AMPCO Interrogatory #30

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

Interrogatory

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

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

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

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

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

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

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

Response

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

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

Board Staff Interrogatory #61

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

Interrogatory

Reference:
Ref: Exh D2-2-3, Attachment 1, page 6

For the DRP Execution Phase, calculation and payment of all cost incentives and disincentives will be done on an aggregate basis for all completed units.

a) Please explain how this will work in practical terms with the CRVA for DRP. For example, will the CRVA only be cleared at the completion of all four units?

b) Were any incentive or disincentive payments made during the definition phase?

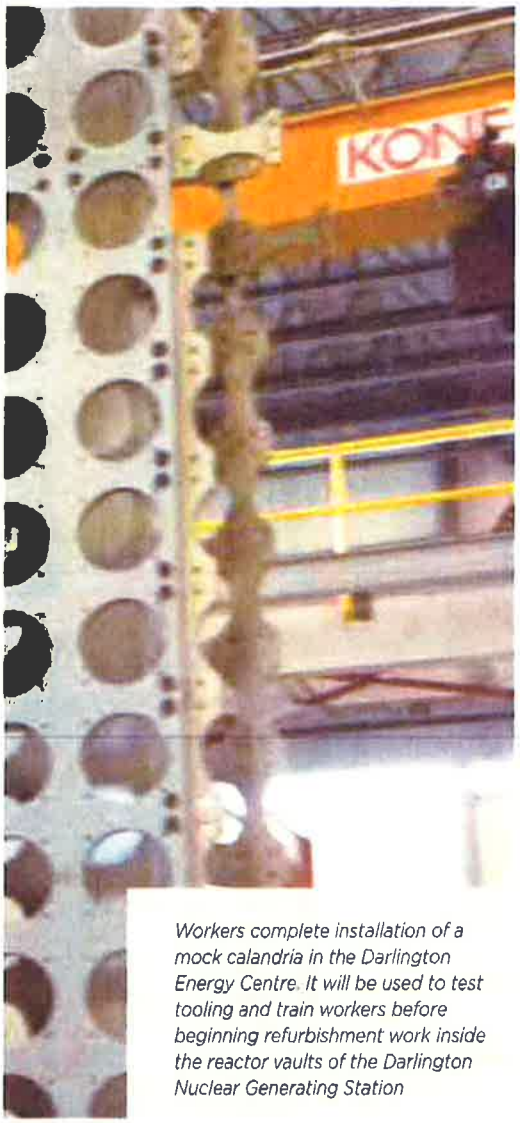
Response

a) The costs of the DRP will reflect accrued incentives and disincentives at the completion of each unit as per OPG accounting process in accordance with US GAAP. The CRVA treatment of these amounts will be the same as for other sources of variance from OEB-approved capital and non-capital costs. Variances in non-capital costs are included in the CRVA as incurred, and the revenue requirement of variances in capital costs is included in the CRVA on the basis of variances in amounts placed in service. OPG anticipates that the CRVA balance would be cleared periodically in the normal course in conjunction with other deferral and variance account balances.

b) While OPG's Definition Phase concluded at the end of 2015, some vendor Definition Phase activities are still ongoing as contemplated in their agreements, and in some cases, will continue to September, 2017. It is not currently anticipated that any incentive payments will be made by OPG. OPG will assess potential disincentives at the time of completion. Notwithstanding the above, with respect to the Retube and Feeder Replacement contract, a $1,000,000 lump sum disincentive payment was paid to OPG as consideration for the movement of the target date for a limited number of Definition Phase work activities. Less than 2% (approximately $18M) of work was outstanding to meet the milestone. In addition to the disincentive payment, OPG also established realistic but aggressive milestones and associated disincentives for the remaining Definition Phase work so as to incentivize the contractor to complete the work.

Witness Panel: Darlington Refurbishment Program

2013 LTEP



Workers complete installation of a mock calandria in the Darlington Energy Centre. It will be used to test tooling and train workers before beginning refurbishment work inside the reactor vaults of the Darlington Nuclear Generating Station

30 universities and six major research centres, many of them in Ontario. The nuclear industry generates $2.5 billion in direct and secondary economic activity in Ontario every year. Retaining this nuclear expertise is crucial.

The province's nuclear generating stations at Darlington, Bruce and Pickering have historically provided about half of the province's electricity supply. The 2010 LTEP forecast that new capacity would need to be built at Darlington. New nuclear capacity is not needed at this time because the demand for electricity has not grown as expected, due to changes in the economy and gains in conservation and energy efficiency. The decision to defer new nuclear capacity helps manage electricity costs by making large investments only when they are needed.

Ontario continues to have the option to build new nuclear reactors in the future, should the supply and demand picture in the province change over time. The ministry will work with OPG to maintain the licence granted by the Canadian Nuclear Safety Commission, to keep open the option of considering new build in the future.

The government will ensure a reliable supply of electricity by proceeding with the refurbishment of the province's existing nuclear fleet taking into account future demand levels. Refurbishment received strong, province-wide support during the 2013 LTEP consultation process. The merits of refurbishment are clear:

- Refurbished nuclear is the most cost-effective generation available to Ontario for meeting baseload requirements.
- Existing nuclear generating stations are located in supportive communities, and have access to high-voltage transmission.
- Nuclear generation produces no greenhouse gas emissions.

Ontario plans to refurbish units at the Darlington and Bruce Generating Stations. The refurbishment has the potential to renew 8,500 MW over 16 years. The province will proceed with caution to ensure both flexibility and ongoing value for Ontario ratepayers. Darlington and Bruce plan to begin refurbishing one unit each in 2016. Final commitments on subsequent refurbishments will take into account the performance of the initial refurbishments with respect to budget and schedule by establishing appropriate off-ramps.

The nuclear refurbishment sequence shown in Figure 14 will be implemented subject to processes designed to minimize risk to ratepayers and to government. For example, appropriate off-ramps will be implemented should operators be unable to deliver the projects on schedule and within the established project budget.

The nuclear refurbishment process will adhere to the following principles:

1. Minimize commercial risk on the part of ratepayers and government;
2. Mitigate reliability risks by developing contingency plans that include alternative supply options if contract and other objectives are at risk of non-fulfillment;
3. Entrench appropriate and realistic off-ramps and scoping;
4. Hold private sector operator accountable to the nuclear refurbishment schedule and price;
5. Require OPG to hold its contractors accountable to the nuclear refurbishment schedule and price;
6. Make site, project management, regulatory requirements and supply chain considerations, and cost and risk containment, the primary factors in developing the implementation plan; and
7. Take smaller initial steps to ensure there is opportunity to incorporate lessons learned from refurbishment including collaboration by operators.

OPG ACTIONS TAKEN/PLANNED IN ALIGNMENT WITH LTEP PRINCIPLES

2013 LTEP – Nuclear Refurbishment Principles	OPG Actions Taken/Planned in Alignment with LTEP Principles
Minimize commercial risk on the part of ratepayers and government	• Locked down project scope well in advance of starting construction;. • Fully developed engineering and planning of the work so that it is 100 per cent complete prior to the start of construction; • Built a full-scale mock-up of the Darlington reactor and vault and used them to fully test the tools and determine tooling durations in order to build a reliable schedule. All workers will be trained using the tools in the mock-up prior to working in the plant; • In phases, developed a Release Quality Estimate that incorporates a high-confidence budget and schedule for the work; • "Unlapped" Unit 2 from subsequent units so that the focus can be on planning and construction of a single unit to ensure its success while documenting lessons learned from the first unit and applying them to work processes on subsequent units; • Utilizing target price contracts for the execution phase that are based on developing cooperation, transparency, and risk sharing with key vendors; • Utilizing fixed price contracts for certain execution phase scope that is well defined and where risk transfer to a third party is appropriate; • Negotiated various off-ramps and stages into contracts; and • Established a robust risk management process to directly identify and administer commercial risks.
Mitigate reliability risks by developing contingency plans that include alternative supply options if contract and other objectives are at risk of non-fulfillment	• Decision to "unlap" Unit 2 from the other unit refurbishments, which predated the LTEP, was intended to mitigate performance risk and allow the DRP team to focus on refurbishing the first unit prior to commencing subsequent units. If the first unit is not successful, off-ramps are in place; the second unit refurbishment will not commence until the first unit is successfully returned to service. • Risk assessment and appropriate contingency and mitigation plans for each execution work package have been developed. • OPG's investment in the reactor mock-up is being used to perform full integration and commission testing of tools needed for refurbishment; lessons are being learned on the mock-up,

OPG External Oversight Assessment	MOE Assessment	Comments
Concern for the need of the ESMSA contractors who have recently been awarded contracts to mature rapidly to make up for the initials delays resulting from the changes in OPG's contract strategy.	Concern remains over OPG's performance in managing the work of the ESMSA contractors to meet high performance standards related to safety, quality, cost and schedule.	There is good alignment in this area.

8. Alignment with the Principles of the Long Term Energy Plan

The MOE's 2013 Long Term Energy Plan identified seven principles by which it expects OPG and Bruce Power to follow in the development and execution of their respective un its. The following table provides observations which demonstrate alignment by OPG as well as opportunities for additional alignment.

Principle	Observations of Alignment	Possible Opportunities
1. Minimize commercial risk on the part of ratepayers and government.	The majority of DNR contracts are fixed/firm price with the remaining tied to cost and schedule performance. Commercial individuals embedded on each project team to manage commercial risk. Project scope has been defined to the component level, and detailed engineering will be completed prior to the start of construction. OPG has invested in a reactor mock-up and training facility, to perform full testing of the tools, processes and procedures, as well as train staff prior to performing work on the actual reactors. The contract with SNC/Aecon includes provisions that allow OPG to take over the tooling and the mock-up at the conclusion of the Definition Phase if the parties are unable to negotiate the target price contract for the Execution Phase.	Incentives in the RFR contract were developed and established on the basis of four unit performance, allowing the RFR contractor to make-up cost overruns and schedule delays to the first unit on subsequent units. However, the LTEP prioritizes the urgency of a success on Unit 2. This will need to be included in the Class 2 estimate for the RFR and TG projects.

KPMG
Nuclear Refurbishment Research Report, May 2015

5. DETAILED FINDINGS

Planning

Planning New Building Projects

One industry expert described new building projects as requiring intensive, in-depth planning with detailed cost breakdowns. In particular, he emphasized the importance of bottom-up planning.

- Several projects have been unsuccessful because they set a price in advance at top levels and planned to meet that price as opposed to working from the bottom-up to generate an accurate estimate.
- Planning should include tasks to be addressed, different stages of installation, who is responsible for each stage of the process, and when the tasks should be accomplished.
- Accomplishment of work breakdown structure, cost breakdown structure, and organizational breakdown structure allows proper evaluation of the full scope of the project.

> *"The trick is to start with the work breakdown structure, get to the bottom, populate the organization with trades, foremen, etc. across the bottom i.e. those who know the work and have the experience and build the estimates to the top."*

Another of our experts emphasized the importance of planning for not just the primary side (primary reactor coolant) but also the secondary side (radiation protection). As the secondary side was last to complete, some engineers left to work on other projects before it was done resulting in safety issues with the plant.

Planning Before Breaking Ground for New Builds

One industry expert estimated the planning process as taking 4-5 years before you can really start construction.

- Planning should begin with a clear concept and initially take the form of a multi-tier estimate, filling in more definitive / detailed estimates throughout the planning process.

Another expert suggested planning initially focus on the scope of what was to be done and lead to a timeframe for completion.

AMPCO Interrogatory #74

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

Interrogatory

Reference:
Ref: D2-2-7 Page 8 Chart 2

Preamble: Of the total $1.7B of DRP contingency, $694.1M (40%) is attributed specifically to Unit 2.

a) Please provide the DRP contingency allocated to Units 1, 3 and 4 on the same basis as Chart 2.

b) Does the Monte Carlo analysis differentiate between Units?

c) If the contingency for Unit 2 is not used, please discuss how the funds will be treated and if any remaining contingency funds will be reallocated to other units.

d) Please provide the amount of Unallocated Program Contingency allocated to Unit 2.

Response

a) An allocation of contingency to Units 1, 3 and 4 on a similar basis as shown in Ex. D2-2-7, p. 8, Chart 2 is not available. Please refer to L-4.3-1 Staff-057 for the allocation of contingency to each of the four units across the Major Work Bundles, Facilities and Infrastructure Projects and Safety Improvement Opportunities, Project Execution and Operations and Maintenance functions and Unallocated Program Contingency.

b) The Monte Carlo analysis performed was a four-unit, integrated analysis. While the inputs were created on a unit by unit basis, only integrated results were produced. OPG did not run an independent unit by unit model (e.g., a Unit 2 model, a Unit 3 model, etc.) as this would not be an accurate representation of the four-unit DRP.

c) If Unit 2 is completed with less than the estimated contingency spent, the contingency would be retained for possible use on other units, based on the risk profile of those units, subject to approval by OPG's Board of Directors, or retained at the Program level until the end of the four-unit refurbishment when the program is complete. This approach is consistent with that outlined by Pegasus Global Holdings for management of unused contingency within a megaprogram (see Ex. D2-2-11, Attachment 3, p. 29).

Witness Panel: Darlington Refurbishment Program

In the event of any unallocated Unit 2 contingency when Unit 2 goes in-service, the revenue requirement impact of the reduced in-service amounts would be recorded in the Capacity Refurbishment Variance Account and returned to ratepayers in a future term (refer to L-9.2-2 CCC-040).

d) Please refer to L-4.3-1 Staff-057 for the amount of Unallocated Program Contingency allocated to Unit 2.

April 2015

of contractors to perform field execution to high performance standards. This demonstration should be led by the core refurbishment execution team, and encouraged prior to breaker open.

- Tied to execution is the fact a good fraction of the work is first time execution for the vendor, very infrequently performed work or first of a kind method. This refurbishment outage is the first time for the Joint Venture to execute a re-tube and feeder replacement. It is the first time in a decade for B&W to clean the Darlington steam generators. And the equipment and process for the handling and reduction of re-tube radioactive waste is first of a kind. OPG has taken a number of actions to mitigate the risk – the most visible being the full-scale reactor mock-up. The need for OPG to have effective oversight and the ability to identify and respond to degrading execution performance is essential for project success.

- There is confidence that the RQE will be completed on time. However, there is a risk that the JV's target price plus requested contingency will exceed the class 4d estimate by a sufficient amount to have a target price not achieved. OPG and the JV are working diligently to resolve a number of remaining issues. A failure to achieve an acceptable target price will require OPG to implement an alternative plan in a relatively short period of time.

- The performance of the fuel handling equipment during the defueling of the reactor will set the stage for the first phase of the refurbishment outage. The station has an initiative to improve fuel handling equipment reliability. This initiative is challenging, and is being monitored by a station oversight committee and the Defueling Project's senior management oversight committee.

In summary, OPG has the infrastructure and framework for execution of the outage at the time of breaker open. The ability to demonstrate successful execution of projects and initiatives during the next 18 months will be needed to provide confidence in the ability to effectively execute the outage.

There have been several upcoming changes within the refurbishment organization identified this quarter. The President and Chief Executive Officer, Tom Mitchell, has notified the OPG Board of Directors of his intention to resign when a replacement is identified. Glenn Jager has been appointed President of OPG Nuclear and Chief Nuclear Officer. This will continue the current situation of one senior executive having responsibility for both nuclear operations and the Darlington Refurbishment Project. In addition, the Director of Operations and Maintenance (DOM) and the Maintenance Manager have notified the organization of their upcoming retirement. The new DOM will be the fourth in just over two years, a challenge to both knowledge retention and consistent direction within that organization.

- The workshop concept is good and leverages the work ongoing with risk identification since the start of the Project. However, the key to success is how the projects/functions develop appropriate contingency inputs. This is no small task considering the available time and the amount of effort involved. Individuals from the Risk Management Group will work with the project and functional groups to facilitate acceptable input for RQE. However, project and functional personnel must develop the justifiable content.
- When BMcD/Modus began work on the Project, risk was a very low priority for the managers. Over the last year, additional management focus has been placed on developing and rationalizing risks, and management's goals are well known to the project managers. Some groups have embraced risk analysis, but others pockets within the team have produced contingency input merely to meet the RQE deadline; despite effective Risk Management tools, infrastructure and a support organization. RQE will be the test of how deeply the DR Team understands the risk aspect of their work.
- Some of the estimates of the impact costs were not derived using accepted estimating practices—but were based upon the project manager or functional group representative's "gut feel". The calculations for the cost impacts of discrete risks should be estimated and vetted by the Estimating team with the same rigor as the base cost estimates.
- The Risk Management Team will also review all registers to identify and resolve duplicate and overlapping entries. Clarity and precision in the risk descriptions will influence how efficiently this review can be conducted. Eliminating such redundancy only increases confidence.
- The BOP team has a significant challenge. Its major contractor has noted performance issues on Campus Plan projects, nssitating significant BOP schedule and cost contingency in order to have sufficient funds budgeted. That creates problems developing firm estimates and schedules. Nonetheless, absent detailed Construction Work Packages, fairly accurate OPEX for executing some of the BOP work, such as valve repair/replacement, can be employed. To develop the best input for RQE contingency, the BOP team has to rely on creative approaches such as existing DNGS OPEX, SME input and appropriate risk analysis. BOP (and, where necessary, other groups) are working closely with the Risk Team to timely develop acceptable contingency inputs.

The Project Controls team managing RQE is intent on issuing a number of key questions for the team to consider in looking at their contingency. In developing the global, program level contingency, the DR Team should fully consider the following risk areas as part of that exercise:

- ***Address vendors' concerns regarding OPG's role as overseer and integrator of the work***: Each of the vendors have voiced their concern that OPG's history is to provide multiple points of contact during a work cycle, who often provide conflicting information and direction and otherwise interfere with the field work. For the Project to be successful, the DR Team needs to dispel these fears with an optimized Execution Phase organization with clear accountabilities, and ensure that the Station and the Project are fully integrated. To address this, the DR Team has identified a plan to test its Readiness to Execute the work using actual work scheduled in 2015-16 prior to Breaker Open. This plan should be finalized and fully vetted for RQE and tracked with appropriate metrics and targets during the coming year. Nonetheless, for purposes of RQE, these risks need to be fully addressed.
- ***Fully analyze and account for the distinct risks inherent with the performance of Units 3, 1 and 4***: RQE is establishing a control budget for measuring OPG's performance on all four units. While this is sufficient for establishing the control budget's base cost, the full DR Project as it currently is planned actually consists of four separate and distinct execution models: Unit 2 is intended as a stand-alone project; Unit 3 will be completed while Unit 1 is started; Unit 1 will be started simultaneous to Unit 3's completion and completed at the same time Unit 4 is started; and Unit 4 will be "lapped" at its start by Unit 1. The DR Team has embedded certain risks regarding the subsequent units; these should be vetted for consistency and whether they cover the impact, needed resources, and other key factors that could make the execution of the subsequent units different, if not

November 2013

The process itself is well-formulated and should serve the intended purpose. However, the DR Team's execution within the process should be addressed. From our sampling of the process, we have found the DR Team is not consistently developing the materials needed for the GRB's evaluation. Some comments and recommendations are as follows:

Observation from Gate Review Process	Recommendations
Quality and consistency of the materials in Gate packages should be addressed. Gate review packages are often hastily assembled by the project teams and provided to the GRB only shortly before the gate review meetings.	➢ Gate package development should follow the existing schedule and key documents should be delivered well in advance of the GRB. ➢ The quality of the gate packages presented to the GRB would be improved by timely delivery of materials prior to pre-vetting sessions within the Project Team.
Within gate packages, there are requirements for explaining variances in cost estimates, there is no formal controlled process for presenting these changes. We have generally found little consistency between the various files kept on the bundles, and in some cases, the estimates used for gate reviews were not preserved.	➢ Improve record keeping and chain of document retention. ➢ Provide a reconciliation of the estimates presented with the gate package to prior estimates (i.e., 4b, 4c) and the basis of estimates so that changes can be traced and sources are identifiable. ➢ Provide an estimate reconciliation within the standard gate package template. ➢ The estimates developed for evaluation at the gates should follow the same general vetting methodology and adhere to the same quality and consistency standards described in Attachment C.
Although designed to provide a forum for challenging scope and cost estimates, the gate review process has thus far had mixed results for that purpose.	➢ In addition to Project Controls, the DR Team should consider utilizing a 3rd Party (e.g., Finance and the Controllership) to provide an independent analysis and examination of the sufficiency of the gate packages. The 3rd party can report to the GRB its findings and concerns.

Now that the Project's scope has essentially been determined, the Team's focus should turn to fully supporting the work that will be done in the Gate Process. We have recommended to Management the need to drive down to the lowest levels of the DR Team the importance of schedule and cost consciousness. Senior Leadership has accepted these recommendations and is implementing changes to the process that should address these concerns.

D. Assessment of Contingency and Management Reserve

BMcD/Modus undertook a review of contingency to determine how discrete risk elements are accounted for in the 4c Cost Estimate. Our review found that while risks are being identified and analyzed in a reasonable manner, the value of individual risks are not directly traceable or otherwise transparent all the way through the estimate to the bottom line. Instead, management has made a decision to carry Monte Carlo Output risk amounts at a more global level, namely, at the project bundle level only. As a result, discrete risks and associated amounts are merely subsumed into a single contingency number with no tractability back to the individual risk elements.

BMcD/Modus has the following observations regarding the methods the DR Team is using for establishing and managing contingency and management reserve:

EP Interrogatory #12

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

Interrogatory

Reference:
Exhibit D2, Tab 2, Schedule 7, page 5

1. Does OPG have a list of other major infrastructure projects that have used the Palisade software to establish their contingency?

2. Is OPG aware of any cost overruns at projects that have used the Palisade software to establish their contingency?

Response

1. No. However, information on the Industries and types of applications where Palisade's @Risk software has been used can be found at Palisade's website.

   @Risk is a widely used software in many industries to perform risk analysis including Monte Carlo analysis and decision tree analysis. It is not only used for major infrastructure projects.

   The Palisade website states that they have been in business for over 30 years, have 150,000 users, including 93 Fortune 100 companies.

2. OPG is not aware of cost overruns at projects that have used the Palisade software to establish their contingency.

Witness Panel: Darlington Refurbishment Program

 He works closely with the technical and sales staff, ensuring that customer feedback is heard. He personally oversees the development and evolution of every one of the fifteen software products Palisade sells. Prior to Palisade, he was a risk analysis consultant.

Roy Nersesian

Professor
Leon Hess Business School at Monmouth University

Roy Nersesian is a professor at the Leon Hess Business School at Monmouth University in New Jersey. He is the author of *Energy Risk Modeling* published by Palisade Corporation. This book is an outgrowth of his teaching energy modeling at Columbia University. He is also the author of *Energy Economics* recently published by Routledge.

David Robertson

Enterprise Risk Management
Duke Energy

David Robertson has over 18 years of experience in regulated utilities, manufacturing, public accounting and financial accounting. He specializes in drawing upon many disciplines to find creative solutions to complex problems. At Duke Energy, David is responsible for the completion of the Enterprise Risk Assessment, an annual presentation to the Board of Directors that outlines the top risks to the company, and the development of the company's risk registers. David has a background in economics and engineering. He is a licensed Certified Public Accountant (CPA) and holds a Master's of Business Administration (MBA) from Wayne State University

Mark Rudd

President
Rudd Asset Management

Mark Rudd is President and Founder of Rudd Asset Management (RAM). Based on a strong technical background, RAM applies proven risk management techniques to a variety of assets. In addition to energy project consulting and development, RAM provides risk management analysis for investments, and financial projects. Drawing upon an MBA from the University of Chicago and over 12 years as a commercial realtor, Mark Rudd is experienced in doing real estate project analysis and financial modeling.

N. Ryan Smith, P.Eng

Manager - Project Risk Management
Ontario Power Generation

Ryan Smith is a Professional Engineer with 15 years of project management experience in a diverse set of roles for both contractor and owner organizations. Ryan's project management interests revolve around the strategic and intangible aspects of the project work, including organizational effectiveness, leadership, and risk and decision management. Most recently, Ryan was assigned to establish and implement from the ground up an industry leading project risk management program for the Nuclear Projects organization at Ontario Power Generation and develop the life cycle contingency estimate for the 10 year $12.8 billion refurbishment of four nuclear units on the shores of Lake Ontario.

JD Solomon, PE, CRE, CMRP

Vice President
CH2M

JD Solomon is the Vice President with CH2M and serves as a senior consultant focusing on risk, reliability, and strategic decision making. Some of his areas of practice include infrastructure health and prognostics, financial management, operations and maintenance (O&M) optimization, and master planning. He is a Certified Reliability Engineer (CRE), Certified Maintenance and Reliability Professional (CMRP), is certified in Lean Management, and is a Six Sigma Black Belt. JD has a Professional Certificate in Strategic Decision and Risk Management from Stanford, an MBA from the University of South Carolina, and a BS Civil Engineering from NC State.

Alejandro Uribe

Wholesale Market Planning Leader
Celsia Energy

Alejandro is a Mechanical Engineer with a Master in Systems Engineering (National University of Colombia). He has worked in the electricity sector since 2001. He has worked for the Electricity Market Administrator (XM), and for several utility companies in Colombia. Currently he works as Wholesale Market Planning Leader at Celsia, a subsidiary of Grupo Argos.

Gustavo Vinueza

October 2013

Table 8 – Target Cost & Fixed Fees

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

Note: * Escalation not included.

7.6 Risks Excluded From Risk Registers

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

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

7.7 Impact of Separate Unit Risk Models

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

May 2016

for any project. In addition the status of the reporting needs to reflect future performance and status.

a. Vendor performance during the execution of the refurbishment project is not known, but the initial preparatory projects should be a good source of productivity and performance data.

15. **Change Management:** The Change Management Process is critical to enable visibility of scope and cost changes to the project. Anticipating and trending changes, assessing the impact of these changes, promptly agreeing to the cost or schedule impacts with vendors, and including these changes in the forecast. It is suggested to Trend, Change Order, scope and design changes. The Process should recognize two types of changes, those initiated by OPG, and those initiated by the Contractors as a result of unforeseen conditions or events. There are many examples of these processes available to the OPG team and external help can be sought to address this if required.

16. **Contingency:** Messaging of contingency allowance and "cost at risk" is inconsistent. In some presentations OPG is showing only "vendor cost" as risk, excluding risk of cost overruns for O&M and Project Support. However the Contingency breakdown shows contingency for O&M and Project Support Services. It is suggested that this inconsistency be corrected.

17. **Project Record:** OPG is subject to intense scrutiny by multiple agencies and regulators. For prudency hearings purposes it will be critical to write the facts and evidence that support any cost increases. OPG will need to demonstrate prudent management of risks and cost overruns and the application of best management practices to support the case for any overruns to be passed through to the rate payers. The creation of an "independent" project record (detailed with daily records and monthly reports) will also be critical to protect OPG from contractor claims if required. OPG should appoint an appropriate person(s) to monitor, collect and draft project records and prepare detailed risk assessment reports on a monthly basis in advance of OEB hearings, and in support of any contract claims or future contract settlement negotiations or litigation.

18. **Project Risks:** Several commercial risks should be carefully managed:
    - Vendor material cost increases (prices not fixed in contracts).
    - Schedule Change Impacts (schedule is still live and a potential gap is being created between the current schedule and the contractual schedules). The fact that schedules are not yet resource loaded may also imply changes and bring cost impacts due to changes in resource quantities and cash flow curves.
    - Change Orders have the potential to increase the Target Cost. Scenario analysis should be done to understand potential pessimistic outcomes and have mitigation plans in place.
    - OPG removed risk / contingency from the JV price prior to contract signing on the assumption that "OPG is the best party to manage such risks". Contingency was then

a probabilistic distribution of results (loss distribution). For this process to happen, the user needs the software @RISK, which brings this type of power calculation to the final user.

The calculation is applied for each item to the Duration or the Cost of the program, depending on the bucket where the item is located.

Once each one of the input sheets is filled and calculated, a series of reports were designed and built to support the decision making process and bring easy to understand the information obtained after the simulation process. Adding the probabilistic dimension to the model means that each risk or item included in the buckets aforementioned will have different levels of impact, represented by percentiles. E.g. the risk of a project delay could represent between 30 and 75 days of delay in the project depending on the risk appetite of the user: 75 days will be very conservative (P90) and 30 days will be very optimistic (P10).

Each report added to the model focuses in Cost or Duration, giving the analyst the possibility of analyzing the model from several points of view: Duration uncertainty, Cost uncertainty, Risk Uncertainty, etc., at several confidence levels.

Working with percentiles is regular in this type of models and OPG requested a Drill-down report, which will let the users navigate through the different risks and analyze the components of each one. That means, a given bucket can have 100,000 in P90 risk, and it could be made of several items: Item 1 = $25,000, Item 2 = $70,000, Item 3 = $5,000. Summing up percentiles is not permitted and Palisade and OPG worked in an approximation report called "Summary Report" which automatically adjust each risk's results in order to make this Drill Down report work. This is, again, an approximation of the final results.

2.3 Basic Assumptions for running the model

The model includes some important conceptual assumptions that should be considered for calculation purposes:

- The model has to be run with the latest version of the information, gathered from the SMEs.
- Each item included into the calculation can affect cost, duration of both. There are items that are setup to affect Duration only (Schedule Risks) and others designed to affect Costs only (Cost Uncertainty).
- Each risk is applied to each unit. There are four units included in the program and risks will be detailed individually. If a risk affects 4 units, it should be disaggregated in 4 items.
- A list of bundles has been setup initially for the model to be broke up.
- The percentile defined to be the conservative tail was P90 (90%). It is around this percentile that all analyses were generated.
- The numbers used in the parameters for the distribution are the Post-mitigation numbers. It is assumed that there are no further opportunities for improvement reflected in each item's setup.

2.4 The Process

The process that OPG was following was discussed and refined with Palisade. This design was analyzed in detail during Palisade's Visit #2 and it follows the phases below:

OPG used @Risk, a leading risk analysis software tool from Palisade Corporation, an internationally recognized leader in this field. As noted above, OPG also retained a risk modelling subject matter expert from Palisade to assist in the architecture and robustness of the model and oversee the simulation. KPMG found that such use of a risk modelling subject matter expert is considered a best practice for infrastructure projects of a similar nature and scale.

An integrated Monte Carlo simulation representing execution of the entire Program on a four-unit basis was conducted. Monte Carlo simulation is a computerized mathematical technique that replicates execution of the project thousands of times, accounting for potential realization of risk events and uncertainties, which allows quantitative analysis and decision making. It provides decision makers with a range of possible outcomes and the probabilities that those outcomes will occur to certain confidence levels. This technique builds models of possible results by substituting a range of values for any factor that has inherent uncertainty. The model is then used to calculate the results in an iterative manner, involving thousands of iterations, each using a different set of random values from the probability functions.[3] The intent is to simulate the outcome of DRP risk and uncertainty variables thousands of times and integrate these results to determine the confidence levels of contingency sufficiency. The RQE contingency estimate was a high confidence estimate based on the risk and uncertainty profile.

After initial contingency development workshops were completed and a preliminary contingency estimate was prepared, management reviews were held to validate the overall adequacy of the contingency estimate. This further ensured that the level of detail and the input of risks and uncertainties were reasonable and prudent. KPMG reviewed the inputs and simulation outputs and found that OPG developed a robust model by completing quality and data integrity checks after the contingency development workshops were held. KPMG also found that OPG's use of statistical correlations for the schedule analysis to simulate the interdependence of related activities is considered to be best practice.

[3] Palisade Corporation, *Monte Carlo Simulation* <http://www.palisade.com/risk/monte_carlo_simulation.asp>.

August 2016

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

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

Table 2: 4-Unit Contingency Summary

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

Table 3: 4-Unit Contingency Summary by Type

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

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

Two issues that the DR Team needs to resolve in the upcoming examination of the Engineering functional cost include: (1) the level of support needed for replication engineering for the units subsequent to Unit 2; (2) the roles, responsibilities and level of effort needed from OPG Engineering and vendors in support of the field work and commissioning. There is valuable OPEX from Pickering Unit 1 RTS that should be reviewed in making these decisions.

C. Documentation and Data Alignment

The DR Team's data management group is working to align the Project's RQE and schedule data so that costs can be properly viewed and assessed over the entire Project's lifecycle at the work package/scope level. A key aspect of this work is properly mapping data so that the planned and actual cost of performing each element of scope can be baselined and then traced over time. The data management team is currently correcting flaws in data mapping present from the Project's inception. This work is essential to establish and maintain a proper Control Budget going forward from RQE. In addition, this data mapping is integral for future plant configuration control, and will be necessary for OPG to support rate recovery of its investment. If these issues are not resolved in the near term, the DR Team will risk struggling with data alignment issues throughout the entire Project. We have provided management with an assessment of current challenges in the Project's Cost Management system that provides further explanation of these problems in comparison with best practices. We recommend the DR Team make data alignment a priority for RQE so that further rework of these systems can be avoided and RQE has the data integrity necessary.

D. Areas of Focus - RQE Quality

RFR Project-Class 2 Estimate	Overall Risk Perspective 

RFR represents approximately 35% of the total estimated DR Project cost, and thus the largest single risk to RQE. Since receiving SNC/Aecon's Class 3 estimate for RFR in June 2014, OPG's challenge has been to vet SNC/Aecon's plan and pricing of this work to ensure it is achievable, accounts for the OPEX from past refurbishments, improvements to the tool set and the value of the planning effort to date, including the full-scale mock-up at the DEC.

Moreover, OPG is motivated to close the approximate $700M gap between SNC/Aecon's Class 3 Estimate and the amount OPG carried in its 4d Cost Estimate for RFR. OPG believes that SNC/Aecon's Class 3 estimate was conservative and included opportunities for SNC/Aecon to realize in the Class 2 estimate and its planning for RFR's execution. OPG has made SNC/Aecon fully aware of its position relative to these opportunities.

SNC/Aecon's Class 2 estimate was initially targeted for delivery by April 10, 2015, though SNC/Aecon was unable to meet this deadline. OPG provided SNC/Aecon with an extension to May 8, 2015 to ensure SNC/Aecon was providing an estimate package of requisite quality[1]. The OPG team also recognized that while monitoring and vetting the SNC/Aecon's incremental progress was necessary and beneficial, the OPG team now needs to review and vet the estimate as a whole.

SNC/Aecon and OPG have agreed on a number of key areas that will ease the vetting of the Class 2 Estimate, including:

- The critical path duration of 1084 days, including OPG's responsibility of 186 days from breaker open to defueling and 223 days after RFR is completed to breaker closed. SNC/Aecon's schedule and estimate are premised on it controlling the critical path in the vault for the 676 days in the middle (the "RFR Duration"). SNC/Aecon's RFR Duration was determined on the basis of its Tool Performance Guarantee ("TPG") durations that were tested in the mock-up and modified by assumptions gained from OPEX of prior CANDU refurbishments. Importantly, SNC/Aecon's RFR Duration is shorter than the actual duration of Wolsong, which was the previous best

[1] SNC/Aecon's Class 2 Estimate was received concurrent with the preparation of this report; thus, we cannot comment on its content at this time.

the result of a competitive process which resulted in the contractors agreeing to some unique provisions that are used for all contracted work with these vendors. As an example, when used as an EPC, the contractors who lead these consortia are required to bid engineering work on a fixed-price basis with no profit for themselves. The construction work is all cost reimbursable target price, and the performance incentives include up to a 50% reduction of profit, though this and some other disincentives built into the contract have proven thus far to be much less effective in practice than concept at driving the contractors' behavior and performance.

The impetus for having P&M execute the Campus Plan work was that through the Definition Phase of Refurbishment, the DR Team was not assembled as an execution organization, but a planning one. P&M was an existing service resource with some experience in managing the ESMSA contractors. P&M's work on the Campus Plan Projects is funded by Refurbishment and it must report its progress to Refurbishment, though these business units are otherwise autonomous. Until recently, other than these approvals and the fact that both organizations use the ESMSA Contractors, there was very little else in common between Refurbishment and P&M, including the project management procedures utilized for their respective projects. P&M's project management procedures were not developed to manage multi-year projects of the size and scope of some of the Campus Plan Projects. Over the last several months, P&M has begun to manage the Campus Plan projects in accordance with the project management procedures developed for the DR Project in an attempt to implement industry-standard risk, cost and schedule controls. Additionally, the new VP has implemented a series of organizational and strategic initiatives with the goal of improving performance.

As of April 2, 2014, the Campus Plan Projects are estimated to cost in aggregate approximately $660M (an increase of $111.5 Million over the Board of Directors approved 2014 Business Case release for this work) and the work varies widely in size and complexity. The performance of the work is largely split between the two ESMSA contractors, Black & McDonald and ES Fox. Deadlines for completion of these Projects vary based on the project's and stations' needs; AHS is scheduled to be complete prior to the DNGS Vacuum Building Outage ("VBO") in mid-April 2015, while all the remaining work is scheduled to be completed one year later, in April 2016, to allow enough time for commissioning prior to the October 2016 Refurbishment Project's breaker open milestone. Many of these Campus Plan Projects involve the construction of commercial buildings that are made more complex because of their location on or adjacent to the nuclear island, which impacts their associated design requirements for such things as nuclear safety, security, and seismic requirements. Additionally, these are brownfield projects on a site where soil quality issues and underground interferences are the norm and coordination with the operation of DNGS must be managed.

Over the last quarter, BMcD/Modus has engaged in a number of activities related to the Campus Plan Projects. In this regard, we have:

- Reviewed the reasons for significant cost variances in five of the largest Campus Plan and Prerequisite Projects: D20 Storage Facility; Auxiliary Heat System Building ("AHS"); Water & Sewer; RFR Island Annex Building ("RFRISA"); and Retube Waste Processing Building ("RWPB"). Our goal was to determine the root cause of the Campus Plan Projects' variances so that past mistakes will not be repeated. We chose to examine the RWPB, which is being built by SNC/Aecon and managed by the DR Team, for a real-time direct comparison with the ESMSA-managed projects.
- Reviewed the Campus Plan Projects' schedules prepared by the vendors to identify any major gaps. This review led our team to make a series of recommendations to the P&M and DR Teams, and our subsequent monitoring of progress of the vendors' ongoing redevelopment of their detailed schedules for each of the major projects.
- Examined the risk management process within the P&M organization, including its ability to properly identify, avoid, mitigate and monetize risk.
- Reviewed the design and scoping process and identified the causes for the extreme inaccuracy of the vendors' engineering cost and schedule estimates.

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

Chart 1

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

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

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

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

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

Witness Panel: Darlington Refurbishment Program

Chart 2

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

$305.4

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

Chart 3

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

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

$38.6 million

Witness Panel: Darlington Refurbishment Program

	not on the unit. The results of the mock-up testing have been incorporated into the tooling performance guarantee, which sets the target schedule and price, with the RFR vendor.
Entrench appropriate and realistic off-ramps and scoping	• OPG has engaged in a deliberate process with numerous off-ramps for the definition phase including Board of Directors oversight and annual releases of funds. • Each contract has off-ramp provisions allowing OPG to terminate, with or without cause; OPG would be accountable to reimburse contractors only for any reasonably incurred costs. • Scope review process in place to minimize scope of work performed in refurbishment period to address things that must be done to extend life or that can only be done in drained/defueled state. • OPG has fully examined the scope of the Unit 2 refurbishment project and optimized the work based on OPG's regulatory commitments and/or analysis of the best time to perform the work.
Require OPG to hold its contractors accountable to the nuclear refurbishment schedule and price	• OPG, in implementing all of its contracts, is highly focused on achieving value for money; there are incentives and disincentives related to achieving the cost and schedule set out in the contracts. • Contracts with major contractors have been developed and vetted utilizing a deliberate, staged and gated process with requirements for budget, schedule, scope, and risk identification at each gate. • Contracts have specific negotiated incentives and disincentives that are calculated toward promoting the contractor's (and OPG's) responsible management of the work. • OPG is implementing a detailed, integrated Level 3 schedule that will encompass all of the contractors' and OPG's work, as well as a rolled-up Level 2 Control and Coordination Schedule that is used as a higher level interfacing tool. • OPG has implemented cost control systems that are geared toward holding contractors accountable. These systems include earned value and budget controls, as well as validation of progressive project plans, through a gated process. • OPG performs analysis of all pricing and checks estimates for contractors' work. • OPG's senior management have established separate regular steering committees with each of the major contractors' executives which provide senior level leadership with a forum to discuss progress, potential and real issues impacting performance and commercial issues.
Make site, project management,	• RQE fully considered all of the factors listed in advance of execution of the work.

regulatory requirements and supply chain considerations, and cost and risk containment, the primary factors in developing the implementation plan	• Taking lessons from Pickering A, the DRP team completed the identification of all regulatory requirements well in advance of final design and construction. • OPG has completed the design and proving of the RFR tools. • Procurement of all long lead materials commenced well in advance of the start of the first unit refurbishment with all deliverable dates confirmed to be well in advance of the need dates. Mitigation plans are in place for any material that is not on hand well in advance of the need date. • OPG has implemented, in accordance with Project Management Institute standards and Association for Advancement of Cost Engineering best practices, project controls and risk management programs, as well as a continuous improvement focus, to refine these tools as the outage nears. • OPG has retained external oversight and engaged other corporate functions in providing input and assurance that the DRP team is meeting its commitments.
Take smaller initial steps to ensure there is opportunity to incorporate lessons learned from refurbishment including collaboration by operators.	• To fully incorporate lessons learned from the refurbishment of the first unit (Unit 2), the start of refurbishment work on the second unit (Unit 3) has been delayed until the completion of the first unit. While Unit 2 is underway, lessons learned will be captured and incorporated into Unit 3 planning. • OPG has filled key positions in its project management team with individuals having direct experience with prior CANDU refurbishments. • OPG has contracted with SNC/Aecon, whose subsidiary CANDU Energy (formerly AECL) has been associated with each of the prior refurbishments. • OPG and its contractors have studied lessons learned and operating experience from prior projects and incorporated those into the DRP. • OPG routinely collaborates with other CANDU operators directly and through the CANDU Owner's Group. OPG established a Memorandum of Understanding with Bruce Power to support collaboration.

1

Attachment to L-04.3-6 EP-010

NR Actual Cost - Inception To-Date thru Breaker Open*

Line #	Description	Cost $
1	NR - Retubing & Feeder Replacement	937,949,240
2	NR - Turbine Generator	160,845,807
3	NR - Balance of Plant	114,376,802
4	NR - Fuel Handling	16,077,766
5	NR - Defueling	32,407,982
6	NR - Steam Generator	19,366,569
7	NR - Specialized Projects	34,504,861
8	NR - Shutdown, Layup and Services	40,945,397
9	NR - Refurbishment Support Facilities	31,990,108
10	NR - Unit Islanding	47,746,244
11	NR - Waste Disposal	-
12	**SubTotal Bundle Projects**	**1,436,210,776**
13	NR - Campus Plan F&IP Projects	622,647,482
14	NR - SIO - Safety Improvement Opportunities	256,978,669
15	**SubTotal Campus Plan Projects**	**879,626,151**
16	NR - Project Office	16,002,968
17	NR - Contract Management	13,123,285
18	NR - Engineering	151,226,535
19	NR - Managed Systems Oversight	17,905,424
20	NR - Planning & Controls	90,628,877
21	NR - Program Fees & Other Support	62,470,071
22	NR - Supply Chain	18,556,229
23	NR - Project Execution / Construction OS	31,353,248
24	NR - Operations and Maintenance	94,892,941
25	NR - Release 3	125,299,260
26	NR - Release 4	9,078,379
27	**SubTotal Functions**	**630,537,217**
28	Escalation **	-
29	Interest **	-
30	**Nuclear Refurbishment Program**	**2,946,374,144**

* Represents AC thru Sept 30,16 and estimated costs Oct 1 - 15, 2016

* Note: escalation and Interest are allocated and reported as against each bundle and function.

Board Staff Interrogatory #61

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

Interrogatory

Reference:
Ref: Exh D2-2-3, Attachment 1, page 6

For the DRP Execution Phase, calculation and payment of all cost incentives and disincentives will be done on an aggregate basis for all completed units.

a) Please explain how this will work in practical terms with the CRVA for DRP. For example, will the CRVA only be cleared at the completion of all four units?

b) Were any incentive or disincentive payments made during the definition phase?

Response

a) The costs of the DRP will reflect accrued incentives and disincentives at the completion of each unit as per OPG accounting process in accordance with US GAAP. The CRVA treatment of these amounts will be the same as for other sources of variance from OEB-approved capital and non-capital costs. Variances in non-capital costs are included in the CRVA as incurred, and the revenue requirement of variances in capital costs is included in the CRVA on the basis of variances in amounts placed in service. OPG anticipates that the CRVA balance would be cleared periodically in the normal course in conjunction with other deferral and variance account balances.

b) While OPG's Definition Phase concluded at the end of 2015, some vendor Definition Phase activities are still ongoing as contemplated in their agreements, and in some cases, will continue to September, 2017. It is not currently anticipated that any incentive payments will be made by OPG. OPG will assess potential disincentives at the time of completion. Notwithstanding the above, with respect to the Retube and Feeder Replacement contract, a $1,000,000 lump sum disincentive payment was paid to OPG as consideration for the movement of the target date for a limited number of Definition Phase work activities. Less than 2% (approximately $18M) of work was outstanding to meet the milestone. In addition to the disincentive payment, OPG also established realistic but aggressive milestones and associated disincentives for the remaining Definition Phase work so as to incentivize the contractor to complete the work.

Witness Panel: Darlington Refurbishment Program

AMPCO Interrogatory #33

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

Interrogatory

Reference:
Ref: Exhibit D2-2-2 Page 1

Preamble: DRP is a multi-phased program made up numerous individual projects of various sizes.

a) Please provide the total number of individual projects for the DRP.

b) Please provide the number of individual projects under each of the five major work bundles.

c) Please confirm the total number of prime contractors working on the DRP.

d) Please provide a table that shows the number of projects managed under each prime contractor.

Response

a) There are 501 active projects within the DRP program and for all phases and units. An active project is defined as a project with a planned value (budget) which in summation totals $12.8B.

b) The following chart provides a breakdown of the 501 projects across the five major work bundles (Items 1-5), as well as the Facility and Infrastructure and Safety Improvement projects (Item 6) and the OPG oversight organizations (Item 7):

Chart 1

Project Bundle Grouping	# of Projects
1. Retube and Feeder Replacement	17
2. Turbine Generator	27
3. Balance of Plant	234
4. Fuel handling / Defuelling	26
5. Steam Generator	23
6. F&IP/SIO	24
7. OPG Programmatic/Functional	150

Witness Panel: Darlington Refurbishment Program

Grand Total	**501**

c) There are six prime contractors working on the DRP as listed in part d).

d) The following chart shows the number of projects managed under each prime contractor:

Chart 2

Prime Contractor	**# of Projects**
Alstom	5
Black & McDonald (ESMSA)	13
BWXT/Candu Joint Venture	10
E.S. Fox (ESMSA)	90
GE-Hitachi	4
SNC/Aecon Joint Venture	31
OPG - Inspection & Maintenance Services	10
OPG - Oversight	249
OPG - In-House Projects	74
Other	15
Grand Total	**501**

July 2016

2. The level of readiness to execute the project is most advanced in the 'lead-in segment' (but decreases with subsequent segments), for example;
   - The level of preparation, teamwork, and ownership for the reactor defueling appears to be good.
   - The level of preparation for the installation of the 'bulkhead' appears adequate.
   - The RFR component of the 'removal segment' (removal of reactor components such as pressure tubes etc) appears to be well planned. The use of the mock-up is a valuable tool, and is being used to practice and to perform tool testing.

Work activities such as the Heat Transport Pump motor movement (currently a requirement exists to stop work in the reactor vault while hoisting motors) and the currently planned radiography in the reactor vault could still impact the critical path schedule, and have not been resolved. (Note, this is not an all inclusive list).

3. Project preparation, planning, and scheduling is incomplete in part due to the processes and infrastructure to close-out the construction work, complete the necessary documentation reviews, and then plan and execute the commissioning and "return to service" activities are not well advanced. Scheduling the return of plant systems should govern how the construction work is sequenced. Failure to follow this pattern will result in having to revise the schedule and add to the required resources to complete the schedule. ***The RCRB considers this crucial to the success of the project.***

Once the unit is shut down and defueling is commenced, the RCRB is concerned about the organization's ability to manage the challenges of execution while completing return to service planning. Key resources such as availability of certified staff with project experience will be at a premium. In addition, with all the issues that the management team currently has to manage (for example the need to develop mitigation plans for potentially late campus plan projects), then add the inevitable discovery issues with a shutdown unit in the execution phase. It is critical for the success of the project that these issues are resolved in a timely manner.

Recommendation #2

a) It is the RCRB experience that some form of "close out group" needs to be created to ensure that the close out of construction work is done correctly and timely (with quality and ensuring that gaps do not exist which demonstrate the work was completed as specified). There is considerable project related OPEX to support the formation of this group or function. Currently within the "Projects and Modifications" group, elements of this function currently exist and could be modelled.

August 2013

In our view, the OPG cost estimate team exhibits a reasonable composition of talents including experience mix. However, as is true with most nuclear refurbishments, the DR Team will be constantly challenged as the Project progresses.

In order to test the quality of the estimate, BMcD/Modus randomly sampled several line items of cost in the Class 4 Estimate. As a result of this sampling, we found some minor inconsistencies, such that the OPG team should consider assigning a quality resource to scrub estimate sheets for errant inclusions or exclusions, as well as perform quality checks on spreadsheet formulae and the like so as to end up with the most reliable work product reasonable. This is industry best practice particularly on projects involving repetitive work.

iii. Observations Regarding the RFR Estimates

As noted above, we do not believe that the current SNC/Aecon estimate does not comply with the standard definition of a Class 4 Estimate as such definition is used by AACE, or the industry at large. SNC/Aecon's Class 4 Estimate is based almost entirely on a scale-up of a reference plant (Wolsong) with all known or perceived imperfections removed (an issue itself subject to considerable ambiguity). In developing this "perfect" theoretical estimate, SNC/Aecon and OPG intentionally (and in accordance with the JV Agreement) overlooked central considerations of the AACE guidelines identify for classification of estimates, as summarized below:

- ***The Class 5 through Class 3 Estimates do not include contingencies amounts.*** Per AACE Recommended Practice 18R-97, the expected (+/-) accuracy ranges for Class 1 through Class 5 cost estimates have meaning only after application of contingency (typically at a 50% level of confidence).[59]

- ***Project maturation was not considered in the Class 4 Estimate.*** Per AACE Recommended Practice 18R-97, and in line with industry practice, the maturity level of project definition is the primary determinant of an estimate class – maturity level generally comprises engineering percent complete. For example, in a Class 5 Estimate, the expected level of project definition (as measured by engineering) would range between 0 to 1% of total engineering being complete. For example, a key deliverable for measuring engineering percent complete would be number of completed block flow diagrams. Similarly, for a Class 4 Estimate, the expected level of project definition would range from 1% to 15% of total engineering complete and key design deliverables would include a number of completed block schematics, process flow diagrams (PDFs) for main process systems and preliminary engineered process and equipment lists.

- ***That SNC/Aecon and OPG did not follow AACE for the Class 4 Estimate is intentional, as the JV Agreement's language would preclude classification of these estimates within AACE.*** OPG Management should recognize that this very large and significant portion of the DR Project is being measured, estimated and monetized in a manner that is different from the other scopes of work on the Project. However, as noted, this is by contractual design, as SNC/Aecon is not obligated to provide monetized input regarding the items in the Risk Register until the conclusion of the target price negotiations, which is scheduled for May 2015.

- ***The development of a "perfect" reference plant comes freighted with ambiguity.*** To the uninformed observer, SNC/Aecon's Class 4 Estimate could appear to represent a model for the best possible

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

August 2013

outcome (aka optimal performance) for the DR Project. However, the current Class 4 Estimate actually represents a model of "perfect" performance that the DR Team believes is unrealistic to expect in the real world at any location, even perhaps Wolsong. Further, the "reference plant" is actually not Wolsong (which, to date, represents the most successful RFR project from a schedule standpoint) but a modified Wolsong absent approximately 19% of its as-built durations, then scaled-up to match the Darlington parameters. Thus, OPG may well be subject to managing the Project to a wholly unrealistic mile post.

- ***Ultimately, BMcD/Modus recommends that OPG focus on the value derived from the Class 4 Estimates not on whether it meets AACE's definition of a Class 4 Estimate***. The RFR work is different from many major construction scopes whereas the AACE classification is ordinarily applied to work that is largely repetitive and akin to a manufacturing process in which tooling, reliability and assembly-line precision is required. Developing an estimate that summarizes the best possible performance of such an operation has significant value.

OPG should be extremely cautious in regard to characterizing its current estimate as being anything other than *current best efforts toward compliance with the AACE estimate classification scheme*. The current estimate nevertheless has great value and should be viewed as a useful benchmark as OPG progresses to an AACE Class 3 Estimate where the cost estimating work product must shine, no excuses allowed.

d. Class 3 Estimate Progression

The starting point for development of the Class 3 Estimate is the Class 4 Estimate and the Project Estimating Plan. From this point forward, the Class 3 Estimate will be *looking forward* utilizing well-defined Process Flow Diagrams (PFDs), preliminary Construction Work Packages and applicable N-Procedures that are unique to the DR Project and based on SNC/Aecon's view of constructability. This methodology change could result in task-based duration and man-hours variances; indeed, it could result in improvements from greater knowledge and improvements to the tooling that will be tested in the mock-up. The Class 3 estimate's efficacy will determined by the completeness and availability of detail within the design, procurement, mock-up facility and tool testing work efforts, all of which will facilitate progress to the requisite depth and accuracy.

Any developing variances (to the extent existing) will be logged and vetted within the Class 3 Estimate progression cycle. The Class 3 Estimate will be structured as an integrated program to allow for further progression to Class 2 Estimate. OPG expects that the Class 3 Estimate will reflect the SNC/Aecon's estimate of 100% "wrench time" based on the maturation of the DR Project's design and the proving-out of the tool set in the mock-up. SNC/Aecon and OPG will further review certain mitigation strategies and actions to reduce risks in the Execution Phase which will be monetized in the Class 2 Estimate.

As stated previously, the Class 3 Estimate will use the Class 4 Estimate as the basis for further development and some important activities and aspects of that effort will include:

- The establishment and maturation of key inputs that will drive the estimate (e.g., Process Flow Diagrams, Engineering and Construction Work Package development and Risk Register).
- A review of the experience and OPEX during the Class 5 and Class 4 Estimate work effort and adjustment of processes and methodology, as appropriate, for continued development of the Class 3 Estimate.

November 2013

2. SNC/Aecon Class 3 Estimate Plan

SNC/Aecon is required under the contract to submit its next phase of estimate on May 15, 2014. This estimate has been termed a "Class 3 Estimate" though, as with the earlier SNC/Aecon Class 5/4 estimates, the AACE-based definition for this estimate is imperfect at best. While this Class 3 Estimate will turn the focus from OPEX gathered at other stations to DNGS, it will still not account for risks, nor will it strictly adhere to other AACE requirements. The DR Team recognizes the need to monetize risks in concert with the Class 3 Estimate and will seek visibility to these risk items. The SNC/Aecon and OPG Teams are meeting weekly to reach an agreeable Class 3 Estimate Plan which should put the concerns over the basis of the estimate to rest.

SNC/Aecon's team announced at the October 28, 2013 project meeting that the Class 3 Estimate development has no float through May 15, 2014. BMcD/Modus identified that SNC/Aecon's Monthly Report for September 2013 showed SNC/Aecon had earned extremely little time (only 335 hours) in preparing the Class 3 Estimate to date. SNC/Aecon believes that there is an anomaly or error in this report, though the amount of work apparent to date on the Class 3 Estimate suggests that SNC/Aecon needs to significantly ramp-up this effort. This also bears close monitoring over the next quarter.

B. Scope Rationalization Process / Unlapping of Unit 2

In 2Q 2013, the DR Team's Senior VPs initiated a process to review, scrutinize, and rationalize the DR Project's scope. This process was performed by a "Tripartite Review Team" drawn from the Project Team, the station and a team of independent reviewers including VPs external to the DR Project who have knowledge of the plant. The Tripartite Review Team evaluated the DR Project's scope with a view of the Project's objectives as well as requirements/commitments that have been made to the CNSC. The Tripartite Review Team's results were aggregated and presented to the DR Project and DNGS station representatives for future review and disposition by the Project Scope Review Board ("PSRB").

In all, the Tripartite Review Team reviewed 579 DSRs with an estimated value of $4.865 B and determined that 210 DSRs with an estimated value of $212M should be removed from the DR Project's scope. In addition, 22 DSRs totaling $125M are slated for further review and potential future action. The chart below summarizes the results of the Tripartite Review Team's evaluation:

Tripartite Review Team Recommendations

Funding Stream	Total DSR Database	Confirmed To Perform In Refurb.	Not Reviewed[1]	Further Review Needed/Potential Further Reduction	Recommended to Cancel
Nuclear Refurbishment	$4,827	$4,468 M	$32 M	$125 M	$202 M
Other	$70 M	$60 M	$0	-	$10 M
Total	**$4,897 M**	**$4,528 M**	**$32 M**	**$125 M**	**$212 M**

BMcD/Modus has followed this process from its conception and found it to be robust. In fact, the DR Team should review OPEX from this process to improve the gate process. We have the following observations:

[1] These DSRs were not considered by the Tripartite Review Team and thus remain the DR Project's scope.

April 2015

Filed: 2016-10-26
EB-2016-0152
Exhibit L, Tab 4.3
Schedule 1 Staff-072
Attachment 24
Page 40 of

performance, OPG is relying on accountability of the contractor, creation of the Vendor Leadership Forum and the execution construction organization's field presence as the strategy to address potential weaknesses by contractors. For core refurbishment projects, emphasis is being placed on having quality schedules and estimates for the completion of all aspects of the work and having the detailed schedules in place prior to a particular phase of the beginning.

m. Not responding to adverse trends in a timely and effective manner

These projects have had several, longstanding issues, starting with the D_2O storage project, but also cost estimates, development of reliable schedules, completion of engineering, performance of subcontractors and interfacing with the station to execute field work. Many of these issues existed for several months – some years. The P&M organization has not been effective at identifying and addressing performance issues in a timely and effective manner in order to limit their impact on safety, quality, cost and schedule delays. This behaviour of not identifying and addressing performance issues is similar to the cause of the Pt LePreau calandria tube insertion production and quality event.

Refurbishment management's strategy to reduce this risk includes the following items:

i. Establishing a meeting focus on performance against plan and the identification/resolution of issues.

ii. The future creation of a project Change Control Board.

iii. Creation of a Project Decision Making forum.

iv. Formalizing the purpose and function of the 'contrarian' in the deliberations of important program and project decisions.

v. Formalize the application and use of Event Free Challenge meetings for critical work.

These actions will support addressing this issue. However, there should be recognition and actions to improve the culture to drive issues to a more timely and effective resolution. The slow response to address the management of the large engineering backlog, the resolution of BOP and shutdown/layup/services contracts and the RWPB performance issues can be used to help refurbishment mid management understand the issue and the need for its reduction.

January 2016

Filed: 2016-10-26
EB-2016-0152
Exhibit L, Tab 4.3
Schedule 1 Staff-072
Attachment 27
Page 3 of 23

1. Minister Summary

Previous quarterly reports provided a detailed quarterly review of trends, accomplishments and challenges related to the Darlington Nuclear refurbishment project. With the completion of the Definition Phase at 2015 yearend, the focus of the refurbishment project has transitioned into execution of its Ready to Execute (RTE) Plan.

A number of achievements have been made through the Definition Phase of the project; including:

- The Release Quality Estimate for the refurbishment of the four Darlington units was prepared and approved by the OPG Board of Directors. This included the estimated cost (including contingency) and duration for the defined scope of work for the four units.
- The OPG contracting strategy was developed and implemented. This contracting strategy is designed to retain vendors best qualified to perform the work contracted to them, while appropriately transferring risk and minimizing risk premium. The key risks are associated with safety, quality, cost overruns and schedule extensions. Of the $12.8B high confidence total cost estimate of the Darlington Refurbishment Project, $5.3B (including the $0.8B spent to date) has or is to be spent by contractors for the engineering, planning, procurement and field execution of the five core refurbishment project bundles.
- OPG declared success in meeting the August 15, 2015 milestone for the completion of design engineering. However, this was accomplished with a large number of outstanding items for resolution. As stated in previous reports, the process to accept design agency deliverables may not be sufficiently rigorous to ensure high quality products. This risk has been realized in a number of projects, most recently the STOP (Shield Tank Overpressure Protection) project. The design was incorrect in assumptions regarding the size of the pressure pulse when switching pumps. This resulted in the field installation during the Unit 3 fall outage not being acceptable, removed from service, and the unit returned to service without the modification installed. The response to this event should include a review of the extent of condition and cause.
- OPG has received the required regulatory approvals for the refurbishment of the four units. This includes approval of the Environmental Assessment, the Integrated Safety Review that includes Component Condition Reports and the Global Assessment, and the Integrated

Refurbishment Construction Review Board Review July 18 - 22, 2016

Confidential (Commercially sensitive issues are discussed in this document)

Background:

The Refurbishment Construction Review Board (RCRB) conducted a review of the Darlington Refurbishment project from July 18 through July 22, 2016. This report is based on document reviews during the preparation for the review, interviews with Refurbishment personnel, and plant walk-downs during four days of the onsite visit.

The RCRB provides a report of its activities to the President Nuclear and Chief Nuclear Officer, which includes both observations and recommendations to improve performance.

The RCRB team consisted of the following members:

External members:

Ken Ellis
Drew Fetters
Britt McKinney
Mike Rencheck
Ike Zeringue

Internal member:
Paul Pasquet

The RCRB would like to recognize the excellent support provided by Jennifer Vulanovic, Irena Doslo, and Graem Meteer; their preparation and hard work enabled the RCRB to productively conduct this review.

The RCRB has made a limited number of key recommendations which the project needs to address with priority. The recommendations have been flagged and although no "formal" action plans are being requested, the RCRB will expect a briefing during the next visit to ensure progress is being made.

Executive Summary:

It is clear to the RCRB that progress has been made getting "ready to execute" the refurbishment project at Darlington Station. The team is impressed with the collaboration and level of preparations associated with the Fuel Handling readiness for defueling, turbine generator work, and the Re-tube Feeder Replacement (RFR) project. Likewise, other support aspects such as the project "material staging" facility is world class and is one of the best organized and laid out facilities that the RCRB has seen.

Key Issues and recommendations:

There are a number of issues that require prompt attention by the refurbishment leadership team given there is less than 3 months to breaker open on the unit entering its refurbishment outage.

1. Currently, the execution of the pre-requisite refurbishment work is behind schedule and a "bow wave" of activities is starting to occur. Only 21 of 67 prerequisite work windows are complete or on schedule, the remainder are delayed.

A work completion rate of approximately 150 tasks per week is currently being completed. A rate of 2 to 3 times that will be needed to complete the prerequisite work prior to the shutdown of the unit. In addition, execution of some of the planned work is progressing more slowly than expected due to the complexity of the work, late discovery, or late identification of issues (e.g. Shutdown Cooling HX replacements).

Portions of this work is key to the start of the project and has completion dates that are 'just in time' for their use. The current schedule for a number of the prerequisite activities have little float. For example:

- The construction of the waste processing building, which is required to receive re-tube waste has little float.
- The sequence of Shutdown Cooling HX replacement, Primary Heat Transport System heavy water transfer header maintenance, and the unbudgeted outage to address the STOP modification short-falls will require good co-ordination and has little schedule float.

Recommendation #1

The RCRB recommends that action is taken to both understand why the desired task/work off rate is not being achieved and take the required actions to ensure this work is completed as scheduled.

It was noted during the review week that no routine "T+1" type meeting is held to both identify and rectify schedule challenges and hold staff accountable for achieving the schedule. Carrying out schedule reviews may partially rectify this issue.

2. The level of readiness to execute the project is most advanced in the 'lead-in segment' (but decreases with subsequent segments), for example;
   - The level of preparation, teamwork, and ownership for the reactor defueling appears to be good.
   - The level of preparation for the installation of the 'bulkhead' appears adequate.
   - The RFR component of the 'removal segment' (removal of reactor components such as pressure tubes etc) appears to be well planned. The use of the mock-up is a valuable tool, and is being used to practice and to perform tool testing.

Work activities such as the Heat Transport Pump motor movement (currently a requirement exists to stop work in the reactor vault while hoisting motors) and the currently planned radiography in the reactor vault could still impact the critical path schedule, and have not been resolved. (Note, this is not an all inclusive list).

3. Project preparation, planning, and scheduling is incomplete in part due to the processes and infrastructure to close-out the construction work, complete the necessary documentation reviews, and then plan and execute the commissioning and "return to service" activities are not well advanced. Scheduling the return of plant systems should govern how the construction work is sequenced. Failure to follow this pattern will result in having to revise the schedule and add to the required resources to complete the schedule. ***The RCRB considers this crucial to the success of the project.***

   Once the unit is shut down and defueling is commenced, the RCRB is concerned about the organization's ability to manage the challenges of execution while completing return to service planning. Key resources such as availability of certified staff with project experience will be at a premium. In addition, with all the issues that the management team currently has to manage (for example the need to develop mitigation plans for potentially late campus plan projects), then add the inevitable discovery issues with a shutdown unit in the execution phase. It is critical for the success of the project that these issues are resolved in a timely manner.

Recommendation #2

a) It is the RCRB experience that some form of "close out group" needs to be created to ensure that the close out of construction work is done correctly and timely (with quality and ensuring that gaps do not exist which demonstrate the work was completed as specified). There is considerable project related OPEX to support the formation of this group or function. Currently within the "Projects and Modifications" group, elements of this function currently exist and could be modelled.

b) As discussed above, a return to service group needs to expeditiously complete both the conceptual and detailed planning associated with returning of layed up / operating and modification systems and components to service. This activity needs to be monitored and tracked by the Refurbishment management team.

4. During the RCRB review a number of reports with associated metrics were reviewed. In a number of cases it was difficult to determine how these metrics rolled up to the refurbishment score card.

Recommendation #3

While the project docs have a large number of metrics, they do not consistently provide an accurate, integrated picture of project health. The metrics identify individual project performance but do not adequate portray the integrated project execution and status. A "pyramidal system" of metrics and performance indicators is needed to effectively manage a project of this complexity. There are a sufficient number of metrics generated; they need to be strategically applied to allow management to focus on the problem areas. The RCRB recommends on a priority basis, the following changes be made to the existing metric set:

- Where qualitative measures of readiness are used, Management needs to ensure a challenge process exists to ensure the rating chosen reflects the true level of readiness.
- As was discussed during the on site visit, individual departments need to produce "score cards" supported by metrics which roll up to an "overall refurbishment" score card.

5. Currently, the project is being managed from the 'online' operational perspective. It is being viewed as a 'very large planned outage' using traditional outage processes. From experience on past refurbishment projects, the RCRB views this as a significant challenge to efficiently use those processes to manage the project, given the scale of work being planned and executed.

   The "operational model" for this project needs to change, and be based on: eliminating unnecessary reviews and approvals, streamlining of processes to support work execution, and only requiring operational involvement where value is added. In addition, except for OP&P revisions, there have been few requests for relief on reactor safety constraints (e.g. SLOD, Single Line of Defence) from Refurbishment staff.

   There are a number of interface issues between the site and the project that needs to be resolved, and are well behind when they should have been decided. These are adversely affecting the organization's ability to obtain clarity on standards and expectations associated with execution of the project.

Recommendation # 4

One of the fundamental premises of a strong culture is to ensure that written expectations exist; staff need to understand the expectations and then follow them. In addition, with the reactor defueled and the unit separated from containment there exists a once in the life of the operating unit an opportunity to streamline the work processes so only those that truly add value (be it from a safety / quality / schedule or cost perspective) are in effect. In order to achieve these two basic principles a team needs to be struck utilizing personnel with external project experience to do the following:

- Review the expectations associated with the execution of work (be it approvals to go to work / approvals to modify work instructions / modify designs packages / expectations for how work is carried out etc)
- Identify the value added components (and eliminate the non value added components)
- Look to minimize the operational constraints and constraints posed by operations personnel
- Obtain craft and vender input as to what constraints appear not to be adding value
- Ensure that constraints that may be relaxed are taken into account in the return to service process
- Produce a refurbishment document set for staff to follow defining the expectations for doing work and when they apply (which phase or segment in the project they apply). In addition transition plans need to be in place to move between project work segments (as referenced in the level 1 project plan) or between states as referenced in the Operating policies and principles.

6. There is a cultural tolerance for acceptance of work delays. This tolerance for work delays is being enabled by the leadership team. There is a lack of understanding for what it means to be an 'accountable organization.' Example:
   - Project pre-requisite milestones have moved multiple times
   - Currently no T+1 nor "schedule adherence" accountability meetings exist.

Recommendation # 5

As discussed is this report both in this section and in the observations section, the level of accountability and understanding of what accountability means must be improved on the project. This includes a common understanding by both OPG staff and the contract partners of what it means to be an accountable organization. The RCRB is not suggesting that a management style be implemented that is not consistent with the culture of OPG. OPG does have stated norms and expectations when it comes to accountability and has examples where people and organizations

do demonstrate the required behaviours. The leadership team needs to ensure what is expected is clearly understood, then modeled by the leadership team and subsequently re-enforced and coached.

For a project with multiple contractors, a number of different types of contacts and a large number of interface points between OPG and its Vendors, it is very important that all people involved are truly ready to execute their work. Failure to have a high level of readiness including having the processes whereby work is executed and closed out, can put the project at risk.

It is the view of the RCRB that unless the appropriate amount of progress is made resolving these 5 recommendations, a significant impact to the project schedule and cost will occur.

Observations

During the course of the review week, a large number of observations and interviews were carried out. Outlined below are a number of insights.

1. Refurbishment Work Processes:

The refurbishment project is currently being planned, controlled and scheduled as a "large planned outage." This is not recommended by the RCRB. If OPG determines that it is to be performed as a large 'normal plant process' outage, then the current refurbishment schedule is at risk. Change processes (for CWPs/work plans/ ITPs/ field changes, etc.) need to be streamlined. The RCRB recommends that the process is flow-charted, and the non-value-added steps removed. In addition, the process expectations must be clearly communicated.

- An example of the inefficiencies noted above was found regarding the use of the OPG guidance document associated with making field changes. The relocation of an EQ label on a junction box using the contractor engineering vendors to process this change was estimated to cost upwards of $10K. This document serves as a guide for when field changes are to be used and are clearly inappropriate.
- The vendor/OPG work flow is not aligned to common goal or methodology. (For example, it was unclear if work reports were to be used on the project).
- Managing of field changes, CWPs is not fully vetted and tested for efficiency.
- TSSA involvement must be clearly identified and co-ordinated. Indications are that it has not been fully considered and needs further development.
- The Expedited Material Acquisition process needs to be streamlined. Only associated "value-added" activities should be mandated.
- The vendors openly state the current processes are placing stress on their ability to complete work. These remarks have not been dealt with appropriately (or dispositioned) by OPG.
- Engineering will have 10 resident engineers with design authority. The JV are being directed to utilize this concept as well. This is seen as positive by the RCRB.

2. A fully staffed commissioning group must be put in place:

   - Operations clarity regarding Return to Service (RTS) is still outstanding, and lacks a clear direction (RTS philosophy is not decided). Construction work must be sequenced based on the methodology of the RTS. Currently, there is effectively no RTS group (staffing of this group does not appear to be a priority). There is a small effort being done informally via spreadsheets, which is not part of the Work Control Process. Integration of equipment and systems that will be in 'layup' conditions have not been considered as part of the RTS thought process, but need to be integrated. 'Layup' equipment is being viewed as 'normal outage restoration.' The use of 'partial' versus 'fully compete' system or equipment turnover is not decided.
   - The philosophy of "What does the end state of the project look like" still needs to be documented. RTS activities are not scheduled yet.
   - Communication to the Operation staff on how decisions will be made, or what priorities or philosophies the staff needs to follow and is substantially behind.
   - Metrics are not developed around the key commissioning/RTS activities.

3. Culture: Sense of urgency & accountability:

   - The station needs to articulate and enforce what success looks like associated with accountability. Very simply: do what you say you are going to do, when you say you are going to do it, and do it with the requisite quality. The leadership team lacks the "discipline" to re-enforce the needed attributes associated with accountability.
   - Management behaviour when Schedule expectations are missed is weak. The prevailing 'discussion' at a meeting is focused on when the new target completion date is, but little to no discussion as to why was it missed, why was there no previous warnings or requests for assistance, why there was not a previous recovery plan to ensure the target completion date would not be missed, what is the cumulative impact of the delay on both the project and colleagues, what follow-up is needed, who needs to rally around mitigating the negative impact of the delay, who has overall ownership or corrective action.
   - Any 'enforcement' that does occur is driven by meetings (not process), and the lessons learned appear to be forgotten going forward.
   - "Accordion" was a word used to describe the current scheduled activities. There is a perception that there is still the four month 'defueling window' to plan and execute work before "real" outage starts. Thus there appears to be a perceived 'four-month float' in the work, and conversely little importance (or belief) placed on schedule discipline.

- Further examples of being comfortable (tolerance, willingness to use up schedule float):
    i. EPG3 – work completion is very tight, but there is also a very complicated testing sequence. This project is at risk of not meeting the date committed to CNSC.
    ii. D_2O storage building – looking at November for piping fully installed. The fully complete date is currently scheduled for April 2017. This date has slipped, substantially. The RTS need by date is also April 2017. If completed as scheduled, it will have zero margin.
- In short, both the management team and the contract partners need to make it very uncomfortable for those who do not deliver on their commitments, and offer support wherever they can to get the commitments back on track. That will be the commencement of a true team.

4. Organizational interface:

Both the project and the station have aggressive work programs, performance targets and objectives to achieve. In some cases, these objectives may result in competing priorities that need to be managed. During interviews it was apparent that in some cases, issues may not 'bubble-up' to the right level and the right decision maker. This is needed in order to set the proper priorities. As a consequence, issues may be lingering at a lower management level in the organization for longer periods of time than they should be. An organization with an execution mindset can't allow these types of issues to languish.

Three different types of organization models can be used for the refurbishment project being executed at Darlington:

1. There is a senior leader on the DN site who is accountable for all day-to-day and long-term activity going on at the site.
2. The project is essentially self-contained and antonymous, and does not rely on the other organizations for services etc.
3. The project organization reports to a higher level in the organization.

Currently, a hybrid organization exists which relies on a significant level of alignment, interaction, mutual support, and teamwork. The current approach is not yet mature, and may be difficult to sustain going forward. Clearly, 100% autonomy is not possible. The RCRB is suggesting that a review of how the project is interfacing with the plant, as well as what should be the role of Operations, needs to be periodically reviewed.

August 2013

2. Additional Observations and Recommendations

As with any commercial strategy for a large capital project, there are risks associated with the multi-prime EPC model chosen by OPG for the DR Project. Many of these risks have been recognized and are being monitored by OPG, though they must be discussed on an ongoing basis as realization of some of these risks will impact the success or failure of the DR Project.

- With the multi-prime management approach, Owner's traditionally hire construction managers or program managers to coordinate the EPC contractors' work, and owner's engineers to review program compliance. OPG has chosen to fill these roles, and its success will be dependent its ability to employ a strong, capable and experienced construction management team that is able to effectively coordinate and track the work of such a large, complex project. We would also recommend that the DR Team integrate key construction management individuals into the DR Project Team as early as possible in the Definition Phase.
- OPG's preferred EPC contracting strategy is a new project delivery model introduced for the DR Project. It is also different from that used by OPG's vendors on past projects. Business cultural differences between OPG and vendors' management philosophies will have to be closely managed.
- The RFR contract dwarfs the other major project scopes, and there is a tendency to think of SNC/Aecon as the Project's full-wrap EPC contractor. This is not the case, and management needs to devote attention to the other projects to optimize adjacent project coordination and minimize interferences.
- The ESMSA vendors' performance and OPG's management of the vendors' work on the current Campus Plan scope has been mixed. OPEX from the D20 Storage Facility includes evidence of failures on both OPG's and the vendor's part to recognize that key details were missing from that project's definition which led to unrealistic schedule and readiness expectations[34]. The DR Team should examine these lessons learned going forward.
- The Program/Project approach has the risk of creating "silos" between the Project teams. Although each of the major Project Bundles are self-contained units, the Program must be managed by OPG as a whole, with a single, integrated schedule, cost control system and risk management approach.

Developing a contracting strategy for such a large project has to include a number of key variables. Some contracting approaches are more risky for the owner than others. Some are unsuitable for certain situations. Some strategies work for some owner organizations but do not work for others because the strategy depends on the owner's strengths. There is evidence that OPG took these major considerations into account in deciding on the contracting strategy it is following. However, this strategy will require some significant changes to OPG's prior large capital project mindset, and while growing pains are expected, the Project's success will be largely determined by OPG's willingness to embrace the role and recognize and control the risks associated with the chosen method.

C. Project Controls

OPG's Project Controls team is responsible for essential functions of Schedule, Budget, Risk Management and Document Control. The following is our assessment of the development of each of these key elements to date.

[34] D20 Storage and Drum Handling Project: Modification Planning Lessons Learned Report, D-LLD-38000-1001 (March 4, 2013)

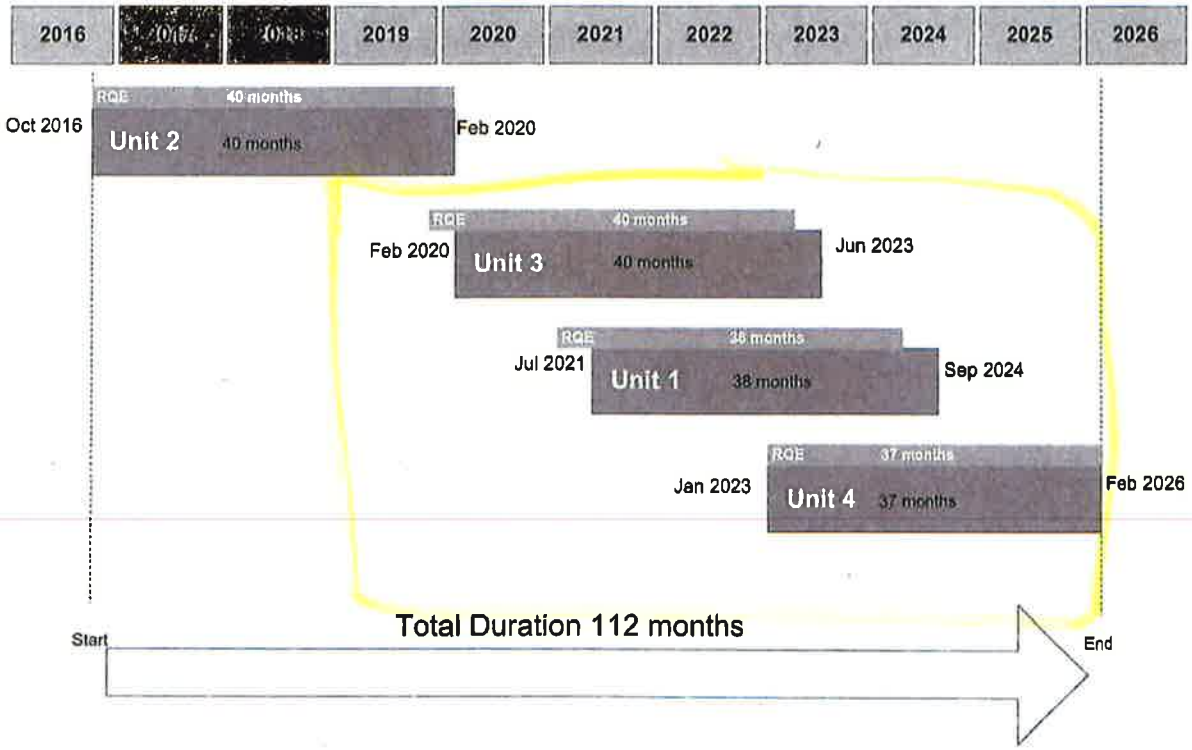
August 2016

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

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

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

Figure A: Refurbishment 4-Unit High Confidence Project Schedule



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

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

November 2015

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

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

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

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

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

Current Estimate of Darlington Refurbishment LUEC

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

Darlington Refurbishment LUEC

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

March 2014

C. Balance of Plant and Other Projects

In our 4Q 2013 Report, we discussed the impact of the review by the Blue Ribbon Panel of DR Project scope. The final recommendations have been made and have been reviewed through the Project Scope Review Board process. As noted on our prior reports, the process OPG used for this review was robust and consistent with the DR Project's management processes. With scope essentially locked down, the attention of the BOP, Services and Islanding projects shift to allocating the work to the performing contractors (mostly ESMSA or SNC/Aecon), completing detailed engineering and establishing target price budgets for the work. Some early indications of scope/pricing from the ESMSA have been mixed. For one such work package, the contractor misunderstood OPG's requirements and submitted a bid premised on re-performing a significant amount of the engineering work that OPG had already performed. The DR Team has rejected these proposals and clarified its requirements, which is delaying the issuance of this work package. The DR Team has increased the time for verifying estimates (from one week to two weeks) to ensure the contractors' pricing and scope are properly aligned. We have recommended the DR Team further align this process by requiring the ESMSA provide its detailed estimates in a manner that facilitates comparison with the internal check estimates from Faithful & Gould. These actions should improve the quality of future ESMSA estimates, though this bears close attention.

IV. Functional Groups Update

A. Engineering

1. Scope Definition

The DR Team has placed significant emphasis on defining scope well in advance of RQE and has set critical milestones for measuring scope definition. One such goal is achieving "Health of Scope" to support detailed design work. The DR Team reports that it is on target to achieve Health of Scope 4, in which all modification work will be known, by the October 2014 milestone. The team's ability to meet this milestone was greatly enhanced by the work of the Blue Ribbon Panel.

Through the end of January, 2014, Engineering had completed 112 Modification Design Packages with 27 known packages remaining. This represents excellent progress over the last year, and the May 2014 milestone for completing MDPs should be met.

2. Planning of Engineering Work

As recommended in the BMcD/Modus 4Q 2013 report, OPG's Engineering attention has shifted from the Definition Phase to planning the next design phases, utilizing the Construction Industry Institute's ("CII") ***Front End Planning for Revamp and Renovation Projects*** as a source of industry best practices. OPG's focus on planning has initiated a 'bottom-up' work hour estimating process for engineering activities that will lead to a more precise resource forecast. Engineering also initiated the use of an engineering deliverables-based blackout chart, the development of which has identified additional issues with the Integrated Level 3 schedule that should enhance the coordination of interrelated activities.

Engineering's focus on planning has also brought attention on the engineering partners of the ESMSA vendors who are responsible for the detail design phase for BOP and F&I work. As noted, ESMSA engineering performance on the F&I projects has been lagging. The DR Team is now taking a much more active role in the management and execution of the F&I projects, and has sought alignment between OPG and the ESMSA's engineering companies' senior management.

The EPC requirements in the ESMSA contracts have compelled constructors and engineering companies who were not previously partnered, to join forces. In our experience, joint ventures of this nature can take several years and several project cycles to mature. The ESMSA joint ventures are still on the early part of this learning curve. The shift within OPG to greater reliance upon external service providers has resulted in some duplication of work effort, churn and mistakes by the ESMSA vendors along with OPG's late recognition of its essential role in managing these vendors. OPG Engineering is moving away from a culture of "observation at a distance" to a much more proactive engagement and active management of the engineering service providers. We continue to encourage this shift in role and perspective.

- Reviewed the management structure and capabilities of the P&M team that started this work down the current path. We have also spent time with P&M's new VP and members of P&M's restructured leadership team to convey our findings and recommendations and gauge the effectiveness of P&M's current initiatives to improve performance and mitigate these earlier management failures.

As noted, these Campus Plan Projects have been plagued by myriad problems that have resulted in significant schedule and cost variances. Our findings show that the predominant cause of these overruns was P&M's original strategy to use a project "oversight" management model for the EPC contracting strategy utilized by OPG that was inappropriate in application and lead to a series of cascading management failures and contractor performance issues. The oversight management model employed a disengaged, "hands-off" approach by the P&M organization which caused the fledgling P&M organization to: (1) wrongly assume that the contractors understood the scope on the basis of performance specifications that outlined scope initial requirements; (2) utilize inexperienced project managers; (3) allow Operations & Maintenance and other OPG stakeholders to initiate scope changes to these projects long after the conceptual design period ended; (4) to accept the poor schedules and cost estimates by the contractors without appropriate vetting and challenge, and which were not updated to incorporate the impact of scope changes on a timely basis; and (5) to inaccurately or untimely report the projects' progress, risks and cost and schedule overruns to the DR Team and senior management.

B. OPG Contractor Management and Contractor Performance

1. Summary

Based on the information we have reviewed, it is apparent that P&M put excessive faith in the ESMSA Contractors' ability to perform this work and an over-reliance on the perceived ability of the EPC contracting model to shift project risk to the contractor and alleviate the need for active project management. As a result, OPG chose to provide oversight of the contractor's work at arms-length. In a recent self-assessment related to the D2O Storage Project's delays, the P&M Project team ("P&M Team") noted that at the onset of the Project, P&M believed "the EPC Process" would mitigate known risks via "project efficiency gains due to the expertise and autonomy of the contractor."[2] This exemplified OPG management's initial hands-off approach to project management that P&M piloted under which the contractor was given autonomy to develop its own scope requirements without process monitoring. As noted in P&M's self-assessment, this model resulted in "unclear expectations, re-work, frustration."[3] P&M's error was misunderstanding the essential nature of the ESMSA contracts, which are not fixed-price EPC contracts that shift all risk and responsibility for performance to the contractors (nor were they ever meant to be). The majority of the Campus Plan Project's execution cost is being performed on a cost-reimbursable target price, where contractors have only a portion of their fee at risk in the event that the target price is exceeded. In our experience, the nature of this work (refurbishment and construction of new facilities on an operating nuclear site) and the fact that the contract is cost reimbursable, require the owner to engage in active management of the contractors and coordinate interfaces. This means providing very specific instructions to lock down scope at the project's conceptual design phase and holding the contractors accountable on a daily basis to meet expected cost and schedule.

- Moreover, it is apparent that the P&M Team did not have the necessary experience, training or internal management direction to properly manage this work. Attachment B is a matrix that provides a summary of our observations regarding the five major ongoing F&I Projects. This matrix shows, among other things, that in the management of the work, P&M:
- Routinely accepted poor quality schedules and cost estimates without adequate vetting;

[2] SCR Number D-2013-19100, January 22, 2014.
[3] Id.

- Single-point responsibility for coordination of the engineering, procurement and construction elements of these projects through these ESMSA partnerships has not been realized, leading to inefficiency, confusion and rework. Moreover, significant OPG intervention has been required to achieve the results obtained to date.

The results of these deficiencies have become clearly apparent: an inability to predict engineering performance, significant churn, poor cost performance and frustration at all levels of the collective organization. These deficiencies have driven Senior Leadership to make changes to the remaining engineering effort for the ESMSA work. These changes include:

- Shifting to a culture of 'active management' of the engineering work;
- Utilizing a collaborative front-end planning methodology for the remaining work;
- OPG taking a leadership role in developing and monitoring the engineering schedules;
- For work in progress, OPG will increase monitoring and provide ready answers through embedded staff within the engineering vendor organizations; and
- For work that has not started, OPG will provide management and direction of the engineering work.

This is a bold but necessary move and one that is endorsed by BMcD/Modus. We will continue to monitor the progress made under this revised plan and provide additional recommendations for streamlining the design process as necessary.

2. Scope Definition

Overall, as mentioned in the BMcD/Modus Assurance Report on Scope, we believe that the DR Team has taken a balanced approach to the development of the DR Project scope. The initial scope identification effort incorporated scope beyond that of refurbishment and life extension, potentially increasing the budget and project complexity. However, to balance this out, the DR Team has continuously monitored and repeatedly tested the included scope through scope reviews and de-scoping exercises. Additionally, the team has monitored scope definition through the gate review process and Health of Scope (HOS) metrics. Through this extended process we believe that the DR Team has struck an important balance between overly limiting scope (and risking scope growth during execution) and being overly-inclusive (and risking excessive project budgets).

The resultant Darlington Scope Requests (DSR's) drive engineering. Through April 24, 2014, Engineering had completed 142 MDP's. While this met OPG's goal, the number of MDP's continues to rise and is now at 161 (as compared to 139 in our last report) with 19 known packages remaining. This is particularly important considering the new path OPG has chosen to take for ESMSA engineering.

However, whereas scope definition may be sound, the development of solutions is not. As the revised plan for ESMSA engineering takes root, the DR Team also needs to examine the assumptions and engineered solutions. The DR Team's Senior Leadership initiated a new control, a monthly Options Review Board ("ORB"), the intent of which is to re-review the approaches the project teams are taking and see if the means and methods in the plan are appropriate, cost effective and still required. At the first ORB, the BOP, Shutdown/Lay-up and Services projects identified initial plans for six different scopes that needed to be reconsidered. These different subprojects suffered from many of the same problems evident with the Campus Plan Projects discussed above, thought these problems are being exposed, escalated and resolved. The ORB found:

- OPG's design requirements can cause confusion, misalignment and very expensive solutions that defy common sense. As an example, based on the guidance from the original MDP, the dehumidification of the turbine deck would have cost upwards of ten times more than OPG has spent in the past performing the same work on laid-up fossil units.

October 2014

Filed: 2016-10-26
EB-2016-0152
Exhibit L, Tab 4.3
Schedule 1 Staff-072
Attachment ??
Page 16 c

- The potential of an insufficient number of qualified radiation protection coordinators to support project execution. This should be addressed through the awarding of the radiation protection services contract.

Corrective Action Program and Use of Operating Experience – WHITE

There have been no changes to the performance in the areas of the Corrective Action Program and Operating Experience. OPG has implemented several high level lessons learned from previous refurbishment projects; including Browns Ferry, Pickering A and Bruce A. These include the need for detailed planning and preparations prior to the start of execution of the project, the need for an integrated schedule, the project reporting to the Chief Executive Officer and the use of a reactor mock-up to verify re-tube tooling and train staff. In addition, there has been an improvement in the identification and distribution of lessons learned throughout the refurbishment organization. These are reviewed by the refurbishment leadership team in its monthly Corrective Action Review Board meeting. There is one area of operating experience for which the manner that the project has implemented is unclear. That area is the review and incorporation of appropriate Significant Operating Experience Reports and equivalent. These are reports issued by WANO (World Association of Nuclear Operators) and INPO (Institute of Nuclear Power Operations) related to significant adverse trends within the industry and they provide both the causes and required actions by individual plants.

The Corrective Action Program is in place and is being used. The majority of issues adverse to quality have been identified in the engineering activities. This is not surprising since engineering represents the most active function at this time. Although the refurbishment CAP program is good, the program implemented by the Projects and Modifications (P&M) organization has several known weaknesses. This should be a concern to the refurbishment organization since the Campus Plan and SIO projects are being managed by the P&M organization and thus conditions adverse to quality are managed though its CAP.

OPG Oversight – YELLOW

The effectiveness of the OPG independent external oversight team (BMcD/Modus) to identify adverse performance trends is adversely impacted by the a certain loss of independence resulting from their providing detailed advice, direction and support to the refurbishment management team.

January 2015

Filed: 2016-10-26
EB-2016-0152
Exhibit L, Tab 4.3
Schedule 1 Staff-072
Attachment 23
Page 24 of

process is the owner acceptance of design agency products. It is not clear that OPG's owner acceptance is fully aligned with industry practice. Given the cost impact and latent risk of engineering errors, it is recommended that OPG request WANO/INPO to perform a review of its engineering processes, specifically its owner acceptance of design agency products.

In conclusion, further management focus is required to support the timely completion of quality engineering packages.

Incorporating Lessons Learned from the Campus Plan and Safety Improvement Projects

With the acceptance of performance weaknesses the contract management of the Campus Plan and Safety Improvement projects and ESMSA contractors, there is a need for refurbishment management to take concrete actions to address the individual lessons learned to prevent similar performance in the core refurbishment projects.

The challenges associated with the Campus Plan and Safety Improvement Opportunity projects are well acknowledged by OPG senior refurbishment management, with routine updates to the Nuclear Oversight Committee (NOC) of the OPG Board of Directors. This challenge has been identified in the monthly reports to the MOE since April 2013. OPG is managing these projects for their completion prior to the start of Unit 2's refurbishment outage. Where completion is challenged (such as the D_2O storage building project), an alternative project is under development to accomplish the requirement for Unit 2. Because of the increased oversight by the NOC and management's increased focus on these projects, it is felt there is no need to continue the specific challenge related to the performance of these projects. The performance will continue to be monitored and reported in the report's scorecard.

These projects have had a number of lessons learned that need to be effectively addressed by the refurbishment organization for the successful refurbishment of the Darlington units. Some of these are recognized by OPG senior management because they have resulted in direct impact on cost overruns and schedule delays. However, there are several that observations and monitoring of the daily activities of these projects. With the exception of refurbishment maintenance and work management, the monitoring of daily performance of these is not performed by refurbishment management. However, if refurbishment manager does not take concrete actions to prevent these (or similar) lessons learned these observations will have negative contributions to the ability for a successful refurbishment outage. These lessons learned and OPG's current ability to prevent a recurrence in performance is summarized in the following table.

January 2015

Lesson Learned	Basis	OPG actions and effectiveness	Likelihood of recurrence
Poor cost estimates	OPG recognizes that several of these projects were started and continued without the appropriate level of cost estimate.	There is increased rigour in the cost estimates for the core projects and revised estimates for these projects. This includes collaborative front end planning for a better understanding of the scope of work and the use of third party estimates for comparison.	Low
Poor execution schedules	Many of these projects started and continued without detailed schedules for engineering and field activities. There is an effort to recover this problem as the projects are in progress.	OPG is supporting the vendors in the development of detailed schedules. There is a requirement for detailed schedules as part of the gate review process. Currently there are struggles obtaining detailed schedules for engineering deliverables.	Medium
Completion of engineering prior to the start of field execution	These projects have started prior to the completion of engineering. Currently there are examples of design engineering delaying field execution in these projects. This will likely continue through the completion of these projects.	This is one of the high level lessons learned that OPG addressed through its infrastructure and milestones for the refurbishment project. That is the basis for having the engineering complete milestone a year prior to the start of the Unit's refurbishment outage. Even with the current challenges in managing the engineering workload, there is sufficient float to complete engineering by the start of execution.	Low

January 2015

Lesson Learned	Basis	OPG actions and effectiveness	Likelihood of recurrence
Management of subcontractors	These projects have had issues with the performance of subcontractors. Issues have included the delivery of engineering products in a timely manner, some engineering quality problems, timely delivery of parts, some quality issues related to parts manufacture, field execution rework and safety performance.	Similar issues have started with the management of subcontractors for core refurbishment projects.	High
Not effectively using station processes	There are a number of station processes which are required to be used by the contractors, but are not effectively implemented. These include work management processes, work protection, work authorization, event free challenge process, etc. Refurbishment operations and maintenance is assisting in facilitating the ESMSA contractors through some of these processes.	It is assumed that the contractors and subcontractors will have processes similar to the OPG processes. This is believed to be a contractual requirement. Processes have not been fully aligned or equivalent in the few cases that have been tested. For example, during Q4 there have been incidents involving lifting and rigging with both the Joint Venture and ES Fox. The initial Turbine Generator FME plan was rejected.	Medium

July 2015

The following Lessons Learned have a medium likelihood of recurrence without on-going management focus and successful completion of planned actions:

b. Completion of engineering prior to the start of field execution

Many of the Campus Plan and Safety Improvement Opportunities (SIO) projects started and continued field construction without the completion of detailed engineering. This continues for some important projects such as EPG 3, CFVS, D_2O Storage Building and the Auxiliary Heating System. This has contributed to on-going revisions to costs and schedules. These projects demonstrate the consequences of not starting field execution before engineering is actually completed. This was previously identified by OPG refurbishment management as one of the major lessons learned from previous refurbishment and large nuclear projects. Engineering must be completed prior to the start of field execution. As a result, OPG established a milestone for the completion of engineering of August 2015. Even with the current challenges in managing the engineering workload, there is sufficient float to complete engineering for the projects being executed after Unit 2 breaker open.

The current challenge is for core refurbishment projects that are being executed prior to Unit 2 breaker open. The RWPB has started construction without completion of engineering or nuclear safety analysis. It is recognized that engineering has been done for the portions of procurement and construction that have started, but this is not the standard of engineering complete prior to start of construction that refurbishment management is striving. It is not surprising that cost and duration estimates have been revised on a number of occasions. The current cost estimate is $108M and target completion date of December, 2016.

In addition, there are several shutdown/layup/services and support projects to be executed in 2015 and 2016, as prerequisites to breaker open. These include Breathing Air installation, Service Air installation, Negative Pressure Containment modifications and several facilities. The August 15th milestone for completion of engineering will not be met for some of these projects and this results in downstream impacts of the procurement of materials and generation of CWPs. Refurbishment management is initiating a plan to manage the impact of the late engineering.

c. Poor engineering and field execution schedules

Through the duration of the Campus Plan and Safety Improvement Opportunity projects, the organization has been plagued with inaccurate and unreliable

OPG ACTIONS TAKEN/PLANNED IN ALIGNMENT WITH LTEP PRINCIPLES

2013 LTEP – Nuclear Refurbishment Principles	OPG Actions Taken/Planned in Alignment with LTEP Principles
Minimize commercial risk on the part of ratepayers and government	• Locked down project scope well in advance of starting construction; • Fully developed engineering and planning of the work so that it is 100 per cent complete prior to the start of construction; • Built a full-scale mock-up of the Darlington reactor and vault and used them to fully test the tools and determine tooling durations in order to build a reliable schedule. All workers will be trained using the tools in the mock-up prior to working in the plant; • In phases, developed a Release Quality Estimate that incorporates a high-confidence budget and schedule for the work; • "Unlapped" Unit 2 from subsequent units so that the focus can be on planning and construction of a single unit to ensure its success while documenting lessons learned from the first unit and applying them to work processes on subsequent units; • Utilizing target price contracts for the execution phase that are based on developing cooperation, transparency, and risk sharing with key vendors; • Utilizing fixed price contracts for certain execution phase scope that is well defined and where risk transfer to a third party is appropriate; • Negotiated various off-ramps and stages into contracts; and • Established a robust risk management process to directly identify and administer commercial risks.
Mitigate reliability risks by developing contingency plans that include alternative supply options if contract and other objectives are at risk of non-fulfillment	• Decision to "unlap" Unit 2 from the other unit refurbishments, which predated the LTEP, was intended to mitigate performance risk and allow the DRP team to focus on refurbishing the first unit prior to commencing subsequent units. If the first unit is not successful, off-ramps are in place; the second unit refurbishment will not commence until the first unit is successfully returned to service. • Risk assessment and appropriate contingency and mitigation plans for each execution work package have been developed. • OPG's investment in the reactor mock-up is being used to perform full integration and commission testing of tools needed for refurbishment; lessons are being learned on the mock-up,

GEC Interrogatory #4

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

Interrogatory

Reference:
Exhibit D2-2-11 Attachment 3 Page 9 of 122
"It is typical for megaprograms, such as the DRP, to be managed on a planned duration that is less time than reflected in the high-confidence schedule."

And at p. 10 "The Facilities and Infrastructure Projects (F&IP) and Safety Improvement Opportunities (SIO) were not necessarily completed per the initial planned schedule and estimate…"

a) Please provide details of the various percentage schedule delays and percentage cost overruns in the F&IP and SIO projects relative to the high confidence schedule and estimate and the planned schedule and estimate.

b) Please provide an analysis of the degree of adherence to date to the high confidence and the panned schedules for each major work component of the DRP. Please do so with reference to the highest level schedule (as described at page 31 of the Pegasus evidence) that existed at the time of OPG's prior OEB application and with respect to the initial version of the level 5 schedule.

c) Please provide a complete history of the DRP's expected unit completion dates and outage duration schedules showing initial assumptions and changes to date.

Response

a) The F&IP and SIO projects were not planned in the same manner as the Unit 2 refurbishment outage, with planned (target) and high confidence schedules and estimates. OPG is therefore unable to provide the analysis requested. Variance explanations for F&IP projects greater than $20M, where the project cost variance was greater than 10% are provided in Ex. D2-2-10, pp. 11-22.

b) As OPG has just begun to execute the refurbishment outage on Unit 2 (Breaker Open was on October 15, 2016), this analysis is not possible.

Witness Panel: Darlington Refurbishment Program

- Modus Strategic Solutions Canada Company and Burns & McDonnell Canada Ltd. Review of the RQE development process (Ex. D2-2-8, Attachment 3); and
- an expert panel, comprised of four individuals with retube and feeder replacement experience, review of the cost estimate for retube and feeder replacement (Ex. D2-2-8, Attachment 4).

4.0 REGULATORY FRAMEWORK

4.1 Amendments to O. Reg. 53/05

On January 1, 2016, Ontario Regulation 53/05, *Payments Under Section 78.1 of the Ontario Energy Board Act* (O. Reg. 53/05) was amended to include additional provisions that deal with nuclear refurbishment costs and to define the scope of the OEB's jurisdiction in considering this application. In relation to the DRP, the amendments concern the following key aspects:

- The need for the DRP has been established by the regulation. As set out in the regulation, in setting nuclear payment amounts during the period from January 1, 2017 to the end of the DRP, the OEB shall accept the need for the DRP in light of the Ministry of Energy's 2013 LTEP and the related policy of the Minister endorsing the need for nuclear refurbishment.[5]
- If the OEB is satisfied that costs of the DRP were prudently incurred and financial commitments were prudently made, the OEB must ensure that OPG recovers its capital and non-capital costs and firm financial commitments incurred for the DRP.[6]
- The OEB must permit OPG to establish a rate smoothing deferral account for the DRP.[7]
- In setting payment amounts for the deferral period (i.e. from January 1, 2017 to the end of the DRP), the OEB must determine, on a five year basis for the first ten years of the deferral period, and thereafter on such periodic basis as the OEB determines, the portion of the approved nuclear revenue requirement for each year that is to be deferred for purposes of making more stable the year-over-year changes in the

[5] O. Reg. 53/05, s. 6(2), para. 12(v).
[6] O. Reg. 53/05, s. 6(2), para. 4.
[7] O. Reg. 53/05, s. 5.5.