CAPITAL PROJECTS – NUCLEAR OPERATIONS

1.0 PURPOSE

This evidence provides a project listing and the business case summaries ("BCS") that support the capital expenditures and the in-service amounts for the Nuclear business unit (excluding the Darlington Refurbishment Program which is addressed in Ex. D2-2-1) during the IR term. These capital expenditures reflect the nuclear capital budget presented in Ex. D2-1-2.

The evidence also provides project specific summaries of new major capital projects (Tier 1 projects) since EB-2016-0152 and consistent with the OEB's Decision and Order in EB-2016-0152, divides the discussions as between those that at the Development or Definition phases, and those at or beyond Execution phase.

In Section 3.5, OPG discusses how its customer engagement process informed planning for capital projects in the portfolio. Section 4.1 provides in-service variances explanations.

2.0 CAPITAL PROJECTS LISTING

The following tiered reporting structure, consistent with the OEB's filing guidelines, has been used to present the evidence for all capital projects that have budgeted expenditures in the IR term or in-service amounts during the bridge year or IR term, or have been completed since EB-2016-0152.

Tier 1:

Individual projects with a total cost of $20M or more. For these projects, summary level information is provided in Ex. D2-1-3, Tables 1a – d, and BCSs[1] are provided in Attachment 1 to this exhibit. Consistent with past applications, business case summaries are not provided for security-related projects, however, Attachment 1 provides a brief description of security-related projects included in Ex. D2-1-3, Table 1a-d.

[1] BCS amounts generally reflect point estimates. For projects in early definition stage, the BCS estimate may be based on a range, or no estimate may be provided. In these instances the current estimate of the total project cost is provided in Ex. D2-1-3 Table 1a-d.

There are 79 Tier 1 projects comprising three categories: Ongoing Projects from EB-2016-0152; Completed/Deferred/Cancelled Projects from EB-2016-0152; and New Projects approved since EB-2016-0152. Further information on Tier 1 projects is provided in Section 3.0 below.

All of the Tier 1 projects listed in Ex. D2-1-3, Table 1a-d, with 17 exceptions, have a final in-service date before or during the IR term. The final in-service amounts for all projects are provided in Ex. D2-1-3, Table 1a-d along with the in-service amount for the IR term. The 17 exceptions are as follows:

- #31524 Darlington Roof Replacement Project - November 2027
- #80022 Darlington OH180 Aging Management Hardware Installation - June 2028
- #80078 Darlington Digital Control, Common Process and Sequence of Events Monitoring Computer Aging Management - February 2028
- #80122 Darlington Main Power Output Protection System Replacement - August 2027
- #80123 Darlington Group II Pressure Transmitter Replacement - January 2028
- #80148 Darlington Fuel Handling Control Computer Input/Output Subsystem (Multiplexer) and Interprocessor Communication Replacement - April 2027
- #82883 Darlington Class 1 I Rectifier Replacement - December 2032
- #82947 Darlington Fuelling Machine Head Major Component Replacement - May 2027
- #83052 Darlington Fuel Handling Power and Signal Cable Catenary Replacement - January 2027
- #83076 Darlington Phase 2 Station Battery Replacement - December 2028
- #83298 Darlington Secondary Systems High Priority Control Valve Replacements - December 2027
- #83480 Darlington 4kV Motor Refurbishment and Replacement - June 2028
- #83484 Darlington Isolated Phase Bus Refurbishment - June 2028
- #84009 Darlington Air Operated Valve Replacements - December 2028
- #84551 Darlington Motor Operated Valve Replacements - December 2028
- #83299 DN Condenser Steam Discharge Valve Control System Replacement – December 2027

- #31716 DN Neutron Over-Power Ion Chamber & In-Core Flux Detector Amplifier Replacement (Reactor Regulating System, Shutdown System 1 & Shutdown System 2) – April 2027

As noted in Ex. D2-1-2, there is one capital non-portfolio expenditure during the IR term for the capitalization of the Darlington Water Treatment Plant Finance Lease with a total cost in excess of $20M. This is further described in Section 3.2 of this exhibit.

In addition to Total Project Cost and In-Service Amounts, Ex. D2-1-3, Tables 1[2] includes Total Project Cost in EB-2016-0152 and Total Cost per First Execution BCS (if available).

Tier 2:
Individual projects with a total cost of $5M to $20M, for which summary level information is provided in Ex. D2-1-3, Tables 2a through 2g. There are 91 Tier 2 projects listed in Ex. D2-1-3, Tables 2a through 2g.

Tier 3:
Individual projects with a total cost of less than $5M, for which aggregated information is provided in Ex. D2-1-3, Table 3. There are 117 Tier 3 projects listed in Ex. D2-1-3, Table 3.

There are a further 53 projects in the project portfolio (unallocated) category (as described in Ex. D2-1-2), which are projects in the project identification or project initiation phases. These projects are presented in Ex. D2-1-3, Tables 5a and 5b. OPG expects that during the IR term, some of these projects (or other projects yet to be identified) will move from the project identification and initiation phases into the project definition or execution phase as part of the ongoing portfolio management process (Ex. D2-1-1, Section 3.1). As indicated in Ex. D2-1-3,

[2] The project total cost figure is the estimate contained in the most recent, approved BCS available at the time OPG's evidence was developed. That estimate can increase or decrease as the project is refined through planning. The planned in-service cost during the IR Term is based on the information supporting OPG's 2020-2026 Business Plan and may reflect a more recent forecast than the estimate included in the BCS. The Total Project Cost of Completed/Deferred/Cancelled Projects (from EB-2016-0152) at the time of preparing the 2020-2026 Business Plan, represent actual costs.

Tables 5a and 5b, preliminary forecasts indicate that 12 of these projects will have a total project cost greater than $20M.

3.0 PROJECT-SPECIFIC INFORMATION - TIER 1 PROJECTS

Exhibit D2-1-1, Section 3.2, provided details on OPG's asset management and investment planning process that identifies the need for new projects, assesses project options and then prioritizes the selected new projects to move forward. As stated in Ex. D2-1-1, Section 3.2.1, the identification of new projects involves a rigorous process that considers asset reliability, maintenance practices and asset performance trends to assess obsolescence and the need for project funding. Exhibit D2-1-1, Attachment 1 also provides a more detailed description of the Project Lifecycle and Management, along with a chart setting out the Association for the Advancement of Cost Engineering ("AACE") Estimate Class and Accuracy Ranges.

Consistent with the OEB's directive in EB-2016-0152 that OPG file the costs for each major capital project based on the first execution business case,[3] the information for Tier 1 projects has been divided into two sub-categories:

i. <u>Tier 1 Projects at the Initiation, Development or Definition Phase</u>

These are projects that have an approved development or definition phase BCS but for which execution has not been approved. Projects in the development and definition phases are undergoing review of alternatives, delivery strategy, baseline scope, and are considered to be at a planning stage. For this reason the total project cost forecast associated with these projects can have a large variance as depicted by the project's AACE estimate class and corresponding accuracy range.

ii. <u>Tier 1 Projects at, or beyond, the Execution Phase</u>

These are projects that have an approved execution BCS, reflecting the approval to move forward with physical construction and commissioning of the work. At this phase, detailed engineering, procurement, and detailed construction/installation planning have been completed and therefore the total project cost estimate has a higher level of definition and

[3] EB-2016-0152, Decision and Order, p. 22.

accuracy than projects in the earlier phases. Projects in execution phases are still subject to known and unknown risks, this uncertainty can result in cost (and schedule) variances as described in the AACE estimate class and accuracy ranges.

Thirty-six Tier 1 projects are listed in Ex. D2-1-3, Table 1a-d as new projects that have been approved for development, definition or execution since EB-2016-0152. Project #84235, Darlington Primary Heat Transport Liquid Relief Valve Modifications (Waterhammer), was listed in EB-2016-0152 as Project OM&A (#38933 Darlington Primary Heat Transport Liquid Relief Valve Modifications (Waterhammer) and was subsequently re-classified as capital. Details of these projects are presented in Section 3.1 below.

Additionally, the following seven projects previously identified at Tier 2 in EB-2016-0152 are now classified as Tier 1 projects based on updated estimates. Detailed descriptions of these projects and associated variances are presented in Section 3.6.

- #31426 Darlington Fuel Handling Inverter Replacement
- #31516 Darlington Station Lighting Retrofit
- #80023 Darlington Steam Generator Level Control Valves Replacement
- #80036 Darlington R22 Refrigerant Air Conditioning Unit Replacement:
- #80063 Darlington Standby Generators Protective Relay Replacement
- #33258 Darlington Replacement of Emergency Power System Uninterruptible Power Supply
- #40691 Pickering B Emergency Power Generator and Main Output Power Protective Relay Replacement.

Business case summaries for all Tier 1 projects, with the exception of security projects, addressing project need, alternatives considered, assessment of key risks, projected cash flows and projected total cost, and project cost variances, are provided in Attachment 1 to this exhibit.

3.1 New Tier 1 Projects

3.1.1 New Tier 1 Projects at the Initiation, Development or Definition Phase

Project #80122 Darlington Main Power Output Protection System Replacement. The Main Power Output system consists of main generators, main output transformers, unit service transformers, station service transformers and transmission lines. The electromechanical protective relays are aged and obsolete, with limited spares available. Functional failure of the protective relays impacts both grid reliability and the power supply to the plant safety systems. In addition to replacement of the protective relays, the project includes modifications to ensure compliance with Independent Electricity System Operator ("IESO"), Market Rules (NERC PRC-002-2), and to install protection against a loss of phase event, which has led to unit shutdowns and primary heat sink loss at three non-OPG nuclear stations in recent years. The total project cost is estimated at $65M based on its BCS. Planned final in-service is August 2027 with an in-service amount during the IR term of $75.0M.

Project #80123 Darlington Group II Pressure Transmitter Replacement. Hundreds of existing pressure transmitters are nearing their end of service life at Darlington Nuclear Generating Station. The transmitters are obsolete and few spares are available. The reliability of these electronic devices degrades with age. Failure rates of these components result in impairments in nuclear process and safety systems including the Moderator System, Emergency Coolant Injection, Negative Pressure Containment, Liquid Injection Shutdown System and Shutdown System 2. If failure occurs and spares are not readily available, OPG will need to take forced outages or an extended outage. The total project cost is forecast to be $47.7M. Planned final in-service is January 2028 with an in-service amount during the IR term of $29.0M.

Project #80148 Darlington Fuel Handling ("FH") Control Computer Input/Output ("I/O") Subsystem (Multiplexer) and Interprocessor Communication Replacement. The objective of this project is to replace the obsolete fuel handing computer input/output subsystems. The obsolete computer components are no longer manufactured and

repair/refurbishment of defective components is not a viable strategy. If these subsystems are not replaced, Darlington fuel handling would experience frequent failure with potential lower generation due to derating of units and eventual shutdown as the units could not be fueled. The total project cost is forecast to be $23.4M. Planned final in-service is April 2027 with an in-service amount during the IR term of $21.0M.

Project #80150 Darlington Fire Resistant Fluid ("FRF") Pump Improvement. The Darlington FRF power package is designed to supply pressurized and conditioned fluid to control the steam turbine valves and devices in the governing, trip and over speed protection circuits. Fire resistant fluid is vital for turbine protection, operation and control. The Darlington FRF power package is obsolete with no spares. Replacement of the FRF power package will also reduce the risk of varnish build-up and other deposits that can plug the filters on turbine control equipment and result in reduced system reliability due to unplanned outages. The total project cost is forecast to be $30.0M. Planned final in-service is November 2025 with an in-service amount during the IR term of $25.0M.

Project #82883 Darlington Class I Rectifier Replacement. The objective of this project is to replace 60 Class I rectifiers, which are obsolete and approaching end of service life. These rectifiers supply critical loads with Class I DC power from the Class II AC busses. Class I Power is very important for maintaining safety, as it provides an uninterruptible DC power to support proper operation of various safety systems. The reliability of these rectifiers is essential for reliable normal power supply to charge Class I battery banks, thereby ensuring uninterruptible power supply to nuclear system related loads and overall maintenance of system health. The total project cost is forecast to be $42.3M. Planned final in service is December 2032 with an in-service amount during the IR term of $17.0M.

Project #82890 Darlington Transformer Control Cabinet Wiring System Replacement. The objective of this project is to replace transformer control cabinets, which connect cables to the system control panel. The transformer control cabinets are in degraded condition and are obsolete. The total project cost is forecast to be $26.8M. This project has been deferred

subsequent to the completion of the current BCS and no in-service amounts are forecast during the IR term. A bridging solution is in place until the replacement is completed.

Project #82947 Darlington Fuelling Machine Head Major Component Replacement. The objective of this project is to refurbish the eight fuelling machine heads to ensure sustained reliability until the end of commercial operations at Darlington. The major components in the fuelling machine heads have not been replaced since commissioning and are beginning to show wear. Failure of any of these components could result in stranding a fuelling machine on reactor during fuelling. Proactive replacement will mitigate against this risk and ensure high reliability. Additionally, key mechanisms will be updated with modern technology as the current technology is obsolete. The total project cost is forecast to be $98.0M. Planned final in-service is May 2027 with an in-service amount during the IR term of $59.0M.

#83039 Darlington Rapid Delivery Machine. Routine inspection of the fuel channels is a Canadian Nuclear Safety Commission ("CNSC") reactor operating license condition. The objective of this project is to design, fabricate and commission a pressure tube inspection machine that will replace the aging Channel Inspection and Gauging Apparatus for Reactors ("CIGAR"). The expected key benefits from completing this project include:

- reducing the time required to perform fuel channel inspections;
- decreasing the length of the regular planned outages, which will increase generation; and
- reducing the amount of manual work and radiation dose required for fuel channel inspections and fuel handling maintenance.

This project will allow for more available critical path time for fuelling machine maintenance during unit outages. Increasing maintenance will improve fuel handling reliability and reduce the potential for forced outages as fuel machine reliability has historically been a frequent cause of forced outages. The total project cost is forecast to be $162.2M. Planned final in-service is May 2025 with an in-service amount during the IR term of $113.2M.

Project #83052 Darlington Fuel Handling Power and Signal Cable Catenary Replacement. The power and signal cable catenaries supply power to the fuel handling trolley and bridge systems and connect them to the control room. The existing cables are approaching

their expected service life. Degraded cables can affect fuel handling reliability, leading to increased maintenance and possible production losses. The total project cost is forecast to be $24.6M. Planned final in-service is January 2027 with an in-service amount during the IR term of $8.7M.

Project #83297 Darlington Large Moderator Temperature Control Valve Replacement. This project is to replace the large moderator temperature control valves ("TCV") valves across all four Darlington units (16 in total). The moderator TCVs perform the critical function of precisely controlling the cooling of the moderator during unit operation and these have experienced an increasing trend of reliability and maintenance issues. Complete replacement with redesigned valves and digital positioners will provide more reliable operation and require lower maintenance, as well as allowing online condition monitoring. Total project cost is forecast to be $36.9M. Planned final in-service is June 2026 with an in-service amount during the IR term of $26.2M.

Project #83298 Darlington Secondary Systems High Priority Control Valve Replacements. The objective of this project is to replace high priority control valves in the boiler feedwater, condenser air extraction and powerhouse upper level service water systems which are obsolete and have experienced an increasing trend of reliability and maintenance issues. The replacement of these control valves reduces the long term maintenance associated with maintaining specified system margins ensuring overall plant reliability. Total project cost is forecast to be $35.4M. Planned final in-service is December 2027 with an in-service amount during the IR term of $26.5M.

Project #83299 Darlington Condenser Steam Discharge Valves Control System Upgrade. The objective of this project is to replace the actuators and associated controls to improve reliability. The Condenser Steam Discharge Valves bypass main steam to the condensers when the turbine is unavailable, maintaining steam generator and primary heat transport temperature and pressure, and thereby maintain cooling of the reactor fuel. Total project cost is forecast to be $29.7M. Planned final in-service is December 2027 with an in-service amount during the IR term of $18.5M.

Project #83480 Darlington 4kV Motors Refurbishment and Replacement. The purpose of this project is to proactively replace or refurbish approximately 130 4kV motors to avoid motor failure. These motors have been in service for over 25 years. The project will be undertaken over a period of 8 to 10 years and will support station operation over its planned service life. These motors are for various systems including nuclear systems and reactor safety systems including motors used in the primary heat transport ("PHT") feed pump and turbine generator lube oil systems. The project will initially consist of a pilot to undertake seven strategically selected 4kV motor replacements to obtain operating experience. This pilot will provide better definition of scope and costs and minimize risk prior to proceeding with the remaining replacements. Depending on the system in which the motor(s) are installed, motor failure could result in a lengthy forced outage/shutdown of reactor units. Total project cost is forecast to be $278.8M. Planned final in-service is June 2028 with an in-service amount during the IR term of $89.8M.

Project #83484 Darlington Isolated Phase Bus Refurbishment. The Isolated Phase Bus System conveys unit generator power to the main output and station service transformers, and provides inputs for protective relaying, voltage regulation, synchronizing, metering, and fault current limiting. The project goal is to extend the service life of this system as well as ensure continued integrity, functionality, and reliability until station end of life. The total project cost is forecast to be $62.4M. Planned final in-service is June 2028 with an in-service amount during the IR term of $22.9M.

Project #83558 Darlington Fuel Handling Service Area Bridge F5 Ball Screw Assembly Replacement. The objective of this project is to replace the service area bridge ball screw assemblies in the East Fuelling Facility Auxiliary Area ("EFFAA"). The service area bridge supports the fuelling machine head, suspension and catenaries for operations in the EFFAA such as discharge of irradiated fuel, loading of new fuel and calibration/outage work. The ball screws raise and lower the service area bridge to allow access to the appropriate port for these operations. A component condition assessment determined that the ball screws are approaching end of service life. Total project cost is forecast to be $28.2M. Planned final in-service is June 2025 with an in-service amount during the IR term of $11.8M.

Project #83664 Darlington Unit 2 Turbine Control and Auxiliary Systems Upgrade. The replacement of the Unit 2 turbine generator, control cards, electro-hydraulic controllers, generator excitation control cards, and generator auxiliary skids is required to mitigate the aging effects of the components, eliminate financial impact due to unexpected production loss, and ensure U2 operation until station end of life.

The Turbine Controls and Auxiliary System replacement is being completed on Units 1, 3 and 4 through the DRP. As discussed in EB-2016-0152, installation of the Unit 2 Turbine Controls was excluded from Unit 2 scope in order to mitigate risk given that Unit 2 was the first unit to be refurbished. Incorporating this large first-of-a kind modification on the conventional side would have introduced unnecessary additional risk into the planning and execution of the Unit 2 refurbishment involving primarily reactor side components. The complexity of this scope requires two outages to replace the system on Unit 2 as it reaches end of life, and to ensure a consistent control system for all of the turbine sets in Units 1-4. The total project cost is forecast to be $112.7M. The planned final in-service is July 2025 with an in-service amount during the IR term of $102.1M.

Project #83828 Fleet Monitoring Initiative (Monitoring and Diagnostic Centre). This project is to implement the use of online equipment condition monitoring sensors at OPG's generating and support facilities to improve plant performance by improving equipment reliability (see also discussion on the Right Time, Right Work, Right Value nuclear fleet initiative in Ex. F2-1-1 Section 3.5.2). The Monitoring and Diagnostic Centre future plans are to apply data from new sensors to perform diagnostics on equipment such as generators, motors and transformers as well as thermal performance. This will be done using machine learning, advanced analytics and physics based modeling to provide early warning of degradations and diagnosis of specific failure mechanisms that are causing plant efficiency losses or could lead to equipment failures. The project delivers benefits through avoided costs of equipment failures and the optimization of maintenance programs. The total project cost is forecast to be $29.3M. Planned final in-service is July 2023 with an in-service amount during the IR term of $16.0M.

Project #83916 Darlington Fuel Handling Calibration Facility Component Replacement Project. There are 9 fuel handling calibration facilities for fueling machine heads located in the pressure test facility and fueling facility auxiliary area. Each calibration facility has electrical and mechanical components, which are at the end of their service life. The majority of the components are obsolete with no spares available. The fueling machine calibration facilities are needed to maintain reliable operations and avoid unplanned failures of the fueling machines that would lead to unit derate or unit shutdown. This project will replace the calibration facility components with new components or by replicating obsolete components through reverse engineering. The total project cost is forecast to be $22.4M. The planned final in-service is July 2025 with an in-service amount during the IR term of $22.4M.

Project #84009 Darlington Air Operated Valve Replacements. Darlington has over 7,000 air operated valves ("AOV"s), of which, approximately 500 are critical. The objective of this project is to replace a subset (294) of the critical AOVs that are approaching the end of their service lives. Many of these valves are no longer supported by the original equipment manufacturer and this results in a challenge to meet operational or nuclear safety margin requirements. The replacement of these AOVs is necessary to preserve specified system margins and ensure overall plant reliability. The total project cost is forecast to be $85.7M. The planned final in-service is December 2028 with an in-service amount during the IR term of $39.5M.

Project #84551 Darlington Motor Operated Valve Replacement. Darlington has over 1,200 motor operated valves ("MOV"s), of which, approximately 150 are critical. The Darlington's critical MOVs are approaching end of service life. Many of these valves are obsolete and overall equipment reliability is declining. During a review of MOVs OPG determined that some critical valves have limited margins to perform their intended safety functions. The proposed valve/actuator upgrades will increase the safety margin for these valves. This project is intended to eliminate obsolescence, regain capability margins and sustain long-term operation to station end of life. Where applicable, digital controls will be used to allow for condition based maintenance. The replacement of these MOVs is necessary to preserve specified system margins and ensure overall plant reliability. The total project is forecast to be $44.5M the

planned final in-service date is December 2028 with an in-service amount during the IR term of $29.3M.

Project # 84939 Darlington Revenue Metering Transformer Replacement. The objective of this project is to update the revenue metering system to meet the IESO Market Rules and Measurement Canada regulations, as well as ensure continued reliable operation over station service life. The scope includes replacing the revenue metering current transformers and capacitor voltage transformers at both the main output transformer and station service transformer. The total project cost is forecast to be $35.9M. The planned final in-service date is October 2026 with an in-service amount during the IR term of $25.5M.

3.1.2 New Tier 1 Projects with Execution Phase BCS

Project #80124 Darlington Obsolete Controller Replacement. The objective of this project is to replace the approximately 350 controllers used to monitor and control process variables such as temperature, pressure, level and flow, in various systems in the station, including nuclear and special safety systems. In accordance with Integrated Aging Management requirements, OPG must undertake component condition assessments on systems, structures and components to evaluate the health of critical components. Following which, OPG must address aging related issues, obsolescence management and strategic and critical spares (Ex. D2-1-1). OPG has determined that the controllers identified through this process must be proactively replaced to support safe and reliable plant operation over Darlington's station service life due to obsolescence of spare parts, aging, reduced reliability and to avoid forced outages. These controllers have also been identified as obsolete by the original equipment manufacturer. The total project cost is forecast to be $38.0M. Planned final in-service is December 2026 with an in-service amount during the IR term of $13.1M.

Project #80126 Darlington Emergency Power Generator 1 and 2 Replacement. The objective of this project is to replace Darlington's Emergency Power Generator ("EPG") 1 and EPG2 in accordance with commitments to the CNSC through the Integrated Implementation

Plan.[4] OPG's component condition assessments have concluded that several critical components are degraded and require repair or replacement. OPG cannot perform the required repairs as there are no spare parts on hand and the components to be repaired are not commercially available due to outdated technologies and obsolescence. Replacement is required to ensure reliability of EPG1 and EPG2 over station service life. The total project cost is forecast to be $176.2M. Planned final in-service is May 2022 with an in-service amount during the IR term of $89.4M.

Project #83049 Darlington Copper Piping Replacement. The objective of this project is to replace copper piping used in the low pressure service water and powerhouse upper level service water system with stainless steel piping. There have been numerous functional failures due to erosion, corrosion and turbulence effects. Additionally, as the existing piping does not meet modern codes and standards, it has required a variance from the Technical Standards and Safety Authority. The original BCS planned for the installation of new copper piping for 44 locations within the station with an estimated project cost of $29.8M. Scope was added to this project through a superseding BCS to complete the installation of another 16 locations (4 per unit) on critical pumps in the station resulting in an increase of project cost of $15.3M. The total project cost is forecast to be $45.1M. Planned final in-service is December 2022 with an in-service amount during the IR term of $6.0M.

Project #83053 Darlington Shutdown Cooling Heat Exchanger Powerhouse Upper Level Service Water Piping Replacement. The objective of this project is to replace 1,000 to 1,250 feet (per unit) of large diameter service water supply and return lines to the shutdown cooling heat exchangers as well as other selected lines. Due to microbiologically induced corrosion, the walls of these lines are thinning and eventually will fall below code minimums. Failure could impair the function of the shutdown cooling system, which is the primary shutdown heat sink for the reactor fuel. The total project cost is forecast to be $75.2M. Planned final in-service is January 2025 with an in-service amount during the IR term of $50.5M.

[4] As part of CNSC licencing of Darlington, a Periodic Safety Review is prepared that includes an assessment against modern codes and standards, a safety factor review, a global assessment report, and an ensuing Integrated Implementation Plan for the corrective actions and safety improvements, as discussed at Ex. D2-2-1, Section 4.4.

#83072 Pickering Buried Blowdown Pipe Replacement. The objective of this project is to replace buried carbon steel piping that recent inspections have determined is degraded and could fail during operation. Replacing this pipe is necessary to address operational and steam safety concerns. Failure of the piping would necessitate an extended forced outage to repair or replace the failed section. The total project cost is forecast to be $20.9M. Planned final in-service is December 2020 with no in-service amounts during the IR term.[5]

Project #83076 Darlington Phase 2 Station Battery Replacement. The objective of this project is to replace the lead-calcium batteries installed in Class I power and emergency power systems between 2001 and 2009. The existing batteries are approaching end of service life. This project will ensure continued reliable operation of the back-up power system at Darlington. The total project cost is forecast to be $34.5M. Planned final in-service is December 2028 with an in-service amount during the IR term of $18.6M.

Project #83088 Pickering Low Pressure Feedwater Heat Exchangers Replacement

The objective of this project is to replace the low pressure feedwater heat exchangers in Pickering Unit 1 and Unit 4. Inspections in 2013/2014 confirmed tube leaks and significant degradation of the tubes, which resulted in the need to plug various tubes. Heat exchangers of this type are designed with additional tubes so that, in the event of a leak, the leaking tube(s) can be plugged and still maintain design heat transfer. However, as the number of tubes plugged in each heat exchanger increases, there are fewer extra tubes available to address leaking tubes that are plugged. Increased plugging also accelerates degradation and increases risk of heat exchanger unavailability, which has the potential to result in extended forced unit outage. The total project cost was $22.0M. Final in-service was May 2018.[6]

Project #83296 Darlington Main Output Transformer and Unit Service Transformer Replacement. The objective of this project is to proactively replace the three main output transformer phases and the unit service transformer in each Darlington unit to ensure reliable

[5] While the planned final in-service date occurs within the EB-2016-0152 IR term; this new project was approved after the EB-2016-0152 application was filed.
[6] Ibid.

operation over station service life. Industry experience indicates that the service life of transformers of this size and rating is 30 to 40 years with typical operating and maintenance practices. The existing transformers are now entering that range. A limited failure would result in unit shutdown for a prolonged period and significant loss of production. In the event of a catastrophic failure, due to the absence of inter-phase blast walls, there would be significant damage to two or more phases as well as the potential for work place injuries. Consequently, it is prudent to replace the transformers to minimize production and safety risks. Total project cost is forecast to be $170.1M. Planned final in-service is June 2024 with an in-service amount during the IR term of $98.4M.

Project #83556 Darlington Turbine Hall Crane Controls Upgrade. This project is to upgrade the controls systems on the two turbine hall cranes. The control systems are currently obsolete and approaching end of service life. This project will address this obsolescence and ongoing reliability issues by upgrading the crane controls to technology that is prevalent in the industry. The total project cost was estimated to be $19.7M in the first execution BCS. A Project Over-Variance Approval was authorized in July 2020 to increase the total project estimate to $23.6M to account for the discovery of out-of-specification components that increased the scope of the replacements and the need to upgrade original equipment manufacturer materials to meet nuclear quality requirements. Planned final in-service is December 2020 with no in-service amounts during the IR term.[7]

Project #83559 Darlington Irradiated Fuel Bay Permanent Fuel Inspection Equipment in East and West Fuelling Facility Auxiliary Area. The objective of this project is to install a new inspection facility for irradiated fuel bundles and to upgrade the existing inspection/test facility. Darlington has committed to the CNSC to inspect 20 irradiated used fuel bundles per year per unit. The current inspection equipment is prone to failures due to equipment end of life and lack of support for obsolete technology, resulting in its becoming increasingly unavailable to conduct inspections. The total project cost is forecast to be $25.0M. Planned final in-service is May 2022 with an in-service amount during the IR term of $8.9M.

[7] Ibid.

Project #83668 Pickering High Pressure ("HP") Turbine Spares. This project is to purchase High Pressure Turbine Spindle spares. During 2016 inspections, stress corrosion cracks were discovered in the Unit 7 high pressure spindle body. The cracks are not repairable. The lead time for new turbines is 12-16 months, so obtaining spares minimizes future operating risk to Pickering. The total project cost is forecast to be $21.3M. Final in-service was August 2019 with no in-service amount during the IR term.[8]

Project #84235 Darlington Primary Heat Transport Liquid Relief Valve Modifications (Waterhammer). The objective of this project is to modify the Primary Heat Transport Liquid Relief Valves to address an ongoing regulatory issue. While necessary modifications to the valves were implemented following initial commissioning of Darlington (i.e., 1989-1992) to address operational issues, as part of the Darlington Integrated Implementation Plan, OPG committed to the CNSC to replace these valves. The total project cost is forecast to be $86.8M. Planned final in-service is July 2026 with an in-service amount during the IR term of $43.5M.

Project #84799 Darlington Primary Heat Transport Pump Rotor Inspect/Replace. This project is part of Darlington's Integrated Implementation Plan commitment to replace one PHT pump per unit (internal components) as required. The failure of any of the 4 PHT pumps in a unit would lead to a forced outage, which, depending on the extent of the failure, could be lengthy. To take advantage of a refurbishment outage window, the first inspection took place on Unit 2, where one pump was identified for replacement. OPG will attempt to schedule the work for the remaining units during refurbishment windows if lead times for materials, planning, and execution allow. Additional replacements may be required, depending upon the condition of the inspected pumps. The total project cost is forecast to be $89.2M, including contingency for the replacement of an additional three pumps should it be required. Should use of this contingent funding be required, approval will be sought through a future BCS. The planned final in-service date is October 2026 with an in-service amount during the IR term of $46.4M.

[8] Ibid.

3.2 Darlington Water Treatment Plant Finance Lease

The existing water treatment plant ("WTP") at Darlington is approaching its end of service life and needs to be replaced to ensure a reliable supply of ultra-pure demineralized water is available for Darlington's ongoing operations. This water is essential to Darlington's operations and its supply is critical to maintaining station reliability for the life of the station.

Based on the assessment of options and financial analysis presented in Attachment 2, the WTP will be built using a Design, Build, Finance, Operate and Maintain ("DBFOM") contracting strategy, which outsources the construction, operations and maintenance of the plant to a third party specializing in high purity demineralized water management.

The location selected as best for the new WTP is north of the sally port on the east side of the station. A separate WTP Interconnections Project (Attachment 1, Tab 7, project #31535) will construct and commission station tie-ins designed to segregate the WTP, enabling it to be built outside the security fence.

Following a 2018 Request for Proposal, OPG selected a preferred vendor for the DBFOM strategy to negotiate an agreement for the supply of ultra-pure demineralized water for the next 30 years. The proposed agreement consists of fixed monthly payments for capital, fixed operations and scheduled rehabilitation, plus a monthly variance payment for consumables driven by water usage. Under the DBFOM contracting model, the vendor will be the legal owner the new WTP.

In accordance with US GAAP, the underlying demineralized water supply agreement will represent a finance lease arrangement, requiring recognition of a finance liability and capital asset, which will be subject to depreciation. The asset and liability value is to be calculated as the sum of present value of eligible payments under the contract, per US GAAP. Any contractual payments not included in the calculation of the asset and liability value would be

treated as Nuclear Operations Base OM&A. The 2020-2026 Business Plan includes an initial estimate of $138.6M for the WTP asset.[9]

For ratemaking purposes, OPG has included the WTP asset in its proposed rate base, as consistent with the financial accounting treatment and contemplated in the OEB Accounting Procedures Handbook.[10].

As discussed in Attachment 2, some of the details of the DBFOM proposed agreement that determined the WTP asset value are subject to the completion of negotiations with the vendor and the Power Workers' Union ("PWU") related to the operations and maintenance of the WTP, but this is not expected to have a material impact on the economic analysis, which selected the DBFOM as the preferred option.

3.3 Completed Projects

Sixteen Tier 1 projects have been completed since EB-2016-0152. Business Case Summaries for all projects are provided in Attachment 1 to this exhibit.

Project #25619, Darlington Operations Support Building Refurbishment, was completed under budget at $61.3M versus forecast total project cost of $62.7M (EB-2016-0152, Ex. D2-1-3, Table 1).

Project #25609, Security Physical Barrier System, was completed on budget at $67.2M versus forecast total project cost of $62.7M (EB-2016-0152, Ex. D2-1-3, Table 1).

Project #31508, Darlington Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment, was completed over budget at $55.5M versus forecast total project cost of $52.9M (EB-2016-0152, Ex. D2-1-3, Table 1). This project was included in a

[9] Finalization of planning assumptions including as they relate to the details of the DBFOM agreement and in-service schedule may result in changes in the projected asset value, including through reclassifications with Base OM&A expenses as determined in accordance with US GAAP.

[10] Article 425 of the OEB Accounting Procedures Handbook discusses finance lease treatment and considerations. Indicators of a finance lease are discussed at Article 425, p. 4. Regulatory treatment is discussed at Article 425, p. 8.

programmatic approval with projects #49158, Pickering 5 - 8 Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment and #49299, Pickering 1 and 4 Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment. Unused contingency from the Pickering projects was re-allocated to this project to increase the approved funding to $55.9M. The overall Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment program was completed under-budget ($114.1M versus forecast total program cost of $115.6M).

Project #31717, Darlington Maintenance and Computer Development Facility (Capital), was completed under budget at $35.6M versus forecast total project cost of $43.2M (EB-2016-0152, Ex. D2-1-3, Table 1).

Project #31552 Darlington Condenser Cooling Water ("CCW") and Low Pressure Service Water ("LPSW") Travelling Screens Replacement, was completed under budget at $33.0M versus forecast total project cost of $37.6M (EB-2016-0152, Ex. D2-1-3, Table 1).

Project #32202, Darlington Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment was completed under budget at $23.1M versus the forecast total project cost of $28.0M (EB-2016-0152, Ex. D2-1-3 Table 2d).[11]

Project #33955 Darlington Shutdown System ("SDS") Computers Aging Management, was completed on budget at $20.3M versus forecast total project cost of $20.3M (EB-2016-0152, Ex. D2-1-3, Table 1).

Project #36001, Darlington Purchase of PHT Pump Motor Capital Spares was completed under budget at $27.6M versus forecast total project cost of $30.8M (EB-2016-0152, Ex. D2-1-3, Table 1).

[11] Project was incorrectly identified as a Tier 2 project in EB-2016-0152, Ex. D2-1-3, Table 2d.

Project #41023, Pickering Unit 1 and 4 Fuel Channel East Pressure Tube Shift Tooling (Capital), was completed under budget at $27.7M versus forecast total project cost of $38.6M (EB-2016-0152, Ex. D2-1-3, Table 1).

Project #41027, Pickering Fukushima Phase 2 Beyond Design Basis Event Emergency Mitigation Equipment, was completed over budget at $49.7M versus forecast total project cost of $46.3M (EB-2016-0152, Ex. D2-1-3, Table 1). This project was included in a programmatic approval with project #32202, Darlington Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment. Unused contingency from the Darlington project was re-allocated to this project to increase the approved funding to $50.5M. The overall Fukushima Phase 2 Beyond Design Basis Event Emergency Mitigation Equipment program was completed under-budget ($72.9M versus forecast total program cost of $74.3M).

Project #46634, Pickering Fuel Handling Single Points of Vulnerability Equipment Reliability Improvement Project (Capital), was completed on budget ($21.2M versus forecast total project cost of $27.3M (EB-2016-0152, Ex. D2-1-3, Table 1).

Project #49158, Pickering Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment, was completed under budget ($41.7M versus forecast total project cost of $44.0M). This project was included in a programmatic approval with projects #31508, Darlington Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment and #49299, Pickering 1 and 4 Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment. Unused contingency from the Pickering projects was re-allocated to the Darlington project to increase its approved funding as discussed above. The Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment program was completed under-budget ($114.1M versus forecast total program cost of $115.6M).

Project #66600, Pickering Machine Delivered Scrape Project was completed over budget ($27.0M versus forecast total project cost of $26.1M) (EB-2016-0152, L-04 2-1 Staff 043).

Project #73706, Darlington Holt Road Interchange Upgrade, was completed under budget ($26.7M versus forecast total project cost of $28.6M (EB-2016-0152, Ex. D2-1-3, Table 1).

Project #80111 Darlington Generator Stator Core Capital Spare was completed under budget ($30.8M versus forecast total project cost of $35.0M) (EB-2016-0152, Ex. D2-1-3, Table 1).

Project #40976 Pickering B U58 Fuel Handling Reliability Improvement Project was completed over budget ($40.4M versus forecast total project cost of $37.3M) (EB-2016-0152, Ex. D2-1-3, Table 1). The increase of $3.1M was mainly due to project management costs and additional interest associated with the extension of the project to 2018. Additionally, costs related to construction, safety and quality oversight for multiple additional outages and online no-fuel windows were incurred.

3.4 Deferred/Cancelled Projects

There are no deferred or cancelled projects from EB-2016-0152.

3.5 Customer Engagement – New Capital Projects

In 2018 and 2019, OPG engaged Innovative Research Group Inc. ("Innovative") to undertake a customer engagement process. The goal of this process was to obtain feedback on outcomes that matter to customers to help inform the business plan underlying this application. Detailed information on the customer engagement process is provided in Ex. A2-2-1 with further details provided in Innovative's report, which is filed as Attachment 4 to Ex. A2-2-1.

As part of the customer engagement process, Innovative sought customer feedback on several potential nuclear capital investments. OPG and Innovative limited the consultation to three representative nuclear capital projects that, at the time, were beginning the identification and prioritization stage without an approved BCS:

- Darlington Vapour Recovery System ("VRS")
- Darlington Air Compressors Replacement
- Darlington Crane Project

Customer feedback on capital investment decisions varied. Among the example projects, none of the options considered were favoured by a clear majority of customer groups.

On the VRS, there was a slight preference by both residential and business customers for the more expensive option of replacing the system entirely. However, OPG has determined that the optimal investment is to improve the existing system. This approach will allow OPG to address a critical operational and safety risk and provide redundancy related to breathing air restrictions when two units are undergoing refurbishment. In contrast, system replacement would not provide redundancy and would extend system down time. Moreover, improving the existing VRS system is expected to result in substantial savings compared to a system replacement.

On the Air Compressors Replacement project, residential customers favoured replacing all of the identified compressors proactively, while business customers were essentially split between proactive replacement and maintaining an inventory of spares. OPG is planning to proactively replace all 19 air compressors at Darlington in alignment with customer feedback. This investment would mitigate operational risk as the identified compressors' condition is expected to deteriorate.

On the Crane Project, residential customers were split between comprehensive and partial replacement approaches, while business customers preferred the partial replacement approach by a 10% margin. In alignment with customer feedback, OPG is planning to refurbish up to 14 cranes during the IR term and defer refurbishment of the remaining cranes.

The three projects presented to customers are listed in Ex. D2-1-3, Tables 5a and 5b, as potential Portfolio Projects (Unallocated). OPG anticipates that these projects will proceed to be funded through the unallocated component of the project portfolio.[12]

[12] Identified in Ex. D2-1-3 as the following projects: Breathing, Instrument and Service Air Compressor Replacement, Powerhouse Cranes Refurbishment, and Vault and Containment Vapour Recovery Systems Component Replacement.

3.6 Project Variance Explanations

There are seventeen ongoing Tier 1 projects for which total forecast project cost variances currently exceed 10% as compared to total forecast project cost provided in EB-2016-0152.[13]

Project cost variances will occur as the project moves through the five phases of a project lifecycle (Ex. D2-1-1, Attachment 1), primarily due to issues such as changes in project scope and/or schedule, including:

- **Proactive disposition of constructability issues:** The goals of the definition phase of a project life cycle as discussed at Ex. D2-1-1, Attachment 1, include defining the project and demonstrating readiness for execution. Among the activities undertaken in this phase are development of the project cost estimate and execution plan, assessment of risk and development of mitigation plans. Applying Collaborative Front End Planning ("CFEP") during the definition phase includes supplemental constructor input, which, in some cases identifies construction execution risk leading to proactive scope increases affecting project cost and or schedule. Ex. D2-1-1 further describes the CFEP process.
- **Optimization of schedule to optimized unit condition:** Installation of plant modifications are best achieved during optimized unit conditions such as unit outages, system outages or appropriate sequencing of other activities. During the definition phases of the project lifecycle when cost estimates and scheduling are being developed, assumptions related to unit outages, system outages or sequencing are based on the then planned outage schedule. As outages are scheduled and completed, this can lead to changes in the original assumptions underpinning cost and scheduling estimates.
- **Pilots:** OPG may implement a pilot to review and incorporate appropriate lessons learned prior to the project execution phase. This ensures efficiency gains are achieved in subsequent parts of a project. Pilots also facilitate a risk-based analysis on the scope of a project to identify any deficiencies in approach before substantial resources are committed for full execution. In some cases, realized risk may result in scope increases that affect the cost and schedule reflected in the execution phase estimate.

[13] Total project costs as provided in BCSs filed in EB-2016-0152, Ex. D2-1-3 Attachment 1;L-4.2-1 Staff-28, Staff-40, Staff-41, and Staff-43; L-4.2-13 PWU-006; and Ex. J15.5.

As projects proceed through the life cycle phases, project costs will vary within an accuracy range based on the level of definition and the associated class of estimate,[14] as defined by the industry best practices (AACE) due to increased definition of the project scope and cost. While the estimated cost of several Tier 1 projects has increased since the estimate provided in EB-2016-0152, the estimated cost at completion remains within the accuracy range associated with the level of definition at the time of the previous estimate. OPG has identified in the project variance explanations set out below those projects with variances within the accuracy range and those projects that have progressed to an execution BCS. As described in Section 3.0 above, projects in the early lifecycle stages have a greater variance in their cost estimates as the scope, engineering and strategy is still being defined. Individual project cost variance analysis for each of the seventeen Tier 1 projects with greater than 10% variance are discussed below.

As with Section 3.0, and consistent with the OEB's directive in EB-2016-0152 that OPG file the cost of each major capital project based on the first execution business case and the final proposed amount for which OPG is seeking approval, variance explanations are subdivided into two sections:

- Projects that were in the Initiation, Development or Definition Phase when presented in EB-2016-0152; and
- Projects that had an Execution Phase BCS when presented in EB-2016-0152.

3.6.1 Projects in the Initiation, Development or Definition Phase in EB-2016-0152

Project # 31524 Darlington Roof Replacement Project. The current total project cost is forecast to be $116.9M, which is an increase of $78.6M from the Initiation Phase Class 5 estimated total project cost of $36.3M provided in EB-2016-0152.[15] The Class 5 estimate filed in EB-2016-0152 reflects a preliminary project definition typical for the phase of the project at

[14] Ex. D2-1-1, Attachment 1, for more information about estimate class and accuracy range.
[15] Total project cost set out in EB-2016-0152, Ex. D2-1-3, Table 1 incorrectly identified total project cost for Project #31524 as $38.3M.

that time. Planned final in-service is November 2027, with an in-service amount during the IR term of $66.2M. This project continues to be in the definition phase.

This project is to replace flat roofs on the main powerhouse and other area buildings within the nuclear protected area. The roofs are approaching the end of their service life and need to be replaced to protect various nuclear and conventional systems in the station.

In 2013, OPG sent out a request for proposal to the Extended Services Master Services Agreement[16] ("ESMSA") vendors. The ESMSA vendors responded with compliant quotations, which were reviewed by OPG's estimating group who confirmed that the prices were reasonable and within industry estimating guidelines. As the contract price was higher than expected, OPG proceeded with a phased approach and only awarded the preliminary design phase of this project to the selected ESMSA vendor. The balance of the project was deferred to accommodate priorities within the nuclear capital portfolio, as discussed in EB-2016-0152.

In 2018, based on the completed preliminary design, the estimated total project cost had increased to $116.9M. A pilot was undertaken for a limited number of station roofs to validate the estimate and further evaluate the approach on the project scope, cost, contracting strategy and schedule, thereby optimizing future phases of the project. The results of the pilot are being finalized, with an expectation of a reduced project cost, and will be factored into the Execution Phase BCS, which is planned to be submitted for approval in Q1 2021. The level of project definition along with the optimal contracting strategy to be established through the pilot will provide a more accurate class of estimate.

Project #31544 Darlington Radiation Detection Equipment Obsolescence. The current total project cost is forecast to be $45.0M. The scope of this project originally included the work that now comprises projects #84400 and #84399.[17] However, in order to ensure that adequate resources are available to provide design and execution due to the varying needs of each system grouping, and in order to gain cost and schedule efficiencies, approval was obtained

[16] See Ex. D2-1-1, Section 3.4 for further description of the ESMSA contracts.
[17] Projects #84399 and #84400 are Tier 2 projects as shown in D2-1-3, Table 2F.

to execute the scope as three separate projects, which will be completed by three separate Engineering, Procurement, and Construction ("EPC") vendors. The total project cost estimate for all three projects is $78.0M (of which $45.0M is attributed to the remaining scope of project #31544), which is an increase of $31.1M from the Definition Phase Class 5 estimated total project cost of $46.9M provided in EB-2016-0152. Planned final in-service is September 2023, with an in-service amount during the IR term of $22.3M. The forecast increase to total project forecast of $78.0M is within the Class 5 estimate accuracy based on the project definition level at the time of EB-2016-0152. This project continues to be in the definition phase.

Seven of the radiation detection systems that are required to ensure regulatory compliance, protect the public, and facilitate daily operation are at the end of their service life. This equipment requires replacement due to obsolescence and aging management issues.

The scope in project #31544 includes the Post Accident Radiation Monitoring System and Stack Monitoring system. The Post Accident Radiation Monitoring System provides monitoring capability to facilitate reporting to the public and calculation of evacuation zones. Stack Monitoring monitors stack emissions as required in the Power Reactor Operating License.

The total project cost estimate provided in EB-2016-0152 was from a partial definition BCS based on early conceptual engineering phase releases. Following completion of preliminary engineering, the subsequent BCS incorporated a more complex design than initially assumed, augmented with a more accurate and detailed estimate provided by a third party. The cost increase relates to the increased design and procurement cost associated with the equipment, as well as the more complex design requiring additional engineering review.

Project #31716 Darlington Neutron Over-Power (NOP) and Ion Chamber (IC) Amplifier Replacement (Reactor Regulation System (RRS), Shutdown System #1 (SDS1) and Shutdown System #2 (SDS2)). This project is now in the execution phase. The current total project cost is forecast to be $23.8, which is an increase of $6.1M from the Definition Phase Class 4 estimate provided in EB-2016-0152 of $17.7M. The increase in the total project

forecast cost is within the accuracy range of a Class 4 estimate. Planned final in-service is April 2027, with an in-service amount during the IR term of $9.6M.

Neutron Over-Power, In-Core Flux Detector, and the Ion Chamber amplifiers convert very small current signals from neutron detectors in the nuclear reactor into voltage signals used by the Shutdown System #1 ("SDS1"), Shutdown System #2 ("SDS2") and Reactor Regulation System ("RRS") computers. The amplifiers are a critical component of these systems that regulate and shut down the reactor. The existing amplifiers are obsolete and maintaining system reliability is increasingly challenging due to limited spare units and parts.

The original strategy was to source the amplifiers from the original equipment manufacturers. OPG subsequently determined that the original equipment manufacturers no longer support the technology used at Darlington. In order to maintain diversity between the two Shutdown Systems, two independent equipment vendors will be used, which will prevent any potential design flaws from impacting both shutdown systems. The replacement amplifiers will have the same fit, form and function as the old amplifiers.

The increase in total project cost is due to enhanced engineering oversight required on the highly specialized engineered equipment vendors. This oversight was required to ensure the equipment met the complex technical specifications for this safety system. Due to the project risk relating to reactor safety impacts, additional OPG resources were also required to leverage operations knowledge for field oversight and installations in performing critical steps of the project installation.

Project #80078 Darlington Digital Control, Common Process and Sequence of Events Monitoring Computer Aging. The current total project cost is forecast to be $77.5M, which is an increase of $30.2M from the Definition Phase Class 5 estimated total project cost of $47.3M provided in EB-2016-0152. The increase in the total project cost forecast is within the Class 5 estimate accuracy range. Planned final in-service is February 2028, with an in-service amount during the IR term of $42.2M. This project continues to be in the definition phase.

The primary reason for the increased cost is due to higher than expected costs for reverse engineering and design due to the complexity of the overall system. These cost increases were discovered during engineering work resource reviews of the project; during which additional specialized vendor engineering resources were needed to reverse engineer the components. In addition, there was a scope increase to include the transfer of control relays and additional computer boards and devices within the project scope.

Project #31516 Darlington Station Fluorescent Lighting Fixtures Retrofit. This project is now in the execution phase. The current total project cost is forecast to be $20.7M, which is an increase of $9.3M from the Class 4 estimated total project cost of $11.4M provided in EB-2016-0152 where this was a Tier 2 project. The Class 4 estimate filed in EB-2016-0152 reflected the preliminary project definition available at that time. Planned final in-service is January 2023, with an in-service amount during the IR term of $3.9M.

The objective of the project is to replace obsolete fluorescent lighting in the powerhouse with new, efficient LED lights. The existing lighting at Darlington is over 30 years old and is now reaching its end-of-life. These fixtures and lamps were installed in critical areas such as unit hallways, turbine halls, reactivity decks and the east and west irradiated fuel bays. The station's ability to maintain reliable lighting with these aging fixtures is being severely challenged by:

- Unavailability of magnetic ballasts (rendered obsolete by government regulations on energy efficient ballasts). Electronic ballasts are still available, but have low efficiency and a short lifespan requiring frequent replacements.
- Deteriorating lighting luminescence and declining florescent lamp output requiring frequent lighting replacements, which diverts resources from other important station work.
- Higher energy costs for existing low efficiency fluorescent lighting.
- The requirement to dispose of fluorescent lights containing mercury as hazardous waste.

The estimate provided in EB-2016-0152 was based on historical maintenance data for replacement of lights with standard fluorescent lamp kits. Early in the project, a pilot was launched to further refine the estimate, validate assumptions and characterize the resources required to perform this project in a construction environment. The pilot uncovered installation

issues because Darlington was constructed with fixtures that are not compatible with standard retrofit kits.

In addition, after evaluating the technology and availability of LED lights, the project recommended using LED lights for all replacements rather than a mix of LED and fluorescent lights as was contemplated in the original developmental BCS. Custom LED retrofit kits were explored, however the most reliable and cost effective approach was determined to be replacement of the entire light and light fixtures. As a result, scope was re-evaluated to accommodate the shift from fluorescent to LED lights and to replace full fixtures rather than retrofit.

The pilot determined that many of the lights requiring replacement were in the reactivity deck area. Replacement of these lights was prioritized due to safety concerns surrounding overall light output in that work area. The prioritization of reactivity deck lighting replacements added complexity and cost. Accessing the lights over the reactivity deck is difficult and requires complex scaffolding along with enhanced radiation protection procedures in this work area.

Project #80023 Darlington Steam Generator Level Control Valves Replacement. The current total project cost is forecast to be $38.6M, which is an increase of $22.3M from the Definition Phase Class 5 estimated total project cost of $16.3M provided in EB-2016-0152 where this was a Tier 2 project. The class 5 estimate filed in EB-2016-0152 reflected the preliminary project definition available at that time. Planned final in-service is June 2026, with an in-service amount during the IR term of $38.5M. This project continues to be in the definition phase.

The objective of this project is to retrofit the 32 large standby generator ("SG") level control valves ("LCV") (8 per unit; 2 per SG) and 16 small SG LCV (4 per unit; 1 per SG) with new components (i.e., new actuators and associated ancillary components including positioners, valve trim and packing). The new components have more robust designs to ensure reliable operation, reduce maintenance, and minimize generation and safety risks. The existing valves have a history of excessive maintenance requirements and degradation. Failure of both large

SG LCV in a boiler quadrant, which can occur if one valve fails when the other is already out of service for maintenance, results in the loss of feedwater supply to the SG, causing a forced outage. Since a large SG LCV is typically out of service for corrective maintenance between four and six weeks per year per unit, the risk of a forced outage from a second valve failing is significant.

The cost increase included in this application is primarily due to the movement of 16 small SG LCV from Project #83298 to Project #80023. This change was to ensure overall system reliability and to take advantage of anticipated project execution efficiencies by implementing the same design and installation solution for all LCV replacements. While this scope transfer has increased cost for Project #80023, costs for Project #83298 will be lower due to its reduced scope.

Project #80036 Darlington R22 Refrigerant Air Conditioning Unit Replacement. The current total project cost is forecast to be $36.1M, which is an increase of $21.2M from the Definition Phase Class 5 estimated total project cost of $14.9M provided in EB-2016-0152 where this was a Tier 2 project. The project class 5 estimate filed in EB-2016-0152 reflected the preliminary project definition available at that time. Planned final in-service is January 2026, with an in-service amount during the IR term of $27.1M. This project continues to be in the definition phase.

The objective of this project is to replace 51 air conditioning/dehumidifying units containing R22refrigerant with units using approved non-ozone depleting refrigerant. These units provide cooling to critical equipment, laboratories, control rooms, and other areas, as well as process uses for normal operations and post-main steam line/feedwater line break incident conditions. Existing air conditioning units (“ACUs”) are also degraded and approaching their end of life. Replacement will ensure maintainable and reliable ACUs to the end of station life.

Under the Ozone Depleting Substances and Halocarbon Alternatives Regulations, 2016 and subsequent amendments, gradual reduction of the production and import of oxygen depleting substances is required according to the fixed schedule established by the Montreal Protocol.

Per this schedule, availability of R22 will be phased out completely by 2020. While the units containing R22 can still be operated, after 2020, OPG will be unable to acquire R22 to replace current stock.

Unanticipated cost increases have occurred for this project related to the need to replace Portable Vault Vapour Recovery Dryers and higher quotes for the ACUs. During the Development phase of this project, OPG determined that the Portable Vault Vapour Recovery Dryers had a flaw in the original design which required their replacement.

With respect to the ACUs, in 2017, after development of the Definition BCS, OPG sent out a request for proposals to the ESMSA vendors to perform this project under an EPC contract. Based on preliminary engineering, the proposal assumed installation of ACU units using the original equipment manufacturer's existing design. The ESMSA vendors responded with compliant quotes, which were higher than OPG expected in the Definition BCS. These quotes were reviewed by OPG's estimating group, which confirmed that the prices were reasonable and within industry estimating guidelines.

During the definition phase, the original equipment manufacturer was unable to produce ACU units that complied with modern nuclear standards based on the preliminary engineering. As a result, OPG and ESMSA vendors collaboratively determined to change strategies and use other suppliers who were able to comply with modern nuclear standards. This also resulted in an unforeseen cost increase to the project.

Project #80063 Darlington Standby Generators Protective Relay Replacement. The current total project cost is forecast to be $20.0M, which is an increase of $11.1M from the Definition Phase Class 5 estimated total project cost of $9.9M provided in EB-2016-0152, where this was a Tier 2 project. The class 5 estimate filed in EB-2016-0152 reflects the preliminary project definition available at that time. Planned final in-service is February 2023, with an in-service amount during the IR term of $15.8M. This project continues to be in the definition phase.

This project is to replace electro-mechanical relays with digital relays for the protection of the SG. This replacement is necessary to address relay obsolescence issues and to ensure that spare parts are available for the continued reliable operation of Darlington.

More than 60% of the SG protective relays and auxiliary/ancillary devices are currently obsolete. There is no original equipment manufacturer support for the existing relays and no spares are available in stock. After-market refurbishment and repair support is very limited due to the lack of original equipment manufacturer repair/maintenance documentation. The lack of spare parts will continue to degrade the station's ability to maintain the existing equipment, which will negatively affect reliability and system health.

At the time of the Definition Phase estimate, the engineering strategy for this project was to use “off-the-shelf” materials to avoid customizations. However, EPC vendor estimates for detailed design to accommodate the integration and installation of the “off-the-shelf” materials were greater than estimates made at the time of the preparation of the Definition BCS. The EPC vendor estimates were assessed by OPG’s estimating group, who confirmed that the price was reasonable and within industry estimating guidelines.

Project #31426 Darlington Fuel Handling Inverter Replacement.[18] This project is now in the execution phase. The current total project cost is forecast to be $26.2M, which is an increase of $11.8M from the Class 3 estimated total project cost of $14.4M provided in EB-2016-0152, as a Tier 2 project. While characterized as a project Class 3 estimate when filed in EB-2016-0152, the level of project definition was reflective of a Class 5 estimate, which would have been typical for the phase the project was in at that time. Planned final in-service is April 2021, with no amounts coming into service during the IR term.

The objective of this project is to replace the 14 fuel handling inverters which provide power for the operation of critical components required to fuel the reactors and to perform mandatory online and outage maintenance activities. These 14 inverters have been in service since the

[18] Project #31426 was a combination of Definition Phase/Execution Phase BCS in EB-2016-0152.

early 1980's. Of the 14 inverters, two support operations at the Pressure Testing Facility - and 12 support operations of the 6 trolley half systems. The deficiencies for the fuel handling inverters include reaching end-of-life, obsolete technology, depleted spare parts, unavailability of components and increased maintenance requirements. New fuel handling inverters are more reliable and longer lasting, and will reduce required maintenance resources, while increasing system monitoring, diagnostics, troubleshooting and reliability. Inverter failures could result in decreased fueling capacities, increase risk of unit derates, and disruptions in the fueling machine overhaul program, all of which would result in lower generation and increased maintenance costs.

OPG began the process to assess replacement of fuel handling inverters prior to the decision to proceed with a fuel handling refurbishment program at Darlington.[19] A decision was subsequently made to defer the Pressure Testing Facility installation from 2014 to 2017 to better align with the FH refurbishment program and to ensure optimal configuration of the FH equipment. The need to align with the FH refurbishment program resulted in project scope expansion to incorporate FH inverter software process improvements, which increased project costs, but ensured Darlington would have improved fuel handling capability.

Pressure Testing Facility installations were completed in the first phase of this project. Lessons learned from the first phase were evaluated to optimize future project phases. Among the lessons learned was to increase the use of station staff to leverage operational knowledge and manage the significant technical risk associated with commissioning the trolley inverter replacements. While this approach will increase cost, it is necessary to successfully execute this first of a kind installation for Darlington.

In summary, the primary contributors to the variances have been:

- scope addition for software and operational data deliverables
- additional costs for OPG project oversight
- new tooling for trolley inverter setup

[19] The FH refurbishment program consists of a number (approximately 17) individual projects with the objective of improving fuel handling capability and reliability at Darlington.

- increased station support for engineering and field work due to scope addition
- increased third party vendor costs for trolley installations
- additional third party engineering costs to incorporate past operating experience for new installations.

3.6.2 Projects with Execution Phase BCS in EB-2016-0152

Project #31412 Darlington Class II Uninterruptable Power Supply Replacement. The current total project cost is forecast to be $63.6M, which is an increase of $8.5M from the Class 3 estimated total project cost of $55.1M provided in EB-2016-0152. The forecast total project cost of $63.6M is within the Class 3 estimate accuracy presented in EB-2016-0152. Planned final in-service is March 2025, with an in-service amount during the IR term of $25.2M.

The objective of the project is to restore the Darlington Uninterruptible Power Supply ("UPS") Class II power system to a reliable and maintainable state. Class II UPS supplies critical loads to 27 critical station systems including safety systems instrumentation, digital control computers, emergency lighting, cooling for critical equipment and other uses. The project started with a pilot to confirm the optimal installation sequence strategy. Valuable lessons learned during the pilot changed the installation strategy to a phased delivery to minimize the risk to plant operations. The change in installation sequence resulted in the need to accommodate unit work schedules and system availability resulting in the following cost increases:

- additional project management and OPG oversight costs,
- additional Engineering, Procurement, Construction contract costs, and
- foreign exchange rate variance.

Project #31532 Darlington Powerhouse Water Air Conditioning Units Replacement. This project is now in the execution phase. The current total project cost is forecast to be $38.2M, which is an increase of $11.6M from the Class 4 estimated total project cost of $26.6M provided

in EB-2016-0152.[20] The total project forecast is within the Class 4 estimate accuracy based on the project definition level at the time of EB-2016-0152. Planned final in-service is January 2023, with an in-service amount during the IR term of $3.1M.

The ACUs in the Powerhouse are approaching end of service life. Cooling coil leaks (due to inadequate condensate drainage resulting in corrosion) and loose fan blades have caused the ACUs to be unavailable on multiple occasions. The preferred alternative is to replace 90 ACUs with new units to improve equipment reliability and maintainability.

The cost variance on this project is primarily attributable to cost increases to accommodate reactor safety restrictions associated with ACU installations. These restrictions require on-going station support (e.g., radiation protection and reactor safety), to ensure availability of ACUs during the installation phase, which is necessary to maintain the design basis of critical safety equipment.

Additional cost is also associated with re-engineering of the ACUs during the definition phase as well as modifications to structural steel supports required to accommodate heavier ACUs.

Project #33621 Darlington Secondary Control Area Air Conditioning Unit Replacement. The current total project cost is forecast to be $36.0M, which is an increase of $7.7M from the Class 3 estimated total project cost of $28.3M provided in EB-2016-0152. The forecast total project cost of $36.0M is within the Class 3 estimate accuracy presented in EB-2016-0152. Planned final in-service is August 2025, with an in-service amount during the IR term of $9.6M.

The Secondary Control Area (**"**SCA") air conditioning system comprises 10 air conditioning units, two per SCA. The purpose of the air conditioning system is to provide a suitable environment for the reliable operation and long service life of the electrical and electronic equipment, comfortable working conditions for operating personnel, and emergency smoke removal.

[20] The BCS included in L-04.2-1 Staff-028 was designated as being in the execution phase although the total project cost was a class 4 estimate.

These ACUs are at end of life and are experiencing high functional failures. In addition, the ACUs used across the station are from four different manufacturers so parts are not interchangeable. As three of the four manufacturers are no longer in business, a complete set of spare parts cannot be procured. The decreasing reliability of these ACUs, increasing difficulty in obtaining spare parts and increasing maintenance workload all contribute to an enhanced risk to unit operation, which could result in a complete station shutdown. The project is to replace all SCA ACUs with reliable units supplied by a single manufacturer.

Additional scope was added to include the installation of improved Emergency Service Water piping to resolve inadequate Emergency Service Water flow. Larger Emergency Service Water supply and return lines will be installed, which will bring the system back to design conditions and significantly reduce the risk of a forced outage due to elevated SCA temperatures. The engineering piping and piping design packages required revisions as a result this additional scope, which increased construction cost.

Project #33819 Darlington Vibration Monitoring System Replacement for Major Pump-sets. This project is now in the execution phase. The current total project cost is forecast to be $55.4M, which is an increase of $31.6M from the Class 5 estimated total project cost of $23.8M provided in EB-2016-0152[21]. The class 5 estimate filed in EB-2016-0152 reflects the preliminary project definition available at that time.. Planned final in-service is November 2026, with an in-service amount during the IR term of $18.0M.

Darlington's Vibration Monitoring System components have been failing due to age, radiation and other environmental factors. In addition, the existing Vibration Monitoring System does not provide adequate vibration monitoring to maintain the reliability of various station-critical components and equipment.

[21] The BCS submitted in EB-2016-0152 was designated as being in the execution phase but the class estimate and related accuracy reflects a project definition phase.

The project involves the replacement of Vibration Monitoring System for all 12 major pump-sets with commercially available equipment, replacement and commissioning of the Data Acquisition and Analysis System and ensuring spares are available.

The cost variance in this project is attributed to scope additions to the preliminary scope such as the inclusion of Vibration Monitoring System on new critical auxiliary shutdown cooling pumps, and connecting the Vibration Monitoring System to OPG's Local Area Network. Unforeseen complexities relating to ground fault installations required additional construction and design efforts, which extended the project duration, and resulted in increased project management and interest costs.

Project #33973 Standby Generator Controls Replacement. The current total project cost is forecast to be $46.3M, which is an increase of $6.7M from the Class 3 estimated total project cost of $39.6M provided in EB-2016-0152. The forecast total project cost of $46.3M is within the Class 3 estimate accuracy presented in EB-2016-0152. Planned final in-service is March 2021, with an in-service amount during the IR term of $0.4M.

Four Darlington standby generators provide backup power for designated nuclear safety support systems. Darlington's power operating license requires standby generators to be available whenever there is nuclear fuel within the reactor core. In the event that none of the standby generators can be made available within a 24 hour period, a controlled shutdown of all four units must be initiated.

Various control and monitoring components for the standby generators have become obsolete. Manufacturers of the original components no longer provide replacement parts or service the equipment. This project involves the replacement of obsolete control and monitoring equipment on Darlington's standby generators, which will ensure standby generator reliability, and availability as required by the power reactor operating license. The new equipment will also provide data logging and diagnostic capability for effective standby generator maintenance.

The increase of $6.7M was associated with the design and construction costs required to address discovery work related to SG 2 and 3. In addition, remediation for fuel control valves on SG 1 and vibration issues on SG 4 that resulted in the need to replace the gas generator were added to the scope.

Project #38948 Darlington Zebra Mussel Mitigation Improvements

The current total project cost is forecast to be $36.6M, which is an increase of $7.3M from the Class 2 estimated total project cost of $29.3M provided in EB-2016-0152 (Ex. J15.5, Attachment 2). Planned final in-service is December 2021, with no amounts coming into service during the IR term.

Zebra mussel fouling has impaired the reliability of plant systems that use lake water, due to the undesired presence of the invasive freshwater mussel. These service water systems provide cooling water to a number of safety and safety related loads such as shutdown cooling, heat exchangers, shutdown cooling pump motor coolers, moderator heat exchangers, liquid zone control, and critical air conditioning units. Zebra mussel fouling can, and has, result in equipment unavailability that can lead to unit derates and shutdowns.

A chlorination system was previously installed to control zebra mussels, but the frequencies of chlorination dosing were not adequate and over time the zebra mussels adapted to the dosing. To address the continuing risk posed by the invasive Zebra mussel, the project scope involved implementation of a Zebra Mussel Mitigation Improvement system that allows for continuous chlorination across all 4 units, as well as installation of new piping and a permanent de-chlorination system to reduce the chlorine concentration at the outfall to meet environmental limits. Consistent with industry recommended practices (e.g., World Association of Nuclear Operators), the system design required integration with the main control room for appropriate integration of the Zebra Mussel Mitigation Improvement system with Nuclear Operations.

The increase of $7.3M was primarily a result of further modifications to the original design based on field discovery issues where construction sequence and methodology required revision. Accommodating for these adjustments extended the duration of the project, resulting

in increased costs for OPG project management and engineering oversight, as well as increased interest expense.

Project #33258 Darlington Replacement of Emergency Power Supply Uninterruptable Power Supply. The current total project cost is forecast to be $24.6M, which is an increase of $8.0M from the Class 3 estimated total project cost of $16.6M provided in EB-2016-0152 as a Tier 2 project. Planned final in-service is February 2022, with an in-service amount during the IR term of $2.1M.

The project objective is to restore the reliability of the Emergency Power System ("EPS") by replacing life-expired uninterruptible power supplies. The EPS uninterruptible power supply system is a seismically qualified alternate electrical power supply and distribution system to Group 2 Nuclear Safety related loads. It must be operable and available during normal and shutdown unit conditions per Operating Policies and Principles.

Deteriorating system reliability has been attributed to aging static component failures. Maintaining the system has become increasingly difficult due to a lack of spare parts. Although a base maintenance initiative was implemented in 2008, it did not include circuit breaker, magnetic component, peripheral and capacitor replacement, all of which are required to provide reliable system operation until station end of life. The project involves the continued replacement of Uninterruptible Power Supply units to improve system health. The selected Uninterruptible Power Supply systems are more reliable, have tighter output tolerances and possess self diagnostic and monitoring features.

The increase of $8.0M since EB-2016-0152, is a result of increased efforts that were required for EPS installation and removal work primarily attributed to:

- Increased OPG project management oversight costs due to additional design oversight as well as project delay because of scheduling conflicts with other electrical work programs combined with station resource challenges.
- Increased installation costs from changes in design and work packages based on experience from previous installations.

- Increased vendor costs of EPS Uninterruptible Power Supply system installation on Unit 3 and Unit 4.

Project #40691 Pickering B Emergency Power Generator (EPG) and Main Output Power (MOP) Protective Relay Replacement. The current total project cost is forecast to be $29.7M, which is an increase of $18.7M from the Class 2 estimated total project cost of $11.0M provided in EB-2016-0152 as a Tier 2 project. Planned final in-service is October 2019, with no amounts coming into service during the IR term.

The initial scope of the project was to replace the existing electro-magnetic relays with microprocessor based multifunction relays or modern replacements on the EPGs and Main Output Power units on Pickering Units 5-8 and to ensure spares are readily available. The existing electromechanical relays are obsolete and there are no spares. Failure of a relay could result in EPG unavailability, unit forced outages or forced extensions to planned outages. Additionally, replacement of the protective relaying schemes was required to ensure that OPG complied with Northeast Power Coordinating Council ("NPCC")/IESO regulatory requirements.

The North American Electric Reliability Corporation oversees the reliability of the bulk electricity systems in North America. The IESO and OPG are members of one of its regional entities – NPCC, and the IESO is the Reliability Coordinator that enforces compliance. Under NPCC regulations, the step up transformer, main output transformer, and station service transformers have been identified as bulk power systems elements in Ontario. As this project was making changes to the protection systems of bulk power system elements, these changes must be acceptable to the NPCC Task Force on System Protection.

A review by the NPCC Task Force on System Protection and IESO raised the following issues:

i. Protection Circuit A/B of all Pickering Main Output Power share a neutral current transformer; and
ii. Pickering 5-83088 Sequence of Event recorder is tied to the Unit(s) Digital Control Computer time but not synchronized to within 2 milliseconds of Universal Coordinated Time.

To address these issues, OPG installed a second neutral grounding current transformer in each of Pickering Units 5-8 and installed equipment for time synchronisation on the Sequence of Events recorder.

4.0 CAPITAL PROJECT IN-SERVICE INFORMATION

OPG's actual and forecast in-service capital additions for the period 2016-2026 are summarized in Ex. D2-1-3, Table 4a-4b. The forecast in-service amounts in the bridge years and test period represent a combination of projected in-service amounts for specific (Tier 1, 2 and 3) projects as presented in Ex. D2-1-3, Tables 1a, 1b, 1c, 1d, 2a, 2b, 2c, 2d, 2e, 2f, 2g and 3, and a supplemental in-service amount, which is a forecast of in-service declarations that can be expected in the bridge and test years[22] consisting of:

- Undefined projects: the supplemental in-service amount is primarily a forecast of in-service amounts for currently undefined projects that make up the Portfolio Projects (Unallocated) portion of capital expenditures. The supplemental in-service amount assumes currently undefined projects will eventually become approved projects, and therefore, consistent with the project specific in-service forecast amount, excludes any project contingency amounts.
- Timing: The timing of in-service project-specific (Tier 1, 2 and 3) forecast amounts could change as completed work packages for specific projects may be deemed ready for service earlier or later than forecast.

Exhibit D2-1-3, Table 4a-4b includes actual to forecast (or OEB Approved) variance analysis for 2016, 2017, 2018 and 2019, which are discussed in Section 4.1 below. For completeness, Table 4a-4b also includes planned minor fixed asset expenditures, which are placed in-service in the year of acquisition.

4.1 In-Service Amount Variance Explanations

Numerous factors can affect both the amount of an in-service declaration and its timing. In-service amounts can vary relative to forecast year-over-year, driven by changes in the level of

[22] Supplemental forecast to reconcile BCS in-service estimates to final business plan.

capital expenditures and the timing of project installations which are frequently tied to specific unit or station outages. Also, if a project that is forecast for completion in a particular year is delayed by even a month or two such that it carries into the following year, it has a significant impact on actual in-service amounts for both years. Resolution of final project acceptance issues may also shift in-service timing.

The amount of the in-service declaration can also be directly affected by project cancellation decisions. After a project is cancelled, alternative replacement projects will be pursued; however, it is not always possible to advance an alternative project to the installation stage (e.g., if the work requires a specific outage for execution). When alternative replacement projects are pursued, the in-service date may ultimately be at an earlier or later date then the cancelled project.

Overall, based on 3 years of actuals and 2 years of budget information, OPG expects capital in-service additions to exceed the OEB approved amount, and to be roughly equal to OPG's forecast before OEB in-service forecast adjustment as provided in EB-2016-0152.

Further details regarding annual in-service variances are provided below. The variance explanations are based on the reforecast in-service amounts that were the basis for the response to Undertaking J21.1 in EB-2016-0152 that were ultimately reflected in the approved nuclear payment amounts. The reforecast included in-service amounts for new projects that were listed in EB-2016-0152, Ex. D2-1-3, Table 5a and 5b.

2019 Actual versus 2019 OEB Approved

The decrease in actual in-service amounts in 2019 compared to the OEB Approved amounts (-$20.8M) is due to reduced amounts in Operations and Project Support (-$39.8M) and Darlington (-$35.2M), as well as the elimination of the Supplementary In-Service Forecast budgetary allowance (-$16.6M), and OEB's forecast adjustment (-$38.5M), offset by increased amounts in Pickering (+$27.0M), Minor Fixed Assets (+$4.5M) and Pickering Extended Operations (+$0.8M).

The decrease in the Operations and Project Support in-service amount is due mainly to Project #83039 Darlington Rapid Delivery Machine (-$44.3M), where the variance is attributable to a schedule shift at the start of the project, which delayed the in-service of the final machines.

The decrease in Darlington in-service amounts is due mainly to Project #80126 Darlington Emergency Power Generator 1 and 2 Replacement (-$36.2M), where the variance is attributable to design drawings revisions necessary to reflect as found conditions prior to installation of the EPGs.

The increase in Pickering in-service amounts is due to 29 projects with higher than planned in-service amounts (+$31.3M total), offset by six projects with reduced in-service amounts in the period (-$4.2M total). The most notable variance is Project #83668 Pickering High Pressure Turbine Spindle (+$10.7M) for the second of two turbine spindles that was not included in the previous submission.

There were no capital projects approved in EB-2016-0152 for the Pickering Extended Operations initiative. Subsequently, OPG determined that Project #84792 Pickering Extended Operation Firewater Buried Ring Header South (+$0.8M) met the criteria for capitalization. Additionally, there were initiative-specific Minor Fixed Asset acquisitions (+$5.0M).

2019 Actual versus 2018 Actual

The decreased in-service amounts in 2019 compared to 2018 (-$64.2M) are due to decreased in-service declarations in Pickering (-$29.6M), Darlington (-25.3M) and Operations and Project Support (-$11.9M), which were offset slightly by increases in Minor Fixed Assets (+$1.8M) and Pickering Extended Operations (+$0.8M).

The decrease in Pickering in-service amounts is due to 25 projects with lower than planned in-service amounts (-$43.0M), offset by 22 projects with increased in-service amounts in the period (+$13.4M). The most notable change is Project #83088 Pickering Low Pressure Feedwater Heat Exchangers Replacement (Capital) (-$18.5M), due to completion of the field installation of the heat exchangers in 2018.

The decrease in Operations and Project Support in-service declarations is due mainly to Projects #66600 Pickering Machine Delivered Scrape Project (-$4.7M) and #60168 Nuclear Waste Management Tritium Deuterium Oxide Transportation Package Replacement (-$3.6M), due to completion of the projects in 2018 as well as Project #83051 Darlington Feeder and Fuel Channel Baseline Inspections (-$2.3M) which was partially completed in 2018.

The decrease in Darlington from 2018 to 2019 in-service declarations is due to 43 projects with decreases (-$165.2M) partially offset by 37 projects with increases (+140.2M). Most notable decreases include Projects #38948 Darlington Zebra Mussel Mitigation Improvements (-$34.8M) which was completed in 2018; #73566 Darlington Primary Heat Transport Pump Motor Replacement (-$15M); and, #84235 Darlington Primary Heat Transport Liquid Relief Valve Modifications (Waterhammer) (-$14.0M) due to substantial completion of Unit 2 scope in 2018. Notable increases include Projects #80126 Darlington Emergency Power Generator 1 and 2 Replacement (+$19.4M) due to completion of Emergency Power Generator 2 electrical auxiliaries installation; and, #80144 Darlington Primary Heat Transfer Pump Motor Overhaul (+$12.9).

The increase in Pickering Extended Operations is due to the partial in-service declaration of Project #84792 Pickering Extended Operation Firewater Buried Ring Header South (+$0.8M) in 2019.

2018 Actual versus 2018 OEB Approved

The increased capital in-service amounts in 2018 compared to 2018 OEB Approved (+$71.1M) are due to higher in-service of Darlington projects (+$69.5M), Pickering projects (+$18.9M), as well as an increase in Minor Fixed Assets (+$1.7M), and OEB's forecast adjustment (-$35.5M). The increases are offset by Operations and Project Support projects (-$29.5M), and the Supplemental In-Service Forecast (-$24.9M).[23]

[23] In EB-2016-0152, the 2018 OEB Budget in-service amounts for approved projects totalled $309.8M but the in-service forecast assumed per the business plan that the in–service amount would be $334.7M, based on assumption that undefined projects would eventually become approved projects, and be in-service in that year. Therefore there was a positive supplemental in-service adjustment of $24.7M. Actual 2018 in-service was $355.9M.

At Darlington, in-service declarations for projects included in EB-2016-0152 (+$69.5M) were higher than the OEB Approved amounts. Notable variances from EB-2016-0152 include:

- Project #38948 Darlington Zebra Mussel Mitigation Improvements (+$34.6M). The in-service variance is due to delay in completing the improvements, originally planned for 2017 (+$26.4M) and increases in the cost of the project (+$8.2M) arising from resolution of field discovery issues as well as increased project management and interest cost due to the extended duration.
- Project #31426 Darlington Fuel Handling Inverter Replacement (+$12.6M). The variance is due to delays in completing the replacements as planned in 2017 and 2018, incorporation of operating experience into the design as well as increased project management and interest costs due to the extended duration.
- Project #73566 Darlington PHT Pump Motor Replacement (+$15.3M). The variance is primarily due to an increased number of new motors (versus refurbished motors) being installed as replacements and advancement of the schedule to complete the replacements to December 2019 instead of June 2022.
- Project #31710 Darlington Shutdown Cooling Heat Exchanger Replacement (+$9.3M). Variance is due to delays arising from a significant increase in field execution time from heat stress and additional design and analysis to address design issues, quality requirements and the requirement for additional temporary supports.
- Project #31508 Darlington Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment (+$8.6M). Variance is due to a lack of available installation resources and additional design changes that pushed completion of the modifications into 2018.
- Project #38942 Tritium Removal Facility Tritium Emissions Reduction Project (-$4.6M). Variance is due to cancellation of the project.
- Project #31520 Darlington Replacement of Obsolete Online Chemistry Analysers (-$4.7M). Variance is due to operational constraints that limited the number of analysers that could replaced in parallel, thereby increasing the overall installation period and delaying the final in-service.
- Project #31524 Darlington Roof Replacement Project (-$6.0M). The variance is due to a change in project strategy whereby only a pilot replacement was done in 2018 to gain experience and address issues identified.

- Project #33819 Darlington Vibration Monitoring System Replacement for Major Pump-sets (-$6.3M). Variance is due to delays related to issues with establishment of safe working conditions for installation of the upgrades and delays in the window for the installation in Unit 2.
- Project #31701 Darlington Tritium Removal Facility Cryogenic Refrigeration System Turbine Oil Supply System / Turbine Replacement (-$7.4M). Variance is due to identification of several issues during design review ultimately resulting in project deferral in 2019.
- Project #31544 Darlington Radiation Detection Equipment Obsolescence (-$7.6M). Variance is due to the need for increased internal and vendor engineering, which has delayed the acquisition and installation of the new radiation detection equipment.

At Pickering, in-service declaration is higher than the OEB Approved amount (+$18.9M). Notable variances from EB-2016-0152 include:

- Project #41044 Pickering A Standby Generator Protective Relay Upgrade (-$2.8M). Variance is due to rescheduling of installation on 034 SG2 to 2019 due to unavailability of 034 SG1.
- Project #80069 Pickering A Firewater Buried Ring Header Replacement (North Loop) (-$3.6M). Variance is due to de-scoping of the South Loop portion of the project due to high risks associated with field execution.
- Project #40972 Pickering A Standby Generator Reliability Upgrades (-$3.9M). Variance is due to rescheduling of upgrade work following discovery of issues during the first upgrade.
- Project #46634 Pickering A Fuel Handling Single Point of Vulnerability Equipment Reliability Improvement Project - Capital (-$4.3M). Variance is due to deferral of work by the station from outages in 2017 and 2018 to later years.
- Project #40976 Pickering B Fuel Handling Reliability Modifications (+$2.4M). Variance is due to rescheduling of outage work by the station from 2016 and 2017 to 2018.
- Project #40691 Pickering B Emergency Power Generator and Main Output Power Protective Relay Replacement (+$2.1M). Variance is due to the station moving the 2017 outage to 2018.

- Project #40977 Pickering Daily Tritium Sampler Replacement (+$1.8M). Variance is due to the addition of an additional sampler to the scope of the project, which increased the cost and moved the final in-service to 2018.
- Project #41027 Pickering Fukushima Phase 2 Beyond Design Basis Event Emergency Mitigation Equipment (+$1.8M). Variance is due to delays in the 2017 outage program work and a large number of open available for service actions completed in 2018.

In-service amounts for new projects (+$23.0M) accounted for the rest of the Pickering variance, primarily Project #83088 Pickering Low Pressure Feedwater Heat Exchangers Replacement (Capital) (+$13.4M) and Project #83668 Pickering High Pressure Turbine Spares (+$10.7M).

In Operations and Project Support, in-service declarations for projects listed in EB-2016-0152 were lower than the OEB Approved amounts (-$29.5M). In-service declarations for new projects were -$37.4M lower, notably Project #82929 Security Project B (-$18.3M) and Project #82930 Security Project C (-$18.3M).

2018 Actual versus 2017 Actual

The decrease in capital in-service amounts in 2018 compared to 2017 (-$74.1M) is due to lower in-service amounts for Pickering projects (-$113.9M), Operations and Project Support projects (-$26.2M) and Darlington Spacer Retrieval (-$5.8M). These decreases are slightly offset by higher in-service amounts for Darlington Projects (+$81.8M), and Minor Fixed Assets (-$9.9M).

Decreased in-service amounts at Pickering (-$113.9M) are due to the following projects being fully placed in-service in 2017: #41027 Pickering Fukushima Phase 2 Beyond Design Basis Event Emergency Mitigation Equipment (-$45.5M), #49158 Pickering B Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment (-$29.6M), and #49299 Pickering A Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment (-$11.2M). Additionally, Project #40976 Pickering B Fuel Handling Reliability Modifications (-$14.4M), and Project #49146 Pickering Fire Code Compliance for Relocatable Structures (-$13.9M) had significant amounts placed in-service in 2017 compared to 2018.

The Operations and Project Support projects in-service amounts decrease in 2018 compared to 2017 (-$26.2M) mainly due to Project #66600 Pickering Machine Delivered Scrape Project (-$17.1M), and Project #25918 Sally Port Physical Barrier Installation (-$9.6M).

The increase of in-service amounts at Darlington (+$81.8M) is mainly due to Project #38948 Darlington Zebra Mussel Mitigation Improvements (+$34.8M) which shifted from 2016 to 2018 due to discovery work and scope changes, and new Project #84235 Darlington Primary Heat Transport Liquid Relief Valve Modifications (+$19.2M), which had significant in-service amounts in 2018.

The decreased in-service amount for Darlington Spacer Retrieval (-$5.8M) reflects the completion of this project in 2017.

2017 Actual versus 2017 OEB Approved

The increase in actual capital in-service amounts in 2017 compared to the OEB Approved amounts (+$33.3M) is due to increased in-service amounts at Pickering (+$7.5M) increased Minor Fixed Asset acquisitions (+$5.6M). and OEB's forecast adjustment (-$47.9M), offset by reduced in-service amounts at Darlington (-$22.1M), Operations and Project Support (-$6.6M), Darlington Spacer Retrieval (-$0.6M)

The reduction in Darlington in-service amounts compared to the 2017 OEB Approved amounts is due primarily to Project #38948 Darlington Zebra Mussel Mitigation Improvements (-$26.4M), which was placed on hold for commercial issues in 2016, causing the project to miss its planned in-service in 2017 following resumption of work.

The reduction in Operations and Project Support in-service amounts is due primarily to delayed in-service dates in Project #66600 Pickering Machine Delivered Scrape Project (-$3.1M), Project #83051 Darlington Feeder and Fuel Channel Baseline Inspections (-$2.1M) and Project #80131 Nuclear Waste Management ISO Transportation Package/Trailer Replacement (-$1.8M).

The increase in Pickering in-service amounts compared to the OEB Approved amounts is primarily due to the Fukushima Projects #41027 Pickering Fukushima Phase 2 Beyond Design Basis Event Emergency Mitigation Equipment (+$8.9M), Project #80069 Pickering A Firewater Buried Ring Header Replacement (North Loop) (+$4.7M), Project #49298 Pickering A Replacement of Unit 1, Unit 4 and Irradiated Fuel Bay (IFB)-A Stack Monitors (+$3.8M), Project #46634 Pickering A Fuel Handling Single Point of Vulnerability (SPV) Equipment Reliability Improvement Project – Capital (+$3.6M), and Project #49158 Pickering B Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment (+$3.2M). These increases were offset by delayed in-service amounts in Project #83088 Pickering Low Pressure Feedwater Heat Exchanger Replacement (Capital) (-$8.0M) and other projects.

2017 Actual versus 2016 Actual

The increased capital in-service amounts in 2017 compared to 2016 (+$178.0M) are due to higher in-service amounts for Pickering projects (+$132.4M), increased Minor Fixed Asset spending (+15.4M), increased Darlington Spacer Retrieval (+$5.0M) and Operations and Project Support projects (+$40.8M), which are slightly offset by lower in-service amounts at Darlington (-$16.3M)

Increased in-service amounts at Pickering (+$132.4M) are mainly due to the timing of in-service of the Fukushima Projects #41027 Pickering Fukushima Phase 2 Beyond Design Basis Event Emergency Mitigation Equipment (+$47.6M), Project #49158 Pickering B Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment (+$27.8M), Project #40976 Pickering B Fuel Handling Reliability Modifications (+$20.1M), Project #49299 Pickering A Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment (+$12.3M), and Project #49146 Pickering Fire Code Compliance for Relocatable Structures (+$12.1M).

The decreased in-service amounts at Darlington (-$16.3M) are due to Project #34000 Darlington Auxiliary Heating System (-$87.6M) and Project #73706 Darlington Holt Road Interchange Upgrade (-$24.9M), which were both placed fully in-service in 2016. This was offset by the 33 projects placed in-service in 2017, notably Project #31508 Darlington Fukushima Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment (+$38.2M), Project #32202 Darlington Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment (+$19.2M), Project #73566 Darlington Primary Heat Transport (PHT) Pump Motor Replacement (+$12.3M), and Project #36002 Darlington Main Output Transformer Capital Spares (+$8.6M).

The increased in-service amounts for Operations and Project Support (+$40.8M) are due to Project #66600 Machine Delivered Scrape (+$21.8M), Project #25918 Sally Port Physical Barrier Installation (+$10.1M), and Project #66594 Channel Inspection and Gauging Apparatus for Reactors Gap System and Drive Reliability (+$8.3M).

The increase in Darlington Spacer Retrieval in-service amount (+$5.0M) is due to the in-service of the tooling scheduled for 2016 being delayed until 2017.

2016 Actual versus 2016 Budget

The decrease in capital in-service amounts in 2016 compared to 2016 Budget (-$210.7M) is due to lower in-service of Darlington Projects (-$105.6M), Pickering projects (-$98.0M), Operations and Project Support projects (-$34.2M), as well as a decrease in Minor Fixed Assets (-$14.7M). The increases are slightly offset by the increased Supplemental In-Service Forecast (+$41.8M).[24]

The decreased in-service amounts at Darlington (-$105.6M) are due to 44 projects, with a total decrease of (-$108.3M) primarily from projects Project #38948 Darlington Zebra Mussel Mitigation Improvements (-$18.9M), Project #31508 Darlington Fukushima Phase 1 Beyond

[24] In EB-2016-0152, the 2016 Budget in-service amounts for approved projects totalled $460.5M, even though the expected in-service amount for approved projects totalled $507.9M. An adjustment of $47.4M was reflected as a negative supplemental in service amount in 2016. The forecast of in-service amounts for approved projects was therefore reduced to $460.5M. Actual in-service was $270.2M as much of the capital that was expected to be placed in-service in 2016 was actually placed in-service in 2017.

Design Basis Event Emergency Mitigation Equipment (-$16.4M), Project #36002 Darlington Main Output Transformer Capital Spares (-$7.6M), Project #32202 Darlington Fukushima Phase 2 Beyond Design Basis Event Emergency Mitigation Equipment (-$6.9M), Project #80144 Darlington Primary Heat Transport (PHT) Pump Motor Overhaul (-$6.0M), Project #33224 Darlington Auxiliary Boiler Feed Pump Seal Cooling (-$5.3M), and Project #33973 Darlington SG Controls Replacement (-$5.0M). This was offset by four projects totalling (+$2.9M), primarily Project #73706 Darlington Holt Road Interchange Upgrade (+$2.5M).

Decreased in-service amounts at Pickering (-$98.0M) are mainly due to the timing of in-service of the Fukushima Project #49158 Pickering B Phase 1 Beyond Design Basis Event Emergency Mitigation Equipment (-$12.7M), Project #40976 Pickering B Fuel Handling Reliability Modifications (+$11.5M), Project #49146 Pickering Fire Code Compliance for Relocatable Structures in Un-Zoned Area for Pickering Station (-$10.4M), Project #41023 Unit 1 and 4 Fuel Channel East Pressure Tube Shift Tooling (Capital) (-$7.7M), and Project #41027 Pickering Fukushima Phase 2 Beyond Design Basis Event Emergency Mitigation Equipment (-$7.3M).

The decreased in-service amounts at Nuclear Support Divisions (-$34.2M) are due to Project #66600 Machine Delivered Scrape (-$18.9M), Project #25918 Sally Port Physical Barrier Installation (-$8.8M), and Project #66594 Channel Inspection and Gauging Apparatus for Reactors Gap System and Drive Reliability (-$4.5M).

LIST OF ATTACHMENTS

Attachment 1: Business Case Summaries and Supporting Information

Attachment 2: Darlington Water Treat Plant Business Case Justification Memo

Note: Business Case Summaries included in Attachment 1 are marked “Confidential” or “Internal Use Only”, however, OPG has determined them to be non-confidential either in their entirety or with redactions as indicated.

Attachment 1

1.0 Business Case Summaries

Section 3.0 below provides a list of capital projects with a total project cost (actual or forecast) of $20M or greater. The business case summaries ("BCS") for the projects listed are attached.[25] Business case summaries are provided for all projects, with the exception of Security projects, as discussed in Section 2.0 below.

2.0 Security Project Description and Need

This section provides a brief project description of any security-classified nuclear projects included in D2-1-3, Table 1a-d for which BCSs are not provided.

In all cases, these security projects are being undertaken to meet Canadian Nuclear Safety Commission security requirements (Ex. A1-6-1, Section 8), which are common to both OPG nuclear stations (Pickering and Darlington).

Project #82929 Security Project B. This project is to proactively replace obsolete components within the security systems at Darlington. Total project cost is $32.7M. Planned final in-service is September 2021.

Project #82930 Security Project C. This project is to proactively replace obsolete components within the security systems at Pickering. Total project cost is $22.9M. Planned final in-service is March 2021.

[25] OPG has requested confidential treatment of certain business case summaries under the OEB's Practice Direction for Confidential Information

3.0 Business Case Summary Index

Tab No	Project Number	Business Case Summary (Title)	BCS Approval Date
		ONGOING PROJECTS FROM EB-2016-0152	
1	31412	Darlington Class II Uninterruptible Power Supply Replacement	Nov-17
2	31426	Darlington Fuel Handling Inverter Replacement	Aug-18
3	31516	Darlington Station Lighting Retrofit	Mar-19
4	31518	Darlington Restore Emergency Service Water Margins	Sep-18
5	31524	Darlington Roof Replacement Project	Mar-19
6	31532	Darlington Powerhouse Water Air Cooling Unit (ACU) Replacements	May-19
7	31535	Darlington Water Treatment Plant Interconnections	Jun-19
8	31542	Darlington Install Multi-Gas Analyzers on Transformers MOT/SST/UST	Jun-18
9	31544	Darlington Radiation Detection Equipment Obsolescence ((Stack Monitoring & Post Accident Radiation Monitoring System (PARMS))	Jan-18
10	31710	Darlington Shutdown Cooling Heat Exchanger Replacement	Feb-18
11	31716	Darlington Neutron Over-Power (NOP) and Ion Chamber (IC) Amplifier Replacement (Reactor Regulation System (RRS), Shutdown System #1 (SDS1) and Shutdown System #2 (SDS2))	May-18
12	33258	Darlington Replacement of Emergency Power System (EPS) Uninterruptible Power Supply	May-17
13	33621	Darlington Secondary Control Area Air Conditioning Unit Replacement	Oct-18
14	33631	Darlington Chiller Replacement to Reduce CFC Emissions	Sep-10
15	33819	Darlington Vibration Monitoring System Replacement for Major Pump-sets	Jul-20

16	**33973**	**Darlington Standby Generator Controls Replacement**	**Oct-17**
17	**33977**	**Darlington Digital Control Computer (DCC) Replacement**	**Oct-17**
18	**34000**	**Darlington Auxiliary Heating System Facility**	**May-16**
19	**38948**	**Darlington Zebra Mussel Mitigation Improvements**	**Jan-18**
20	**73566 80144 36001**	**Darlington Primary Heat Transport Pump Motor Replacement Overhaul and Capital Spare[26]**	**Jul-17**
21	**80022**	**Darlington OH180 Aging Management Hardware Installation**	**Sep-19**
22	**80023**	**Darlington Steam Generator Level Control Valve Replacement**	**Nov-19**
23	**80036**	**Darlington R22 Refrigerant Air Conditioning Unit (ACU) Replacement**	**Jul-19**
24	**80063**	**Darlington Standby Generators Protective Relay Replacement**	**Jun-20**
25	**80078**	**Darlington Digital Control, Common Process and Sequence of Events Monitoring Computer Aging Management**	**May-18**
26	**40691**	**Pickering B Emergency Power Generator (EPG) and Main Output Power (MOP) Protective Relay Replacement**	**Dec-17**
		COMPLETED/DEFERRED/CANCELLED FROM EB-2016-0152	
27	**25619**	**Darlington Operations Support Building Refurbishment**	**Aug-15**
28	**31508 49158 49299**	**Fukushima Phase 1 Beyond Design Basis Event (BDBE) Emergency Mitigation Equipment (EME)[27]**	**Aug-16**
29	**31552**	**Darlington Condenser Cooling Water (CCW) & Low Pressure Service Water (LPSW) Travelling Screen Replacement**	**Dec-16**
30	**31717**	**Darlington Maintenance and Computer Development Facility (Capital)**	**Mar-12**

[26] Projects 73566, 36001 and 80144 are combined in a single Business Case Summary.
[27] Projects 31508, 49158 and 49299 are combined in a single Business Case Summary.

31	**32202 41027**	**Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment[28]**	**Aug-16**
32	**33955**	**Darlington Shutdown System (SDS) Computers Aging Management**	**Jul-16**
n/a[29]	**36001**	**Darlington Purchase of Primary Heat Transport Pump Motor Capital Spares**	**Jul-17**
33	**73706**	**Darlington Holt Road Interchange Upgrade**	**Feb-14**
34	**80111**	**Darlington Generator Stator Core Capital Spare**	**Sep-15**
35	**41023 49247**	**Pickering A Fuel Channel Reconfiguration & East & West Shift Tooling**	**Sep-14**
36	**40976**	**Pickering B U58 Fuel Handling Reliability Improvement Project**	**May-16**
37	**46634**	**Pickering A Fuel Handling Single Point of Vulnerability (SPV) Reliability Improvement Capital**	**May-12**
38	**66600**	**Pickering Machine Delivered Scrape Project**	**Oct-17**
		PROJECTS NOT IN EB-2016-0152	
39	**80122**	**Darlington Main Power Output Protection System Replacement**	**May-18**
40	**80123**	**Darlington Group II Pressure Transmitter Replacement**	**May-20**
41	**80124**	**Darlington Obsolete Controller Replacement**	**Feb-19**
42	**80126**	**Darlington Emergency Power Generator 1 and 2 Replacement**	**May-18**
43	**80148**	**Darlington Fuel Handling Control Computer Input/Output Subsystem (Multiplexer) & and Interprocessor Communication Replacement**	**Feb-19**
44	**80150**	**Darlington Fire Retardant Fluid (FRF) Pump Improvement**	**May-18**
45	**82883**	**Darlington Class 1 Rectifier Replacement**	**May-18**
46	**82890**	**Darlington Transformer Control Cabinet Wiring System Replacement**	**Jan-19**

[28] Projects 32202 and 41027 are combined in a single Business Case Summary
[29] Tab 20

47	**82947**	**Darlington Fueling Machine (FM) Head Major Component Replacement**	**Oct-18**
48	**83049**	**Darlington Copper Piping Replacement**	**Aug-19**
49	**83052**	**Darlington Fuel Handling (FH) Power & Signal Cable Replacement**	**Apr-19**
50	**83053**	**Darlington Shutdown Cooling Heat Exchanger Powerhouse Upper Level Water Piping Replacement (PULSW) Piping Replacement**	**Jul-18**
51	**83076**	**Darlington Phase 2 Station Battery Replacement**	**Jul-19**
52	**83296**	**Darlington Main Output Transformer and Unit Service Transformer Replacement**	**Jul-19**
53	**83297**	**Darlington Large Moderator Temperature Control Valve Replacement**	**May-17**
54	**83298**	**Darlington Secondary Systems High Priority Control Valve Replacements**	**Mar-19**
55	**83299**	**Darlington Condenser Steam Discharge Valves Control System Upgrade**	**Nov-18**
56	**83480**	**Darlington 4kV Motors Refurbishment and Replacement**	**May-18**
57	**83484**	**Darlington Isolated Phase Bus Refurbishment**	**Jul-20**
58	**83556**	**Darlington Turbine Hall Crane Controls Upgrade**	**Jul-20**
59	**83558**	**Darlington Fuel Handling (FH) Service Area Bridge F5 Ball Screw Assembly Replacement, and DN Fuel Handling SAB Ball Screw and Jack Assembly Capital Spares**	**Oct-18**
60	**83559**	**Darlington Irradiated Fuel Bay (IFB) Permanent Fuel Inspection Equipment in East & West Fueling Facility Auxiliary Area**	**Mar-18**
61	**83664**	**Darlington Unit 2 Turbine/Generator Electronic Controls and Generator Auxiliaries Upgrade**	**Dec-19**
62	**83916**	**Darlington Fuel Handling Calibration Facility Component Replacement Project**	**Feb-19**
63	**84009**	**Darlington Air Operated Valve (AOV) Replacements**	**Mar-20**
64	**84235**	**Darlington Primary Heat Transport Liquid Relief Valves Modifications [2]**	**Dec-18**
65	**84551**	**Darlington Motor Operated Valve (MOV) Replacements**	**Mar-20**

66	**84799**	**Darlington Primary Heat Transport (PHT) Pump Rotor Inspect / Replace (RECL)**	**May-20**
67	**84939**	**Darlington Revenue Metering Transformer Replacement**	**Nov-19**
68	**83072**	**Pickering Buried Boiler Blowdown Pipe Replacement**	**Jul-19**
69	**83088**	**Pickering A LP Feedwater Heat Exchangers Replacement (Capital)**	**Mar-18**
70	**83668**	**Pickering High Pressure Turbine Spares**	**Nov-17**
71	**83039**	**Darlington Rapid Delivery Machine (RDM)**	**Aug-18**
72	**83828**	**Fleet Monitoring Initiative (Monitoring and Diagnostic Centre)**	**Mar-20**

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