FILED DECEMBER 7, 2018

# Darlington Refurbishment Program Annual Report

AS PER DECISION AND ORDER IN EB-2016-0152

# TABLE OF CONTENTS

INTRODUCTION ..... 2
EXECUTIVE SUMMARY ..... 2
DARLINGTON REFURBISHMENT PROGRAM STATUS ..... 3
OVERVIEW ..... 3
PROGRESS ..... 3
SAFETY ..... 5
Campaigns, Programs and Initiatives ..... 6
RADIOLOGICAL SAFETY ..... 7
Program Radiological Events ..... 7
QUALITY ..... 7
SCHEDULE ..... 8
COST ..... 10
Performance Metrics Summary ..... 10
ENGINEERING ..... 10
PROCUREMENT ..... 12
OPG's Overall Contracting Strategy ..... 12
Procurement Status for Unit 2 ..... 12
CONSTRUCTION ..... 12
Construction Progress Summary ..... 12
Labour Relations Issues Summary ..... 13
Environmental Issues Summary ..... 13
TESTING, START-UP AND COMMISSIONING ..... 13
Return to Service (RTS) Summary ..... 13
RTS Process ..... 14
PROGRAM RISKS AND RISK MANAGEMENT ..... 14
STAFFING ..... 15
OPG Unit 2 Resources ..... 15
Efforts to Fill Open Positions ..... 15

ONTARIO POWER GENERATION

**OPG Confidential Exclusive**

**FOR INFORMATION to the Ontario Energy Board**

November 30th, 2018

**DARLINGTON REFURBISHMENT PROGRAM**

## INTRODUCTION

This report provides the status of the Darlington Refurbishment Program (DRP), hereafter referred to as the "Program". The Program comprises Unit 2, early in-service work and pre-requisite projects.

Unless otherwise noted, this report includes a summary and a review of the Program performance through September 30th, 2018.

This is the first in a series of annual reports to be provided by Ontario Power Generation (OPG) to the Ontario Energy Board (OEB) pursuant to the OEB's decision and order in EB-2016-0152.[1]

## EXECUTIVE SUMMARY

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

The Release Quality Estimate (RQE) for the four-unit refurbishment is $12.8 billion. Under RQE, the first unit to be refurbished (Unit 2) is scheduled to be returned to service in the first quarter of 2020 and the last unit is scheduled to be completed by 2026. The RQE formed the basis of OPG's May 2016 pre-filed evidence in EB-2016-0152. Since the development of the RQE in November 2015, OPG continued detailed planning and preparations for execution of Unit 2 and established a Unit 2 Execution Estimate (U2EE). This estimate was approved by OPG's Board of Directors in August 2016 and has been used to establish Unit 2 project baselines for cost and schedule monitoring. Details of the U2EE were provided in EB-2016-0152, Exhibit L, Tab 4.3, Schedule 1, Staff-055. Detailed planning associated with U2EE confirmed that the overall program and associated contingencies were within the $12.8 billion RQE, but resulted in a 1% increase specific to program costs for Unit 2 and the early in-service work and pre-requisite projects. The OEB approved the EB-2016-0152 revenue requirements based on the RQE forecasts per Ex. N2, Tab 1, Schedule 1 in that proceeding. The High Confidence Schedule[2] discussed in this Report is unchanged between the RQE and the U2EE.

[1] EB-2016-0152, Decisions with Reasons, dated December 28, 2018, p.44, Table 16.
[2] OPG's description of the High Confidence Schedule is found under the "Schedule" section in this report. Note that any reference to 'as planned' or 'on plan' refers to the High Confidence Schedule.

OPG commenced the refurbishment of Unit 2 in October 2016. The Program has been divided up into segments of work that focus on the various refurbishment stages that Unit 2 must go through prior to returning to service. The first segment, which includes the de-fuelling of the reactor and the physical separation of Unit 2 from the three operating units, was completed in the first half of 2017 in accordance with the High Confidence Schedule. The second major segment, which included the disassembly and removal of the existing reactor components, was completed in May 2018 in accordance with the High Confidence Schedule. Unit 2 is currently in the third major segment, the installation and reassembly of reactor components. To date, the third segment is progressing as planned with the installation of all calandria tubes and a number of systems have been returned to service in accordance with the High Confidence Schedule. Preparation activities for the fourth segment, the restart of Unit 2, have commenced and 22 of 58 systems have been returned to service.

Anticipating that a mega-project such as the Darlington Refurbishment would be subject to varying degrees of risks, OPG built contingency into the High Confidence Schedule to help address risks that materialize as the refurbishment progresses. Since the beginning of the project, OPG has used its risk management and project control processes to address project risks effectively within existing contingencies. With a large portion of the work on Unit 2 now complete, and looking ahead at the work that remains, OPG expects to have sufficient contingency to address the remaining risks and complete the Program at the in-service amounts approved by the OEB.

OPG continues to identify, document, evaluate and incorporate lessons learned from ongoing and completed projects into future work, leading to opportunities to execute work more efficiently.

## DARLINGTON REFURBISHMENT PROGRAM STATUS

### OVERVIEW

Key Program highlights include:

- SAFETY: Over 11 million hours have been worked since Unit 2 breaker open in October 2016 and there have been no lost time injuries. Safety performance continues to be 10 times better than the average construction industry performance in Ontario.
- QUALITY: There were no high level quality events or impacts to the High Confidence Schedule; however, as anticipated, there have been low level events resulting in rework.
- SCHEDULE: Execution of the Unit 2 Refurbishment is currently 70% complete and forecasting ahead of the 40-month High Confidence Schedule.
- COST: Life-to-date Program costs are $4.57 billion. The Current Estimate at Completion consistent with the predicted early in-service date to complete all Program work is $5.62 billion, which is within the amounts approved by the OEB.

### PROGRESS

The following is a status summary of the major work groupings since the start of Unit 2 refurbishment. As expected, there have been challenges during execution, however the Program remains on track.

- De-Fuel & Islanding (Critical Path Work)
  During the first segment of the Program, all of the fuel bundles for Unit 2 were successfully removed from the reactor core and moved to the used fuel bay for storage. Additionally, bulkheads were installed to separate Unit 2 from the rest of the station and, following the repair of weld defects, the

pressure test hold point was completed to confirm that Unit 2 was completely isolated from the operating units. Segment one was completed in April 2017.

- Re-tube & Feeder Replacement (RFR) (Critical Path Work)

  The second major segment of the Program, the removal segment, is complete. During this segment, the remaining reactor components, including end fittings and fuel channel assemblies and feeders, were all removed safely. Following removal of the reactor components, key inspections were done on components such as the calandria and bellows. The reactor face was cleaned in preparation for new components.

  The Program's third major segment, the installation segment, is underway. In this segment, new fuel channel assemblies and feeder pipes are being installed. The calandria tube installation series is complete and fuel channels are being installed. This work is forecast to be completed in Q1 2019. Feeder installation is also progressing in parallel with the installation of the fuel channel assemblies and is forecast to be completed in Q2 2019.

- Turbine Generator (TG)

  Since September 2017, all three low pressure turbine rotors and all major turbine stationary components were removed for inspection and repaired as required. All generator cooling water hoses were replaced, the generator current transformers and high voltage bushings were replaced, minor stress corrosion cracking on the turbine rotors was repaired, and steam valves, vessels and heat exchangers were inspected and repaired. Technical issues experienced during TG execution and work required based on the results of inspections delayed the completion of the TG work. However, the re-assembly phase is progressing and the remaining inspection-based repairs are being closed out. The TG project is forecast to be completed by early 2019 with no impact to Unit 2 return to service or critical path.

- Balance of Plant (BoP)

  Work completed in the BoP bundle includes electrical maintenance work, water systems maintenance, and the replacement of a number of large valves throughout the primary heat transport and moderator systems. Primary and secondary side steam generator clean work and substantial work related to the adjuster rods replacement, horizontal and vertical flux detector replacement is complete. Preparations are currently underway to execute activities related to restoring Unit 2 as well as the completion of a shutdown cooling system modification. The majority (85%) of the BoP work is complete with a few work programs continuing into 2019.

- Return to Service (RTS)

  Preparation activities for the restart of Unit 2 have commenced and 22 of 58 systems have been returned to service. RTS work will continue through 2019 when the work is forecast to be complete and the unit brought back online.

- Facilities & Infrastructure Projects (F&IP) and Safety Improvement Opportunities (SIO)

  Of the 11 F&IP and SIO projects in the Program, 10 have been placed in service. The Shield Tank Overpressure Protection (STOP) installation is complete on Units 1, 3, and 4 and will be complete on Unit 2 in Q1 2019 as planned.

- Integrated Implementation Plan (IIP)

  Annual IIP tasks are commitments to the Canadian Nuclear Safety Committee (CNSC). To date, OPG has completed 44 out of 51 tasks and the remaining 7 are on plan for completion by year-end 2018.

## SAFETY

Safety is a paramount priority for OPG. Due to this focus on safety, OPG has one of the lowest injury rates in the Canadian electricity sector.[3] The Canadian Electricity Association (CEA) awarded OPG the President's Award of Excellence for its 2017 safety performance. Additionally, the Canadian Nuclear Safety Commission has awarded the Darlington Nuclear Generating Station the highest possible safety performance rating for the last eight consecutive years in publicly released safety assessments.

In order to maintain this safety performance, OPG continues to set challenging targets for its day-to-day operations. Notwithstanding that the Program work is being executed by contractors and trades in a very complex construction environment, OPG purposefully sets the same challenging targets and expects the same level of performance from the Program. This expectation has resulted in a Program safety performance that is 10 times better than the overall construction industry average as illustrated in Table 1.

OPG employs a variety of leading indicators to ensure that issues are addressed before incidents occur. OPG's practice of proactively tracking events where no injuries occur, but where there is potential for harm, is one example of a leading indicator. OPG carefully logs and reviews each of these incidents and adopts corrective actions to prevent future incidents.

In 2017, the first full year of execution of the Program, there was an increase in the number of people working on the Program, which resulted in a proportional increase in the number of incidents with higher potential for harm. In 2018, the number of these incidents dropped significantly demonstrating the effectiveness of OPG's rigorous approach to safety.

### Performance Metrics Summary

**Table 1** provides a summary of the Program safety performance and includes OPG and contractor employees.

**Table 1 – Safety Performance Metrics**

| | | Historical Actuals | | 2018 | | |
|---|---|---|---|---|---|---|
| **Category** | **Measure** | **2016** | **2017** | **Q3 YTD** | **OPG Target[2]** | **Ontario Construction Industry[3]** |
| **Safety** | All Injury Rate (per 200k hours) [1] / Total Recordable Injury Frequency | 0.64 | 0.49 | 0.36 | 0.37 | 4.53 |
| | Lost Time Due to Injuries | 0 | 0 | 0 | 0 | N/A |

Notes:
1 In 2018, OPG selected Total Recordable Injury Frequency (TRIF), replacing All Injury Rate (AIR), as a measure for evaluating health and safety performance, which reflects a change instituted by the Canadian Electrical Association. Total Recordable Injury Frequency is the average number of fatalities, lost time injuries, medical treatment injuries and restricted work injuries per 200,000 hours worked.
2 OPG sets very challenging targets for its operations and expects the same level of performance from the Program.
3 This rating is the most current safety rating for the Ontario Construction Industry.

[3] Compared to the Industrial Health and Safety Association injury rate.

## CAMPAIGNS, PROGRAMS AND INITIATIVES

OPG developed a corporate 'Why iCare to Work Safely' campaign that underlies all OPG's safety initiatives and programs. The purpose of this campaign is to encourage workers to view safety as a personal endeavour and to reinforce OPG's robust safety culture.

OPG's strong safety performance is underpinned by the practice of monitoring low level precursor issues and proactively taking action to reduce the risk of serious events from occurring. With the 'iCare' message in place, the following are additional safety campaigns, programs and initiatives that OPG and its vendor partners have launched:

- **Seven Life Saving Rules Campaign (March 2017 – Ongoing)**
  This campaign was developed to communicate industrial safety to all trades and to educate contractors about OPG's higher safety standards, the fact that adherence to these rules is mandatory, and that there is zero tolerance for violations.
- **Working at Heights (July 2017)**

  This initiative, which aligns with the Ministry of Labour's focus on this area for the construction industry, is aimed at improving worker awareness and the ability to perceive risk and hazard recognition. The initiative emphasized required equipment inspections and improvements in physical barriers and housekeeping to better manage falling objects.
- **Safety Stand-Down (November 2017)**

  Safety stand-downs are a standard industry practice to pause work and reset workers' attention to focus on safety. In keeping with OPG's safety practice to monitor low level precursors and proactively reduce the risk of higher-level events, one of OPG's major vendor partners stood down their workforce, with OPG's support, due to concerns over a small but increasing number of incidents related to potential conventional workplace safety issues.
- **Continuous Air Monitoring Sampling for Calandria Tube and Calandria Tube Insert Removal (January 2018)**

  OPG installed continuous air monitors in the vault during removal of fuel channel reactor components to provide more accurate, real time indications of changing air quality conditions and ensure worker safety and comfort while working at the reactor face.
- **Material Handling (February 2018)**

  The initiative was aimed at enhancing material movement planning, job site risk recognition and increasing awareness of experience from both the nuclear industry and other industries.
- **Musculoskeletal Disorder (MSD) and Hand Injury Prevention (May 2018)**

  OPG collaborated with its vendor partners to implement actions such as:
  - purchasing improved dexterity gloves for both conventional and radiological work;
  - engaging in strategic communication with workers regarding glove use policy;
  - increasing MSD awareness and consideration during work planning; and
  - creating a Two Minute Jobsite Drill to help workers recognize work tasks that could potentially lead to an MSD Injury.
- **Heat Stress Campaign (Summer 2017 – Summer 2018)**

  The primary strategy of this campaign was to increase worker awareness and ensure workers in the field could recognize signs and symptoms of heat stress. The campaign included the construction of 5 cooling tents, distribution of water bottles, promotion of hydration and the entire organization taking a proactive approach to heat stress awareness.

## RADIOLOGICAL SAFETY

OPG has a robust Radiation Protection (RP) program and overall performance continues to be good with total worker dose better than plan. No worker has received a dose above either regulatory limits or OPG's own more stringent internal targets. Based on the execution work done to date, the Program is currently on track to finish with the lowest Collective Radiation Exposure (CRE) of any nuclear refurbishment completed to date. This is a result of OPG's robust nuclear safety culture and its As Low As Reasonably Achievable (ALARA) RP program.

### PERFORMANCE METRICS SUMMARY

**Table 2** provides a summary of the Program radiological safety performance and includes OPG and contractor employees.

| Table 2 – Radiological Safety Performance Metrics | | | | | | |
|---|---|---|---|---|---|---|
| | 2016 Year End | | 2017 Year End | | 2018 End of Q3 | |
| | Actual | Target | Actual | Target | Actual | Target |
| CRE (person-rem) | 17.4 | 26.5 | 1144 | 1383 | 626 | 694 |
| Unplanned Exposures | 0 | 0 | 0 | 0 | 0 | 0 |

One event of interest to OPG's nuclear regulator, the Canadian Nuclear Safety Commission (CNSC), occurred in February 2018, and corrective actions and improvement initiatives have been implemented or continue to be underway throughout the year. Further details on this event are outlined under 'Program Radiological Events'.

### PROGRAM RADIOLOGICAL EVENTS

In February 2018, two workers in the Re-tube Waste Processing Building (RWPB) received an unplanned internal dose of alpha radiation. Although doses involved were small (less than 1% of the legal limit)[4], the CNSC performed a Reactive Inspection and requested that OPG provide detailed information to show that OPG had adequate controls over RP practices throughout the Program. OPG provided a comprehensive response with corrective measures on oversight of RP practices in the field, training of field RP staff, and documentation of survey results, among others. Other improvement initiatives are also being pursued to better align RP work schedules with Vendor partners' schedules, improve pre-job briefings, and investigate opportunities in RP innovation for efficiency gains.

### QUALITY

There have been no high-level Quality events or impacts to the High Confidence Schedule to date on the Program. OPG's contractors are required to perform all work safely and diligently, in an organized and timely manner, and in accordance with the agreement, applicable laws and prudent practices. Notwithstanding the exercise of prudent practices by OPG and its contractor, a certain amount of typical rework is to be expected on a project of this nature. As such, OPG included an allowance for rework in its agreements with its contractors and included sufficient contingency in its High Confidence Schedule in recognition of this risk. OPG's Quality Management program monitors lower level quality issues and OPG works collaboratively with its contractors to ensure mitigation measures are implemented to prevent

[4] This event did not meet the criteria to be classified as an 'unplanned exposure' as in Table 2.

recurrence. Lessons learned from lower level incidents are incorporated into the planning of future Unit 2 work as well as future unit refurbishment planning.

### PROGRAM QUALITY EVENTS

Complexities related to welding of dissimilar metals required to accommodate components used to measure the flow of water through the feeder pipes were encountered during feeder fabrication. These issues are not unique to OPG as dissimilar metal welds have presented a world-wide industry challenge. OPG, together with the Electric Power Research Institute (EPRI), CanAtom, Candu Energy and US research labs, a specialized mill in France, BWXT in Cambridge and Laker Energy Products, successfully overcame the feeder pipe fabrication challenges.

This is a major industry breakthrough and will result in significant benefits to the nuclear industry as it has solved a life-limiting condition for CANDU reactors.

While the start of feeder pipe installation was delayed due to this challenge, there was no impact to the High Confidence Schedule as rework was considered in the contingency built into the original plan. The feeder work program is progressing in parallel with fuel channels on critical path. OPG continues to monitor execution of the feeder pipe installation closely and is taking actions to mitigate any further delays.

## SCHEDULE

OPG measures Program progress against two estimates:

1. A High Confidence Schedule (released by OPG publicly in 2016 and reviewed by the OEB as part of OPG's 2017-2021 rate application[5]); and
2. A shorter "Working Schedule" that excludes contingency, which OPG uses to manage day-to-day activities. Schedule Performance Index (SPI)[6] is measured against the Working Schedule.

The difference between these two schedules is that the High Confidence Schedule includes contingency amounts that were quantified based on detailed analysis of risks and these contingency amounts are expected to be utilized over the course of the Program. The Working Schedule is used to calculate performance metrics, for example Schedule Performance Index (SPI), and manage day-to-day activities, allowing for early escalation of issues. The use of a Working Schedule is an industry leading best practice for large and complex projects.

### PERFORMANCE METRICS SUMMARY

The Program is currently tracking ahead of the High Confidence Schedule and forecasting a late 2019 completion date.

**Table 3** provides a summary of the Program schedule performance as of October 29th, 2018.

[5] While the budget for U2 and associated campus plan projects increased between RQE and U2EE, the High Confidence Schedule did not change.

[6] This strategy provides an early indication of potential risks or issues and allows OPG to proactively manage Program performance.

| Table 3 – Schedule Performance Metrics | | | | | |
|---|---|---|---|---|---|
| **Measure** | **2016 Year End Actual** | **2017 Year End Actual** | **2018 Q3 Actual** | **Working Schedule Target** | **High Confidence Schedule Target** |
| Days Ahead of / Behind High Confidence Schedule Life-to-Date [1] | 28 Days Ahead | 10 Days Ahead | 33 Days Ahead | N/A | 27-Feb-2020 |
| Critical Path Days Ahead of / Behind[3] Working Schedule Life-to-Date | 19 Days Ahead | 47 Days Behind | 50 Days Behind | 19-Sep-2019 | N/A |
| Schedule Performance Index (SPI) [2] | 0.97 | 0.94 | 0.92 | 1.00 | N/A |
| Forecast Completion Date [3] | 31-Aug-2019 | 5-Nov-2019 | 8-Nov-2019 | N/A | N/A |

Notes
1 Days Ahead/Behind is calculated as progress for all work currently completed relative to the life-to-date allotment of Contingency Days available in the High Confidence Schedule.
2 Schedule Performance Index is calculated for construction, commissioning and inspection work packages only against the Working Schedule.
3 Critical Path Days Ahead/Behind and Forecast Completion Date are calculated as progress for all work currently completed relative to the Working Schedule and does not consider projected gains or losses for future work.

**Table 4** provides a summary of the key Program milestones and the actual and forecast completion against the High Confidence Schedule. Each segment was completed or is currently forecasted to be completed ahead of plan.

| Table 4 – Key Unit 2 Milestone Status | | |
|---|---|---|
| **Key Milestone** | **Planned Completion [1]** | **Actual/ Forecast** |
| Segment 1 [Lead In] Complete | April 27th, 2017 | April 9th, 2017 |
| Segment 2 [Removal] Complete | June 2nd, 2018 | May 5th, 2018 |
| Segment 3 [Install] Complete | August 7th, 2019 | May 6th, 2019 |
| Segment 4 [Lead Out/Return to Service] Complete | February 27th, 2020 | November 8th, 2019 |

Note
1 Planned completion date refers to the High Confidence Schedule.

## COST

### PERFORMANCE METRICS SUMMARY

Total Program costs are currently $4.57 billion life to date. Forecast total life cycle cost at completion is expected to be $5.62 billion, which is within the amounts approved by the OEB, recognizing that risks remain, particularly those associated with Return to Service as discussed below.

Similar to SPI, Cost Performance Indicator (CPI) is measured against the working schedule budget that excludes contingency. The CPI for Unit 2 is 0.90.

**Table 5** provides a summary of the key Program cost performance.

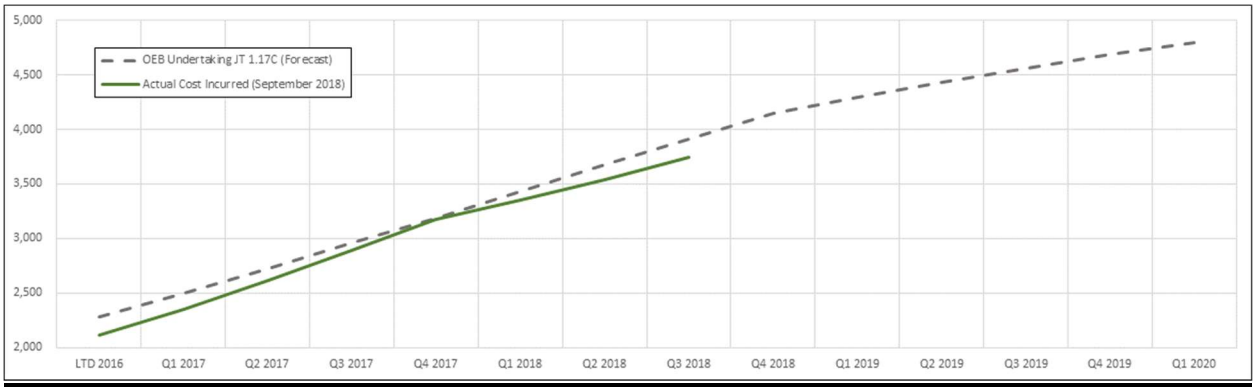
| Table 5 – Cost Performance Metrics [1] | | | |
|---|---|---|---|
| **CPI** | **Life to Date Q3 2018 (LTD) Actual Cost** | **Current Estimate to Complete (ETC)** | **Current Estimate at Completion (EAC)** |
| 0.9 | $4.57 Billion | $1.05 Billion | $5.62 Billion |

Note
1 Program expenditures include Capital and Operations, Maintenance and Administration (OM&A) costs consistent with OEB-approved amounts.

In its December 28th, 2017 Decision and Order in EB-2016-0152, the OEB included Actual Versus Forecast Cumulative Capital Costs as part of OPG's annual reporting requirements. This requirement was further defined in JT1.17C in the same proceeding as quarterly cost flows for the Unit 2 in-service amount of $4.8 billion approved by the OEB (excludes early in-service and pre-requisite projects that are included in Table 5 above). Table 6 and Figure 1 provides this information:

| Table 6 – Actual Vs Forecast Cumulative Capital Costs | | |
|---|---|---|
| **M$** | **OEB Undertaking JT 1.17C (Forecast)** | **Actual Cost Incurred (September 2018)** |
| **LTD 2016** | 2,280 | 2,118 |
| **Q1 2017** | 2,501 | 2,350 |
| **Q2 2017** | 2,721 | 2,616 |
| **Q3 2017** | 2,960 | 2,886 |
| **Q4 2017** | 3,188 | 3,175 |
| **Q1 2018** | 3,433 | 3,348 |
| **Q2 2018** | 3,674 | 3,536 |
| **Q3 2018** | 3,909 | 3,742 |
| **Q4 2018** | 4,147 | |
| **Q1 2019** | 4,292 | |
| **Q2 2019** | 4,435 | |
| **Q3 2019** | 4,563 | |
| **Q4 2019** | 4,689 | |
| **Q1 2020** | 4,800 | |
| **Total** | 4,800 | |

**Figure 1 – Actual Vs Cumulative Capital Cost Curve**




## ENGINEERING

Aggregate earned value for engineering is 99% complete for Unit 2. This figure includes both vendor and OPG engineering work that is being performed for the Program.

All planned engineering work is complete for Unit 2 and the majority of engineering requirements through execution are complete. Field engineering activities continue as planned to ensure issues are resolved as they emerge and designs are modified in field as required.

Major engineering accomplishments in the period include:

- A process was designed to ensure successful return to service of Unit 2 components. This "System Available for Service" process was developed, piloted and finalized and has been used to successfully return 22 systems to service. Training for staff involved in restart activities is underway.

- A construction/field engineering group was established to focus on improving processes and enable the timely response to field-initiated changes.

- Lessons learned from previous work is being captured and applied to all future work.

- Engineering review forums were enhanced for strong management and control of scope.

In addition, the following First of a Kind (FOAK) projects are being monitored closely:

- Shutdown Cooling System enhancements involving the addition of two new auxiliary shutdown cooling pumps which are currently in the installation phase.

- Steam Generator Inlet Strainers are being designed, fabricated and tested to enhance the build-clean process and mitigate the impact of any foreign material in the heat transport system. Delivery of the strainers is expected early in 2019.

- Modifications to improve margin in the Emergency Service Water system following a main steam line break and provide an emergency water supply for Beyond Design Basis Accidents (BDBA). The project is currently in-progress to complete early 2019.

## PROCUREMENT

### OPG'S OVERALL CONTRACTING STRATEGY

To manage the work associated with the Program, OPG uses a "multi-prime contractor" model in which there is more than one prime contractor working on the Program. OPG, as the owner, has a separate contract with each prime contractor. Each prime contractor is responsible for completion of the work that is within the scope of its contract. As the owner, OPG is the integrator among the prime contractors and is responsible for the entire Program.

OPG's contract management approach allows for early identification and quick resolution of issues, while holding each party to its respective accountabilities in accordance with contract terms and conditions. OPG's contract provisions tie contractors' incentives to the long-term success of the Program and align OPG and contractors' goals. This approach was developed from lessons learned in other refurbishment projects and is considered an industry best practice.

OPG has developed robust processes and tools to ensure all services and materials are brought in on time, on budget, safely and with quality. OPG's extensive contract management processes track contractors' costs and performance. These processes also ensure that issues are addressed and parties are held to their respective accountabilities under contract terms and conditions.

### PROCUREMENT STATUS FOR UNIT 2

At the end of Q3 2018, over 95% of all the requested materials for Unit 2 refurbishment were on site, with delivery of the remaining material items on track.

## CONSTRUCTION

### CONSTRUCTION PROGRESS SUMMARY

The execution of Unit 2 is currently 70% complete. The bulk of the construction on Unit 2 is related to the disassembly and removal of the existing reactor components, followed by the installation and reassembly of the new reactor components. The following key construction challenges have been encountered and addressed during Unit 2 refurbishment (see the Safety and Quality sections for other challenges encountered):

- The construction of the Re-tube Waste Processing Building (RWPB) was delayed, which created a risk to the building being available in time to receive waste from the End Fitting Removal series. To mitigate this risk, OPG assembled a dedicated team of subject matter experts to assist the contractor, perform targeted oversight and advise on certain aspects of the remainder of the facility's construction. This action contributed to the RWPB being made available for use on time to receive the first delivery of end fittings with no impact to critical path.
- During the removal phase there were a few construction series that experienced tooling issues. An integrated Tool Management team was assembled to focus on resolving issues quickly using equipment suppliers and industry experts from previous nuclear refurbishment programs. The work involved enhanced use of the mock-up facility at the Darlington Energy Complex, to prepare for subsequent series, and optimizing equipment operation. As a result, some tooling issues were mitigated.
- Recent industry refurbishment operating experience on foreign material in the Heat Transport (HT) system during unit restart was assessed. The identified risk will be mitigated with the insertion of

strainers during HT system commissioning. Mock-up testing of the approved strainer design has shown favourable results. Once testing has been completed, the temporary strainers will be installed as an additional barrier to remove foreign material from the system.

- Welding upper feeders to the existing reactor inlet / outlet headers involved production challenges associated with tooling performance and weld quality during the Upper Feeder Installation series. OPG established a technical team, which included industry experts, to mitigate these challenges through tool set-up and evaluation of weld requirements.
- The calandria tube installation series experienced challenges with a limited number of rolled joint leak tests due to site conditions. A cross-functional team reviewed the efficacy of the test requirements, developed a cleaning process to establish a better seal and brought in new tools from Pickering to corroborate the previous test results.
- The adjuster rod replacement project was challenged by the discovery of several elongated titanium rods. A team was formed to modify the removal process. This allowed work to proceed and lessons learned will be used in subsequent unit refurbishments.
- The moderator system valve rehabilitation project was challenged with insufficient weld purge and nitric acid build up. The team worked through technical and scheduling issues in order to accomplish the work safely and with quality.

The following were key construction challenges with the Turbine Generator (TG) work program.

- Inspections done on the low-pressure turbine rotors identified required repairs. Under tight timelines, a large lathe was located, leased, transported and assembled to machine the spindles. This significant undertaking was a first-of-a-kind for OPG's nuclear stations and involved complex logistics and coordination with multiple internal and external groups throughout North America. These repairs have now effectively extended the life of the rotors for at least another 30 years.
- Final inspection of condenser diffuser welds revealed repairs required prior to return to service. Multiple vendors are collaborating to find the required number of qualified welders to expedite the repairs to ensure years of reliable operation.

### LABOUR RELATIONS ISSUES SUMMARY

There have been no labour relations impacts on the Program to date and OPG is proactively taking steps to mitigate any future issues.

### ENVIRONMENTAL ISSUES SUMMARY

To date, the Program has had no reportable spills or infractions. Emissions are better than target and well below all regulatory limits.

## TESTING, START-UP AND COMMISSIONING

### RETURN TO SERVICE (RTS) SUMMARY

Preparation activities for the restart of Unit 2 have commenced and 22 of 58 systems have been returned to service.

Over the period, the following RTS focus areas were identified:

- returning systems to service to support the first Restart Control Hold Point (RCHP);
- working with vendor partners on documentation submissions required to support the start up of Unit 2; and

- finalizing station integration plans to ensure resources, plans and procedures are in place to support the successful start of Unit 2.

**RTS PROCESS**

The RTS process is a highly complex process and involves eight planned RCHPs, addressing regulatory and non-regulatory checks. The first RCHP will confirm that all system requirements have been met prior to refilling the moderator with heavy water. The second RCHP is a regulatory hold point prior to loading the reactor with fuel. As Unit 2 refurbishment moves through the eight RCHP's, stringent measures are in place to ensure safety and quality are maintained at all times and each system is subjected to rigorous checks and testing prior to being returned to service.

In order to ensure worker safety and to reinforce the significance of this crucial segment, OPG has developed a 'Road to Restart' communications campaign that outlines the five important stages leading up to Unit 2 returning to service. The five stages are:

1. Fuel Channels Installed – focus will be on the moderator being filled
2. Feeders Installed – focus will be on fuel load and the heat transport system being filled
3. Primary Heat Transport Strainer Clean – focus will be on Unit 2 warming up
4. Auxiliary Shutdown Cooling Complete – focus will be on containment being restored
5. Plant Restored – focus will be on the approach to criticality and then full power operation

The 'Road to Restart' messaging will be at the forefront of the Return to Service organization and will be reinforced with workers throughout the remainder of all Unit 2 work.

**RTS RISKS FOR UNIT 2**

Actions are in place to mitigate risks associated with returning the Unit 2 to service such as foreign material exclusion, hot conditioning of the unit and integration between the station and the Program.

## PROGRAM RISKS AND RISK MANAGEMENT

OPG uses a robust risk management process where risks are identified, classified, quantified and mitigated to the extent possible. In a project of this size and scope, global experience dictates that there will be uncertainties that cannot be entirely mitigated or avoided. As such, OPG maintains a detailed inventory of risks and contingency amounts in accordance with the recommended practices of the Association for the Advancement of Cost Engineering – a leading authority in the area of project cost estimation. These contingency amounts are expected to be used over the course of the Program.

The following two risks associated with trades are actively being managed by OPG:

**1. AVAILABILITY OF SKILLED CRAFT RESOURCES / SUPERVISION FOR FUTURE UNITS**

Shortage of skilled trades is a risk for the Program. OPG identified this risk early in the Program and has taken mitigating actions, which are tracked and regularly reported to senior management and OPG's Board of Directors.

OPG continues to address gaps in the availability of skilled trades. In particular, OPG is continuing its collaboration with Bruce Power, relevant unions, educational institutions and other stakeholders to minimize potential cost and disruptions to the Program. This collaboration involves three streams to mitigate the risk of skilled trades' availability as outlined below:

a. collaboration between OPG, Bruce Power, vendors and trade unions to develop enhanced skilled trades' supply and demand data;

b. initiatives to build capacity within the current supply of trades by streamlining processes at both OPG and Bruce Power, including coordinated security processing and training, as well as modified shift schedules to attract talent;
c. building new sources of supply by promoting trades programs through recruitment initiatives at local job fairs, community outreach and specific initiatives to increase the level of interest of women and indigenous peoples in the trades; and
d. working with various Provincial entities and other Canadian organizations across the country such as trade unions, colleges and other stakeholders, to increase the supply of skilled trades.

**2. TIMELY RENEWAL OF COLLECTIVE AGREEMENTS FOR UNIONIZED CONSTRUCTION TRADES**

The collective agreements at risk relate to construction trades. The construction agreements are set to expire on April 30th, 2020 for all construction and Electrical Power Systems Construction Association collective agreements. However, Nuclear Program Agreements (NPA) expire December 31st, 2032, which mitigates construction collective agreement labour disruption risks throughout the life of the Program. The NPA is an appendix to the current collective agreements and will be included in each renewal collective agreement occurring during the term of the NPA.

The PWU and Society agreements typically are effective for two to three years. OPG is in the process of collective bargaining with PWU and Society.

For other risks and challenges, see the 'Construction' and 'Testing, Start-up and Commissioning' sections.

## STAFFING

### REFURBISHMENT RESOURCES

**Table 7** provides a summary of the OPG Resources on the Refurbishment program.

| Measure | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|
| RQE | 501 | 740 | 752 | 758 |
| Actual Full Time Equivalents (FTEs)[1] | 535 | 766 | 821 | |

Note

1 Actual FTEs for 2018 are as of September year to date

### EFFORTS TO FILL OPEN POSITIONS

OPG has a number of programs in place to attract, retain and develop qualified personnel for the Program. Management continues to use corporate-wide succession planning and talent review processes to identify and prepare future leaders to assume key roles over the life of the Program.

OPG's Enterprise Projects Organization is focused on implementing a standardized and scalable project delivery model throughout the enterprise. This organization has developed a training program specifically designed to advance project management capability across the organization. In addition, OPG's succession planning program and mentoring initiatives are designed to ensure that capability is sustained throughout the Program.