

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 #:	16-33819	Document #:	D-BCS-60060-10005
Project Title:	DN Vibration Monitoring System Upgrades for Major Pump-sets		
Class:	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others:	Investment Type:	Sustaining
Phase:	Execution	Release:	Superseding
Facility:	Darlington	Target In-Service or Completion Date:	2021-07-31

Project Overview
Approval is requested for a change in scope of the Vibration Monitoring System Upgrade for Major Pump-sets project for Darlington, from 6 to 12 pump-sets due to increased failures and unavailable spare parts. In addition the existing Data Acquisition system will be commissioned. No additional release of funds is required at this time. The present Partial Execution BCS approved release is \$9,554k, including ████████ of contingency. The total cost of the Project is estimated at \$23,811k including ████████ contingency. The previous total project estimate was \$12,766k including ████████ contingency. The quality of estimate for the total project is Class 5. The business objective of this project is: - To ensure a reliable pump-set vibration monitoring system is in operation to protect rotating equipment and provide operations warning to shutdown pump sets before unsafe events occur. - Minimize future production losses and unavailability of critical equipment because of damage caused by vibration problems on major pump sets. The scope covered by the present release is: - Revise the scope of work document by OPG - Revision of the Preliminary Design package by OPG - Verify the cost estimate for additional scope - Prepare and issue RFP for competitive bids to approved ES MSA contractors - Preparation of a Future Release BCS for installation and commissioning The future release will fund: - Replacement of the VMS on all major pump-sets, which are considered critical to nuclear safety and/or unit operation: - Moderator, - Aux Moderator, - Primary Heat Transport, - Heat Transport Feed, - Shutdown Cooling, - Main Boiler Feed, - Aux Boiler Feed, - Condensate Extraction, - Aux Condensate Extraction, - Condenser Cooling Water, - Low Pressure Service Water - Emergency Service Water - Upgrade and commissioning of the Data Acquisition and Analysis System (DAAS) to maintain continuous historical trending or diagnostic operating data for equipment assessment. - Specification of spares for the new Vibration Monitoring systems

Type 3 Business Case Summary

Project #: 16-33819

Document #: D-BCS-60060-10005

Project Title: DN Vibration Monitoring System Upgrades for Major Pump-sets, <Superseding> <Execution> Release

Project Overview

This project has had:

- A number of project releases
- A number of changes in project scope
- A project deferral (Oct 2014 to Mar 2015)

A summary of project history is included in Table 1.

Table 1 Release and Project Status Summary for 33819 DN VMS Upgrade Project

Date	Description	Release & Cost	Reference
4 May 2004	Project Charter		[1]
17 Mar 2006	Partial BCS including Turbine/Generator and 12 Pump sets: • Condensate Extraction • Aux Condensate Extraction • Main Boiler Feed • Aux Boiler Feed • Low Pressure Service Water (LPSW) • Condenser Cooling (CCW) • Main Moderator • Aux Moderator • Primary Heat Transport (PHT) • PHT Feed • Shut Down Cooling (SDC) • Emergency Service Water [U0] (ESW)	Definition plus long lead materiel Release \$1,250k (contingency) Total \$7950	[2]
14 Sep 2009	Revised Project Charter		[6]
11 Mar 2011	Superseding BCS to revise scope. Turbine/Generator scope moved to project 31359. Reduced scope of VMS to pump-sets critical to nuclear safety: • Main Boiler Feed • CCW • Main Moderator • PHT • PHT Feed • SDC Parts scavenged from this partial release will be additional spares for remaining systems.	Release: \$1,132k Total To Date: \$2,382k Total Project: \$12,596k	[3]
24 Aug 2012	Partial Execution BCS: • Main Boiler Feed • CCW • Main Moderator • PHT • PHT Feed • SDC For one unit under this release, subsequent 3 units under future release.	Release: \$7,172k Total To Date: \$9,554k Total Project: \$12,766k	[4]
16 Oct 2014	Project placed in deferred state		[7]
18 Mar 2015	Project returned to active status as of 1 Apr 2015		[8]
8 May 2015	Revised Project Charter		[1]
Q3 2015	New Superseding BCS – change in scope: Original 12 major pump sets	Released: \$9,554k No new release required. Total Project: \$23,019k	This BCS

OPG Confidential
 OPG-FORM-0076-R005

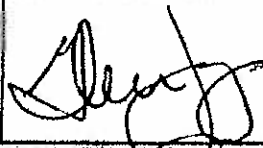
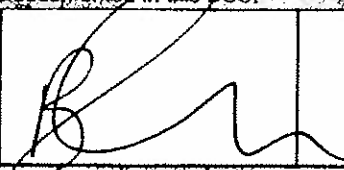
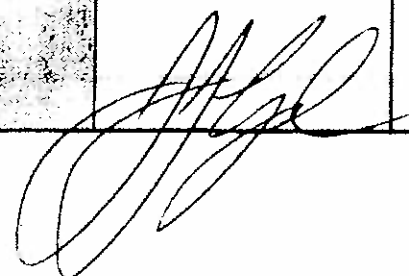
Type 3 Business Case Summary

Project #: 16-33819

Document #: D-BCS-60060-10005

Project Title: DN Vibration Monitoring System Upgrades for Major Pump-sets, <Superseding> <Execution> Release

Project Cash Flows, NPV, and OAR Approval Amount									
(\$)	LTD	2015	2016	2017	2018	2019	2020	2021/22	Total
Currently Released	3,874	171	3,427	2,082					9,554
Requested Now									
Future Required			404	2,381	6,616	3,770	201	102	13,454
Total Project Cost	3,874	171	3,853	4,443	6,616	3,770	201	102	23,008
Ongoing Costs									
Spares						800			800
Inventory								3	3
Grand Total	3,874	171	3,853	4,443	6,616	4,570	201	105	23,811
Estimate Class:	Class 5				Estimate at Completion:				
NPV:					OAR Approval Amount:		\$23,811k		
Additional Information on Project Cash Flows (optional):									

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			17 Sept 2015
I concur with the business decision as documented in this BCS.			
Finance Approval: Beth Summers Senior Vice President, and Chief Financial Officer per OPG-STD-0075			30 Sept 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: Jeffrey Lybush President, and Chief Executive Officer per OAR 1.1			5 Oct 2015

Type 3 Business Case Summary

Project #: 16-33819

Document #: D-BCS-60060-10005

Project Title: DN Vibration Monitoring System Upgrades for Major Pump-sets, <Superseding> <Execution> Release

Business Case Summary

Part A: Business Need

The vibration monitoring systems (VMS) at the Darlington Nuclear Generating Station are designed to warn operations staff of vibration problems on the major pump-sets (SCI 60060) across all units, and common equipment. This equipment being monitored is criticality code of either 1 or 2 indicating its importance to nuclear safety or unit operation. The VMS consists of transducers and signal conditioning modules to monitor the vibration levels and compare those levels against established set-points.

- (a) While the pump-set system continues to operate, VMS components have been failing due to age, radiation or other environmental factors. There are minimal or no functional spares available and the equipment is obsolete. Maintenance of the system has been deferred due to lack of spares. Eventually some pump-sets will not have any functioning vibration monitoring or alarms.
- (b) As part of the original design the systems had a data acquisition and analysis system (DAAS) but this was never successfully commissioned. The system therefore does not have continuous historical trending or diagnostic capabilities. Trending is now accomplished on a six week predefined using portable vibration equipment and head office vibration analysts are brought in to setup temporary diagnostic equipment when major issues arise (usually after the vibrations have already occurred on the pump-set).
- (c) When a pump-set suffers high vibrations due to transients, it is difficult for the predictive group to capture the transient and thus difficult for the vibration analysts to pinpoint how severe the damage to the pump-set may have been without data acquisition. This could lead to extended downtime for the pump-set if closer inspections of equipment health are required since the extent or source of the vibrations incurred is unknown. In some instances, this could also lead to unit de-rate or outage.

An extract from an EPRI Report [Generation Maintenance Applications Center: Conventional Vertical Pump Maintenance Guide, Report 3002000922] succinctly summarizes the business need:

"The most common vibration problems associated with vertical pumps are unbalance and misalignment.

These problems can result in reduced pump performance and/or catastrophic failure. Early detection is important to facilitate maintenance planning and to avoid lost revenue due to plant load reductions. In extreme cases, these problems can result in forced outages. In some instances, early detection and analysis can lead to remedying the cause of the vibration without dismantling the unit.

Early detection can best be achieved through the use of a vibration monitoring system and/or frequent measurement and review by experienced staff."

Part B: Preferred Alternative: Complete upgrade of VMS on all Major Pump-sets

Description of Preferred Alternative

The major pump-sets Vibration Monitoring System (VMS) will be upgraded to ensure that they are operational throughout the continuous operation of Darlington. This alternative is technically feasible, uses commercially available equipment and addresses the business need by installing vibration monitoring systems on the major pump-sets to identify high vibration to the control room staff so that the problems can be addressed proactively. The recommended upgrade strategy is as follows:

- Replace the VBS on all major pump-sets: Moderator, Aux Moderator, Primary Heat Transport, Heat Transport Feed, Shutdown Cooling, Main Boiler Feed, Aux Boiler Feed, Condensate Extraction, Aux Condensate Extraction, Condenser Cooling Water, Low Pressure Service Water and Emergency Service Water with commercially available equipment.
- Upgrade and commission the Data Acquisition and Analysis System (DAAS) to maintain continuous

Type 3 Business Case Summary

Project #: 16-33819

Document #: D-BCS-60060-10005

Project Title: DN Vibration Monitoring System Upgrades for Major Pump-sets, <Superseding> <Execution> Release

Part B: Preferred Alternative: Complete upgrade of VMS on all Major Pump-sets**Description of Preferred Alternative**

historical trending or diagnostic operating data for equipment assessment.

- Ensure spares are available for remaining station end of life.

Deliverables:	Associated Milestones (if any):	Target Date:
Revise Preliminary Design	Preliminary Design Complete	15 Jan 16
Obtain approval for Partial Definition/Execution Release	Approval of Partial Definition/ Execution Release BCS	30 May 16

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

The no project alternative is not recommended as:

- There are minimal or no spares available to replace existing pump-set VMS equipment, which is obsolete and degrading due to age and other environmental factors.
- No aftermarket manufacturers can be identified to provide support for the existing components.
- Based on current system health, the system will not remain operational throughout the continued operations of Darlington until the end of each unit life (between 2046 to 2050 dependant on the unit)

Alternative 3: Delay Work

The delay work alternative is not recommended as:

- Any delay will increase the possibility of the station declaring a pump-set as unavailable, which will minimise the redundancy available to the control staff to operate the affected unit in a standard configuration.
- Without a functioning vibration monitoring system, there is an increased risk that DNGS operations and maintenance will be unaware that a vibration problem exists on a pump-set such that the condition worsens overtime.

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

k\$	LTD	2015	2016	2017	2018	2019	2020	2021/22	Total
Currently Released	3,874	171	3,427	2,082					9,554
Requested Now	-								
Future Required	-		404	2,361	6,616	3,770	201	102	13,454
Total Project Cost	3,874	171	3,831	4,443	6,616	3,770	201	102	23,008
Ongoing Costs	-								
Spares						800			800
Inventory								3	3
Grand Total	3,874	171	3,853	4,443	6,616	4,570	201	105	23,811
Estimate Class:	Class 5			Estimate at Completion:					
NPV:	N/A			OAR Approval Amount:		\$23,811k			

Additional Information on Project Cash Flows (optional):

Project cash flow includes contingency. Total value of inventory to be scrapped is \$248.00 (Ref: Appendix E)

Type 3 Business Case Summary

Project #: 16-33819

Document #: D-BCS-60060-10005

Project Title: DN Vibration Monitoring System Upgrades for Major Pump-sets, <Superseding> <Execution> Release

Part E: Financial Evaluation

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

Summary of Financial Model Key Assumptions or Key Findings:**Part F: Qualitative Factors****Part G: Risk Assessment**

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	There is a risk that project cost will increase due new contract negotiations and increased scope.	Project will ensure that deliverables and experience gained as a result of the already approved design package is used during the design to support the expanded scope and new contract strategy	Medium	Low
Scope	There is a risk that the new system may be unable to utilize the existing cables from the field to the common room, S-103.	Existing cables will be inspected for physical damage to shielding and overall cable insulation materials. In addition end to end testing will be conducted by the contractor as a prerequisite to reconnection.	Medium	Medium
Schedule	There is a risk that the completion of Detailed design complete milestone (PO12) for D1831 Outage may not be achievable.	Ensure that the SOW and RFP states clearly the Design Completion Milestone as a firm target date to meet D1831 and that MA022 planning is adhered to through weekly updates by the ESMSA contractor.	Medium	Medium
Resources	There is a risk that internal design resources are unavailable to start the revision of the Preliminary Design requirements to suit the new scope of work.	internal design resources are unavailable to start the revision of the Preliminary Design requirements to suit the new scope of work.	Medium	Medium
Quality/ Performance	There is a risk that the Quality / Performance of the new vendor during installation-planning, installation, commissioning and AFS may impact cost and/or schedule.	Perform increased oversight by the Project as documented in the approved Project Oversight Plan. Contractor Field Engineer and QA to perform more detailed assessing walk downs, in addition to normal quality surveillance. General contingency allocated to this risk.	Medium	Low
Technical	There is a risk that newly procured VMS equipment does not operate as intended	Ensure any exceptions or assumptions that the vendor indicates do not affect the operability of the equipment. Ensure that factory testing complies with technical specification and witnessed by stakeholder representatives	Medium	Low

Additional Risk Analysis:

Type 3 Business Case Summary

Project #: 16-33819

Document #: D-BCS-60060-10005

Project Title: DN Vibration Monitoring System Upgrades for Major Pump-sets, <Superseding> <Execution> Release

Part H: Post Implementation Review (PIR) Plan

Type of PIR Report	Target In-Service or Completion Date	Target PIR Completion Date
Simplified PIR	2021-07-31	2022-07-31

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Vibration Monitoring coverage on all Major Pump-sets	Full coverage on 12 major pump sets not available	Full coverage on 12 major pump-sets	Health Reports	SRE
TCR filed VMS	Many TCR's filed to mask out alarms on major Pump-sets	No TCR's on system due to spares or obsolescence	Health Report	SRE
Data Acquisition and Analysis System (DAAS)	DAAS non operational	Replacement DAAS early warning system	Health Report	SRE
System Spares	System Spares unavailable	System Spares available and in inventory.	Health Report	SRE
Maintenance Strategy	Existing Technology assisted by hand held instrument support	SMP to include a recovery process and strategy	Maintenance Pre-requisites	SRE/MC

Part I: Definitions and Acronyms

BCS – Business Case Summary
 CNSC – Canadian Nuclear Safety Commission
 EC- Engineering Change
 EPC- Engineering, Procurement and Construction
 DAAS - Data Acquisition and Analysis System
 DNGS- Darlington Nuclear Generating Station
 OPG – Ontario Power Generation
 OPEX – Operating Experience
 SCR – Station Condition Record
 SRE – System Responsible Engineer
 TCR - Temporary Change Request
 VMS – Vibration Monitoring System

Type 3 Business Case Summary

Project #: 16-33819

Document #: D-BCS-60060-10005

Project Title: DN Vibration Monitoring System Upgrades for Major Pump-sets, <Superseding> <Execution> Release

This page is intentionally left blank

Type 3 Business Case Summary

Project #: 16-33819

Document #: D-BCS-60060-10005

Project Title: DN Vibration Monitoring System Upgrades for Major Pump-sets, <Superseding> <Execution> Release

For Internal Project Cost Control

Type 3 Business Case Summary

Project #: 16-33819

Document #: D-BCS-60060-10005

Project Title: DN Vibration Monitoring System Upgrades for Major Pump-sets, <Superseding> <Execution> Release

Appendix A: Summary of Estimate

Project Number:	16-33819									
Project Title:	DN – Vibration Monitoring System Upgrades for Major Pump-Sets									
k\$	LTD	2015	2016	2017	2018	2019	2020	2021/22	Total	%
OPG Project Management	922	57	155	177	185	165	42	20	1,723	9
OPG Engineering (including Design)	861	70	94	47	24	19	15	5	1,135	6
OPG Procured Materials	103								103	1
OPG Other		4	19	32	32	15			102	1
Design Contract(s)										
Construction Contract(s)										
EPC Procurement										
EPC Contract(s)										
Material										
Commissioning Close out										
Interest										
Subtotal										
Contingency										
Total	3,874	171	3,831	4,443	6,616	3,770	201	102	23,008	

Notes

Project Start Date	2006-02-09	Total Definition cost (excludes unspent contingency for Nuclear)	
Target In-Service (or AFS) Date	2021-07-31	Contingency included in this BCS (Nuclear only)	
Target Completion Date	2022-12-31	Total contingency released plus contingency in this BCS (Nuclear only)	
Escalation Rate	2%	Total released plus this BCS without contingency (Nuclear only)	
Interest Rate	5%	Total released plus this BCS with contingency (Nuclear only)	\$9,554k
Removal Costs	\$145k	Estimate at Completion (includes only spent contingency for Nuclear)	

Prepared by:**Approved by:**Francis Davis
Design Projects Darlington
Project Leader IIDate
2015-07-22Ricardo Fiorini
Design Projects Darlington
Section ManagerDate
2015-07-30

Type 3 Business Case Summary

Project #: 16-33819

Document #: D-BCS-60060-10005

Project Title: DN Vibration Monitoring System Upgrades for Major Pump-sets, <Superseding> <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)					2020-2022	Total Project Estimate
			2014/LTD	2015	2016	2017	2018	2019	
Initiation	Partial	Mar 2006	7,950						7,950
Preliminary	Superseding	Mar 2011	7,233	2,411	2,951	962			12,596
Execution	Partial	Aug 2012	6,794	2,201	3,000	663	108		12,766
Execution	Superseding	Jul 2015	3,874	171	3,831	4,443	6,616	4,570	23,811

Project Variance Analysis

k\$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management	922	3,859	1,723	-2,136	OPG design cost was included in the last BCS. Scope increase requires increased oversight. Cost shown for OPG support has been verified through a third part estimate.
OPG Engineering (including Design)	861	0	1,135	1,135	OPG design cost was included in Project Management above in the last BCS. Scope increase requires revision to the Preliminary engineering specifications and more design oversight
OPG Procured Materials	103	0	103	103	All material cost in the EPC contract package. Cost addition for procurement oversight
OPG Other		0	102	102	Required OPG support was not included in the last BCS
Design Contract(s)					
EPC Construction Contract(s)					
EPC Procurement					
EPC Contract(s) Material					
Commissioning Close out					
Interest					
Subtotal					
Contingency					
Total	3,874	12,765	23,008	10,243	

Type 3 Business Case Summary

Project #: 16-33819

Document #: D-BCS-60060-10005

Project Title: DN Vibration Monitoring System Upgrades for Major Pump-sets, <Superseding> <Execution> Release

Appendix C: Financial Evaluation Assumptions

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

Appendix D: References

1. Project Charter: D-PCH-60060-10001 R002
2. Partial Release: D-BCS-60060-10001 Rev 000
3. Superseding Partial Release: D-BCS-60060-10002 Rev 000
4. Execution Partial Release: D-BCS-60060-10003 Rev 000
5. Project Value Engineering Report: NK38-REP-60060-0282607
6. Project Charter: D-PCH-60060-10001 R001
7. Deferral of Project: NK38-CORR-60060-0481895
8. Restart of Project: NK38-CORR-60060-0536793
9. The following SCRs provide a sample of the issues experienced by the field transducers: D-2003-09694, D-2004-02247, D-2005-06434, D-2007-03736, D-2007-09389, D-2008-07066
10. The following SCRs provide a sample of the issues for these signal conditioning modules: D-2003-00792, D-2003-04903, D-2003-07547, D-2005-04987, D-2007-04891
11. The following SCRs describe some situations where temporary vibration monitoring equipment was required to help diagnose a vibration problem: D-1998-00842, D-2001-03423, D-2001-05983, D-2003-02994, D-2008-11611

Project #: 16-33819

Document #: D-BCS-60060-10005

Project Title: DN Vibration Monitoring System Upgrades for Major Pump-sets, <Superseding> <Execution> Release

Appendix E: Spare Parts Inventory (to be written off)

CATID	Description	Unit Price	Status	On Hand	Total Spares
38585	MOUNT, ANTI VIBRATION, -, MOUNT RICHCO QM5 , FOR STACK MONITORING PUMP MOTOR SET	\$2.00	READY	123	\$246.00
250701	KIT, .., VIBRATION MONITORING	\$539.83	READY	0	\$0
519082	TRANSDUCER, VELOCITY, -, -, 5.7MV/MM/S@100HZ, PIEZO-ELECTRIC, HIGH TEMPERATURE, C/W 6 METRE INTEGRAL CABLE (FOR SG VIBRATION MONITORING)	\$2,748.38	READY	0	\$0
638214	MONITOR, VIBRATION, -, VIBRATION MONITORING SYSTEM FOR PUMP SETS, (SCI 60060)	\$400,000.00	READY	0	\$0
646500	SOFTWARE, ANALYZER, BENTLY NEVADA SYSTEM 1, VIBRATION MONITORING AND ANALYSIS SOFTWARE	\$23,111.00	READY	0	\$0
638217	MONITOR, VIBRATION, -, VIB. MONITORING SYSTEM FOR TURBINE GENERATOR, (SCI 64117)	\$23,111.00	READY	0	\$0
					\$246.00

Project Over-Variance Approval

Final Security Classification of the BCS: **Internal Use Only**

This form should not be used for over-variances in excess of 20% of cost or schedule or both. Submit this form with attachment of the latest approved Business Case Summary.

Part A: Project Information						
Project #:	16-33955		Title:	DN SDS Computers Aging Management		
Phase:	Execution		Class:	Capital	Records File:	NK38-68000-T10
	LTD	2014	2015	2016	Future	Total
Current Approval	15,645	2,704	173	0	0	18,522
Amount Requested	-	(103)	1,556	283	0	1,736
New Total Release	15,645	2,601	1,729	283	0	20,258

Brief Description of the Project:
The DN SDS Computers Aging Management Project (16-33955) is a capital project and includes the following items:
(a) Full replacement of the SDS1 and SDS2 Monitor Computers
(b) Eliminate need for a separate SSMC by incorporating functionality into the replacement Monitor Computers
(c) Full replacement of the SDS1 and SDS2 Display/Test Computer CRT monitors with modern display units
(d) Engineering required to enable use of higher density memory chips on SDS2 Trip Computer EPROM boards
(e) Preliminary engineering required to achieve a solution for replacing the SDS2 Trip Computer DEC boards
For items (a) and (b), all the Design ECs have been approved, and authorized by the Design Authority. Installation and commissioning planning activities are complete. The first Unit installations are currently scheduled for February 2015, with the remainder to follow later in 2015.
Items (c), (d), and (e) have all been completed.

Reason for Schedule Variance:
The previous Over-Variance for the project was approved in July 2014. It included the following milestones:
1. SDS1/2 Monitor Computers (MCs) – AFS Declaration – First Unit (October 2014)
2. SDS1/2 Monitor Computers – AFS Declaration – Final Unit (December 2014)
3. Project Closeout (June 2015)
Since then, the first unit installation has been delayed from October 2014 to February 2015 due to a number of factors. Chief amongst these are:
1. The fibre optic module (FOM) performance issues identified in the July Over-Variance could not be resolved satisfactorily (see SCRs D-2014-25110 and D-2014-29542). As such, the FOMs from the existing MCs had to be repackaged to fit into the new MC cabinets. Testing of the existing MC FOMs has been successful and there are sufficient spares available to meet the expected service lifetime. However, this required an intent revision to the new MC Hardware Design ECs.
2. In May 2014, a problem with the new MCs was identified during long-term testing. It was not fully understood at the time of the July Over-Variance, but since then has been resolved and fully tested. It required a revision to the new MC Software Design ECs.
3. Preparation of the Online Wiring update for the new MCs required more effort than originally planned. This was due to the changes required for the FOM issue identified above and to resolve legacy issues. This work has recently been completed.
The Design EC Release Group #5 submission which includes the revised MC Hardware Design ECs for Unit 2 and Unit 3 was authorized by the Design Authority in November 2014. Design EC Release Group #6 submission which includes the revised MC Hardware Design ECs for Unit 1 and Unit 4 will be submitted for authorization by the Design Authority by February 2015.
Installation of the Fibre Patch Panels on all Units was completed in September 2014. This will support the new MC installations.
Assuming the new MC installations go ahead as currently planned (last Unit installation is currently scheduled for November 2015), the ECC and project closeout activities will not be completed until May 2016.

Reason for Cost Variance:

**Project Over-Variance
Approval**

There are a number of contributors to cost over-runs, including the issues described above:

1. Current interest charges to the project are approximately \$62K per month. The delay from October 2014 to February 2015 for the first unit installation will result in a cost increase of approximately \$250K.
2. The effort required to complete the SDSPI Gateway and PIDS PI Server changes Design ECs to support the new MCs was underestimated. This is largely due to the issue identified in SCR N-2014-16580, and amounts to approximately \$100K.
3. The previous estimate (\$250K) from Operations Support to complete the updates to all Operations documents was too low. The latest estimate is approximately \$90K higher. This extra charge will be incurred after all installations are complete and is based on the effort expended to finish the pre-installation work.
4. The effort required by both the engineering team and Drawing Office staff to update Online Wiring was underestimated by approximately \$100K. This work has just been completed.
5. The incremental cost required by the engineering team and other staff to prepare the revisions to both the MC Hardware and Software Design ECs was approximately \$250K. This work, while substantially complete is still ongoing.
6. The effort required to install, commission and AFS the new MCs was underestimated by approximately \$57K per Unit, partly because they are more involved than was originally planned 5 years ago. This works out to \$228K for all four Units.
7. The effort required to perform the closeout activities was substantially underestimated, chiefly due to the effort required to update the drawings to modern format. This works out to approximately \$250K for all four Units.

The Over-Variance from July 2014 allocated [REDACTED] of contingency for future issues. Of this, [REDACTED] was used to complete the work carried out in 2014. This means that there is not enough contingency remaining to support the cost variance.

Options Considered to Mitigate Overruns:

The project is now at a stage where options to mitigate overruns are substantially reduced. Field installations should proceed as quickly as possible to avoid further installation delays and additional interest costs. The project team is working with contributing organizations like the Drawing Office, Field Engineering, Operations Support and the System Engineers to ensure costs and delays are kept to a minimum.

The hardware and software design teams have resolved the latest Monitor Computer technical issues effectively and efficiently. The teams will continue to work effectively and efficiently through final Design EC authorizations and installation and closeout efforts.



Records File Information:
 Final Security Classification of the
 completed form is determined below
 00120.3 - P For Nuclear
 08707.021 - P For All Others

OPG-FORM-0077-R001*

Project Over-Variance Approval

Part B: Variance Detail				
k\$	Current Approval	Amount Requested	Variance	Comments
OPG Project Management	2,850	2,915	65	
OPG Engineering	4,212	4,622	410	Full Release BCS did not break out Managed Task and Augmented Staff charges.
Permanent Materials	1,600	1,800	200	Some extra computer equipment, computer software and software license charges.
Design and Construction				
Consultants				
Other Contracts/Costs				
Interest				
Subtotal				
Contingency				
Total	18,522	20,258	1,736	
Removal Costs Included				Included in Design and Construction originally

Part C: Review/Approvals			
	Signature	Comments	Date
Recommended by: Glenn Jager Project Sponsor			YYYY-MM-DD 2015-02-04
Finance Approval: Beth Summers Position per OPG-STD-0076			YYYY-MM-DD 2015-02-03
Approved by: Tom Mitchell Per OAR Element 1.1			2015-02-25 YYYY-MM-DD

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

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 #:	16-33973	Document #:	D-BCS-49100-10005
Project Title:	DN SG Controls Replacement		
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:	May 2017

Project Overview
We recommend the release of \$ 8.713M, including [REDACTED] base costs plus [REDACTED] of contingency). The total to date released (including this released) is \$32.436M (including [REDACTED] of contingency). The estimated total project cost is \$ 39.535 M, including [REDACTED] of contingency. The quality of the estimate for this release is Class 3, and for the total project is Class 3. The revised total project cost is based on installation and commissioning lessons learned from the first SG controls system. Installation and commissioning on the 1ST SG completed and significant project risk has been retired. The OPEX from this 1ST SG has allowed improved estimates on the remaining installation and commissioning work. To date, the 1ST SG controls system replacement has been completed and placed into service with open items. The open items are the result of technical issues that were discovered during commissioning, and need to be addressed on the 1ST SG to minimize risk before proceeding to the next SG. Detailed design, fabrication, testing and delivery (to OPG inventory) of controls equipment for the remaining SGs have been completed, but lessons learned from the 1ST SG have not been incorporated into the detailed design. This release will fund the following scope of work: • Complete open items for the 1ST SG. • Update the design of the 2ND, 3RD and 4TH SGs with the lessons learned from the 1ST SG. • Complete installation, commissioning and Available for Service (AFS) for the 2ND SG. • Prepare Full Execution Release BCS The future release will fund the following scope of work: • Installation, commissioning and AFS of the 3RD SG. • Installation, commissioning and AFS of the 4TH SG. • Engineering Change closeout for all SG's. • Project close-out. Problem Statement/Business Need: The Darlington Standby Generators (SGs) are required to provide backup power to designated safety support systems. Various control and monitoring components for the SGs have become obsolete. Manufacturers of the original components no longer provide replacement parts or service the equipment. In some cases, these manufacturers no longer exist. The present stock of critical parts is expected to be depleted in as little as 3-5 years. This project will replace the controls system for each of the four SGs. The business objectives of this sustaining project are to: - Replace the obsolete equipment with equivalent functional equipment; - Maintain the reliability & availability of the SGs to meet the current station requirements;

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

OPG-TMP-0004-R004 (Microsoft® 2007)

Page 1 of 111

Type 3 Business Case Summary

Project #: 16-33973

Document #: D-BCS-49100-10005

Project Title: DN SG Controls Replacement, <Partial> <Execution> Release

Project Overview

- Provide data logging function of the SGs and increased diagnostic capabilities for effective maintenance programs. The improved availability and reliability will support extended plant life operation after Darlington refurbishment.

Summary of Preferred Alternative:

The scope of the SG controls system replacement includes the governor, voltage regulator, vibration and overspeed protection, trips and alarms, synchronizer, data logging and trending, field operator controls and interface, limited field sensors, and power supplies to suit the new equipment.

History of BCS releases and project cost estimates:

The total project cost is now estimated at [REDACTED] plus [REDACTED] of contingency, compared to [REDACTED] plus [REDACTED] of contingency in the previous release.

The previous release was approved in November 2014 providing a life to date release of \$23.723M (including [REDACTED] contingency) to do detailed design and procurement of all four SGs and also to install and commissioning of the 1ST SG. The primary contributors to cost increase and contingency adjustment are:

- 1) Technical issues (open items) that could not be resolved during commissioning of the 1ST SG.
- 2) The latest estimate for incorporating lessons learned from the 1ST SG into the detailed design of 2ND, 3RD and 4TH SG is higher than the estimate in the last BCS.
- 3) The interest cost in the last BCS was underestimated.
- 4) Estimate accuracy (including contingency calculation) can now be better estimated with the lessons learned from the 1ST SG controls.

Project Cash Flows, NPV, and OAR Approval Amount

k\$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	21,776	1,947							23,723
Requested Now	-	4,594	3,917	202					8,713
Future Required	-		3,020	4,029	71				7,120
Total Project Cost	21,776	6,541	6,937	4,230	71				39,555
Ongoing Costs	*1,304								1,304
Grand Total	23,080	6,541	6,937	4,230	71				40,859
Estimate Class:	Class 3			Estimate at Completion:		[REDACTED]			
NPV:	NA			OAR Approval Amount:		\$40.859 M			

Additional Information on Project Cash Flows (optional):

* Life time spares have been purchased and placed into OPG inventory

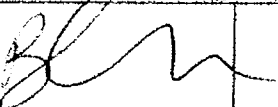
Internal Use Only
OPG-FORM-0076-R005

Type 3 Business Case Summary

Document #: D-BCS-49100-10005

Project #: 16-33973

Project Title: DN SG Controls Replacement, <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 CNO Project Sponsor			23 APR 2015
I concur with the business decision as documented in this BCS.			
Finance Approval: Beth Summers CFO per OPG-STD-0076			May 1, 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 CEO per OAR 1.2			May 4, 2015

Type 3 Business Case Summary

Project #: 16-33973

Document #: D-BCS-49100-10005

Project Title: DN SG Controls Replacement, <Partial> <Execution> Release

Business Case Summary

Part A: Business Need

The Standby Generators (SG) provide backup power for designated safety support systems. Darlington's Power Reactor Operating License requires availability of Standby Generator power at all times. Unavailability would require shutdown of all generating units if at least one SG could not be made available within 24 hours.

The Darlington SG Controls System components are over 20 years old, and are susceptible to unpredictable failure. Reliability of the controls system is negatively impacted by aging. The SGs need to be able to perform their intended function in a loss of grid power event or accident scenario.

Maintainability of the Controls System is at risk, because components are no longer supported by the original equipment manufacturer. Current trends indicate that our stock of critical spare parts could potentially be depleted in as little as 3-5 years. The current overall SG system health status is "healthy and stable"; however, a direct sub-system specific indicator, Controls & Instrumentation, is coded "marginal and declining" due to obsolescence of equipment and unavailability of spare parts.

The consequent threat is loss of generation (i.e. forced shutdown of all units due to unavailability of SGs). In order to continue operating Darlington Station, availability of the SGs must be maintained at design specifications.

Part B: Preferred Alternative: Replace the SG Controls Systems - Complete Installation and Commissioning for All SGs.

Description of Preferred Alternative

Complete replacement of controls systems is recommended, because such an approach:

1. Improves reliability of SG controls systems for remainder of and extended plant life.
2. Ensures availability of spares.
3. Consistent with OPEX from Pickering B SGs, Darlington EPGs & Pickering B EPGs.

The scope of the SG controls system replacement includes the governor, voltage regulator, vibration and overspeed protection, trips and alarms, synchronizer, data logging and trending, field operator controls and interface, limited field sensors, and power supplies to suit the new equipment.

To date, the 1ST SG controls system has been completed and is available for service. Detailed design, fabrication, testing & delivery to OPG inventory of 2ND, 3RD & 4TH SG control equipments have been completed. EPC contractor has started miscellaneous procurement and 90% of the materials have been received and now in EPC contractor's warehouse.

This alternative will complete installation and engineering close-out for the 2ND, 3RD & 4TH SGs by the selected EPC contractor (PO# 218521). Commissioning for the 2ND, 3RD & 4TH SGs and the engineering close-out for the 1ST SG will be performed by OPG internal resources.

Deliverables:	Associated Milestones (if any):	Target Date:
<u>This Release:</u> • Installation, commissioning and AFS of the 2ND SG. • Approved Full Execution Release BCS.	<u>This Release</u> - Partial Execution BCS Approval - EPC Contract Phase III issued - Start of Installation for the 2ND SG - AFS for the 2ND SG - Full Execution BCS Approved	28May2015 30Jun2015 02Sep2015 19Jan2016 30May2016
<u>Future Release:</u> • Installation, commissioning and AFS of the 3RD SG. • Installation, commissioning and AFS of the 4TH SG. • Engineering Change closeout for all SG's. • Project close-out.	<u>Future Release:</u> - Start of Installation for the 3RD SG - AFS for the 3RD SG - Start of Installation for the 4TH SG - AFS for the 4TH SG - Project Closeout	31May2016 20Sep2016 09Jan2017 16May2017 16May 2018

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

Type 3 Business Case Summary

Document #: D-BCS-49100-10005

Project #: 16-33973

Project Title: DN SG Controls Replacement, <Partial> <Execution> Release

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 – Do Nothing, Stop the Project

The "Do Nothing" option is not recommended since the 1ST SG controls system has been completed and is available for service. It is assumed that the lessons learned from the 1ST SG will be effectively implemented on the 2ND, 3RD & 4TH SGs. The unavailability of the SG Controls Systems poses significant risks of partial or complete failure of Standby Class III power, in turn, posing a generation risk to the Darlington Station. Also, the anticipated problem of depleting spare parts for the other three SGs could potentially result in multiple SGs simultaneously being unavailable to support the Station.

Alternative 3: Delay Work – Delay Controls Replacement

Not recommended since the 1ST SG controls system has been completed and is available for service. Major delays to the project could lose continuity in expertise and knowledge within OPG's resources as well as control equipment vendor's resources. The unavailability of the SG Controls Systems poses significant risks of partial or complete failure of Standby Class III power. Also, the anticipated problem of depleting spare parts for the other three SGs could potentially result in multiple SGs simultaneously being unavailable to support the Station.

Alternative 4: Compile Substitute Parts From Alternate Suppliers/Utilities

This option was investigated without success in the conceptual design. At this stage, this alternative is again non-viable because it is only a short term strategy of retaining obsolete analog controls refurbished/supplied from other suppliers/utilities that would not guarantee (extended) life-cycle support of Darlington station following refurbishment.

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

k\$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	21,776	1,947							23,723
Requested Now	-	4,594	3,917	202					8,713
Future Required	-		3,020	4,029	71				7,120
Total Project Cost	21,776	6,541	6,937	4,230	71				39,555
Ongoing Costs	*1,304								1,304
Grand Total	23,080	6,541	6,937	4,230	71				40,859
Estimate Class:	Class 3			Estimate at Completion:					
NPV:	N/A			OAR Approval Amount:		\$40.859 M			

Additional Information on Project Cash Flows (optional):

* Life time spares have been purchased and placed into OPG inventory

Part E: Financial Evaluation

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

Summary of Financial Model Key Assumptions or Key Findings:

As per OPG-STD-0076, an economic justification is not required for sustaining investments/projects.

Part F: Qualitative Factors

This investment shall ensure:

- Controls system components salvaged upon installation of the 1st unit and subsequent units shall be available as spares thereby providing an interim bridging strategy until all 4 SG retrofits are completed by 2017.
- Improve diagnostics capabilities to trouble-shoot SG thereby facilitating maintenance programs to the extent of

Type 3 Business Case Summary

Project #: 16-33973

Document #: D-BCS-49100-10005

Project Title: DN SG Controls Replacement, <Partial> <Execution> Release

Part F: Qualitative Factors

lowering elective and corrective maintenance backlogs and effectively shortening SG outage durations.

- New controls systems (as per Pickering and Darlington EPG operating experience) require reduced preventive maintenance thereby effectively shortening SG outage durations. Similar projects, performed at Darlington for Emergency Power Generators, Pickering B for Standby Generators, and more recently, Emergency Power Generators were reviewed, and in all these cases the controls systems were completely replaced.

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	1) There is risk that project cost will increase through interest charges as a result of delays to project completion. 2) There is risk that OPG initiated delays could result in less than adequate commercial arrangements with vendors. 3) There is risk that EPC Contractor costs are under estimated.	1) Mitigate - The project will be placed in deferral status if major delays (greater than 6 months) are encountered. Accept - Remaining risks is accepted with general contingency. 2) Accept - This risk cannot be mitigated, and is accepted with contingency. 3) Mitigate - The Contractor's estimate has been adjusted with actual costs from the first unit. Accept - Remaining risk is accepted with contingency.	Medium	High
Scope	1) Market rules have changed since the Standby Generators were last registered, and IESO has requested changes to protection setting outside the scope of this project. There is risk of cost increase and schedule delay.	1) Mitigate - Come to a resolution with IESO such that the schedule of next SG is not impacted.	Medium	Medium
Schedule	1) SG outage schedule is vulnerable to emergent SG breakdown maintenance/repair. Such emergent issues could result in project delays in the order of months. There is also risk that major emergent issues could shuffle the order of execution of the remaining SG controls replacements. 2) This BCS reflects a spring 2015 Vaccum Building Outage (VBO), and the next SG is scheduled to start installation in September 2015. However, the start of the 2015 VBO has been moved from April to September. The full impact assessment and mitigation strategy have not been completed yet. There is risk of delay to the completion of the next SG.	1) Mitigate - For delays greater than 6 months the project will be placed in deferral status. Detailed designs have been completed for all of the remaining SGs. All design packages will be revised to incorporate the lessons learned from the first SG, allowing the flexibility to change the order of SG controls installations. Accept - Remaining risk is accepted with general contingency. 2) Mitigate - The planning of the next SG will be integrated with the Station plan. The project schedule will minimize impact to VBO. Accept - Remaining risk is accepted with general contingency.	High	Medium
Resources	1) If there are major delays to the SG outage schedule the project could lose continuity in expertise and knowledge within OPG resources (primarily DTL/MTL/FTL roles). Plus, there is risk of losing continuity in control equipment vendor's	1) Mitigate - Project staff will be retained for at least the second SG, but will be reassigned temporarily if there are major delays in the project schedule. Accept - The risk of losing vendor resources cannot be mitigated, and	High	Medium

Type 3 Business Case Summary

Project #: 16-33973

Document #: D-BCS-49100-10005

Project Title: DN SG Controls Replacement, <Partial> <Execution> Release

Part G: Risk Assessment				
Risk Class	Description of Risk	Risk Management Strategy		Post-Mitigation
	resources/ expertise, which are critical for commissioning. 2) Per experience from the first SG commissioning, Station resources are limited, and there is the risk of delay to commissioning if there are emergent issues. 3) The second SG is scheduled to start installation in September 2015. The D1531 outage has also been moved from April to September, 2015. This puts the outage in parallel with commissioning of the next SG controls, and is expected to further stretch the limited Station resources required for commissioning. There is risk of delay to commissioning from shortage of Station resources. 4) Installation for the remaining SGs has been brought back under OPG's construction QA program to minimize risk; and as a result, the miscellaneous materials procured by the EPC Contractor need to be transferred to OPG inventory. There is a risk that the limited Procurement Engineering and Supply Chain resources may delay the transfer of materials, and impact the installation schedule.	is accepted with general contingency. 2) Mitigate - The Project will work with the Station to plan up front and secure resources to support commissioning. 3) Mitigate - The resource load will be reviewed with the Station at Senior Management level. Resource commitments will be arranged early in the planning process. Accept - Remaining risk is accepted with contingency. 5) Mitigate - Procurement Engineering and Supply Chain have already been engaged early to ensure that the work load is assessed and a resource plan can be put in place to support the transfer and meet the installation schedule. Accept - Remaining risk is accepted with contingency.		
Quality/ Performance	1) There will be a learning curve for the EPC Contractor in providing engineering support for execution. There is some risk in the Contractor performance since they do not have experience from the first SG. 2) Darlington OP&P does not allow for more than one SG to be removed from service at any time. Forced outage of any SG during the installation or commissioning of this project will result in more than one SG outage, which may affect the station's operation.	1) Mitigate - OPG's Project and Design team will provide additional oversight during the execution of the next SG. 2) Mitigate - Controls system components salvaged from the retrofitted SGs will be available as spares for the remaining SGs, thereby providing an interim bridging strategy until all SGs retrofits are completed in 2017. This may help in reducing the SG outage time.		Low Low
Technical	1) A new vibration monitoring system was installed on the 1ST SG, but compatibility issues were discovered during commissioning. An interim solution was implemented; however, a long term risk has been identified, and it is being investigated by the equipment manufacturers (sub-vendor). There is a risk that resolution would escalate cost. 2) A number of other technical issues remain open from the 1ST SG commissioning. The resolution of these open items is in progress, and	1) Mitigate - To minimize risk and rework to the remaining SGs, the vibration monitoring issue will be resolved prior to proceeding to installation of the next SG. The start of installation of the 2ND SG has been postponed by approximately 4 months to allow time for the resolution. 2) Mitigate - The issues will be resolved prior to starting the installation of the next SG. The start of installation of the 2ND SG has been postponed by approximately 4		Medium Medium

Type 3 Business Case Summary

Project #: 16-33973
Project Title: DN SG Controls Replacement, <Partial> <Execution> Release

Document #: D-BCS-49100-10005

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation
	there is a risk that the scope/complexity of resolving these items is greater than estimated, and could delay the schedule and escalate cost.	months to allow time for the resolution. Accept - Remaining risk is accepted with contingency.	
	3) Technical issues unique to an SG may get discovered. This may delay commissioning schedule and or escalate cost.	3) Accept - This risk cannot be mitigated. Accepted with general contingency.	

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 2017	Dec 2017

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
SG System Health Report	Spare parts status in System Health Report (Yellow) Work Order Backlog in System Health Report (Yellow)	Spare parts status in System Health Report (White) Work Order Backlog in System Health Report (White)	Update System Health Report's status on the indicator.	Performance Engineering (i.e. System Responsible Engineer)
Class III System unavailability (including the SG)	$\leq 17.6 \times 10^{-3}$ (Reactor Safety Target)	$\leq 17.6 \times 10^{-3}$ (Reactor Safety Target)	S-99 Annual Reliability Report	Reactor Safety
SG System reliability & maintainability (all SGs combined).	Average number of functional failure due to Controls System related issues is more than 2 per 6 month reporting period (based on 2001 to 2014)	Minimal functional failures (i.e. ≤ 1 per 6 month reporting period due to Controls system issues).	Monitoring System health report/SCR	Performance Engineering (i.e. System Responsible Engineer)

Part I: Definitions and Acronyms

BCS	Business Case Summary
BTU	Building Trades Union
DTL	Design Team Leader
ECC	Engineering Change Control
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPC	Engineer Procure & Construct
EPG	Emergency Power Generator
ES-MSA	Extended Services Master Service Agreement
FTL	Field Team Leader
IESO	Independent Electricity System Operator
Load Bank	A portable resistive/inductive electrical load device used to apply load to the SG when testing "island operation." In "island

Type 3 Business Case Summary

Document #: D-BCS-49100-10005

Project #: 16-33973

Project Title: DN SG Controls Replacement, <Partial> <Execution> Release

Part I: Definitions and Acronyms

	operation" the SG is isolated from the electrical grid.
LTD	Life to Date
MTL	Modification Team Leader
OEM	Original Equipment Manufacturer
OP&P	Operating Principles & Policies
OPEX	Operating Experience
PM	Project Management
SG	Standby Generator
TMOD	Temporary Modification
VBO	Vacuum Building Outage

Filed: 2016-05-27

EB-2016-0152

Exhibit D2-1-3

Attachment 1, Tab 9, 33973

Page 11 of 16

Internal Use Only

OPG-FORM-0076-R005

Type 3 Business Case Summary

Project #: 16-33973

Document #: D-BCS-49100-10005

Project Title: DN SG Controls Replacement, <Partial> <Execution> Release

This page is intentionally left blank

Filed: 2016-05-27

EB-2016-0152

Exhibit D2-1-3

Attachment 1, Tab 9, 33973

Internal Use Only

Page 12 of 16

OPG-FORM-0076-R005

Type 3 Business Case Summary

Document #: D-BCS-49100-10005

Project #: 16-33973

Project Title: DN SG Controls Replacement, <Partial> <Execution> Release

For Internal Project Cost Control

Type 3 Business Case Summary

Project #: 16-33973

Document #: D-BCS-49100-10005

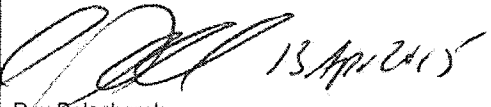
Project Title: DN SG Controls Replacement, <Partial> <Execution> Release

Appendix A: Summary of Estimate

Project Number:	16-33973									
Project Title:	DN SG Controls Replacement									
k\$	LTD	2015	2016	2017	2018	2019	2020	Future	Total	%
OPG Project Management	5,279	844	1,303	707	71				8,204	21
OPG Engineering (including Design)	2,690	370	181	186	0				3,427	9
OPG Procured Materials	6,626	558	563	193	0				7,940	20
OPG Other										
Design & Construction Contract(s)										
EPC Contract(s)										
Consultants										
Other Contracts/Costs										
Interest										
Subtotal										
Contingency										
Total	21,776	6,541	6,937	4,230	71				39,555	100

Notes

Project Start Date	Dec 2006	Total Definition cost (excludes unspent contingency for Nuclear)	
Target In-Service (or AFS) Date	May 2017	Contingency included in this BCS (Nuclear only)	
Target Completion Date	May 2018	Total contingency released plus contingency in this BCS (Nuclear only)	
Escalation Rate	2.00%	Total released plus this BCS without contingency (Nuclear only)	
Interest Rate	5.00%	Total released plus this BCS with contingency (Nuclear only)	\$32.4M
Removal Costs	\$50k	Estimate at Completion (includes only spent contingency for Nuclear)	

Prepared by:	Approved by:
 Rajbir Singh Section Manager, Design Projects Date 13 APR 15	 Ray Balachorek Manager, Design Projects Date 13 APR 15

Type 3 Business Case Summary

Project #: 16-33973

Document #: D-BCS-49100-10005

Project Title: DN SG Controls 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
			LTD	2015	2016	2017	2018			
DEF	FULL	2006-DEC	17,937	0	0	0	0		0	17,937
EXE	PARTIAL	2009-DEC	23,724	0	0	0	0		0	23,724
EXE	PARTIAL	2011-SEP	21,768	0	0	0	0		0	21,768
EXE	PARTIAL	2013-JAN	23,184	4,018	450	0	0		0	27,652
EXE	PARTIAL	2014-NOV	22,081	10,181	5,839	450	0		0	38,551
EXE	PARTIAL	2015-FEB	21,776	6,541	6,937	4,230	71		0	39,555

Project Variance Analysis					
k\$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management	5,279	7,343	8,204	861	- The variance is due to some technical problem in cost distribution, some engineering work in 2014 was charged to a project management activity. There were also some legacy undistributed costs that were distributed to the wrong section. The cost distribution is now corrected.
OPG Engineering (including Design)	2,690	3,144	3,427	283	- The OPG Engineering estimate is higher in this BCS than the last BCS to resolve the 1st SG open items**.
OPG Procured Materials	6,626	8,800	7,940	-860	- The OPG Procured Materials estimate is lower for this BCS because the controls equipment vendor commissioning support cost was distributed as OPG Procured Materials in the last BCS but now distributed as Design & Construction Contract in this BCS. The cost distribution is now corrected.
OPG Other					
Design & Construction Contract(s)					
EPC Contract(s)					
Consultants					
Other Contracts/Costs					
Interest					

Type 3 Business Case Summary

Project #: 16-33973

Document #: D-BCS-49100-10005

Project Title: DN SG Controls Replacement, <Partial> <Execution> Release

Project Variance Analysis					
k\$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
Subtotal					
Contingency					
Total		38,551	39,555	1,004	Total increase is mainly from the additional fund to resolve 1 ST SG open items**, the increase of SG design revision cost in incorporate lessons learned from 1 ST SG***, increase of interest estimate. However, some of the increase is offset by the decrease of contingency.

** Total cost of resolving open items for the 1ST SG is estimated to be \$518k.

*** Total cost to update the detailed design of the remaining three SGs is estimated to be \$1.3M.

Type 3 Business Case Summary

Document #: D-BCS-49100-10005

Project #: 16-33973

Project Title: DN SG Controls Replacement, <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.
- 2.
- 3.

Financial:

- 1.
- 2.
- 3.

Project Life:

- 1.
- 2.
- 3.

Energy Production:

- 1.
- 2.
- 3.

Operating Cost:

- 1.
- 2.
- 3.

Other:

- 1.
- 2.
- 3.

List further detail below as appropriate from the Financial Evaluation:

Appendix D: References

NK38-PLAN-49100-0446079 - Project Management Plan

Project Over-Variance Approval

Final Security Classification of the BCS: **OPG Confidential**

This form should not be used for over-variances in excess of 20% of cost or schedule or both. Submit this form with attachment of the latest approved Business Case Summary.

Part A: Project Information						
Project #:	16-33977	Title:	Darlington DCC Replacement			
Phase:	Execution	Class:	Capital	Records File:	D-BCS-69100-10001	
	LTD	2013	2014	2015	Future	Total
Current Approval	17,831	2,024	1,508	695	0	22,058
Amount Requested	-	0	0	589	2,262	2,851
New Total Release	17,831	2,024	1,508	1,284	2,262	24,909

Brief Description of the Project:

We request approval of a superseding release of \$2.851M for a total release of \$24.9M (base costs plus contingency) to complete the replacement of the Digital Control Computers (DCC) and Main Control Room (MCR) display systems at Darlington.

Long-standing DCC reliability problems at Darlington were identified as a cause for plant shutdowns, transient events and unnecessary challenges to the operators. Maintaining the long term operability of these computers is difficult due to the following factors: hardware obsolescence, diminishing support from the industry, declining in house engineering resources and decreasing maintenance capabilities for this obsolete 1970 vintage technology.

This project is to provide qualified replacements for the Unit DCCs, Common Process (CP) computer and Sequence of Events Monitoring Computers (SEM) with emulator-based systems that will ensure reliable operation for the current life of the station, prevent obsolescence and avoid a shortage of spare parts.

The scope of this project also includes the DCC annunciation system improvement (i.e. significant reduction of the nuisance alarms during outages) and the replacement of the MCR Ramtek display systems for the DCC, CP and SEM computers.

Accomplishments to date:

- Replacement of the first Unit DCC during D1341 outage. Proper planning and execution of this major replacement work resulted in a flawless transition from legacy to new DCC equipment with no adverse impact on the Unit operation.
- Successful replacement of the CP and SEM computers with hardware emulators.
- Installation of improved annunciation software in all Unit DCCs, which resulted in the elimination of over 100,000 nuisance alarms per outage.

The valuable design and installation/commissioning experience gained from previous project accomplishments will be carried into subsequent Unit DCC installations and the display system replacements.

Reason for Schedule Variance:

The external contract milestones for the design and manufacturing of the DCC/CP/SEM computer replacements (hardware emulators) were delayed by more than 3 years due to the following reasons:

- Underestimate of the DCC hardware emulator design complexity by the vendor
- Inadequate vendor resource planning, even though a formal Procurement Strategy was established to mitigate concerns with scarce vendor resources
- Unexpected technical issues discovered during the prototype testing at the vendor site and in the OPG Computer Development Facility at Darlington

This delay was documented in a number of PCRAFs between 2008 and 2011, and is now behind us.

Project Over-Variance Approval

The requirement of having the first Unit DCC installed during an outage contributed to an additional project delay of almost one year, as the installation had to wait for the first available outage, D1341, after the design was complete.

The delays in the DCC emulator design and testing resulted in a late start of the engineering work for the Ramtek display system replacement. Given the current availability of necessary and scarce specialized engineering resources, it is estimated that the project end date will be delayed from 2015 to 2016.

Reason for Cost Variance:

The main reasons for \$2,851K cost variance are:

- SAVHO charges for 2010 through 2016 because of a change in accounting treatment, evaluated at \$1,076K, were not planned when the original project cash flows were developed.
- Additional interest of \$1,283K due to project delays.
- Underestimated or unexpected OPG labor costs, which are partially offset by lower materials and external contracts costs. Details for each cost variance category are provided under "Comments" in Part B.

Options Considered to Mitigate Overruns:

The remaining element for completion of this project is replacement of the Ramtek display system. Consideration was given to dropping this from project scope. However this is an aging, obsolete and unsupported system which is important for Unit operation. It would have to be scoped into the Darlington Refurbishment Project as an alternative, but the technical risk is greatly reduced by completing this work prior to the Refurbishment outage.

Since the Ramtek display system replacement is also needed for the Fuel Handling Computer Replacement project (33815), synergy will reduce the cost impact on this project (33977). In addition, the vendor who produced the DCC emulator will design and manufacture the Ramtek emulator interface with the DCC and the lessons learned by both the vendor and OPG will benefit the Ramtek replacement work.

**Project Over-Variance
Approval**

Part B: Variance Detail				
Choose an item.	Current Approval	Amount Requested	Variance	Comments

Project Over-Variance Approval

OPG Project Management	1,183	2,017	834	There are two main factors that contributed to additional budget request: - The extension of the project life by over 4 years - Additional project support staff not identified in the original estimate The variance \$834K consists of \$640K labor and \$194K SAVHO.
OPG Engineering	4,639	7,120	2,481	Additional OPG engineering resources were required to perform the following DCC emulator related activities: - Support to the vendor design revisions required to resolve unexpected technical issues found during the prototype testing in a real SEM/CP/DCC hardware and software configuration - Involvement in troubleshooting, comprehensive testing and support to the emulator Factory Acceptance Test - The original validation test plan was supplemented with additional integration testing of the DCC software shipment XY22 and offline commissioning of RRS and other control programs. This software shipment will be installed in all Unit DCC hardware emulators starting in the fall of 2013. A significant portion of the display system replacement design, mainly software emulation, will be performed in-house. Outsourcing is not a viable option due the lack of external expertise in the display systems used at Darlington. The variance \$2,481K consists of \$1,900K labor and \$581K SAVHO.
Permanent Materials	3,215	1,941	(1274)	The original estimate for permanent materials was based on the assumption that the computer and display system replacements would consist of custom made hardware devices with the same functionality. As the design evolved, it was determined that a significant portion of the original device functions would be accomplished by software emulation. This implies less materials and more OPG engineering activities than estimated.

Project Over-Variance Approval

Design and Construction				
Consultants				
Other Contracts/Costs				
Interest				
Subtotal				
Contingency				
Total	22,058	24,909	2,851	
Removal Costs Included				

Part C: Review/Approvals			
	Signature	Comments	Date
Recommended by: Wayne Robbins Chief Nuclear Officer Project Sponsor		None	2013-06-18
Finance Approval: Donn W. Hanbidge SVP & Chief Financial Officer			2013-06/24
Approved by: Tom Mitchell President & CEO		None	2013-06-26



Records File Information:
Original to PM File
Retention: 2 years after
close of project

Internal Use Only
N-FORM-10994-R006*

AISC Part B: Decision Record

Project Information			
Project Number:	16-33977	Project Title	Darlington DCC Replacement
BCS Controlled Document Number:	D-BCS-33977-10001		
Project Phase:	☐ Initiation	☐ Definition	☒ Execution
Release Type:	☐ Partial	☐ Full	☒ Superseding
Sponsoring BU:	Darlington NGS		
Classification:	☐ OM&A	☒ Capital	☐ Capital Spare ☐ Provision
Investment Type:	☐ Regulatory	☒ Sustaining	☐ Value Enhancing

Approval for Submission to AISC		
Submitted By:	Signature:	Date:
D. Diguier		May 14, 2013
Title: Project Manager		
Verified By:	Signature:	Date:
D. Zerkee		14 May 13
Manager Investment Management		
Approved By:	Signature:	Date:
D. Townsend		14 May 2013
BU Engineering Director		

AISC Disposition:	
☒ Submission Approved ☐ Submission Cancelled ☐ Submission Deferred ☐ Submission Returned for Rework	Signature: Chair - AISC Date: Jun 5, 2013
Comments regarding AISC disposition: <i>Actions completed</i>	

*Associated with N-PROC-AS-0039, Project and Portfolio Management



Routing Sheet

Type 3 Business Case Summary Darlington Auxiliary Heating System Project 16-34000

Routing	Location	Action	Signature	Date
Art Rob VP, Projects & Modifications 703 5435	O11-4	Reviewed by	SW for Art Rob	July 14, 15
Glenn Jager President, OPG Nuclear & Chief Nuclear Officer	P82-6	Approved by	Approved	July 15/15
Beth Summers SVP & Chief Financial Officer	TCH19	Approved by	[Signature]	July 23, 2015
Tom Mitchell President and CEO	TCH19	Approved by	[Signature]	July 27, 2015
Susan Wood EAA to Art Rob 703-5807	O11-4	Return for Distribution		

Date: 14-Jul-15



Aux Heating Steam Full BCS APPROVAL

July 8, 2015

DARLINGTON AUXILIARY HEATING SYSTEM PROJECT

DECEMBER REQUIRED

The purpose of this submission is to request Board of Directors approval of a Superseding Release of \$17.126 Million to complete the Auxiliary Heating System new Boilerhouse Project

BACKGROUND

The revision to the business case represent the final release required to complete the full in service of the boiler house project including the demolition of the original construction boiler house.

The boiler house project is being built under the ES MSA contract as a full EPC contract model which has required the stage release of the project as it has transferred through the various project phases

The project was originally released under the Refurbishment project as part of the Facilities and Infrastructure bundle of work and has been subject to the gated release process at the various project phases.

To date, the project has been through 5 gated releases covering the predefinition phase to partial construction execution as the project engineering evolved.

Gate 1 - \$437k - Preliminary concept and development of Design requirements

Gate 2 - \$1,245K - Definition Development Phase - to complete site reviews and develop RFP for the EPC contract

Gate 3 - \$4,850k - Definition Release - to complete the modification design requirements and progress detailed design

Gate 4 - \$33,432k - Partial Execution phase - to fund completion of design, long lead materials and commencement of construction

Gate 5 - \$42,407 - Partial Execution release - to fund engineering completion, construction activities, all material procurement and tie in work to existing facilities, commissioning, AFS, and detailed engineering for demolition of the original construction boiler house

The total of the previous 5 Gate release amounts is \$82.3M

Current Release Request - \$17,126 k to fund the completion of the construction, commissioning and AFS, demolition phase for old boiler house and close out

There was a decision to re-allocate the AHS project from the Refurb portfolio to the Asset Investment Screening Committee (AISC) funding as part of ongoing operational investment prior to the project being completed. As such, a transfer of the partially executed project to the new funding source has been completed in May 2015 and the release strategy for the completion of the project is now being requested under a revision to the Business Case Summary instead of the Gated Release Process used in the Refurbishment Program release

Current Request

The estimated cost to complete the installation and commissioning of the Auxiliary Heating System including the demolition of the existing Construction Boiler House requires a further \$17,126k to bring the full release amount to \$99.497 Million, including \$0.5 Million contingency.

The increase in cost to construct is the result of several factors including higher than anticipated interest costs associated with delays in the construction in service.

Higher Engineer-Procure-Construct contract costs resulting from:

- o Scope changes - \$2.8 Million
- o Under-estimation of engineering, construction and commissioning support - \$7.0 Million
- o Labour rate variances in the contract including foreign exchange impacts and increases due to the lengthened schedule - \$4.0 Million
- o Higher project management and internal support cost - \$1.7 Million

RECOMMENDATION

That the Board of Directors approve the full release of \$17.126 Million (including \$0.5 Million contingency). This will bring the total release to date to \$99.497 Million (including \$0.5 Million contingency).



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

Internal Use Only
 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 #:	16-34000	Document #:	D-BCS-00120.3-10021
Project Title:	Darlington Auxiliary Heating System Project		
Class:	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others:	Investment Type:	Regulatory
Phase:	Execution	Release:	Full
Facility:	Darlington	Target In-Service or Completion Date:	2016-10-31 (New AHSF AFS)

Project Overview
We recommend the release of \$17,126k, including \$500K of contingency. The estimated total project cost is \$99,497K, including \$500K of contingency. The quality of the estimate for this release is Class 2, and for the total project is Class 2. This release will fund the following scope of work: - Completion of Construction, Available For Service (AFS) and Engineering Change (EC) Close-out of the new Darlington Nuclear Generating Station (DNGS) Auxiliary Heating System (AHS) Boilerhouse Facility. - Complete demolition of the Construction Boilerhouse (CBH). Problem Statement/Business Need: The current Construction Boilerhouse provides back-up heating steam to DNGS to maintain the station above 10°C when all operating units are shutdown. This existing Boilerhouse is beyond its useful service end of life and has a total capacity of supplying up to approximately 45,000 kg/hr steam which does not meet the required 110,000 kg/hr as specified in the Design Requirements. The business objective of this Regulatory project is to provide a source of reliable back-up steam to the DNGS main heating steam header to support irregular operating conditions in the event when all four turbine units are shut down in the winter to mitigate potential major equipment damage due to freezing. This will be achieved by replacing the existing original CBH with a new facility that can, in the event of a four unit shutdown, provide reliable back-up steam at a sufficient capacity to provide the required calculated equivalency (110,000 kg/hr) of steam lost from the turbine units. This back-up steam will contribute significantly to maintaining the temperature inside the Powerhouse and Tritium Removal Facility/Heavy Water Management Building (TRF/HWMB) above 10°C to prevent impairment of essential systems due to freezing. The Investment Type of this Project is Regulatory as it is part of Ontario Power Generation's (OPG) commitment to the Canadian Nuclear Safety Commission in closing out a Regulatory Action Request to resolve outstanding issues related to the CBH. A key component of OPG's action plan to address the CBH legacy issues include this project with an objective of determining and implementing the most viable alternative to the current CBH. This project is categorized as an ongoing operational support project required to meet the additional extended Darlington Station life. The project funding will be accommodated within the Nuclear Operations Portfolio. The on-going operating costs will be funded from Darlington Station OM&A. Summary of Preferred Alternative: The preferred alternative is Construction of a New AHS Facility with an unavailability target of 1×10^{-2}, as well as a required heating steam rate of 110,000 kg/hr as specified in the Design Requirements. Two oil fired, water tube boilers are considered the best selection for boilers of this size and capacity. Key deliverables for this release include completion of remaining installation, Commissioning of AHS Facility, AFS, and Closeout activities. Completion costs for the demolition of the Existing Construction Boilerhouse are also included in this BCS.

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

Internal Use Only
OPG-FORM-0076-R005

Type 3 Business Case Summary

Document #: D-BCS-00120.3-10021

Project #: 16-34000
Project Title: Darlington Auxiliary Heating System Project

Project Overview

History of BCS releases and project cost estimates:

Definition Developmental Phase (\$437k total: \$427k base cost + \$10k contingency) was released in November 2010 to fund completion of a Gap Analysis Report of the preferred alternative, revise Design Requirements and complete a Black Start Option Benefit Cost Analysis and Economic Risk Assessment. A previous developmental phase release had been approved for the project in 2006 but the project was deferred in 2008 to allow for completion of the Design Basis. Of the 2006 release, \$904k was spent.

Definition Developmental Phase (\$1,245k total: \$1,094 base cost + \$151 k contingency) was released in October 2011 to fund the completion of the preliminary site investigation, and Request For Proposal (RFP) process for the Engineer, Procure, Construct (EPC) Contract.

Full Definition Phase (\$4,850k total: \$3,980k base cost + \$870k contingency) was released September 2012 to complete modification planning and initiate engineering of the new AHS.

Partial Definition Phase (\$33,432k total: \$27,349k base cost + \$6,083k contingency) was released in November 2012 to fund the detailed engineering, major component procurement and construction of the new AHS Boilerhouse.

Partial Definition Phase (\$42,407k total: \$36,611k base cost + \$5,796k contingency) to fund completion of Engineering; Materials Procurement; Facility and Tie-ins Construction, Commissioning, AFS and EC Close-out of the new AHS; EPC Contract Award for Demolition of existing CBH, and Modification Planning and Detailed Design for Demolition of CBH.

Full Execution Phase – This BCS (\$17,126k total: \$16,626k base cost + \$500K contingency) to fund completion of Facility and Tie-ins Construction, Commissioning, AFS and EC Close-out of the new AHS; and Complete demolition of the Construction Boilerhouse (CBH).

History of scope and schedule changes:

The total project cost has increased from \$85,102k to \$99,497k as a result of:

- Additional OPG Costs to support the extended Project duration from March to October for Available for Service of the New AHS.
- Additional support from Project Control Center to provide an interface with the Station to support tie-in work.
- Additional Contract for a Boiler Subject Matter Expert to augment the Project Team.
- Underestimation of the OPG Radiation Protection support required for the In-Station installations of Steam, Condensate and High Pressure Demineralised Water.
- Engineering costs have also increased substantially due to:
 - Underestimation in design complexity,
 - Late receipt of Vendor Information to support design,
 - Underestimation of the Contractual obligations per the Contractor Owner Interface Requirements,
 - Addition of a Chemical Storage Annex due to an undersized building footprint,
 - The large number of Requests For Information between Constructor and their Design Agency.
- Engineering and Construction costs for the Steam and Condensate lines to go through the Security Fence instead of under the Security Fence to minimize risk of buried services encountered utilizing directional boring technology,
- Underestimation of dewatering costs,
- Underestimation of material and construction costs. Several major material items, including boilers and auxiliary equipment, required custom design to accommodate the limited space of the building footprint, which was not part of the original bid by the Contractor.
- Procurement and Construction proceeding based on a staged release of Engineering packages. This led to inefficiencies in material procurement and construction activities.

The overall Project schedule has been impacted as a result of the challenges identified above. The Engineering completion milestone in the previous BCS of August 11, 2014 has been changed to June 12, 2015.

The new AHSF Available for Service is scheduled for October 31, 2015.

Internal Use Only
OPG-FORM-0076-R006

Type 3 Business Case Summary

Document #: D-BCS-00120.3-10021

Project #: 16-34000
Project Title: Darlington Auxiliary Heating System Project

Project Overview

Demolition of the CBH and close-out of the Project will be also completed under this Full Execution BCS. The completion date for project close-out is June 2017.

Key Assumptions and Risks:

A summary of the key risks can be found in Part G.

Project Cash Flows, NPV, and OAR Approval Amount

k\$	LTD	2016	2016	2017	2018	2019	2020	Future	Total
Currently Released	60,380	21,991							82,371
Requested Now		12,756	4,265	105					17,126
Future Required									
Total Project Cost	60,380	34,747	4,265	105					99,497
Ongoing Costs									
Grand Total	60,380	34,747	4,265	105					99,497
Estimate Class:	Class 2			Estimate at Completion:		\$98,997k			
NPV:	N/A			OAR Approval Amount:		\$99,497k			

Additional Information on Project Cash Flows (optional):

This project is not expected to increase operating costs (Darlington Station OM&A) beyond the current operating costs for the existing Construction Boilerhouse.

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 CNO			18 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			July 13, 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 and CEO per OAR 4.1			July 27, 2015



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

Internal Use Only

OPG-FORM-0076-R005*

Type 3 Business Case Summary

Project #: 16-34000

Document #: D-BCS-00120.3-10021

Project Title: Darlington Auxiliary Heating System Project

Business Case Summary

Part A: Business Need

Under normal or abnormal operating conditions, the temperature inside the Darlington Nuclear Generating Station (DNGS) Powerhouse, and Tritium Removal Facility/Heavy Water Management Building (TRF/HWMB) and other support buildings is required to be maintained to prevent freezing. This is achieved using the existing heating steam system and local electrical heating equipment. Section 11.3.1 of the Darlington Safety Report, requires that a system be in place to prevent equipment and line freezing in the event of a design-basis four unit shutdown in the winter.

When all operating units are shutdown, the current approach is to use the Construction Boilerhouse (CBH) to provide back-up heating steam to the DNGS main heating steam header. The design basis for the CBH is to provide sufficient heating steam to maintain the station temperature above 10°C in these circumstances.

The CBH facility was placed in service at the time of site construction in the early 1980's and has a total capacity of supplying up to approximately 45,000 kg/hr steam. The oil-fired boilers are used infrequently and were obtained at the time from other former Ontario Hydro construction projects. Electric boilers are also incorporated and provide the majority of the steam supply. The boilers and related equipment have received only limited and intermittent maintenance. The condition of the remaining systems, structures, and components has been assessed under Component Condition Assessments (CCA's). The piping and pipe supports require immediate field work. Other components require attention within the next 1-5 years.

The current CBH facility at Darlington cannot continue to provide the required capability because:

- It is past its useful end of life.
- It does not have sufficient installed capacity to supply the required 110,000 kg/hr steam which includes new uses such as the D2O Storage Facility and new Water Treatment Plant.
- The existing building and oil feeder piping do not meet the current code requirements.
- It was never designed as a permanent system or structure hence it is costly to maintain (foundation upgrades, pipe maintenance in pits, etc.)
- It does not meet the reliability requirements of an unavailability target of 1×10^{-2} .

Note: This project is not a post-Fukushima action item.

Part B: Preferred Alternative: Construct New Auxiliary Heating Steam Facility (AHS) Facility

Description of Preferred Alternative

This option is recommended. The new AHS system shall be designed to an unavailability target of 1×10^{-4} , as well as a required heating steam rate of 110,000 kg/hr as specified in the Design Requirements. A quantity of two oil fired, water tube boilers are considered the best selection for boilers of this size and capacity. The total on-going operating costs are currently estimated at \$350k per year. This on-going operating cost is not incremental, and is equal to the current operating costs of the CBH.

Major activities and deliverables completed under the November 2010 Developmental BCS Release include:

1. A Gap Analysis Report was issued to determine whether the previous recommendation of constructing a new Auxiliary Heating Steam Facility was still feasible based on requirements identified in the Generation of Thermal Hydraulic Information for Containments (GOTHIC) Analysis and revised Project Charter.
2. Design Requirements were revised based on future uses of heating steam, such as the new Water Treatment Plant and D2O Storage Facility.
3. Black Start Option Benefit Cost Analysis and Economic Risk Assessment.

Major activities and deliverables completed under the October 2011 Developmental BCS Release include:

1. Completed Civil, Mechanical, and Electrical ground scanning and drawing review of new AHS proposed site.
2. Completed Preliminary Geotechnical Analysis at the building site.
3. Completed a GOTHIC Analysis of the previously omitted site facilities to identify areas of vulnerability that will remain after implementation of this project.
4. Performed ultrasonic thickness condition assessment/inspection of the existing steam/condensate piping located in Unit 1 and Unit 3 to evaluate whether it will reach station End of Life in 2055.

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

Internal Use Only/ Internal Use Only
OPG-FORM-0076-R005

Type 3 Business Case Summary

Project #: 16-34000

Document #: D-BCS-00120.3-10021

Project Title: Darlington Auxiliary Heating System Project

Part B: Preferred Alternative: Construct New Auxiliary Heating Steam Facility (AHS) Facility

Description of Preferred Alternative

Major activities and deliverables completed under the September 2012 Full Definition BCS Release include:

1. Award Engineer, Procure, Construct (EPC) Contract to successful Extended Services Master Service Agreement (ES MSA) vendor for New AHS Boilerhouse
 - o Complete Modification Planning.
 - o Complete Geotechnical Investigation at the building site.
 - o Identification of Long Lead Items.
2. Front End Planning, preparation of Partial Execution Release BCS, and Project Execution Plan (PEP)

Major activities and deliverables Completed under the November 2012 Partial Execution BCS Release include:

1. Release of Phase 2 and Phase 3 funding to complete:
 - o 75% of Detailed Design
 - o Site Preparation – Relocation / mitigation of buried services within the Owner Only Construction Island.
 - o Materials Procurement.
 - o Relocation of a Security Camera which will be obstructed by the AHS Facility.
 - o Installation of domestic water hydrant.
2. Front End Planning, Project Management Plan (PMP), and preparation of subsequent Partial Execution Release BCS.

Major activities and deliverables Completed under the May 2014 Partial Execution BCS Release include:

- o *EPC Contract Phase 1 Release Deliverable:*
 - 90% Completion of Detailed Design packages.
- o *EPC Contract Phase 3 Release Deliverables:*
 - Procure outstanding longlead materials.
 - 60% Facility and Building Services including tie-ins,
 - 60% Process and ancillaries,
 - 50% Station System tie-ins,
 - Prepare Detailed Commission Spec.

This Full Execution BCS Release will fund the following:

1. Cost increases associated with previously released Scope of Work for the new AHS Boilerhouse:
 - o *EPC Contract Phase 3 Release Deliverables:*
 - Complete Detailed Design
 - Complete AHS Facility and Building Services including tie-ins,
 - Complete Pipe Fabrication,
 - Complete installation of AHS Process and ancillaries,
 - Complete installation of Station System tie-ins,
 - Commission AHS Facility and Process,
 - Available for Service for new AHS Facility and Process, and
 - Engineering Change Close-Out of the AHS Facility and Process,
 - Execution of CBH Demolition,
 - CBH Available for Service,
 - Engineering Change Close-Out of the CBH
 - Project Lessons Learned and Project Closeout
2. New Scope additions:
 - o Addition increase of ES MSA Vendor Core Team Costs.
 - o Through the Security fence design vs under.
 - o Increased Costs due to extended Schedule.
 - o Additional support from Boiler Subject Matter Expert.
 - o Underestimation of the OPG Radiation Protection for work inside the Protected Area.
 - o Additional Engineering costs to support the new AHS and CBH Demolition.
 - o Dewatering and dewatering winterization.
 - o Master Equipment List and Bill of Material header work to be completed by Contractor.
 - o Commissioning work plan strategy changes to be completed by Contractor.
 - o Stress Analysis of the Standby Generator fuel lines.

Internal Use Only
OPG-FORM-0076-R005

Type 3 Business Case Summary

Document #: D-BCS-00120.3-10021

Project #: 16-34000
Project Title: Darlington Auxiliary Heating System Project

Part B: Preferred Alternative: Construct New Auxiliary Heating Steam Facility (AHS) Facility		
Description of Preferred Alternative		
Deliverables:	Associated Milestones (if any):	Target Date:
New AHS - Detailed Engineering Complete	New AHS-Detailed Eng Complete	June 12, 2015
New AHS - Installation and Commissioning Complete	New AHS-Final AFS	Oct 31, 2015
Demo CBH - Demolition Planning Complete	Demo CBH-Start of Demolition	June 15, 2016
Demo CBH - Building Demolition Complete	Demo CBH-Final AFS	Oct 30, 2016
Project Close Complete	Plan Complete	June 30, 2017

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 – Status Quo – No Project

The option of Status Quo (Do Nothing) is not recommended. The existing Construction Boilerhouse does not meet a unavailability target of 1×10^{-2} . Additionally, the condition of the systems, structures and components has been assessed under CCA's which indicate that the piping and pipe supports require immediate field work. Other components require attention within the next 1-5 years. Furthermore, the existing boilerhouse only supplies 45,000 kg/hr steam, while the new Design Requirements indicate the back-up steam required is 110,000 kg/hr.

Alternative 3: Delay Work – Delay Construction of New AHS Facility

This option is not recommended. Delaying this project will result in significant OM&A costs (foundation upgrades, pipe maintenance in the pits, etc.) to the existing boiler house identified in the CCAs. This alternative was considered and eliminated, therefore, not included in the financial evaluation.

Alternative 4: Boiler Rental

Boiler rental from an external company to the end of Darlington's post-refurbishment station life (2055) is not recommended. Two different options for Boiler rental were preliminarily examined; delivery of portable boilers during an emergency situation and on-site rental units.

- **Delivery of Portable Generators During an Emergency:** The most critical disadvantage is the high potential for significant delays before full capacity steam is available and provided for use in the plant, due to reliance on an external company and the logistics involved in mobilization, transportation to site, and set-up in an emergency situation. Estimates range from 24-36 hours before the boiler units reach site, plus additional connection time before steam will be available. Further disadvantages include
 - high stresses induced in boiler components and structures due to difficulties in alignment during installation or sagging foundation over time,
 - a larger footprint since portable boilers generally have horizontal cylindrical design to allow for transport on highways and
 - 3-4 units would be needed to meet the required demand since portable boiler capacity is currently limited to about 34,000 kg/hr for highway transportation,
- **On-Site Rental Units:** This alternative is also not desirable due to the following:
 - the boilers would require a small enclosure and heat tracing on the feed water piping for protection from the elements,
 - portable boilers and equipment on the skid would not be tagged to OPG standards. As such, a contract with a third party would be required for maintenance and operation (approximately \$200-400k / year, 2012 budgetary costs), and
 - rental costs for the required size / number of portable units is estimated at approximately \$180k/month (\$2.2M / year 2012 estimate), depending on the length of the contract.

In addition, similar to the Recommended Alternative, this option would still require installation of a new steam line, and steam condensate, fuel and demineralized water tie-ins to the station, as well as the possibility of new electrical lines to support the rental units. These costs are expected to have increased in the same proportion since 2012 as the costs of the Recommended Alternative. For these reasons, the costs for this alternative were not updated in 2014 and it was not included in the financial

Internal Use Only Internal Use Only
OPG-FORM-0076-R005

Type 3 Business Case Summary

Project #: 16-34000
Project Title: Darlington Auxiliary Heating System Project

Document #: D-BCS-00120.3-10021

Alternative 4: Boiler Rental
evaluation for this release.
Alternative 5: Construct New AHS Facility with Black Start Capability
This alternative was considered and eliminated. This would add approximately \$20M to the total initial project costs of Alternative 1, plus an additional \$0.75M in maintenance costs per year totalling ~ \$45M from 2015 to 2055. Two independent assessments were obtained: an economic risk assessment performed internally by Nuclear Finance, and a Black Start economic assessment performed externally, which both concluded that it is not economically justified to include a Black Start capability into the new AHS. This alternative is, therefore, not included in the financial evaluation for this release.
Alternative 6: Refurbish Existing Construction Boilerhouse
This alternative was considered and eliminated. Similar to the Base Case, Refurbishment of the existing Construction Boilerhouse is not recommended based on the fact it does not meet the minimum unavailability target, nor does it supply the required amount of steam per the Design Requirements. Much of the existing infrastructure still requires replacement since it cannot support the station to its current post refurbishment end of life date (2055). This alternative is, therefore, not included in the financial evaluation for this release.
Alternative 7: Alternative Fuel Supplies
Alternative fuel supplies were examined for the AHS including electric, gas, and electric/oil combination fired boilers. These types of boiler facilities are not recommended. The cost to install new electric transmission lines and a switchyard, or natural gas transfer lines to site is in excess of \$6M (per preliminary 2012 estimates). Dealing with two types of technology for combination boilers adds further logistical and cost concerns. Considering the Boilerhouse facility does not operate frequently, the additional costs associated with installation are not justified. This alternative is, therefore, not included in the financial evaluation for this release.
Alternative 8: Co-Generation Plant
This alternative was considered and eliminated. A Co-Generation plant is not recommended due to the high initial investment cost of greater than \$100M (2012 estimate). There are also no corporate drivers to support this alternative at this time. Additionally, it is unlikely that real estate would be available at Darlington to site the co-generation plant in such a way that the steam transmission lines can be kept reasonably short. Delays due to likely need for an environmental assessment will make meeting the project schedule impossible.). This alternative is, therefore, not included in the financial evaluation for this release.

Part D: Project Cash Flows, NPV, and OAR Approval Amount									
Choose an Item	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	60,380	21,991							82,371
Requested Now		12,756	4,265	105					17,126
Future Required									
Total Project Cost	60,380	34,747	4,265	105					99,497
Ongoing Costs									
Grand Total	60,380	34,747	4,265	105					99,497
Estimate Class:	Class 2				Estimate at Completion:		\$98,997k		
NPV:	N/A				OAR Approval Amount:		\$99,497k		
Additional Information on Project Cash Flows (optional):									
This project is not expected to increase operating costs (Darlington Station OM&A) beyond the current operating costs for the Construction Boiler House.									

Part E: Financial Evaluation					
k\$	Preferred Alternative	Base Case	Delay Work	Alternative 4	Alternative 5
Project Cost	98,997k				
NPV	N/A				
Other (e.g., IRR)					

Internal Use Only Internal Use Only
OPG-FORM-0076-R005

Type 3 Business Case Summary

Document #: D-BCS-00120.3-10021

Project #: 16-34000
Project Title: Darlington Auxiliary Heating System Project

Summary of Financial Model Key Assumptions or Key Findings:
(1) Discount rate of 7%.
(2) Escalation rate of 2%.
(3) Interest rate of 5% on capital costs.
(4) Project Costs include demolition costs.

Part F: Qualitative Factors
- This project will mitigate increased risk during refurbishment for reliable and sufficient heating steam in the event of a four unit outage, as there will be extended durations where two units are shutdown for scheduled refurbishment activities, effectively increasing the likelihood of a four unit outage. - A Station Containment Outage (SCO) is currently scheduled for 2022 during refurbishment; therefore, the AHS will be required to provide steam for TRF processes and heating to the station during that time period.

Part G: Risk Assessment				
Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	The CBH Demolition risk is that underground soil contamination may be encountered during demolition resulting in remediation of site being required.	Accept: EPC Contractor to safely remediate and dispose of contaminated soil. Allocated contingency of \$250K to cover the cost of site remediation.	Medium	Medium
Cost	There is a CBH Demolition risk that unknown asbestos and lead maybe encountered requiring remediation and removal during demolition.	Accept: EPC Contractor to safely remediate and dispose of hazardous material. Allocated contingency of \$200K to address this risk.	Medium	Medium
Schedule	There is a risk that Operation and Maintenance Training will not be in place for the AFS date. Training department cannot complete the TNA until they have all the information from the Project. I.e. Flowsheets, Vendor Data, Operational Manuals, Maintenance Procedures.	Mitigate: Fleet Training Operations, Operations Line Management, the Vendor and project staff will work together to support completion of the Training Needs Analysis (TNA). Once Fleet Training has been provided the opportunity to complete an initial review of the Operating documentation a training recovery plan will be developed with the involvement of all stakeholders. This training plan will include completion dates for the TNA, vendor training plan accepted by OPG, training material development and training delivery.	High	Medium
Schedule	There is a risk the New AHSF Final AFS date could be extended due to underestimation and misalignment by Vendor of what deliverables must be completed prior to AFS. I.e. Spare Parts identified and Procured, Preventative Maintenance identified and scheduled, Maintenance Procedures, Operating Manuals and Operational Flow sheets.	Mitigate: Weekly AFS readiness meetings are setup with the Vendor and stakeholders to understand all the requirements that must be completed in order to achieve AFS. Project is seeking assistance of Refurbishment Operations and Maintenance to help vendor identify these deliverables.	High	Medium

Internal Use Only
OPG-FORM-0076-R005

Type 3 Business Case Summary

Project #: 16-34000
Project Title: Darlington Auxiliary Heating System Project

Document #: D-BCS-00120.3-10021

Part G: Risk Assessment				
Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
Quality/ Performance	There is a risk that the Project turnover documentation from the Vendor may not be accepted by OPG due to missing information and quality issues.	Mitigate: Weekly meetings are setup with Vendor and OPG to review packages that are currently completed. OPG will accept packages as they are completed.	Medium	Low
Cost	The Fixed Price Cost To Complete (CTC) price from Contractor states that \$79.4M is required to complete the New AHS Facility. The Vendor stated the assumption in the CTC if the AFS date extends past Oct 2015 due to delay from OPG, extra funding would be required.	Accept: The Project is working with the Station to monitor and influence any delays that OPG may impose on the Contractor.	Med	Med
			Choose an item.	Choose an item.
Additional Risk Analysis:				
See Risk Management Plan within the Project Management Plan for a comprehensive list of risks.				

Part H: Post Implementation Review (PIR) Plan				
Type of PIR Report	Target In-Service or Completion Date		Target PIR Completion Date	
Comprehensive PIR	2015-10-31 (New AHSF)		2017-08-30	
Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Provide heating steam flow rate of 110,000 kg/hr as per Design Requirements.	45,000 kg/hr	110,000 kg/hr	Acceptance of commissioning results and subsequent successful AFS of new AHS.	Performance Engineering /Operations & Maintenance / Project Design
Identify all susceptible equipment and components vulnerable to freezing in the vulnerable areas identified by the GOTHIC analysis.	Current revision of GOTHIC analysis identifies all areas of the plant which are vulnerable, but does not identify the susceptible equipment and components in those areas.	Identify all process equipment vulnerable to freezing and complete walk downs and document susceptible equipment and components in these areas.	Acceptance of revised GOTHIC analysis report and subsequent identification of affected equipment in vulnerable areas before AFS.	Design
Reliability requirements satisfied.	Does not meet requirements.	1×10^{-2}	Design Acceptance of vendor submitted analysis report.	Projects Design

Part I: Definitions and Acronyms	
AFS	Available for Service
AHS	Auxiliary Heating System
ASL	Approved Suppliers List
BCS	Business Case Summary
CBH	Construction Boiler House
CCA	Component Condition Assessment
CMO	Contract Management Office
COMS	Constructability, Operability, Maintainability, Safety
CTP	Consent to Proceed

~~Internal Use Only~~ Internal Use Only
OPG-FORM-0076-R005

Type 3 Business Case Summary

Document #: D-BCS-00120.3-10021

Project #: 16-34000
Project Title: Darlington Auxiliary Heating System Project

Part I: Definitions and Acronyms

DNGS	Darlington Nuclear Generating Station
DR	Design Requirements
EC	Engineering Change
ECC	Engineering Change Control
EOL	End of Life
EPC	Engineer, Procure, Construct
ES MSA	Extended Services Master Service Agreement
FE	Field Engineering
FMOD	Facilities Modification
GOTHIC	Generation of Thermal Hydraulic Information for Containments
HWMB	Heavy Water Management Building
JSA	Job Safety Analysis
MOE	Ministry of Environment
OPEX	Operating Experience
OPG	Ontario Power Generation
OPS	Operations
PCA	Project Change Authorization
PDRI	Project Definition Rating Index
PEP	Project Execution Plan
PSVS	Power House Steam Venting System
QS	Quality Surveillance
RAB	Reactor Auxiliary Bay
RFP	Request for Proposal
RP	Radiation Protection
SOW	Scope of Work
TH	Turbine Hall
TRF	Tritium Removal Facility

Internal Use Only~~Internal Use Only~~
OPG-FORM-0076-R005

Type 3 Business Case Summary

Document #: D-BCS-00120.3-10021

Project #: 16-34000
Project Title: Darlington Auxiliary Heating System Project

This page is intentionally left blank

~~Internal Use Only~~~~Internal Use Only~~
OPG-FORM-0076-R005

Type 3 Business Case Summary

Document #: D-BCS-00120.3-10021

Project #: 16-34000
Project Title: Darlington Auxillary Heating System Project

For Internal Project Cost Control

Internal Use Only
OPG-FORM-0076-R005

Type 3 Business Case Summary

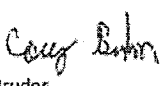
Document #: D-BCS-00120.3-10021

Project #: 18-34000

Project Title: Darlington Auxiliary Heating System Project

Appendix A: Summary of Estimate										
Project Number:	18-34000									
Project Title:	Darlington Auxiliary Heating System Project									
\$	LTD	2015	2016	2017	2018	2019	2020	Future	Total	%
OPG Project Management and Support	4,336	945	466	65					5,812	6
OPG Engineering (including Design)	2,322	327	168	40					2,857	3
OPG Procured Materials	19	31							50	0
Other (Vendor Core Team)	878	429							1,307	1
Design Contract(s)	822								822	1
EPC Contract(s)	50,164	29,901	3,683						83,748	84
Consultants										
Other Contracts/Costs										
Interest	1,839	2,562							4,401	4
Subtotal	60,380	34,195	4,317	105					98,997	
Contingency	0	500							500	1
Total	60,380	34,695	4,317	105					99,497	100

Notes			
Project Start Date	2006-03-23	Total Definition cost (excludes unspent contingency for Nuclear)	\$3,980 M
Target In-Service (or AFS) Date	2015-10-31 (New AHSF)	Contingency included in this BCS (Nuclear only)	\$500 K
Target Completion Date	2017-06-30	Total contingency released plus contingency in this BCS (Nuclear only)	\$12,379 K
Escalation Rate	2.00%	Total released plus this BCS without contingency (Nuclear only)	\$98,997 K
Interest Rate	5.00%	Total released plus this BCS with contingency (Nuclear only)	\$99,497 K
Removal Costs	\$4.758 M (\$4.398M EPC Contract and \$0.360M OPG)	Estimate at Completion (includes only spent contingency for Nuclear)	\$98,997 K

Prepared by:	Approved by:
 Cory Bruder Technical Engineer/Officer Darlington Projects	 Mike Marino Section Manager Darlington Projects
July 10, 2015 Date	10 Jul 2015 Date

Type 3 Business Case Summary

Document #: D-BCS-00120.3-10021

Project #: 16-34000

Project Title: Darlington Auxiliary Heating System Project

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
			2011	2012	2013	2014	2015	2016		
Initiation	Developmental	2006-03-23	23,505							23,505
Initiation	Developmental	2010-11-08	4,627	3,062	13,122	11,989	13,043	251		46,094
Definition	Developmental	2011-10-04	1,521	1,130	10,537	19,018	5,946	464		38,616
Definition	Full	2012-09-17	1,429	2,677	14,425	23,821	3,023	190		45,565
Execution	Partial	2012-11-01	1,429	1,644	14,092	25,615	2,625	202		45,607
Execution	Partial	2014-05-16	1,429	1,467	14,932	57,407	9,374	493		85,102
Execution	Full	2015-05-22	1,429	1,467	14,932	42,552	34,695	4,317	105	99,497

Project Variance Analysis					
k\$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management and Support	4,336	4,244	5,812	1,568	\$587K increase due to the extended duration of Project from March 2015 AFS to October 2015 AFS. \$154K added for OPG Project Control Centre (PCC) Support. \$130K added for increased OPG Project Management support providing Oversight / Reporting and Coordination within OPG Support Groups from April 2014 to October 2015. \$181K added for Operations Boiler Subject Matter Expert to assist in review of Operational Documentation and Flowsheet Support. \$202K increase due to underestimation of OPG Radiation Protection to support the In-Station installations for: Steam, Condensate and High Pressure Demin Water and RP scanning trucks. \$141K increase due to the underestimation of the OPG Drawing Office to complete the Drawing Documentation required for OPG Work Protection and Operations. \$173K increase due to the underestimation of the Operation manuals and Maintenance Procedures.
OPG Engineering (including Design)	2,322	2,740	2,857	117	\$117K increase due to the extended duration of Project and the strategy to release engineering packages with holds so construction can keep progressing.
OPG Procured Materials	19	0	50	50	As per the ES MSA Agreement OPG to pay for welding consumables.
Other (Vendor Core Team)	878	942	1,307	365	\$365K increase due to the extended duration of the Project.
Design Contract(s)	822	822	822	0	Historical Design Contract costs to complete GOTHIC Analysis, Black Start Evaluation, Geotechnical Analysis and Hazard Assessment. Costs were captured under EPC

Type 3 Business Case Summary

Document #: D-BCS-00120.3-10021

Project #: 16-34000

Project Title: Darlington Auxiliary Heating System Project

Project Variance Analysis					
k\$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
					Contracts in the last BCS.
Construction Contract(s)	0	0	0		12. N/A
EPC Contract(s)	50,164	66,448	83,748	17,300	13. AHS Approved Project Change Requests (PCA's) due to Design and Construction scope changes totalling \$3,938K 14. AHS EPC Vendor Cost to Complete increase totalling \$13,362K due to: - Underestimation in the Engineering Construction / Commissioning support requirements resulting in an increase of \$5,441K. - Material procurement underestimation resulting in an increase of \$929K. - Fabrication cost underestimation resulting in an increase of \$1,500K. - Underestimation of Sub-Contractor costs for insulation, scaffold, painting and civil support resulting in \$2,778K. - Schedule extension resulting in Labour increase of \$2,714K.
Consultants	0	0	0		N/A
Interest	1,839	4,110	4,401	291	15. Interest costs have increased due to extended schedule.
Subtotal	60,380	79,306	98,997	19,691	
Contingency	0	5,796	500	(5,296)	16. Contingency (\$5,296K) from the previous release has been transferred to the base cost. 17. Risks have been re-assessed and contingency allocated of \$500K is required
Total	60,380	85,102	99,497	14,395	

Type 3 Business Case Summary

Document #: D-BCS-00120.3-10021

Project #: 16-34000

Project Title: Darlington Auxiliary Heating System Project

Appendix C: Financial Evaluation Assumptions

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

Project Cost:

1. Installation, and commissioning estimates do not change significantly outside of allotted contingency.
2. Sufficient funds in the portfolio.

Financial:

1. Discount Rate of 7%.
2. Escalation rate of 2%.
3. Interest rate of 5% on Capital costs.

Project Life:

1. The new AHS will remain in service to the end of Darlington's post-refurbishment life (2055).

Operating Cost:

1. The total on-going operating costs for the new AHS Boilerhouse are currently estimated at \$350k per year. These costs were not included in the financial evaluation as they are not incremental operating costs.

Other:

1. The new AHS is classified as a non-Safety Related System.

Appendix D: References

D-BCS-00120.3-10011 – Developmental BCS
D-BCS-00120.3-10013 – Developmental BCS
D-BCS-00120.3-10002 – Full Definition BCS
D-BCS-00120.3-10003 – Partial Execution BCS
D-BCS-00120.3-10020 – Partial Execution BCS
NK38-CORR-00531-15249

Filed: 2016-05-27

EB-2016-0152

Exhibit D2-1-3

Attachment 1, Tab 11, 34000

Page 20 of 20

Internal Use Only

OPG-FORM-0076-R005

Type 3 Business Case Summary

Document #: D-BCS-00120.3-10021

Project #: 16-34000

Project Title: Darlington Auxiliary Heating System Project

Type 3 Business Case Summary

Final Security Classification of the BCS: **OPG Confidential**

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

Executive Summary and Recommendations			
Project #:	16-36001	Title:	Purchase of PHT Pump Motor Capital Spares
Phase:	Execution	Release:	Superseding
Facility:	Darlington	Records File:	D-BCS-33130-10003
Class:	Capital Spare	Investment Type:	Sustaining

Project Overview

We recommend the release of \$15.4 M (\$15.4 M base costs plus \$0 M contingency).
This brings the total release to \$30.8M (\$0 contingency) which is the contract cost for the capital spares.

Two new motors are currently being procured from the Original Equipment Manufacturer (OEM) under the original release. This release is to provide for an additional 2 motors for a total of 4 Primary Heat Transport (PHT) pump motor capital spares. This would permit refurbishment of up to 4 motors per year and accelerate the risk mitigation associated with motor failure and resulting potential for significant revenue losses.

Background:

There are four 100% duty PHT pumps per unit, for a total of 16 with one spare motor available on standby. Failure of any one of the operating motors will result in a prolonged forced outage depending on availability of the spare motor.

Ozone has been found in 8 of the 16 PHT motors with six of the 8 motors having ozone concentrations that are 10 times industry tolerance. The presence of ozone is evidence of partial discharge in the stator windings and/or electrical connections, which is a 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 in 2014.

There is operational experience that motors manufactured by the same OEM have similar problems at other U.S. stations. The OEM has formally notified OPG that based on their assessment of the condition of the PHT pump motors; they believe that five of the motors could fail at any time.

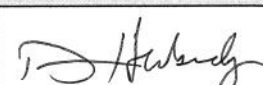
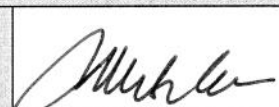
The current situation, with one spare available (in deteriorated condition), permits refurbishment of only one motor per year and carries significant risk of an extended forced outage should a motor fail during the 5 month refurbishment window or fail catastrophically and delay the program for 2 to 3 years again compounding the risk.

The balance of the PHT pump motors are being considered for refurbishment starting in 2014 and continuing into the refurbishment project. The recommended change in strategy from two motors per year to three and up to four motors per year will require additional funds to accommodate this refurbishment strategy.

Type 3 Business Case Summary

Page 2 of 17

Project Cash Flows									
M\$	LTD	2013	2014	2015	2016	2017	2018	Future	Total
Currently Released		15.4							15.4
Requested Now	-	15.4							15.4
Future Required	-								
Total Project Cost									30.8
Ongoing Costs	-								
Grand Total									30.8
Estimate Class:	Class 1			Estimate at Completion:			30.8		
NPV:	\$170.8 M			OAR Approval Amount:			30.8		
Additional Information on Project Cash Flows (optional): Totals may not add up due to rounding.									

Approvals			
	Signature	Comments	Date
This BCS represents the best option to meet the validated business need in a cost effective manner.			
Recommended by: Wayne Robbins Project Sponsor		None	2013-05-16
I concur with the business decision as documented in this BCS.			
Finance Approval: Donn Hanbidge SVP - Chief Financial Officer			2013-05-29
I confirm this project will address the business need, is of sufficient priority to proceed, and provides value for money.			
Approved by: Tom Mitchell President & CEO, per OAR #			2013-05-31

Type 3 Business Case Summary

Final Security Classification of the BCS: **Choose an item.**

Business Case Summary

Part A: Business Need

Business Need:

The business objective for the acquisition of the capital spares is to mitigate the risk of unit forced outage(s) due to failure of a PHT Pump Motor through the initiation of a schedule of planned refurbishments.

The current motors are experiencing increasing ozone levels, which indicate higher than normal levels of degradation in the windings, in some cases 10 times higher than industry tolerances. The manufacturer has formally notified OPG that five of the motors could fail at any time. There is no installed redundancy in the PHT pump motors and failure would result in a prolonged unit shut down. The existing standby spare is required to manage the risk associated with an unforeseen motor failure during operation. A condition assessment will be performed on the first motor refurbished in 2014.

Part B: Preferred Alternative

Description of Preferred Alternative: Purchase four spare motors, replace three at a time

Purchase two additional spare PHT motors for a total of four new motors. The plan would replace from two motors per year to three and up to four motors per year at a time, along with a spare motor available for standby. The worst motors would be overhauled by 2016, with the last motor being refurbished in 2018. Purchasing two additional motors immediately would lessen the exposure to probable revenue loss because of the improved reliability. The risk would be reduced, to a forced outage of approximately 5 weeks to install the spare motor. (Motor overhaul with rewind is \$2.5M/motor) See attached proposed motor replacement schedule.

The intended storage area for these spare motors is adjacent to the existing spare motor on the turbine hall floor Unit 4. These motors are supplied with storage stands which would be shipped with the motors.

Civil Design calculations required for floor loading purposes and Space allocation will be address by Plant Design under their base budget.

At the end of the refurbishment stage, Darlington will have five spares PHT pump motors available which will allow for the needed motor condition assessments and routine in-depth maintenance as required.

Deliverables:

Purchase two additional pump motors (complete with motor stands) at a price of \$15.4M, for at total of 4 spare motors on stands to be delivered in 2013.

Associated Milestones (if any):
Target Date:

Sept. 30, 2013

Type 3 Business Case Summary

Part C: Other Alternatives

Base Case: Status Quo – Purchase two spare motors, replace one at a time

Senior and Corporate management have committed to accelerating risk mitigation associated with motor failure.

Alternative 2: Purchase four motors, replace two at a time

Replace the motors two at a time keeping one additional spare for a total of two good spares on hand (not crediting the degraded motor pulled from Unit 2). With only one good spare on hand, and with unknown reliability of 8 of 16 PHT pump motors, there is a risk of an extensive forced outage due to single or multiple PHT motor failures. A single motor failure with a spare on hand would result in a 5 week forced outage while a two motor failure with only one spare on hand would result in up to 9 months forced outage. Motor replacements would be completed by 2020.

Alternative 3: Purchase four motors, replace four at a time

The feasibility of performing four motor changeouts in a planned outage and refurbishing them prior to the next installation window has not been determined to sufficient confidence. It is likely that four motors would require an outage extension and until some experience is gained motor shops capacity may be limited to three motors in the available window between installations. In addition, there would be a long window of vulnerability with limited to no spares (only spare would be the old motor pulled from Unit 2 which should not be credited and used only in an emergency). This alternative can be re-evaluated as the program progresses based on findings/needs and experience.

Alternative 4:

N/A

Part D: Project Cash Flows

M\$	LTD	2013	2014	2015	2016	2017	2018	Future	Total
Currently Released	-	15.4	-	-	-	-	-	-	15.4
Requested Now	-	15.4	-	-	-	-	-	-	15.4
Future Required	-	-	-	-	-	-	-	-	-
Total Project Cost	-	-	-	-	-	-	-	-	30.8
Ongoing Costs	-	-	-	-	-	-	-	-	-
Grand Total	-	30.8	-	-	-	-	-	-	30.8
Estimate Class:	Class 1	Estimate at Completion:		30.8		OAR Approval Amount:		30.8	

Additional Information on Project Cash Flows (optional):

Totals may not add up due to rounding.

Type 3 Business Case Summary**Part E: Financial Evaluation**

M\$	Preferred Alternative	Base Case	Alternative 2	Alternative 3	Alternative 4
Project Cost	30.8	N/A	30.8	30.8	
NPV (after tax)	171.2	-384.4	170.3	139.2	

Summary of Financial Model Key Assumptions (see Guidance on this Type 3 BCS Form):

- (1) Reliability analysis of the base case (no spares) and recommended alternative (four spares) simplified by assuming a one component without spare and one component with spare system.
- (2) It is assumed that only one motor would fail on the unit, i.e. there would not be simultaneous failure of two or more motors on any individual generating unit.
- (3) The failure rate of the existing motors is assumed to be 5.76×10^{-6} failures per hour based on the failure rate assumed in the Darlington Probabilistic Risk Assessment.
- (4) The failure rate of the new and refurbished motors is assumed to be 4.76×10^{-6} failures per hour based on a study for the U.S. Nuclear Regulatory Commission "Aging Assessment of Large Electric Motors in Nuclear Power Plants (NUREG/CR-6336)

Part F: Qualitative Factors

The above business case does not take into account any motor failures which cause total destruction of the motor. The purpose for purchasing two additional pump motors is to allow us to send up to four motors out for overhaul or condition assessment, while leaving the existing spare motor available and on site for emergency motor exchanges. By overhauling and doing condition assessments, we are endeavouring to make sure our motors are reliable.

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost				
Scope				
Schedule				
Resources				
Quality/ Performance				
Technical				
Other				

Additional Risk Analysis:**Part H: Post Implementation Review (PIR) Plan**

Type of PIR	Target Project In Service Date		Target PIR Completion Date	
Not Applicable	YYYY-MM-DD		YYYY-MM-DD	
Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Risk Level	Medium	Low	BURSA Score	Nuclear Engineering
Risk Timeline	Risk to 2020	Mitigated by 2018	Motors refurbished by 2018	Nuclear Engineering

Type 3 Business Case Summary

--	--	--	--	--

Part I: Definitions and Acronyms

BCS - Business Case Summary

NPV – Net Present Value

OM&A - Operating, Maintenance and Administration

OPEX - Operating Experience

OPG - Ontario Power Generation

PD – Partial Discharge Testing

PHT – Primary Heat Transport

PM – Pump Motor

PO - Purchase Order

QA - Quality Assurance

RFI – Request for Information

RFP - Request for Proposal

RFQ - Request for Quotation

Type 3 Business Case Summary

This page is intentionally left blank

Type 3 Business Case Summary

For Internal Project Cost Control

Type 3 Business Case Summary**Appendix A: Summary of Estimate**

Project Number:	16-36001	Facility:	Darlington							
Project Title:	Purchase Of PHT Pump Motor Capital Spares									
Estimated Cost in M\$										
	LTD	2013	2014	2015	2016	2017	2018	Future	Total	%
OPG Project Management										
OPG Engineering										
Permanent Materials		30.8							30.8	100
Design and Construction										
Consultants										
Other Contracts/Costs										
Interest										
Subtotal		30.8							30.8	
Contingency										
Total		30.8							30.8	
Removal Costs Included										

Notes

Project Start Date	2012-01-01	Project Completion or In-Service Date	2013-09-30
Interest Rate	N/A%	Escalation Rate	N/A%
Definition Cost Included	\$N/A M	Estimate at Completion	\$30.8 M

Prepared by:	Approved by:
 Ralph Stube Section Manager - Mechanical 2013-05-07	 for Nalini Valliere Department Manager 2013-05-07

Type 3 Business Case Summary

Appendix B: Comparison of Total Project Estimates										
Phase	Release	Date (YYYY-MM-DD)	Total Project Estimate in M\$ (by year including contingency)						Later	Total Project Estimate
			2012	2013	2014	2015	2016	2017		
Execution	Full	2010-04-09	12.0	-	-	-	-	-	-	12.0
Execution	OVA	2011-09-26	-	15.0	-	-	-	-	-	15.0
Execution	Super	2013-03-28	-	30.8	-	-	-	-	-	30.8

Project Variance Analysis					
Estimated Cost in k\$					
M\$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management					
OPG Engineering					
Permanent Materials		15, 400	30, 800	15,400	Increase number of pump motors being purchased from 2 to 4.
Design and Construction					
Consultants					
Other Contracts/Costs					
Interest					
Subtotal					
Contingency					
Total					
Removal Costs Included					

Type 3 Business Case Summary**Appendix C: Financial Evaluation Assumptions**

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

Project Cost:

- (1) Cost of motors is \$30,795k per OEM quotation.
- (2) Two motors are received in August 2013 and two in September 2013.

Financial:**Project Life:**

- (1) Reliability evaluation conducted to end of 2032 only.

Energy Production:

- (1) Net output of DN unit assumed to be 878 MW.

Operating Cost:

- (1)

Other:

- (1) Reliability analysis of the base case (no spares) and recommended alternative (four spares) simplified by assuming a one component without spare and one component with spare system. This simplification is justifiable since the failure of one motor would result in a forced outage; however, it does over-estimate the benefits. To offset that benefit, the analysis is truncated at 2032 (i.e. assuming no benefit past that date)
- (2) It is assumed that only one motor would fail on the unit, i.e. there would not be simultaneous failure of two or more motors on any individual generating unit. This allows the probability of the failure of the simplified single component to be calculated as the intersection of the individual probabilities.
- (3) The failure rate of the existing motors is assumed to be 5.76×10^{-6} failures per hour based on the failure rate assumed in the Darlington Probabilistic Risk Assessment
- (4) The failure rate of the new and refurbished motors is assumed to be 1 per 24 years based on a study for the U.S. Nuclear Regulatory Commission "Aging Assessment of Large Electric Motors in Nuclear Power Plants (NUREG/CR-6336)

Attach further detail as appropriate from the Financial Evaluation spreadsheet.

Appendix D: References

Enterprise Risk ER19731 – "Darlington Primary Heat Transport Pump Motor Failures Impacting Station Operations"

Memorandum, B. Duncan to T. Mitchell and D. Hanbridge, "Procurement of Two Additional Heat Transport System Pump Motor Capital Spares (total of four)", 02 December, 2011.

Type 3 Business Case Summary

This Guidance section should be deleted prior to submission of the BCS.

Guidance for Completing this Type 3 Form:

Always use the latest revision of the Form!
Verify this is the latest revision through PowerSearch,
or Finance BCS Toolkit intranet website.

Final Security Classification

Determine the Final Security Classification of the BCS from the drop-down list before both the Executive Summary and Recommendations and Part A. Refer to OPG-STD-0030 Classification, Protection and Release of Information.

Executive Summary and Recommendations*Records File Information*

Refer to OPG-PROC-0019, Records and Document Management for the requirements and expectations of record filing after the BCS is submitted.

The SCI used for record filing should be:

- 00120.3 for Nuclear BCSs.
- 08707.021 for BCSs of all other business units and corporate groups.

Submitted BCSs shall also be filed according to local BU governance, which may require different SCIs.

Project Overview

State the following:

- What needs to be done and why it needs to be done.
- When the investment/project will be completed.
- Key business objectives.
- Expected benefits of the investment/project.
- Whether the investment/project is within the original scope as specified in the approved Business Plan and/or Life Cycle Plan.
- Brief history of previous releases.
- Level of confidence for current request.
- If critical to the decision, any constraints on the investment/project or its timing.

Project Cash Flows

This table in the Executive Summary and Recommendations section is the same as the table in Part D: Project Cash Flows. See guidance for Part D: Project Cash Flow.

Approvals

Provide the title and name of the individuals making the three required signatures: the Project Sponsor, the individual providing Finance Approval, and the Approver of the BCS per the OAR. The Comments cell is to allow brief hand-written comments. For example, "see comment on Part D", which would refer to a hand-written comment later in the BCS document. These comments would be minor in nature; otherwise a reviewer would require revisions to the BCS before signing the document.

Business Case Summary**Part A: Business Need**

This section describes the business needs or opportunities that gave rise to the investment. It provides background and context for the investment including: the investment's purpose, what's driving the investment, why the investment needs to be addressed now, what are the impacts of not proceeding, key assumptions, identification of any subsequent commitments or obligations, and the benefits or constraints that the investment will create. Provide studies, experience or lessons learned from similar investments, if available. If this submission relates to a subsequent approval, provide a quick overview of investment history.

If the investment is a subset of a program, or if the issue to be addressed is symptomatic of a broader issue that requires additional response, provide the context and identify the related response, whether planned or anticipated.

Part B: Preferred Alternative

This section describes expected business results and objectives, including resourcing requirements, when the investment will be completed, and any major milestones. The proposal section must put the investment into the proper context by providing the link between the investment and the business strategy for the asset and/or other planned investments in that asset.

Describe the link between this investment and business strategy or other investments. Disclose if the resourcing is in place. Alternatively, if the investment is not in the business plan, or if the scope has changed relative to the Business Plan, reasons for the change(s) must be provided.

State the expected benefits and what is being delivered, without specifying vendor name(s). Describe briefly project execution strategy, regulatory approvals, third party agreements, project management, and basis for the cost and schedule contingencies, if applicable. Highlight any constraints on the investment or on its timing, and any constraints or obligations created by the investment.

Deliverables

In the Deliverables section, list the project deliverables and target completion dates, including associated milestones (such as unit in-service dates and external or regulatory milestones).

Part C: Other Alternatives

This section describes viable alternatives considered, including associated risks. At minimum, include a Base Case: Status Quo – No Project. Other alternatives may include:

- Deferring the project.
- Different means to meet the same business need.
- Completing partial scope.
- Alternatives with additional scope.

Part D: Project Cash Flows

This table in Part D: Project Cash Flows is very similar to the table under Project Cash Flows in the Executive Summary and Recommendations section.

This table provides a yearly breakdown of estimated project costs, including amounts currently released from earlier BCSs if applicable, the new amounts being requested now in this BCS, and estimated future requirements not currently requested. Contingency shall be included in these amounts.

The new amounts being requested are for actual work to be completed and for any costs that will be committed to through that work. For example, if an equipment purchase is bundled with a maintenance contract for a committed period, the committed payments under the maintenance contract must be included in the current request. Ongoing Costs include any costs related to the investment that would not be part of the project budget, including ongoing incremental operating costs, and acquisition of inventory.

The Future column is the sum of expected future cash flows beyond the last year shown in the table.

Type 3 Business Case Summary*Estimate Class*

Estimate Class is a cost estimate classification system developed by the Association for the Advancement of Cost Engineering International (AACE) which defines the estimate "quality" based on the input information used and the project's stage of development. AACE uses five estimate classes with Class 5 being the least accurate, and Class 1 being the most accurate.

Estimate Class	Class 5	Class 4	Class 3	Class 2	Class 1
Phase	Identification	Initiation	Definition	Execution	Execution
Level of Project Definition (%)	0% to 2	1 to 15	10 to 40	30 to 75	65 to 100
Expected Accuracy Range (%)	-50 to +100	-30 to +50	-20 to +30	-15 to +20	-10 to +15

OAR Approval Amount

For BCSs up to and including Definition Phase work, the OAR Approval Amount is the cumulative total actual and committed cost to date, not the estimated total investment/project cost. For Execution Phase BCSs or BCSs that cover multiple phases including Execution, the OAR Approval Amount is the estimated total investment/project cost, including cumulative cost to date.

Additional Information on Project Cash Flows (optional)

Relevant information such as the delta between approved business plan cash flows and requested release, may be entered into this open-field table cell.

Part E: Financial Evaluation

This section describes and compares the key alternatives considered. Only the most relevant alternatives shall be listed in this table for comparison. The analysis includes financial evaluations, economic analysis, and comparisons of the alternatives based on total project cost, after-tax NPV, and any other financial metric deemed appropriate by the project sponsor (e.g., IRR, discounted payback, etc.) The BCS Financial Evaluation Model is available on the Finance website and is updated periodically to help facilitate financial analysis. Attach further detail as appropriate from the Financial Evaluation spreadsheet.

Summary of Financial Model Key Assumptions

List key assumptions used in the Financial Evaluation. For Part E, provide a brief summary of the most important assumptions that are listed in Appendix C.

Part F: Qualitative Factors

Qualitative factors gained (or lost) from the investment and how an initial specification will be measured within the post implementation review (to the extent feasible). Qualitative factors could include: sustainable energy development impacts; community, government, and customer relations; staff relations issues, technical or operational considerations, reliability, health and safety issues, and other intangibles.

Part G: Risk Assessment

This section identifies the risks associated with the investment and the plans to manage or mitigate these risks. Refer to OPG-STD-0062, Project Risk Management Standard and local business unit standards for guidance on completing and documenting risk assessments. Each BU can add risk areas specific to its business.

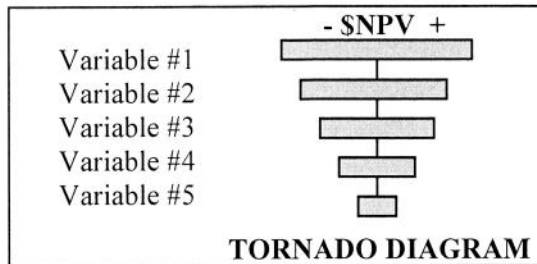
Extra Risk Classes may be added by changing "Other" to a specific risk class and/or inserting extra rows to the table.

The Risk Analysis section discusses, as appropriate for the project, quantitative risk factors that relate to the project financial evaluation, including considerations such as:

- Present and discuss material impacts/consequences of variations in the basic assumptions, e.g., price of electricity used for revenue, sales forecast, service life, etc. Discuss likelihood of occurrence.

Type 3 Business Case Summary

- Based on risks identified and mitigation measures implemented, indicate whether the financial analysis completed for the recommended alternative includes the contingency required for OPG residual risks, and their impact on the estimated in-service date.
- The extent of the risk assessment and the risk analysis techniques employed should be commensurate with the magnitude of the cash flows and the degree of uncertainty associated with the critical assumptions upon which the investment is based.
- For Major Projects, the risk analysis section will typically include sensitivities of the investment to various risk factors or scenarios, and a discussion of their likelihood of occurrence. A convenient way of presenting the results of the risk assessment on the variability of the NPV to changes in the critical variable is to include a graph or tornado diagram as shown below.



- For larger investments, more advanced risk analysis techniques such as Monte Carlo may be suitable. These techniques require analysts with appropriate training; contact your local Finance support to discuss applicability and to arrange Finance analytical support if required. The limitations of Monte Carlo or any other risk assessment technique must be considered in their application, and require a time commitment from the project team and stakeholders to develop and estimate model inputs.

Part H: Post Implementation Review (PIR) Plan

PIR plan is a succinct description of the project benefits using measurable parameters. The PIR plan should clearly specify what is to be measured, who is responsible for measuring it, and when the measurement should take place, along with any requirements for establishing pre-project baseline information for comparison purposes.

Extra PIR metrics may be added by inserting extra rows to the table.

The PIR plan should contain the following five main elements:

- What:** Key deliverables or benefits of the project clearly defined in measurable parameters, including a clear description of the reference or baseline from which the incremental benefits or changes due to the project are to be measured.
- How:** A brief description of how each parameter is going to be measured.
- Who:** The name of the group, department, or individual that will be measuring the benefits.
- When:** When the measurement of the benefits will take place.

In addition, the Project Sponsor and key stakeholders may specify other items such as the types of lessons learned and recommendations to be captured during the execution of the PIR.

Part I: Definitions and Acronyms

Define key technical terms and list acronyms to assist reviewers of the document.

Appendix A: Summary of Estimate

Note: All content from Appendix A onwards, including this Guidance section, contains a level of detail that is intended for OPG internal use only and should be removed before a copy of a BCS is released to an external party.

Type 3 Business Case Summary

To assist the reviewer in understanding the cost estimate in the BCS, this table provides a breakdown of various cost components by year, with explanatory notes as appropriate.

Note: The label "Project Completion or In-Service Date" is intended to provide flexibility for projects that do not have a specific "In-Service Date", such as engineering studies in future decisions or for future regulatory documents.

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

This section provides the history of past releases and their associated estimates, with explanations of changes as appropriate.

Appendix C: Financial Evaluation Assumptions

This section is intended to provide a reviewer with an overall understanding of the key assumptions used in the financial evaluation, to help a reviewer confirm that relevant drivers and appropriate assumptions were used in the analysis. The main considerations in the economic evaluation of the alternatives are outlined below:

Cost and Schedule Estimates

The work breakdown structure (WBS) of the project usually provides detailed information on the cost of the project and should be referred to while estimating the costs and schedule. Best practices in project cost and schedule estimating should be applied wherever possible including using lessons from similar experiences and benchmarks. Requests for quotations from competitive sources are another option to obtain detailed estimates. Schedule and cost estimates must obtain stakeholders' inputs and be reviewed by the key stakeholders of the project before being finalized.

Taxes

All investments must be assessed on an after-tax basis. Users will be required to properly classify the capital assets for Capital Cost Allowance (CCA) purposes. The financial evaluation model provided on the Finance website will compute the initial income tax impacts for most types of investments; the model also contains the latest CCA rates for most types of investments. For further information on CCA, sales taxes and tax shields, please contact your local Finance support group.

Cost of Capital

An appropriate cost of capital or discount rate must be used to ensure that an adequate return is provided to shareholders. For investments related to the manufacturing and processing of electricity for regulated nuclear and base-loaded hydroelectric facilities, the discount rate is generally lower than for unregulated facilities. This is partly due to regulated assets having a more predictable revenue stream, and hence lower risk than unregulated generation facilities.

For projects and business opportunities that are clearly outside of OPG's core business, or are not related to the manufacturing and processing of electricity, the project's cost of capital should be used, instead of OPG's cost of capital. Updated rates for OPG's core business are posted in the BCS Financial Evaluation Model. Contact Investment Planning for assistance.

Revenue Forecasts

The revenue forecast from generation assets must be based on the OPG System Economic Values (SEVs). The appropriate SEVs for the applicable time frame are selected based on the characteristics of the generation asset being evaluated (e.g., peaking vs. baseload). Contact your local Finance support group for further guidance on using SEVs.

Appendix D: References

The reference documentation and attachments contain the detailed numbers, calculations, and any other analysis done probing the need and substantiating the justification for the investment. This documentation includes: cost estimates, financial evaluation sheets, risk assessment tables, modeling assumptions, project execution plan, technical studies, and any other specific studies related to the investment.

Type 3 Business Case Summary

Additional Attachments

Additional documents be prepared as separate documents and enclosed with the BCS for reviews and approvals (e.g., multiple file attachments to e-mails).

The final signed version of the BCS may then be combined with all the attachments in a single PDF file.

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 #:	49247/49229/41023	Document #:	N-BCS-31100-10002 – R003
Project Title:	PA Fuel Channel Reconfiguration & East & West Shift Tooling		
Class:	☒ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☒ CMFA ☐ Provision ☐ Others:	Investment Type:	Sustaining
Phase:	Execution	Release:	Superseding
Facility:	PNGS - U1 & U4	Target In-Service or Completion Date:	14-Mar-2016

Project Overview
We recommend an additional superseding release of \$10,664k (including \$6,248k contingency) to complete required Fuel Channel (FC) maintenance for Pickering Units 1 and 4. With this release, the total project cost is \$39,005k (including \$6,248k contingency), and is composed of Capital (\$29,739k, including \$5,923k contingency), CMFA (\$8,872k, including \$325k contingency) and OM&A (\$393k which has been spent and the work is completed). The quality of the estimate for this release is Class 2. The length of this project has been increased as result of moving this work from P1411 and P1541 outages to the P1511 and P1641 outages. Risks 7, 8 (7. Design Agency Labour Dispute, 8. Work is considered a modification and not maintenance) from the previous BCS revision have been removed from this project. Risks 1, 8, 9, 12, 14, 15 identified in this BCS have been reduced as result of performing the phase 1 reconfiguration during P1211. Problem Statement/Business Need: Pressure tube (PT) axial elongation due to in-service creep is life limiting for Pickering Units 1 & 4. Fuel channel maintenance activities are required to allow Units 1 & 4 to achieve their planned service lives (2020), and possibly beyond 2020. <i>from 22-Aug-2014</i> The business objective of this project is to complete reconfiguration of FC positioning assemblies (PA) to allow FC assemblies to achieve their planned service lives. The original scope of this project was to reposition all the fuel channels for Pickering Units 1 and 4, as per plans prepared at the time of Pickering A Return to Service. During the initial year of work it was realized that this may not be the best solution due to technical issues and associated risks, including a high potential for discovery work and long outage critical path durations (which also impacted on personnel radiation dose). [Ref 1, 6]. An Engineering Decision Meeting was held on the 28th of April 2011 at Pickering to clarify technical issues and risks, and evaluate reconfiguration vs. Repositioning. After all factors were considered, reconfiguration was determined to be the preferred solution. [Ref 1, 6]. The following has been completed: - Design of Positioning Assemblies for Unit 1 has been completed and released for modification. - Procurement and receipt of long lead raw materials for the new positioning assemblies PNGS units 1 & 4. - Contingency tooling for repositioning fuel channels for PNGS unit 1 developed. - Repositioning (shift) critical Fuel Channels (reference NA44-SOW-31100-00007 R01) in 2012, to allow Unit 1 to operate to its next scheduled outage (2015) has been completed (Project 49229) [R-6]. - A toolset to support reconfiguration for unit 1 has been developed; refinements are required for efficiency [Ref 3]. - Installation of positioning assemblies at Calandria lattice sites with known interference (requiring significant installation risk) for Unit 1 in 2012. These PAs have been left unlocked until reconfiguration is performed during P1511.

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Project Overview

This superseding release is required to address the following scope of work:

- Additional manufacturing costs of approximately \$400k is required for contingency yokes for unit 1 that incorporate lesson learned from P1211 [Ref 5].
- Additional constructor and design cost of approximately \$2,000k is required to cover field conditions discovered during P1211 execution [Ref 5].
- Optimization of the toolsets, modification of the working platform and canopies will cost approximately \$1,700k to gain efficiencies for reconfiguration during P1511 [Ref 5].
- Specific Contingency of \$1,500k for the risk of reconfiguration work extension during P1511 and \$1,000k for P1641 is being requested.
- General contingency of \$3,700 for risks ~~assess~~ ^{assessed} in Part G Risk Table.

Summary of Preferred Alternative:

The preferred maintenance solution is to perform reconfiguration of the fuel channels. At Pickering units 1 and 4, this will involve installing new positioning assemblies on the free end, locking the channels from that end and unlocking the PA's of the current locked end. This will accommodate the FC axial growth by permitting the channel to grow in the opposite direction to the end of station life. A summary of the rationale of recommending this alternative is as follows:

- Minimizing the risks associated with feeder management because of maintaining the current feeder positions.
- Previously, the FC's were equipped with PA's on both ends of the reactor with one end locked.
- Effects of existing PA condition are minimized for execution of the work.
- The scope of work is well defined. Repositioning has the potential for discovery work (e.g. F/C's difficult to move, damaged PA hardware, maintaining feeder clearances).
- Minimal and less complex tooling and procedures; activity is repetitive and simple.
- Station high performance goals set for execution and total radiation exposure are more achievable as work is predictable.
- Avoidance of unit forced outages due to FCs reaching their bearing limit.
- Additional margin on operation time to 2020.
- Reconfiguration is more cost effective.

We recommend continuing the design, fabrication, commissioning and reconfiguration of new easy-to-install positioning assemblies for the current free ends of U1 and U4 to permit reconfiguration of the fuel channels.

History of previous BCS releases and project cost estimates:

BCS	Release Type	Investment	Scope
N-BCS-31100-10002 – R000 (22 Jan 2010)	Developmental	Capital: \$700k including \$50k contingency	To complete preliminary engineering to support fuel channels "on-bearing" operation of PNGS Units 1 and 4 until end of life (2020).
N-BCS-31100-10002 – R001 (14 Jun 2011)	Partial	Capital: \$10,100k including \$700k contingency. Did not include OM&A release for execution during P1211.	To develop tooling to support repositioning of fuel channels of PNGS Units 1 during P1211. Repositioning of PNGS U4 was to have been funded by OM&A and executed during P1541.
N-BCS-31100-10002 – R002 (10 Sep 2012)	Superseding	Total project cost of \$29,278k (including \$5,760k contingency), and was composed of Capital (\$21,991k, including \$5,590k contingency), CMFA (\$6,856k), and OM&A (\$432k including \$170k contingency).	To develop tooling, complete detail design (fuel channel modification) and purchase new positioning assemblies to support reconfiguration during P1411 and P1541.

History of scope and schedule changes:

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Project Overview

Project scope includes:

- Design and procurement of Positioning Assemblies and installation tool sets for Pickering Units 1 & 4.
- Repositioning (shift) critical Fuel Channels completed during P1211 [Ref 1], to allow Unit 1 to safely continue to operate till the next scheduled outage (2015).
- Installation of positioning assemblies at Calandria lattice sites with known interference (retiring significant Installation risk) for Unit 1 completed during P1211. These PAs were left unlocked until reconfiguration is performed during P1511.
- During P1511, the remaining PAs will be installed and full reconfiguration of Unit 1 will be executed.
- During P1641, the installation of PAs and full reconfiguration of Unit 4 will be executed.
- Engineering and Project close out in 2016, following AFS of both Units.

Key Assumptions and Risks:

Refer to Part G of this document.

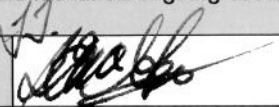
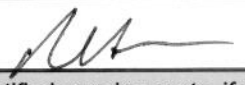
Project Cash Flows, NPV, and OAR Approval Amount

k\$	LTD	2014	2015	2016	2017	2018	2019	Future	Total
Currently Released	12,280	10,008	5,834	218					28,340
Requested Now	-	-2,073	5,657	7,080					10,664
Future Required	-								
Total Project Cost	12,280	7,935	11,491	7,298					39,005
Ongoing Costs	-								
Grand Total	12,280	7,935	11,491	7,298					39,005
Estimate Class:	Class 2				Estimate at Completion:		\$32,757k		
NPV:	\$12,198k				OAR Approval Amount:		\$39,005k		

Additional Information on Project Cash Flows (optional):

Refer to NPV sheet for more information.

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: Brian E McGee, SVP, Pickering			22 Aug 2014
I concur with the business decision as documented in this BCS.			
Finance Approval: Robin Heard, SVP and CFO (acting)			5 Sep 14
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: T. Mitchell, CEO per OAR 1.1			8 Sep 14

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Business Case Summary

Part A: Business Need

During operation, Fuel Channels (FCs) are subject to an environment of high temperatures, pressures, and neutron irradiation. The resulting stresses cause changes in the pressure tube dimensions and material properties. One of the dimensional changes, axial elongation, affects FC position on its bearings. The fuel channels design has absolute limits on fuel channel length and accommodation for FC movement on its bearing – Available Bearing Travel (ABT). At PA, ABT limits will be reached for Units 1 in 2015 (154 KEFPH) and for unit 4 in 2016 (175 KEFPH). [Ref 3].

The original scope of this project was to reposition all the fuel channels for Pickering Units 1 and 4, as per plans prepared at the time of Pickering A Return to Service. During the initial year of work it was realized that this may not be the best solution due to technical issues and associated risks, including a high potential for discovery work and long outage critical path durations (which also impacted on personnel radiation dose). [Ref 1, 6].

An Engineering Decision Meeting was held on the 28th of April 2011 at Pickering to clarify technical issues and risks, and evaluate reconfiguration vs. Repositioning. After all factors were considered, reconfiguration was determined to be the preferred solution. [Ref 1, 6].

A major challenge for performing FC repositioning is to manage the feeder clearances. There is a high risk of having feeder to feeder, feeder to yoke or feeder to end-fitting port contact; while still trying to maintain the FC's shift within the minimum and maximum shift values and their allowable feeder Gray-loc stresses.

Table 1: The different Scenarios for maintaining the FCs on bearing till the End of Life of units 1 and 4

Alternative	Duration on Critical Path (Days)	Radiation Exposure (Rem)
Preferred - Reconfiguration	28 days	88
Alternative 2 - Base case - No project	Forced outage 84 days	259
Alternative 3 - Repositioning at defined intervals	63 days	200

Assumptions: for dose calculations, it is assumed that the dose rate inside the shielding canopy will be approximately 100mRems/hr. If the FC are reconfigured then the total time for finishing the whole reactor face will be 14 days (24 hrs shifts), while for repositioning (shifting) the FCs, the time will be 3 hrs per every reconfigured channel.

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Part B: Preferred Alternative: PROCEED WITH RECONFIGURATION OF THE FUEL CHANNELS

Description of Preferred Alternative

The preferred maintenance alternative is to proceed with reconfiguration of the fuel channels. At Pickering units 1 and 4, this will involve installing new positioning assemblies on the free end, locking the channels from that end and unlocking the PA's of the current locked end. This will accommodate the FC axial growth by permitting the channel to grow in the opposite direction to the end of station life. It should be noted that prior to PNGS re-tube (LSFCR), the FCs were equipped with positioning assemblies on both ends of the reactor, with one locked end and one unlocked (free) end. After re-tubing, the free end PAs were removed, and only the locked ends PAs were left. A summary of the rationale of recommending this alternative is as follows:

- Minimizing the risks associated with feeder management because of maintaining the current feeder positions.
- Previously, the FC's were equipped with PA's on both ends of the reactor with one end locked.
- Effects of existing PA condition are minimized for execution of the work.
- The scope of work is well defined. Repositioning has the potential for discovery work (e.g. F/C's difficult to move, damaged PA hardware, maintaining feeder clearances).
- Minimal and less complex tooling and procedures; activity is repetitive and simple.
- Station high performance goals set for execution and total radiation exposure are more achievable as work is predictable.
- Avoidance of unit forced outages due to FCs reaching their bearing limit.
- Additional operation time beyond 2020.
- Reconfiguration is more cost effective.

We recommend continuing the fabrication, installation, commissioning and reconfiguration of new easy-to-install positioning assemblies for the current free ends of U1 and U4 to permit reconfiguration of the fuel channels.

Although an expedited design schedule was set, All Positioning Assembly Components were not available for installation during P1211. As a result, repositioning (shift) of critical fuel channels (14) from unit 1 were shifted during P1211 to allow continued operation of the unit the planned outage in 2015 (with a 6 month operating buffer). The project will continue to be executed as follows:

1. During P1511, the remaining positioning assemblies will be installed and full reconfiguration of the unit shall be performed.
2. During P1641, the installation of PAs and full reconfiguration of Unit 4 will be executed.
3. Engineering and Project close out in 2016, following AFS of both Units.

Deliverables:	Associated Milestones (if any):	Target Date:
PNGS Unit 1		
Reconfiguration of U1 (P1511)	U1 Phase 2 Full Face PA installation and reconfiguration	26-Jan-2015
In Service Declaration – U1	In-Service Declaration Issued - PA Unit 1	15-Mar-2015
PNGS Unit 4		
Reconfiguration of U4 (P1641)	U4 Full Face PA installation and reconfiguration	9-Feb-2016
In Service Declaration – U4	In-Service Declaration Issued - PA Unit 4	14-Mar-2016

Part C: Other Alternatives

Alternative 2: BASE CASE – NO PROJECT

"Do Nothing" after fuel channels reach their allowable bearing travel (ABT) limit would necessitate shutdown of the Units as it is a licensing requirement that fuel channels remain on bearing (reference CSA-N285.4-05, section 12.2.5.2.3). Repositioning the fuel channels with the available manual tooling, platforms and shielding during forced outages would add considerable radiation exposure and cost. Augmented staffing costs, manual tooling costs has been calculated at \$15,000k and \$500k respectively for Unit 1 and Unit 4. The total loss for status quo would be \$34.9M.

Keeping the units in service necessitates repositioning or reconfiguration the FCs during major planned outages to attain the design life of the pressure tube. Based on projected operating hours [Ref. 3], the plan is to reconfigure FCs of Unit 1 in 2015 and Unit 4 in 2016.

Alternative 3: PROCEED WITH THE REPOSITIONING (SHIFT) OF FUEL CHANNELS

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Alternative 3: PROCEED WITH THE REPOSITIONING (SHIFT) OF FUEL CHANNELS

Proceed with repositioning fuel channels prior to them reaching their ABT during planned outages. This could be accomplished by:

1. Partial repositioning of fuel channels.
 - For unit 1, complete repositioning of 80 FCs during P1511, then repositioning of 120 FCs in P1711, followed by full repositioning of the remaining FCs in U1 during P1911.
 - For unit 4, complete repositioning of 113 FCs during P1641 and Full Repositioning of U4 during P1841.
2. Full Repositioning of Fuel Channels
 - For unit 1, complete repositioning during P1511
 - For unit 4, complete repositioning of FCs during P1641

Due to the complexity and accessibility problems at the current fixed end, existing manual tooling to manipulate the PAs to push and pull the fuel channels would be used. On the current free ends, new tooling would have to be developed to assist with pushing or pulling the fuel channels as it was discovered during repositioning of the fuel channels during P1211 that additional forces were applied and approached the limitation of the available toolset. No manual tooling for unit 4 exists and would have to be developed.

The tooling and the manual operations would be capable of performing a series of shift operations which would finish up with the channels in their new positions on bearing. The minimum required clearances between the feeders on both ends of the reactor must be monitored and maintained. Fuel channels may be shifted in successive steps and more than once to their final position to maintain feeder clearances. A summary of the rational of this alternative is as follows:

- Avoidance of unit forced outages due to FCs reaching their bearing limit.
- Avoidance of the PA design and manufacturing costs as compared to Reconfiguration.

Proceeding with the Repositioning of the PNGS U1 &U4 FCs is not preferred due to complexity of feeder gaps management that may dictate cascade shifting to make the shifting possible. The availability and the cost of augmented staff add another rational against selection of this option.

Alternative 4:

N/A

Alternative 5:

N/A

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

k\$	LTD	2014	2015	2016	2017	2018	2019	Future	Total
Currently Released	12,280	10,008	5,834	218					28,340
Requested Now	-	-2,073	5,657	7,080					10,664
Future Required	-								
Total Project Cost	12,280	7,935	11,491	7,298					39,005
Ongoing Costs	-								
Grand Total	12,280	7,935	11,491	7,298					39,005
Estimate Class:	Class 2				Estimate at Completion:		\$32,757k		
NPV:	\$12,198 k				OAR Approval Amount:		\$39,005 k		

Additional Information on Project Cash Flows (optional):

Refer to NPV sheet for more information.

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Part E: Financial Evaluation					
k\$	Preferred Alternative	Base Case	Alternative 3	Alternative 4	Alternative 5
Project Cost	39,005	N/A	33,904		
NPV	12,198	N/A	4,932		
PV	- 22,716	- 34,915	- 29,982		

Summary of Financial Model Key Assumptions or Key Findings:

Although the project cost of the preferred alternative is higher than the others, its implementation will introduce an easy-to-install positioning assembly hardware that will shorten the reconfiguration execution outage windows and hence results in higher positive NPV as compared to other alternatives.

Refer to NPV sheet for more comparative evaluation information.

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

Project Cost:

1. Total project cost estimate is: **\$39,005k** (including a contingency of **\$6,248k**)
2. Project OM&A estimate cost is: **\$393k** (which has been spent and the work is completed).
3. Project CMFA estimate cost is: **\$8,872k** (including a contingency of **\$325k**).
4. Project Capital estimate cost is: **\$29,739k** (including a contingency of **\$5,923k**).
5. Quality of Estimate: **Release +20% to -15%.**

Financial:

1. Interest Rate : 5%
2. Discount Rate: 6%
3. Depreciation Rate (Capital): Generating Equip 8%
4. NPV : \$12,198 k
5. IRR: N/A.
6. Discounted Pay Back: N/A.

Project Life:

1. Project Type: Sustaining
2. Project AFS date: 14 Mar 2016
3. Project Life End: 23 Sep 2016

Part F: Qualitative Factors

- **Sustainable energy development impacts:** The project provides energy production sustainability for units1 and 4.
- **Stakeholders Relations:** Keeping the low cost energy is a government strategic goal.
- **Technical or operational considerations:** The project permits the operability of units1 and 4 to the end of life.

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Part G: Risk Assessment				
Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
1. Cost	There is a risk that some positioning assemblies do not fit onto the end-fitting.	Accept: Establish contract with design agency for engineering support.	Low	High
2. Cost	There is risk that additional number of mechanics may be needed to accommodate dose uptake during P1511.	Mitigation: - Good planning, efficient tooling, and use of job specific shielding to minimize the dose uptake. - Hire additional number of mechanics to maintain the dose within an acceptable level.	Low	Medium
3. Cost	There is a risk that work that must be completed within backup heat sink #9 and heat sink #5 resulting in extension of execution contract with Constructor.	Accept: - Add a contingency to cover the additional cost of extended reconfiguration window. - Arrange an efficient work performance and use of job specific planning to minimize the lost time.	Medium	Medium
4. Scope	This is risk that repositioning of fuel channels maybe required to prevent feeder to feeder, and feeder to feeder yoke or feeder to other fuel channels contact once the fixed end is unlocked.	Mitigation: - Additional resources to perform contingency procedure are available. - Perform pre feeder inspections prior to performing reconfiguration. - A repositioning plan is developed and in place. - Shifting tools for both units are available.	Medium	Medium
5. Quality/ Performance	There is risk that Reactor face Dose rates at Pickering unit 1 may be higher than anticipated. This will impact projected dose targets and execution cost to this project.	Mitigation: - The PA hardware was designed to be efficiently installed by one person. - Efficient PA installation and removal tooling were designed and procured. - Modifications to platform to permit its use as a worker positioning device - Modification to the shielding structure to minimize dose and expedite reconfiguration - Procurement of reactor face Radi-shielding. - Procedures to decrease job time/dose and allow best workers shielding.	Medium	Medium
6. Quality/ Performance	There is risk that vendor can't meet expedited manufacturing schedule for P1641	Mitigation: - Monitor vendor schedule with bi weekly meetings. - Additional costs may be incurred for expediting the PA manufacturing.	Medium	Medium
7. Planning	There is a risk that there are insufficient resources to carry out this work under the OPG C of A for pressure boundary during P1511 and P1641.	Mitigation: - Develop an efficient resource plan with work force deployment. - Obtain PT from other work groups (project design) - Contract work via ESMSA	Medium	Medium
8. Planning	There is risk that the purchase order placed for PA's does correspond with	Mitigation: A statistical analysis performed to	Medium	Medium

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Part G: Risk Assessment				
Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
	the required PA's to fit the end-fitting seats. Insufficient number of undersized yokes ordered.	estimate the quantity of undersized yokes was performed. Adequate quantities of undersize yokes are ordered.		
9. Planning	There is risk that the purchase order placed for PA's does correspond with the required PA's to fit the end-fitting seats. Insufficient number of oversized yokes ordered.	Mitigation: - A statistical analysis performed to estimate the quantity of oversize yokes was performed. - Adequate number of oversize yokes is ordered as a contingency.	Low	Medium
10. Execution	There is risk that shifting the FC does not move during contingency repositioning of FC's to maintain feeder clearances.	Mitigation: The Manual RT tool was designed to reaches Max allowable force (plus contingency)	Low	Medium
11. Execution	There is risk that FC is over shifted and need re-adjust with respect to bearings during contingency shift of channels to maintain feeder clearances.	Mitigation: Good procedures are developed and qualified staff shall be utilized.	Low	Medium
12. Execution	There is risk that the condition of the PA's are poor resulting in difficulty with manipulation (corrosion/Jammed Nuts)	Mitigation: - Tools were designed for higher forces and torques that may be useful in difficult cases. - Application of lubricants to ease removal of east EF positioning assemblies	Medium	Medium
13. Execution	There is risk safety assessment does not support installing and locking a group of PA's resulting in the execution on site by site bases which leads to higher dose, longer execution and cost.	Avoid: Perform safety assessment to permit locking a group of Fuel Channels simultaneously on both sides of the reactor.	Low	High
14. Regulatory	There is risk that CNSC does not approve feeder stress analysis approval submission required to support reconfiguration.	Avoid: MCED communicate responses to CNSC questions to ensure getting the needed analysis approval.	Low	High
15. Execution	There is risk that the new positioning assemblies impacts installation of the reactor face jigsaw panels.	Mitigation: - The stud may contact the insulation panel, but by design, only have a 0.5" stud encroachment on an insulation panel. - Up to 13 different stud sizes with incremental increase of approximately 1/8" will be used to minimize stud encroachment. - A top-hat jig will be used to verify that stud encroachment does not affect the proper installation of the insulation panel.	Low	High

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Part H: Post Implementation Review (PIR) Plan				
Type of PIR Report		Target In-Service or Completion Date	Target PIR Completion Date	
Simplified PIR		14 MAR 2016	23 SEP 2016	
Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
ABT	ABT is reached in 2015 for unit and 2016 for unit 4.	Unit 1 and 4 can reach end of life at 2020 with margin.	STEM and Spot Face measurements	MCED
Feeder clearance are maintained	Future feeder to feeder contact is possible.	Maintain feeder to feeder clearances.	Feeder inspection per Life Cycle Management Plan.	MCED
Time to complete the reactor face work	Historical data from shift programs executed in 1982-1984	14 days for Unit 1 and 14 days for Unit 4	Time Monitored by IMS Project team and OCC.	IMS
Total radiation exposure	Manual reposition - 185 Rem	Reconfiguration – 96 Rem	Controlled and measured by Radiation Exposure Permits	RPD

Part I: Definitions and Acronyms	
AFS	Available For Service.
ABT	Available Bearing Travel
BCS	Business Case Summary.
BP	Business Plan.
CANDU	Canadian Deuterium-Uranium.
ECR	Engineering Change Request.
EDM	Engineering Decision Making.
EF	End Fitting.
ETCR	Engineered Tool Change Request.
FC	Fuel Channel.
FTE	Full Time Equivalent.
HMI	Human-Machine Interface.
IEV	Impact on Economic Value.
IMS	Inspection, Maintenance Services.
IRR	Internal Return Rate.
LTD	Life To Day.
NPI	Nuclear Performance Index.
NPV	Net Present Value.
OPEX	Operational Experience.
ORSS	Overhead Radiation Shielding Structure.
PA	Positioning Assembly.
PEP	Project Execution Plan.
PIR	Post Implementation Review.
SFCR	Single Fuel Channel Replacement.
STEM	Scanning Tool for Elongation Measurement.

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

This page is intentionally left blank For Internal Project Cost Control

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Appendix A-1: Summary of Estimate of Capital Project									
Project Number:	41023								
Project Title:	PA Fuel Channel Reconfiguration & East & West Shift Tooling								
k\$	LTD	2014	2015	2016	2017	2018	2019	Total	%
OPG Project Management	3,313	205	207	176				3,901	13
OPG Engineering (including Design)	297	343	217	254				1,110	4
OPG Procured Services and Materials	2,020	2,901	2,114					7,035	24
Construction Contract(s)	170	221	412	11				813	3
Execution			3,231	3,171				6,402	22
Commissioning and Training		1,574	278	658				2,510	8
Interest/SAVH	283	424	839	500				2,045	7
Subtotal	6,083	5,668	7,296	4,769				23,816	80
Contingency		500	3,150	2,273				5,923	20
Total	6,083	6,168	10,446	7,042				29,739	100

Notes			
Project Start Date	SEP 2012	Total Definition cost (excludes unspent contingency for Nuclear)	\$23,816k
Target In-Service (or AFS) Date	MAR 2016	Contingency included in this BCS (Nuclear only)	\$5,923k
Target Completion Date	SEP 2016	Total contingency released plus contingency in this BCS (Nuclear only)	\$5,923k
Escalation Rate	2%	Total released plus this BCS without contingency (Nuclear only)	\$23,816k
Interest Rate	5%	Total released plus this BCS with contingency (Nuclear only)	\$29,739k
Removal Costs	N/A	Estimate at Completion (includes only spent contingency for Nuclear)	\$23,816k

Prepared by:		Approved by:	
Hassan A Hassan Assoc. Eng., RMP Project Leader or Project Manager	 Date 2014-08-05	Sid Tavares Project Manager, RMP Project Manager or Project Sponsor	 Date 2014-08-05

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Appendix A-2: Summary of Estimate of CMFA									
Project Number:	49247								
Project Title:	PA Fuel Channel Reconfiguration & East & West Shift Tooling								
k\$	LTD	2014	2015	2016	2017	2018	2019	Total	%
OPG Project Management	1,636							1,636	18
OPG Engineering	963	629	191					1,783	20
Design and Materials	1,486	444	200					2,130	24
Tool Fabrication	726			231				957	11
Commissioning	2	297	409					708	8
SAVH	447	107	131					685	8
Interest	544	90	14					648	7
Subtotal	5,804	1,566	945	231				8,547	96
Contingency		200	100	25				325	4
Total	5,804	1,766	1,045	256				8,872	100

Notes			
Project Start Date	JAN 2010	Total Definition cost (excludes unspent contingency for Nuclear)	\$8,547k
Target In-Service (or AFS) Date	MAR 2016	Contingency included in this BCS (Nuclear only)	\$325k
Target Completion Date	SEP 2016	Total contingency released plus contingency in this BCS (Nuclear only)	\$325k
Escalation Rate	2%	Total released plus this BCS without contingency (Nuclear only)	\$8,547k
Interest Rate	5%	Total released plus this BCS with contingency (Nuclear only)	\$8,872k
Removal Costs	N/A	Estimate at Completion (includes only spent contingency for Nuclear)	\$8,547k

Prepared by:		Approved by:	
Hassan A Hassan Assoc. Eng., RMP Project Leader or Project Manager	 Date 2014-08-05	Sid Tavares Project Manager, RMP Project Manager or Project Sponsor	 Date 2014-08-05

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Appendix A-3: Summary of Estimate of OM&A Project									
Project Number:	49229								
Project Title:	PA Fuel Channel Reconfiguration & East & West Shift Tooling								
k\$	LTD	2014	2015	2016	2017	2018	2019	Total	%
OPG Project Management	56							56	14
OPG Engineering									
Training	99							99	25
Execution	188							57	48
Vendor Support	13							13	3
Commissioning									
SAVH	38							38	10
Interest									
Subtotal	393							393	100
Contingency									
Total	393							393	100

Notes			
Project Start Date	JAN 2010	Total Definition cost (excludes unspent contingency for Nuclear)	\$393k
Target In-Service (or AFS) Date	MAR 2016	Contingency included in this BCS (Nuclear only)	0
Target Completion Date	SEP 2016	Total contingency released plus contingency in this BCS (Nuclear only)	0
Escalation Rate	2%	Total released plus this BCS without contingency (Nuclear only)	\$393k
Interest Rate	5%	Total released plus this BCS with contingency (Nuclear only)	\$393k
Removal Costs	N/A	Estimate at Completion (includes only spent contingency for Nuclear)	\$393k

Prepared by:		Approved by:	
Hassan A Hassan Assoc. Eng., RMP Project Leader or Project Manager		Sid Tavares Project Manager, RMP Project Manager or Project Sponsor	
 Date 2014-08-05		 Date 2014-08-05	

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <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
			2011	2012	2013	2014	2015	2016		
1	Developmental	Dec 2009	2.053	7.247	0.500					9.800
2	Partial	Feb 2011	2.053	10.120	2.027					14.200
3	Superseding	Jul 2012	2.053	10.086	1.078	10.008	5.834	0.218		29.278
4	Superseding	Jul 2014	2.053	9.150	1.078	7.935	11.491	7.298		39.005

Project Variance Analysis

k\$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management	5,005	2,407	5,592	3,185	Additional project management and resources to support the complex sub-projects required and extension to project until 2016 due to outage re-alignment.
OPG Engineering	1,193	1,487	2,893	1,406	Additional engineering support (MCED, EMD) required for feeder analysis, end-fitting jacking and the locking of fuel channels on both ends and seismic analysis.
Design and Materials	3,828	8,203	9,165	962	This variance is result of additional design and manufacturing requirements to accommodate the lessons learned from phase 1 installation during P1211 including the larger than expected variation of the unit 1 end-fitting seats. In addition the cost of engineering was higher due to the labour disruption of the design agency, additional design rigour to address manufacturing non-conformances.
Construction	170	472	813	341	This variance is result of developing representative fuel channel mock-up for training and tooling development.
Tools, commissioning and Training	652	1,752	4,286	2,534	This variance is result of the higher than expected as result of : - Higher than expected constructor costs for mobilization associated with P1511. Specific contingency is to be drawn to support this execution work. - A larger work force is required to ensure full scope is completed. The estimated dose planned for P1511 and P1641 is higher than had been planned (48 R). This variance also includes the constructor costs for P1641; currently this work is assigned to PWU but due to the overlapping work-programs, OPG cannot support this work with base employees. As such, a PSA will be requested to re-assign the execution work back to the BTU.
Execution	188	5,242	6,590	1,348	This variance is result of the higher than expected as result of : - Higher than expected constructor costs for execution during P1511. Specific contingency is to be drawn to support this execution work. - A larger work force is required to ensure full scope is completed. The estimated dose planned for P1511 and P1641 is higher than

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <Execution> Release

Project Variance Analysis					
k\$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
					had been planned (48 R). This variance also includes the constructor costs for P1641; currently this work is assigned to PWU but due to the overlapping work-programs, OPG cannot support this work with base employees. As such, a PSA will be requested to re-assign the execution work back to the BTU.
Interest / SAVH	1,244	3,955	3,417	-538	Dependant on overall project labor and capital cost.
Subtotal	12,280	23,518	32,757	9,239	
Contingency		5,760	6,248	488	Jurisdiction has been finalized for the execution work. Execution during P1511 has assigned to the Building Trades Union (BTU) and during P1641 it is assigned to the Power Workers Union (PWU). It is planned that the work for P1641 will be reassigned to the BTU due to the overlapping work programs at DNGS and PNGS. As such, specific contingency that had been requested in the last superseding release [Ref 1] for \$3,200k is included the project budget. Additional Contingency of \$1,500k for the risk of reconfiguration window outage extension during P1511 and \$1,000k for P1641 is being requested. The balance of other is general contingency for the additional risks identified in part G of this BCS.
Total	12,280	29,278	39,005	9,727	

Type 3 Business Case Summary

Project #: 49247/49229/41023

Document #: N-BCS-31100-10002 – R003

Project Title: PA Fuel Channel Reconfiguration & East & West Shift Tooling, <Superseding> <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. Total project cost estimate is: **\$39,005k** (including a contingency of **\$6,248k**)
2. Project OM&A estimate cost is: **\$393k** (which has been spent and the work is completed).
3. Project CMFA estimate cost is: **\$8,872k** (including a contingency of \$325k).
4. Project Capital estimate cost is: **\$29,739k** (including a contingency of \$5,923k).
5. Quality of Estimate: Release +20% to -15%.

Financial:

1. Interest Rate : 5%
2. Discount Rate: 6%
3. Depreciation Rate (Capital): Generating Equip 8%
4. NPV : \$12.198 M
5. IRR: N/A.
6. Discounted Pay Back: N/A.

Project Life:

1. Project Type: Sustaining
4. Project AFS date: 14 Mar 2016
5. Project Life End: 23 Sep 2016

Appendix D: References

1. N-BCS-31100-10002-R002.
2. NA44-SOW-31100-00007 R01.
3. N-PLAN-01060-10002, Rev. 14.
4. NPV Excel sheet.
5. I-LLD-31100-50000 - LESSONS LEARNED REPORT - RECONFIGURATION OF PNGS UNIT 1 DURING
6. I-CORR-31100-0395634 - MINUTES - EDM MEETING FOR FUEL CHANNEL RECONFIGURATION