ONTARIO POWER GENERATION

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Business Case Summary

Project #	10-83828	**Controlled Doc #**	N-BCS-09701-0671681
Project Title	Fleet Monitoring Initiative (Monitoring and Diagnostic Centre)		
Facility	PNGS, DNGS	**Investment Classification**	Sustaining
Project Level (Scalability)	B	**Financial Classification**	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others: [if applicable]
Release: Gate and Project Phase	☐ Choose an item. G0☐: Initiation ☐ Choose an item. G1☐: Choose an item.		☒ Partial G2A: Definition ☐ G3: Execution
Estimate Class (overall project)	Class 4	**Target Project Completion Date**	DEC-2023

Recommendation

We recommend a release of $3,740 K, including [redacted] of contingency. This will bring the total released-to-date to $9,146 K including [redacted] of contingency. The previously approved contingency was released to the project.

The estimated total project cost is within the range of $25 M to $40 M.

This release is requesting a partial definition of Phase III scope for the Monitoring and Diagnostic Centre including design engineering and procurement. The project will implement a pilot to install and commission 50 sensors (of 3800 sensors) at PNGS and DNGS to establish a Class 3 estimate for future installations. Future releases will request completion of Phase III design engineering, procurement and installations, and the development of an advanced data analysis application.

Investment Cash Flows

$K	LTD	2020	2021	2022	2023	2024	2025	Future	Total
Previous releases	4,656	750							5,406
Current request	-	3,740							3,740
Total released to date	**4,656**	**4,490**	**-**	**-**	**-**	**-**	**-**	**-**	**9,146**
Future required	-	TBD	TBD	TBD	TBD				TBD
Total Project Cost									
Ongoing Costs	-								
					Gate:	**G2**	**OAR Approval:**		$9,146 K

Approvals	Signatures	Date
The recommendation, including the identified ongoing costs, if any, represents the best option to meet the validated business need.		
Recommended by: Project Sponsor Jenny Leung Manager, Equipment Reliability Nuclear Engineering	Jenny Leung	March 6, 2020
I concur with the business decision as documented in this BCS.		
Finance Approval: Brett Lemmon Finance Controller – Darlington	Brett Lemmon	Mar 19, 2020
I confirm that this investment/project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.		
Line Approval per OAR 1.1: Dean Townsend VP, Engineering Strategy Nuclear Engineering	Dean Townsend	March 25, 2020

EXECUTIVE SUMMARY – Project Overview

Business Need

This project is to implement the use of low-cost online equipment condition monitoring sensors (wired & wireless) at both Darlington and Pickering nuclear generating stations to allow more important work to be performed. Upon completion of this project, OPG will provide significant improvement to the existing sensors, communications, analytics, interconnectivity, and data visualization.

Currently, equipment condition assessment in the power generation industry is primarily relying on inspection campaigns during scheduled outages and online maintenance schedules. Inspection scope is currently primarily developed based on pre-determined time intervals, past events, and probabilistic models. Real-time monitoring of predictive indicators has been identified as an area of improvement in the stations.

OPG established a Monitoring & Diagnostic Centre (M&DC) within the Nuclear and Renewable Generation organizations to leverage new equipment condition monitoring technologies to develop a strategic approach for implementing advanced monitoring and diagnostic capabilities. These new technologies will be fundamental in ensuring equipment reliability and transitioning to CBM the nuclear stations.

Preferred Alternative

The M&D Center predictive analytics tools allow analysts to visualize actual and expected performance of an asset including detailed information on ambient conditions, unit loading, and operating modes. Using the Advanced Pattern Recognition (APR) software, the M&D Centre is able to improve equipment reliability and performance while avoiding potential failures. Implementing this project is estimated to improve thermal performance efficiencies and transition time based maintenance to condition based maintenance.

In order to ensure that all of the Nuclear fleet's critical equipment's failure modes are captured, the M&D Centre project is requesting a partial release for the design engineering, procurement, installation and commissioning of new sensors at both PNGS and DNGS between 2020-2023.

The project has been divided into the following four (4) phases:

Phase I: Establishing a Monitoring & Diagnostic (M&D) Centre.

Phase II: Initial Planning and Pilot Installs.

Phase III: Design Engineering, Procurement and Installations.

Phase IV: Advanced Data Analytic Application.

This release is requesting a partial release (Gate 2A) of Phase III to execute the design engineering and procurement activities, as well as to complete Phase II pilot installations and commissionning of 50 sensors at PNGS and DNGS to establish a Class 3 estimate for future installations. OPEX within the organization has proven the benefits of implementing pilot projects to obtain lessons learned as well as more accurate cost and schedule estimates.

The scope for this release includes:

PNGS:

- Transformer Dissolved Gas Analyzers (DGA) U1-8.
- SRV Room Temperature Monitoring U5-8
- Class IV switchgear ESA U1, 4, 5-8 (PNGS A and B)
- Class III switchgear ESA U1, 4, 5-8 (PNGS A and B)

DNGS

- Transformer Mixed Gas Analyzers (MGA) U0, 1-4.
- EQ Rooms Temperature Monitoring U0, U1-4.
- Class IV switchgear U1-4
- Class III switchgear U1-4

Business Need

For Project Level A or B

This project is to implement the use of online equipment condition monitoring sensors (wired & wireless) at both Darlington, Pickering nuclear generating stations to transition time based maintenance to condition based maintenance and improve plant performance. Upon completion of this project, OPG will provide significant improvement to the communications, analytics, interconnectivity, and data visualization through existing and new sensors.

Business Need	For Project Level A or B

The Nuclear and RG organizations are leveraging new equipment condition monitoring technologies to develop a strategic approach for implementing advanced monitoring and diagnostic capabilities. Through Continous On-line Monitoring (COLM) guides, sensor technologies across OPG will cover failure mode analysis of components to monitor equipment health and allow early detection of equipment degradation/anomalies. By detecting degradations early, catastrophic or consequential failures will be avoided, and work will be planned in advance to reduce costly time-based Preventive Maintenance (PM) with condition-based maintenance tasks to perform the right work at the right time.

The M&D Center predictive analytics tools allow analysts to visualize actual and expected performance of an asset including detailed information on ambient conditions, unit loading, and operating modes. Using the APR software, the M&D Centre is able to provide an opportunity for improving equipment reliability and performance while avoiding potential failures.

Preferred Alternative:	**Advanced Continuous Online Monitoring (COLM) Program**

Description of Preferred Alternative

In the development phase of the Monitoring & Diagnostic Centre project, an evaluation on both nuclear and RG business units was conducted to define the scope of the project. In this process, critical and non-critical station assets were identified requiring additional failure mode coverage such as temperature, vibration, electrical signature analysis to provide full failure mode coverage. The benefit of this coverage is for the M&D Centre analysts to monitor the assets, and in the case of performance deviations, the M&D Centre team will work with various parts of the organization to mitigate the risk of catastrophic failures and accidents and plan and extend outage work.

The project is requesting a partial release of Phases II and III to execute the design engineering, procurement, installation and comissioning activities for sensors at PNGS and DNGS. The installation and comissioning activities of 50 sensors will fall under a pilot to obtain lessons learned and better estimates for future installs. Station staff, including maintenance, operations, system and component engineers, and other subject matter experts will be heavily involved in the planning and execution of the project. The project will also work together with various other stakeholders within OPG's organization, such as CIO, RG, Nuclear Waste, Supply Chain, Finance, Design Engineering, Performance Engineering, Operations, Work Control and Maintenance, to plan and execute the project successfully.

The project has been divided into the following four phases:

(COMPLETED) **Phase I**: Establish the M&D Centre (2017-2018):

- Perform M&D Centre evaluation (OPG Nuclear & RGPM Business units)
- Procure and utilize an Advanced Pattern Recognition (APR) software
- Hiring of staff

(IN PROGRESS) **Phase II**: Initial Planning & Pilot Installs (2018-2019):

- Identify fleet monitoring priority equipment scope
- Design OPG OLM information architecture
- Develop the preliminary design engineering scope
- Sensor installations pilot

(PARTIAL RELEASE) **Phase III**: Design Engineering & Installations (2020-2022):

- Develop detailed design engineering packages for selected scope
- Procurement of required hardware and software equipment
- Installation of required hardware and software equipment
- Implement Start-up, commissioning and site turn over of selected scope
- Plan outage installations
- Route new data into the plant historian

(FUTURE) **Phase IV**: Advanced Data Analytic Application (2021-2023):

- Develop advanced diagnostics and prognostics
- Design fleet data integration/visualization for decision optimization analytics

M&D Centre Functional Model

Existing and future plant data that are received from equipment sensors are stored in the Plant Information (PI) data historian. The data will then be used by the Advanced Pattern Recognition (APR) software (e.g. PRISM), and thermal performance software (PEPSE/PMAX).

Business Case Summary

Preferred Alternative:	**Advanced Continuous Online Monitoring (COLM) Program**
Description of Preferred Alternative	
Existing data stored in PI has been integrated into models developed by the M&D Centre staff. These models will detect early warnings of equipment failures and abnormal operating conditions at both PNGS and DNGS. The M&D Centre project has also been working with various initiatives such as the Right Work, Right Time, Right Value (RWRTRV) and Value Based Maintenance (VBM) initiatives to execute work in alignment with on-going OPG maintenance activities.	

Deliverables:	**Associated Milestones (if any):**	**Target Date:**
Previous releases:		
1. Perform M&D Centre evaluation (OPG Nuclear & RGPM Business units)		2018
2. Hiring of staff		2018-2019
3. Identify fleet monitoring priority equipment scope		March 2019
4. Develop the preliminary design engineering scope		November 2019
Current release:		
5. 100% Detail Design Complete for: • EQ / SRV Room Temperature Monitoring • Mixed / Dissolved Gas Analyzers (M/DGAs) • Class III Motor Current Signature Analysis (MCSA) • Class IV Motor Current Signature Analysis (MCSA)	100% Detail Design Complete (OPG Acceptance) - G2A - Class IV Switchgear for Darlington: 30 Jun 2020	June 30, 2020
6. Procurement (PO issued): • EQ / SRV Room Temperature Monitoring • Mixed / Dissolved Gas Analyzers (M/DGAs) • Class III Motor Current Signature Analysis (MCSA) • Class IV Motor Current Signature Analysis (MCSA)	Procurement - ESA - Class IV Switchgear Materials – PO Issued - Darlington: 20 Jul 2020	July 20, 2020
7. Finish of Installation: • EQ / SRV Room Temperature Monitoring • Dissolved Gas Analyzers (DGAs)	FOI - Finish of Installation - G2A - DNGS - EQ Rooms Temperature Monitoring - DNGS - U0, U1-4: 29 Jun 2020	June 29, 2020
8. Available For Service (AFS): • EQ / SRV Room Temperature Monitoring • Mixed / Dissolved Gas Analyzers (M/DGAs)	AFS - Available for Service - G2A - DNGS - EQ Rooms Temperature Monitoring - DNGS - U0, U1-4: 27 Jul 2020	July 27, 2020
Future release (Future phases):		
9. Develop detailed design engineering packages		Phased approach 2020-2022
10. Procurement of required hardware and software equipment		
11. Installation of required hardware and software equipment		
12. Implement Start-up, commissioning and site turn over of selected scope		
13. Plan outage installations		
14. Close out activities		

Alternative 2:	**Base Case – No Project**
The benefits described in the Nuclear Fleet Scope Summary (N-REP-01500-00003) would not be realized if this project does not proceed.	

Alternative 3:	**Delay Work**
Delays on executing this project will result in missing critical timelines required to meet benefits expected from installing more coverage at PNGS. This will also reduce equipment reliability benefits and maintain the current risks of FLRs.	

Key Risk Assessment — For Project Level A, B or C

Risk Class	Description of Risk	Response Type/ Actions	For Additional Review	Residual Ranking
Cost	Cost estimate exceeded.	Mitigate: Continuous monitoring of cost by the Cost and Schedule Analyst (CSA) and Project Leader. Pilot installs will be executed to provide better estimates for future installs to control costs.	No	Low
Schedule	Delays establishing procurement contracts Delays in installations	Mitigate: Work closely with Supply Chain SPOC to evaluate the proposals received for the Data Acquisition and Analysis System (DAAS). Currently working with Supply Chain, Law, and Renewable Generation to ensure meeting the target completion deadlines.	No	Medium
Quality	Lack of expertise to execute work	Mitigate: Use of third party experts with previous experience at Duke Energy and successful implementation of M&D Centres and working closely with station SMEs to ensure alignment on scope and expectations.	No	Low

Financial Evaluation

$M	Preferred Alternative	Base Case (No Project)	Delay work	Alternative 4	Alternative 5
Project Cost	$25-40	N/A	N/A		
NPV	N/A	N/A	N/A		
Other: (e.g., IRR)					

Analysis of Financial Evaluation – Key Assumptions and Key Results:

A financial evaluation is not required for sustaining projects.

Qualitative Factors — For Project Level A or B

Some of the qualitative factors provided by the Preferred Alternative are as following:

- Contribute to reducing Forced Loss Rate (FLR)
- Contribute to the nuclear fleet reduction target for preventive maintenance on selected critical & non-critical maintenance-hours. This includes reduction of electrical and mechanical maintenance work dedicated to major equipment PM tasks, optimizing instrument calibrations and eliminating a significant amount of manual condition monitoring data collection (vibration, electrical testing, oil analysis, non-destructive testing, etc.)
- Improve unit heat rates through on-line thermal performance monitoring

Post Implementation Review (PIR) Plan (refer to OPG-PROC-0056)			
Type of PIR Report	Simplified/Standard PIR	**PIR Completion Date**	12-2023
☒ Detailed PIR KPIs will be provided in future BCS(s) when Execution Phase BCS release is requested.			

PIR KPIs	Current Baseline	Target Result	How to measure?	Who will measure?

APPENDICES

Appendix A1: Summary of Estimate - Released to date								
Project Number:	**10-83828**							
Project Title:	**Monitoring and Diagnostic Centre**							
$K	**LTD**	**2020**	**2021**	**2022**	**2023**	**Future**	**Total**	**%**
Project Mgmt	230	110					340	4%
Engineering	[redacted]							
Procurement								
Construction								
Commissioning								
Closeout								
Subtotal								
Contingency								
Subtotal w/ Contingency								
Interest								
Total	**4,656**	**4,490**	**-**	**-**	**-**	**-**	**9,146**	**100%**
Removal Costs (incl. above)							-	0%

Appendix A2: Summary of Estimate – Notes			
Escalation Rate	2.5%	**Interest Rate (going-forward)**	4.33%

Appendix A3: Summary of Estimate – In-Service Estimates				
$K	Only applicable to capital projects. In-Service amount shall include interest but exclude removal costs.			
Project #	**Date (YYYY-MM-DD)**	**Description**	**Amount**	**%**
10-83828	3/15/2020	Advanced Pattern Recognition Model Building Equipment Analytics	[redacted]	51%
10-83828	6/30/2020	Engineering, Procurement and Installation of Pilot	[redacted]	49%
Total			[redacted]	100%

Prepared by:		Reviewed and Endorsed by:	
Hassan Jaber Monitoring and Diagnostic Centre Project Leader	3/6/2020 Date	Jenny Leung Manager, Equipment Reliability Project Sponsor	3/6/2020 Date