

PROGRAM PLANNING

1.0 OVERVIEW

To ensure successful execution of the Darlington Refurbishment Program ("DRP"), OPG made a major investment in planning during the Definition Phase. This has enabled OPG to establish detailed scope and a high-confidence schedule and cost estimate, thereby minimizing the risk of scope creep, schedule delays and resulting increases in cost. This Ex. D2-2-4 describes OPG's extensive planning effort, which will enable the DRP to be completed on time and on budget.

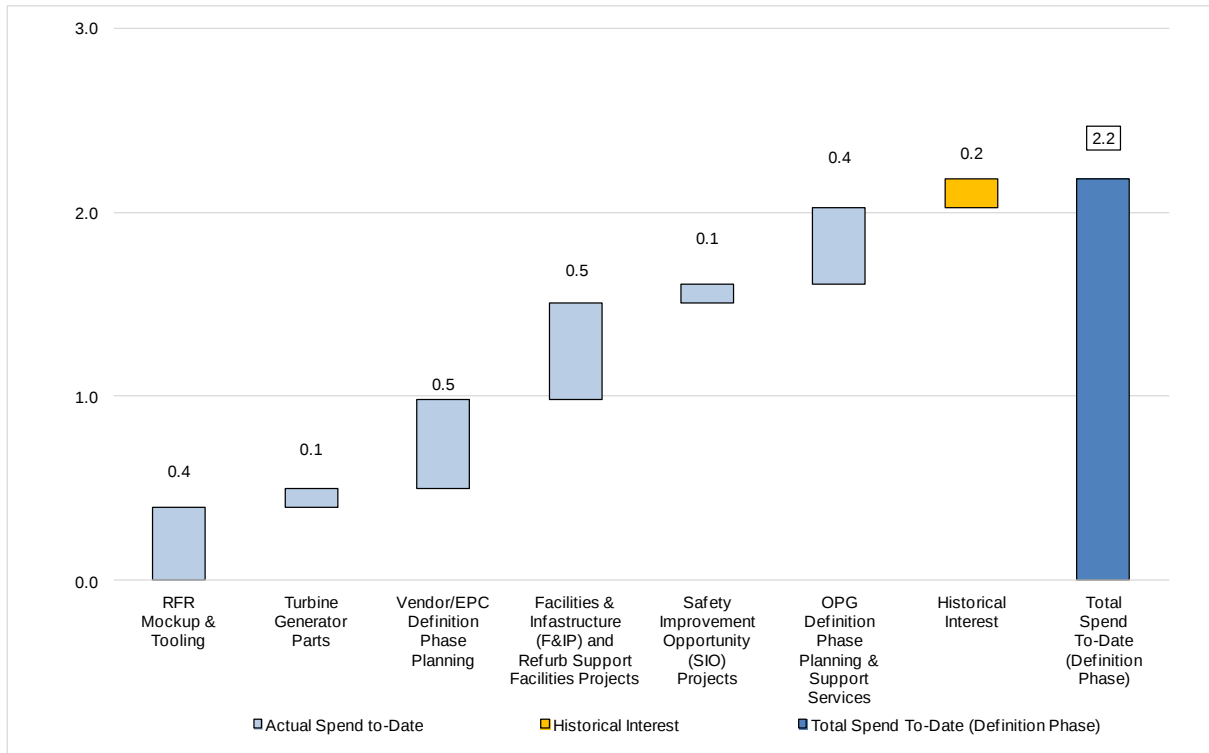
2.0 PLANNING

2.1 Investment in Planning

OPG has organized the DRP into three phases: Initiation, Definition and Execution. Detailed descriptions of the phases are set out in Attachment 1. The Initiation Phase was successfully completed at the end of 2009 with OPG's Board of Directors granting approval to proceed with the DRP. The Definition Phase, which commenced in 2010 to plan and prepare for the start and execution of the Unit 2 refurbishment, was concluded in December 2015 with OPG's Board of Directors approving the Release Quality Estimate ("RQE"). In the Definition Phase, and in anticipation of the start of the Execution Phase, OPG made a significant investment to maximize cost estimate and schedule accuracy.

Life-to-date Program expenditures (to the end of 2015), which includes the extensive planning work carried out during the Initiation Phase and the Definition Phase, are \$2.2B inclusive of interest and escalation. A high level summary of the expenditures in the Definition Phase is provided in Figure 1, below.

Figure 1
Summary of Life to Date Definition Phase Spending to December 31, 2015 (B\$)



The primary outputs of the Definition Phase was: (i) complete planning, including scoping, engineering, cost estimating, and scheduling, (ii) complete pre-requisite activities to enable the refurbishment including facilities, tooling, and a full scale reactor mock-up, and (iii) to obtain approval from OPG's Board of Directors as well as from the Province of the four-unit cost and schedule budget, or RQE, for the DRP. Obtaining RQE signified that detailed planning was complete and set in place a Program level scope, cost and schedule baseline for the four-unit DRP. In addition, RQE approval established the basis for release of Execution Phase funding for the Unit 2 refurbishment. OPG successfully met the following key Definition Phase milestones in order to obtain RQE approval:

- *Scope Definition:* Developed a detailed definition of scope, including clarification of what work is required to be done during the refurbishment outage versus the work occurring outside the refurbishment outage, and established the regulatory scope

which was incorporated into the Canadian Nuclear Safety Commission (“CNSC”) – approved Integrated Implementation Plan (“IIP”);

- *Lessons Learned*: Incorporated review of operating experience and lessons learned into Program planning;
- *Engineering*: Completed detailed design engineering for all Unit 2 scope and modifications to be implemented within the DRP;
- *Reactor Mock-Up, Tool Fabrication and Testing*: Completed a full scale reactor mock-up and Retube and Feeder Replacement (“RFR”) tooling development and testing in the mock-up to inform schedule task durations and train staff;
- *Cost Estimation*: Documented the basis of estimate and underlying assumptions for all major cost elements within the entire Program in accordance with Class 3 estimate quality requirements, as defined by AACE International, a non-profit association that is a recognized authority in project and program cost and schedule management, formerly known as the Association for the Advancement of Cost Engineering (“AACE”); and
- *Scheduling*: Developed an integrated Level 2 schedule for the Program and an integrated and resource-loaded Level 3 schedule for the Unit 2 preparation and Execution Phase;
- Obtained and responded to the findings of an independent assessment of RQE; and
- Updated the DRP Business Case Summary.

OPG’s achievements during the Definition Phase with respect to the integration of lessons learned, engineering completion and reactor mock-up, tool fabrication and testing are discussed below. OPG’s achievements regarding scope definition are discussed in Ex. D2-2-5, scheduling in Ex. D2-2-6, contingency development in Ex. D2-2-7, and cost estimation and RQE in Ex. D2-2-8.

2.1.1 Lessons Learned

OPG’s planning efforts included reviews of operating experience and lessons learned from OPG Nuclear and Hydro projects, as well as past CANDU and other nuclear refurbishments. Projects reviewed included New Brunswick Power’s Point Lepreau refurbishment, OPG’s

Pickering 'A' return to service and safe storage projects, Bruce Power's Unit 1 and 2 refurbishments, Korea Hydro & Nuclear Power's Wolsong-1 refurbishment, Tennessee Valley Authority's Watts Bar refurbishment, and construction of Southern Company's Vogtle Nuclear Generating Plant Units 3 and 4. OPG conducted benchmarking visits and projects reviews, and participated in industry working groups on refurbishment (e.g., CANDU Owners Group working group, World Association of Nuclear Operators). OPG incorporated additional operating experience from non-nuclear mega projects such as the Niagara Tunnel and Lower Mattagami River projects, the London Olympics, Alberta Oil Sands, the Toronto Union Station redevelopment, and Heathrow Airport Terminal 5. OPG's lessons learned program will continue during the execution phase and new benchmarking and collaborations are planned. As set out in Chart, key lessons learned and OPG's responses include:

Chart 1

Key Lessons Learned

Lesson Learned	Response
Large scale refurbishment projects can negatively impact plant performance.	An independent refurbishment organization has been established to minimize impact on plant operation.
Nuclear operating companies do not have the resources or capability to manage and execute large projects.	Implemented the multi-prime contractor model for execution, while OPG retains overall management responsibilities and oversight.
Insufficient front-end planning as a primary source of megaproject failures identified by statistical information based on benchmarking of 318 megaprojects.	DRP has adopted the Construction Industry Institute Front End Planning approach and AACE's recommended practices regarding estimate development.
Delays and cost impacts were incurred as a result of tooling incompatibility and a lack of worker training and task familiarity at the work face.	DRP scope of work includes the construction of a full scale reactor mock-up and full testing of the tools as part of schedule development. Further, tooling and use of the mock-up supports training of staff prior to field work.
The regulatory approval process can be time consuming and increase project risk if approval is not obtained at an early enough stage of the project.	Early engagement of the CNSC enabled OPG to submit and obtain acceptance of the process and scope for the ISR and EA at the initial stages of the assessments. The IIP, which lays out the scope for the project, has been approved by the CNSC (December 2015).
Lack of involvement of dedicated Operations & Maintenance	An Operations and Maintenance organization is embedded in the DRP, while being fully integrated

organization can result in commissioning and restart issues.	with station operations. Both the DRP and the operating Darlington station report to the Chief Nuclear Officer.
Implementation of good project management processes and controls is important in ensuring delivery of a project scope on schedule and within cost.	Adopted PMI, Construction Industry Institute, and AACE recommended practices, processes and controls to administer the Program.

OPG has also worked with its contractors to ensure lessons learned from reviewed projects relating to contractor safety, quality, cost and schedule are integrated into the DRP major work bundles. Contracts for all major work bundles have been awarded and OPG has worked in close collaboration with its contractors to ensure accurate design, engineering, scoping, cost estimating and scheduling.

2.1.2 Engineering Completion

An important achievement during the Definition Phase was that all major contracts required to execute the DRP scope were awarded, which enabled OPG to then work with the contractors to complete the detailed engineering. This includes contracts for each of the major work bundles. Descriptions of the contracts for the major work bundles are provided in Ex. D2-2-3. The contractors under each of the major contracts are responsible for completing detailed engineering and work planning for each of the Darlington Scope Requests (or "Scope Requests", as further discussed in Ex. D2-2-5) relating to their respective contracts. OPG established a milestone date of August 14, 2015 for these contractors to complete the detailed engineering for all Unit 2 modification-based scope and OPG has been successful in achieving this objective. Specifically, design modification packages for all committed major scope items identified prior to January 1, 2014 for Unit 2, except those that were exempt¹, have been reviewed and accepted. Any additional scope identified after January 1, 2014 will be completed as soon as reasonably practicable. Cost estimates and preliminary schedule durations for the work relating to the additional scope were included in the RQE.

The engineering completion milestone was met through a collaborative effort between OPG and OPG's engineering partners. The completion of engineering provides OPG's contractors

¹ Exempt engineering change packages had no impact on the DRP's ability to achieve the RQE milestone.

1 with the ability to develop accurate estimates and schedules for the work and provides the
2 basis for purchasing materials.

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4 2.1.3 Reactor Mock-Up, Tool Fabrication and Testing

5 During the Definition Phase, OPG completed construction of the reactor mock-up, which is
6 part of the RFR work bundle and was placed into service in March 2014. The reactor mock-
7 up allows training to be conducted by OPG and its contractors prior to execution, so that
8 those who will be doing work on the reactors during the refurbishment outages do not
9 consume valuable time to overcome the significant learning curve associated with work
10 procedures and equipment. This is particularly important with respect to critical path work.
11 The full scale reactor mock-up responds to operating experience from the Bruce Power and
12 Pt. Lepreau projects, where significant delays and cost impacts were incurred as a result of a
13 lack of worker training and task familiarity at the reactor work face.

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15 Also significant is that the DRP requires a number of customized tools to be developed and
16 tested for use during the Execution Phase. As part of its comprehensive planning process for
17 the RFR work bundle, tool development has been completed. Tools are able to be tested and
18 workers trained on those tools using the reactor mock-up. This responds to operating
19 experience from the Bruce Power and Pt. Lepreau projects where significant delays and cost
20 impacts were incurred as a result of tooling incompatibility. RFR tool testing in the reactor
21 mock-up is now 100 per cent complete. The result of this tool testing is a major determinant
22 of the critical path because it enables management to determine with a high degree of
23 accuracy the duration required to complete various activities. This data has been considered
24 in sequencing tasks and in refining and optimizing project schedules. Consequently, OPG
25 has a high degree of confidence in its schedule for the RFR work bundle.

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ATTACHMENTS

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3 Attachment 1: Detailed Description of Program Phases

DETAILED DESCRIPTION OF PROGRAM PHASES

OPG has organized the Darlington Refurbishment Program (“DRP” or the “Program”) into the following phases:

- Initiation Phase – OPG commenced the Initiation Phase in late 2007 to determine the preliminary scope of work for the DRP and to perform an economic feasibility assessment. This phase was successfully completed at the end of 2009 with OPG Board of Directors approval of management’s recommendation to proceed to the Definition Phase of the DRP.
- Definition Phase – OPG commenced the Definition Phase in 2010 to plan and prepare for the start and successful execution of Unit 2 refurbishment. The Definition Phase is critical to the success of the Program, as discussed in Ex. D2-2-4. Through activities carried out during this phase, OPG defined the scope of the work to be undertaken, developed a detailed Program schedule and developed the Release Quality Estimate (“RQE”), which is the 4-unit cost and schedule estimate to execute the Program. In addition, several of the Facility and Infrastructure Projects and Safety Improvement Opportunities were completed in this period. The Definition Phase came to a successful conclusion in December 2015 with OPG Board of Directors’ approval of the RQE. This included a release of funds to commence Unit 2 execution preparation and mobilization activities for the period ending in October 2016, which coincides with the start of the Unit 2 refurbishment. The Definition Phase was further divided into two sub-phases, as follows:
 - Preliminary Planning Sub-Phase (January 2010 to December 2011): This sub-phase involved establishing the initial Program management organization, confirming contracting strategies, forming commercial relationships with key contractors, developing Program controls governance, and submitting the Environmental Assessment and Integrated Safety Review for Canadian Nuclear Safety Commission review and acceptance.

- 1 ○ Detailed Planning Sub-Phase (January 2012 to December 2015): This sub-
2 phase involved implementing all major contracts, completing all planning
3 including detailed engineering and tool development, procuring required long
4 lead materials, finalizing scope, developing the RQE, and preparing an
5 updated business case for the DRP.
- 6 • Execution Phase and Return-to-Service – as of January 2016, OPG has transitioned
7 to the Execution Phase of the Program. From January to October 2016, this phase
8 will include Unit 2 execution preparation and mobilization activities. The balance of
9 this phase will involve completion of all planned aspects of refurbishment and
10 associated re-commissioning and re-licensing tasks.