ONTARIO POWER GENERATION

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OPG-FORM-0076-R005*

Type 3 Business Case Summary

To be used for investments/projects meeting Type 3 criteria in OPG-STD-0076.

Executive Summary and Recommendations

Project Information			
Project #:	Project # 82816	**Document #:**	D-BCS-73720-10001-R000
Project Title:	DN Vault Cooling Coil Replacement		
Class:	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others:	**Investment Type:**	Regulatory
Phase:	Execution	**Release:**	Partial
Facility:	Darlington	**Target In-Service or Completion Date:**	Sept 2020

Project Overview

We recommend the release of $11,936 k, including [redacted] of contingency.
The estimated total project cost is $ 26,322 k, including [redacted] of contingency.

The quality of the estimate for this release is Class 2, and for the total project is Class 3.
Specific contingency is applied to account for scope uncertainty.

The business objective of this project is to reduce the risk to Darlington operations from leaking or reduced flow vault cooling coils. Selected coils will be replaced to allow the units to operate with low risk until their respective unit refurbishment outages.

This release will fund the following scope of work:

- Replace leaking and degraded vault cooling coils in outages D1512, D1511, D1521, D1531, D1541, D1641
- Prepare for contingent forced outage(s) for coil replacement
- Complete the design for 2 piece coils where required for targeted installations
- Acquire specialized tooling for coil replacement
- Prepare a subsequent release BCS to address remaining replacements require before the respective refurbishment outages.

Tube plugging or repair of installed coils is not part of this project scope.

Vault cooling coils provide cooling to the reactor vault under operating conditions. Under Loss of Coolant Accident (LOCA) conditions they remove heat from the steam ladened atmosphere and maintain vault negative pressures.

Many vault cooling coils are leaking which requires the coils to be valved out. Six coils were replaced in D1512. There are currently 5 leaking coils across the station; Unit 2 (3 coils), Unit 3 (1 coil) and Unit 4 (1 coil). Vault temperatures can approach shut down limits of 61°C associated with Negative Pressure Containment System (NPCS) Level 2 impairment due to high summer lake water temperatures. Reduced cooling capacity from high service water temperature, leaking coils isolated and degraded flow from coil fouling, have contributed to lowered cooling margins. In addition, Environmental Qualification (EQ) margins are being reduced due to the elevated temperatures experience by EQ equipment.

Coil replacement was planned scope for refurbishment outages (DSR-TS0280-1), and is a IIP committment. A portion of this regulatory work is being advanced to outages preceeding refurbishment as leaking coils and coils with degraded flow need to be replaced now to increase margins to avoid impairments due to vault temperatures. Replacement of coils in D1512 was initiated to allow Unit 1 to operate through the summer of 2015.

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OPG-FORM-0076-R005

Type 3 Business Case Summary

Project #: Project # 82816
Document #: D-BCS-73720-10001-R000
Project Title: DN Vault Cooling Coil Replacement, <Partial> <Execution> Release

Project Overview

Summary of Preferred Alternative:

Replace only coils with leak(s) and coils with significant degradation in available planned outage(s) leading into each unit's refurbishment outage. Remaining coils will be replaced during the refurbishment outage under DSR-TS028-1.

Valving in leaking coils to maintain vault temperatures may be used as temporary mitigation provided leak rates are manageable. Repairing of leaking coils can be attempted during outages, with the repair strategy dependent on leak size and location. Repairing leaking coils increases cooling capacity after returning the coil to service but may not provide adequate temperature margin to avoid NPCS impairments. Tube plugging reduces coil cooling capacity and leak repair does not reduce the probability of other tube leaks in the coil. Cooling coil replacement is preferred over plugging or repair. Costs associated with plugging or repair are not included in this project.

Replacement coils have recently been procured for inventory and installed. Material and installation costs are known with high confidence.

Key Assumptions and Risks:

Scope of work for each planned outage will target leaking coils and coils with degraded flow. Initiation of leaks in in-service coils in not predictable. Some coils due to known interferences will require 2 piece replacement coils increasing project costs. As such the project scope for each outage up to 2020 may vary. Significant specific contingency is included in the project estimate to address the uncertain number of coil replacements. This project is not currently in the Business Plan. Project approval is under element 1.2

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OPG-FORM-0076-R005

Type 3 Business Case Summary

Project #: Project # 82816
Project Title: DN Vault Cooling Coil Replacement, <Partial> <Execution> Release

Document #: D-BCS-73720-10001-R000

Project Cash Flows, NPV, and OAR Approval Amount

k$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released									
Requested Now	-	7,000	4,935						11,936
Future Required	-			2,810	2,719	5,573	3,284		14,386
Total Project Cost		7,000	4,935	2,810	2,719	5,573	3,284		26,322
Ongoing Costs	-								
Grand Total		7,000	4,935	2,810	2,719	5,573	3,284		26,322

Estimate Class:	Class 3	**Estimate at Completion:**	[redacted]
NPV:		**OAR Approval Amount:**	$26,322k

Additional Information on Project Cash Flows (optional):

The Requested Now amount of $11,936k includes costs captured from the successful installation of 6 coils in D1512, and the planned installation of 12 additional coils in the remainder of 2015 and 2016. It also includes general contingency of [redacted] for this work and specific scope contingency of [redacted] for replacement of an additional 2 coils in D1641.

Significant specific contingency has been carried to account for uncertain scope (total number of coil requiring replacement). Contingent scope includes an additional 2 coil replacements in each of; D1641, D1831 and D1941. Refer to table in Part B of this BCS.

The total project cost of $26,322k includes [redacted] of contingency. The future release BCS is planned for Q3 2016. At that time additional coils will have been installed, and higher confidence on the total forecasted total number of coils replaced is expected.

Approvals

	Signature	Comments	Date
The recommended alternative, including the identified ongoing costs, if any, represents the best option to meet the validated business need.			
Recommended by (Project Sponsor): Glenn Jager, President OPG Nuclear, and Chief Nuclear Officer			30 NOV 2015
I concur with the business decision as documented in this BCS.			
Finance Approval: Beth Summers C. CROZZOLI, SVP and Chief Financial Officer per OPG-STD-0076			Dec 2/15
I confirm that this project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.			
Approved by: Jeff Lyash, President & CEO, Ontario Power Generation Inc. per OAR 1.2			Dec 3/15

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Type 3 Business Case Summary

Project #: Project # 82816
Document #: D-BCS-73720-10001-R000
Project Title: DN Vault Cooling Coil Replacement, <Partial> <Execution> Release

Business Case Summary

Part A: Business Need

Vault cooling coils provide cooling to the reactor vault under operating conditions. Under Loss of Coolant Accident (LOCA) conditions they remove heat from the steam ladened atmosphere and maintain vault negative air pressures. Vault Evnrivonmental Qualified (EQ) equipment in the vault is also protected from elevated temperature thermal degradation. They are Nuclear Class 3 Components.

There is a total of 64 coils across the station (4 units x 4 Air Cooling Units [ACU]/unit x 4 coils/ACU). The coil material is 5/8"OD x 0.049 wall ASME SB-75 UNS C12200 tubes with 0.009" thick ASTM B-152 UNS C11000 fins. The Design life is 25 years. A component condition assessment at 15 years inservice (2006) indicated a maximum wall loss of ~ 27% at the coil u-bend due to flow erosion corrosion. An additional assessment performed in 2013 recorded a measured wall loss of ~ 42% at the coil u-bend with a maximum of 52%. Coil replacement was planned in nuclear refurbishment (DSR-TS0280-1), and is an IIP committment. There are known interferences such that selected coils would need a split coil design for replacement if it occurred before refurbishment.

Darlington has experienced vault cooling coil leaks. The failure mechanism are attributed to errosion corrosion and pitting corrosion. Heat transfer capability has also decreased due to coil fouling from zebra mussels, silt and other debris . Early in 2015 there was 10 leaking coils across the station: Unit 1 (5 coils), Unit 2 (3 coils), Unit 3 (1 coil) and Unit 4 (1 coil). As coils are found to be leaking they are valved out of service. As coils are valved out of service vault temperatures increase.

Vault cooling coils form part of the Negative Pressure Containment System (NPCS). System normal operation and impairments are:

- Design Vault temperature: 37.8 °C
- Level 3 Impairment: Alarm set-point 55.0 °C
- Level 2 Impairment: Shut down limit 61.0 °C

Placing leaking vault coolers back in service to control vault temperatures, introduces normal water into the vault atmosphere and downgrades heavy water vapour recovery. It was expected that Unit 1 operation would have been impacted by summer high cooling water temperatures. Vault vapour recovery was expected to overwhelm the Tritium Removal Facility (TRF) Upgrader/ Heavy Water Management (HWM) capacity. Excess vapour recovery would need to be drummed and would have put the fall 2015 HWM plan for the Darlington Vacuum Building Outage (VBO) in jepardy. Operating long term with vault leaks increases upgrader operating costs. Six coils were replaced in D1512 to address this risk, and increase margins on EQ equipment thermal degradation.

Delay in addressing vault cooling coil leaks is a significant risk to Darlington operations.

Part B: Preferred Alternative: Replace Selected Vault Cooling Coils ahead of Refurbishment

Description of Preferred Alternative

Replace only coils with leak(s) and coils with significant degradation in available planned outage(s) leading into each unit's refurbishment outage. Remaining coils will be replaced during the refurbishment outage under DSR-TS028-1.

A two piece replacement coil is required for selected installations as accessibility issues are known.

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Type 3 Business Case Summary

Project #: Project # 82816
Project Title: DN Vault Cooling Coil Replacement, <Partial> <Execution> Release

Document #: D-BCS-73720-10001-R000

Alternative 5:

Part D: Project Cash Flows, NPV, and OAR Approval Amount

k$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	-								
Requested Now	-	7,000	4,935						11,936
Future Required	-			2,810	2,719	5,573	3,284		14,386
Total Project Cost		7,000	4,935	2,810	2,719	5,573	3,284		26,322
Ongoing Costs	-								
Grand Total		7,000	4,935	2,810	2,719	5,573	3,284		26,322

Estimate Class:	Class 3	**Estimate at Completion:**	[redacted]
NPV:		**OAR Approval Amount:**	$26,322k

Additional Information on Project Cash Flows (optional):

The Requested Now amount of $11,936k includes costs captured from the successful installation of 6 coils in D1512, and the planned installation of 12 additional coils in the remainder of 2015 and 2016. It also includes general contingency of [redacted] for this work and specific scope contingency of [redacted] for replacement of an additional 2 coils in D1641.

Significant specific contingency has been carried to account for uncertain scope (total number of coil requiring replacement). Contingent scope includes an additional 2 coil replacements in each of; D1641, D1831 and D1941. Refer to table in Part B of this BCS.

The total project cost of $28,322k includes [redacted] of contingency. The future release BCS is planned for Q3 2016. At that time additional coils will have been installed, and higher confidence on the total forecasted total number of coils replaced is expected.

Part E: Financial Evaluation

k$	Preferred Alternative	Base Case	Do More	Plug	
Project Cost	[redacted]	N/A	N/A	N/A	
NPV					
Other (e.g., IRR)					

Summary of Financial Model Key Assumptions or Key Findings:

Part F: Qualitative Factors

As the rate of degradation is not fully understood advancing needed coil replacements would eliminate risk of;

- challenging TRF upgrader capacity which could impact VBO and Refurbishment strategies
- pushes to planned outages to complete all vault cooler work which is currently scoped in refurbishment
- uncertainty associated with patching and/or plugging leaking coils as bridging only should coil fail in a different location or the repair fail prior to refurbishment

Type 3 Business Case Summary

Project #: Project # 82816
Document #: D-BCS-73720-10001-R000
Project Title: DN Vault Cooling Coil Replacement, <Partial> <Execution> Release

Part B: Preferred Alternative: Replace Selected Vault Cooling Coils ahead of Refurbishment

Description of Preferred Alternative

This strategy will mitigate the risk of:

- Unplanned outages associated with high vault temperatures (NPCS Impairment)
- Accelerated EQ equipment aging due to elevated vault temperatures
- Challenging TRF Upgrader operations and costs
- Extensions to planned outages to complete all vault cooler work which is currently planned in refurbishment.

This project is not in the current Operations Business Plan. Partial scope is being advanced from Refurbishment scope to mitigate existing operational risks. Replacement coils have been procured for inventory, and 6 coils have been replaced in D1512. Material and Installation costs are well known.

Scope (Forecast Coils Replaced)	2015 D1512, D1511 D1521, D1531 D1541	2016 D1641	2017 D1711	2018 D1831	2019 D1941	2020 D2011	Total
Planned	12	6	4	2	6	4	34
Contingent[1]		2		2	2		6
Total	12	8	4	4	8	4	40

1) Specific contingency applied to account for the contingent scope. Contingent scope impact on critical path would be assessed for D1641 and D1941.

Deliverables:	Associated Milestones (if any):	Target Date:
Replace 6 coils in D1512 (complete)		30 June 2015
Replace high risk coils in D1511, D1521, D1531 & D1541	AFS	20 Dec 2015
Replace high risk coils in D1641	AFS	15 July 2016
Refine future scope for 2017 to 2020 outages	Future Release BCS	15 Sept 2016

Part C: Other Alternatives

Alternative 2: Base Case – No Project

Without action, vault temperatures may not be maintained within the operating margins for NPCS and degradation of EQ equipment will be accelerated due to elevated temperatures. An unplanned outage is likely. Placing leaking coils back in service carries significant risk of exceeding TRF Upgrader capability and potential impacting the VBO HWM strategy, and future upgrader operating costs.

Alternative 3: Do More – Replace All Coils in Units 1 & 4 and Half Coils in Unit 3

Given the long duration of operation of Unit 1 and Unit 4 to their respective refurbishment outages and the uncertain rate of coil degradation, plan to replace all the coils in these units. Half the coils in Unit 3 to ensure sufficient operating margin remains to refurbishment.

Alternative 4: Plug Leaking Coils

Plugging the tubes and then placing the coil back in increases cooler capacity but decreases cooler efficiency and may not provide sufficient margin on NPCS and EQ. Plugging does not reduce the probability of future leaks on that coil and is therefore not an effective mitigation on its own. Not all leak locations are repairable due to accessibility within the coil. This alternative is not recommend, although may be used as a bridging strategy to eventual replacement.

Alternative 5:

Type 3 Business Case Summary

Project #: Project # 82816
Document #: D-BCS-73720-10001-R000
Project Title: DN Vault Cooling Coil Replacement, <Partial> <Execution> Release

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	There is a risk that cost could increase due to the need for emergent coil replacement and/or physical accessibility challenge the replacement.	Specific contingency allotted for emergent coil replacement. A two piece coil is being pursued where accessibility issues are known.	Medium	Low
Scope	There is a risk that scope could increase due to the need for emergent coil replacement.	Target leaking coils in upcoming outages. Include contingency for emergent replacement. Remaining scope to be completed under Refurbishment scope.	Medium	Low
Schedule	Target coil replacements exceeds planned outage duration	Target leaking coils and at most risk coils. Additional replacements under subsequent planned outages or during refurbishment outage.	Medium	Low
Resources	There is a risk that resources may not be available to execute the required scope planned for a given outage.	Work will be contracted.	Low	Low
Quality/ Performance	2 piece coil gasket life may lead to periodic replacement	Selection of gasket material to optimize service life.	Low	Medium
Technical	Risk of unknown interference or accessibility issues arising during coil replacement.	A two piece coil is being pursued where accessibility issues are known. Repair and/or plugging could be used if the option permitted.	Medium	Low

Additional Risk Analysis:

Part H: Post Implementation Review (PIR) Plan

Type of PIR Report	Target In-Service or Completion Date	Target PIR Completion Date
Simplified PIR	July 2020	Dec 2020

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Coil Leakage	Many coils have significant leaks requiring isolation	Replaced coils have zero leaks and are valved in for service	Visual inspection following replacement and flows established.	Maintenance
Coil Isolation	Leaking coils valved in to control vault temperatures	No leaking coils required to be in-service to control vault temperature	Visual inspection following replacement and flows established.	Maintenance
Negative Pressure Containment System Impairment	Vault temperature approaching alarm set point of 55°C (Level 3 impairment). Summer vault temperature is expected to reach shut-down limit of 61°C (level 2 impairment)	Margin exists on Level 3 impairment of NPCS	Operations monitoring	Ops
Leakage to containment	Challenging TRF Upgrader capacity Increased upgrader costs	Leakage well within upgrader capacity with sufficient margin to accommodate planned outages	Collection & input to upgrader	TRF Technical

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Type 3 Business Case Summary

Project #: Project # 82816

Document #: D-BCS-73720-10001-R000

Project Title: DN Vault Cooling Coil Replacement, <Partial> <Execution> Release

Part I: Definitions and Acronyms
NPCS – Negative Pressure Containment System
VBO – Vacuum Building Outage
TRF – Tritium Removal Facility
EQ – Environmental Qualification
HWMB – Heavy Water Management Building

Type 3 Business Case Summary

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Type 3 Business Case Summary

Project #: Project # 82816

Document #: D-BCS-73720-10001-R000

Project Title: DN Vault Cooling Coil Replacement, <Partial> <Execution> Release

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Type 3 Business Case Summary

Project #: Project # 82816
Document #: D-BCS-73720-10001-R000
Project Title: DN Vault Cooling Coil Replacement, <Partial> <Execution> Release

Appendix A: Summary of Estimate										
Project Number:	Project # 82816 82816									
Project Title:	DN Vault Cooling Coil Replacement									
Choose an item	LTD	2015	2016	2017	2018	2019	2020	Future	Total	%
OPG Project Management		268	138	95	49	151	104		**805**	4%
OPG Engineering (including Design)		167	60	41	21	66	45		**401**	2%
OPG Procured Materials		[redacted]								
OPG Other										
Design Contract(s)										
Construction Contract(s)										
EPC Contract(s)										
Consultants										
Other Contracts/Costs										
Interest										
Subtotal		6,087	3,476	2,443	1,346	3,798	2,856		**20,006**	100%
Contingency		913	1,459	367	1,373	1,775	428		**6,316**	32%
Total		**7,000**	**4,935**	**2,810**	**2,719**	**5,573**	**3,284**		**26,322**	

Notes			
Project Start Date	June 2015	**Total Definition cost** (excludes unspent contingency for Nuclear)	[redacted]
Target In-Service (or AFS) Date	Jul 2020	**Contingency included in this BCS** (Nuclear only)	
Target Completion Date	Jul 2020	**Total contingency released plus contingency in this BCS** (Nuclear only)	
Escalation Rate	3%	**Total released plus this BCS without contingency** (Nuclear only)	
Interest Rate	5%	**Total released plus this BCS with contingency** (Nuclear only)	**$11,936k**
Removal Costs	$2,760k included in (e.g., EPC Contracts)	**Estimate at Completion** (includes only spent contingency for Nuclear)	[redacted]

Prepared by:	Approved by:
Bob Grandoni Technical Advisor Programming Date 2015-11-20	Dave Burger Manager, Performance Engineering Date 2015-11-20

Type 3 Business Case Summary

Project #: Project # 82816
Document #: D-BCS-73720-10001-R000
Project Title: DN Vault Cooling Coil Replacement, <Partial> <Execution> Release

Appendix B: Comparison of Total Project Estimates and Project Variance Analysis

Comparison of Total Project Estimates

Phase	Release	Approval Date	Total Project Estimate in k$ (by year including contingency)						Future	Total Project Estimate
			2015	2016	2017	2018	2019	2020		
Execution	Partial	Nov 2015	7000	4935	2810	2719	5573	3284		26,322

Project Variance Analysis

k$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management					
OPG Engineering (Including Design)					
OPG Procured Materials					
OPG Other					
Design Contract(s)					
Construction Contract(s)					
EPC Contract(s)					
Consultants					
Other Contracts/Costs					
Interest					
Subtotal					
Contingency					
Total					

Variance explanation not required – First BCS

Type 3 Business Case Summary

Project #: Project # 82816
Project Title: DN Vault Cooling Coil Replacement, <Partial> <Execution> Release

Document #: D-BCS-73720-10001-R000

Appendix C: Financial Evaluation Assumptions
Key assumptions used in the financial model of the Project are (complete relevant assumptions only):
N/A

Appendix D: References
NK38-REP-73720-100005-R002
NK38-REP-73720-0473755
NK38-REP-73720-0485570

Appendix E: Photo - Leaking Coil at U-bend

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Type 3 Business Case Summary

To be used for investments/projects meeting Type 3 criteria in OPG-STD-0076.

Executive Summary and Recommendations

Project Information			
Project #:	Project #10-73566 Project #16-80144	**Document #:**	D-BCS-33130-00001 R000
Project Title:	DN PHT Pump Motor Replacement & Overhaul		
Class:	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others:	**Investment Type:**	Sustaining
Phase:	Execution	**Release:**	Partial
Facility:	Darlington	**Target In-Service or Completion Date:**	JUN-2022

Project Overview

We recommend the release of $48.7M, including [redacted] of contingency.

The estimated total project cost is $129.5M, including [redacted] of contingency.

The estimated total cost of overall Primary Heat Transport (PHT) Pump Motor program, including the four spare motors previously released, is $160.3M including [redacted] of contingency.

This partial release Business Case Summary (BCS) will bring the release-to-date to $53.8M which includes [redacted] contingency. A release of $ 5.1M was obtained under approved Refurbishment Gate 3 release package in December 2014 for installation of 5 (five) motors starting in D1531 under project # 10-73566. As well, four new spare motors either received or are to be received through Capital Portfolio project 16-36001 – DN Purchase of PHT Pump Motor Capital Spares.

The replacement and overhaul of the PHT Pump Motors was previously included in the Darlington Refurbishment PHT and Auxiliary Scope Nuclear Sub-Bundle. A review of the scope of this project determined that it this not core scope and has been reclassified as Operations support work. This BCS finalises the transfer of both the replacement and overhaul projects to Nuclear Operations Portfolio.

The deliverables of this BCS include the following.

- Replacement/installation of six out of 16 (sixteen) PHT pump motors during Darlington outages, D1512/D1531/D1641/D1711 including transport and pre-testing, prior to execution.
- Refurbishment of 7(seven) PHT pump motors. The refurbishment contract is currently being negotiated. 6 motors are to be replaced with one spare motor to be included in the release of motors to be refurbished.
- Purchase of a trailer for handling PHT pump motor transfers at site.

An Execution Full Release BCS to support completion of the overall scope of work will be submitted for approval in November 2017.

Problem Statement/Business Need:

There are 16 operating PHT motors operating on site – 4 per unit. Additionally, there is one spare motor that was removed from service in 2010 and is not credited as a viable spare. PHT pump motors are 100% duty with no installed redundancy. Failure of any one of the operating motors will result in a forced outage and could result in an extended outage depending on availability of spare motors.

The current condition assessments of PHT pump motors are at medium, high or very high risk and have an increasing probability of failure until replaced by new or refurbished motors. There are indications of winding deterioration in 15 of the 16 Primary Heat Transport (PHT) pump motors. The presence of ozone is a sign of partial discharge in the stator windings and/or electrical connections. Partial discharge is the precursor of a short to ground for the stator windings. If the motor fails due to short to ground, the motor will more than likely be unrecoverable. The extent of condition, i.e. the risk to the motors associated with high ozone levels and the deterioration rate will not be fully understood until the first motor is refurbished.

Based on documented operational experience, the expected service life for a motor of this size is 25 to 30 years There is

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Type 3 Business Case Summary

Project #: Project #16-80144 Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

Project Overview

operational experience showing motors manufactured by the same Original Equipment Manufacturer (OEM) have similar problems at other U.S. stations. The failure rate is one per 24 years and deteriorating, based on a study for the U.S. Nuclear Regulatory Commission "Aging Assessment of Large Electric Motors in Nuclear Power Plants (NUREG/CR-6336). With this deteriorating failure rate, the existing motors cannot be expected to run reliably without being fully refurbished. Currently, another Canadian CANDU operator is refurbishing their motors.

The business risk arising from the condition of the pump motors is documented in the Enterprise Risk Management system as "High". OPG's strategic decision to manage this risk is to purchase additional spare motors (previously released), replace and refurbish existing operating motors and restore system capability as well as long term redundancy with the availability of spare motors.

Summary of Preferred Alternative:

Following final receipt/testing/installation/commissioning/turnover of the four new motors starting with in the D1512 outage, the old motors removed from the units will be assessed and refurbished. Once complete, these refurbished motors will then be installed at a rate of up to two motors per outage and each removed motor is to be refurbished until all are replaced. Note, the scheduling on when each motor will be taken out will be assessed based on the potential for degraded components due to partial discharge generated Ozone.

Replacement of existing PHT motors will be completed in all units by 2022. Risk is to be greatly reduced by completing the replacement/refurbishment of the highest priority motors by 2018. This is dependent on vendor contract with schedule that will support refurbishing two motors between planned outages.

History of scope and schedule changes:

This is the original BCS and the scope has not changed.

The Target In-Service dates are in accordance with our outage schedule with one motor to be available for service at the end of D1512 and two motors to be available for service at the end of D1531. One more motor is to be available for service at the end of D1641 outage. Replacement of existing PHT motors will be completed in all units by 2022.

Key Assumptions and Risks:

Current assumption is 1 (one) motor can be overhauled/returned within 8 months, based on vendor feedback. Our contract will include provisions for schedule and performance liquidated damages, but there is a risk that the refurbishment work is not done well and OPG might not get refurbished motors installed as per schedule. The first motor to be sent out for refurbishment is the spare. This motor will be subject to no load test run at OPG on the test stand to confirm it is fit for field installation.
The overhaul vendor must have the shop floor available for 2-3 DNGS motors at a time to support our current schedule. OPG should include a clause to hire more than one vendor for the motor overhaul, in case vendor capacity isn't sufficient.
Contingency plans shall be developed in the event any motors do not meet their delivery milestone, and the effect on downstream motor swaps.

Project Cash Flows, NPV, and OAR Approval Amount

M$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	1.8	2.2	1.1	-	-	-	-	-	5.1
Requested Now		6.2	11.5	31.0	-	-	-	-	48.7
Future Required	-	-	-	-	15.0	12.0	14.0	34.7	60.7
Total Project Cost	1.8	8.4	12.6	31.0	15.0	12.0	14.0	34.7	129.5
Ongoing Costs	-	-	-	-	-	-	-	-	-
Grand Total	1.8	8.4	12.6	31.0	15.0	12.0	14.0	34.7	129.5

Estimate Class:	Class 3	**Estimate at Completion:**	[redacted]
NPV:		**OAR Approval Amount:**	$129.5M

Additional Information on Project Cash Flows (optional):
NPV is not required for a cost benefit as this is a sustaining project.

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Type 3 Business Case Summary

Project #: Project #16-80144
Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

Approvals			
	Signature	**Comments**	**Date**
The recommended alternative, including the identified ongoing costs, if any, represents the best option to meet the validated business need.			
Recommended by (Project Sponsor): Glenn Jager Chief Nuclear Officer			23/06/2015
I concur with the business decision as documented in this BCS.			
Finance Approval: Beth Summers Chief Financial Officer per OPG-STD-0076			14/07/2015
I confirm that this project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.			
Approved by: Tom Mitchell President & CEO per OAR 1.1			15/7/2015

ONTARIO POWER GENERATION

Records File Information:
Records SCI/USI Retention
- See Guidance Section

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Type 3 Business Case Summary

Project #: Project #16-80144
Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

Business Case Summary

Part A: Business Need

There are 16 operating PHT motors operating on site – 4 per unit. Additionally, there is one spare motor that was removed from service in 2010 and is not credited as a viable spare. PHT pump motors are 100% duty with no installed redundancy. Failure of any one of the operating motors will result in a forced outage and could result in an extended outage depending on availability of spare motors.

The current condition assessments of PHT pump motors are at medium, high or very high risk and have an increasing probability of failure until replaced by new or refurbished motors. There are indications of winding deterioration in 15 of the 16 Primary Heat Transport (PHT) pump motors. The presence of ozone is a sign of partial discharge in the stator windings and/or electrical connections. Partial discharge is the precursor of a short to ground for the stator windings. If the motor fails due to short to ground, the motor will more than likely be unrecoverable. The extent of condition, i.e. the risk to the motors associated with high ozone levels and the deterioration rate will not be fully understood until the first motor is refurbished.

Based on documented operational experience, the expected service life for a motor of this size is 25 to 30 years There is operational experience showing motors manufactured by the same Original Equipment Manufacturer (OEM) having similar problems at other U.S. stations. The failure rate is one per 24 years and deteriorating, based on a study for the U.S. Nuclear Regulatory Commission "Aging Assessment of Large Electric Motors in Nuclear Power Plants (NUREG/CR-6336). With this deteriorating failure rate, the existing motors cannot be expected to run reliably without being fully refurbished. Currently, another Canadian CANDU operator is refurbishing their motors.

The business risk arising from the condition of the pump motors is documented in the Enterprise Risk Management system as "High". OPG's strategic decision to manage this risk is to purchase additional spare motors (previously released), replace and refurbish existing operating motors and restore system capability as well as long term redundancy with the availability of spare motors.

Part B: Preferred Alternative: Overhaul of PHT Pump Motors

Description of Preferred Alternative

- The preferred alternative is to overhaul 17 PHT pump motors.
- The preferred alternative is selected against other alternative of buying new motors due to cost and duration.

  Pros:
  - The motors need to be overhauled in order to extend their life expectancy for another 30 years. Similar motors were overhauled at power plants in Canada with good results.

  Cons:
  - Overhaul cost is estimated based on a base scope of work as described in the technical specification. Each motor situation is different and the overhaul cost for each motor could increase based on the results of each motor inspection at the overhaul company. Inspection report for each motor will be reviewed and accepted by OPG and could result in increase of base scope of work as originally estimated.
  - This could create issues with regards to operating and maintaining motors of a slightly different design. The new and overhauled motors are from the same OEM and there are differences with regards to the type of bearing and some other parts used.
  - Staged release supports re-assessment/measure of costs associated with motor refurbishment.

Deliverables:	Associated Milestones (if any):	Target Date:
Issue PO to overhaul PHT pump motors	N/A	Q2-2015

*Associated with OPG-STD-0076, Developing and Documenting Business Cases

Type 3 Business Case Summary

Project #: Project #16-80144 Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

Deliverables:	Associated Milestones (if any):	Target Date:
Installation of 4 (four) new PHT pump motors during D1512, D1531 and D1641.	D1512, D1531 and D1641 milestones for field installation	D1512-15/7/2015 D1531-30/1/2016 D1641-30/8/2016
Ship 2 (two) used PHT pump motors for overhaul (batch # 1) after being removed from units in D1512 and D1531.	N/A	Dec 2015
Receive first 2 (two) overhaul motors (batch # 1) from vendor.	N/A	Apr and Aug 2016
Ship 2 (two) used PHT pump motors for overhaul (batch # 2).	N/A	Jul 2016
Receive 2 (two) overhaul motors (batch # 2) from vendor.	N/A	Mar 2017
Ship 4 (four) used PHT pump motors for overhaul (batch # 3).	N/A	Apr 2017
Receive 4 (four) overhaul motors (batch # 3) from vendor.	N/A	Dec 2017
Ship 2 (two) used PHT pump motors for overhaul (batch # 4).	N/A	Jun 2019
Receive 2 (two) overhaul motors (batch # 4) from vendor.	N/A	Feb 2020
Ship 1 (one) used PHT pump motors for overhaul (batch # 5).	N/A	Feb 2020
Receive 1 (one) used PHT pump motors for overhaul (batch # 5).	N/A	Oct 2020
Ship 2 (two) used PHT pump motors for overhaul (batch # 6).	N/A	Dec 2020
Receive 2 (two) used PHT pump motors for overhaul (batch # 6).	N/A	Aug 2021
Ship 2 (two) used PHT pump motors for overhaul (batch # 7).	N/A	Sep 2021
Receive 2 (two) used PHT pump motors for overhaul (batch # 7).	N/A	May 2022
Ship 2 (two) used PHT pump motors for overhaul (batch # 8).	N/A	May 2022
Receive 2 (two) used PHT pump motors for overhaul (batch # 8).	N/A	Dec 2022

Part C: Other Alternatives

Summarize all viable alternatives considered, including pros and cons, and associated risks. Other alternatives may include different means to meet the same business need, and a reduced or increased scope of work, etc.

Alternative 1: Base Case – Do Nothing

This is not an option. Motor replacement has to be scheduled based on Partial discharge and ozone indications. The business risk is documented under Enterprise Risk management (ERM) risk # ER19731 - DN - Darlington Primary Heat Transport Pump Motor Failures Impacting Station Operations"

Alternative 3: Delay Work

This is not recommended. Delay of work will result in failure of PHT pump motors resulting in unit(s) being

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Type 3 Business Case Summary

Project #: Project #16-80144 Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

Alternative 3: Delay Work
shutdown.

Alternative 4: Buying new motors
This is not recommended due to higher cost and duration. The cut-off cost is $5M. We will re-evaluate this alternative if the overhaul motor cost gets to $5M per motor.

Alternative 5: N/A

Part D: Project Cash Flows, NPV, and OAR Approval Amount

M$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	1.8	2.2	1.1	-	-	-	-	-	5.1
Requested Now	-	6.2	11.5	31.0	-	-	-	-	48.7
Future Required	-	-	-	-	15.0	12.0	14.0	34.7	60.7
Total Project Cost	1.8	8.4	12.6	31.0	15.0	12.0	14.0	34.7	129.5
Contingency	-	-	-	-	-	-	-	-	-
Grand Total	1.8	8.4	12.6	31.0	15.0	12.0	14.0	34.7	129.5

Estimate Class:	Class 3	**Estimate at Completion:**	[redacted]
NPV:		**OAR Approval Amount:**	$129.5M

Additional Information on Project Cash Flows (optional):
NPV calculations are not applicable.

Part E: Financial Evaluation

M$	Preferred Alternative	Base Case	Delay Work	Alternative 4	Alternative 5
Project Cost	127.7				
NPV	NA				
Other (e.g., IRR)					

Summary of Financial Model Key Assumptions or Key Findings:
NPV is not required for a cost benefit as this is a sustaining project.

Part F: Qualitative Factors
Project is to address a station risk which will demonstrate to the public that OPG is managing risk to support the long term viability of DNGS.

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	There is a risk that the cost of refurbishment will increase based of inspection of each motor and additional repairs not included in our technical specification. Cost increase could vary between motors.	Mitigation: Review with overhaul vendor results of the incoming inspection for each motor to determine required repairs/design changes that are optional work as per our technical specification. OPG is to concur with the replacement recommendations, if any.	High	Medium
Scope	Possibility of discovery issues, not	Mitigation: Review with overhaul vendor	High	Medium

Type 3 Business Case Summary

Project #: Project #16-80144
Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
	anticipated, during the assessments.	to determine if replacements are required for major motor parts/ optional work.		
Schedule	There is a risk that the overhauled motors will not be ready in time for the planned sequence of PHT motor swaps. There is a risk with the distance to transport motors of this size as the rules are different in the US and Canada.	Mitigate. Contingency money to be included. Contract includes financial incentives for not exceeding the 8 months overhaul window for each motor. Mitigate: Consider alternatives such as shipping these motors horizontally and add contingency for greater risk during winter season when road closures and maintenance can delay delivery between vendor and OPG.	High	Medium
Resources	There is a risk that the overhaul supplier shop floor may not be able to support an increased volume of motor overhauls to ensure motor availability for the scope. There is a risk that the supplier Design and Analysis department does not have good capability to reverse engineering capabilities and seek third party expertise as they have no previous experience in overhaul of similar size motors. There is a risk that vendor has no capabilities in the decontamination of these motors.	Mitigate: Contingency money to be included to support additional support for a second overhaul vendor to ensure motor overhaul schedules are met. Mitigate: Vendor selection to be monitored to ensure selected vendor has all required resources in place to overhaul these motors on time and provide required technical support during motors operation. Mitigate: Vendor selection to be monitored to ensure selected vendor has decontamination capabilities and experience.	High	Medium
Quality/ Performance	There is a risk that the quality of the overhaul will result in reduced efficiency of the motor as opposed to the OEM efficiency of 96.90% and have a financial impact.	Mitigate: Review proposed overhaul process to ensure efficiency of the motor requirement is met. OPG is looking for Performance liquidated damages with regards to efficiency. Note: Insulation selection (VIP vs hard wire) may impact on mitigation of this risk.	High	Medium
Technical	There is a risk that some parts are obsolete and replacement may require design modifications. This will increase the overhaul cost for each motor.	Mitigate: Use like-for-like replacements to reduce design modifications on each motor.	High	Medium

Additional Risk Analysis:

Type 3 Business Case Summary

Project #: Project #16-80144 Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

Part H: Post Implementation Review (PIR) Plan

Type of PIR Report	Target In-Service or Completion Date	Target PIR Completion Date
Comprehensive PIR	DEC - 2022	DEC - 2023

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Motor condition presents high risk to operations	Of 16 motors; 2 have been identified as having a very high risk of failure, 7 at high risk, and 6 motors at medium risk.	All 16 motors have low risk of failure	Partial discharge monitoring and ozone testing	Components Engineering
Motor efficiency	The existing motor design efficiency is 96.90%	The existing motor design efficiency is 96.90%	Acceptance testing	Components Engineering

Part I: Definitions and Acronyms

Type 3 Business Case Summary

Project #: Project #16-80144
Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

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Type 3 Business Case Summary

Project #: Project #16-80144 Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

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Type 3 Business Case Summary

Project #: Project #16-80144
Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

Appendix A: Summary of Estimate										
Project Number:	Project #16-80144									
Project Title:	DN PHT Pump Motor Replacement & Overhaul									
M$	LTD	2015	2016	2017	2018	2019	2020	Future	Total	%
OPG Project Management	-	0.3	0.2	0.2	0.2	0.2	0.2	0.4	1.7	2
OPG Engineering (Including Design)	-	-	0.1	0.1	0.1	0.2	0.2	0.4	1.1	1
OPG Procured Materials	-	-	0.1	0.1	0.1	0.2	0.2	0.4	1.1	1
OPG Other (Field Engineering, CMO, PCC)	-	-	0.4	0.4	0.4	0.4	0.4	0.8	2.8	3
Design Contract(s)	[redacted]									
Construction Contract(s)										
Traller Cost										
Consultants										
Overhaul Contracts/Costs										
Interest										
Subtotal										
Contingency										
Total	-	3.1	10.7	26.7	12.7	10.0	11.7	27.9	102.8	100

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Type 3 Business Case Summary

Project #: Project #16-80144
Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

Appendix A: Summary of Estimate										
Project Number:	10-73566									
Project Title:	DN PHT Pump Motor Replacement									
M$	**LTD**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Future**	**Total**	**%**
OPG Project Management	0.6	0.4	0.3	0.3	0.3	0.2	0.2	0.8	3.1	12
OPG Engineering (including Design)	-	0.2	0.1	0.1	0.1	0.1	0.1	0.4	1.1	4
OPG Procured Materials	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	1.1	4
OPG Other (Field Engineering, CMO, PCC)	-	0.4	0.3	0.4	0.4	0.2	0.2	0.8	2.3	9
Design Contract(s)	[redacted]									
Construction Contract(s)										
Trailer Cost										
Consultants										
Overhaul Contracts/Costs										
Interest										
Subtotal										
Contingency										
Total	1.8	5.3	1.9	4.3	2.3	2.0	2.3	6.8	26.7	100

Notes			
Project Start Date	JUN-2013	**Total Definition cost** (excludes unspent contingency for Nuclear)	[redacted]
Target In-Service (or AFS) Date	JUN-2022	**Contingency included in this BCS** (Nuclear only)	
Target Completion Date	DEC-2022	**Total contingency released plus contingency in this BCS** (Nuclear only)	
Escalation Rate	2.0%	**Total released plus this BCS without contingency** (Nuclear only)	
Interest Rate	5.0%	**Total released plus this BCS with contingency** (Nuclear only)	$13.3M
Removal Costs		**Estimate at Completion** (includes only spent contingency for Nuclear)	[redacted]

Prepared by:		Approved by:	
Simion Deju Project Manager Projects and Modifications	Date 2015-05-29	John Melmer Section Manager Projects and Modifications	Date 2015-05-29

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Type 3 Business Case Summary

Project #: Project #16-80144
Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

Appendix B: Comparison of Total Project Estimates and Project Variance Analysis

Comparison of Total Project Estimates

Phase	Release	Approval Date	Total Project Estimate in M$ (by year including contingency)						Future	Total Project Estimate
			2015	2016	2017	2018	2019	2020		
Execution	Partial	MAY 2015								

Project Variance Analysis

Choose an item.	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management					
OPG Engineering (including Design)					
OPG Procured Materials					
OPG Other					
Design Contract(s)					
Construction Contract(s)					
EPC Contract(s)					
Consultants					
Other Contracts/Costs					
Interest					
Subtotal					
Contingency					
Total					

Type 3 Business Case Summary

Project #: Project #16-80144 Document #: D-BCS-33130-00001 R000
Project Title: DN PHT Pump Motor Replacement & Overhaul, <Partial> <Execution> Release

Appendix C: Financial Evaluation Assumptions
Key assumptions used in the financial model of the Project are (complete relevant assumptions only):
Project Cost: 1. Replacement cost is the cost of replacing an existing PHT pump motor with a new one at an estimated cost of $6.4M as provided by OEM. 2. Overhaul cost is estimated at as $3.5M per motor. This is the closest cost to the third party estimate of $2,871,519 per motor. This is used to estimate funding required proceed with the first phase of the PHT motor overhaul and award a purchase order to overhaul PHT motors. 3. Transportation cost is estimated from $160,000 (in 2015) to $195,000 (in 2022) per trip. Container cost is estimated at $148,759.

Appendix D: References

ONTARIO POWER GENERATION

Records File Information:
Records SCI/USI Retention
- See Guidance Section

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Type 3 Business Case Summary

To be used for investments/projects meeting Type 3 criteria in OPG-STD-0076.

Executive Summary and Recommendations

Project Information			
Project #:	13-40976	**Document #:**	NK30-BCS-35300-00002
Project Title:	U58 Fuel Handling Reliability improvement Project		
Class:	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others:	**Investment Type:**	Sustaining
Phase:	Execution	**Release:**	Partial
Facility:	Pickering	**Target In-Service or Completion Date:**	2017-07-30

Project Overview

We recommend the release of additional $6,243k, including [redacted] of contingency.
Total release to date is $30,861k including [redacted]k of contingency.
The estimated total project cost is $37,256k including [redacted] of contingency.

The quality of the estimate for this release is Class 2, for the full project the quality of estimate is Class 2.

This release will fund the following scope of work:

- Completion of scope previously released:
  - Y-drive Interference removal/restoration
  - Y-drive train alignment to new design specification
  - Fuel Transfer Elevator system counterweight replacement
  - External design contract for Fuel Handling system modifications
  - Engineer-Procure-Construct contract for Fuel Transporter refurbishment – Engineering portion
- Start and complete the following new scope:
  - Installation of C-ram controller modification package
- Start the following new scope:
  - Partial installation of 90 degree modification package

Problem Statement/Business Need:

The original design requirement for Pickering Unit 5 to 8 Fuel Handling (FH) system availability was 70%, which was consistent with a design capacity factor of 80%. However due to changes in reactivity management procedures, the FH system availability target has been increased to 90%. Furthermore, the FH systems at Pickering station are approaching the end of their design lives, leading to reliability issues arising from significant component obsolescence and end-of-life challenges. FH parts are, in many instances, unique pieces of equipment from the Original Equipment Manufacturer (OEM) and there are no parts available for replacement or technical specifications available to procure.

This project is part of an overall system life management plan detailed in NK30-REP-35300-0441486 PNGS U 5-8 Equipment Reliability Recovery Plan – Fuel Handling that will ensure reliable operation of the FH systems to the end of their operational life. This project addresses performance issues through upgrades to address single points of vulnerability, replacement of obsolete components, and modifications to improve system reliability.

Summary of Preferred Alternative:

The preferred alternative is to replace and/or modify single point of vulnerability (SPV) and highly critical items (as identified by the Equipment Reliability Analysis Program), and replace obsolete equipment and implement modifications to improve the reliability of the FH systems.

*Associated with OPG-STD-0076, Developing and Documenting Business Cases

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Type 3 Business Case Summary

Project #: 13-40976
Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

Project Overview

History of BCS releases and project cost estimates:

Phase	Release	Date	Total Project Cost(k$)
Definition & Execution	Partial	August 2012	29,000
Definition & Execution	Partial	August 2013	29,000
Execution	Partial	March 2015	37,256

The estimated total cost (without contingency) has increased due to the following:

- Scope addition including FM 90 Degree Rotation upgrade, C-RAM Controller upgrade, and FT elevator counterweight replacement. Incremental cost $1,055k
- Additional project management cost for extended project life till 2017. Incremental cost $587k
- Additional engineering and material cost to address legacy design issues. Incremental cost $300k
- Additional OPG labour costs related to construction for multiple additional outages and design modification packages. Incremental cost $3,000k
- Additional construction contract costs for Y-drive interference removal, Y-drive alignment to design basis & multiple planned outages. Incremental cost $950k
- EPC contracts for modification work – Fuel transporter refurbishment modification. Incremental cost $1,500k
- Additional Interest burden for extended project life till 2017. Incremental cost $590k

History of scope and schedule changes:

Scope Additions:

- Installation of Fuelling Machine FM 90 Degree Rotation Upgrade. Incremental cost $900k
- Replacement of Fuelling Machine Magazine & C-RAM Controllers. Incremental cost $75k
- FT elevator counterweight replacement. Incremental cost $80k

Scope Removals:

- Remote Irradiated Fuel Bay water level monitoring modification. Associated reduction $400k
- FM Drain Line modification. Associated reduction $11k

The Project scope was not executed as planned during 2013 and 2014 planned outages due to insufficient outage window availability and material unavailability. The balance of the scope has been deferred for future planned unit outages and no-fuelling windows. Based on current scheduling estimates, all project scope execution will be complete by May 2017. As a result the project completion milestone is revised to November 2017 compared to December 2015 as per original BCS.

Key Assumptions and Risks:

Project execution schedule will be accommodated in planned outages and online no-fuelling windows through 2017.
Long lead materials will be available in time for planned execution.
Specialized OPG FH personnel and experienced execution resources are available.

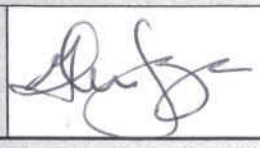
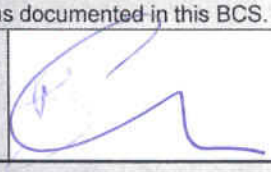
Project Cash Flows, NPV, and OAR Approval Amount

k$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	17,663	6,955						0	24,618
Requested Now	-	3,388	2,615	240				0	6,243
Future Required	-		3,942	2,453				0	6,395
Total Project Cost	17,663	10,343	6,557	2,693				0	37,256
Ongoing Costs	-	0	0	0	0	0	0	0	0
Grand Total	17,663	10,343	6,557	2,693				0	37,256

Estimate Class:	Class 2	**Estimate at Completion:**	[redacted]k
NPV:	NA	**OAR Approval Amount:**	$37,256k

Type 3 Business Case Summary

Project #: 13-40976
Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

Approvals			
	Signature	**Comments**	**Date**
The recommended alternative, including the identified ongoing costs, if any, represents the best option to meet the validated business need.			
Recommended by: Glenn Jager Chief Nuclear Officer		No further scope addition permitted	27 May 2015
I concur with the business decision as documented in this BCS.			
Finance Approval: Beth Summers Chief Financial Officer			12 JUNE/15.
I confirm that this project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.			
Approved by: Tom Mitchell President & CEO Per OAR 1.1			22 JUNE 15

ONTARIO POWER GENERATION

Records File Information:
Records SCI/USI Retention
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Type 3 Business Case Summary

Project #: 13-40976
Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

Business Case Summary

Part A: Business Need

The original design requirement for Fuel Handling (FH) system availability at Pickering Units 5 through 8 was 70%. This is consistent with a design capacity factor of 80%. However due to changes in reactivity management procedures the FH system availability target has been increased to 90%. The FH systems at Pickering station are approaching the end of their design life, leading to significant component obsolescence and reliability challenges. FH parts are, in many instances, unique pieces of equipment from the Original Equipment Manufacturer (OEM) and there are no replacement parts available or technical specifications available to procure.

These issues have the following impacts:

Forced Loss Rate (FLR): FH system failures can result in unit de-rating or shutdown, depending on the extent and time required for failure resolution. While reactivity deficits due to a lack of fuelling can be accommodated temporarily by withdrawing adjuster rods, Heat Transport System aging effects now mandate that Units 5 and 6 be de-rated when adjusters are withdrawn. Units 7 and 8 will also be subject to this as they approach their end of operational service. Failures also impact on the Reactivity Management Index targets.

Performance Improvement: An audit was performed and issues were identified by World Association of Nuclear Operators (WANO), Nuclear Safety Review Board and Self Assessments. Areas For Improvement (AFIs) pertaining to equipment reliability are identified and summarized along with action plans in Pickering WANO AFI status updates.

Nuclear Safety: FH equipment failures can represent a nuclear safety concern due to irradiated fuel either in the Fuelling Machine magazines with the Fuelling Machines locked on channel, or in inoperative fuel transfer system components. This challenges the ability of the FH systems to cool the fuel and prevent releases of radio nuclides.

Outage Campaigns: Continued Operations activities rely strongly on fuel channel inspections. F/Ms are in constant use during outages to support inspection campaigns which are usually critical path. Maintaining or bettering the critical path schedule during outages is vital to returning the units to service and resuming power production. Any FH system unavailability will have a direct and negative impact on critical path during these outages.

End of Commercial Operation: During the safe storage phase following the end of Pickering 5 to 8 commercial operation, the FH systems will be required to defuel the units and subsequently move the fuel into dry storage.

Part B: Preferred Alternative: Replace/Overhaul FH SPV equipment

Description of Preferred Alternative

The preferred alternative is to replace and/or modify SPV / High Critical items (as identified by the Equipment Reliability Analysis Program as per AP-913 guidelines) and replace obsolete equipment and implement modifications to improve the reliability of the FH systems. This includes the development of Engineering Changes, procurement of long lead material, and field execution. Scope of work includes units 5, 6, 7, 8, and 058:

Replacement of FM D2O/Oil Catenaries – all scope complete
Replacement of FM electrical cable harnesses – Unit 5 complete
Replacement of life expired FM bridge drive components
- Y-Drive speed reducer gear boxes – Units 6 and 8 complete
- Clutch & Brake for Y-Drive – Units 6 and 8 complete
- Mitre Boxes for Y-Drive (excluding valve room) – Units 6 and 8 complete

Ball Nuts & Thrust Bearing replacement
Replacement of obsolete instrumentation and control components
Process indication meters for FM/FT systems
Replacement of TM U/L RAM Advance & Retract Valves
Replacement of TM Level Lowering Valves
Replacement of Fuel Transfer Mechanism valves and traps
Replacement of 6 pumps motors 35390-PM1/PM2 (Only 1 pump to be replaced on unit 5 and unit 8)
Replacement of transfer mechanism and conveyor components
Conveyor Cart Overhaul and Replacement of wire rope cables – Units 5, 7, and 8 complete
Conveyor Ram replacements (-056 and -078)
Replacement/Refurbishment of FT components
FT Oil/D2O catenary hoses
FT cable harnesses
FT clutch & brake for Magazine drive

*Associated with OPG-STD-0076, Developing and Documenting Business Cases

Type 3 Business Case Summary

Project #: 13-40976 Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

Part B: Preferred Alternative: Replace/Overhaul FH SPV equipment

Description of Preferred Alternative

Elevator Assembly overhaul (excluding lower sprocket replacement) – Units 6, 7, and 8 complete
Overhaul of Rolling Shield mechanism
Engineering, Material procurement, and Construction for FH Modifications including:

- Irradiated Fuel Bay B sumps high level alarm switch modification (ECR 13155)
- Irradiated Fuel Bays lighting modification (ECR 17821)
- Fuel Transfer valve modification (ECR 16059)
- Fuelling Machine Y-drive filter element modification (ECR 17855)
- Fuelling Machine Bridge Trolley Platform Handrail modification (ECR 18550)
- Guide sleeve latch ring modification (ECR 22019)
- D2O sub-micron supply filter to Fueling Machine modification (ECR 21986)

B-RAM Oil Motor modification (ECR 16061)
Fuel Transporter modification
FM 90 Degree Rotation modification
C-RAM Controller modification

Deliverables:	Associated Milestones (if any):	Target Date:
Unit 6 Replacement/Overhaul (balance)	U6 Outage Installation complete	P1561
Unit 6 Modification Installation SOI	Unit 6 IOP No-Fuelling Window SOI	2016-06-30
Unit 7 Replacement/Overhaul (balance)	U7 Outage Installation complete	P1671
Unit 7 Modification Installation SOI	Unit 7 IOP No-Fuelling Window SOI	2016-06-30
Unit 8 Replacement/Overhaul (balance)	U8 Outage Installation complete	P1681
Unit 8 Modifications Installation SOI	Unit 8 IOP No-Fuelling Window SOI	2016-06-30
Unit 5 Replacement/Modifications (balance)	U5 Outage Installation complete	P1551
Unit 5 Modifications Installation SOI	Unit 5 IOP No-Fuelling Window SOI	2016-06-30
Detailed Engineering for FH Modifications	Detail Design Completion	2016-03-30
Unit 058 Modifications Installation SOI	Modifications Installation SOI	2016-06-30

Part C: Other Alternatives

Summarize all viable alternatives considered, including pros and cons, and associated risks. Other alternatives may include different means to meet the same business need, and a reduced or increased scope of work, etc.

Alternative 2: Base Case – No Project

Maintaining the status quo is not an acceptable option for the following reasons:

- FH Systems will continue to be a contributor to unit de-ratings and forced outages and result in large financial losses
- Considering component obsolescence and unavailability of spare parts, the probability of equipment failure will continue to increase within the intended station life
- Failures will continue to disrupt Outage critical path and IOP scheduled activities

With Fuel Handling equipment or system failures, there is an employee and public safety risk if irradiated fuel cannot be transferred to the appropriate location where adequate cooling is available.

Alternative 3: Delay Work – Project execution delayed for 2 years

This alternative does not satisfy the objectives of this project. Delays have already occurred that draw out the project timeline. Further delay is not recommended because:

- Delaying the project will impact key business production objectives with high probability of existing Fuel Handling system equipment failure

Type 3 Business Case Summary

Project #: 13-40976
Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

Alternative 3: Delay Work – Project execution delayed for 2 years
• Any cost savings would be offset by the increased risk and consequence of forced outages due to equipment failure
The delay period has a negative impact on the probability of aging equipment failure.

Part D: Project Cash Flows, NPV, and OAR Approval Amount

k$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	17,663	6,955						0	24,618
Requested Now	-	3,388	2,615	240					6,243
Future Required	-		3,942	2,453				0	6,395
Total Project Cost	17,663	10,343	6,557	2,693				0	37,256
Ongoing Costs	-	0	0	0	0	0	0	0	0
Grand Total	17,663	10,343	6,557	2,693				0	37,256

Estimate Class:	Class 2	**Estimate at Completion:**	[redacted]
NPV:	NA	**OAR Approval Amount:**	$37,256k

Part E: Financial Evaluation

k$	Preferred Alternative	Base Case	Delay Work	Alternative 4	Alternative 5
Project Cost	37,256	NA	39,142	-	-
NPV	NA	NA	NA	-	-
Other (e.g., IRR)					

Summary of Financial Model Key Assumptions or Key Findings:

Major scope execution to be complete by May 2017.
Design modification costs are estimated based on preliminary design details wherever design is not complete

Part F: Qualitative Factors

An audit was performed and issues were identified by World Association of Nuclear Operators (WANO), Nuclear Safety Review Board and Self Assessments. Areas For Improvement (AFIs) (P-2011-16413, P-2011-07217) pertaining to equipment reliability were identified and summarized along with an action plan in the Pickering 2012 WANO AFI status update. Reference NK30-REP-35300-0441486 (PNGS U 5-8 Equipment Reliability Recovery Plan – Fuel Handling). Investment in this project scope will address AFIs identified through the peer review.

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	There is a risk that cost may exceed estimated values. The cost estimate for FH system modification portion of this project is based on preliminary engineering assumptions. Overall costs of materials, engineering, and installation may vary based on detail design results.	Contingency is included to address overall costs of materials, engineering, and installation. To execute in IOP no-fuel windows, work will be scheduled to efficiently share resources with other vendor work to eliminate mobilizing/de-mobilizing costs.	Medium	Low
Scope	There is a risk that discovery field configuration issues may increase the	Fuel Handling group have reviewed the scope. Pre-installation walkdowns will	Medium	Low

Type 3 Business Case Summary

Project #: 13-40976 Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

Part G: Risk Assessment				
Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
	scope. The scope of this project is bound by the approved project charter.	be completed to anticipate and address configuration management or maintenance related issues and address outside project scope where practical. General contingency is included to address discovery issues that may arise during assessing and installation. OPEX and Lessons Learned from project scope completed to-date on other units have been reviewed included in planning documentation with sufficient time allocated to address all OPEX through the execution.		
Schedule	There is a schedule risk due to: a) The ability to complete the project scope in planned outages due to material unavailability. b) The ability to complete the required prerequisite work due to required no-fuel windows and specialized resource requirement. c) The ability to execute scope within the outage window is at risk due to limited work space, interferences with other work Vault and FM Service Room work in progress.	a) Supply Chain engaged and majority of material identified. Advanced funding obtained to initiate orders of long lead materials. Work that does not have materials on site for the required outage will have to be rescheduled to future planned outages or IOP no-fuelling windows where appropriate. b) Recovery Plan integral with the station FH Reliability plan and Reactivity Management Plan to schedule opportunity to complete project scope. c) Work closely with the Outage group and Fuel Handling to coordinate activities. The work is reviewed for assement durations and coordination. The Outage group to schedule the required windows.	Medium	High
Resources	There is a risk that dedicated resources not secured from OPG and external resources. Project & Modifictaions personnel are not experienced with specialized Fuel Handling equipment/components.	Use dedicated resources, augment staff where required and use overtime if necessary. Recovery Plan integral with the station FH Reliability plan prepared to ensure resources are balance and assigned to complete project scope. External engineering resources available to support incremental if required. Any resource issues will be escalated as required. Fuel Handling Technical and Assessing units will assist/consult the projects group to help build expertise. Contingency is included to address this risk.	Low	Low
Quality/ Performance	There is a risk that quality and performance of installed modifications	Use qualified and experienced vendors (ASL list) with access to quality	Medium	Low

Type 3 Business Case Summary

Project #: 13-40976 Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
	are not as expected. Issues may stem from quality of design, manufacturing, or installation.	manufacturing facilities. OEM supplier for critical components that may include failure mode and reliability testing. Quality oversight for installation phase by system and component maintainers in Fuel Handling and Engineering Lessons learned to be implemented in the planning phase preceding each execution.		
Technical Enterprise Risk	There is a risk that expected design parameters may not be achievable or system performance requirements cannot be met.	Station Engineering and FH department available to review and disposition or provide direction to anomolies found during commissioning and post maintenance testing. The rehabiliation scope is short-term replacing components with like-for-like replacements and improving efficiency through component upgrades/improvements without changing the system design basis. This is repeated from unit to unit. OPEX gathered from previous installation to improve efficiency of exectuion and minimize errors in execution are incorporated prior to subsequent executions. As a result, there is low impact on enterprise risk. General contingency used to address any technical support required above project scope.above project scope.	Medium	Low

Additional Risk Analysis:

None

Part H: Post Implementation Review (PIR) Plan

Type of PIR Report	Target In-Service or Completion Date	Target PIR Completion Date
Simplified PIR	2017-07-30	Dec 2017

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Forced loss rate due to equipment unavailability	YTD FLR 6.8 %	FLR < 1 %	FLR attributed to FH equipment failure related to project scope	Senior Manager Fuel Handling
FH equipment availability rate	88.5 %	>90 %	Percent of time the fuelling system is available to fuel/de fuel	Senior Manager Fuel Handling

Type 3 Business Case Summary

Project #: 13-40976
Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
			due to equipment failure related to project scope	

Part I: Definitions and Acronyms
AFI – Area For Improvement
FH – Fuel Handling
FT- Fuel Transfer
IFB-Irradiated fuel bay
FM – Fuelling Machines
OEM – Original Equipment Manufacturer
SPV – Single Point of Vulnerability
NFW- No Fuelling Window
WANO – World Association of Nuclear Operators

Type 3 Business Case Summary

Project #: 13-40976
Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

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Type 3 Business Case Summary

Project #: 13-40976
Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

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Type 3 Business Case Summary

Project #: 13-40976
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release
Document #: NK30-BCS-35300-00002

Appendix A: Summary of Estimate										
Project Number:	13-40976									
Project Title:	U58 Fuel Handling Reliability improvement Project									
k$	LTD	2015	2016	2017	2018	2019	2020	Future	Total	%
OPG Project Management	880	400	350	200	0	0	0	0	1,830	4.9
OPG Engineering (including Design)	605	150	190	50	0	0	0	0	845	2.7
OPG Procured Materials	3,356	4,200	1,250	350	0	0	0	0	9,156	24.6
OPG Other	5,566	250	200	150	0	0	0	0	6,166	16.5
Design Contract(s)	[redacted]									
Construction Contract(s)										
EPC Contract(s)										
Consultants										
Other Contracts/Costs										
Interest										
Subtotal										
Contingency										
Total	17,663	10,343	6,557	2,693	0	0	0	0	37,256	100

Notes			
Project Start Date	2012-08-15	**Total Definition cost** (excludes unspent contingency for Nuclear)	[redacted]
Target In-Service (or AFS) Date	2017-07-30	**Contingency included in this BCS** (Nuclear only)	
Target Completion Date	2017-11-30	**Total contingency released plus contingency in this BCS** (Nuclear only)	
Escalation Rate	2.5%	**Total released plus this BCS without contingency** (Nuclear only)	
Interest Rate	5%	**Total released plus this BCS with contingency** (Nuclear only)	$37,256k
Removal Costs	$0.0	**Estimate at Completion** (includes only spent contingency for Nuclear)	[redacted]

Prepared by:	Approved by:
Rathin Bagchi Sr. Technical Officer, Pickering Projects Date: March 11/2015	Nahil Rahman Director, Pickering Projects Date: 12 May 2015

Type 3 Business Case Summary

Project #: 13-40976
Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

Appendix B: Comparison of Total Project Estimates and Project Variance Analysis

Comparison of Total Project Estimates

Phase	Release	Approval Date	Total Project Estimate in k$ (by year including contingency)						Future	Total Project Estimate
			2012	2013	2014	2015	2016	2017		
Definition	Partial	2012-08-15	9,000	9,650	8,050	2,300	0	0	0	29,000
Execution	Partial	2013-07-30	1,970	7,935	8,630	10,108	357	0	0	29,000
Execution	Partial	2015-02-27	1,970	9,392	6,301	10,343	6,557	2,693	0	37,256

Project Variance Analysis

k$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management	880	1,243	1,830	587	Additional cost to manage the project for longer period than expected due to extension of project execution till 2017.
OPG Engineering (including Design)	605	905	995	90	Additional engineering cost for legacy design issues.
OPG Procured Materials	3,356	9,127	9,156	29	Present material cost estimate is higher than previous BCS estimate due to additional material cost to mitigate field discovery issues and FH modification packages.
OPG Other	5,566	2,895	6,166	3,271	OPG labour costs related to construction for multiple additional outages and design modification packages.
Design Contract(s)	[redacted]				
Construction Contract(s)					
EPC Contract(s)					
Consultants					
Other Contracts/Costs					
Interest					
Subtotal					
Contingency					
Total	17,663	29,000	37,256	8,256	

Type 3 Business Case Summary

Project #: 13-40976
Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

Type 3 Business Case Summary

Project #: 13-40976 Document #: NK30-BCS-35300-00002
Project Title: U58 Fuel Handling Reliability improvement Project, <Partial> <Execution> Release

Appendix C: Financial Evaluation Assumptions
Key assumptions used in the financial model of the Project are (complete relevant assumptions only):

Project Cost:

1 Future costs are estimated using the actual costs incurred for equivalent work in previous units.
2. Cost for the design modification scope is estimated from preliminary design details.

Financial:

1. Reduction in FLR contribution is assumed to be obtained in units 5-8 as a result of partial scope execution as of date.
2. It is assumed that the equipment will be placed in service immediately after the project scope execution is complete

Project Life:

1. Based on current assumptions all project scope execution will be complete by May 2017.

Operating Cost:

1. There will be no incremental operating costs arising from this project.

Appendix D: References
NK30-REP-35300-0441486(PNGS U5-8 Equipment Reliability recovery Plan-Fuel Handling)

ONTARIO POWER GENERATION

Business Case Summary - Routing

Fukushima Phase 2 Beyond Design Basis Event Emergency Mitigation (Capital) **13-41027/16-32202**

Name / Title / Phone	Location	Action	Signature	Date
Glenn Jager President, OPG Nuclear and Chief Nuclear Officer	P826FL A	Concur with BCS		30 JUL 2015
Dwight Zerkee Senior Manager, Investment Management	P823A6			4 Aug 15
Carla Carmichael VP Nuclear Finance	O11011			4/8/15
Beth Summers SVP and Chief Financial Officer	TCH19-F27	Approve BCS		7/8/2015
Tom Mitchell President and Chief Executive Officer	TCH19-A24	Approve BCS		AUG 8/15
Helen Kubalek Business Support Central Nuclear 702-4082	P82	Return for Distribution		

ONTARIO POWER GENERATION

Records File Information:
Records SCI/USI Retention
- See Guidance Section

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Type 3 Business Case Summary

'To be used for investments/projects meeting Type 3 criteria in OPG-STD-0076.'

Executive Summary and Recommendations

Project Information			
Project #:	13-41027 (Capital) 13-41028 (MFA) 16-32202 (Capital) 16-32204 (MFA)	**Document #:**	N-BCS-09013-10008
Project Title:	Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment		
Class:	☐ OM&A ☒ Capital ☐ Capital Spare ☒ MFA ☐ CMFA ☐ Provision ☐ Others:	**Investment Type:**	Regulatory
Phase:	Execution	**Release:**	Partial
Facility:	Pickering Nuclear Generating Station (PNGS) Darlington Nuclear Generating Station (DNGS)	**Target In-Service or Completion Date:**	15DEC2017

Project Overview

We recommend the release of $40,585k, including [redacted] of contingency to fund the capital part of this project. The Fukushima response projects also require a additional $3,250k in Minor Fixed Asset (MFA) funding release. We also recommend the approval of the write-down of $1,201k to OM&A resulting from the removal of the Darlington hydrogen igniter repowering from the scope of the project.

This Execution-Partial Release Business Case Summary (BCS) will bring the release-to-date to $58,208k including [redacted] contingency (Table 1). This is compared to the previous release of $17,623k, including [redacted] contingency. The MFA funding for the Fukushima Phase 2 response is now $15,928k compared to $12,678k in the previous release ($3,250k increase).

Table 1: Project Release Summary

RELEASE-TO-DATE (k$)			
k$	**Pickering**	**Darlington**	**Release Total**
Capital	[redacted]		
MFA			
Subtotal			
Capital Contingency			
MFA Contingency			
Contingency*			
Total Capital	**31,627**	**26,581**	**58,208**
Total Release (including MFA)	**45,450**	**28,686**	**74,136**

Available for Service (AFS) for all modifications is planned by December 2017. The estimated total project budget is $74,325k including [redacted] contingency (Table 2) for the capital scope.

Table 2: Overall Project Summary

Project Cost (k$)			
k$	**Pickering**	**Darlington**	**Project Total**
Capital	[redacted]		
MFA			
Subtotal			
Capital Contingency			
MFA Contingency			
Contingency*			
Total Project Cost (Capital)	**46,302**	**28,023**	**74,325**
Total Project Cost (incl. MFA)	**60,125**	**30,128**	**90,253**

(*) Contingencies noted in Tables 1 and 2 above include both general and specific. See Appendix C for details.

*Associated with OPG-STD-0076, Developing and Documenting Business Cases

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Project Overview

Problem Statement/Business Need:

As a result of the event at the Fukushima Daiichi Nuclear Power Plant on March 11, 2011 and at the direction of the Canadian Nuclear Safety Commission (CNSC), Canadian Nuclear Power Plant operators undertook reviews which have confirmed the safety of the OPG Nuclear Fleet for all design basis events.

The bounding scenario for a Beyond Design Basis Event (BDBE) has been defined by OPG and its industry partners as a sustained and total loss of AC power with degraded site access and consequential loss of heat sinks resulting from the coincident failure of the Hydro One electrical system and the loss of existing standby and emergency generators at the nuclear stations. This approach is consistent with what has already been implemented/ planned by other Canadian nuclear utilities and nuclear operators in the United States.

In response to the CNSC Fukushima Action Items (FAI), OPG has undertaken actions to improve the capability to respond to a very low probability BDBE.

The immediate initial response to halt progression of an event and ensure cooling of the reactor core is addressed under the Phase 1 project.

The business objective of the Fukushima Phase 2 project is to protect containment and provide core cooling after 72 hours. This will be achieved by providing capability to maintain the Moderator System as a heat sink, containment pressure control and recovery of water inside containment as well as long term monitoring for BDBE conditions. The Phase 2 scope also allows for protection of containment for a BDBE that proceeds to a severe accident within the 72 hour period.

The Phase II business objective is achieved by:

- Acquiring new Emergency Mitigating Equipment (EME) which includes portable diesel-driven generators, equipment to connect to station systems, fuelling equipment and compressors to support the mitigation activities.
- Providing procedures as well as system, structure and component modifications to support mitigation.
- Completing a review of all plant equipment used in BDBE response for hazard robustness and operability under BDBE response conditions.

The scope and cost of the project has evolved in parallel with the lessons learned from the Fukushima event and the industry response to said event. The initial release scope was primarily a rapid response effort to the emergent issues raised by the Fukushima event. Since that initial release, the scope and cost of the project has evolved to reflect the lessons learned at Fukushima and align with developing industry practices for BDBE response. Areas where this has contributed to additional scope and cost from the original release include:

- Evolution of the required electrical loads to be supported in Phase 2 and rationalization of the load list to support generation of a practically deployable size and cost.
- Higher than anticipated costs for switchgear and test equipment cost.
- Functionality review scope which includes identification or generation of robustness assessments for all equipment used in the BDBE response (Phase 1 and 2) and functionality assessments of equipment to be operated under a BDBE response.
- Additional scope to address refuelling requirements for EME equipment.
- Refinement of scope resulting from preliminary engineering.
- Significant fluctuations in US/CDN exchange rates.
- Removal of the hydrogen igniter scope at Darlington.

This evolution in scope is the basis for the overall estimate quality of Class 4. Design is not yet complete for several items, and several items including the functionality reviews and fuelling study are in a conceptual phase.

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Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Project Cash Flows

k$	LTD	2015	2016	2017	2018	2019	Future	Total
Currently Released	7,015	9,016	1,592	-	-			17,623
Requested Now		8,561	29,301	2,713	10			40,585
Future Required		-	3,357	11,835	925			16,117
Total Project Cost	7,015	17,577	34,250	14,548	935			74,325
MFA		4,919	9,228	1,781	-			15,928
Ongoing Costs		80	60	160	194	194	3,447	4,135
Inventory - Spares		20	40	40	6	6	153	265
Grand Total	7,015	22,596	43,578	16,529	1,135	200	3,600	94,653

Estimate Class:	Class 4	**Estimate at Completion:**	[redacted]
NPV:	N/A	**OAR Approval Amount:**	94,653

Additional Information on Project Cash Flows (optional):

- Requested Now includes $20,434k for PNGS (including [redacted] contingency) and $20,151k for DNGS (including [redacted] contingency). In Appendix A, a breakout of PNGS and DNGS Project Cash Flows is shown.
- Ongoing Costs are the incremental OM&A costs to support EME operation, testing and maintenance. Ongoing Costs from 2015 to 2062 are included in this table.
- NPV is not applicable as this is a Regulatory Project.

Approvals

	Signature	Comments	Date
The recommended alternative, including the identified ongoing costs, if any, represents the best option to meet the validated business need.			
Recommended by (Project Sponsor): Glenn Jager President, OPG Nuclear Chief Nuclear Officer Project Sponsor			30 JUL 2015
I concur with the business decision as documented in this BCS.			
Finance Approval: Beth Summers SVP & Chief Financial Officer per OPG-STD-0076			August 7, 2015
I confirm that this project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.			
Approved by: Tom Mitchell President & CEO per OAR 1.1			8 AUG 2015

ONTARIO POWER GENERATION

Records File Information:
Records SCI/USI Retention
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Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Business Case Summary

Part A: Business Need

As a result of the event at the Fukushima Daiichi Nuclear Power Plant on March 11, 2011 and at the direction of the Canadian Nuclear Safety Commission (CNSC), Canadian Nuclear Power Plant operators undertook reviews which have confirmed the safety of the OPG Nuclear Fleet for all design basis events.

OPG has also undertaken actions which will address conditions for beyond design basis events (BDBE) equivalent to those which occurred at Fukushima, in response to the CNSC FAIs. OPG and industry partners have developed a "bounding scenario" to assess overall station robustness against BDBE, which has been defined as a sustained and total loss of AC power with degraded site access and consequential loss of heat sinks which could lead to severe fuel damage. This event would require coincident failure of the Hydro One electrical system and the loss of existing standby and emergency generators at the nuclear stations.

OPG's strategic decision to manage this very low probability event is to secure portable emergency mitigation equipment (EME) to provide alternative means of supplying make-up cooling water to steam generators, heat transport systems, moderator systems, and irradiated fuel bays. The EME would also power the secondary control area and shutdown system room panels to maintain monitoring of critical safety parameters. This approach is consistent with what has already been implemented/ planned by other Canadian nuclear utilities and nuclear operators in the United States.

The Fukushima Phase 1 project, addresses the PNGS and DNGS station response for a BDBE to cool the core using onsite resources for the first 72 hours. The Phase 2 Fukushima project addresses progression to a more severe event, protecting containment and managing water inventory through the recovery of existing systems, structures and components. Protection of containment is achieved by providing heat sinks (containment air conditioning units) to minimize the energy (heat and pressure) within containment and manage water inventory. Water levels in containment pose a risk to the containment structure that must be mitigated to preclude failure.

Part B: Preferred Alternative

Description of Preferred Alternative: Install Permanent Quick-Connection Points for the Acquired EME to Power EPS/Hydrogen Igniters, Provide Portable Air Supply for Airlock Seal Integrity, Provide Additional Monitoring Capability and Procurement of Additional EME; Remove Hydrogen Igniter scope from Darlington

PNGS Proposal

The Pickering Phase II project is broken-up into the following:

Electrical Power Restoration: Deploy power supplies via trailer mounted diesel generators to restore critical Emergency Power System (EPS) loads on Units 5-8 and critical class II and III loads on Units 1-4, including preparation of generator storage area with shore power. Preliminary design for permanent modifications in the protected area was completed by OPG.

Repower Hydrogen Igniters: Provide an alternative means to power existing hydrogen igniters after a BDBE, because P5-8 existing Class II power source is not considered available post BDBE and is not picked up by the restoration of EPS.

Airlock Seal Integrity: Provide a portable solution to allow connection of the emergency air bottles, stored permanently, directly to the seals, thus bypassing the air supply system and diminishing most of the leaks. Long term air supply will be achieved by replacing these bottles.

Additional Monitoring Capability: Provide additional portable monitoring capability following a BDBE where required.

Repower Main Volume Vacuum Pumps: Provide portable (Cat 4) solution to power the Main Volume Vacuum Pumps to support Filtered Air Discharge System operation.

Phase II Fuelling Strategy: Assess and develop modifications, processes, methods and procedures to meet BDBE equipment fuelling requirements.

Functionality Gap Assessment: Provide a comprehensive gap report to validate that each modification flow path (system interface) satisfies functional and Review Level Condition requirements. Resolution of gaps is limited to the specific contingency provision as related to the bounded modification requirements. Existing station deficiencies outside the bounds of the respective BDBE modification requirements are excluded.

Additional Emergency Mitigating Equipment (EME): Support emergency power restoration, airlock seal compressors and diesel fuelling activities.

*Associated with OPG-STD-0076, Developing and Documenting Business Cases

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Part B: Preferred Alternative
Description of Preferred Alternative: Install Permanent Quick-Connection Points for the Acquired EME to Power EPS/Hydrogen Igniters, Provide Portable Air Supply for Airlock Seal Integrity, Provide Additional Monitoring Capability and Procurement of Additional EME; Remove Hydrogen Igniter scope from Darlington
DNGS Proposal The Darlington Phase II project is broken-up into the following: **Electrical Power Restoration:** Deploy power supplies via trailer mounted diesel generators to restore critical Emergency Power System (EPS) loads on Units 5-8 and critical class II and III loads on Units 1-4, including preparation of generator storage area with shore power. Preliminary design for permanent modifications in the protected area was completed by OPG. **Airlock Seal Integrity:** Provide a portable air supply to maintain airlock seal integrity following a BDBE. The selected option is deployment of diesel air compressors and airlines. **Additional Monitoring Capability:** Provide additional portable monitoring capability following a BDBE where required. **IFB Ventilation:** Provide a deployable, post BDBE ventilation capability in the Irradiated Fuel Bays (IFB's). Long term post BDBE decay heat removal from the IFBs is via boiling and water makeup. Ventilation will control H2 hazards and limit steam migration to other areas of the plant. **Phase II Fuelling Strategy:** Assess and develop modifications, processes, methods and procedures to meet BDBE equipment fuelling requirements. **Functionality Gap Assessment:** Provide a comprehensive gap report to validate that each modification flow path (system interface) satisfies functional and Review Level Condition (RLC) requirements. Resolution of gaps from this assessment is limited to the specific contingency provision as related to the bounded modification requirements. Existing station deficiencies outside the bounds of the respective BDBE modification requirements are excluded. **Additional Emergency Mitigating Equipment (EME):** EME to support emergency power restoration, airlock seal compressors and diesel fuelling activities. **Repower Hydrogen Igniters:** This modification has been removed from scope at Darlington. The $1,201k expended to date on this scope will be written off to OM&A.

Part C: Other Alternatives
Alternative 1: Do Nothing
This is not an option as Fukushima Phase II is a Regulatory Management action.
Alternative 2: Delay Work
This is not an option as OPG has determined that currently, there is insufficient capability at both PNGS and DNGS to address BDBE situations. The work is also required for support of continued operation of Pickering NGS and long term operation of Darlington NGS.
Alternative 3: N/A
N/A
Alternative 4: N/A
N/A
Alternative 5: N/A
N/A

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Part D: Project Cash Flows, NPV, and OAR Approval Amount

k$	LTD	2015	2016	2017	2018	2019	Future	Total
Currently Released	7,015	9,016	1,592	-	-			17,623
Requested Now		8,561	29,301	2,713	10			40,585
Future Required		-	3,357	11,835	925			16,117
Total Project Cost	7,015	17,577	34,250	14,548	935			74,325
MFA		4,919	9,228	1,781	-			15,928
Ongoing Costs		80	60	160	194	194	3,447	4,135
Inventory - Spares		20	40	40	6	6	153	265
Grand Total	7,015	22,596	43,578	16,529	1,135	200	3,600	94,653

Estimate Class:	Class 4	**Estimate at Completion:**	[redacted]
NPV:	N/A	**OAR Approval Amount:**	94,653

Additional Information on Project Cash Flows (optional):

- Requested Now includes $20,434k for PNGS (including [redacted] contingency) and $20,151k for DNGS (including [redacted] contingency). In Appendix A, a breakout of PNGS and DNGS Project Cash Flows is shown.
- Ongoing Costs are the incremental OM&A costs to support EME operation, testing and maintenance. Ongoing Costs from 2015 to 2062 are included in this table.
- NPV is not applicable as this is a Regulatory Project.

Part E: Financial Evaluation

k$	Preferred Alternative	Base Case	Delay Work	Alternative 4	Alternative 5
Project Cost	74,325	N/A	N/A	>$500,000	
NPV	N/A	N/A	N/A	N/A	
Other (e.g., IRR)					

Summary of Financial Model Key Assumptions or Key Findings:

NPV is not applicable as this is a regulatory project.

Part F: Qualitative Factors

Regulatory: The initial qualitative factor will be to meet OPG actions undertaken as part of the Fukushima Action Items which have been submitted to the regulator proactively in order to circumvent a regulatory order.

Community Relations: Project demonstrates to the public that OPG is applying lessons learned from the Fukushima event in a timely manner.

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	1. Cost growth due to refinement of industry, regulatory and station approaches to BDBE response. 2. Incomplete design packages at time of estimate may result in cost increase. 3. Exchange rate fluctuations impacting ES-MSA labour and major equipment cost.	1. Accept – General Contingency included 2. Accept – General Contingency included 3. Accept – Contingency included	Medium	Medium
Scope	1. As a result of system functionality gap assessment, additional scope not covered in this BCS may result. 2. Assumptions to employ Category 4 modification process (non-ECC) may become invalid as engineering progresses, resulting in scope growth to follow ECC process instead. 3. Scope for some modifications has limited definition, which may lead to significant EPC contract changes.	1. Accept – process scope change as required. Specific contingency carried [redacted] 2. Mitigate – Challenge engineering to develop Cat. 4 solutions, and coordinate with stakeholders to ensure acceptability. 3. Accept – General Contingency included	Low	High
Schedule	1. The IOP and outage prerequisite milestones for the implementation of the modifications may be difficult to meet. 2. Modifications may affect critical plant systems and assumed installation windows, including access to outage windows, are subject to change.	1. Mitigate – Identify and co-ordinate with work management early, agreeing on recovery plans where non-compliant with N-PROC-MA-0013 and N-PROC-MA-0022. 2. Mitigate – develop designs that are likely to be non-critical path outage work or IOP.	Medium	Medium
	3. Darlington will have to execute isolations for EPS Bus tie ins as well as ESW header modifications during VBO outage in 2015.	3. Mitigate – This work is planned, assessed and accepted in the 2015 VBO. Scope performed in VBO has been minimised.		
	4. All installation work planned for 2015 at DNGS will compete for station and vendor support with the 2015 VBO. VBO has recently been rescheduled to late 2015. Ability to schedule field work in this period is at risk. (DN only)	4. Mitigate – non-Vacuum Building Outage (VBO) installations have not been committed for 2015. Where feasible, initial unit installations will be initiated in late 2015.(DN Only)		
	5. Several designs require EPS power supplies. Access for tie-ins to these supplies may significantly impact installation schedules where conflicts with other station work or conditions arise. This has already	5. Mitigate – Close coordination with the station work management and/or work control to minimize risk.		

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
	had significant impacts on the EPS Phase I modifications.			
	6. Late design completion for Electrical Power Restoration Unit 4 work may lead to de-scoping from P1641 outage schedule.	6. Mitigate -- Close coordination with the EPC vendor and Design during design process to expedite completion and prepare recovery plans for work management as required to inject work into scope.		
	7. Hydrogen Igniters implementation may require an outage depending on final design. (PN)	7. Mitigate – Close coordination with the EPC vendor and Design during design process to determine if outage is required, and scope work into outages early with formal change process (PN)		
Resources	Availability of contract/Project Design /Design Projects resources during ECC process and contract interface requirements due to large volume of vendor submissions.	Mitigation – EPC schedule to incorporate staggered reviews where possible to minimize OPG work group resources. Internal design resources are utilized to mitigate the impact on the schedule.	Low	Medium
Quality/ Performance	The large volume of work and compressed schedule may affect the work quality and may require rework	Mitigation – OPG Oversight Plan will include activities to prevent/reduce quality issues. Where feasible, this release brings implementation schedules in line with station online and outage planning timelines to reduce compression.	Low	Medium
Technical	1. BDBE response is a relatively new undertaking in the industry. Evolution of industry practices and standards around BDBE response may obsolete or lead to changes in current plans.	1. Mitigate – Direct working relationship with industry through Fukushima Oversight Group, regulator, and national and international standards organizations to manage change.	Medium	Medium
	2. Outcome of Probabilistic Risk Assessment (PRA) reviews may add new requirements for deployment time of EME equipment and impact design (may also impact scope above).	2. Accept – Contingency identified to address potential addition to project scope		

Additional Risk Analysis:

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Part H: Post Implementation Review (PIR) Plan

Type of PIR Report	Target In-Service or Completion Date	Target PIR Completion Date
Comprehensive PIR	2017-11-15	2018-10-15

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
CNSC Regulatory approval/acceptance	Fukushima Actions Items (FAIs) 1.3.1 and 1.3.2	Completed FAIs	FAI closure.	Regulatory Affairs
Emergency Response Capability for Electrical Power Restoration Emergency Response Capability for Portable Air Supply to Maintain Airlock Seal Integrity	No initial capability	Demonstrate deployment and simulated hookup of EME to required systems. Target of < 24 hours.	BDB Drill with EME deployment and simulated connection performed and evaluated.	Manager, Emergency Preparedness
Additional monitoring for Severe Accident	No initial capability	Demonstrate deployment and simulated hookup of EME to required systems. Target of 4 hours after request for deployment.	BDBE Drill with EME deployment and simulated connection performed and evaluated.	Manager, Emergency Preparedness
Electrical Power Restoration Generators Storage Area in Service	No initial storage area	Storage area available and in service	Available for Service Issued	Manager, Facilities
Functionality Review	Existing documentation or new documentation for BDBE to be reviewed for applicability	Documented review and assessment	Accepted report	Manager, Projects Design
Fuelling Capability	Phase I Fuelling capability exists.	Sustained fuelling capability for Phase II deployment.	Fuelling equipment test results accepted	Manager, Emergency Preparedness

Part I: Definitions and Acronyms

BDBE – Beyond Design Basis Event
BDB Drill – Beyond Design Basis Drill
EME – Emergency Mitigation Equipment
EPR-- Emergency Power Restoration
EPC – Engineering, Procurement and Construction
ERT – Emergency Response Team
ESW – Emergency Service Water System
EWS – Emergency Water System
FAI – Fukushima Action Item
OPEX – Operating Experience
RLE – Review Level Earthquake

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Part I: Definitions and Acronyms
SCO – Station Containment Outage

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Type 3 Business Case Summary

Project #:	13-41027 (Capital) 13-41028 (MFA) 16-32202 (Capital) 16-32204 (MFA)	Document #: N-BCS-09013-10008
Project Title:	Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release	

For Internal Project Cost Control

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Attachment A: Pickering Phase II Deliverables	
Previous BCS Deliverables	**Status**
(1) Provide Emergency Power Restoration (including DG Storage)	Detailed design release I Q4 2014. Major equipment procurement in progress. Final Design in progress based on equipment selection. Installation activities in 2016.
(2) Maintain Airlock Seal Integrity	Design in progress, target to complete Q1 2016
(3) Additional Portable Instrument Monitoring	Design in progress, target to complete Q4 2015
(4) Hydrogen Igniters	Design in progress, target to complete Q1 2016
(5) Repower Main Volume Vacuum Pumps	Design in progress, target to complete Q2 2016
(6) Perform functionality and preventative maintenance assessment	Design in progress, target to complete Q2 2016
(7) Provide equipment location identification, labeling and tagging	In progress

Attachment A: Darlington Phase II Deliverables	
Deliverables	**Status**
(1) Repower the emergency power system (EPS) through either odd or even connection with sufficient capacity to support defined loads	Detailed design release 1 Q4 2014 Major equipment procurement in progress Final Design in progress based on equipment selection Installation activities in 2017
(2) Maintain Airlock Seals	Design Complete AFS in Q2 2016
(3) Additional Portable Monitoring	Design in comments and dispositions Implementation Q1/2 2016
(4) Repower H2 Igniters	Cancelled
(5) IFB Ventilation	Design In progress
(6) Functionality Review	Definition Phase Initial ES-MSA Quote received Based on N-CORR-09013-0512222
(7) Fuelling Review	Definition Phase
(8) Additional EME	Major equipment for EPS restoration Airlock seals identified MFA procurement in progress Capital items pending funding release

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Deliverables:	Associated Milestones	Target Date:
PNGS (Current Release)		
Outage Design Completed-Electrical Power Restoration (U4)	Engineering Complete (ECP)	20-Dec-15
Outage AFS-Electrical Power Restoration (U4)	Available for Service (AFS)	P1641
IOP Detailed Engineering Completed-Electrical Power Restoration	Engineering Complete (ECP)	26-May-16
IOP Detailed Engineering Completed-Additional Monitoring Capability	Engineering Complete (ECP)	21-Sep-15
IOP Detailed Engineering Completed-Airlock Seal Integrity	Engineering Complete (ECP)	19-Mar-16
IOP Detailed Engineering Completed-Hydrogen Igniters	Engineering Complete (ECP)	30-Mar-16
Detailed Engineering Complete - Repower Main Volume Vacuum Pumps (CAT 4)	Engineering Complete (ECP)	29-Mar-16
Detailed Engineering Complete - Functionality Assessments	Engineering Complete (ECP)	29-Apr-16
Detailed Engineering Complete - PM Evaluation for Flow Path Components	Engineering Complete (ECP)	29-Apr-16
PNGS Future Release (not covered by this release)		
IOP AFS Completed-Electrical Power Restoration	Available for Service (AFS)	15-May-17
IOP AFS Completed-Additional Monitoring Capability	Available for Service (AFS)	28-Jul-17
IOP AFS Completed-Airlock Seal Integrity	Available for Service (AFS)	14-Jul-17
IOP AFS Completed-Hydrogen Igniters	Available for Service (AFS)	23-Jun-17

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Deliverables:	Associated Milestones	Target Date:
DNGS (Current Release)		
Portable Monitoring	Engineering Complete (ECP)	Nov 30, 2015
IFB Ventilation	Engineering Complete (ECP)	Nov 20,2015
Design complete EPS Phase II Restoration	Engineering Complete (ECP)	July 30,2016
Airlocks	Available for Service (AFS)	Jun 30,2016
Portable transmitters	Available for Service (AFS)	Jun 30,2016
IFB Ventilation	Available for Service (AFS)	Nov 30,2016
DNGS Future Release (not covered by this release)		
EPS II	Available for Service (AFS)	Nov 30,2017
Phase II Fuelling	Available for Service (AFS)	Dec 15,2017
Station Assessment Review	Engineering Complete (ECP)	Jan 15,2017
Project Closeout	Project Closeout (PCO)	Oct 15,2018

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Appendix A: Pickering and Darlington Fukushima Phase II Projects Summary (Capital)									
Project Number:	13-41027 (PNGS) and 16-32202 (Capital) 16-32204 (MFA)								
Project Title:	Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment								
k$	LTD	2015	2016	2017	2018	2019	Future	Total	%
OPG Project Management	656	706	900	455	361			3,078	4%
OPG Eng. & Support	1,937	698	1,109	450	240			4,434	6%
EPC Contract(s)	[redacted]								
Materials (OPG)									
Other Contracts/Costs									
Interest									
Subtotal									
Contingency									
Total	7,015	17,577	34,250	14,548	935			74,325	100%
Inventory - Spares		20	40	40	6	6	153	265	-

Appendix A: Pickering and Darlington Fukushima Phase II MFA Projects Summary									
Project Number:	13-41028 (PNGS) and 16-32204 (DNGS)								
Project Title:	Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment								
k$	LTD	2015	2016	2017	2018	2019	Future	Total	%
MFA		4,919	9,228	1,781				15,928	100%
Subtotal		4,919	9,228	1,781				15,928	100%
Contingency		-	-	-				-	0%
Total		4,919	9,228	1,781				15,928	100%
Removal Costs Included		-	-	-	-	-	-		

Appendix A: Summary of Estimate – Pickering Capital									
Project Number:	13-41027								
Project Title:	Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment								
k$	LTD	2015	2016	2017	2018	2019	Future	Total	%
OPG Project Management	320	333	599	451	361			2,064	4%
OPG Eng. & Support	948	441	896	450	240			2,975	6%
EPC Contract(s)	[redacted]								
Materials (OPG)									
Other Contracts/Costs									
Interest									
Subtotal									
Contingency									
Total	3,494	10,855	20,412	10,606	935			46,302	100%
Inventory - Spares	-	10	20	20	3	3	24	80	-

Appendix A: Summary of Estimate – Pickering MFA									
Project Number:	13-41028								
Project Title:	Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment								
k$	LTD	2015	2016	2017	2018	2019	Future	Total	%
MFA		4,919	7,123	1,781				13,823	100%
Subtotal		4,919	7,123	1,781				13,823	100%
Contingency		-	-	-				-	0%
Total		4,919	7,123	1,781				13,823	100%
Removal Costs Included									

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Appendix A: Summary of Estimate – Darlington Capital									
Project Number:	16-32202								
Project Title:	Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment								
k$	LTD	2015	2016	2017	2018	2019	Future	Total	%
OPG Project Management	336	373	301	4				1,014	4%
OPG Eng. & Support	989	257	213	-				1,459	5%
EPC Contract(s)	[redacted]								
Materials (OPG)									
Other Contracts/Costs									
Interest									
Subtotal									
Contingency									
Total	3,521	6,722	13,838	3,942				28,023	100%
Inventory - Spares	-	10	20	20	3	3	129	185	-

Appendix A: Summary of Estimate – Darlington MFA									
Project Number:	16-32204								
Project Title:	Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment								
k$	LTD	2015	2016	2017	2018	2019	Future	Total	%
MFA			2,105					2,105	100%
Subtotal			2,105					2,105	100%
Contingency			-					-	0%
Total			2,105					2,105	100%
Removal Costs Included									

Project # Description [$k]	Previous Release			Requested Now			Released-to-date		
	Base Cost	Contingency	Total	Base Cost	Contingency	Total	Base Cost	Contingency	Total
13-41207: Pickering	[redacted]		11,193	[redacted]		20,434	[redacted]		31,627
13-41208: Pickering MFA			6,678			7,145			13,823
Pickering Grand Total			17,871			27,579			45,450
16-31508: Darlington Capital			6,430			20,151			26,581
16-31510: Darlington MFA			6,000			-3,895			2,105
Darlington Grand Total			12,430			16,256			28,686
TOTAL (Capital)			17,623			40,585			58,208
GRAND TOTAL			30,301			43,835			74,136

**Note: 3,322k contingency was released for Pickering via 41027-PCRAF-002 (March 2015)*

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Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Notes			
Project Start Date	2012-11-15	Total Definition cost (excludes unspent contingency for Nuclear)	[redacted]
Target In-Service (or AFS) Date	2017-12-15	Contingency included in this BCS (Nuclear only)	
Target Completion Date	2018-12-15	Total contingency released plus contingency in this BCS (Nuclear only)	
Escalation Rate	3.00%	Total released plus this BCS without contingency (Nuclear only)	
Interest Rate	5.00%	Total released plus this BCS with contingency (Nuclear only)	$58,208k
Removal Costs	-	Estimate at Completion (includes only spent contingency for Nuclear)	[redacted]

Prepared by:	Approved by:
Ahmed Smaili Section Manager, Projects	28 Jul 2015 Nahil Rahman Director, Pickering Projects
Brian Graham Section Manager, Projects	27/7/2015 Ray Balachorek Manager, Design Projects

Appendix B: Comparison of Total Project Estimates and Project Variance Analysis

Comparison of Total Project Estimates

Phase	Release	Approval Date	Total Project Estimate in k$ (by year including contingency)						Future	Total Project Estimate
			2012-14	2015	2016	2017	2018	2019		
Definition	Full	9/13/2011	31,336	8,116	504	-	-			39,956
Definition/ Execution	Partial	11/11/2013	30,301	15,824	2,617	3,188	3,000			54,930
Execution	Partial	This BCS	7,015	22,496	43,478	16,329	935			90,253

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Project Variance Analysis (PNGS)

k$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management	320	2,366	2,064	-302	
OPG Eng. & Support	948	909	2,975	2,066	Increased OPG Oversight due to added scope
EPC Contract(s)	[redacted]				
Materials (OPG)					
Other Contracts/Costs					
Interest					
Subtotal					
Specific Contingency					
General Contingency					
Total	3,494	23,484	46,302	22,818	
MFA	-	6,678	13,823	7,145	Additional EME equipment required than originally planned (generators, vehicles, etc.) and reflective of increased modification scope.
Grand Total	3,494	30,162	48,074	17,912	

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Project Variance Analysis DNGS (16-32202, 16-32204)					
k$	LTD*	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management	336	749	1,014	265	Increased duration, scope definition issues. Additional scope.
OPG Eng. & Support	989	1,081	1,459	378	Increased duration, scope definition issues. Additional scope.
EPC Contract(s)	[redacted]				
Materials (OPG)					
Other					
Interest					
Subtotal					
Specific Contingency					
General Contingency					
Total	3,521	18,766	28,023	9,257	
MFA	-	6,000	2,105	-3,895	Cancellation of DNGS specific generators, cost, addition of portable switchgear and provision for additional fuelling equipment.
Grand Total	3,521	24,766	30,128	5,362	

*Approximate to 2014 year end.

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Appendix C: Financial Evaluation Assumptions

Key assumptions used in the financial model of the Project are (complete relevant assumptions only):

Project Life:

1. PNGS: 6 years through 2021
2. DNGS: 45 years through 2055

Note: A reduced scope of this project will be required for approximately an additional 7 years until remaining fuel is removed from each IFB

Energy Production:

1. Modifications are planned to be implemented within current outage windows, no outage extensions anticipated to install modification on outage units

Operating Cost:

1. Ongoing Incremental OM&A Costs: The real (2015$) estimate for future ongoing incremental OM&A costs is approximately $4,400 k. The assumption for ongoing cost is based on DNGS project life above plus 7 years for fuel bay support to 2062. The DNGS spare parts cost carries the same assumption. The assumption for spare parts is PNGS end of operations in 2021 plus 7 years for fuel bay support. Upon completion of all design packages, an improved quality estimate for spare parts will be generated for subsequent business cases.

Other:

PNGS Contingency:

The following is a breakdown of the contingency included within this BCS:

1.) General contingency at [redacted] of forward costs
2.) [redacted] for Functionality Gap resolution to address any issues found from the Functionality Gap assessment.
3.) [redacted] for main volume vacuum pump change to permanent modification from Cat 4.
4.) [redacted] to cover uncertainty on EPR cable routing on P1-4 CL3 BUS.
5.) [redacted] capture estimate uncertainty on EPR procurement and construction, given limited design information available.

DNGS Contingency:

1.) General contingency at [redacted] of forward costs
2.) A special contingency of [redacted] capital has been added for the USD exchange risk on material and ES-MSA labour.
3.) A special contingency or [redacted] for actions arising from the functionality review.
4.) A special contingency of [redacted] in the event that the Phase II fuelling review calls for permanent modifications

A Special contingency of [redacted] was removed on the basis that additional PARS and Phase II EME pump reconfiguration are no longer required.

Appendix D: Key Contributors to Scope Changes

PNGS:

1. **Emergency Power Restoration**
2. **Airlock Seal Integrity (simplified concept to include Cat 4 elements)**
3. **Functionality/RLC/Gap Assessment**
4. **Hydrogen Igniters**

DNGS:

1. **Phase II EPS Restoration. Design, material and installation.**
2. **Functionality/RLC/Gap Assessments**
3. **Phase II Fuelling Strategy**
4. **Removal of PARs and EME Pump reconfiguration contingencies from Phase II scope**
5. **H2 Igniter Repowering - Cancelled**

Type 3 Business Case Summary

Project #: 13-41027 (Capital) 13-41028 (MFA)
16-32202 (Capital) 16-32204 (MFA)

Document #: N-BCS-09013-10008

Project Title: Fukushima Phase II Beyond Design Basis Event Emergency Mitigation Equipment, <Partial> <Execution> Release

Appendix E: References

[1] P-PCH-09013-00001, Beyond Design Basis Fuel Cooling For Pickering
[2] D-PCH-09013-10001, Beyond Design Basis Fuel Cooling For Darlington
[3] N-CORR-01130-0460943, Redundancy Reliability And Operating Time Requirements For OPG Emergency Mitigating Equipment

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