Darlington Refurbishment

Business Case Summary

November 14, 2013, Revision 1

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1.0 RECOMMENDATION:

In 2009, OPG’s Board of Directors approved the Economic Feasibility Assessment and the Business Case Summary related to the refurbishment of the Darlington Nuclear Generating Station. The Board approved the project and released funds to commence preliminary planning within the Definition Phase in accordance with the Program’s release strategy. Management also approved the release of funds in November 2011 and November 2012 to complete detailed planning activities within the Definition Phase. The purpose of this Business Case Summary is to provide an update on the status and economics of the Darlington Refurbishment Program (“DRP”) and to request funding to continue to complete planned 2014 detailed planning activities within the Definition Phase.

In 2010, Management communicated that the project cost would be less than $10 Billion in 2009$ which is equivalent to $10.8 Billion in 2013$, excluding capitalized interest and escalation. Taking into account the current level of cost and schedule development, Management continues to communicate, with high confidence, that the cost of the DRP will be less than $10 Billion in 2013$, excluding capitalized interest and escalation. By asserting high confidence that the DRP will be less than $10 Billion in 2013$, Management is indicating increasing confidence regarding the maximum amount likely to be expended. The $10 Billion cost estimate in 2013$ is $12.9 Billion including capitalized interest and future escalation.

The current point estimate being used for the calculation of the Levelized Unit Energy Cost (“LUEC”) is Billion (2013$), including Billion of project and program contingency and $820 Million life-to-date costs to the end of 2013. This point estimate also includes approximately Million in provision funds related to Re-tube Waste Containers as well as Million related to facility improvements required at Darlington due to an additional 30 years of post-refurbishment operations. This project estimate, including capitalized interest and future escalation translates into a completion cost of Billion.

At a cost of Billion (2013$), the Levelized Unit Energy Cost (“LUEC”) of refurbishing and continuing to operate the Darlington units for a further 30 years is estimated to be 7.9 ¢/kWh (2013$), based on a high-confidence estimate of the Darlington Refurbishment Program. Excluding costs for fixed Corporate Overheads for Pension and Other Post-Employment benefits which are independent of the decision to refurbish Darlington, the LUEC is estimated at 7.5 ¢/kWh (2013$). In 2010, Management had communicated that the project LUEC would be less than 8 ¢/kWh in 2009$, which is equivalent to 8.7 ¢/kWh in 2013$.

The economics of refurbishing the Darlington Station are comparable with Combined Cycle Gas Turbines (CCGT) at a median long-term forecast of gas prices of approximately $6/mm BTU and assuming carbon prices of $15 - $30/tonne. At median gas prices and $15/tonne carbon prices, the LUEC for CCGT is estimated at 7.5¢/kWh (2013$), with the carbon pricing accounting for 0.6 ¢/kWh of that LUEC. At low long-term gas prices of about $4/mmBTU and zero carbon prices, the price of CCGT would be more favourable than the price for refurbishing the Darlington Station. It should be noted that the costs to make gas-fired generation carbon-free (i.e. carbon sequestration), is estimated to be the equivalent of a $100/tonne carbon price, which would add 4 ¢/kWh to the LUEC of a CCGT.

While CCGTs have shorter execution lead times, lower up-front investment and lower ongoing operations, maintenance and administrative costs, there are significant uncertainties with regards to future gas prices and the potential implementation of carbon prices. There are other considerations which contribute to and support the favourable economic assessment for refurbishing the Darlington Station. These include:

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

Management’s assessment is that the refurbishment of the Darlington Station would also be competitive with the recently completed refurbishment of Bruce Units 1 and 2. Based on the Auditor General’s 2007 assessment of the price being received by Bruce Power for the output of Bruce Units 1 and 2, management has estimated the LUEC for those units at approximately 8.5 ¢/kWh (2013$).

Since the 2009 Feasibility Assessment, and as communicated in November 2011 and November 2012 as part of the Detailed Planning release of funds (Release 4b), Management has revised the overall timeline and release strategy for Darlington Refurbishment, including the submission of the Release Quality Estimate (RQE) in October 2015 and a first unit refurbishment start date of October 2016.

As a result of OPG’s improving confidence in the life of critical components at Darlington and the resulting opportunity this creates to maximize the value of the asset and to smooth overall rate impact while mitigating execution risk of the DRP, Management recommended the removal of the overlap of the first and second refurbishment units in June, 2013, effectively delaying the beginning of the refurbishment outages on the 2nd, 3rd and 4th units by nominally 18 months each. This schedule change was approved by the CEO and forms the base schedule planning assumption for this November 2013 updated Business Case.

Management is seeking a partial release of Detailed Planning funds (Release #4c) to complete 2014 planned deliverables in the amount of $680 Million. The total cumulative funds released to the project, including this release, will total $1,608 Million including capitalized interest, escalation, and contingencies.

<table>
<thead>
<tr>
<th>$ Millions (including contingency)</th>
<th>Cash Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LTD 2012</td>
</tr>
<tr>
<td>Currently Released (Releases #1 - 4b)</td>
<td>380</td>
</tr>
<tr>
<td>Requested Now (Release #4C)</td>
<td>-15</td>
</tr>
<tr>
<td>Cumulative Release</td>
<td>365</td>
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</table>

Management, in planning for the DRP, has negotiated contracts that limit OPG’s exposure should a decision be made not to continue the DRP. Based on the amount of work currently in progress, should a decision be made not to continue the DRP, the currently committed cost to close the project, including demobilization of project staff and cancellation of existing contracts, material orders, etc., is estimated to be $200 Million. Management is not requesting a release of funding for demobilization costs with this release.

Key 2014 Deliverables, as defined in Appendix D, to be completed in the Detailed Planning Phase include:

- Integrated Improvement Plan (IIP) and Global Assessment Report (GAR) to support the 10 year license application for Darlington in 2014.
- Progression of refurbishment pre-requisite work including construction of facilities and infrastructure projects, safety improvement projects (e.g. Third Emergency Power Generator,
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Containment Filtered Venting System), as well as scope defining inspections and unit islanding modifications.

- Negotiation and award of remaining major contracts by Q1 2014 including Steam Generators and Turbine Generator Engineering and Construction contracts.
- Progression of detailed engineering.
- Reconstruction of the Holt Road Bridge to improve traffic flow to the project and in order to not impact traffic flows in the adjoining communities.
- Progression of design, fabrication, and testing of R&FR tooling and mock-ups to determine project durations for re-tube and feeder replacement activities.
- Scope finalization and further development of the project RQE to be issued by October 2015.
- Development of project agreements with the Building Trades Union ("BTU") through EPSCA; and continued discussions with the Power Workers Union ("PWU") to establish labour certainty throughout the DRP.

2.0 SIGNATURES

Submitted By:

Bill Robinson
Senior Vice President, Nuclear Projects

Approval per OAR Element 1.3.

Finance Approval:

Donn Hanbridge
Chief Financial Officer

Tom Mitchell
President and Chief Executive Officer
BACKGROUND AND ISSUES:

In June 2006, the Ontario Government directed OPG to begin feasibility studies on refurbishing its existing nuclear plants. The need for refurbishment of nuclear plants was also addressed in the Ontario Power Authority’s Integrated Power System Plan I (IPSP I) issued in 2007 and the Ontario Government’s Long-term Energy Plan issued in November 2010 and in the Government’s Supply Mix Directive issued to the OPA in February 2011. At the time of writing, the Ontario Government was in the process of revising the Long-term Energy Plan (known as LTEP II) for potential issuance in late 2013, and it is expected to include a recommendation that the refurbishment of Darlington be pursued.

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

The initiation Phase concluded on December 21, 2009 with OPG Board approval of management’s recommendation to proceed to refurbish the Darlington units. In November 2009, concurrent with approval to proceed with the project, the Board of Directors released $240.7 Million for Preliminary Planning within the Definition Phase of the project. Funding included $102.5 Million for Preliminary Planning, as well as $138.2 Million for the design and construction of facility and infrastructure projects required prior to refurbishment of the units and/or to support the post-refurbishment operations period.

On November 17, 2011, OPG’s Board of Directors approved the revised overall project timeline, the updated Program Release Strategy incorporating an October 2015 Release Quality Estimate (revised from October 2014 in order to incorporate tool testing results from the Re-tube and Feeder Replacement project), and Management’s recommendation to move to the Detailed Planning Phase including a partial release of $436 Million.

In November 2012, OPG updated the DRP economics including cost and schedule updates, post-refurbishment operational assumptions, and the resulting Levelized Unit Energy Costs (LUEC). OPG’s Board of Directors approved a further partial release of funds, for 2013 deliverables, in the amount of $492 Million for a cumulative project release of $928 Million.

Total releases to date are $928 Million for the Preliminary Planning and Detailed Planning Phases of the Definition Phase. OPG is requesting an additional $680 Million to complete 2014 deliverables within the Definition Phase of the project for a cumulative release of $1,608 Million. The total Definition Phase cost estimate is projected to be $2,365 Million. Releases to date and projected are shown in Figure 1 – Darlington Refurbishment Program – Release Summary.

A detailed cost and schedule and release quality estimate is planned to be completed by October 2015 and the execution of the first unit’s refurbishment outage is planned to start in October 2016.
Status of Work in the Definition Phase:

The status of Detailed Planning is reported to the Nuclear Oversight Committee on a quarterly basis; the latest report, as of September 30, 2013, provides a status of the Detailed Planning Phase.

The following is a summary of the major planning activities.

a. **Project Planning**

   **Project Management**

   The Project Management organization, using a “strong project matrix” model, for the Definition Phase of the project has been put in place. The key roles on the project team include Engineering, Execution, Supply Chain, Contract Management, Managed Systems Oversight, and Project Planning and Controls. All positions report to the Senior Vice President of Nuclear Refurbishment who has the overall accountability to deliver the project.

   The project is currently developing the organization model and supporting strategies, including professional staffing and labour strategies, for the execution phase of the project.
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Project Governance

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

Project Planning

At the time of the initial economic feasibility assessment in 2007, the Darlington Nuclear units were predicted to reach their nominal end-of-service lives in 2019 to 2020, based on a nominal fuel channel life expectancy of 210,000 Effective Full Power Hours. End-of-service life predictions are continually reviewed as new inspection information and knowledge of possible degradation mechanisms becomes available and forecast productions levels are updated. Based on the expectation of nominal end-of-service lives in 2019 to 2020 for the Darlington units, on June 12, 2008 the CEO approved the initial planning assumptions for Darlington Refurbishment, including the reference schedule. At that time, the planning assumptions were based on a first unit refurbishment start date of October, 2016. Each unit’s refurbishment was to last 25 months, and, with a 4 month overlap of unit outages, the overall duration (elapsed time) of the refurbishment outage window would be 88 months for the 4 units with 100 actual outage months.

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

OPG has pursued increased fuel channel life for both Pickering and Darlington through the Fuel Channel Life Management Project with the aim of developing high confidence in the fuel channel service lives. Recent developments indicate that there may be an opportunity to extend the lives of the fuel channels at Darlington beyond the nominal life of 210,000 EFPH. This opportunity is being explored through a Fuel Channel Life Extension project, which builds on the work accomplished in the Fuel Channel Life Management project. The Fuel Channel Life Extension (FCLE) project is scheduled to be launched in early 2014 and has, as one of its objectives, the achievement of high confidence in 235,000 EFPH on the fuel channels at Darlington.

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

This schedule will continue to be developed in the Detailed Planning phase in consultation with planning work to be performed in conjunction with the Re-tube and Feeder Replacement (R&FR) vendor. A release quality performance baseline schedule will be issued as part of the RQE in October of 2015.

The following table provides a summary of the current refurbishment start dates and overall durations currently in use for planning purposes.
Table 1: Current Darlington Schedule Planning Assumptions

<table>
<thead>
<tr>
<th>Unit</th>
<th>Start of Refurbishment Outage</th>
<th>Finish of Refurbishment Outage</th>
<th>Duration (months)</th>
<th>Overlap on Previous Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2</td>
<td>October 2016</td>
<td>September 2019</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>October 2019</td>
<td>September 2022</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td>D3</td>
<td>March 2021</td>
<td>February 2024</td>
<td>36</td>
<td>19</td>
</tr>
<tr>
<td>D4</td>
<td>October 2022</td>
<td>September 2025</td>
<td>36</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Total Unit Outage Months (4 units)</td>
<td></td>
<td>144</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Refurbishment Window</td>
<td></td>
<td>108</td>
<td></td>
</tr>
</tbody>
</table>

Scoping

A Scope Review Board ("SRB") with supporting governance was put in place to approve the scope of the DRP. The technical scope for the refurbishment project was initially confirmed in May 2012. Since that time, as a result of engineering studies and analysis, results of planned inspections, and completion of regulatory submittals including the Integrated Safety Review ("ISR") and the Environmental Assessment ("EA"), scope continues to be developed and finalized.

Contracting

The DRP is a multi-phase project made up of individual projects of various sizes. As part of the Definition Phase, OPG developed an overall Commercial Strategy and separate Contracting Strategies for all major project work packages.

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

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

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

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

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

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

OPG found that although there was price certainty in a lump sum turnkey strategy, it came at a cost including loss of control of design, schedule and management of key aspects. Additionally, the risk premium was out of proportion to the corresponding transfer of risk since various exclusions or force majeure provisions diminished the transfer of risk.
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Under the project management model, one firm would be responsible for planning the project, negotiating requirements and managing the work packages. Although this provides the owner with project management experience, there can be lack of alignment between the project manager, owner and contractors, especially if the project manager was also participating in the completion of an aspect of the project. There would also be a risk premium factored into the arrangement.

In examining the alternatives, OPG took into consideration lessons learned from other nuclear refurbishment projects such as the consequences of schedule slippage and replacement power where a lump sum turnkey agreement was used; and in another instance, a mid-project commercial strategy change (i.e. the abandonment of the project management model and the adoption of the multi-prime model).

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

Engineering

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

As of September 30, 2013, over 140 owner specified modification design packages (MDP) have been prepared. These MDP packages define the scope requirements and are provided to the major project contractors in order to perform detailed engineering. Engineering is on track to complete all MDP’s, approximately 180, by mid 2014.

In parallel, Engineering, as the Design Authority, is providing oversight of all engineering deliverables being prepared by each contractor working on the DRP.

In 2013, Engineering also completed 57 engineering studies in order to further define scope.

An update of the OPG construction and engineering design standard manuals which will be provided to all contractors working on the DRP was also completed in 2013.

Cost Recovery and Financing

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

OPG continues to discuss with the Province the need for greater assurance of cost recovery and has suggested regulatory changes to facilitate this. The Province continues to support the DRP and OPG expects that the Long Term Energy Plan to endorse the DRP.

In the current OEB application, OPG is seeking recovery of OM&A costs associated with the project, and findings that OPG’s commercial and contracting strategies for the DRP are reasonable and that the capital expenditures that we have proposed for 2014 – 2015 are reasonable.
b. **Major Projects**

**Re-tube and Feeder Replacements**

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

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

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

During the definition phase, OPG and its selected contractor will complete the detailed design of the project, procure long lead materials, fabricate long lead components and tools, test the specialized tooling and complete final planning activities. At the conclusion of the definition phase, the "execution phase target price" will be determined to estimate the total cost to complete the execution phase work with upper and lower cost sharing bands. Financial incentives also exist for early completion of each unit outage, and financial penalties exist for failure to complete unit outages within the agreed upon schedule.

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

a. **R&FR Mock-ups**

Re-tube and Feeder full-scale Calandria mock-up construction is in progress; reactor components have been ordered, installation of East and West Vault structural steel is complete, fueling machine bridge installation is complete, fabrication of the fuel channel components are in progress, and reactor face machining has commenced.

b. **R&FR Tooling**

On July 31, 2013, R&FR tooling preliminary engineering was completed ahead of schedule. Assignment of purchase orders to subs to fabricate the tools is currently in progress.

c. **Execution Phase Planning**

Detailed Engineering for station modifications required to execute the Re-tube and Feeder replacement work program are now in progress. Long lead material orders, including end-fittings, pressure tubes, feeder tubes etc. are in progress of being awarded. A Class 4 cost and schedule estimate has been completed; the project is now developing comprehensive work packages (CWPs) in preparation for development of a Class 3 estimate by Q2, 2014.

**Turbine Generator**

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

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

The scope of the work for the second contract includes the field work required for installations, repairs and replacements of equipment and components, and engineering integration of the OEM equipment with the OPG Engineering Change Control process. The contract is following the competitive procurement process and is expected to be awarded early in 2014.

Fuel Handling

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

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

The non-field related work will be performed under an Engineering Services and Equipment Supply contract issued to GE-Hitachi Nuclear Energy Canada Inc. (GHNEC) on May 17, 2013. The contract is made up of firm/fixed price for components and equipment and a cost reimbursable element for technical support during the defueling operation.

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

The second work area of Fuel Handling is refurbishment of the Fuel Handling systems. The work for the Fuel Handling System has been divided into 6 work packages. As part of the 2013 Darlington Scope Review, a portion of the scope has been transferred to the Darlington Station to be performed as part of the stations Fuel Handling Reliability project. The balance of the scope will be awarded in late 2013 and early 2014.

Steam Generators

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

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After evaluating the work and other contracting considerations, OPG has decided to bundle all of the Steam Generator Work into one work package to be competitively bid. OPG considered various contracting models and determined that the Steam Generator work package fits well into a model where an EPC contract is negotiated.

A Request for Proposal (RFP) for Steam Generator primary side clean was issued on February 28, 2013. Bids have been subsequently received and evaluated and contract negotiations are complete. The contract is expected to be awarded before the end of November 2013.

Balance of Plant

Balance of Plant work represents the remaining work to be performed by the DRP that is not included in one of the above major packages.

As a result of the Darlington Scope Review the balance of plant project scope has been reduced. The remaining scope has been evaluated and divided into 4 bundles based on system and/or location.

A team has been established to review procurement options to expedite contract award for this work. Options include the direct allocation of work to the existing Extended Services Master Service Agreement contractors and procurement with additional vendors issued for specialized work; i.e. Shut Down System (SDS) computer replacement.

c. Facility and Infrastructure Projects

Darlington Energy Complex

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

Water and Sewer

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

The project is currently in the execution phase. The Water/Sewer main will go into service in 2013. The execution of the west pumping station and related water/sewer distribution lines to support Refurbishment facilities will be installed in mid 2014. The demolition of the existing Sewage Treatment Plant will also commence in 2014.

Heavy Water Storage and Drum Handling Facility

The Heavy Water (D2O) Storage and Drum Handling Facility project will provide heavy water storage capacity during refurbishment and support ongoing station operations. This storage capacity is needed for the heavy water removed from the reactors being refurbished (approximately 1,500 m3, per unit) and to facilitate flushing and other support operations associated with the preparation of the Darlington units for refurbishment work. The project will also implement improvements for heavy water management at the Tritium Removal Facility (TRF) including increasing operational storage; adding D2O drum handling, cleaning, testing, and storage capability; and consolidating offices for TRF staff.
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The project commenced start of installation on October 1, 2013 with a planned 2015 in-service date.

Darlington Operations Support Building Refurbishment

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

The project is currently in the definition phase; detailed design will be complete in early 2014 at which time the project will commence the refurbishment of the OSB facility. Preliminary Supply and Install contracts will be awarded in late 2013 for cladding/windows, elevator, HVAC, and Cladding. The targeted in-service date for the facility is October 2015.

Auxiliary Heating System

This project will provide a source of reliable back-up steam to the Darlington main heating steam header. Back-up steam is needed to support irregular operating conditions such as an event where all four turbine units are shut down in the winter, to mitigate potential major equipment damage due to freezing. This will be achieved by replacing the existing original Construction Boiler House with a new facility that can, in the event of a four unit shutdown, provide reliable back-up steam at a sufficient capacity to meet the station’s needs. This back-up steam will contribute to maintaining the temperature inside the Powerhouse and Tritium Removal Facility/Heavy Water Management Building at levels needed to prevent impairment of essential systems due to freezing.

The project is currently in the definition phase; detailed engineering is underway. The facility has a planned in-service date of April 2015.

Electrical Power Distribution System

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

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

Holt Road Interchange Upgrade

Refurbishment of the Darlington units requires a significant increase in personnel and material deliveries to the station and the area immediately to the west of the station. The current road infrastructure cannot handle the anticipated increase in vehicular traffic, which would result in delays and increased cost. Additionally, backups onto Highway 401 and the South Service Road would impact commuters going to and from the Greater Toronto Area from Bowmanville and points east as well as impacting other businesses adjacent to the Darlington site.

Improvements to the Highway 401/Holt Road interchange are required to minimize traffic delays that could impact on the cost and schedule of the Refurbishment project and minimize the impact of the project on the surrounding community and the environment.
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Road access was identified as a key risk to the Darlington New Nuclear Project (DNNP) due to the volume of traffic from the simultaneous execution of new station construction and refurbishment of the existing Darlington units. In 2008, the DNNP agreed to fund preliminary design work for the upgrade of the Holt Road interchange, which was supported by the DNNP Environmental Assessment. However, with the delay in the New Nuclear Project, design work was stopped in the summer of 2011.

The Environmental Assessment for Darlington Refurbishment and Continued Operations confirmed the need for the upgrade. A follow-up assessment was completed in January 2012 to determine the impact of DN Refurbishment only. This assessment recommended improvements, albeit at a lesser scope.

In November 2011, the Darlington Refurbishment project opened discussions to resume design work based on refurbishment staffing and material delivery volumes only. This design work resumed in February 2012 with a Memorandum of Understanding (MOU) between OPG and the MTO regarding funding signed in August 2012.

OPG is currently finalizing its business case recommending that the Holt Road Interchange upgrade project proceed.

d. Regulatory Projects

Environmental Assessment

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

Integrated Safety Review

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

Integrated Implementation Plan and Global Assessment Report

OPG is currently in the process of preparing the Integrated Implementation Plan (IIP) and Global Assessment Report (GAR), as well as a licensing application for the DRP; all will be submitted to the CNSC by December 2013, with approvals expected by early 2015. The new licence will allow OPG to execute the refurbishment and continue to operate DNGS for an additional 30 years assuming all licence conditions and regulatory obligations are met.

e. Safety Improvement Projects

Powerhouse Steam Venting System

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

The project is projected to be in-service in the fourth quarter of 2015.

Containment Filtered Venting System (CFVS)

The Containment Filtered Venting System detailed design contract was awarded ahead of schedule to E.S. Fox / HSL / Westinghouse on August 27, 2013.
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Darlington Fire Water System
The purpose of this portfolio project is to separate the Emergency Service Water system, required for reactor safety, from the fire water systems. The project is currently in the conceptual phase.

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

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

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

The Emergency Power Generator 3 project is forecast to be placed in service in the fourth quarter of 2015.
3.0 ALTERNATIVES AND ECONOMIC ANALYSIS

Alternatives

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

This alternative positions OPG to be ready to execute a successful refurbishment of the first Darlington unit in October 2016, by ensuring that the Definition Phase of the Project is focussed primarily on readiness of the first unit, applying operating experience/lessons learned of other refurbishments, and lowering overall execution phase risk on the first unit. This will also provide OPG with a better opportunity to apply lessons learned on the first unit against subsequent units.

The execution schedule for this alternative is described in Section 3.0 of this Business Case Summary. To enable this alternative, the Fuel Channel Life Extension Project, which is being submitted for Board approval concurrently with this Refurbishment Business Case and which has, as its goal, achievement of high confidence in fitness-for-service of the fuel channels to 235,000 Effective Full Power Hours (EFPH) would need to be successful.

Economic assessment shows that this recommended alternative is more economical to the Ontario system than the previous overlapped alternative provided that the units can be operated to 235,000 EFPH, particularly on the last unit to be refurbished, Unit 4. Should the Fuel Channel Life Extension Project indicate, with sufficient lead time, that the Darlington Units cannot be safely operated to as high as 235,000 EFPH, Management has the option of modifying the schedule to mitigate the risk of idle time and significant cost impacts.

This alternative mitigates risk to the execution of the refurbishment of the first two units; as there would be no overlapping execution periods. This alternative also provides additional time for lessons learned on the first unit to be applied to subsequent units. However, by extending the overall outage window, this alternative does result in increased costs of OPG Program Management and Support, by approximately $130 Million, and there are greater challenges with this alternative than with Alternative 2 (overlap of the first two units) in retention and continuity of the trades’ staff and potentially some key project staff.

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

This alternative also positions OPG to be ready to execute a successful refurbishment of the first unit at Darlington in October 2016. However, this alternative carries increased risk relative to Alternative 1 in the Definition phase of the first two units, by dividing the attention of resources preparing for the first unit’s refurbishment between the first two units. The overlapping execution phases would also result in greater risk to the execution of the first two units, and provides reduced time, compared to alternative 1, to incorporate lessons learned from the first unit into the execution phases of the remaining units.

Economic assessment shows that this Alternative is less economical to the Ontario system, if 235,000 EFPH are achievable on the fuel channel life. Thus, provided that the units can operated to 235,000 EFPH or beyond, particularly on the last unit to be refurbished, Unit 4, Alternative 1 is preferred. Should the Fuel Channel Life Extension Project conclude that the Darlington Units cannot be safely operated to 235,000 EFPH; Management has the option of reverting modifying the schedule to fully or partially mitigate idle time risks.
Alternative 3: Delay the Approval of continued work in the Definition Phase of the DRP by 1 or more years – NOT RECOMMENDED.

This alternative would result in a suspension of the Definition Phase work, including work on the required infrastructure to execute the program, and would likely result in increased costs to demobilize and remobilize the significant planning, engineering, project management and oversight organization which OPG has built up over the past several years. There is a risk of a loss of key resources to other projects, in particular, competing refurbishment projects on the Bruce units. The risk of “idle time” on all of the units increases relative to Alternative 2, but is decreased on Units 1, 3, and 4 relative to Alternative 1.

Economic analysis shows that this alternative is more costly to the Ontario system than the recommended alternative (Alt 1).

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

Refurbishment of the Darlington units is supported by the Ontario Power Authority’s (OPA) IPSP I and is included in the Ontario Government’s Long-Term Energy Plan (LTEP) (2010) and in the Supply Mix Directive (2011) issued by the Government to the OPA, and is expected to be included in the LTEP II plan to be released in the fall of 2013. Compared to CCGT options, which require a lower capital investment, the refurbishment of Darlington exposes OPG to significant risk exposure because of the high capital cost. However, CCGT options are more expensive on a life cycle basis than the Darlington Refurbishment Project at median gas price forecasts and assumed carbon taxes and have significantly higher exposure to the risk of fuel costs increases, during their operating lives.

Economic Assessment

An assessment has been done of the relative economics of Alternatives 1, 2 and 3 at different assumed lives of the fuel channels. This assessment is summarized in the comparative Net Present Value Table below. Positive numbers mean that the Alternative is more economical; negative numbers mean that the Alternative is worse. It should be noted that, should the targeted number of EFPH not be achieved, there are mitigating actions that could be taken to avoid idling the units prior to refurbishment, including adjusting the refurbishment schedule and/or performing selective maintenance or replacements of fuel channels to enable the units to continue to operate until their refurbishment outages.

<table>
<thead>
<tr>
<th>Alternatives Compared</th>
<th>Operating Life Achieved (EFPH)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>210,000</td>
</tr>
<tr>
<td>2016 Start with No Overlap of 1st and 2nd Units (Alt 1) vs. 2016 Start with 1st and 2nd Units Overlapped (Alt 2)</td>
<td>-755</td>
</tr>
<tr>
<td>2016 Start with No Overlap of 1st and 2nd Units (Alt 1) vs. 2017 Start with 1st and 2nd Units Overlapped (Alt 3)</td>
<td>-15</td>
</tr>
<tr>
<td>2017 Start with 1st and 2nd Units Overlapped (Alt 3) vs. 2016 Start with 1st and 2nd Units Overlapped (Alt 2)</td>
<td>-715</td>
</tr>
</tbody>
</table>

Conclusions:

1. Provided beyond 235,000 EFPH can be achieved, it is forecast to be slightly more beneficial to the Ontario system to remove the overlap of the first two units, than to retain the original over-lapped schedule.
2. In all except the 210,000 EFPH case, it is more beneficial to the Ontario system to start in 2016 with the overlap removed on the first two units, than to delay the entire refurbishment program by 1 year (and retain the overlap). At 210,000 EFPH, the two cases are virtually breakeven.
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3. In all cases, if the overlapped schedule were maintained, it is more beneficial to the Ontario system to start in 2016 than to delay the entire refurbishment program by 1 year.

The recommended alternative for the Darlington Refurbishment Program has been assessed against other feasible generation projects including new Combined Cycle Gas.

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

Since the 2009 Feasibility Assessment, and as communicated in November 2011 and November 2012 as part of the Detailed Planning release of funds (Release 4b), Management has revised the overall timeline and release strategy for Darlington Refurbishment, including the submission of the Release Quality Estimate (RQE) in October 2015 and a first unit refurbishment start date of October 2016.

The economic assessment has been updated to reflect current knowledge and understanding of the Darlington refurbishment project and to reflect additional experience from other refurbishment projects. In 2010, Management had communicated that the project would be less than $10 Billion in 2009$ which is equivalent to $10.8 Billion in 2013$. Taking into account the current level of cost and schedule development, Management can now state with high confidence that the cost of the DRP will be less than $10 Billion in 2013$. By asserting high confidence that the DRP will be less than $10 Billion in 2013$, Management is indicating increasing confidence about the maximum amount likely to be expended. All of these figures exclude capitalized interest and future escalation. The $10 Billion in 2013$ translates into a completion cost $12.9 Billion, including capitalized interest and escalation, by the end of the project.

The current point estimate being used for the calculation of the Levelized Unit Energy Cost (“LUEC”) project is Billion (2013$), including Billion of project and program contingency. This project estimate, including capitalized interest and future escalation translates into a completion cost of Billion.

At a cost of Billion (2013$), the Levelized Unit Energy Cost (“LUEC”) of refurbishing and continuing to operate the Darlington units for a further 30 years is estimated to be 7.9 ¢/kWh (2013$), based on a high-confidence estimate of the Darlington Refurbishment Program. Excluding fixed Corporate Overheads for Pension and Other Post-Employment benefits which are independent of the decision to refurbish Darlington, the LUEC is estimated at 7.5 ¢/kWh (2013$). In 2010, Management had communicated that LUEC for the Darlington Refurbishment Program would be less than 8 ¢/kWh in 2009$, which is equivalent to 8.7 ¢/kWh in 2013$.

The economics of refurbishing the Darlington Station are comparable with Combined Cycle Gas Turbines (CCGT) at a median long-term forecast of gas prices of approximately $6/mm BTU and assuming carbon prices of $15 - $30/tonne. At median gas prices and $15/tonne carbon prices, the LUEC for CCGT is estimated at 7.5¢/kWh (2013$), with the carbon pricing accounting for 0.6 ¢/kWh of that LUEC. At low long-term gas prices of about $4/mm BTU and zero carbon prices, the price of CCGT would be more favourable than the price for refurbishing the Darlington Station. It should be noted that the costs to make gas-fired generation carbon-free (i.e. carbon sequestration), is estimated to be the equivalent of a $100/tonne carbon price, which would add 4 ¢/kWh to the LUEC of a CCGT.

While CCGTs have shorter execution lead times, lower up-front investment, lower ongoing operations, maintenance and administrative costs, there are significant uncertainties with regards to future gas prices and the potential implementation of carbon prices. There are other considerations which contribute to and support the favourable economic assessment for refurbishing the Darlington Station. These include:
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- The use of an existing generation site with a proven environmental record and a supportive host community avoids the additional costs to OPG (and ratepayers) of site selection, securing environmental approvals and development of host community support at an unproven green or brown field site. It also avoids the additional costs to ratepayers of establishing a new transmission infrastructure.

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

Management’s assessment is that the refurbishment of the Darlington Station would also be competitive with the recently completed refurbishment of Bruce Units 1 and 2. Based on the Auditor General’s 2007 assessment of the price being received by Bruce Power for the output of Bruce Units 1 and 2, management has estimated the LUEC for those units at approximately 8.5 ¢/kWh (2013$).

The future operating costs and performance of Darlington are a significant aspect of the economic assessment. An updated analysis has been completed of past performance in order to forecast the expected capability factor for the Darlington units in the post-refurbishment period. A capability factor of 88% has been used in this economic assessment with a range of 83% to 93%. Given the historical performance and the bottom-up analysis carried out by Darlington Operations, there is medium to high confidence in achieving this capability factor over the post-refurbishment life of the station.

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

Table 2: Darlington Post-Refurbishment Costs and Performance Forecasts

<table>
<thead>
<tr>
<th>Post-Refurbishment Operations Estimates</th>
<th>Average Cost / Unit (Overnight 2013 $M)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Direct Station Costs Post-Refurbishment</td>
<td>130</td>
<td>Consistent with Current Business Plan levels and previous BCS, adjusting for Business Transformation.</td>
</tr>
<tr>
<td>Annual Support Costs Post-Refurbishment (1)</td>
<td>110</td>
<td>Estimate based on Current Business Plan forecast adjusted for Business Transformation. Updated since last BCS to reflect planned shutdown of Pickering A and B.</td>
</tr>
<tr>
<td>Plant Performance Post Refurbishment (Gross Capability Factor)</td>
<td>88%</td>
<td>Range is 83%-93%. Darlington performance for the past 10 years is 89% and the station has achieved 90.7% over the past 5 years. The station’s performance since in-service has been 84.5%.</td>
</tr>
</tbody>
</table>

(1) The Annual Support Costs shown exclude past-service Pension and OPEB costs.

As shown in Figure 1, Management’s current best estimates, based on further definition work done during the Detailed Planning phase, indicate a high confidence (70% - 90%) that the Levelized Unit Energy Cost (LUEC) for refurbishment and continued operation of Darlington will be in the range of 7.6 ¢/kWh (2013$).
November 14, 2013

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to 8.1 ¢/kWh (2013$). OPG continues to maintain a very high confidence that the refurbishment of the Darlington units will result in a LUEC of less than 8.7¢/kWh (2013$), which is equivalent to the very high confidence of less than 8¢/kWh (2009$) as stated in 2010.

Figure 1: Darlington Refurbishment Levelized Unit Energy Cost Confidence Ranges

On the basis of the updated economic analysis which continues to show the refurbishment of Darlington is economic relative to the other generation options, Management recommends proceeding with the expenditures in the Detailed Planning phase of the Definition phase of the Darlington Refurbishment Project.
4.0 **THE PROPOSAL**

Approve the continuation of the Definition Phase of the Darlington Refurbishment Project by approving a release of funds to complete 2012 Detailed Planning deliverables within the Definition Phase, which includes the following Detailed Planning work program:

Key 2014 Deliverables to be completed in the Detailed Planning Phase include:

- Integrated Improvement Plan (IIP) and Global Assessment Report (GAR) to support the 10 year license application for Darlington in 2014.
- Progression of refurbishment pre-requisite work including construction of facilities and infrastructure projects, safety improvement projects (e.g. Third Emergency Power Generator, Containment Filtered Venting System), as well as scope defining inspections and unit islanding modifications.
- Negotiation and award of remaining major contracts by Q1 2014 including Steam Generators and Turbine Generator Engineering and Construction contracts.
- Progression of detailed engineering.
- Reconstruction of the Holt Road Bridge to improve traffic flow to the project and in order to not impact traffic flows in the adjoining communities.
- Design, fabrication, and testing of R&FR tooling and mock-ups to determine project durations for re-tube and feeder replacement activities.
- Scope finalization and further development of the project RQE to be issued by October 2015.
- Development of project agreements with the Building Trades Union ("BTU") through EPSCA; and continued discussions with the Power Workers Union ("PWU") to establish labour certainty throughout the DRP.
Table 3 below, provides a summary of the key milestones for the Definition Phase.

### Table 3: Overview of the Darlington Refurbishment Detailed Planning Phase Key Milestones

<table>
<thead>
<tr>
<th>REGULATORY KEY DATES</th>
<th>Milestone Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNSC Staff Issue Final ISR Sufficiency Report</td>
<td>06-Feb-2012</td>
</tr>
<tr>
<td>CNSC Decision on EA</td>
<td>15-Mar-2013</td>
</tr>
<tr>
<td>CNSC Certification of RWC Transportation Package Design</td>
<td>22-Jan-2014</td>
</tr>
<tr>
<td>CNSC Staff Acceptance of Final ISR Report</td>
<td>5-Jul-2013</td>
</tr>
<tr>
<td>IIP Approval by CNSC</td>
<td>31-Dec-2014</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CAMPUS PLAN KEY DATES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All Campus Plan Building &amp; Facilities Ready for Service</td>
<td>15-Apr-2016</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>REFURBISHMENT KEY DATES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Priority Projects Contracts All Awarded</td>
<td>01-Mar-2012</td>
</tr>
<tr>
<td>R&amp;FR Mock-up Available for Service</td>
<td>15-Jul-2014</td>
</tr>
<tr>
<td>Program Health Review Finished</td>
<td>15-Oct-2014</td>
</tr>
<tr>
<td>R&amp;FR Tooling Available for Service</td>
<td>15-Aug-2015</td>
</tr>
<tr>
<td>All Projects Detailed Engineering Finished</td>
<td>15-Aug-2015</td>
</tr>
<tr>
<td>Unit 2 Refurbishment Readiness Assessment Finished</td>
<td>15-Oct-2015</td>
</tr>
<tr>
<td>Unit 2 Initial Stage Materials and Tools On Site</td>
<td>15-Jul-2016</td>
</tr>
<tr>
<td>Unit 2 Breaker Open (BO)</td>
<td>15-Oct-2016</td>
</tr>
</tbody>
</table>

Legend: **Green** = Complete
DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY

5.0 QUALITATIVE FACTORS OR FACTORS NOT FULLY QUANTIFIED

CO2 Reduction:

The refurbishment of Darlington retains 3500 MW of nuclear base load generation on the Ontario Electricity system for another 30 years which contributes to Provincial and Federal goals of the reducing CO2 emissions from electricity generation. Based on approximately 0.4 Tg of CO2 emissions avoided for each Terawatt-hour of generation (assuming efficient gas-fired plant would replace Darlington, the refurbishment of Darlington would result in approximately 800 Tg of CO2 emissions avoided over the post-refurbishment life of the station.

Decommissioning Fund Impacts:

Proceeding with the refurbishment of Darlington, and extending its life by 30 years, results in a decrease in the present value of the liability related to the eventual decommissioning of Darlington. This reduction in the liability has already been incorporated into OPG’s financial statements as of 2010 following Board approval to proceed to the Definition Phase in 2009. This has reduced the risk to the ratepayers around future cost increases for decommissioning. As of September 2013, the decommissioning fund for OPG’s stations was fully funded, partly as a result of the reduction in the present value of the liability caused by the assumption of Darlington refurbishment. A decision not to proceed with the refurbishment would result in an increase in the liability on OPG’s books, and could require additional contributions to the fund to make up any resultant shortfalls, with resultant impacts to the electricity rates.

Workforce Impacts:

Darlington Nuclear is a major employer within Durham Region. As of December 2010, approximately 2600 persons worked at the Darlington Nuclear site including 1800 station employees, and 800 employees who support the station and the Darlington Waste Management Facility. If Darlington were to be shutdown, there would be a gradual reduction of these staff as units are removed from service, prepared for safe storage, then placed in a safe store state over the late 2010s and early 2020s.

OPG is the second largest private sector employer in the Region of Durham, and the largest in the Municipality of Clarington, and is associated with approximately 2.4% and 12.3% of total employment (direct, indirect and induced) in the Region and Municipality, respectively.

Darlington Nuclear has attracted nuclear related businesses, helping to establish a Durham Energy Industry Sector Cluster (e.g. Eastern Power, Eco-tech, Black and MacDonald; AREVA, New Horizons Systems Solutions, etc.).
6.0 RISKS

A Risk Management Plan has been developed and issued for the overall refurbishment project; risks at both the project and program level are identified and mitigating actions are prepared to ensure that the risk is appropriately managed. Key Business Case Risks and Opportunities are summarized below:

- **Station Performance Risks/Opportunities:** OPG is using an average station performance of 88% capability factor over the post-refurbishment life of the Darlington Station. Although this performance level is slightly below the station’s demonstrated performance over the past 10 years of 89%, and a few percentage points below recent station performance (past 5 years) of 91%, it is imperative that preventative and corrective maintenance programs at the station be maintained at or above the current high standards, in order to assure performance of the station at these high levels for its entire post-refurbishment life.

- **Support Costs Risks:** OPG faces losses of economies of scale as the nuclear fleet shrinks. Thus, OPG must carefully manage the transition from operating a 10-unit nuclear fleet pre-2020 to a 4 unit nuclear station (i.e. Darlington Station only) post 2024, in order to ensure that the long-term operating and support costs for the Darlington Station remain at or below current levels. Initiatives have already begun as part of business transformation to effect this transition, and further initiatives need to be implemented to streamline organizations and support services delivery as the shutdown of the Pickering station approaches.

- **Program Costs and Schedule:** The DRP is still in Definition Phase and several estimates remain at the conceptual level. Several major contracts have not yet been awarded and there have been cost pushes, relative to the current conceptual estimates, in the R&FR contract and the Turbine Generator (TG) contract. This risk will be gradually reduced as major contracts are finalized and the Release Quality estimate is developed. Schedule development work has so far not revealed any significant risks to the refurbishment durations. Bearing in mind that previous refurbishment projects have encountered major schedule delays, management must remain vigilant during both the Definition Phase and Execution Phase to avoid schedule delays. Contracts are being structured to ensure that schedule adherence is a top priority.

- **Financing and Cost Recovery:** There is a risk that OPG may not be able to fully recover prudently incurred costs upon return to service of the units. OPG continues to discuss with the Province the need for greater assurance of cost recovery and has suggested regulatory changes to facilitate this. Given that the DRP will require significant funding during the Definition Phase leading up to the Release Quality Estimate, the capital at risk, and hence the need for cost recovery assurance is increasing.

- **Station Operating Life Risk:** Recent developments indicate that there may be an opportunity to extend the lives of the fuel channels at Darlington beyond the nominal life of 210,000 EFPH. This opportunity is being explored through a Fuel Channel Life Extension project, which builds on the work accomplished in the Fuel Channel Life Management project. The Fuel Channel Life Extension (FCLE) project is scheduled to be launched in early 2014 and has, as one of its objectives, the achievement of high confidence in 235,000 EFPH on the fuel channels at Darlington. In June 2013, based on improving confidence in the life of critical components at Darlington and the expectation of positive results from the FCLE project and the resulting opportunity this creates to maximize the value of the asset and to smooth overall rate impact while mitigating execution risk of the DRP, Management recommended the removal of the overlap of the first and second refurbishment units. This was approved by the CEO and forms the base planning assumption for this Business Case.

The recommended refurbishment schedule, which removes the overlap of the first two unit refurbishment outages, requires the achievement of approximately 230,000 EFPH in order to eliminate the risk of idle time on the last unit to be refurbished, Unit 4. Mitigation of this risk includes the planned Fuel Channel Life Extension Project. Should high confidence in a station life of greater
than 210,000 EFPH not be achieved, and provided this knowledge is obtained with sufficient lead

time, there is an opportunity to adjust the schedule and re-align start dates of the subsequent units in

order to reduce station operating life risks, thereby mitigating the significant cost of idle time if the

units were to be shutdown prior to the project team being ready to commence the refurbishment.
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7.0 POST IMPLEMENTATION REVIEW (PIR) PLAN

A Comprehensive Post Implementation Review (PIR) shall be carried out by an independent team prior to the completion of the Definition Phase: The PIR will review and confirm the following:

1. Verify that the stated targets, milestones, deliverables, etc. were achieved and confirm readiness to proceed to the execution phase,
2. Make recommendations for the execution phases on the project, and,
3. Document the lessons learned for use in the subsequent stages of the project.

The Comprehensive PIR Independent Team will be appointed and will include the Independent Oversight Organizations as well as key OPG staff independent of the DRP.

The PIR should complete an independent and systematic evaluation of the work completed in the Definition Phase including the following:

- Review the completeness of the Program Management Plans and execution strategies for the Execution Phases of the project including:
  - Project Management organization with detailed role and accountability descriptions that are comparable to similar successful mega projects,
  - Development of appropriate labour strategies for the project that is consistent with the corporate HR strategy and reflective of the projected skill requirements and availability during the project’s life-span,
  - Contractual relationships established for major components such as Re-tube, Fuel Handling, Turbines and Generators, which are comparable to similar successful projects, and,
  - Review of project scope, the Release Quality Estimate, the overall project schedule, the integrated risk register, and the overall LUEC of the project, with detailed input from key stakeholders.

- Finalization of financing and cost recovery arrangements with required internal and external parties in a manner that is comparable to similar successful projects.

- Review of contracting strategies for balance of plant and execution phase work developed based on a process that is comparable to similar successful projects.

- Completion of initial Infrastructure (e.g. Training and Mock-up Building, Water and Sewer work), preliminary planning and design work and issuance of contracts.

- Review and confirmation of the regulatory strategy and an assessment of regulatory certainty for the DRP, and,

- Preparation of an updated BCS with up to date information.
1. Overview of Release Strategy

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

The overall release strategy is described in Figure 1.

This release strategy is based on an October 2016 1st unit outage and incorporates an October 2015, 2015 Release Quality Estimate ("RQE") date in order to incorporate the results of Re-tube and Feeder Replacement tooling production test results into the overall baseline schedule in order to increase Management’s confidence in the projects scope, cost, and schedule estimate at RQE.

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

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

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

As described in Figure 1 above, the project has been divided into phases. A description of the deliverables for each phase has been provided.

Initiation Phase – Releases 1 to 2

The initiation phase included the following activities:

- Determine preliminary project scope through the completion of a Plant Condition Assessment (PCA) with a special focus on the life-limiting components, such as feeders and fuel channels. Studies were also conducted to assess the condition of all major station components, and methods and timing for carrying out the required refurbishment scope would be proposed.
- Planning for the ISR, including a review of modern codes and standards, and an EA.
- Assessed the various execution options (e.g., contracting, project management, work management, governance) for the Definition and Execution Phases of the Refurbishment Project, and recommended an execution strategy.
- Identification of an initial project organization for the Definition and Execution Phases.
- Developed a communication plan to ensure stakeholders are informed of OPG’s Refurbishment Project and obtain their support for the decision.
- Developed Project Management support such as Project Controls, performance measures, schedules, risk and contingency processes, project metrics and reports.
- Developed a preliminary schedule and cost estimate for the refurbishment outages, and a Refurbishment Outage Preparation Plan that included both key and supporting scope (organization, infrastructure, oversight, plant and programmatic work, risk contingencies and allowances). Construction Islanding is a key study to determine the supporting scope.
- Prepared a recommendation with respect to proceeding to refurbish the Darlington station to OPG Senior Management, OPG’s Board of Directors and Shareholders. Supported this recommendation through the completion of a Business Case Summary (BCS).

Definition Phase - Preliminary Planning – Release 3

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

- The project Management organization for the Definition Phase of the project has been put in place. The key roles on the project team include Engineering, Execution, Supply Chain, Contract Management, Managed Systems Oversight, and Project Planning and Controls. All positions report to the Senior Vice President of Nuclear Refurbishment who has the overall accountability to deliver the project.
- An overall contract strategy document has been developed and approved for the project. Additionally, contract strategy documents for each major work component, i.e., Re-tube and Feeder Replacement, Fuel Handling, Turbine Generators, Steam Generators, and Balance of Plant has been developed.
- The ISR final report, a required regulatory document that assesses and documents key safety factors against modern codes and standards, was submitted to the CNSC in October 2011. The CNSC issued their assessment of the ISR on July 5, 2013. The assessment concluded that the ISR meets applicable regulatory requirements.
**DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY**

**APPENDIX A – RELEASE STRATEGY AND DESCRIPTION OF WORK PHASES**

- The EA Screening Report was submitted to the CNSC December 1, 2011. The CNSC released its decision on the EA on March 14, 2013. The overall finding of the CNSC is that the project will not result in any significant adverse environmental effects given the proposed mitigations. Both the Integrated Safety Report and Environmental Assessment are precursors for the CNSC approval of the Integrated Improvement Plan which will allow the project to proceed and the Darlington Station to be operated for an additional 30 years post refurbishment.

- Project controls governance and supporting tools, including cost management, scheduling, estimating, risk management, and change management have been implemented. Governance has been put in place, establishing the review and approval process for all major program scope and funding through the Scope Review Board (SRB) and the Gate Review Board (GRB). The technical scope for the refurbishment project was finalized in 2011 and the SRB will continue to review and approve scope deletions and/or additions due to plant configuration, regulatory or code changes, on a reduced frequency for the duration of the project. Funds are released by the GRB, as projects proceed through each phase of the gate process.

- Labour strategies have been developed for the project with labour agreements in place with Society. Additionally, in July 2011, OPG declared the Darlington Refurbishment Project a “Rehabilitation” project which invoked the Chestnut Park Accord Agreement. Subsequently, the committee has reviewed and assigned approximately 90% of the craft work to the Building Trades Union (BTU) with approximately 5% assigned to the Power Worker's Union and another 5% to be determined.

- An organizational “strong project matrix” model has been deployed for the Refurbishment Project. The model is in the process of being implemented. Staffing guidelines recognizing the model and the fact that OPG will be performing oversight of Engineer, Procure, Construct (EPC) contractors have been established.

- Cost Recovery and Financing confirmation is underway. As cost recovery and/or financing certainty is currently not confirmed, the project will request a release of funds for 2014 portion of the Detailed Planning Phase only. Upon cost recovery and financing confirmation, the project will request a release of the remaining Detailed Planning funds.

- The project economics and the BCS have been updated based on the latest known information.

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

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

- Completion of all Outage preparation plans and unit pre-requisite work, including infrastructure and facilities required to execute the Refurbishment as well as unit modifications to enable unit islanding and isolation.

- Finalization of all project scope and progression of engineering.

- Integrated Implementation Plan and Global Assessment report submitted to the CNSC and approvals obtained. OPG is currently in the process of preparing the Integrated Implementation Plan (IIP) and Global Assessment Report (GAR), as well as a licensing
application for the DRP; all will be submitted to the CNSC by December 2013, with approvals expected by early 2015. The new licence will allow OPG to execute the refurbishment and continue to operate DNGS for an additional 30 years assuming all licence conditions and regulatory obligations are met.

- Orders for long lead items issued and delivery dates confirmed, where required.
- Contracts for Engineering, Detailed Planning and pre-execution outage work (i.e., development of mock-up and tooling for Re-tube, awarded or partially released to key vendors).
- Establishment of an independent oversight process and assurance model.
- Preparation of a Release Quality Estimate (“RQE”) including detailed cost estimates and a detailed execution phase schedule based on approved scope.
- Update of the Program Business Case, with a full project cost estimate, and presented to Senior Management, the Board of Directors and Shareholder, with a project execution strategy recommendation, for approval.

**Field Execution and Closeout Phase – Releases 5 to 8**

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

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

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

**Operations Phase**

The Operations phase is the return to service of the units, starting around 2019, when the first unit refurbishment is complete.
## DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY

### APPENDIX B – SUMMARY OF ESTIMATE

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Darlington Nuclear Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Title:</td>
<td>Darlington Refurbishment Program (DRP) Definition Phase</td>
</tr>
</tbody>
</table>

### Estimated Cost in Million $

<table>
<thead>
<tr>
<th>Year</th>
<th>LTD 2013</th>
<th>2014</th>
<th>2015</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Projects</td>
<td>266</td>
<td>348</td>
<td>309</td>
<td>923</td>
<td>39</td>
</tr>
<tr>
<td>Includes: Retube and Feeder Replacement, Fuel Handling, Defueling, Steam Generators, Turbine Generators, and Balance of Plant projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility and Infrastructure Projects</td>
<td>201</td>
<td>147</td>
<td>93</td>
<td>441</td>
<td>19</td>
</tr>
<tr>
<td>Holt Road Improvements</td>
<td>3</td>
<td>14</td>
<td>16</td>
<td>33</td>
<td>1</td>
</tr>
<tr>
<td>Operations/Maintenance Support</td>
<td>13</td>
<td>16</td>
<td>29</td>
<td>58</td>
<td>2</td>
</tr>
<tr>
<td>OPG Oversight and Program Support</td>
<td>245</td>
<td>124</td>
<td>123</td>
<td>492</td>
<td>21</td>
</tr>
<tr>
<td>Regulatory, including CNSC Fees</td>
<td>54</td>
<td>8</td>
<td>2</td>
<td>64</td>
<td>3</td>
</tr>
<tr>
<td>Insurance</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Interest</td>
<td>32</td>
<td>52</td>
<td>81</td>
<td>165</td>
<td>7</td>
</tr>
<tr>
<td>Contingency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Escalation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>820</td>
<td>788</td>
<td>756</td>
<td>2,365</td>
<td></td>
</tr>
</tbody>
</table>

### Notes:

1. LTD costs include all costs related to the Darlington Refurbishment project Definition Phase, including Preliminary Planning (2010 to 2011) and Detailed Planning (2012 and 2013, based on 2013 Year End forecast). 2014 and 2015 cash flows represent forecast expenditures for each year.

   The above table excludes initiation phase (2007 to 2009) costs incurred prior to approval of the project in 2010 totaling $34M. These costs are not eligible for capitalization within the DRP.

2. Interest and Escalation rates are based on current allocation rates provided by Corporate Finance.

### Prepared by: G. Rose
- Director, Planning and Control
- Nuclear Refurbishment

### Approved by: D. Reiner
- SVP, Nuclear Refurbishment
1.0 Assessing the Economics of Refurbishment

In order to assess the economics of the refurbishment decision on Darlington, the following key factors must be considered:

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

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

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

1.1. Refurbishment Scope, Cost and Reference Schedule

1.1.1. Refurbishment Scope

The main scope of work during the refurbishment of each Darlington unit is the replacement of fuel channels (pressure tubes and calandria tubes) and feeder pipes (up to the feeder header). The refurbishment scope does not include replacement of the steam generators. The scope also includes provisions for outage support work (unit islanding, facilities, construction island barriers, heavy water management, and radioactive waste management).

Since 2009, significant progress has been made in defining the scope of the refurbishment work and the categorization of this scope has become more granular. Core scope and non-core scope has been clearly defined, with both core scope and non-core scope divided into several categories for ease of categorization, review and decision-making. Certain categories of non-core scope must successfully pass a cost-benefit analysis test before being considered for inclusion in the refurbishment scope. There are now formal on-going assessments of the technical merits, costs, and funding requirements of each proposed scope item and formal review and approval of proposed scope by the Scope Review Board. Required regulatory scope has been identified through CNSC approval of the Environmental Assessment and CNSC staff assessment of the Integrated Safety Review. Following initial approval, secondary reviews of non-core scope have also been executed as a result of a broad scope review and also triggered in part by a re-assessment of Component Condition Assessments and these reviews have led to further rationalization of the scope.

Non-core refurbishment scope includes advancement of future life-cycle work (i.e. work that would be necessary in the post-refurbishment life to ensure that the plant can continue to operate safely and reliably during its post-refurbishment life), where it makes business sense to advance this work into the refurbishment outage, e.g. because of the duration of the work or the state of the plant required to execute the work.
1.1.2. Refurbishment Costs

In conjunction with the scope reviews and updates, cost estimates for the refurbishment scope of work have been updated as part of the Detailed Planning activities. As well, benchmarking has continued against publicly available costs of other on-going CANDU refurbishment projects at Pt. Lepreau and the Bruce 1 & 2 Units and lessons learned from these projects continue to be incorporated into the Darlington Refurbishment Program cost estimate.

A contract has been let for the main scope of the refurbishment outage, i.e. the re-tube and feeder replacement activities and definition phase work is well underway. The establishment of this contract has resulted in improving cost certainty on this major component of the scope. Other project bundles, such as Fuel Handling, Defueling, Turbine Generator and Steam Generator have either had contracts let or are in the final stages of evaluation and negotiation. Updated estimates of the OPG Program Management and Oversight function have also been completed.

Table C1 summarizes the Refurbishment Project costs which were utilized in the economic assessment. The overnight cost estimate for the known scope of work is Billion. With Billion of contingency added to bring the bottom line total to Billion (2013$), this is considered a high confidence (90% confidence) estimate.

For the purposes of preparing sensitivity analyses, ranges were applied to the most likely estimates in each line item of the cost estimate.

Table C1: Refurbishment Project Costs Used in the Updated Economic Assessment

<table>
<thead>
<tr>
<th>Category of Work</th>
<th>Nov-13</th>
<th>Nov-12</th>
<th>Nov-11</th>
<th>Nov-09</th>
<th>Plan/Plan 09-13</th>
<th>Description of Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Contracts (RFR, FH, Defueling, SG, TG)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Vendor EPC (Engineering, Procurement, Construction) costs for major component work programs, including re-tube and feeder replacement, turbine generator upgrades and digital control system, Steam Generator primary side clean, and fuel handling equipment refurbishment.</td>
</tr>
<tr>
<td>Balance of Plant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Vendor EPC costs for refurbishment of balance of plant equipment including implementation of 3rd Emergency Power Generator and Containment Filtered Venting.</td>
</tr>
<tr>
<td>Islanding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes containment isolations (bulkheads), 530 management modifications and negative pressure containment.</td>
</tr>
<tr>
<td>Holt Road Improvements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>Operations &amp; Maintenance Support</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>Waste Mgmt &amp; Waste Containers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>New Fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>Facilities and Infrastructure Projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>Total Direct Work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>OPG Project Management and Support</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>Total Direct plus Indirect Work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>Contingency and Management Reserve</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>Total Project Estimate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>Capitalized Interest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>Total Project Estimate Incl. Interest (2013$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>Future Escalation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
<tr>
<td>Total Project Estimate (5 of the year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Estimate from MTO. Stand alone BCS to be provided to BoD. Includes In-Station Facilities.</td>
</tr>
</tbody>
</table>
Figure C1 provides the anticipated cash flows for the DRP, based on the current estimate.

**Figure C1: Darlington Refurbishment Program Anticipated Cash Flow**

OPG continues to benchmark its cost and schedule assumptions and plans against other CANDU refurbishments. OPG’s refurbishment schedule is based on the Wolsong refurbishment actual duration, pro-rated to account for the Darlington Station’s larger unit size (480 fuel channels in a Darlington or Bruce unit vs. 380 fuel channels in a CANDU 6 design).

Table C2 provides a comparative assessment, based on publicly available information, of the current cost and schedule of the Darlington Refurbishment as compared to other CANDU refurbishments.

**Table C2: Darlington Refurbishment Comparison to Other Refurbishments**

<table>
<thead>
<tr>
<th>Station (Per Unit)</th>
<th>Start Date</th>
<th>Planned / Actual Duration (Months)</th>
<th>Planned / Actual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darlington Station</td>
<td>OCT 2016</td>
<td>36/TBD</td>
<td></td>
</tr>
<tr>
<td>Pt. Lepreau</td>
<td>MAR 2008</td>
<td>18/55(^{(1)})</td>
<td>$1.0B/$1.4B(^{(2)})</td>
</tr>
<tr>
<td>Wolsong</td>
<td>APR 2009</td>
<td>22/28(^{(1)})</td>
<td>Not Available</td>
</tr>
<tr>
<td>Bruce A Units 1 &amp; 2(^{(3)})</td>
<td>OCT 2005</td>
<td>25/84 for 2 units</td>
<td>$1.4B/$2.4B ($4.8B/2 units)</td>
</tr>
</tbody>
</table>

Notes:
(1) Pt. Lepreau and Wolsong are for CANDU 6 designs with 380 calandria/pressure tubes and a dedicated fuelling machine versus the Darlington and Bruce designs of 480 pressure tubes and a shared fuel handling system. Refurbishment assessed the Wolsong actual duration and pro-rated applicable series to conclude that the corresponding duration for the Darlington Station is approximately 34 months.
(2) An additional in replacement energy costs, operations and maintenance costs, and incremental financing for non-project related costs was incurred by New Brunswick Power.
(3) Bruce scope includes replacement of Steam Generators as well as large Balance of Plant scope due to fact that units were in a laid-up state prior to refurbishment. Refurbishment of Units 1 and 2 commenced in October 2005 with Unit 1 complete in September 2012 and Unit 2 in October 2012, for a total of 7 years (84 months). The cost estimate publicly quoted is from November 2010; it is uncertain whether this cost estimate includes all of the applicable capitalized interest costs and/or operations and maintenance costs that can be directly attributable to the project.

OPG Confidential and Commercially Sensitive. Disclosure of information contained in this document could result in potential commercial harm to the interests of OPG and is strictly prohibited without the express written consent of OPG.
1.1.3. Contingency and Risks - Refurbishment

Included in the refurbishment estimate is an allowance for uncertainties in project scope, costs and schedule. In addition, allowances are added for known discrete risks.

At the 50%, 70% and 90% confidence levels the total amounts included for contingency and risks are approximately [Amount] Billion, [Amount] Billion and [Amount] Billion, respectively. The contributing factors to these contingency amount estimates are broken out as follows:

- **Cost Estimate Uncertainty**
  
  This contingency item represents the amount that has to be added to the most likely estimates of the project bundles and project support and oversight estimates to bring the confidence level in these estimates to a certain level of confidence, e.g. 50% probability or 90% probability. This is due to the cost estimate ranges developed for each scope item showing more of a potential to increase than to decrease. This results in the expected value being higher than the most likely estimate. Recent progress in developing contracts for the project bundles and in reviewing and refining the project support and oversight estimates has resulted in a reduction in the amount of contingency needed for this item.

- **Contingent Work Risk**
  
  This contingency item represents an amount that has been estimated for potential work that may be required following inspections of equipment prior to and during the refurbishment outages. This potential work was identified during scope development activities during both the Preliminary Planning and Detailed Planning Phases.

- **Labour/Materials Price Risk**
  
  This item deals with risks associated with the potential for labour and material prices to be higher than expected in tight markets and is in addition to the cost estimate uncertainty. High demand for qualified workers and the required materials may occur if concurrent infrastructure improvement projects in Canada and worldwide result in tightening markets for labour and materials. As contracts are finalized, the contingency required for Labour/Materials Price Uncertainty will decline.

- **Discrete Risk Items**
  
  This item reflects contingency to address discrete risks listed in the risk register that are not accounted for in the other risk categories shown above. It includes regulatory delays, materials delays, rework risks and discovery work.

- **Schedule Uncertainty Risks**
  
  This item reflects the schedule uncertainty risk; the complexity of the project poses a risk to meeting the schedule. Schedule uncertainty risk should improve as the Detailed Planning Phase of the Project progresses.

The estimates for each of these contributors to contingencies and risks at the 50%, 70% and 90% confidence levels are shown in Table C3.
## Table C3: Contingency & Risk Amounts added to the Darlington Project Cost Estimate

<table>
<thead>
<tr>
<th>#</th>
<th>Category</th>
<th>Examples</th>
<th>Contingency (2013$M)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>50% Conf.</td>
</tr>
<tr>
<td>1</td>
<td>Cost Estimate Uncertainty</td>
<td>Risk that actual cost of project scope is higher than planned.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Uncertainty in costs of project Bundles such as R&amp;FR, Fuel Handling, T/G set and Balance of Plant</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Contingent Work</td>
<td>Work which may be required dependent on inspection results.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repair and/or replace equipment that could not be visually assessed / tested during the condition assessments.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Labour/Material Price Uncertainty</td>
<td>Risk that labour &amp; materials prices may escalate higher than forecast</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Labour market pressures lead to higher than expected labour prices</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Discrete Risk Items</td>
<td>Known risks that the project will manage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Regulatory delays, Material Delays, Rework, Discovery Work</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Schedule Estimate Uncertainty</td>
<td>Risk that actual duration of the refurbishment is longer than planned</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Longer duration results in continued overhead costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The resulting distribution of Darlington refurbishment project costs is shown in Figure C2.

**Figure C2: Darlington Refurbishment Project Costs Uncertainty**

```
1.1.4. Refurbishment Reference Schedule

**Unit Refurbishment Duration:** The duration of the refurbishment outage of the Darlington units continues to be assessed at nominally 36 months per unit.

**Timing of Unit Refurbishment Outages:**

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

The refurbishment schedule considers a range of factors. Key considerations included minimizing refurbishment planning and execution risks while maximising the value of the asset to the Ontario electricity system prior to refurbishment, bearing in mind the expected operational lives of the units. If readiness to refurbish cannot be achieved (e.g. lead time constraints have prevented the acquisition of necessary materials or tooling) before a unit reaches its operational end-of-life, there is a risk of idle time being incurred on the unit. On the other hand, operational life is forsaken when units are shutdown for refurbishment before they reach the limiting component end-of-life. Because the end-of-life dates of the four Darlington units would occur within approximately a 1-2 year span, it is necessary to stagger the start dates of the refurbishments, thereby incurring some forsaken life on the earlier units to be refurbished), in order to minimize the risk of idle time.

OPG has pursued increased fuel channel life for both Pickering and Darlington through the Fuel Channel Life Management Project with the aim of developing high confidence in the fuel channel.
service lives. Recent developments indicate that there may be an opportunity to extend the lives of the fuel channels at Darlington beyond the nominal life of 210,000 EFPH. This opportunity is being explored through a Fuel Channel Life Extension project, which builds on the work accomplished in the Fuel Channel Life Management project. The Fuel Channel Life Extension (FCLE) project is scheduled to be launched in early 2014 and has, as one of its objectives, the achievement of high confidence in 235,000 EFPH on the fuel channels at Darlington. In June 2013, based on improving confidence in the life of critical components at Darlington and the expectation of positive results from the FCLE project and the resulting opportunity this creates to maximize the value of the asset and to smooth overall rate impact while mitigating execution risk of the DRP, Management recommended the removal of the overlap of the first and second refurbishment units. This was approved by the CEO and forms the base planning assumption for this Business Case.

The current planning schedule for refurbishment is that the first unit’s refurbishment will start in October 2016, with nominal refurbishment outage durations of 36 months/unit, and with 0, 19 and 17 month overlaps between the first-to-second, second-to-third and third-to fourth units respectively. The overall refurbishment window remains at 108 months, and the overall unit outage months remain at 144 months.

This schedule was compared to the previous refurbishment schedule which assumed a 2016 start, with the first two units overlapped, and also to a 2017 start with the first two units overlapped. Table C4 summarizes the results of that economic assessment.

Table C4: Relative Present Values of Schedule Alternatives for Darlington Refurbishment

<table>
<thead>
<tr>
<th>Alternatives Compared</th>
<th>Operating Life Achieved (EFPH)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>210,000</td>
</tr>
<tr>
<td>2016 Start with No Overlap of 1st and 2nd Units (Alt 1) vs. 2016 Start with 1st and 2nd Units Overlapped (Alt 2)</td>
<td>-755</td>
</tr>
<tr>
<td>2016 Start with No Overlap of 1st and 2nd Units (Alt 1) vs. 2017 Start with 1st and 2nd Units Overlapped (Alt 3)</td>
<td>-15</td>
</tr>
<tr>
<td>2017 Start with 1st and 2nd Units Overlapped (Alt 3) vs. 2016 Start with 1st and 2nd Units Overlapped (Alt 2)</td>
<td>-715</td>
</tr>
</tbody>
</table>

Conclusions:
1. As long as beyond 235,000 EFPH can be achieved, it is forecast to be slightly more beneficial to the Ontario system to remove the overlap of the first two units, than to retain the original overlapped schedule.
2. In all except the 210,000 EFPH case, it is more beneficial to the Ontario system to start in 2016 with the overlap removed on the first two units, than to delay the entire refurbishment program by 1 year (and retain the overlap). At 210,000 EFPH, the two cases are virtually breakeven.
3. In all cases, if the overlapped schedule were maintained, it is more beneficial to the Ontario system to start in 2016 than to delay the entire refurbishment program by 1 year.

1.2. Post-Refurbishment Assumptions

To fully assess the merits of the option to proceed with the refurbishment of the Darlington plant, all future expected costs of operating the facility over its post-refurbishment life, as well as the expected operating performance of the plant and expected unit life must be forecasted.
1.2.1. Unit Life

Since the Darlington units would have been in service for nominally 60 years by the end of their post-refurbishment lives, it is considered prudent to utilize conservative assumptions for unit lives in the economic assessment, in order to mitigate the risk that an unforeseen equipment issue could emerge which could bring about an earlier than expected end of post-refurbishment life.

The post-refurbishment life of each unit was assumed to be nominally 30 calendar years. This post-refurbishment calendar life was derived from the current design life of pressure tubes of 24 effective full power years (210,000 EFPH) with recognition that, given the knowledge gained about pressure tube degradation mechanisms, future pressure tubes will likely be designed and operated to achieve longer service lives. Thirty calendar years, with an assumed 88% capability factor translates into a pressure tube life of approximately 26 effective full power years (approx. 231,000 EFPH).

Sensitivities on unit lives were run at +/- 2 calendar years.

1.2.2. Annual Station Operating, Maintenance & Projects Costs

Annual OM&A levels were derived based on levels in the current business plan forecast, factoring in OPG’s Business Transformation targets, as well as forecast changes to work programs and approaches expected over the life of the units. OM&A levels were estimated to be nominally the same as the current 2016 Business Plan, with appropriate adjustments over the post-refurbishment period.

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

Ongoing sustaining projects expenditures were estimated based on the current and projected nuclear project portfolio assumptions, as well as benchmarking against other utilities. This was modified by assuming that, in the first year post-refurbishment, 50% of the “typical” annual project costs would be incurred, ramping up to 100% by the 5th year.

Table C5 provides details on the assumptions used for these factors in the analysis.
Table C5: Annual OM&A, Outages & Projects Costs Used in the Economic Assessment

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median Confidence ($M/yr; 2013$)</td>
<td>($M/yr; 2013$)</td>
</tr>
<tr>
<td>Station Base OM&amp;A (^{(1)})</td>
<td>270</td>
<td>280</td>
</tr>
<tr>
<td>Outages OM&amp;A (^{(1)})</td>
<td>110</td>
<td>120</td>
</tr>
<tr>
<td>Projects (Cap &amp; OM&amp;A) (^{(2,3)})</td>
<td>130</td>
<td>127</td>
</tr>
<tr>
<td><strong>Annual Direct Costs</strong></td>
<td>510</td>
<td>527</td>
</tr>
</tbody>
</table>

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

1. Base and Outage post-refurbishment forecasts are based on the current 2016 business plan forecast, and includes all Station Containment/Vacuum Building Outages and cost and scope adjustments as the unit’s age. The Vacuum Building Outage Costs in 2015 were normalized to reflect a planned VBO every 12 years.

2. Capital & OM&A project forecasts are based on current business plan forecasts adjusted for losses of economies of scale upon the shutdown of Pickering and also informed by benchmarking against other utilities. Periodic major projects (e.g. facilities, security) are factored into the long-term projects forecast.

1.2.3. Annual Support and Overhead Costs

Costs associated with direct and allocated support services are divided into Nuclear and Corporate Support. Examples of nuclear support include Nuclear Engineering, Nuclear Services, Fleet Operations and Maintenance and Inspection and Maintenance Services. Examples of Corporate Support costs include Finance, People and Culture, Business and Administrative Services, Legal Support and Commercial Operations and Environment, which includes Regulatory Affairs. In addition, there are centrally held costs, such as insurance premiums, pension adjustments and interest on Other Post-Employment Benefit obligations which are allocated to the Darlington station.

Based on the following premises: a) that there are economies of scale in the provision of Nuclear and Corporate Support to a large fleet of stations; b) that there are some “centrally held costs” allocated by Corporate to each station that are purely “fixed”, i.e. are not affected by a decision to continue or not continue to operate a station, it has been postulated that, should the nuclear fleet shrink, losses of economies of scale will result in an effective increase in the cost of providing Nuclear & Corporate support services to the remaining stations. Also, the fixed overheads currently allocated to a larger fleet of stations will effectively need to be re-allocated to a smaller fleet, resulting in the allocation of fixed overheads to the remaining stations increasing.

Hence, the analysis of Darlington’s economics is done including only the portion of those costs which are considered incremental to the operation of Darlington. Table C6 shows the incremental support and overhead costs which were assumed in the Updated Economic Assessment. Because it is assumed that the Pickering units will have already been shutdown at the time that the Darlington Station will be in its post-refurbishment period, Darlington’s share of the Nuclear Support Costs and Corporate Support costs will come under upward pressure due to losses of economies of scale. Therefore, in this assessment, for conservative purposes, the incremental view of Darlington’s costs of operation (for economic analysis purposes) is equal to or in select instances (e.g. insurance premiums), worse than the costs which are currently allocated to Darlington in the Business Plan.
### 1.2.4. Station Performance Assumptions

In developing an estimate of the performance of the Darlington units in the post-refurbishment period, a number of factors were considered including historical performance. Recent (5-yr) capability factor performance has been excellent, in the 85%-94% range, with the low year of 85% in 2009 coinciding with the periodic planned station shutdown for the vacuum building outage. Recent planned outage performance and forced loss rates (FLR) have also been very good.

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

- Lifetime performance of the Darlington station has been 84.5% capability factor; last 10 years’ performance has averaged 89% and last 5 years’ performance has averaged 90.7%.
- As part of the assessment for refurbishment, detailed plant condition assessments (PCAs) were completed. These PCAs have been reviewed and plans put in place to address findings, either pre-refurbishment, during refurbishment or post-refurbishment.
- Technical knowledge of equipment reliability issues, including component degradation mechanisms in CANDU reactors and the balance of plant, has improved dramatically over the past 5 decades of the CANDU program, leading to some confidence that there will be fewer unexpected degradation mechanisms uncovered in the future.

These issues were discussed in meetings with senior station personnel and in discussions with the Refurbishment Project Team. The consensus was to assume a reference annual capacity factor of 88% but to analyze over a broad range as shown in Table C7:

### Table C7: Performance Assumptions Used in the Updated Economic Assessment

<table>
<thead>
<tr>
<th>Performance Factor</th>
<th>High Confidence</th>
<th>Medium Confidence</th>
<th>Low Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Capability Factor (%)</td>
<td>83%</td>
<td>88%</td>
<td>93%</td>
</tr>
</tbody>
</table>

The 88% capability factor (medium confidence) is slightly lower than Darlington’s average performance for last 10 years, which was 89%. It is considered conservative given the station’s performance of 90.7% over the last 5 years. The low end performance of 83% (which is 1.5% lower than the station’s since-in-service performance of 84.5%) could result, for example, from a failure to effectively implement the Integrated Aging Management Program (IAMP) and/or an inability to maintain a 3-year outage cycle. It would also allow for large outages for major equipment maintenance during the post-refurbishment period, if necessary. The high end performance of 93% could be achieved if Darlington were to sustain 1st or 2nd quartile INPO performance, funding levels are maintained, the IAMP is effectively implemented, and Human Performance is maintained.
2.0 Results

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

2.1. Levelized Unit Energy Costs

The project’s economics and the BCS have been updated based on the latest information. The updated analysis also indicates 70%-90% confidence that the LUEC for Darlington Refurbishment will be in the range 7.6 ¢/kWh to 8.1 ¢/kWh (2013$) and very high confidence that the LUEC will be less than 8.7 ¢/kWh (2013$). Therefore, management continues to have high confidence that the LUEC of refurbishing and continuing to operate the Darlington units for a further 30 years, as shown in Figure C3, would be less than 8 ¢/kWh (2009$), as provided in November 2009, which is equivalent to 8.7¢/kWh (2013$)).

Figure C3: Levelized Unit Energy Cost Confidence Ranges

Figure C4 shows the percentage contribution of the major components which make up the DRP LUEC. These are: 1) Direct Station OM&A and Fuel costs; 2) Station Support provided by both Nuclear and Corporate Support groups; 3) the DRP itself, and; 4) fixed Corporate Overheads for pension and OPEB.
As shown in Figure C4, the DRP contributes approximately 40% to the total, while the post-refurbishment costs contribute approximately 60% to the LUEC.

**Figure C4: Darlington Refurbishment Levelized Unit Energy Cost – Major Components**

![Pie chart showing DRP and refurbishment investment contributions]

### 2.2. Sensitivity of Results to Changes in Input Assumptions

As documented in Section 1, this Updated Economic Assessment includes a large number of assumptions regarding refurbishment costs and durations, going forward operating and sustaining investment costs and operating performance. For each of these factors, ranges were developed and sensitivity analyses were performed at the low and high ends of these ranges for each of the key input factors. Figure C5 shows the results of the sensitivity analysis. The following helps to understand the impacts of specific changes in underlying assumptions on the magnitude of the Darlington Refurbishment LUEC.

- A $500 Million increase/decrease in DRP costs increases/reduces LUEC by 0.15 ¢/kWh
- An increase in DRP duration of 12 months would increase LUEC by approximately 0.5 ¢/kWh while a 6 month decrease would decrease LUEC by approximately 0.25 ¢/kWh.
- A 5% increase in capacity factor (from 88% to 93%) lowers LUEC by 0.35 ¢/kWh while a 5% decrease in capacity factor (from 88% to 83%) increases LUEC by 0.4 ¢/kWh
- Each $100 Million increase/decrease in post-refurbishment annual costs increases/reduces LUEC by 0.4 ¢/kWh

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

A significant input into the decision-making process on the economic viability of the Darlington Refurbishment is a comparison to the LUECs of other options competing with this project. Figure C6 presents such a comparison.

**Figure C6: Levelized Unit Energy Costs for Darlington Refurbishment and Comparators**

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Lower</th>
<th>Median</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Uncertainties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refurb Cost (2013$)</td>
<td>-10%</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Refurb Duration (months)</td>
<td>-2 mths</td>
<td>5 mths</td>
<td></td>
</tr>
<tr>
<td>Future Performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACF (%)</td>
<td>-5%</td>
<td>88%</td>
<td></td>
</tr>
<tr>
<td>Life of Refurb Units (yrs)</td>
<td>+2 yrs</td>
<td>-2 yrs</td>
<td></td>
</tr>
<tr>
<td>Future Operating Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base OM&amp;A ($M)</td>
<td>-5%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Outage OM&amp;A ($M)</td>
<td>-10%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Sustaining Projects ($M)</td>
<td>-10%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Nuclear Support ($M)</td>
<td>-5%</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Corp Support Incr ($M)</td>
<td>-15%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Fuel ($/MWh)</td>
<td>-15%</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Discount Rate</td>
<td>-1%</td>
<td>7%</td>
<td></td>
</tr>
</tbody>
</table>

**Assumptions:** Darlington Refurb Bruce 1/2 New CCGT
- Low Median High - Low Median High

<table>
<thead>
<tr>
<th>Capital</th>
<th>OM&amp;A</th>
<th>Fuel</th>
<th>CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Low</th>
<th>Median</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overnight capital (C$B)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overnight capital (C$/kW)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Fixed Operating Cost (C$M)</td>
<td>885</td>
<td>965</td>
<td>1,075</td>
</tr>
<tr>
<td>Annual Capacity Factor (%)</td>
<td>93%</td>
<td>88%</td>
<td>83%</td>
</tr>
<tr>
<td>Gas Price ($/MMBtu @ Henry Hub)</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>CO2 Offset Cost (C$/tonne)</td>
<td>0</td>
<td>15</td>
<td>100</td>
</tr>
</tbody>
</table>

**Carbon-free based on Median**
- Low Median High
The economics of refurbishing the Darlington Station are comparable with Combined Cycle Gas Turbines (CCGT) at a median long-term forecast of gas prices of approximately $6/mm BTU and assuming carbon prices of $15 - $30/tonne. At median gas prices and $15/tonne carbon prices, the LUEC for CCGT is estimated at 7.5¢/kWh (2013$), with the carbon pricing accounting for 0.6 ¢/kWh of that LUEC. At low long-term gas prices of about $4/mm BTU and zero carbon prices, the price of CCGT would be more favourable than the price for refurbishing the Darlington Station. It should be noted that the costs to make gas-fired generation carbon-free (i.e. carbon sequestration), is estimated to be the equivalent of a $100/tonne carbon price, which would add 4 ¢/kWh to the LUEC of a CCGT.

While CCGTs have shorter execution lead times, lower up-front investment, lower ongoing operations, maintenance and administrative costs, there are significant uncertainties with regards to future gas prices and the potential implementation of carbon prices. There are other considerations which contribute to and support the favourable economic assessment for refurbishing the Darlington Station. These include:

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

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

Management’s assessment is that the refurbishment of the Darlington Station would also be competitive with the recently completed refurbishment of Bruce Units 1 and 2. Based on the Auditor General’s 2007 assessment of the price being received by Bruce Power for the output of Bruce Units 1 and 2, management has estimated the LUEC for those units at approximately 8.5 ¢/kWh (2013$).

In summary, the Darlington Refurbishment Project’s median confidence LUEC is approximately 7 – 7.5 ¢/kWh, which compares favourably with median confidence CCGT LUECs and with the estimated LUEC of Bruce Units 1 & 2.

3.0 Conclusions of Economic Assessment

The forecast LUEC for Darlington Refurbishment is competitive economically with other available generation options, including Combined Cycle Gas. There is merit to continuing the Definition Phase work and implementing the project based on current economic comparisons.
1.0 Summary of 2014 Expenditures

The expected spend of $788M in 2014 includes $680M of new Release 4c funding plus a carry forward of $108M from 2012 and 2013. The total cumulative funds released to the project, including this release, will total $1,608 Million including capitalized interest, escalation, and contingencies.

<table>
<thead>
<tr>
<th>Major Project Work</th>
<th>LTD 2013</th>
<th>2014</th>
<th>2014 Deliverables/Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retube &amp; Feeder Replacement</td>
<td>229</td>
<td>215</td>
<td>Design, fabrication, and testing of R&amp;FR tooling and mock-ups to determine project durations for RFR activities, as well as procurement of long lead materials</td>
</tr>
<tr>
<td>Fuel Handling</td>
<td>5</td>
<td></td>
<td>Contract award for Fuel Handling main trolley, power track and auxiliaries; commencement of engineering and procurement</td>
</tr>
<tr>
<td>Defueling</td>
<td>4</td>
<td>4</td>
<td>Continued engineering and procurement activities</td>
</tr>
<tr>
<td>Steam Generators</td>
<td>4</td>
<td></td>
<td>Commencement of engineering and procurement activities related to contract award in late 2013</td>
</tr>
<tr>
<td>Turbine Generators</td>
<td>20</td>
<td>26</td>
<td>Negotiations and contract award to Engineering and Construction vendor, as well as continued progress on engineering and procurement of long lead materials</td>
</tr>
<tr>
<td>Balance of Plant</td>
<td>10</td>
<td>65</td>
<td>Award contracts and execution of pre-requisite work and scope defining inspections, as well as continued execution of safety improvement projects (e.g. Third Emergency Power Generator, Containment Filtered Venting System). Also includes Shutdown Safety Computer Replacement and Vault Cooler projects</td>
</tr>
<tr>
<td>Islanding</td>
<td>3</td>
<td>18</td>
<td>Unit islanding modifications including Heavy Water System modifications and Bulkhead</td>
</tr>
<tr>
<td>System Shutdown</td>
<td>0</td>
<td>12</td>
<td>Continued engineering for system shutdown, as well as planning for in station infrastructure</td>
</tr>
<tr>
<td>Holt Road Improvements</td>
<td>3</td>
<td>14</td>
<td>Reconstruction of the Holt Road interchange to improve traffic flow to the project and in order to not impact traffic flows in the adjoining communities</td>
</tr>
<tr>
<td>Operations &amp; Maintenance Support</td>
<td>13</td>
<td>16</td>
<td>Pre-requisite field work and continued planning activities related to unit turnover</td>
</tr>
<tr>
<td>Facilities &amp; Infrastructure Projects</td>
<td>201</td>
<td>147</td>
<td>Further progress on infrastructure required for project and second station life, including OSBR Refurbishment, D2O Storage Facility, Water &amp; Sewer, Electrical Upgrades, RFR Annex, Refurb Project Office and Contractor Facility.</td>
</tr>
<tr>
<td>OPG Oversight and Program Support</td>
<td>300</td>
<td>134</td>
<td>Engineering deliverables including completion of MDRs, progression of detailed engineering, Integrated Improvement Plan (IP) and Global Assessment Report (GAR) to support the 10 year license application for Darlington. Planning deliverables including scope finalization and further development of the project ROE to be issued by October 2015. Also includes project oversight of major contracts/ project bundles and program overheads</td>
</tr>
<tr>
<td>Contingency</td>
<td></td>
<td></td>
<td>Includes allowance for discrete items, cost estimate uncertainty, as well as released contingency for infrastructure projects</td>
</tr>
<tr>
<td>Interest</td>
<td></td>
<td></td>
<td>As spending continues, interest carrying costs increase</td>
</tr>
<tr>
<td>Escalation</td>
<td>0</td>
<td>14</td>
<td>Conversion to 2014$</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>820</strong></td>
<td><strong>788</strong></td>
<td></td>
</tr>
</tbody>
</table>