Rating for each PCC with an outline of the findings in the respective PCC based on documentation and support provided to date:

Estimate Plan Content					
	Purpose of Estimate	**Program Level Execution Plan**	**Construction, Fabrication, and Operating Parameters**	**Project Execution Schedule Basis**	**Estimating Methodology**
Risk Rating	3	3	3	3	3
	Estimating Software	**Coding and Formatting**	**WBS Filing Structure**	**Bulk Commodity Material Quantities**	**Bulk Material Quantity Take-Off**
Risk Rating	3	4	2	2	2

Estimate Plan Content					
	Bulk Material Construction Waste Allowances	**Bulk Commodity Material Pricing**	**Offsite Fabrication**	**Offsite Module Assembly**	**Freight**
Risk Rating	2	2	3	3	2
	Construction Labour Productivity	**Construction Work Week and Overtime**	**Construction Labour Wage rates**	**Construction Subcontracts**	**Construction Indirect Costs**
Risk Rating	2	2	4	4	4
	General Demolition	**Commissioning and Start-up**	**Engineering and Home Office Hours**	**Engineering and Home Office Costs**	**Benchmarking**
Risk Rating	4	2	3	2	2
	Cash Flow / Cost Flow	**Estimate Responsibility Matrix**			
Risk Rating	3	3			

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Purpose of Estimate	3	**Observations:** ▪ Detail found in the Nuclear Refurbishment Project RQE Cost Estimate Plan is sufficient for the purpose of an estimate plan as defined by the AACE requirements (Reference N-MAN-120-10001) ; and ▪ For example, 'Project Controls' (sheet -PC) s.2.3.6 defines requirements for EVM which references N-MAN-120-SCH 7. The 'N-MAN' is a single document that is broken down into chapters.

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Program Level Execution Plan (PEP)	3	**Observations:** ■ OPG has set up the Darlington Nuclear Refurbishment Program as a program, consistent with PMI's Program Management approach. At the Program level, the DRP has developed a set of Program Management Plans ("PgMP") in lieu of a Program level Project Execution Plan ("PEP"); ■ Within each Project bundle, a Project level Project Execution Plan is in place supported by a number of Project level Management Plans ("PMP"). OPG strategically made this decision early in the Definition phase and has since been compliant to the approach; and ■ Although OPG governance includes a DRP Program level set of Management Plans, and detail found in the DRP Project RQE Cost Estimate Plan is sufficient for the purposes of an estimate plan, there is a lack of description regarding the methods of execution in the planning documents. There is not a reference to where a description can be found. For example, some contractors have included specific construction methodologies for their contract. OPG has delegated most of the specific execution details to the contractors. Execution plans exist for some DRP bundles, but a program level plan including all bundles plus areas of interface, vendor scope gaps and OPG direct scope has not been prepared.
Construction, Fabrication, and Operating Parameters	3	**Observations:** ■ Design basis elements are provided in CE.1.020 (A) DESIGN BASIS ITEMS as applied to the level of RQE, but they are not specified as the design criteria level that would exist within EPC; and ■ CNSC requires N285 and N286, which are the rules and requirements for operating a nuclear facility. The standard RD360 regulates the refurbishment. Origins of where the design basis documentation comes from - NP90 and all the work done under NP90 can be traced back to the CNSC directive.
Project Execution Schedule Basis	3	**Observations:** ■ Base Case document and other planning documents refer to 36 month timeline for unit outage. A detailed 4 unit schedule has been developed and will be included in the Program Management Plan.

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Estimating Methodology	3	**Observations:** ▪ The process is in place that dictates the requirements for each class of estimate.
Estimating Software	3	**Observations:** ▪ A description of the estimating software and tools to be used is not clearly addressed in the RQE Cost Estimating Plan but seems to have been covered in the Darlington Nuclear Refurbishment Program Management Work Stream, Applications and Coding Requirements (DRP MWS) document. This document details the tools and applications to be used in the definition and execution stage for scope management, cost management, schedule management, estimating and budgeting and work and document management., which specifies For example, it states that OPG will use US Cost for estimating and cost management (N-MAN-00120-10001-PC-14-R0, section 2.0 OPG applications, section 3.0 - OPG and Vendor applications) ; and ▪ Furthermore, at the RFR Level, the JV estimating plan states that all estimating information is to be captured in a single database (Timberline) and tagged with a unified Project wide coding system. This will then be replicated to OPG's database tool. It also states that estimating information is further captured in the P6 Execution Schedule database to obtain time distributed estimates, resource histograms and cash flow, including resource utilization for crewed shift work with supervision, PMT coverage etc. (DNGS RFR Project - Project Estimating Plan document, 509407-0000-00000-33IM-0001, section 12 - Estimating Tools). It appears OPG has generally met the intent of the AACE guidelines. **Gaps and Risks:** ▪ The AACE guidelines specify that the estimating plan should describe all software and versions to be used including how it is to be used. (I.e.: internal database, interface software). While the applications / software to be used for estimating are clear for OPG and RFR, it is not explicitly defined what the other vendors will be using for cost estimating.
WBS Filing Structure	2	**Observations:** ▪ Initially the WBS in which the program estimate has been presented to date were not consistent with best practices for tracking construction performance and measuring cost variances ; and

PCC	Risk Rating	Observations, and Potential Gaps and Risks
		▪ OPG are developing a WBS by project number and CWP that contains a significant amount of project numbers and line items. **Gaps and Risks:** ▪ An intermediate level WBS is being developed (control accounts). These control accounts should be laid out and communicated prior to check estimate. Such control accounts will be refined and perfected through 2016 and prior to execution as the estimate continues to evolve and gain maturity/increased definition; and ▪ The activities to further develop the control accounts and discussions to design a full CBS (Cost Breakdown Structure) prior to commencement of the U2 outage is ongoing and not yet closed.
Bulk Commodity Material Quantities	2	**Observations:** ▪ The RQE Cost Estimate Plan specifies that: – for owner estimate development (i.e., U2 outage work) material estimates will be defined from purchase orders, material requisitions and/or past material requirements with specific quotes or the most recent material pricing escalated to base year dollars (s. 11.3); – for EPC (JV) estimate development, estimates are prepared according to contractual and approved estimate plans (s. 11.7); and – For EPC (ESMSA) estimate development, estimates are to be prepared according to OPG's estimating requirements (i.e., OPG estimating manuals and templates provided to contractors) s. 11.7. ▪ In terms of Estimate development, the OPG 'Nuclear Refurbishment Cost Estimate' manual specifies that each project (i.e., Bundle) will produce plans / procedures to support estimate preparation, and a detailed list of documents that will need to be provided is in Appendix A (s. 3.2); and ▪ In addition, each project will prepare an Estimate Report Package that will include 'Estimate key quantities and validation report.' (s. 3.2.5). **Gaps and Risks:** ▪ OPG, in conjunction with scope reviews by project teams, are vetting the EPC Contractors' material quantity estimates to improve the quality of the final estimate produced, then it would be important for the EPC Contractor to follow AACE recommended practices (i.e., provide the methodology / basis

PCC	Risk Rating	Observations, and Potential Gaps and Risks
		for the estimate) to promote transparency in how the quantity estimates were developed; and ■ In addition, the RQE is intended to set the Program budget, and materials are (generally) reimbursable in this EPC model so it would be prudent to document the methodology and basis for arriving at the quantity estimates per AACE recommended practice to promote accountability if quantities were to grow in a future phase of the project.
Bulk Material Quantity Take-Off Allowances (Design Development Allowance)	2	**Observations:** ■ OPG EPC Contractors will be primarily responsible for determining the bulk material quantities / allowances. OPG Governance obligates the EPC Contractor to follow AACE recommended practice, which requires an estimate plan that includes the rationale for estimate allowances (known but undefined quantities) in relation to the level of engineering definition. **Gaps and Risks:** ■ OPG, in conjunction with scope reviews by project teams, are vetting the EPC Contractors' material quantity estimates and the design development allowance to improve the quality of the final estimate produced, then it would be important for the EPC Contractor to follow AACE recommended practices (i.e., describe the rationale for estimate allowances in relation to the level of engineering definition) to promote transparency in how the quantity estimates were developed.
Bulk Material Construction Waste Allowances	2	**Observations:** ■ OPG EPC Contractors will be primarily responsible for determining the bulk material quantities / allowances. OPG Governance obligates the EPC Contractor to follow AACE recommended practice, which requires an estimate plan that includes the rationale for estimate allowances (known but undefined quantities) in relation to the level of engineering definition. **Gaps and Risks:** ■ OPG, in conjunction with scope reviews by project teams, are vetting the EPC Contractors' material quantity estimates and the design development allowance to improve the quality of the final estimate produced, then it would be important for the EPC Contractor to follow AACE recommended practices (i.e., describe the rationale for estimate allowances in relation to the level of engineering definition) to promote transparency in how the quantity estimates were developed.

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Bulk Commodity Material Pricing	2	**Observations:** ■ In the OPG EPC model, materials management and procurement will generally be performed by the EPC Contractor; ■ The EPC Contractor is obligated to observe OPG governance for pricing sources / competitive bid process for all major equipment, and bulk material and commodities (ref. Procurement Management Plan - 509407-50IM-0001); and ■ The EPC Contractor Estimating plan also requires that pricing source and methodology for costs such as freight, taxes, duties, etc. shall be based on quotes or industry standard unit prices and estimated quantities/sizes. **Gaps and Risks:** ■ OPG, in conjunction with scope reviews by project teams, are vetting the EPC Contractors' material pricing to improve the quality of the final estimate produced, as well as keep audit ready records of this relevant information then it would be important for the EPC Contractor to follow AACE recommended practices and provide a table that summarizes the source of the pricing information (i.e., budget quotes, firm quotes, in-house estimates, etc.) to promote transparency.
Freight	2	**Observations:** ■ In this EPC model, materials management and procurement will generally be performed by the EPC Contractor; ■ OPG Governance obligates the EPC Contractor to observe OPG plans for pricing sources for all major equipment, and bulk material and commodities (ref. Procurement Management Plan - 509407-50IM-0001); and ■ The 'Nuclear Projects Cost Estimating' manual requires that a summary of how the cost of freight for bulk material be provided (see Appendix D). It appears that this requirement has been incorporated in the EPC contractor's estimating plan as it is specified that the estimate will include 'pricing source and methodology for costs such as freight, taxes, duties, etc. Shall be based on quotes or industry standard unit prices and estimated quantities/sizes.' (Ref. DNGS RFR Project - Project Estimate Plan, s. 7.7, page 36 - Doc#: 509407-0000-00000-33IM-0001). **Gaps and Risks:** ■ OPG, in conjunction with scope reviews by project teams, are vetting the EPC Contractors' freight costs to improve the quality of the final estimate produced, as well as keep audit ready records of this relevant information then it would be important for the EPC Contractor to follow AACE

PCC	Risk Rating	Observations, and Potential Gaps and Risks
		recommended practices and identify the cost and pricing sources for foreign and domestic freight.
Construction Labour Productivity	2	***Adjustments to productivity for labour densit*** **Observations:** ■ The Work Management Function is analysing logistical issues and scope interfaces around RFR. Any labour density issues would be considered by Work Management. In addition the RFR function should review how this has been considered in the estimate. **Gaps and Risks:** ■ Estimating plan will be updated for the RQE Check Estimate and will specify the productivity plan as required by OPG governance. Estimating plan will be updated for the RQE Check Estimate and will specify the productivity plan as required by OPG governance ***Adjustments to productivity for excessive shifts*** **Observations:** ■ The RFR JV had planned in Class 3 Estimate with 7 Day 4 on - 4 off 12 hour shift pattern with 4 crews to do the direct field labour work in the RFR Project. The alternative is to use 6 Day 10 hour shift pattern with 2 crews. The savings are coming from 2 hour less per shift and half the training cost and half the Living out Allowances by reducing from 4 crews to 2 crews. At the same time, the PMT manpower will be halved from 4 crews to 2 crews with similar savings on hours per shift and training costs and Living out Allowances. Instead of 7 days, OPG will extend the critical path by 1/7 as this is a 6 on - 1 off week pattern. What the document does not define is the final solution that seems to be proposed (in agreement with Bruce Power) to go back to 7 day 10 hour shift for critical path, but adding staggered shift starts to get 24 hour coverage (4 crews). **Gaps and Risks:** ■ RFR shit pattern was subject to extensive review and cost analysis ; and ■ The final shift schedules need to be included in the Project Execution Plan, or equivalent document. ***Description of the base productivity calculation*** **Observations:** ■ Productivity Plan is not currently finalized.

PCC	Risk Rating	Observations, and Potential Gaps and Risks
		Gaps and Risks: ■ This should be specified in the RFR Rev B schedule because it is the integrated, resource loaded schedule all the way through to breaker close to be validated when issued. BOE will reflect the basis of costs re: productivity calculations.
Construction Work Week and Overtime	2	**Observations:** ■ The RFR JV had planned in Class 3 Estimate with 7 Day 4 on - 4 off 12 hour shift pattern with 4 crews to do the Direct Field Labour work in the RFR Project. The alternative is to use 6 Day 10 hour shift pattern with 2 crews. The savings are coming from 2 hour less per shift and half the training cost and half the Living out Allowances by reducing from 4 crews to 2 crews. At the same time, the PMT manpower will be halved from 4 crews to 2 crews with similar savings on hours per shift and training costs and Living out Allowances. Instead of 7 days, OPG will extend the critical path by 1/7 as this is a 6 on - 1 off week pattern. What the document does not define is the final solution that seems to be proposed (in agreement with Bruce Power) to go back to 7 day 10 hour shift for critical path, but adding staggered shift starts to get 24 hour coverage (4 crews). **Gaps and Risks:** ■ RFR shit pattern was subject to extensive review and cost analysis; and ■ The final shift schedules need to be included in the Project Execution Plan, or equivalent document
Commissioning and Start-up	2	**Observations:** ■ The AACE guidelines specify that an explanation of how commissioning and start-up costs will be determined should be provided, and a brief description of the related scope is required. KPMG has not seen a document that states how the commissioning and start-up costs are to be determined; and ■ OPG has commissioning specs for all systems and return to service procedures and this would govern activities and the associated estimate. **Gaps and Risks:** ■ Estimating plan will be updated for the RQE Check Estimate to specify more clearly the requirements around commissioning and start up detailed estimates as a progression from current functional estimates.

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Engineering and Home Office Costs	2	***Show how the engineering labour plans are built-up*** **Observations:** ■ As part of the planning documents there is no staffing plan. There are summary level figures that cover the overall staffing. Each FMP and PMP have their own staffing requirements included in their respective documents but there is no global document. Project managers are not responsible for the staff that is being applied to the job as the cost resides elsewhere. There is no clear system for tracking the actual or required number of staff associated with the project at any given time. **Gaps and Risks:** ■ Verify the labour plans within the functional estimates; and ■ Each of the FMP's are summarized into a global staffing plan and this will be included in the Program BOE. ***Identify how other office costs and fees will be covered.*** **Observations:** ■ The individual projects are not being charged for G&A costs. This is not a construction industry best practice; and ■ As the DRP is a program, each of the Function costs, for each unit, will be included in each units cost. **Gaps and Risks:** ■ Identify home office cost treatment.
Benchmarking	2	**Observations:** ■ The RQE Cost Estimate Plan includes some metrics within the appendix. Appendix B CE. 6.080 A has a sample benchmarking document with matrix included; ■ RFR and other bundles have incorporated benchmarking into their estimates, however at a program level further benchmarks should be developed with an emphasis on cost and productivity ratios from past projects, where appropriate comparatives exist; ■ Given the nature of the project there is a lack of overall comparative data to benchmark against due to commercial sensitivity and the confidential nature of this information within most nuclear operator organizations. Project refurbishments are "one of a kind"; and ■ The tool testing being conducted in the Mock-up Facility served as the basis for modifying aspects of RFR estimate Rev1, which is now based on actual performance data. **Gaps and Risks:** ■ Direct sources of benchmark data should be identified, listed and consolidated to support and validate the estimate review.

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Cash Flow / Cost Flow	3	**Observations:** ▪ Resource loaded cash flow scheduled have been developed on a monthly interval.
Estimate Responsibility Matrix	3	**Observations:** ▪ Appendix B of the RQE Cost Estimate Process provides general responsibility, accountability, consult and inform levels. OPG has a corporate organization chart that has all the key roles of the project (project organization chart) that defines who has what positions. The SMPs will define / expand on the roles and responsibilities. And further expanded upon in each FMP and PMP. Transition strategy and agreements are in place between the operations and projects teams.

4.4 Basis of Estimate (34R-05)

Overall Risk Rating: 2

The Basis of Estimate ("BOE") defines the scope for the program, and ultimately becomes the basis for change management for the project. The BOE is used to understand and assess the estimate, independent of any other supporting documentation. A BOE achieves these goals by clearly and concisely affirming the purpose of the estimate being prepared (i.e. cost study, project options, funding, etc.), the scope, pricing basis, allowances, assumptions, exclusions, cost risks and opportunities, and any deviations from standard practices. In addition the BOE is a documented record of pertinent communications that have occurred and agreements that have been made between the estimator and other project stakeholders.

A well-documented basis of estimate will:

- Document the overall project scope;
- Communicate the estimator's knowledge of the project by demonstrating an understanding of scope and schedule as it relates to cost;
- Alert the project team to potential cost risks and opportunities;
- Provide a record of key communications made during estimate preparation;
- Provide a record of all documents used to prepare the estimate;
- Act as a source of support during dispute resolutions;
- Establish the initial baseline for scope, quantities and cost for use in cost trending throughout the project;
- Provide the historical relationships between estimates throughout the project lifecycle; and
- Facilitate the review and validation of the cost estimate.

Initial Gap Analysis

Based on our initial review of pertinent program documents and interviews conducted with the Project Team, a program level BOE document does not yet exist for RQE. Based on our review of various documents that provide components of a BOE that were used for 4D (the Gate 3 RQE BOE was not available at the time of this report) and interviews conducted with the Project Team, the following table summarizes the key gaps that were identified under this guideline:

Summary of Gaps Found in the Initial Assessment:
1. Although each project has a project level BOE, and each function has a functional level estimate, there is not an overall program level summary basis of estimate document. This document will serve the purposes of displaying knowledge of the program, alert the team to potential cost risks and opportunities, record of communications, record of documentation, and will be a legally supporting document. 2. Clearly defined upfront purpose, estimating methodology and cost basis. 3. Process for estimate classification and reasons and justifications for the classification given to each estimate.

4. Establish assumptions, risks and opportunities as well as allowances and reserves.

5. Outline the broader estimating team (OPG and contractors estimating teams) composition, accountabilities, and the quality assurance process.

6. Clarify pricing source and methodology for the breakdown of the bundle costs (i.e., project directs, project indirect, and functional indirect).

Current Summary of Tier Ratings for each PCC:

This section summarizes the assessed Tier Rating for each PCC with an outline of the findings in the respective PCC based on documentation and support provided to date:

Basis of Estimate Topics and Contents					
	BOE Purpose	**Project Scope Description**	**BOE Methodology**	**Estimate Classification**	**Design Basis**
Risk Rating	2	4	2	4	2
	Planning Basis	**Cost Basis**	**Allowances**	**Assumptions**	**Exclusions**
Risk Rating	4	2	2	2	2
	Exceptions	**Risks and Opportunities**	**Containments**	**Contingencies**	**Management Reserve**
Risk Rating	2	2	2	3	2
	Reconciliation	**Benchmarking**	**Estimate Quality Assurance**	**Estimating Team**	
Risk Rating	2	2	2	4	

PCC	Risk Rating	Observations, and Potential Gaps and Risks
BOE Purpose	2	**Observations:** OPG would benefit for a program level BoE (Basis of Estimate) document. This document will serve the purposes of displaying knowledge of the program, alert the team to potential cost risks and opportunities, record of communications, record of documentation, and will be a legally supporting document. Although certain bundles (Re-tube & Feeder Replacement, "RFR") have developed BoE documentation that is in alignment with best practice, other bundles and functions have not completed their BoE's at this time. OPG have produced a draft BoE which is considered a good initial effort to document the main assumptions and principles that guide the Estimate. However the current document does not include many aspects of the contractor's assumptions, such as inclusions and exclusions from the contractor prices, and risks assumed by contractors vis a vis OPG. The recommendation is that the document be further detailed and expanded to include comments forwarded to OPG in an email dated November 3, 2015.**Gaps and Risks:** ▪ Address comments from email dated November 3, 2015. Gathering existing BoE's at bundle and functional level, requesting BoE's from vendors that have not yet provided them, and further developing and collating these documents into a standardized program level BoE should be done prior to RQE. A first draft of this document should be provided prior to RQE.
BOE Methodology	2	**Observations:** ▪ Nuclear Projects Estimating Manual, N-MAN-00120-10001-EST-R002 provides the requirement for Basis of Estimate and a template within App C. This was rolled out through supply chain to the ESMSA contractors coordinated through the bundles and project management, but has not been coordinated at the program level. **Gaps and Risks:** ▪ Program Basis of Estimate is required to be prepared and finalized upon completion of the estimate development process; and ▪ AACE specifies that this section should describe the estimating methodology used for each of the Bundles/functions (i.e., vendor estimates, parametric models, deterministic estimating methods, etc.).

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Estimate Classification	4	**Observations:** ▪ Estimate classification is a strength of OPG's estimating governance and processes, and is considered in BOE governance.
Design Basis	2	**Observations:** ▪ Based on a review of documents, OPG describes how it handles 'modifications' (i.e. the Engineering Change Controls (ECC) Program); and ▪ Current methodology for estimate classification is Nuclear Refurbishment Estimate Classification Requirement and Assignment N-MAN-00120-10001-EST-02-R001 2015-04-01 R000 was developed in DEC 2014. **Gaps and Risks:** ▪ This section should identify the types and status of engineering and design deliverables that were used to prepare the estimate; ▪ In addition, the AACE guideline recommends that two attachments be provided 1.) An estimate deliverables checklist and 2.) The list of all engineering drawings; and ▪ The AACE guidelines also recommends documenting specific quantity metrics such as overall piping quantities etc.
Cost Basis	2	**Observations:** ▪ It appears OPG has not met the AACE guidelines. There does not appear to be any cost basis for Bundles costs in a BOE related document (i.e. Direct Costs). **Gaps and Risks:** ▪ It is not clear as to how the functional project indirects are allocated to each bundle. Thus, it would be difficult for stakeholders to assess the total actual indirect costs for each bundle; ▪ In other words, under the current methodology, it might be unclear to stakeholders as to what are actual direct costs vs indirect costs; and ▪ This section does not describe the methods and sources used for determining all material, labour, and subcontract pricing.
Allowances	2	**Observations:** ▪ A program level BOE does not exist for RQE, but based on our review Allowances it is incomplete and has been noted as an Area For Improvement ("AFI") by OPG. It appears OPG is

PCC	Risk Rating	Observations, and Potential Gaps and Risks
		relying on the EPC Contractors to provide such information. **Gaps and Risks:** ▪ This section should identify the level and types of allowances used in the estimate (i.e. Material Take-off Allowances). This section should also describe any other costs that have not been detailed in the estimate (i.e. Lump sum allowances for specific areas of scope).
Assumptions	2	**Observations:** ▪ Several sources are referenced for assumptions, such as the Assumption Database, FMP's, 4D Templates, EPC Supplier Contracts, and RFR's 4D Planning Basis, Assumptions & Analysis. However a consolidated program level BOE does not exist. **Gaps and Risks:** ▪ The AACE guidelines specify that the assumptions should be included in a BOE instead of being documented in external sources outside of the BOE document.
Exclusions	2	**Observations:** ▪ This section is incomplete and has been noted as an Area For Improvement ("AFI"), but several activities or work that will be performed in the DRP but will not be paid for by the DRP Program have been identified as exclusions. **Gaps and Risks:** ▪ While it appears OPG intends to meet the AACE guidelines, this section has been noted as an AFI. It appears OPG has partially met the AACE guidelines.
Exceptions	2	**Observations:** ▪ This section appears to be incomplete and has been noted as an AFI. Several external sources including the FMPs, Bundle Gated Documents and EPC Contracts are referenced for exceptions. **Gaps and Risks:** ▪ The AACE guidelines specify that the exceptions should be included in this section or as a checklist and attachment to the BOE. While it appears OPG intends to meet the AACE guidelines, this section has been noted as an AFI. It appears OPG has partially met the AACE guidelines.

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Risks and Opportunities	2	**Observations:** ■ A program level BOE does not exist for RQE, but based on the review of documents there appears to be reference to several sources including the Risk Management Plan, the Risk Database RDAR, and the RMO (Risk Management and Oversight) database. **Gaps and Risks:** ■ The AACE guidelines specify that the risks and opportunities should be included in this section and a risk analysis report should be provided as an attachment to the BOE.
Containments	2	**Observations:** ■ This section does not appear to exist. **Gaps and Risks:** ■ The AACE guidelines specify that this section should include cost elements in the estimate related to measures included to prevent and/or mitigate the identified risks (activities identified in the risk analysis report).
Contingencies	3	**Observations:** ■ A Contingency Report has been prepared by OPG, and this will be included in the Program level Basis of Estimate that OPG is currently preparing in advance of the finalization of RQE; ■ It is stated that 4 of the 7 categories (Cost Estimating Uncertainty, Schedule Estimating Uncertainty, Discrete Risks and Contingent Work) were run through a Monte Carlo simulation using the @RISK program; PERT distribution was then used for each individual simulation for these categories; ■ The other three categories (High Impact Low Probability Risks, Campus Plan/F&IP and Insurance Uncertainty) were derived deterministically using expert analysis and will be "tacked on" to the outcome of the Monte Carlo simulations to comprise the 4D contingency estimate; and ■ It appears OPG has addressed the AACE guidelines in terms of contingencies by providing cost elements and risk analysis techniques.
Management Reserve	2	**Observations:** ■ A program level BOE does not exist for RQE, but based on the review of documents that provide components of a BOE, a section called "Contingencies and Management Reserve" does not appear to have a cost element for management reserve located in this section; and

PCC	Risk Rating	Observations, and Potential Gaps and Risks
		▪ A Contingency Report has been prepared by OPG, and this will be included in the Program level Basis of Estimate that OPG is currently preparing in advance of the finalization of RQE. **Gaps and Risks:** ▪ Management reserve is currently being evaluated and will be incorporated into the final RQE submission as well as documented in the Program level Basis of Estimate.
Reconciliation	2	**Observations:** ▪ A Program level Basis of Estimate will be prepared prior to the finalization of RQE. This document will incorporate a reconciliation of RQE against previous estimates and a summary breakdown by projects, functions, phases and major cost element. **Gaps and Risks:** ▪ While OPG has provided overall cost overview and variances, there are no identified reasons for the variances. Furthermore, the Total costs in the variance table is referred to as Program Direct Costs, which will only leave contingency and securities as Program Indirects. Therefore it appears OPG has partially met the AACE guidelines.
Benchmarking	2	**Observations:** ▪ Reference to benchmarking documentation could not be identified within the BOE; and ▪ OPG has provided several benchmarking studies that have been utilized throughout the planning process. These documents should be referenced in the BOE. **Gaps and Risks:** ▪ The AACE guidelines specify this section should document any comparisons of overall estimate metrics, ratios, and factors with similar projects, historical data, and industry data. The use of benchmarking should be referenced in the BOE.
Estimate Quality Assurance	2	**Observations:** ▪ In general, OPG have designed and implemented processes for challenging and performing quality reviews of vendor estimates. However, the documentation of this process does not exist in a program level BOE.

PCC	Risk Rating	Observations, and Potential Gaps and Risks
		Gaps and Risks: ■ The AACE guidelines specify this section should identify all estimate reviews that have taken place, review comments or analysis as an attachment to the BOE. Therefore it appears OPG has partially met the AACE guidelines.
Estimating Team	4	**Observations:** ■ OPG has documentation that does identify the parties responsible for the project and function Bundles and have established an estimate review team. **Gaps and Risks:** The AACE guidelines specify this section should identify all members of the estimating team (i.e. JVs, contractors) including roles and responsibilities.

4.5 Estimate Classification System (18R-97)

Overall Risk Rating: 

The Cost Estimate Classification System provides guidelines for applying the general principles of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The Cost Estimate Classification System maps the phases and stages of project cost estimating together with a generic project scope definition maturity and quality matrix.

Initial Gap Analysis

Based on our initial review of pertinent program documents and interviews conducted with the Project Team, the following table summarizes the key gaps that were identified under this guideline:

Summary of Gaps Found in the Initial Assessment:
1. It is recommended that a more thorough explanation be developed on how OPG will assess the requested Estimate Input Maturity Checklist information and assign a classification rating.

Current Summary of Tier Ratings for each PCC:

This section summarizes the assessed Tier Rating for each PCC with an outline of the findings in the respective PCC based on documentation and support provided to date:

Cost Estimate Classification System			
	Cost Estimate Classification Matrix	**Determination of Cost Estimate Class**	**Characteristics of the Estimate Class**
Risk Rating	4	3	4

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Cost Estimate Classification Matrix	4	**Observations:** • OPG has provided material that directly covers the classification matrix from the AACE recommended guidelines, with an illustration of the classes and expected contingency range for those classes.
Determination of Cost Estimate Class	3	**Observations:** ▪ While OPG has provided material that directly covers the classification matrix taken from the AACE recommended guidelines, the checklist entitled "Estimate Input Maturity

PCC	Risk Rating	Observations, and Potential Gaps and Risks
		Checklist Table" from Appendix B of the RQE Management Plan does not appear to provide a thorough explanation on how this tool will be used and how they will assess if the requested checklist information has been provided. Est. 002 manual provides direction and use for the evaluation.
Characteristics of the Estimate Class	4	**Observations:** ▪ OPG has provided material that directly covers the classification matrix from the AACE recommended guidelines, with an illustration of the classes, expected contingency range, and characteristics for those classes.

4.6 Estimate Review, Validation, and Documentation (31R-03)

Overall Risk Rating: 3

This section covers the basic elements of and provides broad guidelines for the cost estimate review, validation and documentation process. The Estimate Review, Validation, and Documentation is applicable to all estimate types for any industry and is intended for those responsible for and/or participating in an estimate review.

Cost estimates typically represent a complex compilation and analysis of input from many project stakeholders. To ensure the quality of an estimate, budget or bid, a review process is required to ensure that the estimate meets project and organization requirements. The project plan typically requires that the cost estimate:

- Reflect the project strategy, objectives, scope and risks ;
- Be suitable for a given purpose (i.e., cost analysis, decision making, control, bidding, etc.);
- Address the stakeholders' financial and performance requirements; and
- Ensure that all parties agree on and understand the estimate's basis, content and outcome, including the estimate's probabilistic characteristics (i.e., range, cost distribution, etc.).

Initial Gap Analysis

Based on our initial review of pertinent program documents and interviews conducted with the Project Team, the following table summarizes the key gaps that were identified under this guideline:

Summary of Gaps Found in the Initial Assessment:
1. Estimate reviews have not been established at the overall program level with executive management oversight. However, NPET level reviews have since been conducted, and a final round of reviews is scheduled for the October to obtain PM recommendation on the estimate and NPET concurrence.

Current Summary of Tier Ratings for each PCC:

This section summarizes the assessed Tier Rating for each PCC with an outline of the findings in the respective PCC based on documentation and support provided to date:

Estimate Plan Process		
	Plan for Estimate review	**Scope review**
Risk Rating	2	4

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Plan for Management Estimate Review	2	**Observations:** ■ Estimate review is to include the accountable Project Manager, estimating manager, applicable team members and stakeholders per the PM's discretion. No mention in documentation of executive management involvement. This review level works for projects. The DRP is a 10 year $10B program that requires greater scrutiny of key contracts and estimates; and ■ This review process has subsequently been completed and the NPET level was included in various rounds of review. **Gaps and Risks:** ■ Overall program estimate reviews were scheduled to occur in late August to early Sept. This plan was included in the RQE roadmap, but should also have been incorporated or referred to in the RQE Management Plan to establish the review process and timelines at the onset of the process.
Scope Review	4	**Observations:** ■ N-GUID-00400-10000 R0001 lists BOE and scope as items to review as shown in table 2. Drawings, tech specs, equipment list, quantities of major builds and equipment are all engineering details that are listed as items to review as shown in table 2; and ■ NK38-PLAN-09701-10235-R000 lists scope verified as part of the plan to be reviewed by the review team.

4.7 Developing a Project Risk Management Plan (72R-12)

Overall Risk Rating: 4

This section defines practices for developing and implementing a risk management plan for any type of project for any project phase. A risk management plan defines how the project team intends to implement its applicable risk management process. It is recommended that the risk management plan be part of an overall project execution plan ("PEP") or similar integrated project plan to better ensure project objectives are achieved.

The risk management plan describes specific processes, procedures, organization, tools and systems that guide and support effective risk management throughout the life cycle of the project.

This section is intended to provide guidelines (i.e., not a standard) for developing a project risk management plan. This will provide a basis for what most practitioners would consider to be good practices that can be relied upon, and that they would recommend be considered for use where applicable. In general, the risk management plan model includes:

- ensuring risk management objectives are addressed for all stakeholder and project requirements;
- implementing an integrated set of work processes, procedures, and applications to plan, identify, analyze;
- evaluate, treat, and monitor risks specific to the life of the project;
- implementing an organization's integrated suite of risk management applications (tools and systems);
- identifying organizational roles, responsibilities, and accountabilities with respect to risk management;
- producing, updating, and controlling the risk management deliverables;
- communicating risk management information and deliverables;
- initiating the risk management process; and
- Capturing and disseminating learnings for future risk management planning.

The following section covers the AACE Guidelines and supplements them with KPMG's Major Projects Advisory ("MPA") methodologies related to risk. These MPA Methodologies have been added to our AACE Gap Assessment as a complementary analysis, built upon past project and technical experiences.

DRP's Risk Management ("RM") Plan was summarized in a three page section of the since superseded Project Execution Plan ("PEP", NK38-PEP-09701-10001-R002), which was last updated 2011-02-03. The AACE guideline for Risk Management Plan covers a much broader scope than that defined in the PEP RM Plan. The PMP RM plan section does however reference a number of OPG documents that address a number of risk-related items. As such, this assessment applies to all the OPG risk documentation that would apply to project staff.

Initial Gap Analysis

Overall, the risk process is relatively robust within OPG and Nuclear Projects. Significant effort has been focused on improving the risk identification and capture process since late 2014, and the N-MAN for Nuclear Projects Risk Management (N-MAN-00120-10001-RISK R000) is a strong document that successfully attempts to consolidate some of the relevant risk management guidelines into a single reference document.

The risk workshops that will drive the quantitative risk analysis will be occurring in June 2015, and KPMG will attend some of these sessions to better comment on the process that will ultimately result in the contingency calculations to be included in the RQE.

Based on our initial review of pertinent program documents and interviews conducted with the Project Team, the following table summarizes the key gaps that were identified under this guideline:

Summary of Gaps Found in the Initial Assessment:
1 Specific reference to risk management planning should be established at the project level within project governing documents such as a PEP or PMP, not just for the company as a whole. This should include project level responsibilities, schedules, KPIs, etc. that contextualize corporate objectives with respect to the project.
2 Ensure the RMO tool is being used effectively by Project Managers to proactively identify assumptions and manage risks. Develop risk KPIs to drive performance.

Current Summary of Tier Ratings for each PCC:

This section summarizes the assessed Tier Rating for each PCC with an outline of the findings in the respective PCC based on documentation and support provided to date:

Developing a Project Risk Management Plan					
	Scope	**Strategy and Objectives**	**Definitions**	**Roles and Responsibilities**	**Qualitative Risk Assessment**
Risk Rating	2	2	4	3	4
	Quantitative Risk Assessment	**Risk Management Schedule**	**Key Performance Indicators (KPI)**	**Communications**	**Reporting**
Risk Rating	4	4	4	3	3
	Closeout and Lessons Learned	**Reference Documents**			
Risk Rating	4	3			

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Scope	2	**Observations:** ■ The N-MAN is well laid out and clearly indicates the inputs and outputs of the risk management process, and aligns the structure of the document with them. The scope also describes the role of the PMO and the purpose of the RMO tool. The scope of the document is clear, but it is also clear it is intended for Nuclear Projects as a group, and is not specifically contextualized to DRP. **Gaps and Risks:** ■ Without an explicit link between the N-MAN and the RQE management plan or the DRP PEP (or equivalent document), the contextualization of the philosophy in relation to the specific objectives of a project isn't highlighted.
Strategy and Objectives	2	**Observations:** ■ A typical PEP or equivalent document would state the political, environmental and technical challenges of the project and the critical importance of RM to the project's success; ■ Typical PEP or equivalent document sections state high-level strategies and their reasoning, but a PEP document has not been updated to reference RMO tool or updated/consolidated N-MAN; and ■ With respect to risk appetite, the N-MAN notes only that NP risk tolerance is informed by a number of contributors. A sample structure for linking confidence level with contingency approval is given, but no approved process is noted. **Gaps and Risks:** ■ Without linkages between a PEP (or equivalent document) or RQE Management Plan to specific documentation and work instructions regarding RM, successful implementation may not be achieved; ■ Although informally the relative priorities are understood between 1. Cost, 2. Schedule, 3. scope, without explicitly stating as such, there is less assurance that project decisions are aligned with management's priorities; and ■ Without explicit reference or direction, N-MAN users on the project may not understand the corporate risk tolerances and their reporting hierarchy, meaning senior management may not get the information they require.

PCC	Risk Rating	Observations, and Potential Gaps and Risks
Definitions	4	**Observations:** ■ The Risk Management Manual has been created to guide Risk Management activities as a whole for the Nuclear Projects Group. It directs that each project should have either a Risk Management Plan ("RMP") or a Risk Management section within its PMP.
Roles and Responsibilities	3	**Observations:** ■ The RQE Contingency Development Plan (NK38-PLAN-09701-10006-R000) references the Contingency Development Quality Checklist that assigns responsible parties to aspects of the contingency plans; and ■ A detailed RACI (Responsible, Accountable, Consult, Inform) exists for RQE, but a program level RACI does not exist for risk and contingency. **Gaps and Risks:** ■ Although responsibilities are spoken to within the N-MAN, without a clear RACI related to risk, it may be difficult for the Risk Manager to drive performance.
Qualitative Risk Assessment	4	**Observations:** ■ N-MAN contained reference to all relevant qualitative risk assessment elements, including: identification, document control, coding, status, risk matrix, response categories for threats or opportunities, change management, risk register and quality assurance; and ■ The risk Heat Map colours of the N-MAN align with corporate Risk Tolerance matrix reporting guideline.
Quantitative Risk Assessment	4	**Observations:** ■ N-MAN contained reference to all relevant quantitative risk assessment elements, including: cost and schedule risk analysis, contingency and integrated analysis; and ■ Monte Carlo analysis and the recommended contingency has been developed by the PMO Risk Management group based on individual programs and functional inputs as part of an Integrated Model.
Risk Management Schedule	4	**Observations:** ■ Comprehensive Risk Review meetings took place in June in order to support contingency calculation.
Key Performance Indicators ("KPI")	4	**Observations:** ■ The current procedural adherence KPIs around risk management are outlined in the risk dashboard. ■ The tolerance metrics that cover OPG performance areas: – Financial Performance; – Fleet Operating Performance;

PCC	Risk Rating	Observations, and Potential Gaps and Risks
		– Project Performance; – Safety, Environment and Reliability; – Reputation; and – Regulatory Relationship. ▪ R-MAN references that an aspect of Risk Management is Monitoring and Control, and that includes evaluating risk process effectiveness throughout the project lifecycle.
Communications	3	**Observations:** ▪ The N-MAN notes that a Risk Oversight Committee ("ROC") exists, but there is no explicit direction on the frequency or attendance of risk meetings. **Gaps and Risks:** ▪ Without engraining a culture of an ongoing RM process early in the estimate process, it will be difficult for PMs and FMs to buy into the process moving into execution, where ongoing communication on risks will be even more important.
Reporting	3	**Observations:** ▪ The N-MAN discusses some of the Risk reports that may be developed from time to time by the PMO Risk Management team. Additionally, the RMO tool provides templates for certain BI reports. The N-MAN however does not state the requirements that are specific to this project, either RQE or DRP overall. These items should be outlined in a project-specific Risk Management Plan. **Gaps and Risks:** ▪ Without a project specific Risk Management Plan to address the specific requirements for RQE with respect to Risk Management, it is difficult for the PMO RM team to drive performance of the RM process from the users, upon whom they will depend for inputs into the contingency calculations that will support the estimate; and ▪ Without quantitative analysis data tied to the risks within the RMO Tool, it will be difficult for risk owners to effectively manage their risks.
Close-out and Lessons Learned	4	**Observations:** ▪ Corporate process exists for Lessons Learned, know within OPG as OPEX. The standard is referred to within the N-MAN.

5. Work Stream 1: Industry Research & Lessons Learned

5.1 Introduction

In order to supplement our analysis of the OPG DRP RQE and provide real-world information on lessons learned and industry leading practices on nuclear refurbishment projects, KPMG conducted primary and secondary research.

Primary Research

The primary research involved three interviews with individuals with experience in planning and managing nuclear refurbishment projects. The interviews attempted to provide information on the following topics:

- The types of planning that were involved in previous refurbishment projects;
- The timelines for previous projects including how they were estimated, managed, and previous outcomes;
- The role owners played in estimating and planning for a project;
- Budget considerations including; and
  - Budget estimation
  - Budget overruns
  - Cost reduction analysis
- The potential obstacles were encountered during the project.

Secondary Research

The secondary research consisted of a study on nuclear refurbishment and/or new construction projects. Priority has been given to projects that are the most relevant to OPG. The considerations include:

- Nature of the projects – Refurbishment projects have been given preference;
- Location – Canadian projects have been given preference; and
- Technology – Projects involving CANDU reactors have been given preference.

The following projects were identified as being of particular relevance from the best practices and lessons learned perspective:

- Bruce Power A and B Refurbishment Project (Canada);
- Gentilly-2 Shutdown Project (Canada);
- Point Lepreau Refurbishment Project (Canada);
- Watts Bar-2 Construction Project (USA);
- Wolsong-1 Refurbishment Project (Republic of Korea);
- Atucha I and II Construction Project (Argentina);
- Embalse Refurbishment Project (Argentina);
- Madras Refurbishment Project (India); and
- Qinshan Refurbishment Project (China).

5.2 Assessment Rating

For section 6, the Assessment Rating system has been modified and is presented below:

Rating	Symbol	Rating Summary	Rating Description
Tier 4		**Optimized**	Industry Lesson Learned has been *considered and fully incorporated* within OPG's process and control activities.
Tier 3		**Monitored**	Industry Lesson Learned has been *considered and adequately incorporated* within OPG's process and control activities.
Tier 2		**Standardized**	Industry Lesson Learned has been *considered but not fully incorporated* within OPG's process and control activities.
Tier 1		**Unreliable/ Informal**	Industry Lesson Learned has *not been considered or incorporated* within OPG's process and control activities.

5.3 Summary of Findings

Primary Research

The interview process provided an opportunity for experienced nuclear industry professionals to express what they considered to be the most important considerations in a nuclear refurbishment project, and what items would pose the largest potential impact on the estimating process.

The following table catalogues the most commonly mentioned factors relating to the estimating process throughout the course of the interviews. The aforementioned industry professionals, would not in all cases be construction management experts, but rather nuclear operations experts. KPMG considers the right blend of operations experts with construction management experts to be a key element in developing successful mega projects. The intent of the table is not necessarily to demonstrate project management best practices, but rather the views and opinions of industry experts that have participated in major refurbishments.

Topic	Recommendations
Planning and review time required	*The accuracy of an estimate is significantly impacted by the amount of time allocated to planning activities.* ▪ Planning for refurbishment typically takes 16-48 months; and ▪ 30% of the total effort is typically devoted to review activities and project assurance, throughout the duration of a project.

Topic	Recommendations
Scope	*In order to ensure accuracy in cost estimation owners should delve deeply into the details of cost estimates, and lock scope in once they have completed their due diligence.* ■ The tendency for scope creep is one of the most important considerations for the long-term validity of the cost estimate.
Scheduling	*The fulsome use of scheduling software is key to an accurate estimate.* ■ Primavera P6 Scheduling was recommended as a scheduling software.
Mock-ups	*The use of mock-ups allows elements of the estimate to be tested in realistic setting similar to that of the plant and allows for innovative approaches to be tested.*
Work Breakdown Structure	*Work breakdown structures should be built from the bottom up and be broken down by discipline in order to ascertain a full understanding of costs.* ■ The "system window" approach, breaking work down by equipment/item, allows for work to be efficiently coordinated. This allows for a readily understandable methodology for estimate development.
Cost Reduction Analysis	*Cost reduction analysis should be incorporated into estimate planning.*
Degree of Owner Involvement	*Owners should be highly involved in the cost estimation process, as they tend to have the best working knowledge of existing plant conditions.*

Secondary Research

The complexity of nuclear projects places a heightened importance on the application of lessons learned. The following table provides an overview of the lessons learned in the reference projects that were reviewed.

Theme 1 – Underestimating Technical Challenges

Lesson Learned	OPG Status	OPG Rating
Use tested and proven approaches to execution whenever possible, and heed the lessons of past projects. If no proven approach is available, realistic testing should be carried out. In addition, adequate contingency should be reflected in the project schedule and cost basis. ■ Point Lepreau – There were no proven approaches as this was the first time a refurbishment of this type was undertaken. The first attempt by AECL to replace the 380 calandria tubes failed when tiny scratches caused by wire brushes raised concerns that joints might not be reliable for 25 years. The tubes had to be taken out and then reinstalled. A memo prepared for the Prime Minister's Office in December 2012 reported that AECL's total costs were $1.17 billion, more than double the $540 million it initially budgeted for the refurbishment. It said most of that was driven by labour costs associated with schedule overruns; ■ Bruce A – Duncan Hawthorne, President and CEO of Bruce Power, stated that Bruce A Units 1 and 2 having been idled for 17 years made the job "far more complicated" and that the work schedule was "far too ambitious." Hawthorne also stated that the innovative programs of Bruce A "will be held up as a shining example for all CANDU operators facing refurbishment challenges in the future."; and ■ AECL have said that lessons learned from Point Lepreau and Bruce A were invaluable in informing Gentilly-2 and Wolsong-1.	OPG has noted that in all previous Candu refurbishments or restarts that the DRP team has information on, the outage began without 100% design. This was continuously cited as an issue, and as such OPG has targeted that engineering will be 100% for the Gate 3 RQE Milestone [there is some concern that this requirement of the Gate will not be achieved]. Staff from the Bruce refurbishment and other major nuclear projects are being used on the Darlington refurbishment in order to make use of their technical knowledge and lesson learned of the significant risk that technical challenges may present. OPG has significantly invested in utilizing tested and proven approaches to executing the re-tube work by constructing a training facility that includes a full scale reactor mock up, warehouse space for equipment and training classrooms inside the new Darlington Energy Complex ("DEC"), located in Clarington, Ontario. The training facility offers multiple mock-up models including a replica of the Darlington Nuclear station reactor vault. It houses a full-scale, reconfigurable replica reactor suitable for tool performance testing and integration, as well as training purposes. Thirteen additional mock-ups add to the potential and versatility of the training facility.	4

Lesson Learned	OPG Status	OPG Rating
	OPG will be using specially designed tools for component removal and installations, and inspection and repairs. The tooling is being pre-developed and fully tested, and work tasks will be practiced to determine the correct timing and precise sequence needed for each activity. OPG has also re-aligned various work processes based on lessons learned to avoid technological errors from previous projects. For example, the calandria tubes are being removed from the vault and then cut to manageable pieces in lieu of processing the tubes inside the vault as this was the cause of schedule delays on a previous project	

Theme 2 – Project Planning and Leadership

Organizations should have a realistic assessment of their capacity to plan for and manage major refurbishment projects.

Lesson Learned	OPG Status	OPG Rating
There is a correlation between an organizations understanding of a project and the level of project definition, and the impact on a project's budget and schedule. ■ Watts Bar Unit 2 – The capabilities of management and the project organization were inadequate in understanding the work required on Watts Bar Unit 2, leading to a significant underestimate of the project scope and complexity in terms of planning, contingencies and risks. The Watts Bar Unit 2 project plan relied on lessons learned from the restart of Browns Ferry Unit 1 in 2007 rather than the completion of Watts Bar Unit 1 a decade earlier. Walk-downs to confirm plant condition, construction quantities and work to be performed were not fully	OPG has currently considered 1300 Darlington Scope Requests ("DSR"s), and there are ongoing committees where scope is being discussed. However, a tendency towards a siloed culture appears to have created challenges and limits the collabouration between the projects, the functions, and the contractors. Additionally, the matrixed nature of the program limits certain accountabilities for cost and management oversight. Not all projects/bundles are considered in aggregate at each gate which limits the organizational understanding of the entire program as only one item of the program is considered at a time. All projects/bundles have been to a gate and their individual status is understood.	2

Lesson Learned	OPG Status	OPG Rating
completed. Cost estimates did not account for declines in productivity (recognized in the industry) and the challenges of working in cramped places in Watts Bar Unit 2. The 2007 Detailed Scoping Estimating and Planning ("DSEP") study was, in certain cases, an order-of-magnitude estimate rather than an estimate based on specific details. It presented a target cost and schedule rather than a range of potential outcomes, leading to overly optimistic projections of cost and schedule.	The current challenges in obtaining the desired cost estimate and schedule details from all projects and bundles, suggests that the estimate schedule owners may not be collabourating strongly enough in completing RQE. Some functions (i.e. O&M) have not been informed on what level of support is required of them for each program. Each PM is pushing towards the gate, but alignment and timing of deliverables within EPC's contracting model, engineering delays and poor integration within EPC's to produce detailed estimates in time are significant contributing factors.	

Theme 3 – Impact of External Factors

A variety of external factors can impact project feasibility; these factors should be identified as risks and mitigated wherever possible.

Lesson Learned	OPG Status	OPG Rating
▪ Gentilly-2 – In 2012, after postponements and re-evaluations, Hydro-Québec decided the refurbishment of Gentilly-2 was no longer justified from a financial standpoint and the plant was placed in permanent shutdown. One of the key factors in this decision was the drop in natural gas and electricity prices stemming mainly from the development of the US shale gas industry which negatively impacted the export potential for nuclear energy. ▪ Multiple factors contributed to the company's final decision to cancel refurbishment plans including the major problems encountered during the Point Lepreau and Wolsong-1 projects (as well as a better assessment of the full refurbishment	The Business Cases reviewed appear to have considered relevant external factors. OPG has invested in a customized Risk Management and Oversight Tool - the RMO is a sophisticated tool and the feedback from the team has been positive. The tool has been effectively implemented as a way to bring visibility to the project risks, and examine them in the context of the program. Assumptions are also managed in the RMO. Although the tool exists and feedback from the OPG team has been positive, it is unclear if the OPG team is utilizing the tool to its full extent. As the risk information is finalized through the month of June, and risk quantification and qualification meetings are held with each bundle owner, KPMG will witness the process to better understand how the risks are assessed and	4

Lesson Learned	OPG Status	OPG Rating
cycle of a nuclear facility such as Gentilly-2), the disaster at Fukishima, and a change in market conditions.	mitigated through action plans on contingency allocation.	

Theme 4 – Stakeholder Management

Early engagement of stakeholders has helped other refurbishment projects establish and maintain public support.

Lesson Learned	OPG Status	OPG Rating
■ Bruce Power – As of 2013, community support for Bruce Power remained high in spite of significant cost and schedule overruns. According to polls, 90% of respondents agreed that Bruce Power is involved with the community in a positive way. Additionally, 82% said they supported the refurbishment of units 1 and 2. The main reasons for supporting the refurbishment project were job creation (16%), good source of power (10%), already here (9%), and overall good for the economy (8%).	OPG has a website established where they provide information on the refurbishment as well as the following items: ■ Community members can request a DRP briefing by submitting a request or calling a toll free phone number; ■ Semi-annual performance report on the DRP are posted on the website; ■ Established a more active social media presence in 2014 to send alerts and keep followers informed of current activities; ■ DRP information centre located at the DEC which explains the project and the steps to refurbish a reactor; ■ Briefing videos on the website; ■ Phone numbers, email addresses and twitter; ■ DRP annual open door events where OPG and the community come together to visit the training facility, engage directly with OPG DRP team, and learn more about the program	4

6. Work Stream 1: Management Opportunities to Prepare the Estimate for DNRP Execution

This section contains a number of recommendations aimed at addressing the broader governance and process gaps identified with respect to AACE guidelines and estimating best practices through a Stage Gated Funding Process for a major capital program.

Findings have been summarized into major themes: Process, Functional/Indirect Costs, Project Estimating & Scheduling, and EPC Contracting Strategy & Associated Contingency. The specific findings are identified below and OPG are continuing to be implemented and developed for Check Estimate. KPMG recommends that each of these findings be addressed prior to commencement of the execution stage in October 2016.

6.1 Process

6.1.1 Project Cost Classification (Refurbishment vs. Maintenance work) Status: B

KPMG identified some projects within BOP that could overlap with station maintenance work. The rationale for including such maintenance projects within BOP appears to be that some maintenance work can more conveniently be done during the refurbishment period (while the outage is in place and operational impacts are minimized). KPMG believes that such projects should be de-scoped from DRP given that they would likely have to be executed anyway (at a higher cost) even if refurbishment did not take place.

Opportunity:

There is an opportunity in continuing to review the cost classification criteria applied to refurbishment costs to ensure consistency with project accounting treatments.

6.2 Functional/Indirect Costs

6.2.1 Opportunity for Owner Oversight Optimization Status: B

In cases where a program is a collection of projects executed in a single location such as the Darlington refurbishment (more similar to a large project than a program), corporate overhead costs should be in the region of 5-10% of overall costs as a rule of thumb in large infrastructure projects.

When excluding O&M costs ($1.3 Billion) and Engineering Services ($361 Million), the cost of the remaining functions, which represents oversight, support costs and overheads, are in the region of $1.4 Billion for Contract Management, Execution Overheads, Managed Systems Oversight, Nuclear Safety, Planning and Controls, Program Support, Supply Chain, U2 Outage, and Waste Disposal, which together represent 13% of overall costs.

Opportunity:

To set up estimating working sessions at a program level which involve functions and projects on a one to one basis (each functional leader should meet with all project managers). In such sessions, project managers should help the functional leaders identify cost optimization and streamlining opportunities within the functions in an attempt to reduce program wide functional costs.

6.2.2 Increase Project Manager Accountability by 'Projectizing Functional Costs' Status: B

Ideally, ownership of program costs (functions and projects) should be transferred to projects to ensure project managers are collectively accountable for program costs. This would help accelerate the RQE process by forcing the projects to challenge functional budgets and help drive functional planning.

Best practice for program management suggests that in order to drive accountability, execution costs should be rolled upwards as follows: from 1) functions to 2) projects to 3) program level. In any program, the projects are at the core and should be given priority over functions in terms of driving functional staff needs and owning the budgets for their respective bundles where possible and efficient to transfer costs to a project.

Opportunity:

OPG should evaluate all functional department services, and where a function is solely supporting the objective of a project, move the budget to that project.

6.2.3 Consistency of Indirects' Classification Status: B

From a Cost Classification perspective, the distinction between Project Indirects and Functional Indirects could be more clearly defined and more consistently implemented in the DRP governance documents. Different bundles have adopted different approaches with respect to "projectizing" indirects.

Opportunity:

Best practice in other related industries is to prioritize projects over bundles, and empower project managers to decide how much functional staff they need. That staff is typically assigned to the project and included in the project organization chart and project budget (as opposed to functional budget).

6.3 Project Estimating and Scheduling

6.3.1 Improve Visibility on Maturity of Estimate Status: B

Engineering and vendor estimates are lagging behind schedule for BOP and Shut Down-Lay Up. There is risk that Class 2 estimates for these bundles will not be in place prior to execution. These bundles together represent over $600 million of the program budget. A Class 2 estimate for these bundle estimates would typically not be expected at Gate 3 (Board Approval of Program), but would be expected prior to execution in the fall of 2016.

The RQE Management Plan shows that at Check Estimate date (August 2016) of Class 1 Estimates will be in place. Based on the review of current status, there is a moderate risk that this will not occur based on the current status of the estimates in the aforementioned bundles.

With the large amount of tasks and planning activities underway at OPG, it has been a challenge to keep reports updated to show current status of estimate classes and schedules per bundle. Recently a new tracking tool has been developed by the Planning and Controls team which is an adequate tool to track maturity and status of estimates for the DRP projects.

Opportunity:

Further developing and sustaining the tracking tool recently developed will help the OPG team ensure that key milestone dates are kept updated and that the team understand what the current status of estimate and schedule classes is, so that planning to achieve the required state at each milestone can be done

effectively. A Class 2 Estimating team is being put in place to ensure that the Class 2 estimate update is met prior to the execution of Unit 2.

6.4 EPC Contracting Strategy and Associated Estimate Contingency

6.4.1 Contract Risk Sharing – ESMSA *Status: B*

The ESMSA contracting strategy selected by OPG transfers risk to the contractors through the use of a performance fee pool in which the contractor puts [redacted] of their overheads and profits at risk. They will earn back the amount at risk based on their performance tied to Human Performance, Safety, Cost and Schedule performance indicators. The cost involved in performing the work plus [redacted] profits and [redacted] overheads are payable to the contractor, subject to their performance. If the contractor were to incur a cost overrun, schedule delay, a significant safety event or human performance event, the amount payable from the performance fee pool would be adjusted to account for their performance, which impacts their overall profits. OPG monitors the performance indicators and manages the performance fee pool. Even with the performance fee pool, OPG is at risk for cost overruns. The recommendation is that cost scenario analysis be carried out by the OPG Risk team for BOP and Shut Down Lay Up ("SDLU") contracts, and that adequate risk and contingency be included in the RQE for the most probable scenario of cost overruns for those projects.

Opportunity:

The RQE should fully evaluate, quantify and include the risk of overruns for ESMSA contractors participating in the refurbishment program and include such risk in the contingency. Cost scenarios should be analyzed for each project or for the bundles as a whole based on information available from experience in past ESMSA projects.

For example, best practice suggest that an analysis be prepared that includes pessimistic, most probable and optimistic cost scenarios. OPG could then calculate the cost overruns expected under each scenario and the portion of the cost overrun that will be incurred by OPG directly. These figures could then be specifically listed in the breakdown of the contingency calculation to ensure sufficient contingency has been included to cover the risk of overruns. This will also ensure that sufficient contingency detail is provided to allow OPG to directly match any contingency drawdowns for cost overruns against the amount of contingency allocated for this potential risk.

OPG believes that sufficient contingency has been included in the current estimate and KPMG is currently in the process of reviewing the contingency detail.

6.4.2 Contract Risk Sharing – Joint-Venture EPC *Status: B*

The R&FR contracting strategy (RFR contract, Article 8 – Incentives & Disincentives) transfers risk to the contractor and lays out incentive and disincentive percentage applications against the fee dependent on the range of overrun. The symmetric incentive/disincentive measures for Reimbursable Target Cost variances, for both Definition and Execution Phases, are:

Phase		
Definition	**Execution**	
Variance to Target Cost ($M) – Overruns	*Variance to Target Cost ($M) – Overruns*	**Contractor Pain/Gain**
Greater than +7.5	Greater than +250	50% (pain)
+6.5 to +7.5	+200 to +250	45%
+5.5 to +6.5	+150 to +200	40%

+4.5 to +5.5	+100 to +150	35%
+3.5 to +4.5	+50 to +100	30%
+2.5 to +3.5	+25 to +50	25% (pain)
0 to +2.5	0 to +25	0%
0 to -2.5	0 to -25	0%
-2.5 to -3.5	-25 to -50	25% (gain)
-3.5 to -4.5	-50 to -100	30%
-4.5 to -5.5	-100 to -150	35%
-5.5 to -6.5	-150 to -200	40%
-6.5 to -7.5	-200 to -250	45%
Greater than -7.5	Greater than -250	50% (gain)

Table source: RFR Agreement

The pain mechanism selected transfers risk to the contractor, but as any other contracting strategy, also leaves some risk to be borne by the owner ("OPG"). For example the risk of direct cost overruns in the first $25 million variance bracket lies with OPG as the contractor has no cost pain (although the contractor's overhead and fee would be at risk) in the mechanism for such bracket. This would be beneficial in promoting a lower initial bid price from the contractor and reducing overall project costs at the outset, since the contractor would most probably not have priced this risk in their bid. However, it would mean that OPG would have to pay the full cost of the variance up to a $25 million variance from the target cost.

The recommendation is that cost scenario analysis be carried out by the OPG Risk team in conjunction with OPG's Contract Management team and that the most probable risk values for cost overruns (based on past experience) be included in the contingency calculations.

Opportunity:

Fully capture the overrun risk under this contracting strategy when calculating contingency. Incorporate scenario analysis of the risk of OPG borne cost overruns (based on past experience and on the terms of the contract) into the contingency.

For example, best practice suggest that an analysis be prepared that includes pessimistic, most probable and optimistic cost scenarios. OPG could then calculate the cost overruns expected under each scenario and the portion of the cost overrun that will be incurred by OPG directly. These figures could then be specifically listed in the breakdown of the contingency calculation to ensure sufficient contingency has been included to cover the risk of overruns. This will also ensure that sufficient contingency detail is provided to allow OPG to directly match any contingency drawdowns for cost overruns against the amount of contingency allocated for this potential risk.

The current cost estimate includes $1.9 billion in contingency, which OPG believes provides adequate coverage for cost overruns and contracting risks under the JV agreement. KPMG and OPG are performing a joint review of the contingency to ensure sufficient coverage is provided.

7. Work Stream 1: Next Steps WS1

7.1 Summary

As a result of KPMG's independent review to assess OPG's governance and management processes required for the production, monitoring and management of the DRP RQE cost estimating plans, processes and deliverables, 7 Management Findings and 54 AACE gap opportunities were identified in comparisons to industry standards and leading practices. As of November 5, 2015 there are 40 items for OPG action remaining and 21 closed items.

	Gaps	Action OPG	Closed
Critical RQE Gaps – Category A	**0**	**0**	**0**
Development of Estimate Plan Process (36R-08)	4	2	2
Development of Estimate Plan Content (36R-08)	27	14	13
Basis of Estimate (34R-05)	15	14	1
Estimate Classification System (18R-97)	0	0	0
Estimate Review, Validation, Documentation (31R-03)	2	1	1
Developing a Project Risk Management Plan (72R-12)	6	2	4
Overall Management Findings	7	7	0
Total Gaps	**61**	**40**	**21**

All findings have been reviewed with RQE Planning & Controls management, and actions have been identified to address each finding (section 7.2 and 7.3), and OPG is actively progressing the closure of these findings in support of RQE.

KPMG recognizes that the DRP has a due diligence requirement to ensure that the Program cost estimate is both internally and externally validated for quality and reliability against "AACE recommended practices, and with classification requirements as defined in the RL030 definition statement", to verify it is at an appropriate level of maturity to proceed through the upcoming gate(s) at an acceptable level of risk. This ensures that it is comprehensive, well-documented, accurate, and credible to the classification requirements. KPMG acknowledges that in achieving this level of diligence, not all findings are required to be closed in advance of RQE.

The two categories used to define the significance of gaps that are discussed within this Work Stream 1:

Category	Definition
A	Items that could potentially have a material impact on the level of confidence in the final RQE value and should be considered a priority to address as part of RQE.
B	Items having less impact than Category A on the level of confidence in the final RQE value, but will impact the quality of the final estimate produced and should be addressed in 2016 prior to execution as part of the check estimate process.

7.2 Management Findings to Prepare the Estimate for DNRP Execution

Based on the review of the governance processes, KPMG has identified opportunities to further strengthen the management of the RQE process. The specific findings are identified below and OPG are currently working to address them in preparation for Check Estimate. KPMG recommends that each of these findings be addressed prior to commencement of the execution stage in October 2016.

	Finding Description	Action Required	Next Steps	Status
	RQE Development Processes			
1	**Project Cost Classifications (i.e., refurbishment vs. maintenance work):** Build an OPG owned bottom up estimate without "non-refurbishment" scope items – a detailed review will likely lead to identifying cost reduction opportunities.	Finance review of classification of work will be included as part of RQE	1. Classification activities to be complete by RQE and results reflected in RQE submission. 2. Analysis of consolidated RQE will be used to seek out cost saving opportunities	B
	Functional / Indirect Costs			
2	**Opportunity for Owner Oversight Optimization:** Improve collabouration between Project Managers and Functional Team leaders to identify optimization and streamlining opportunities within the functions to optimize program wide functional costs.	Phase 1 functional review complete. Phase 2 functional review by December 2015.	1. OPG to discuss internally for update on current status	B
3	**Increase Project Manager Accountability by 'Projectizing Functional Costs':** Create short-term goals, clarify accountabilities and define intermediate steps to help drive the RQE schedule.	Within each bundle/function, list the responsible persons for the overall project execution plan, cost estimate, and schedule	1. Within each bundle/function, list the responsible persons for the overall project execution plan, cost estimate, and schedule 2. The development of the RQE Program BOE will be inclusive of characterizing the bottoms up estimate for each bundle and estimate classification	B
4	**Consistency of Indirects' Classification:** Clarify the definitions for project indirect costs and functional indirect costs. In addition, functional team leaders need to know what level of support is required by the bundles.	Provide a more consistent definition of indirect costs classification	1. Within each bundle/function, list the responsible persons for the overall project execution plan, cost estimate, and schedule 2. OPG is doing a QA review of each estimate and will document and provide direction to each budget owner to ensure correct and consistent application of indirects.	B
	Project Estimating and Scheduling			
5	**Improve visibility on the maturity of the estimates:** Implement IDB to increase	Create a tracking document to show the status and version of each	1. Excel based tracking file has recently been implemented	B

	transparency with respect to the status of estimates.	estimate/schedule to be included in RQE	2. As the program transitions to US Cost I2 tool, an online tracking tool will be put in place	
	EPC Coordination and Planning			
6	**Contract Risk Sharing - ESMSA:** Ensure that the RQE fully evaluates, quantifies and includes the risk of overruns for current ESMSA contractors.	Demonstrate how historical campus plan cost overruns with ESMSA have been taken into account when calculating contingency In risk analysis for BOP and SDLU projects, ensure contingency analysis includes experience of ESMSA contractors	1. Overrun risk scenarios should be run and feed the contingency calculation.	B
7	**Contract Risk Sharing – Joint-Venture EPC:** Incorporate scenario analysis of the risk of OPG borne cost overruns based on the terms of the contract into the contingency.	Incorporate scenario analysis of the risk of OPG cost overruns based on terms of the contract into the contingency for RFR	1 Overrun risk scenarios should be run and feed the contingency calculation.	B

7.3 AACE Gap Assessment

KPMG's review of the PCCs identified 54 gaps from recommended AACE guidelines and industry leading practices. Out of the 54 gaps there are no longer an category A gaps identified. The remaining 33 gaps are category B and OPG are continuing implement and develop would not materially impact OPG's ability to execute the DRP to a reliable estimate, particularly in light of the fact that the U2 outage would not commence until October 2016, which leaves time for the team to continue progressing and closing out AACE gaps and findings by developing and implementing additional processes and governance to support the estimate as it matures from RQE up to breaker open.

OPG are actively working to address the above items at the time of writing in an effort to strengthen RQE governance and ensure adherence to AACE standards.

The remaining 52 AACE guidelines to be addressed before commencing the U2 outage are listed below, along with the identified next step action items that OPG is currently progressing. As at September 15, 2015, OPG has currently closed 20 of the 52 category B gaps.

PCC#1: Development of Estimate Plan Process (AACE No. 36R-08)

	AACE Guideline	Documentation Gap	Next Steps	Status
Inputs to Estimate Plan Development				
1	Owner estimate requirement including accuracy and review/approval timing.	RQE Management plan does not reference timing of reviews/approvals.	Provide a cross-reference in RQE MP to the latest version of the RQE Roadmap. This cross-reference has been provided in the RQE MP (rev 2), which needs to be approved and issued.	B
2	Contractor review/approval process(es).		Closed	
Standardized Estimate and Schedule Integration Process				

3	Integration of estimate plan with project schedule		Closed	
Estimate Plan Reviews				
4	Review meeting with key stakeholders	Key stakeholders are not identified (only references "senior management"), and review process and expected meeting date deadlines are not currently being followed.	Revision to Terms of Reference ("TOR") needs to be issued. Reference s.2.0. NK38-REF-09701-10005-R0. Also update RQE MP s1.2.	B

PCC#2: Development of Estimate Plan Content (AACE No. 36R-08)

	AACE Guideline	Documentation Gap	Next Steps	Status
Project Execution Schedule Basis				
1	Program Level Execution Plan		Closed	
2	A summary execution schedule (by facility, phase, unit, and commodity/ discipline) is included with the estimate plan.		Closed	
Estimating Methodology				
3	Process should be developed, documented, approved, and implemented that includes guidance on estimate and budget development.		Closed	
4	Process should be in place to ensure that the appropriate stakeholders are involved with and approved of project budgets and estimates.		Closed	
5	Project estimate and budget should be reviewed and approved by the appropriate project stakeholders.		Closed	
6	The team developing the project estimate should have adequate experience and regularly receive support from project stakeholders including the project construction management teams and subject matter experts.		Closed	
Estimating Software				
7	Description of all software and versions to be used including how it is to be used.		Closed	
WBS Filing Structure				

8	Estimate material is filed and maintained according to the WBS	WBS in which the program estimate has been presented to date requires further definition of the controls accounts in order to be effectively used as a control budget for execution purposes (i.e. tracking construction performance and measuring cost variances).	Ongoing activities to further develop the control accounts and design a full CBS (Cost Breakdown Structure) prior to execution. An intermediate level WBS is also being developed (control accounts). These control accounts should be refined through 2016 and prior to commencement of the US outage as the estimate continues to evolve and gain maturity/increased definition.	B
Bulk Commodity Material Quantities				
9	Bulk Commodity Material Quantities	Produce a program level PEP, or equivalent document, and update the program document to include a summary of the contracting strategy.	Estimating plan will be updated for the RQE Check Estimate to specify more clearly the requirements around material quantity estimates and ensure progression of current estimates that have not achieved class 3. The PM's can update the PEP's if they do not include the detailed contracting strategy, or the PgMP for the contracting strategy could be updated to reflect quantity estimates and the status of the RQE.	B
Bulk Material Quantity Take-Off Allowances				
10	Bulk Material Quantity Take-Off Allowances (Design Development Allowance)	OPG, in conjunction with scope reviews by project teams, are vetting the EPC Contractors' material quantity estimates and the design development allowance to improve the quality of the final estimate produced, it is important for the EPC Contractor to follow AACE recommended practices (i.e., describe the rationale for estimate allowances in relation to the level of engineering definition) to promote transparency in how the quantity estimates were developed.	Estimating plan will be updated for the RQE Check Estimate to specify more clearly the requirements around material quantity estimates and ensure progression of current estimates that have not achieved class.	B
Bulk Material Construction Waste Allowances				
11	Bulk Material Construction Waste Allowances	OPG, in conjunction with scope reviews by project teams, are vetting the EPC Contractors' material quantity estimates and the construction waste allowance to improve the quality of the final estimate produced, it is important for the EPC Contractor to follow AACE recommended practices (i.e., describe the rationale for estimate allowances) to promote transparency in how the quantity estimates were developed.	Estimating plan will be updated for the RQE Check Estimate to specify more clearly the requirements around design allowances and ensure vendors provide clear rationale on the use of design (and other) allowances.	B
Bulk Commodity Material Pricing				
12	Bulk Commodity Material Pricing	OPG, in conjunction with scope reviews by project teams, are vetting the EPC Contractors' material pricing	Estimating plan will be updated for the RQE Check Estimate to specify more clearly the requirements around material	B

		to improve the quality of the final estimate produced, as well as keep audit ready records of this relevant information it is important for the EPC Contractor to follow AACE recommended practices and provide a table that summarizes the source of the pricing information (i.e, budget quotes, firm quotes, in-house estimates, etc.) to promote transparency.	pricing estimates and ensure vendors provide clear support for pricing.	
Offsite Fabrication				
13	Offsite Fabrication		Closed	
Freight				
14	Freight	OPG, in conjunction with scope reviews by project teams, are vetting the EPC Contractors' freight costs to improve the quality of the final estimate produced, as well as keep audit ready records of this relevant information.	BOE will reflect the basis of costs re: field engineering costs identified. EPC Contractor should also follow AACE recommended practices and identify the cost and pricing sources for foreign and domestic freight.	B
Construction Labour Productivity				
15	Adjustments to productivity for labour density	The Work Management Function is analyzing logistical issues and scope interfaces around RFR. Any labour density issues would be considered by Work Management. In addition the RFR function should review how this has been considered in the estimate	Estimating plan will be updated for the RQE Check Estimate and will specify the productivity plan as required by OPG governance. Estimating plan will be updated for the RQE Check Estimate and will specify the productivity plan as required by OPG governance	B
16	Adjustments to productivity for excessive shifts	The final shift schedules need to include in the Project Execution Plan, or equivalent document. It is assumed that this change is being incorporated into the schedules	Review PEP (or equivalent document) to ensure the relevant information is included. Align, summarize and make visible the relevant information.	B
17	Description of the base productivity calculation	Productivity Plan has not been identified. But it is a document required by OPG governance.	This should be specified in the RFR Rev B schedule because it is the integrated, resource loaded schedule all the way through to breaker close to be validated when issued. BOE will reflect the basis of costs re: productivity calculations.	B
Construction Work Week and Overtime				
18	Indicate the construction work week basis and applicable shift schedules (i.e.: 8 hours per day x 5 days per week.)	The final shift schedules need to include in the Project Execution Plan, or equivalent document. It is assumed that this change is being incorporated into the schedules.	Work week basis will depend on the contract. However, all the work week and shift schedule should be incorporated into the Rev B schedule and will be validated when issued. The shift schedules need to be included in the PEP.	B
Commissioning and Start-up				
19	Identify how commissioning and start-up costs are determined	The AACE guidelines specify that an explanation of how commissioning and start-up costs will be determined should be provided, and a brief description of the related scope is required. KPMG has not seen a	Estimating plan will be updated for the RQE Check Estimate to specify more clearly the requirements around commissioning and start up detailed estimates as a progression from current functional estimates. OPG has	B

		document that states how the commissioning and start-up costs are to be determined.	commissioning specs for all systems and return to service procedures and this would govern activities and the associated estimate.	
Engineering and Home Office Costs				
20	Show how the engineering labour plans are built-up	As part of the Planning documents there is no staffing plan. There are higher level figures that cover the overall staffing. As noted about each of the FMP and PMP have their own staffing requirements included in their respective documents but there is no global document. Project managers are not responsible for the staff that is being applied to the job as the cost resides elsewhere.	Verify engineering labour plans within functional estimates.	B
21	Identify how other office costs and fees will be covered.	The individual projects are not being charged for G&A costs. This is not a construction industry best practice.	Identify home office cost treatment.	B
Benchmarking				
22	Identify the intended sources of benchmark data	RFR and other bundles have incorporated some benchmark data and OPG has several benchmarking documents, but missing direct sources of how benchmark data will be found and compiled into a report to support the program.	Continue to benchmark direct costs against similar projects where meaningful comparatives are available.	B
Cash Flow / Cost Flow				
23	Sample cash flow according to the intervals required by the owner (monthly, quarterly, etc.)		Closed	
24	Description of how the cash flow will be determined for each category breakdown such as: historical data, project specific progress and manpower profiles, standard payment terms.		Closed	
Estimate Responsibility Matrix				
25	Staffing plans should exist for non-manual, craft, and subcontract workers.		Closed	
26	Staffing curves should be available for non-manual, craft, and subcontract workers.		Closed	
27	All resource assumptions are documented.		Closed	

	AACE Guideline	Documentation Gap	Next Steps	Status
Basis of Estimate Topics and Contents				
1	BOE Purpose	Cost Estimating professionals need the BOE in order to understand and assess the estimate itself. In addition, the BOE is a record of communications and record of documentation utilized to prepare the estimate. More importantly the BOE should contain a greater level of detail for brownfield projects than for greenfield projects, and the larger the project, the more detail it requires. The BOE is also a legally supporting document. AACE specifies that this section should contain a brief and concise description of the total project (i.e. type of project, Scope, overall timing etc.). The purpose section does not clearly summarize the total project, which makes it difficult for the reader / reviewer to understand the context of the BOE.	OPG is producing a Program level Basis of Estimate which will consolidate assumptions and project level basis of estimates from all projects into a comprehensive Program level Basis of Estimate. This will continue to be updated as project level estimates and basis of estimates are updated. A first draft (Revision 1) of the Program level Basis of Estimate is expected to be prepared prior to the completion of RQE.	B
2	BOE Methodology	Nuclear Projects Estimating Manual, N-MAN-00120-10001-EST-R002 provides the requirement for Basis of Estimate and a template within App C. This was rolled out through supply chain to the ESMSA contractors coordinated through the bundles and project management.	Program Basis of Estimate is prepared and finalized upon completion of the estimate development process.	B
3	Estimate Classification		Closed	
4	Design Basis	This section should identify the types and status of engineering and design deliverables that were used to prepare the estimate. In addition, the AACE guideline recommends that two attachments be provided 1.) An estimate deliverables checklist and 2.) The list of all engineering drawings. The AACE guidelines also recommends documenting specific quantity metrics such as overall piping quantities etc.	Current methodology for estimate classification is Nuclear Refurbishment Estimate Classification Requirement and Assignment N-MAN-00120-10001-EST-02-R001 2015-04-01 R000 was developed in DEC 2014 and this revision per date. Will specify Purpose, Methodology, Estimate Classification, Design Basis, Cost Basis, Allowances, Assumptions, Exclusions, Exceptions, Risk and Opportunities, Containments, and Estimate Quality Assurance	B
5	Cost Basis	It is not clear as to how the functional project indirects are allocated to each bundle. Thus, it would be difficult for stakeholders to assess the actual indirect costs for each bundle. Under the current methodology, it might to unclear to stakeholders as to what are actual direct costs vs indirect costs. This section does not describe the methods and sources used for determining all material, labour, and subcontract pricing	Will specify Purpose, Methodology, Estimate Classification, Design Basis, Cost Basis, Allowances, Assumptions, Exclusions, Exceptions, Risk and Opportunities, Containments, and Estimate Quality Assurance Estimating plan will be updated for the RQE Check Estimate and will establish assumptions, risks and opportunities as well as allowances and reserves.	B

6	Allowances	This section should identify the level and types of allowances used in the estimate (i.e. Material Take-off Allowances). This section should also describe any other costs that have not been detailed in the estimate (i.e. Lump sum allowances for specific areas of scope)	The program RQE BOE will specify Purpose, Methodology, Estimate Classification, Design Basis, Cost Basis, Allowances, Assumptions, Exclusions, Exceptions, Risk and Opportunities Containments, and Estimate Quality Assurance	B
7	Assumptions	The AACE guidelines specify that the assumptions should be included in this section. A person who is reviewing the 4D BOE cannot make an assessment of the assumptions since they are documented in external sources outside of the 4D BOE document	The program RQE BOE will specify Purpose, Methodology, Estimate Classification, Design Basis, Cost Basis, Allowances, Assumptions, Exclusions, Exceptions, Risk and Opportunities Containments, and Estimate Quality Assurance	B
8	Exclusions	While it appears OPG intends to meet the AACE guidelines, this section has been noted as an Area For Improvement.	The program RQE BOE will specify Purpose, Methodology, Estimate Classification, Design Basis, Cost Basis, Allowances, Assumptions, Exclusions, Exceptions, Risk and Opportunities, Containments, and Estimate Quality Assurance	B
9	Exceptions	The AACE guidelines specify that the exceptions should be included in this section or as a checklist and attachment to the BOE	The program RQE BOE will specify Purpose, Methodology, Estimate Classification, Design Basis, Cost Basis, Allowances, Assumptions, Exclusions, Exceptions, Risk and Opportunities, Containments, and Estimate Quality Assurance.	B
10	Risks and Opportunities	The AACE guidelines specify that the risks and opportunities should be included in this section and a risk analysis report should be provided as an attachment to the BOE.	The program RQE BOE will specify Purpose, Methodology, Estimate Classification, Design Basis, Cost Basis, Allowances, Assumptions, Exclusions, Exceptions, Risk and Opportunities, Containments, and Estimate Quality Assurance.	B
11	Containments	The AACE guidelines specify that this section should include cost elements in the estimate related to measures included to prevent and/or mitigate the identified risks (activities identified in the risk analysis report).	The program RQE BOE will specify Purpose, Methodology, Estimate Classification, Design Basis, Cost Basis, Allowances, Assumptions, Exclusions, Exceptions, Risk and Opportunities, Containments, and Estimate Quality Assurance. RMO contains project risks actively being managed by the project managers. In the construct of the basis of estimates, known mitigation plans are expected to be incorporated in the base estimates. The P&C lead can extract the costs of risk mitigation form the estimates.	B
12	Reconciliation	A Program level Basis of Estimate will be prepared prior to the finalization of RQE. This document will incorporate a reconciliation of RQE against previous estimates and a summary breakdown by projects, functions, phases and major cost element.	The program RQE BOE will specify Purpose, Methodology, Estimate Classification, Design Basis, Cost Basis, Allowances, Assumptions, Exclusions, Exceptions, Risk and Opportunities, Containments, and Estimate Quality Assurance.	B
13	Benchmarking	While this section is incomplete and has been noted as an Area For Improvement (AFI), this section does	Estimating plan will be updated for the RQE Check Estimate and will specify the	B

		identify several activities or work that will be performed in the DRP.	productivity plan as required by OPG governance.	
14	Estimate Quality Assurance	This section appears to be incomplete and has been noted as an AFI. It references several external sources including the FMPs, Bundle Gated Documents and EPC Contracts.	The program RQE BOE will specify Purpose, Methodology, Estimate Classification, Design Basis, Cost Basis, Allowances, Assumptions, Exclusions, Exceptions, Risk and Opportunities, Containments, and Estimate Quality Assurance. Estimating plan will be updated for the RQE Check Estimate and will specify the productivity plan as required by OPG governance.	B
15	Estimating Team	OPG has documentation that does identify the parties responsible for the project and function Bundles and have established an estimate review team.	The estimating team was articulated in the RQE Cost Estimate Development Plan (NK38-PLAN-09701-10235) and will be incorporated into the BOE.	B

PCC#4: Estimate Classification System (AACE No. 18R-97)

	AACE Guideline	Documentation Gap	Next Steps	Status
			No issues noted	

PCC#5: Estimate Review, Validation, and Documentation (AACE No. 31R-03)

	AACE Guideline	Documentation Gap	Next Steps	Status
Review of estimate				
1	Identified team lead responsible for review process		Closed	
2	Plan for Management estimate review	Estimate review is to include the accountable Project Manager, estimating manager, applicable team members and stakeholders per the PM's discretion. No mention in documentation of executive management involvement. This review process has subsequently been completed and the NPET level was included in various rounds of review.	Overall program estimate reviews were scheduled to occur in late August to early Sept. This plan was included in the RQE roadmap, but should also have been incorporated or referred to in the RQE Management Plan to establish the review process and timelines at the onset of the process.	B

PCC#6: Developing a Project Risk Management Plan (AACE No. 72R-12)

	AACE Guideline	Documentation Gap	Next Steps	Status
Scope				
1	Scope is described with respect to the overall project plan	Risk Management Manual has been created to guide Risk Management activities as a whole for the Nuclear Projects Group. It directs that each project should have either a Risk Management Plan (RMP) or a Risk Management section within its PMP. The RQE Management Plan does not reference an RQE Risk Management Plan nor contain a Risk Management section.	Link into the ongoing risk management process by referring to forums (R-ROC, etc.), risk reports, and active management of key risk areas to satisfy this concern. This should be part of the next update of NK38-PEP-09701-10001. Revise RQE management plan.	B

Strategy and Objectives				
2	Provide a statement of the purpose and objectives of the project in respect to risk management, how project strategies translate into risk management, and the projects risk appetite and priorities	High-level risk strategies and reasoning have been referenced, but no update to RMO tool or updated/ consolidated N-MAN. A sample structure for linking confidence level with contingency approval is given, but no approved process is noted. Although informally the relative priorities are understood between 1. cost, 2. schedule, 3. scope, without explicit reference or direction, N-MAN users on the project may not understand the corporate risk tolerances and their reporting hierarchy, meaning senior management may not get the information they require.	Incorporate new contingency development guide in the revised RQE management plan. Also include slides that describe application of N-MAN to QE. Will be verified when issued.	B
Risk Management Schedule				
3	The RM schedule shows key tasks such as planned integrations with contractors, software implementation milestones, planned qualitative and quantitative risk assessment sessions, planned quality audits, planned closeout activities.		Closed	
Key Performance Indicators ("KPI")				
4	The following are some potential KPIs that may be defined in this section: · treatment plans developed and approved within required time period · timing from identification to assessment and treatment · percentage of risks with action or treatment due dates being met · for risks that occurred, the severity of the actual consequence versus identified consequence		Closed	
Communications				

5	Address specifically when and who participates in risk meetings as well as the minimum frequency of these meetings. There could also be an extension to the overall communications matrix or have a specific risk communication risk matrix. This should indicate who should be receiving copies of reports and other risk deliverables or who just needs to be informed of them being issued.	Closed
Reporting		
6	Reporting may be considered a subset of communications but it will need to address the how and when of such items as: What is to be reported; Who is to write the report(s); When is it to be issued; How is it reported; Is it meant to be a standalone report or part of an overall project report; If it is part of an overall project report, who is coordinating the overall report and when does the risk report need to be issued for inclusion.	Closed

Workstream 2 of the KPMG Report on RQE (pages 80-241)

is filed as confidential information in its entirety

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Darlington RFR Project

Class 2 Estimate – Expert Panel Review

Submission Date: November 24, 2015

PANEL MEMBER SIGNATURES

Bill Pilkington — Date: 2015-11-24

Mike Burke — Date: 2015-11-24

Jamie Higgs — Date: 2015-11-24

James Hopkins — Date: 2015/11/24

EXECUTIVE SUMMARY

The main components (fuel channels and feeder pipes) of the Darlington Nuclear Generating Station (DNGS) reactor cores are approaching the end of their original design service life. Most CANDU reactor operators have chosen to extend the life of their reactors as a cost-effective and reliable source of carbon-free generation by planning and executing a major refurbishment outage.

Ontario Power Generation (OPG) established the Darlington Refurbishment Project to develop and implement a comprehensive work program that will extend the service life of the four reactor units for an additional 30 years of operation. The Project Definition Phase, which began in 2009, has now reached completion. The Project is continuing preparation for the Outage Execution Phase which will extend through the period between 2016 and 2024 to refurbish all four units.

Replacement of the fuel channels and calandria tubes in the reactor core (retubing) and the feeder pipes connecting the fuel channels to the reactor headers is the longest series of activities or critical path of the Refurbishment Project. This work is known as the Retube and Feeder Replacement (RFR) Project. OPG entered into a contract with a Joint Venture (JV) of SNC-Lavalin Nuclear Inc. and AECON Construction Group Inc. to perform the Definition Phase of the RFR Project.

One of the Definition Phase deliverables of the JV is an AACE (Association for the Advancement of Cost Engineering) Class 2 Estimate to perform the execution phase of the RFR Project. As OPG prepares to accept this estimate from the JV as part of the determination of an execution phase target price, then ultimately the Release Quality Estimate for the Darlington Refurbishment Project, due diligence requires independent review of the Class 2 Estimate.

A Third-Party Expert Review Panel (the “Panel”) was constituted by OPG to perform one of these reviews. The Panel is composed of four individuals with previous Retube and Feeder Replacement experience at senior levels in the primary contractor or customer organizations. The product of the Panel’s review is this report outlining both compliance to prudent industry practices as well as observations and recommendations on any potential areas for improvement. The Terms of Reference (TOR) for the Panel are attached as Appendix A. Although the process and schedule followed by the JV and OPG to produce and review the Class 2 Estimate were more complex than anticipated in the TOR, the Panel is confident it has fulfilled its mandate.

The Panel was provided all of the documents necessary to complete its review. The initial set of documents from the Class 3 Estimate submission formed a good knowledge base on how to approach the review of the Class 2 Estimate and where significant effort was required by the JV to progress from Class 3 to Class 2. During the final stages of preparation and following delivery of the first version of the Class 2 Estimate (R0), both the JV and OPG accommodated all requests for additional documents, to observe meetings, and to carry out interviews. Transparency and free sharing of information continued over the period of April to October 2015 through the progression of interaction between OPG and the JV leading to the JV’s submission of the final version of the Class 2 Estimate (R1).

In determining compliance to AACE Class 2 requirements, the Panel concluded that while AACE Class 2 methodology and practices form a sound basis for preparing the Class 2 Estimate, given the unique challenges of this large “brownfield” nuclear project, there should be caution in interpreting the range and confidence levels of the overall result. The Panel concludes that the JV Class 2 Estimate followed the AACE requirements for preparing a Class 2 Estimate. The integrity of the Class 2 process was maintained during the evolution of the estimate from Class 2 R0 to Class 2 R1. As independent verification, the Panel assessed the overall result obtained from the Class 2 Estimate against operating experience. If the actual schedule duration achieved for a Darlington unit RFR is not more than 7 ½ months longer than Wolsong unit 1, after adjusting for unit differences and avoidable delays, then the cost should be within the Class 2 Estimate upper bound. The Panel considers this to represent a very achievable outcome.

Compliance to the OPG contracting strategy is specifically addressed in the Compliance Chapter Report (509407-0000-00000-33RA-0173 “Class 2 Milestone - Compliance”). It is the opinion of the Panel that the strategy used to develop the estimate is in compliance with the OPG contracting strategy as prescribed by the Agreement. It should be noted the Estimate Chapter Report on Scope identifies scope items assumed in the Estimate that require formal acceptance by OPG.

The Panel found risk management to be the most challenging area to review. Risk registers and risk mitigation strategies were being developed and refined in parallel with the Panel review. The Panel is also not certain that they were provided a clear view of all of the JV and OPG internal risk registers due to their confidential and commercially sensitive nature. Nevertheless, the Panel was able to conclude the risk management processes, taken in the context of all of the risk related information provided, is sufficiently mature to support the Class 2 Estimate. The Panel recognizes risk management is a dynamic ongoing process at this stage of a project and, as a result, has made the following recommendations on continued effort in this area:

Recommendation 1: *The Panel recommends the JV continue efforts to refine their understanding of the project risks within their scope of work over the next several months and continue effort on mitigation strategies through the standby phase and into construction.*

Recommendation 2: *The Panel recommends OPG continue efforts to refine their understanding of the complete envelope of all risks related to the RFR Project, including risk ownership, to avoid gaps and duplication over the next several months; and continue effort on mitigation strategies through the standby phase and into construction.*

In the course of its review, the Panel has identified opportunities to improve the basis and accuracy of the Class 2 Estimate. The majority of these findings and recommendations were provided to the JV and OPG project teams early enough for the resulting improvement actions to be incorporated into the Class 2 Estimate R1. The remaining recommendations provided in this report were derived from observations on the status of project preparation and risk mitigation as of the end of October 2015. Any risk to the success of the project posed by the most recent findings can be addressed in the remaining time to the start of related construction activities and through implementation of a comprehensive Standby Plan.

The Target Schedule, based on tool performance testing at the DEC, is essentially equivalent to the one achieved for Wolsong 1 retubing and feeder replacement, adjusted for physical differences between the reactors, and with elimination of known problems. For the first Darlington unit in particular, the Panel believes this Target Schedule is very challenging, but technically achievable based on OPEX and tool/process demonstrations to date.

Recommendation 3: *A realistic working schedule with duration between the best achievable and the most likely schedule needs to be established to align project planning in both organizations. The earlier this schedule is in place, the more effectively the impact of task and logic changes can be managed going forward.*

One of the cornerstones in the retube technology planned to be used on the Darlington RFR Project is volume reduction of high-level retube waste. The highly radioactive reactor components will be put into shielded flasks that will protect the workers from the radiation and then transported to a separate building where they will be volume reduced/segregated in parallel with the reactor face removal work. There are first-of-a-kind concepts associated with the process to be used at Darlington, and while the volume reduction of pressure tubes and calandria tubes has been performed on all recent retube projects (in the reactor vault, in those cases), it has not gone well on any past project.

Recommendation 4: *The Panel believes retube waste processing remains a significant risk to the project. The Panel recommends OPG and the JV put in place a program to perform additional performance tests after factory acceptance testing and then to plan and allow time for comprehensive commissioning and “shake down” tests when the lines are assembled at site.*

The success of all large projects involving construction on an operating site relies heavily on a strong working relationship between the operations organization, the owner's project team, and the project contractor. This is particularly true of major nuclear refurbishment projects where it is difficult to create a fully independent construction island because of common services and common hazards with the operating units.

Recommendation 5: *As the Darlington RFR Project moves toward the implementation phase, it is important create a constructive working relationship between OPG Operations, the OPG Project Team and the JV.*

Recommendation 6: *The impact of the contracting strategy on project execution and teamwork should be examined as it plays an important role in shaping behaviors of the parties.*

The Panel does not see evidence the Project's Radiation Protection (RP) organization has been put in place early and is effectively part of the team planning for the project. As a result, there is a risk that project-specific RP processes and input to retube series procedures will come late and will extend series durations, pushing out the retube schedule.

Recommendation 7: *Establish a Darlington RFR RP organization early with streamlined project-specific procedures. Invest in technology to increase RP effectiveness and reduce dose to both RP technicians and workers.*

The JV have identified their "Tool Management System" as the mechanism to identify, track, repair and test retube tooling. The Panel foresees challenges in keeping this very large and complex toolset at peak performance over four (4) units and 10+ years. Tool performance should be carefully monitored for early signs of potential maintenance/endurance issues during mock-up testing and initial training. The retube mock-ups at the Darlington Energy Centre (DEC) represent a tremendous asset and opportunity to fully prepare for the work. The Panel recommends the DEC be used to its full potential throughout the coming year, including before formal training starts as dictated in the Standby Plan. Although the Standby Plan has not yet been formally accepted by OPG, this acceptance is expected shortly. The Panel see this Plan as an integral part of the preparation for the project, and not an optional exercise.

Recommendation 8: *The mock-ups at the DEC are far superior to anything used on past retube projects. The Panel recommends the DEC be used to its full potential throughout the coming year to refine the processes and challenge the tooling to be used. Some aspects of the concerns identified by the Panel elsewhere in this report can be addressed through a well-executed Standby Plan.*

The aggregate knowledge and experience of the joint venture and OPG subject matter experts (SMEs) who worked on the Class 2 Estimate is commendable. The teamwork that developed in the combined JV/OPG organization established to finalize the Class 2 Estimate R1 was exemplary. It's important this talent be retained and additional experienced staff be brought in to execute the Standby Plan and in staffing for the Outage Execution Phase. Performance on the first unit can be enhanced by having experienced leaders on the construction Project Management Team, even if it means moving some talent from OPG to the JV. This strategy of moving key individuals from the owner's organization to the contractor has been carried out successfully on previous retube projects.

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APPENDICES

1. INTRODUCTION

1.1 Background

The main components (fuel channels and feeders) of the Darlington Nuclear Generating Station's reactor cores are approaching their originally designed end of service life. There are many more productive years that are available from this station if they are replaced, as has been done in most other CANDU reactors.

Ontario Power Generation (OPG) established the Darlington Refurbishment Project to develop and implement a comprehensive work program that will extend the service life of the four reactor units for an additional 30 years of operation. The Project Definition Phase, which began in 2009, has now reached completion. The Project is continuing preparation for the Outage Execution Phase which will extend through the period between 2016 and 2024 to refurbish all four units.

Replacement of the fuel channels and calandria tubes in the reactor core (retubing) and the feeders that connect them to the reactor headers is a major component of the Refurbishment Project. This work is known as the Retube and Feeder Replacement (RFR) Project. OPG entered into a contract with a Joint Venture (JV) of SNC-Lavalin and AECON to perform the Definition Phase of the RFR Project.

One of the deliverables of the JV is an AACE (Association for the Advancement of Cost Engineering) Class 2 Estimate to perform the subsequent phases of the RFR Project. As OPG prepares to accept this estimate from the JV as part of the determination of the target price, then ultimately the Release Quality Estimate for the Darlington Refurbishment Project, due diligence requires reviews of the Class 2 Estimate.

This report documents a review conducted by a team of senior managers with previous Retube and Feeder Replacement experience, who had no prior involvement in the generation of the estimate.

1.2 Terminology Used in this Report

This report documents a review conducted by a team of senior management with previous Retube and Feeder Replacement experience, who had no prior involvement in the generation of the estimate. This team is called the Third-Party Expert Review Panel (informally the **3PEP**, or in this report, "**the Panel**").

The Class 2 Estimate is summarized in one report entitled the "**Milestone Report**". It is supported by a number of **Chapter Reports** dealing with individual elements of the estimate and/or key assessments such as risk assessments and schedule analysis. These Chapters are in turn supported by a large volume of detailed supporting information.

OPG specified the estimate shall be in compliance with the **AACE** (Association for the Advancement of Cost Engineering) Class 2 requirements. Note that elsewhere this may be abbreviated AACEi, with the "i" standing for "international".

There are two (2) major versions of the Class 2 Estimate; the initial issue (**R0**) from the Joint Venture (**JV**) of SNC-Lavalin Nuclear Ltd. and AECON to Ontario Power Generation (**OPG**) in May 2015, and a major revision (**R1**) in September 2015, embodying the results of a collaborative detailed review between OPG and the JV.

During the period from June to August 2015, the JV and OPG assembled a number of joint teams of retubing Subject Matter Experts (**SMEs**) and supporting staff, from their organizations, and put in place a management review process to review the Class 2 Revision 0 estimate in detail. The teams met face-to-face until all issues were resolved. This was termed the "**War Room**" process.

The **Target Schedule** and **Target Cost** referred to in this report are terms from the contract between OPG and the JV. In rough terms, the Target Schedule is the schedule the two parties have agreed represents the "most likely" achievable schedule for the work. The Target Cost is the cost to OPG based upon the Target Schedule.

There is approximate one year remaining before the shutdown of the first unit. During this period OPG and the JV intend to execute a **Standby Plan** to comprehensively rehearse each operation in the realistic retubing and reactor mock-up environment the OPG has constructed at the Darlington Energy Centre (the **DEC**).

1.3 The Panel

The Panel is composed of senior management with previous Retube and Feeder Replacement experience. The members of the Panel are:

- Bill Pilkington
- Mike Burke
- Jamie Higgs
- James Hopkins

Short form resumes of the Panel members are attached as Appendix B.

1.4 Mandate of the Panel

The Terms of Reference for the Panel were agreed by all parties and are attached as Appendix A. The specific mandate of the Panel was given in the following objectives in the Terms of Reference:

	Objective
O1	Become knowledgeable on the Darlington RFR Project and contracting strategy to be able to critically assess the Class 2 Estimate products. This will be achieved by reviewing the estimating plan, and the Class 3 Estimate, and relevant Class 3 Estimate audit plans and findings.
O2	Provide an independent determination if the JV Class 2 Estimate products fully meet the AACE requirements for a Class 2 Estimate.
O3	Determine if the structure of the Class 2 Estimate meets the requirements of OPG's contracting strategy.
O4	Determine if the Class 2 Estimate meets the requirements of decision-making process used by the OPG Board and OPG's Shareholder to approve or deny project funding.
O5	Provide an independent assessment of the effectiveness of the combined JV and OPG project risk management processes, to determine if all risks have been properly identified and quantified, if mitigation strategies are appropriate, and if contingency amounts are consistent with corresponding confidence levels.
O6	Recommend opportunities to improve the basis and accuracy of the Class 2 Estimate and where possible, provide those recommendations to the JV and OPG project estimating teams early enough for improvement actions to be incorporated into the final estimate.

The product of the Panel's review is this report outlining both compliance to prudent industry practices as well as recommendations and observations on any areas of improvement and/or errors and omissions.

1.5 Organization of this Report

This remainder of this report is organized as follows:

Section 2: Summarizes the process and activities of the Panel over its review in an approximate chronological order. It includes the following:

- Review of the Class 3 material leading up to the Class 2 Estimate (Objective O1);
- Identification of key areas for investigation and review of the Class 2 R0 Chapter Reports and supporting documentation;
- Generation of Panel Comments and JV and OPG Responses;
- Review of the Class 2 R1 Chapter Reports and supporting documentation and resolution of outstanding issues.

Section 3: Discusses the findings against the balance of the Objectives (O2 to O6) given to the Panel.

Section 4: Details the findings and observations of the Panel. These were developed from the Panel's initial list of focus areas, and the balance of the objectives (O2 to O6).

Section 5: Summarizes the conclusions and recommendations from the discussion against the Objectives (Section 3) and findings (Section 4).

The report contains a set of appendices to provide back-up material.

2. PANEL REVIEW PROCESS

2.1 Review of Material Leading Up to the Class 2 Estimate

The first activity of the Panel was to review the available information leading up to the Class 2 Estimate. This was performed in advance of receiving any of the Class 2 Estimate documentation.

The Class 3 Estimate, the OPG – JV contract, Joint Venture Project Plans (including the Project Execution, Scheduling, and Estimating Plans) supporting documents, and third-party assessments performed to date were assembled in one location and reviewed by the Panel.

This period of learning addressed Objective O1 of the mandate (Become knowledgeable on the Darlington RFR Project and contracting strategy to be able to critically assess the Class 2 Estimate products. This was achieved by reviewing the estimating plan, and the Class 3 Estimate, and relevant Class 3 Estimate audit plans and findings.).

2.2 Identification of Focus Areas for Investigation and Review of R0 of the Class 2 Estimate

Following a review of the Class 3 Estimate materials provided, the Panel held a working session and developed a list of areas for focused investigation based on potential gaps in the Class 3 materials and the experience of the individual Panel members. This list is provided as Slide 6 of the initial Panel presentation to OPG and the JV (See Appendix D).

R0 of the Class 2 Estimate was provided to the Panel in mid-May, 2015. The Panel collectively reviewed the key Chapters making up the Class 2 Estimate and their supporting documentation. The Panel assigned individual members as leads to review the balance of the Chapters and summarize their findings for consideration by the Panel as a whole. This review was conducted against the Objectives of the Panel, and the list of focus areas for investigation.

2.3 Generation of Panel Comments and JV/OPG Responses

In parallel with appraising itself of the Class 3 and Class 2 (R0) products, members of the Panel conducted a series of interviews with JV and OPG management, estimating, and planning and control staff and the retubing Subject Matter Experts (SMEs) who were involved in preparing and reviewing the estimate. A list of the interviews is provided as Appendix C. Panel members also observed meetings between JV and OPG staff to review draft Chapter Reports and Tool Basis Sheets.

The Panel met in May 2015 for several days to review and further develop the individual Panel member's observations and findings in the form of comments on the Class 2 Estimate. It considered the potential impact of their comments in aggregate and identified several areas where significant improvement could be made to increase confidence in the basis and accuracy of the Class 2 Estimate. These improvement opportunities were assembled into a presentation and delivered to senior members of the JV and OPG project teams in a meeting held on May 22nd, 2015. The presentation is attached as Appendix D.

In total, 191 detailed comments were compiled, with varying degrees of significance, and were delivered to OPG on June 19th. The detailed comments were divided into a set of 128 which the Panel felt warranted a response, and 63 that were provided for the benefit of the JV and OPG project teams but had a low significance and didn't warrant a formal response.

During the period from June to August 2015, OPG reviewed the Class 2 Estimate R0 Chapters through a series of vertical slice reviews and deep dives and established a change log to record comments and concerns for the JV to address. Through the summer period, the Panel participated in weekly teleconferences with the OPG and JV project leads to follow the process.

The Panel reviewed the change log at one point; however it was apparent to OPG the process was moving forward too slowly. In the end, OPG and the JV assembled a number of teams of SMEs and supporting staff from both companies, working together in a War Room environment to debate and resolve differences. Their primary issues list included the change log and tool performance basis sheets. The Panel comments on the R0 Estimate were included for resolution and a joint OPG/JV management review process was put in place to resolve any issues escalated from the teams and to confirm the quality and completeness of the outputs. A Panel member dialed in to several of the management review meetings and confirmed the War Room process was effective. The primary goal of the joint teams was to understand and agree upon a base schedule that assumed all tasks went perfectly, and the amount of schedule "contingency" required to bring the likelihood of success to 50%, as the basis for the Target Schedule. Responses to their R0 Chapter comments were provided to the Panel near the end of this exercise in mid-August. Both the comments and the responses are on file with the JV and OPG.

2.4 Review of the Class 2 R1 Chapter Reports and Supporting Documentation and Resolution of Outstanding Issues

The key Chapters of the Class 2 Estimate (R1) were provided to the Panel at the end of August 2015, with the balance of the Chapters and supporting information following on September 18th. The Panel members reviewed the revised material, and the responses to their initial comments to identify any outstanding issues that needed further investigation and resolution.

During September and October, the Panel held weekly teleconference calls and met with OPG and the JV representatives October 2nd to review the outstanding issues. Several additional interviews were held, and supplementary back up information was provided to the Panel. The Panel then completed its review against the developed its findings (presented in Section 6 of this report).

A draft version of these findings was presented to OPG and the JV on October 23rd. In part, this was to fulfill the Panel's Terms of Reference requirement to provide OPG and the JV time to review the findings and respond to the Panel. The Panel met with OPG and the JV on October 29th and on November 2nd to obtain their feedback. A complete draft of this report was presented on November 9th for final review by OPG and the JV. This report incorporates the feedback from this final review.

3. DISCUSSION

3.1 Objective O2: Compliance to AACE Class 2 Requirements

Objective O2: Provide an independent determination if the JV Class 2 Estimate products fully meet the AACE requirements for a Class 2 Estimate.

The Panel took note of the evolution of detailed AACE compliance assessments performed by the JV as the estimate progressed from the AACE Class 4 to Class 3 to Class 2 stages. There have also been compliance reviews by the OPG and another independent evaluation. Rather than repeating these requirement by requirement type comparisons, the Panel decided it would be of more value to adopt a higher level approach to the determine if the Objective had been fulfilled.

More specifically, the Panel reviewed some of the fundamental assumptions inherent to the AACE requirements, critical elements of compliance, the maintenance of the integrity of the Class 2 process through the War Room process and the evolution from R0 to R1 of the Class 2 Estimate, and compared the schedule derived from tool performance testing to applicable field experience, and the expected ranges of a AACE Class 2 Estimate.

Applicability of AACE Requirements

In order to fully understand and assess this objective, the Panel first looked at the broader picture of the applicability of the AACE requirements to a project of this nature.

The AACE guidelines state they a most applicable to green field projects in the process industry. They do, however, give some guidelines on the use of the methodology for more complex projects:

> *"Typical accuracy ranges for Class 2 Estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the **technological complexity** of the project."*

The guidelines caution the output of the estimate has a 50% chance of being within the suggested ranges.

The JV also recognizes the applicability of the AACE process in its Chapter Report on Compliance:

> *"Nevertheless these [AACE] Recommended Practices were adopted as a useful framework and guideline for the purpose of defining estimate confidence levels and associated expected accuracies based on maturity of project definition as the prime basis for Estimate Classes."*

The Panel concluded that while AACE Class 2 methodology and practices form a sound basis for preparing the Class 2 Estimate, there should be caution in interpreting the range and confidence levels of the overall result. This is discussed further at the end of this section.

Compliance to AACE Requirements

The Panel reviewed the methodology used for the Class 2 Estimate submission against the AACE requirements, the Chapter Report which provides an extensive analysis of compliance including compliance to the AACE guidelines and recommended practices, and another third party assessment of the technical compliance to the AACE requirements.

One of the important measures of compliance to Class 2 requirements is the degree of completeness engineering. The Class 2 requirement is that "Typically, engineering is from 30% to 75% complete". The Panel found in most areas the Class 2 Estimate is based on engineering that is much further progressed than the Class 2 requirement. The pre-procurement engineering for permanent plant equipment is essentially complete and most of the orders of been place. A complete set of prototype tools has been built and tested.

As part of the Panel's review of the individual elements of the estimate (for example, the Project Management Team (PMT) and Direct Field Labour (DFL) estimate, Tool Management, Support Services and Equipment elements), the Panel assessed the level of detail, supporting information and found them to substantiate the conclusions of the Chapter Report and another third party assessment. The Panel concluded JV Class 2 Estimate followed the requirements for preparing a Class 2 Estimate.

Evolution of the Estimate from Class 2 R0 to Class 2 R1

As stated in Section 4.13, "Governance and Process Established for Definition Phase and Development of the Class 2 Estimate", the Panel was concerned the integrity of the estimating process had been maintained throughout the War Room Process.

The Panel was briefed on the War Room process, attended several of the management review meetings, and was provided with the detail record of each of the War Room meetings. The Panel reviewed a sample of these detailed records.

As part of the War Room process, the individual teams were tasked with reviewing and responding to the set of comments prepared by the Panel. A response was provided in late August 2015, and was supplemented by further information, apparently generated after the Panel pointed out the initial response was incomplete, and in many cases inadequate to address its comments. The supplementary information addressed a few of the Panel's concerns, but there were several outstanding issues. In the Panel's opinion these will not materially affect the outcome of the Class 2 Estimate, however they do cast doubt over the integrity of the process, and management's diligence in reviewing and providing the responses.

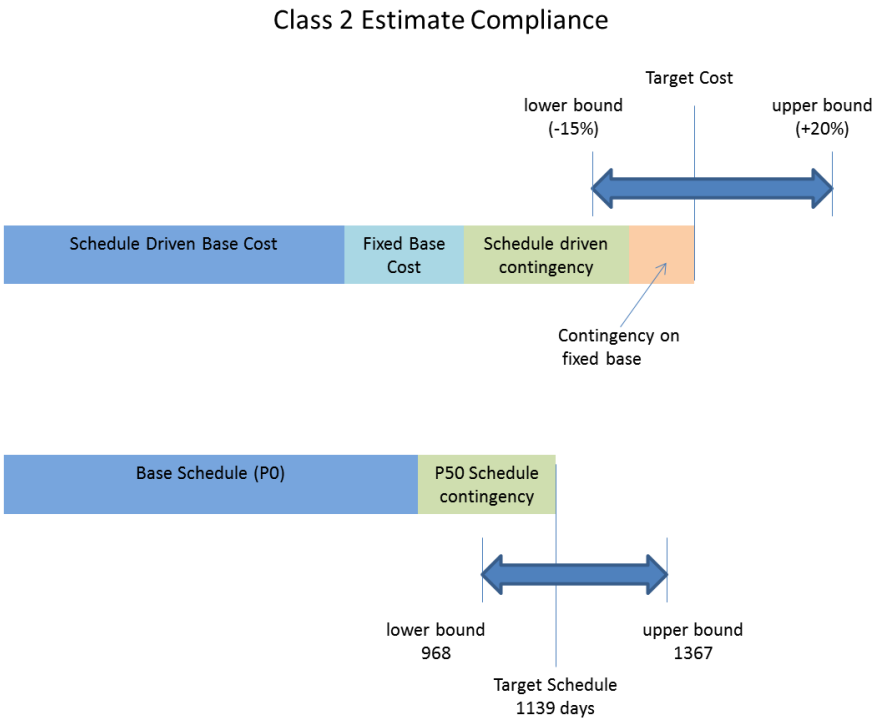
The Panel recommends OPG and JV management conduct a further review of the comments and satisfy themselves they have been adequately addressed and dispositioned.

The conclusion was the War Room process maintained the level of estimate detail, supporting information, documentation and verification required for an AACE Class 2 Estimate.

Class 2 Estimate Target Cost and Schedule

As a litmus test, the Panel assessed the overall result obtained from the Class 2 Estimate against operating experience. Using the AACE guidelines, and assessing this as a project with a high technical complexity, the Class 2 Estimate should have a range between -15% and +20%.

On this project, much of the driver for cost is schedule. To be within Class 2 accuracy, as a rough approximation, the schedule has to be less than 1370 days (1139 + 20%), provided the fixed costs are also contained within the +20% range (See Figure below). In other words, the cost will be within the Class 2 upper bound if the actual schedule is less than 7 ½ months of an extrapolation of how Wolsong 1 should have gone. This is longer than is realistically required.



This result is consistent with the finding that achieving the Target Schedule, particularly on the first unit, will be a challenge and that subsequent units should have an increasing chance of being towards the lower end of the Class 2 tolerance range. Both the JV and OPG are cognizant of the risk inherent in the accuracy of the estimate and its applicability to a project of this type. The overall conclusion is the Objective has been achieved.

3.2 Objective O3: OPG Contracting Strategy

Objective O3: Determine if the structure of the Class 2 Estimate meets the requirements of OPG's contracting strategy.

The Agreement between the JV and OPG represents a necessary departure from the contractual model used on previous retube projects which saw the very large and complex retube and feeder replacement work performed under fixed-price models. The Darlington RFR Agreement is complex however much more appropriately addresses the current climate where for-profit organizations are engaged to plan and execute the work, including mechanisms providing monetary incentives for performance.

The Agreement (particularly Section 3.5 and Exhibit 3.5) prescribes in significant detail the requirements for development of the "Execution Phase Plan", which includes the Execution Phase Milestone Schedule, the Execution Phase Target Schedule and the Execution Phase Target Cost. The Estimate specifically addresses compliance to the Agreement requirements (including Section 3.5/Article 3.5) in the Compliance Chapter Report. It is the opinion of the Panel the strategy for development of the estimate is in compliance with the OPG contracting strategy as prescribed in the Agreement. It should be noted the Estimate Chapter Report on Scope Change Control details scope items assumed in the Estimate that require final clarification by OPG.

Of particular interest is the wording in Section 3.5 of the Agreement where (for example) *"the Contractor and OPG will work cooperatively towards achieving OPG acceptance of the Execution Phase Target Schedule"*. Regular interaction at all levels of the OPG (Project) and JV organizations was observed by the Panel throughout the review period (Spring-Fall 2015).

Based on the Panel review of the R0 submission of the Estimate, and later feedback from both OPG and JV, considerable further collaboration between the parties was required to reach agreement. The War Room exercise in the July/August of 2015 to bring together the OPG and JV teams in a concerted and organized fashion was effective in providing convergence of views of the Estimate, and was an example of how the parties worked together in a collaborate (as opposed to combative) manner, pursuant to Section 3.5 of the Agreement.

As noted elsewhere in this report, the Estimate relies heavily on the Tool Performance Guarantee performance times, which was prescribed by Exhibit 3.5 of the Agreement. One potential concern with such reliance on mock-up performance is the ability to accurately adjust that performance to field conditions. The JV have documented these adjustments in detail in the series basis sheets, however as stated elsewhere in this report, a more "top-down" sanity check on expected performance using OPEX also needs to be considered when assessing the feasibility of the Estimate.

At the time of preparation of this report, it was reported that OPG and the JV have reached agreement on the execution phase target price and schedule, including contingency allowances. It has been reported that this agreement was reached with some adjustment to contractual requirements, many of which were identified as key "Negotiating Strategy" concepts in the Milestone Report such as the incorporation of an RP protocol, the elimination of the Productivity Gains, and an increase in Neutral Band. The Panel does not have visibility to the final details on these adjustments however assurances were provided by OPG and JV they were both in agreement with the adjustments.

3.3 Objective O4: OPG Board and Shareholder Approval Processes

Objective O4: Determine if the Class 2 Estimate meets the requirements of decision-making process used by the OPG Board and OPG's Shareholder to approve or deny project funding.

OPG's original plan was to have the Panel present its report directly to the OPG Board of Directors or to the appropriate Board Committee. In subsequent discussions, OPG Management has decided to receive the Panel's Report and to provide the Panel's findings to the OPG Board along with the results of other independent reviews. Given the number of independent advisors commissioned by OPG's Shareholder, its Board of Directors, and Management, the Panel is satisfied that sufficient oversight exists, and strong governance is in place to guide the decision-making process on whether to proceed with the Darlington Refurbishment Project. As a result, the Panel has not interviewed individuals directly involved in the decision-making process at the OPG Board Level. Regardless, some Panel members have been involved with Board/Shareholder decisions on Refurbishment Projects where the Shareholder is a Provincial or Federal Government Department. Some general observations on the process are as follows:

One of the important features of Refurbishment Projects is a severe financial penalty to deferring the decision to the point that a unit or units are idled at end-of-life of the fuel channels or feeders due to late project approval. Management must know and be able to clearly justify the date the first unit must be shutdown to avoid material project cost/risk increases due to delay.

Based on OPG's willingness to accept the R1 Class 2 Estimate from the JV, it must be shown to result in a strong business case for Refurbishment (with all levels of contingency included) when compared to retiring the nuclear units and moving forward with some other low-carbon option.

Overall, the performance of most refurbished CANDU units has been high enough to expect reliable performance through the life extension period provided there has been a comprehensive condition assessment.

The challenge for Management is to establish confidence the Project will be completed on schedule and on budget. This is where past projects have fallen short due to discovery issues, tooling performance issues, and project management failures. Given the effort that has gone into the definition phase of this project, the Panel is confident Management can demonstrate how these risks have been mitigated

Given the industry's track record, the Shareholder will be sensitive to how much financial risk it will be exposed to. Historically, refurbishment projects have been contracted on a fixed price basis, where the contractor performing the work has been an "agent of the crown". In the case of Darlington, a private contractor is performing the work and the target price contract offers a more suitable proportioning of project risk, with more schedule and cost risk held by the owner. Although proposed modifications to the contracting strategy will result in some additional schedule risk being transferred back to OPG, it is appropriately offset by the JV accepting a lower contingency.

Schedule risk is the largest contributor to project cost risk, and to the consequential loss of revenue if units are late coming back into service. Management should consider making use of the detailed OPEX analysis the JV has produced as an independent means to validate their schedule analysis based on tool performance and increase the confidence of the Board and Shareholder.

The Panel has had challenges accessing the right information and understanding the overall strategy for managing the various components of project risk. The Board and Shareholder will require a clear picture on how risk is being managed, particularly the enterprise/global level risks. Based on the Panel's experience and the discussion on Objective O5 below, OPG Management may still have some work to complete in this area.

3.4 Objective O5: JV and OPG Project Risk Management Processes

Objective O5: Provide an independent assessment of the effectiveness of the combined JV and OPG project risk management processes, to determine if all risks have been properly identified and quantified, if mitigation strategies are appropriate, and if contingency amounts are consistent with corresponding confidence levels.

Process

The Panel reviewed the OPG and the JV risk processes, including a review of governance documents and risk registers of both organizations.

The Risk Management plan followed by the JV for the Class 2 Estimate is comprehensive and acceptable for the project and adequately covers the elements required for Project Risk Management in the industry. The process lays out the framework for managing risk which leads to the development of contingency to establish the execution phase target cost and schedule.

The JV risk model uses Acumen Risk and @Risk software applications to develop schedule risk model and cost risk model. The risk model developed by OPG uses Primavera risk analysis which uses an integrated cost and schedule approach.

Both risk models determine cost and schedule contingency using a Monte Carlo sampling method which is consistent practise. The output of the Monte Carlo calculation provides the schedule contingency at P50 and cost contingency at P50. The risks in the Risk Register and schedule uncertainties have been confirmed and validated by the JV they are included in the Monte Carlo simulation to derive the contingency for schedule and cost of the project at P50 confidence level.

Global risks are each mapped in the risk model to the most applicable series work critical path summary task to represent the impact for the entire unit.

The JV's intention is to regularly maintain and update its risk register throughout the project lifecycle and retire risks and following the mitigating plans and strategy for the risks in the register.

Not all the risks are in the risk model due to contractual arrangements. These risks will reside separately integral to OPG and the joint venture.

The JV and OPG had collaborative risk workshops to identify and qualitatively assess all execution phase risk items and come to agreement on who had ownership of the risk. During the series workshops threats were retired, reduced or transferred. There has been considerable effort put into determining and implementing the mitigating actions that has been accepted by the JV during collaborative work shops.

Substance

The Panel was given knowledge of several risk evaluations for the Project:

- The JV risk evaluation presented as part of the Class 2 Estimate to OPG. This evaluation contains their perception of risks on their specific scope and has been created and maintained as the estimated has progressed and is comparatively mature. The risks have been reviewed with OPG to ensure who is the holder of the risk. There has been considerable effort put into determining and implementing mitigating actions. Nevertheless, these risks appear to have been developed by the individual teams that provided the estimate input. Some are in much more detail than others, and there does not seem to have been a consolidation to ensure consistency and completeness.
- The OPG Project Risk Register containing 255 line items categorized into four types of risks, namely: Program risks, JV risks, RFR risks, and program opportunities. Risks are mapped to the overall Level 1 Execution Schedule. The Panel had similar findings on this evaluation to those on the JV's risk evaluation, and noted it was comparatively less mature in the identification and implementation mitigating actions.
- The JV provided access to its confidential internal assessment of the RFR tooling risks, dealing primarily with the risks to the physical tools (aging and obsolescence) and to a lesser extent with the project management team staffing risks.
- OPG and JV internal risk evaluations which should address big/ long project duration risks, such as changes in government, macro changes in economic environment, electricity demand/supply, and the individual corporate risks.

The Panel was not provided complete visibility to all internal risk evaluations due to their confidential and commercially sensitive nature. It is not apparent if they have overlaps or gaps, nor is it apparent how all of the large / long project duration risks have been treated.

All parties, however, have recognized the top risk to the estimate is failure to meet the schedule, and have structured the work through the Definition Phase with this in mind. Although not explicitly articulated in the risk assessments, the level of effort in building and testing prototype tools, completing detailed work instructions and work plans, and the overall level of planning and preparation have all been aimed at mitigating the risk going forward into the Implementation Phase. The Standby Plan offers significant opportunity to further improve the implementation readiness and schedule risk mitigation.

The Panel was asked to review the contingency amounts and determine if they agree with corresponding confidence levels. By definition, the largest contributor, the schedule driven "contingency" corresponds to the P50 confidence level. The Panel noted the terms "risk" and "contingency" are used describe the increase to the duration to obtain a P50 target schedule and should not be confused with contingency to account for risks above and beyond a reasonably achievable plan.

The Panel concluded that risk management processes, taken in the context of all of the other risk related information provided, is sufficient for the Class 2 Estimate; however, there are areas which are not at the mature stage.

The Panel recognizes that risk management is an ongoing process. It recommends a focused effort in this area to ensure there well defined and complete risks and mitigation strategies to address them.

3.5 Objective O6: Opportunities to Improve the Basis and Accuracy of the Class 2 Estimate

Objective O6: Recommend opportunities to improve the basis and accuracy of the Class 2 Estimate and where possible, provide those recommendations to the JV and OPG project estimating teams early enough for improvement actions to be incorporated into the final estimate.

The Third Party Expert Panel studied products of the Class 3 Estimate, and followed the development activities for the Class 2 Estimate to be ready to respond quickly when the Class 2 R0 estimate was made available to the Panel on May 10, 2015. Despite the geographic challenge of having two members in Argentina, the Panel was able to complete a detailed review of the R0 version of the Class 2 Estimate by May 20th.

A set of 191 detailed comments were compiled, with varying degrees of significance and were delivered to OPG June 19th. The detailed comments were divided into a set of 128 the Panel felt warranted a response, and 63 that were provided for the benefit of the JV and OPG project teams but had a low significance and didn't warrant a formal response. One of the tasks delegated to JV and OPG combined War Room teams of SME's was to respond to all of the Panel's comments as part of their process to resolve all outstanding issues with the Class 2 R0 Estimate to allow the JV to produce a R1 Estimate. As a result, the JV and OPG in May 2015 had the opportunity to incorporate the Panel's comments into the final estimate.

In addition, the Panel considered the potential impact of their comments in aggregate and identified several areas where significant improvement could be made to increase confidence in the basis and accuracy of the Class 2 Estimate. These improvement opportunities were assembled into a presentation and delivered to senior members of the JV and OPG project teams in a meeting held May 22. The presentation is included as Appendix D. The two most significant findings the Panel presented to the JV and OPG can be summarized as follows:

- The JV and OPG needed to come to agreement on the probability of meeting the baseline schedule presented in the Class 2 R0 Estimate. The JV indicated the baseline schedule developed from adjusted Tool Performance Guarantee (TPG) times was "ideal" and unachievable, with a probability at the P0 Level while OPG saw it as achievable with a probability closer to P50. The Panel recommended a sophisticated analysis of OPEX from other retubes should be used to arrive at an independent schedule estimate to validate or invalidate the JV's estimate based on adjusted TPG times.
- Risk and contingency were not factored into the Class 3 Estimate and although a risk register was established, it was not mature. The Panel's review concluded the JV's Risk Register remains immature for the Class 2 Estimate and requires a significant amount of further work. Risk identification is not complete, and mitigation strategies are few and do not instill confidence in their effectiveness.

Both of the above findings and associated recommendations required substantial effort to implement. Although sufficient time has been available and significant progress has made on addressing both, the Panel's initial review of the Class 2 R1 estimate resulted in related findings in both areas.

As soon as the Class 2 R1 estimate was made available to the Panel, a review of the Chapter reports was carried out. Feedback from the JV and OPG indicated both were satisfied with the outcome of the War Room process and that both expected OPG could accept the R1 Estimate and it would become the basis for negotiating the target price and schedule, and the basis for seeking Board and Shareholder approval for the Darlington RFR Project. This signalled it was time for the Panel to prepare our final report based on the Class 2 R1 Estimate. The first draft of the Panel's report consisted of an outline of the report structure with only the findings section sufficiently developed to be useful to the reader. The first draft was delivered to OPG October 23, 2015. The Panel is confident that sufficient time remains before "Breaker Open" on Darlington Unit 2 to address our findings provided a Standby Plan is approved, adequately resourced and started early to mitigate remaining tool performance risks.

The Panel takes the position that this objective of the Terms of Reference (See Appendix A) has been fully met. Actions to improve the basis and accuracy of the Class 2 Estimate have been identified and those findings and recommendations have been provided to the JV and OPG project teams early enough for the majority of those improvement actions to be incorporated into the final estimate. Any risk to the success of the project posed by the most recent findings can be mitigated in the remaining time to the start of the related construction activities and through implementation of a comprehensive Standby Plan.

4. FOCUS AREAS OF REVIEW AND FINDINGS

4.1 Introduction

This section details the main findings and observations of the Panel. These were developed from the Panel's initial list of focus areas and the Objectives and include findings on:

1) Schedule
2) Scope Changes
3) Waste Processing Facility
4) Engineering Change Control
5) Critical Path on OPG Managed Work
6) Importance of the Relationship between the Parties that will Manage the Work
7) Long Term Reliability of Tooling and Equipment
8) Management of a Refurbishment Radiation Protection Program
9) Expertise of the Personnel Preparing the Estimate
10) Unit-over-Unit Improvement
11) Governance and Process for the Estimate
12) Value of the DEC
13) Attention Paid to Major Estimate Contributors
14) Personnel for OPG and JV Project Management Teams

4.2 Project Schedule

The Target Schedule, based on tool performance testing at the DEC, is essentially equivalent to the one achieved for Wolsong 1 retubing and feeder replacement, adjusted for physical differences between the reactors, and with elimination of known problems.

The base schedule (which assumes that all critical path tasks run "perfectly") is an artificial construct for estimating purposes; the probability of achieving it with the current tooling and process is defined as zero (P0). A probabilistic analysis, combining the minimum, maximum, and expected durations of each major critical path activity was performed to determine the duration that had to be added to the base schedule to obtain the "most likely" schedule. The Panel believes the Target Schedule presented in the Class 2 Estimate as the "most likely", with an estimated 50% of success is very challenging, but technically achievable based on OPEX and tool/process demonstrations to date.

A realistic working schedule with duration between the best achievable and the most likely schedule needs to be established to align project planning in both organizations. The earlier this schedule is in place, the more effectively the impact of task and logic changes can be managed going forward.

It will take vigilant project management and worker productivity not generally experienced on retube projects in Canada to achieve a working schedule equivalent to or shorter than the P50 schedule. On the negative side, past experience has shown schedule overruns on the first unit of a multi-unit retube at the same or sister stations. On the positive side, the level of planning and preparation for this project is substantially improved over previous projects, there is an opportunity to further improve the state of readiness for the first unit over the next twelve (12) months, and unit-over-unit gains have been significant on past projects.

Both JV and OPG have spent considerable time and effort developing the most likely schedule, and are aligned. The "Standby Plan" offers significant opportunities to avoid "first unit" delays and achieve gains through further rehearsal and process improvement at the DEC between now and the outage.

The estimate documentation does not clearly and transparently show how all of the available information (OPEX and Tool Performance time data from the DEC) has been used to develop and verify the schedule. The Panel has been shown confidential and proprietary information to demonstrate that this has been done.

4.3 Scope Changes

The JV developed a Chapter Report on Scope Changes. This report is intended to capture all the changes, whether technical or commercial in nature, which occurred during the estimating period of the Definition Phase work program. A significant number of issues were retired during this phase.

A number of scope items have been identified that require final clarification by OPG and the JV and/or formal adoption into the contract documents as part of the amendment agreement. These scope items may have some impact on the final RFR Execution Phase plan if not agreed to in an expedient manner, however are relatively minor compared to the overall Class 2 Estimate. This report assumes that OPG and the JV will bring these items to resolution through the amendments to their agreement and include them in the determination of the Target Cost and Schedule.

4.4 Retube Waste Processing

One of the cornerstones in the retube technology planned to be used on the Darlington RFR project is volume reduction of high-level retube waste in a dedicated building. The concept is the highly radioactive reactor components will be put into flasks that will protect the workers from the radiation and then transported to a separate building where they will be volume reduced/segregated in parallel with the reactor face removal work. While the volume reduction of pressure tubes and calandria tubes has been performed on all recent retube projects (in the reactor vault, in those cases), it has not gone well on any past project.

Bruce, Wolsong and Pt. Lepreau all experienced significant failures of the retube waste reduction equipment. The JV have reported tooling lessons learned have been incorporated, however some aspects of the new retube waste processing system are effectively first-of-a-kind, including severing of the End Fitting. The unique challenges of troubleshooting and maintaining the system once it has been placed in production cannot be understated. It should be noted the severing and waste segregation of End Fittings is considered a critical path activity in the Estimate, meaning any delays in this sequence of work in the Retube Waste Processing Building (RWPB) will have a negative impact on the overall project schedule.

The JV has reported the retube waste processing system has been assembled at the supplier, however has not yet been subjected to the full scope of acceptance testing and reliability cycling. It has also been identified that "Plan B" methods of temporarily managing the retube waste to avoid delays in reactor face work were investigated (e.g. temporary storage); however at this point no feasible options have been identified. The impact is there is currently no "buffer" for the waste should significant issues with the retube waste processing system be encountered. It is for these reasons the Panel believes retube waste processing remains a significant risk to the project, at least for the first unit. It is expected that should this risk be realized in the first unit, there would be some opportunity to mitigate the risk in subsequent units.

4.5 Engineering Change Control

In the preparation for subsequent unit work, the methodology is to prepare the design engineering packages required for all three (3) remaining units in parallel. Executing the work in this manner ensures maximum efficiencies can be obtained and a reduction in cost.

Various unit walkdowns have been completed and differences in each unit will have their own specific engineering change drawing and packages, however, all four (4) units have replica designs for a large majority of the work. The preparation of subsequent unit modifications must follow OPG governance which allows for replica design engineering packages.

The procurement methodology which is part of Engineering Change Control requires the preparation of one (1) procurement package for each scope of work for the subsequent units with delivery times staggered for refurbishments dates. This practise will result in work efficiencies and cost savings.

4.6 Impact of OPG Critical Path Activities

The vast majority of the documents and information provided to the Panel have been generated by the JV in support of the Class 2 Estimate. Very little is known about the details and rigor applied to the planning of critical path activities in the segments of the outage when OPG activities are on the critical path. As a result, there are gaps in the Panel's understanding of the critical path through the period of reactor shutdown and defueling and through the period from vault turnover to OPG until the unit is reconnected to the grid. These periods account for approximately 20% of the total planned outage duration and have a commensurate impact on the overall business case for proceeding with the refurbishment of the Darlington units. This observation/area of interest is only loosely tied to the Panel's Terms of Reference (See Appendix A) through overall JV/OPG risk management and potential obstacles to project approval by the OPG Board and shareholder.

The period of plant shutdown and defueling activities is dominated by cycle time of the fueling machines and can only be brought forward significantly through a change in defueling strategy. Should this occur it would pose a risk to JV mobilization and the planning for early reactor deconstruction activities and prerequisite permanent and temporary modifications. The more likely scenario is delay during defueling due to weakness in risk management. This would extend to time to complete refurbishment, negatively impact project morale and result in significant additional cost of having the JV and OPG project teams mobilized and standing by. The greatest impact will occur if this risk is realized on the first or second units without overlap. Other units have some mitigation opportunity through redeployment of resources.

At the end of a unit refurbishment outage, in the period following the PHT Hydro, delay has less (but not zero) impact on the JV since their planned scope of work is essentially complete. The greatest negative impact is on OPG's overall outage cost and project management challenge. If the delay is significant and occurs during a period of overlapping units, the loss of schedule discipline could strain the availability of some resources and support for the following unit. Based on past refurbishments, whether this risk is realized depends on how OPG manages the balance of plant activities to ensure they do not become the critical path in the later stages of the Refurbishment Outage. This requires the scheduling of work to maintain margin of float, and confirmation of the quality of maintenance and system layup to avoid discovery issues/delays during plant start-up, when secondary side systems are returned to service. In the case of the refurbishment of Bruce Units 1 and 2, and at Point Lepreau, although the retube portions of the outages were many months behind schedule, secondary side planned outage maintenance and modifications and discovery issues during start-up significantly extended the duration of the refurbishment outage.

4.7 Importance of the Relationship between the Parties that will Manage the Work

The success of all large projects that involve construction on an operating site relies heavily on a strong working relationship between the owner's project team and the project Contractor. This is particularly true of major nuclear refurbishment projects where it is difficult to create a fully independent construction island because of common services and common hazards with the operating units.

The Wolsong 1 Refurbishment Project is an example where the operating organization and the owner's project team worked independently and where the owner's project team was focused on driving the Retube Contractor to be successful.

The Bruce 1&2 Retube Project achieved good physical separation of the units under construction. There was, however, competition for resources from the operating units, and the relationship at senior levels between the owner's project team and the Retube Contractor was strained much of the time. Sometimes, the result was project delays, reduced work efficiency and a lack of combined owner/contractor focus on quickly resolving problems and moving forward.

As the Darlington RFR Project moves toward the implementation phase, it is important there be a constructive working relationship between OPG Operations, the OPG Project Team and the JV. The contracting strategy also plays an important role in shaping behaviors of the parties. Generally, the project definition phase does not appear to have served as a strong teambuilding exercise between the JV and OPG. In the remaining year before construction begins, both parties need to put significant effort into developing an effective execution strategy and third-party interface protocol. The Panel believes there is substantial risk that Darlington Operations will have too much authority over the Project and the Panel is not aware of any established policy to define limits of authority. The Panel is also concerned the OPG Project Team will be too intrusive in the workings of the JV Project Management Team, to the detriment of the success of the project. The basis for this risk is the overall capability of the OPG Project Team and behaviors developed during the Project Definition Phase.

4.8 Long Term Reliability of Tooling and Equipment

Darlington RFR presents some unique challenges with respect to the time horizon in which the engineered tools are required to consistently perform. The JV have indicated the tool designs are mostly based on successful tooling from past projects, and all the most recent operating experience on retube tools has been incorporated. However, none of those past projects were required to keep tools running for 10+ years. The closest example to this would be the retube tools currently deployed on the Embalse project (Argentina), some of which were manufactured in 2007 although having seen only two reactor campaigns.

It would not be unexpected to see tooling suppliers to go out of business or at least for the technical expertise to be lost to some extent due to changes in the employment landscape. The Panel believes it is difficult to fully demonstrate through factory acceptance and mock-up testing the tools will continue to perform as design after multiple campaigns and storage intervals over several years, and thus see long term tool reliability as an outstanding risk to the project.

4.9 Management of a Refurbishment Radiation Protection (RP) Program

A mature nuclear operations radiation protection organization and program tends to be overly rule-based and too restrictive to be effective on a refurbishment project. Although overall project dose is high due to the person hours spent at the reactor face or in close proximity to primary heat transport system piping, and open channel beams present a high radiation hazard, the source term is relatively stable and much of the work is repetitive and covered by detailed procedures.

There is also a high level of oversight as the work is being performed to provide a barrier to Radiation Protection (RP) events due to human performance failures. RP staff needs to work closely with the project team and trades staff to develop effective and efficient procedures to govern the work. RP staff need to avoid rigid rules and to examine ALARA as applied to retube work. As an example, a decision was made to allow boilermakers to do specific tasks working with their hands in the radiation beam from an open fuel channel during Point Lepreau retubing. This resulted in higher extremity dose to a small number of workers, but reduced the time to complete the work and therefore lowered the whole body job dose to those workers and to the rest of the crew.

The Darlington RFR Project also presents an opportunity to invest in technology to increase RP effectiveness and reduce dose to both RP techs and workers. With the first Darlington unit shutting down in less than a year, the Panel doesn't see evidence that a project RP organization has been put in place and is effectively part of the team planning for the project. As a result, there is a risk that RP input to retube series procedures will come late, will be inefficient to execute and will extend series durations, pushing out the retube schedule. The Panel recommends that an independent RP organization be put in place early to establish an efficient RP program to govern the RFR Project work. Procedures can be refined working with trades staff on the mock-up to improve efficiency during the Standby Program.

4.10 Experience and Capability of Project Personnel

The aggregate knowledge and experience of the joint venture and OPG Subject Matter Experts (SMEs) who worked on the Class 2 Estimate is commendable.

Resumes of the SMEs were reviewed by the expert Panel along will in depth interviews at the work place. In a majority of cases the people working on the project had previous experience in past refurbishment projects.

The Panel's primary concern was whether there was sufficient trades labour input and buy in to the productivity assumptions.

The team work was exemplary has was evidenced by the organization working to complete the Class 2 R1 Estimate.

Overall, given the number of retube projects that have been completed over the last ten years, there is a large pool of experience available for the start of the Darlington RFR Project. Between the JV and OPG there are already a significant number of SMEs working on the project definition phase. It is important that this talent be retained and that additional experience be brought in to execute the Standby Plan and when staffing for the execution phase. Performance on the first unit can be enhanced by having experienced leaders on the construction Project Management Team, even if it means moving some talent from OPG to the JV. This strategy of moving key individuals from the owner's organization to the contractor has been carried out successfully on previous retube projects.

4.11 Unit-over-Unit Improvement

[redacted]

As previously stated, the Panel feels the schedule for the first unit is demanding, however subsequent units will benefit from the first one.

4.12 Governance and Process Established for Definition Phase and Development of the Class 2 Estimate

For the most part, the requirements of the contract between the JV and OPG for the RFR Project Definition Phase have laid the groundwork for a strong governance process for producing and refining project schedules and cost estimates. A great deal of effort has been invested during the early stages of the Project Definition Phase to establish the processes and procedures governing the rigor and progressive nature of developing the project schedule and cost estimate. Preparation of the governing procedures, use of established OPG processes and procedures, and the compliance process combine to form a robust structure for planning and estimating the work.

Despite the quality of the procedural framework, observations, interviews, and document reviews by Panel members during process execution between February and May 2015 indicate there has been exceptional schedule compression around the contract milestone date for delivering the Class 2 Estimate products to OPG. This has caused inefficiency, and decreased the value from meetings and workshops which were intended to enhance collaboration between JV and OPG planners, estimators and SMEs in arriving at a high quality product. As a result of schedule compression, reviews of JV Class 2 Estimate products have been deferred to later stages in the process, thereby missing opportunities to improve the overall quality of the products as planned in the governance model.

Perhaps the most significant weakness introduced by schedule compression was the immaturity of the project risk identification and mitigation process as it existed when the Class 2 R0 Estimate was issued to OPG. In discussion with OPG, Panel members were told there had also been schedule compression in producing the Class 3 Estimate, resulting in little focus on risk register development since estimates of risk and contingency were excluded by contract from the Class 3 Estimate. Neither party recognized the impact this would have on the quality of risk and contingency development for the Class 2 Estimate.

Schedule compression reduced the quality of the Class 2 R0 Estimate making the task of OPG review for acceptability more difficult. Lack of constructive collaboration between the JV and OPG project teams during estimate preparation led to OPG having less understanding of the delivered product details. The resulting environment of tension, frustration, and a reduced level of teamwork between Contractor and Client led to inefficiency in the comment and disposition process.

A novel War Room approach using combined teams of SME's from both organizations was implemented to disposition comments and escalate any unresolved issues to a combined management oversight team for decision. This led to the JV producing R1 of the Class 2 Estimate with a schedule and cost estimate acceptable to OPG. The Panel listened in on several management review meetings of the War Room team products and recognizes the success of this approach. The Panel noted some gaps in the responses generated by War Room teams to the Panel comments on R0 of the Class 2 Estimate raising some concern over the rigor of the process. While the direction given to the War Room teams by management focused on eliminating duplication and over-conservatism, providing cost reduction targets introduced some potential to erode the objectivity of the Class 2 Estimate.

4.13 Value of the DEC Mock-up and Standby Plan

The size and fidelity of the mock-ups at the DEC are without a doubt far superior to anything used on past retube projects, and are a testament to the JV and OPG teams dedicated to "get it right this time".

As such, the DEC represents a tremendous asset and opportunity to fully prepare for the work. Obviously the Panel recommends the DEC be used to its full potential throughout the coming year, including before formal training starts as dictated in the Standby Plan.

Although the Standby Plan has not yet been formally accepted by OPG, this acceptance is expected shortly, and this Plan represents a true opportunity to refine the processes and challenge the tooling to be used.

As such, the Panel see the Plan as an integral part of the preparation for the project, and not an optional exercise. Some aspects of the concerns identified by the Panel elsewhere in this report can be addressed through a well-executed Standby Plan.

4.14 Attention Paid to Major Estimate Contributors

Much of the cost estimate is a product of the schedule and resource (primarily labour) estimate. The Panel probed a number of the more significant cost estimates contributors such as the Project Management Team, Direct Field Labour, Support Services and Equipment, and Tooling Management. While it is not apparent the JV and OPG took advantage of some possible opportunities to refine the estimates (for example verification of the time based estimates against task based estimates), the resource estimates appear to be within the Class 2 Estimate tolerances.

5. CONCLUSIONS AND RECOMMENDATIONS

The Panel was provided all of the documents necessary to complete its review. The initial set of documents from the Class 3 Estimate submission formed a good knowledge base on how to approach the review of the Class 2 Estimate and where significant work was required to progress from Class 3 to Class 2. During the final stages of preparation, and following delivery of the Class 2 Estimate R0, both the JV and OPG accommodated all requests for additional documents, to observe meetings, and to carry out interviews. Transparency and free sharing of information continued through the progression to the JV's submission of the Class 2 Estimate R1 which has been accepted by OPG. Supplementary information on schedule was provided late in the process, but fully met the Panel's needs. Recent information on the proposed Standby Plan was received at the end of the process and may result in Panel findings already considered, but does not impact the validity of the Panel's review. Risk management for the Darlington RFR Project is complex, with several risk registers held by the JV and OPG. In addition, some risk information arrived late in the Panel's review process, supporting the Panel's view the project will benefit from more work on risk identification, quantification, and mitigating strategies through the standby period, and into the construction phase of the project.

The Panel concludes that it has been given access to all of the documents, processes and individuals necessary to complete an independent review of the AACE Class 2, R0 and R1 Estimate submissions and to meet the objectives of the Terms of Reference.

The Panel unanimously concludes, within their expertise, the JV's submission of R1 of the Class 2 Estimate for their scope of the Darlington RFR Project fully meets the AACE requirements for a Class 2 Estimate, recognizing the limitations of applying the AACE estimating process to a large scale, brownfield nuclear project. The greatest strength in the estimate is the level of engineering completion, and the area that would benefit most from further refinement is the risk management process. The Panel further concludes the JV's Class 2 Estimate R1 meets the requirements of the OPG contracting strategy provided OPG formalizes the exceptions noted by the JV in the Scope Change Control Chapter Report.

Recommendation 1: *The Panel recommends the JV continue efforts to refine their understanding of the project risks within their scope of work over the next several months and continue effort on mitigation strategies through the standby phase and into construction.*

Recommendation 2: *The Panel recommends that OPG continue efforts to refine their understanding of the complete envelope of all risks related to the RFR Project, including risk ownership to avoid gaps and duplication over the next several months; and continue effort on mitigation strategies through the standby phase and into construction.*

The Panel concludes the JV and OPG invested significant effort in addressing the initial findings on the Class 2 R0 Estimate review. Findings related to the Base Line Schedule, and Resourcing the JV Project Management Team and Support Services have been resolved. The JV Project Risk Register is much more complete and mature, and has been accepted by OPG, although the Panel concludes there are still benefits to be realized from continued effort in project risk management. In working toward the Objectives contained in the Terms of Reference, the Panel has drawn on its collective experience to provide input in the areas of seeking higher level approvals for the project, additional input on risk management, and opportunities to improve the basis and accuracy of the Class 2 Estimate. The additional findings of the Panel in carrying out its review are presented in Section 4 of this report.

The Panel concludes consideration of the findings identified in Section 4 of this report and additional effort by the JV and OPG to implement the resulting recommendations can lead to improved confidence in the Class 2 Estimate and overall risk reduction in executing the implementation phase of the Darlington RFR Project.

Recommendation 3: *A realistic working schedule with duration between the best achievable and the most likely schedule needs to be established to align project planning in both organizations. The earlier this schedule is in place, the more effectively the impact of task and logic changes can be managed going forward.*

Recommendation 4: *The Panel believes that retube waste processing remains a significant risk to the project. The Panel recommends OPG and the JV put in place a program to perform additional performance tests after factory acceptance testing then to plan and allow time for comprehensive commissioning and "shake down" tests when the lines are assembled at site.*

Recommendation 5: *As the Darlington RFR Project moves toward the implementation phase, it's important to create a constructive working relationship between OPG Operations, the OPG Project Team and the JV.*

Recommendation 6: *The impact of the contracting strategy on project execution and teamwork should be examined as it plays an important role in shaping behaviors of the parties.*

Recommendation 7: *Establish a Darlington RFR RP organization early with streamlined project-specific procedures. Invest in technology to increase radiation protection (RP) effectiveness and reduce dose to both RP technicians and workers.*

Recommendation 8: *The mock-ups at the DEC are far superior to anything used on past retube projects. The Panel recommends the DEC be used to its full potential throughout the coming year to refine the processes and challenge the tooling to be used. Some aspects of the concerns raised by the Panel elsewhere in this report can be addressed through a well-executed Standby Plan.*

6. REFERENCE MATERIAL

Reference material was provided to the Panel by OPG and the JV:

Class 2 Estimate and Governance Documents

- The JV assembled a complete set of Class 2 RO and R1 documentation for the Panel on a SharePoint site. The Milestone and supporting Chapter Reports provide a list of the reference material. The governance documents (for example the contract between the JV and OPG) were assembled on the same site.

Class 3 Estimate and Supporting Documentation

- Similarly, the JV assembled all of the Class 2 input material, including the Class 3 Estimate, and supporting documentation for the Panel on a SharePoint site. The Class 3 Milestone and supporting mini reports provide a list of the reference material.

Additional Reference Material

- The JV provided access to its commercially confidential OPEX and some of its internal risk analysis.
- OPG provided the third-party assessments that were performed by another independent review team, the detail records from the War Room process and some of its internal risk analysis.
- The AACE recommended practices.

Appendix A – Terms of Reference

Terms of Reference

Revision R0
March 18, 2015

Darlington RFR AACE Class 2 Project Estimate
3rd Party Expert Panel Review

1. Introduction

The Darlington Nuclear Generating Station is approaching its predicted end of service life. The Refurbishment Project has been established to develop a comprehensive work program and execution schedule that will extend the service life of the 4 reactor units for an additional 30 years of operation. This project will mature through three phases; Definition (2009 – 2014), Outage Preparation (2014 – 2015) and Outage Execution (2016 – 2024).

The SNC-Lavalin Nuclear Inc. and AECON Construction Group Inc. Joint Venture (JV) will deliver a project estimate meeting the requirements of a AACE Class 2 (expected range of accuracy -15% to +20%) which will be accepted and used by Ontario Power Generation (OPG) to determine the Retube and Feeder Replacement (RFR) target price, and ultimately the Release Quality Estimate for the Darlington Refurbishment Project.

Process due diligence requires that OPG obtain an independent review of the AACE Class 2 Estimate. This review will be performed by an expert panel comprised of senior management with extensive previous retube and feeder replacement experience. The panel will include direct experience at the SVP level to ensure the technical, financial and organizational savvy to fully understand all aspects of the estimate.

The product of the 3rd Party Expert Panel Review will be a single report assessing compliance to prudent industry practices, identifying any errors or omissions, as well as providing observations and recommendations on any potential areas for improvement.

2. Composition of the Expert Panel

The individuals selected to serve on the Expert Panel bring a broad range of experience in all aspects of CANDU reactor life extension projects including the retube and feeder replacement scope of work. The Panel members are listed below, and individual CV's will be included in the Panel's final report.

- Bill Pilkington, independent consultant (lead)
- Mike Burke, independent consultant
- Jamie Hopkins, contractor working for Candu Energy Inc.
- Jamie Higgs, Candu Energy Inc. employee

3. Points of Contact

In order to effectively manage the cost of time and travel, most of the review effort will be carried out at the offices of the individual panel members. A significant level of support will be required from the JV and from OPG to arrange access to the large volume of documents related to the Class 2 Estimate, and to provide opportunities for observation of the estimate development process involving both JV and OPG staff. The roles of Panel co-lead and SPOC have been established for both the JV and OPG. The individuals filling these roles are identified below, and their functions further described in Section 7, Method of Operation.

- The Panel co-lead for OPG will be Roy Brown, Senior Director, Darlington RFR
- The Panel co-lead for the JV will be Ola Okege, Manager, Risk Management, SNC-Lavalin Nuclear
- The SPOC for OPG will be Lisa Ren to assist the team in providing documents and arranging meetings/interviews and in providing opportunities to observe meetings
- The SPOC for the JV will be Ola Okege in addition to his role as Panel co-lead
- OPG will provide access to an administrative support person

4. Objectives and Scope of Work

In carrying out its review and preparing its report, the 3rd Party Expert Panel Review must cover the following objectives within the scope of work:

1. Become knowledgeable on the Darlington RFR Project and contracting strategy to be able to critically assess the Class 2 Estimate products. This will be achieved by reviewing the estimating plan, and the Class 3 Estimate, and relevant Class 3 Estimate audit plans and findings.
2. Provide an independent determination if the JV Class 2 Estimate products fully meet the AACE requirements for a Class 2 Estimate
3. Determine if the structure of the Class 2 Estimate meets the requirements of OPG's contracting strategy
4. Determine if the Class 2 Estimate meets the requirements of decision-making process used by the OPG Board and OPG's Shareholder to approve or deny project funding
5. Provide an independent assessment of the effectiveness of the combined JV and OPG project risk management processes, to determine if all risks have been properly identified and quantified, if mitigation strategies are appropriate, and if contingency amounts are consistent with corresponding confidence levels.
6. Recommend opportunities to improve the basis and accuracy of the Class 2 Estimate and where possible, provide those recommendations to the JV and OPG project estimating teams early enough for improvement actions to be incorporated into the final estimate

5. Scope of Work

- Review Class 3 Estimate documents
- Review
- Review final drafts Class 2 Estimate products as available and issued documents
- Prepare Preliminary Report with objectives, statement on compliance with AACE Class 2 requirements, target areas of for further review based on initial findings and present to OPG and the JV
- Meetings and further document reviews based on feedback from OPG and the JV on initial findings/recommendations and state of completion of Class 2 Estimate documents
- Compile findings and recommendations and meet with OPG and JV as an opportunity for feedback prior to preparing final report
- Prepare final report meeting OPG requirements and present to OPG and JV and respective oversight groups
- Additional presentations to key stakeholders as requested by OPG and JV

6. Exclusions

- Although Panel members are knowledgeable and able to identify inconsistencies, the Panel will not analyze the fidelity of data migration between Project IT systems.

Appendix B – Short Form Resumes of the Panel

William (Bill) Pilkington

Bill Pilkington is a seasoned nuclear professional; an executive with a track record of success leading nuclear organizations through difficult challenges and periods of fundamental change. He was recently appointed Vice President of Operations and Chief Nuclear Officer for the Canadian Nuclear Laboratories in the transition to a GOCO management structure.

Bill was engaged as advisor to the President of Atomic Energy of Canada (AECL) in September 2010 to provide oversight of the Point Lepreau Refurbishment Project, then given full authority for the project from February 1, 2011. In the year of reactor reconstruction leading to Substantial Completion May 31, 2012, his team gained two months on the project schedule and completed the project $15M under budget.

The Lepreau turnaround was achieved against a backdrop of the restructuring and sale of AECL Commercial Operations. In his role as AECL Senior Vice President, Operations, Bill supported the due diligence process and was a key member of the transition team in the period up to closing of the sale October 2, 2011. Then, as Senior Vice President, Projects and Services for Candu Energy Inc, he led his team through continuing change in the first 20 months of operation of the new company.

Bill's most recognized accomplishment is the successful repair of the National Research Universal (NRU) reactor from the forced outage that followed discovery of a reactor vessel leak in May 2009. Bill assembled and led the team that returned the reactor to safe operation for medical isotope production in August 2010.

From March 2008 until the end of September 2010, Bill was Senior Vice President and Chief Nuclear Officer, leading a workforce of 3000 scientists, engineers and technicians as head of the AECL Research and Technology Division (RTD). The primary RTD missions are Research and Development, primarily in support of CANDU PHWR technology, production of medical isotopes, and reducing the liability of Canada's Legacy Nuclear Waste. In his role as CNO, Bill was instrumental in obtaining World Association of Nuclear Operators (WANO) membership for the NRU reactor.

In his prior two-year assignment with AECL Commercial Operations, Bill led a team of 400 Engineers and Technicians delivering value-added products and services, primarily to the CANDU fleet worldwide. Bill's mission in the commercial division was to improve focus on meeting customer needs based on his years of experience as a utility customer.

Bill was the senior official on site at the Point Lepreau Nuclear Plant from 1994 through 2004, culminating 25 years of career progression in Commissioning, Engineering Operations and Senior Management.

Biographical Sketch:

William (Bill) Pilkington

B.A.Sc., P. Eng.

Jamie Hopkins

Jamie Hopkins is a professional engineer and holds a degree from the University of Toronto in nuclear and thermal power engineering. He has been in the nuclear industry for over thirty five years, with Atomic Energy of Canada Ltd. (AECL), Ontario Hydro, and Candu Energy Inc. He formed his own consulting company in 2013.

Jamie has been involved in almost all facets of the CANDU system. His primary focus been technical and commercial management of projects associated with nuclear research and development, reactor core design, reactor maintenance, and plant life extension.

Jamie was AECL's Project Manager for the replacement of the fuel channels (retubing) at the Pickering Nuclear Station units 3 and 4, and the initial program to retube the Bruce A station in the 1990s. After managing the development and commercialization of the systems to retube CANDU 6 nuclear stations, he became the Project Director for the replacement of the fuel channels and feeders at the Wolsong 1 Reactor in Korea. Following its successful completion in 2011, he began working on the Embalse Life Extension Project. Jamie has spent the last year working at the Embalse CANDU 6 station in Argentina on the implementation of this Project.

During his career he has held the posts of Director of Reactor, Fuel Channel and Materials Engineering, Director of Engineering and R&D Support, and Director of Product and Services Development. He was Canada's representative on the IAEA Working Group on Nuclear Power Plant Life Management during the late 1990s. Jamie was the recipient of AECL's G.L. Brooks Award in 2000 for outstanding engineering contributions over his career.

Biographical Sketch:

J.R. (Jamie) Hopkins
B.A.Sc., P. Eng.

Jamie Higgs

Jamie Higgs is a professional engineer and holds degrees from the University of New Brunswick (Mechanical Engineering) and the Royal Military College of Canada (Nuclear Engineering). Through more than fifteen years in the nuclear industry, Jamie has worked for New Brunswick Power, Atomic Energy of Canada, Limited and now Candu Energy/SNC-Lavalin Nuclear.

Jamie has experience both in an operating station (system engineer) and more recently in a variety of senior site positions on all CANDU6 refurbishment projects.

Through long term site assignments on the Pt. Lepreau Refurbishment Project (Canada), the Wolsong 1 Retube Project (South Korea) and the Embalse Life Extension Project (Argentina) Jamie has held various responsibilities in retube field engineering, including Retube Resident Engineering Manager. Jamie was also the Project Director for the Pt. Lepreau Refurbishment Project from hydrostatic testing through project closeout as well as the Deputy Technical Manager on the Embalse Life Extension Project for 2013-2015. Jamie currently holds the position of Site Resident Engineer for Candu/SNC-Lavalin Nuclear at the Pt. Lepreau Generating Station.

Biographical Sketch:

Jamie Higgs
PhD, P. Eng.

Michael Burke

Michael Burke is a professional engineer and holds a degree from the University of Toronto in mechanical engineering in addition to a diploma from Harvard in management. He has been in the nuclear industry for over thirty six years with Ontario Hydro and Bruce Power Inc. After retiring from Bruce power he formed his own consulting company in 2014.

Michael has been involved in all facets of power plant operations .He worked in the commissioning and technical section of Bruce A power plant in his early career moving into senior management positions in the organization of Bruce A and Bruce B power plants.

Michael held the position of Senior Vice President at both power plants. His most recent portfolio at Bruce Power before retiring was senior vice president of strategic initiatives. This portfolio included laying out the scope for main component replacement for Bruce Units 3-8.

Michael was involved in the first Bruce A single fuel channel replacement program. He also managed a number of SCFR campaigns throughout his working career.

Michael was a project director and vice president of the Bruce 1&2 Refurbishment. He had the responsibility for determining the technical scope for the project including the retube and feeder scope. He was also part of the team negotiating the retube contract with AECL. During the refurbishment period he was a key management member overseeing the implementation of the retube contract.

Biographical Sketch:

Michael Burke
B.A.Sc., P. Eng.

Appendix C – Interviews

Personnel Interviewed	Date	Topics Discussed
JV CWP Lead for: Bulkhead Installation	April 2015	• Related previous experience/background • Use of OPEX • Major Concerns with series
JV CWP Lead for: Retube Waste Processing	April 2015	• Related previous experience/background • Use of OPEX • Major Concerns with series
JV CWP Lead for: (1) Bellows/Lattice Tube Inspections (2) Bellows Replacement (3) Channel Closure/Shield Plug Install and New Fuel Loading (4) CTSB Refurbishment	April 2015	• Related previous experience/background • Use of OPEX • Major Concerns with series
JV CWP Lead for: (1) Pressure Tube Severing (2) End Fitting Removal (3) Calandria Tube Removal (4) Calandria Vessel Inspection	April 2015	• Related previous experience/background • Use of OPEX • Major Concerns with series
JV CWP Lead for: (1) Channel Closure/PA Hardware Removal (2) Fuel Channel Preparation (3) Fuel Channel Installation (4) SFCR (Contingency)	April 2015	• Related previous experience/background • Use of OPEX • Major Concerns with series
JV CWP Lead for: (1) RTP Installation (2) CTI Removal (3) CTSB Conditioning (4) CT Contingency Removal (5) FROB/Dummy Bundle Removal	April 2015	• Related previous experience/background • Use of OPEX • Major Concerns with series
JV Tooling Engineering Manager	April 2015	Rigor of tooling Factory Acceptance Testing (FAT) and tolerance for tooling problems during the TPG work
JV Tooling Delivery Manager/JV Tooling Lead	April 2015	• Completeness of toolsets delivered for TPG work • Management of tooling issues from suppliers
JV Tooling Senior Manager	April 2015	• Overall strategy to ensure OPEX has been incorporated into toolset
JV Support Services Manager	April 2015	• CWP development • Process to incorporate OPEX from past projects into CWPs
JV Engineering Manager	April 2015	• Status of design packages • Process to manage new technical requirements for Darlington RFR • Management of OSM (reactor component) issues at site
JV PHT Vacuum Drying Designer	April 2015	• Confidence in expected system performance • Risks
JV Alternate CWP Lead – all feeder series	April 2015	• Related previous experience/background • Use of OPEX • Major Concerns with series
JV Welding Lead (via email)	April 2015	Expected feeder welding failure rate
JV Project Director/OPG Project Director	April 2015	• Overall estimate development strategy • PMT
JV Project Controls Manager	April 2015	Build-up of retube schedule duration

Personnel Interviewed	Date	Topics Discussed
JV Tooling Manager (Removal Tooling)	April 2015	Process for managing tooling issues
JV Estimation Chief responsible for PMT	April 2015	Process for PMT development
JV Senior Consultant	April 2015	Improvement Initiatives
JV Chief estimator	June 2015	• Related previous experience • Educational background • Use of OPEX • Major concerns with process or end product deliverable
JV Feeder Prep Superintendent	June 2015	
JV Junior Estimator Document control	June 2015	
JV Feeder Welding superintendent	June 2015	
JV Construction scheduler	June 2015	
JV On boarding Manager	June 2015	
JV Compliance SME	June 2015	
JV Volume Reduction SME	June 2015	
OPG SME for pressure tube replacement	June 2015	
OPG fuel channel tools SME	June 2015	
JV SME for data migration	June 2015	

Appendix D – Presentation – Darlington RFR AACE Class 2 Estimate 3rd-Party Expert Panel Review

Darlington RFR
AACE Class 2 Estimate
3rd Party Expert Panel Review

Initial findings on AACE Class 2 Estimate
Rev. 00 dated May 8, 2015

Panel Presentation to OPG and the JV
May 22, 2015

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

VALUES • SAFETY • INTEGRITY • EXCELLENCE • PEOPLE & CITIZENSHIP

PEOPLE POWERING THE FUTURE

ONTARIO POWER GENERATION

Introduction

- 3rd Party Expert Panel (3PEP) Review Objectives (From TOR)
- Review Class 3 products, audit findings
- Assess preliminary Class 2 Information
- Prioritized List of Areas to Investigate CL 2
- Additional OPG Areas to Investigate for CL 2
- Review Class 2 Estimate Rev.00 products
- Preliminary Findings
- Next Steps

3PEP Review Objectives – From TOR

- Review the RFR contracting strategy, estimating plan, and Class 3 estimate as required to prepare to review the CL 2 estimate
  - Complete
- Determine if the JV Class 2 estimate products fully meet the AACE requirements for a Class 2 estimate
  - Requirements met with some exceptions including SS&E estimate, PMT, and areas of assumption
- Determine if the structure of the Class 2 estimate meets the requirements of OPG's contracting strategy.
  - Work in progress – no exceptions to Exhibit 3.5 so far

3PEP Review Objectives – From TOR

- Determine if the Class 2 estimate meets the requirements of decision process used by the OPG Board / Shareholder
  - Work in progress – Product appears complete, but OPG governance needs to be confirmed.
- Provide an independent assessment of the effectiveness of the combined JV and OPG project risk management processes.
  - JV and OPG risk management processes need improvement
  - Hi level OPEX adjusted for Darlington may help validate probabilities
- Recommend opportunities to improve the basis and accuracy of the Class 2 Estimate and where possible, provide these to the JV and OPG project estimating teams early enough for improvements to be incorporated into the final estimate
  - More extensive use of series OPEX would validate estimates

Review Estimating Process & CL 3 Report

- Class 3 Data and Class 2 Preparations Plan Review
  - Class 3 Estimate Milestone Report
  - CL 3 mini-reports
  - Associated schedule logic flow diagrams
  - Org charts, Class 2 Estimating Plan, Shift Patterns and Data Flow
  - Infrastructure and Layout Plans
  - BRG Audit reports
  - Class 3 Peer review
  - Early drafts of Class 2 Chapter Reports.
  - Sample CWP's
  - Schedule Plan
- Meetings with OPG Estimate Review Team
- Observe meetings between JV and OPG

Prioritized List of Areas to Investigate

- Following initial familiarization meetings with OPG and JV estimating teams and review of available CL 3 products, a 3PEP workshop was conducted to identify areas that appeared weak in the CL 3 estimate and required investigation to ensure weakness was eliminated in the CL 2 estimate preparation. Areas were prioritized as follows for potential Project Impact:

1. Risk register, uncertainty, and contingency
2. Global risks not considered
3. Overall use of OPEX
4. Experience and knowledge of SME's
5. Incenting/Maintaining Performance
6. Developing Chapter Reports
7. Qualification of new processes
8. Experience and Qual of Estimators
9. Evolution of Schedule Est. & Basis
10. OPG dedicate experienced staff
11. Schedule compression Impact on CL 2
12. Schedule estimate for Bulkhead Install
13. Validity of AACE CL 2 for RFR Project
14. Quality of CWP's
15. Time estimates for tooling transitions
16. Efficient movement of Workers & Material on site
17. Potential Interferences with Other Work
18. Plan for OEM Support for Tooling
19. Impact of RP and Dose Management
20. Quality of Integration on Bottom up estimates

OPG Request to Review Specific Items

- PMT structure and staffing level estimate
  - Comments on structure
  - Number of positions in PMT
- Support Services resource level estimate
  - Comments on structure
  - Quality of bottom up estimate and impact on CL 2 estimate
- Managing short term fluctuations in Trades demands
  - Strategy on staffing to series estimates – numbers retained vs period of reduced demand and training costs
- Expected change in production rate as each series progresses
  - Provide an estimate of increased productivity due to learning and process improvements during execution of longer series'

Engagement-CL 2 Estimate Development

- Interaction with JV Project and Estimating team members:
  - Presentations from Chapter Leads
  - Observe TPG Basis Sheet Review Meeting
  - Participate in JV Peer Review Team activities
  - Sharing 3PEPR info as it was developed with the Peer Review Team
  - Meetings with:
    - CWP Leads & Manager of CWP development
    - Tool Management team members
    - Greg Morandin
    - Brian Savage
    - Roy Brown
    - Justin Alizadeh

Review of Class 2 Estimate Rev.00

- Key Chapter reports R&C by all team members
- Secondary chapters R&C by one or more team members
- Select CWP's, basis sheets and iSEP's reviewed on a sample basis to support chapter reviews
- Meetings to clarify preliminary comments:
  - Justin Alizadeh
  - Randy Cline
  - Brian Murdoch
  - Roy Brown
  - Ola Okege
  - Peer Review Team members
  - Brian Savage
  - Andre Macatangay

Preliminary Findings - Schedule

- Schedule Build up, Uncertainty and Risk
  - Baseline schedule (no contingency) established using adjusted TPG times and Level 3 CWP's for TMODSs and PMODS
  - JV indicates baseline schedule is "ideal" and unachievable – Probability P0 level
  - JV and OPG need to come to agreement on Probability of meeting the baseline schedule
  - Normalized OPEX from other retubes should be used to validate TPG adjustments and arrive at an approximate P50 schedule

Preliminary Findings - Risk & Contingency

- Risk and contingency were not factored into the CL 3 estimate. Although a risk register was established, it was not mature
- The JV risk register remains immature for the CL 2 estimate. The risk profile has shifted significantly with extreme risks going from zero for CL 3 to nine for CL 2
- Extreme risks, primarily due to JV concern of potential OPG project delay, added without adequate JV/OPG discussion/agreement on risk mitigation strategies
- OPG and the JV need to come to a common understanding on allocation of schedule delay risks and the corresponding contingency applied to target schedule and cost.

OPG Request to Review Specific Items

- PMT structure and staffing level estimate
  - Construction org appears to be right sized, however remaining groups that make up the PMT estimate may be over resourced
  - Supervision on shift could be increased to ensure productivity
  - Safety org over staffed as 2/4 safety techs on shift
  - Engineering org could be reduced due to 90% work c/p prior to execution
  - No requirement for nurse or work protection coordinator on shift
  - Execution close out team should be increased near end of phase

Support Services resource level estimate

- Organization drives a relatively complicated set of interfaces for estimating (and eventual management) of the project
- Use of Windows and Stages to identify personnel and locations, function, working conditions and tasks provides good line of site to estimate basis
- Appears that due care was taken to avoid estimate duplication due to interfaces (task lists in each chapter report and use of ISEPs)
- May benefit from further "backwards pass" to confirm staff utilization at given locations

Next Steps

- To complete it's scope of work per the TOR, the 3PEP requires a CL 2 estimate without obvious "show stoppers"
- To maintain it's independence, the 3PEP should not facilitate negotiations to address the fundamental differences of opinion on risk and contingency that currently exist between the JV and OPG
- Some tasks can continue in advance of release of Rev 01 of the CL 2 estimate – example; assessment of the JV and OPG SME capability
- The 3PEP will be prepared to issue a final report 3 to 4 weeks following receipt of a suitable revision of the CL 2 estimate

3rd Party Expert Panel Review

Questions?