ONTARIOPOWER GENERATION

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

OPG Confidential

OPG-FORM-0076-R005*

Type 3 Business Case Summary

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

Executive Summary and Recommendations

Project Information			
Project #:	Project # 13-83668	**Document #:**	P-BCS-41110-00001
Project Title:	Pickering High Pressure Turbine Spares		
Class:	☐ OM&A ☐ Capital ☒ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others:	**Investment Type:**	Sustaining
Phase:	Execution	**Release:**	Full
Facility:	Pickering	**Target In-Service or Completion Date:**	2020-06-30

Project Overview

We recommend Gate 3 approval and the release of $23,375 k, including $2,125k of contingency.
The estimated total project cost is $23,375k, including $2,125k of contingency.

The quality of the estimate for this release is Class 3. 10% contingency is applied to purchase of components This release will fund the following scope of work:

- Detailed Engineering for two new OEM supplied high pressure turbines
- Supply and delivery of two high pressure turbines with 8MW improvement per turbine for contingency for P1971 and P1951 outages.

Gate Strategy:

This is a capital spare purchase directly from the OEM. The OEM will be performing the detailed design with some minor interface modifications, and design documentation acceptance will be performed by Pickering base plant design. Project Management Centre of Excellence has concurred to proceed directly to Gate 3.

Problem Statement/Business Need:

On November 10th, 2016 during P1671, routine 8-year High Pressure Turbine inspections, the OEM discovered stress corrosion cracks in the Unit 7 high pressure spindle body (P-2016-27993). The cracks were not repairable and it was advised to no longer operate the spindle. Of the six units in operation, two have confirmed cracks and will likely need to be replaced. It is expected that at least four units will eventually require replacement out of six units. Currently, the station has only two viable spares. Therefore, the station requires two additional spares.

The lead time on new turbines is 12-16 months. Therefore, initiating a purchase now will minimize future operating risk to the station. The intention of this project is to initiate purchase of two spares with target delivery in time for installation into Unit 7 during the P1971 outage and Unit 5 during the P1951 outage, if required. The station needs to manage production risks while allowing flexibility depending on the findings of upcoming high pressure turbine inspections.

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

Type 3 Business Case Summary

Project #: Project # 13-83668
Document #: P-BCS-41110-00001
Project Title: Pickering High Pressure Turbine Spares, Full Execution Release

Project Overview

Summary of Preferred Alternative:

The preferred option is to purchase two spare upgraded high pressure turbine modules. The upgrade would result in 8MW per unit of additional production.

The alternatives reviewed are as follows:

1. Purchase two Upgraded High Pressure Turbine Module that offer 8 MW per unit improvement (Preferred Alternative)
2. Base Case – Status Quo
3. Purchase two Identical Spindles (Like for Like) with improved blade design which offer 2 MW per unit improvement
4. Purchase only single Upgraded High Pressure Turbine Module

The primary driver for this project is to sustain the plant operation until 2024. As described above, this capital expenditure is required based on the technical condition of the existing equipment. However, based on the difference in upfront cost and remaining life of operation, the purchase of two upgraded High Pressure turbines is more economic than purchasing two like for like spares. Upgraded turbines will provide potential additional power output and revenue. Purchasing two spares addresses the risk of having cracked turbine spindles resulting in major forced outages on an in-service unit and the associated production losses.

The downside of the upgraded High Pressure Turbine is the potential for incurring cancellation costs if some assumptions prove incorrect (i.e. all remaining spindles are clear of cracks). The cancellation cost is dependent on what stage in the design-manufacturing process the project sits at time of cancellation. Based on the inspection schedule of the units; the assumptions made should be proven prior to incurring any major cancellation fees.

This project is emergent and therefore is not included in the capital project portfolio.

Key background Information/assumptions used to support BCS:

- The OM&A costs for the refurbishing of the current spares (3911A/3885A) are required to mitigate the possibility of an immediate plant shutdown. These costs are not included in this BCS.
- Unit 1 and Unit 4 are currently clear of any indication of cracks and therefore should not require replacement. However, if future inspections indicate that Unit 1 and Unit 4 turbines require replacement, then additional spares may need to be purchased.
- The MW increase for an upgraded module is assumed to be 8MW.
- The financial evaluation assumes System Economic Values provided by Corporate Finance and the projected capacity factors of Unit 7 and Unit 5.

Conclusions:

Based on the inspections to date, it is highly probable that Pickering will have four out of six HP turbines in operation with cracks. The initial inspections are scheduled to be completed by March 2018. The station currently has two spares. Therefore, it is prudent that the station purchase two additional spares to sustain future operation.

This release will be used to secure OPG a place in the OEM supply chain in order to ensure delivery within the timeframe for installation into Unit 7 during the P1971 outage and Unit 5 during the P1951 outage, if required.

OPG Confidential
OPG-FORM-0076-R005

Type 3 Business Case Summary

Project #: Project # 13-83668
Document #: P-BCS-41110-00001
Project Title: Pickering High Pressure Turbine Spares, Full Execution Release

Project Cash Flows, NPV, and OAR Approval Amount						
k$	LTD	2017	2018	2019	2020	Total
Currently Released	0					
Requested Now		1,650	3,300	8,250	10,175	23,375
Future Required						
Total Project Cost	0	1,650	3,300	8,250	10,175	23,375
Ongoing Costs						
Grand Total	0	1,650	3,300	8,250	10,175	23,375

Estimate Class:	Class 3	**Estimate at Completion:**	23,375
NPV:	-2,284	**OAR Approval Amount:**	23,375

Additional Information on Project Cash Flows (optional):

The project cash flows are based on budget quality estimates and project milestones provided by the OEM.
The negative NPV is the outcome a least cost analysis and includes the cost of the spare turbines and benefits of additional production if they are installed. The preferred alternative has an NPV that is 7,778 k$ higher than a like for like replacement.

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 Nuclear President and CNO			3 NOV 2017.
I concur with the business decision as documented in this BCS.			
Finance Approval: Ken Hartwick CFO and SVP Finance per OPG-STD-0076			Nov 7, 2017
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 Lyash President and CEO per OAR 1.2			

ONTARIOPOWER GENERATION

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

OPG Confidential

OPG-FORM-0076-R005*

Type 3 Business Case Summary

Project #: Project # 13-83668

Document #: P-BCS-41110-00001

Project Title: Pickering High Pressure Turbine Spares, Full Execution Release

Business Case Summary

Part A: Business Need

On November 10th, 2016 during P1671, routine 8-year High Pressure Turbine inspections, the OEM discovered stress corrosion cracks in the Unit 7 High Pressure spindle body (P-2016-27993). The cracks were not repairable, and OEM recommended that it was no longer advisable to operate the spindle.

Of the six units in operation, two have confirmed cracks and will likely need to be replaced. It is expected that at least four units will eventaully require replacement out of six units. Currently, the station has only two viable spares. Therefore, the station requires two additional spares.

The intention of this project is to initiate purchase of two spares with delivery that will allow installation into Unit 7 in 2019 (P1971) and Unit 5 in 2019 (P1951) if required. The lead time on new turbines is 12-16 months. Therefore, initiating a purchase now will mitigate the operating risk to the station.

Part B: Preferred Alternative: Two Upgraded Modules with 8MW gain delivered by 2019

Description of Preferred Alternative

The preferred alternative is to purchase of two spare upgraded high pressure turbine modules that will generate 8MW of additional production per unit. The lead time for new turbines is approximately 14 months. Therefore, initiating a purchase now will minimize future operating risk to the station. The intention of this project is to initiate purchase of two spares with target delivery in time for installation into Unit 7 and Unit 5 during the P1971 and P1951 outages, if required. This alternative allows OPG to minimize station risk while also providing the station with the potential for increased revenue for operations from 2019 to 2024.

This release will fund the following scope of work:

- Detailed Engineering for two new OEM supplied high pressure turbines
- Supply and delivery of two high pressure turbines with 8MW improvement per turbine for contingency for P1971 and P1951 outages.

The purchase contract with the OEM will include options to cancel based on the percentage of work completed to date. These options will allow OPG to stop work on the spares in the case future turbine inspections show favourable results. The cancellation terms will be developed as the formal quotation and terms are developed.

Pros:

- Allows OPG to effectively manage risk to station by 2019.
- Provides OPG with a potential upgrade opportunity potential of the 8MW per unit and additional revenue during 2019-2024 time period.

Cons:

- Exposes OPG to cancellation costs if future Pickering HP turbine inspections are all favourable requiring no additional spares.
- Some design work will be required to accommodate the new upgraded design. It is anticipated that only minor modifications to the existing equipment will be required.

Deliverables:	Associated Milestones (if any):	Target Date:
OEM Design Complete		October 20, 2017
Begin Ordering Material		October 23, 2017
Delivery of 1st HP Spindle		December 20, 2018

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

Deliverables:	Associated Milestones (if any):	Target Date:
Delivery of 2nd HP Spindle		August, 15, 2019
Project Close Out		June 30, 2020

Part C: Other Alternatives

Alternative 2: Base Case – Status Quo

Spares 3911A/3885A enter service into Unit 7 and Unit 6. Unit 5 and Unit 8 require 2.5-year inspections @$132k per inspection to cover additional required resources for disassembly. Unit 1 and Unit 4 are assumed clear of cracking.

The status quo will require OPG to manage the cracks through inspections every 2.5 years. A major turbine disassembly normally occurs every 8-10 years on high pressure turbines. The resource requirement to undertake additional inspections will displace from other major turbine work that will be necessary on those units (e.g. generator rotor swap, and low pressure turbine inspections). Mechanical Maintenance turbine resources will be impacted.

This alternative is not recommended because it does not address the risk of operating with cracked spindles. The base case includes two critical assumptions: (1) that Units 1 and 4 are clear of any cracking, and (2) the growth rate of the cracks on the Pickering B units can be managed within the 2.5 years without exceeding critical thresholds. These are two assumptions cannot be validated until Units 1 and 4 are inspected during P1711 and P1841 outages, and multiple inspections are done on affected units to understand the cracking growth rates. If either of these two assumptions are wrong, then new spares will certainly be required to manage the risk.

Pros:

- No capital expenditures
- No additional engineering modifications

Cons:

- Does not fully address risks of operating turbines with known cracks. The risks are currently unquantified. The units have not been fully inspected and the crack growth rate is undetermined.
- Resource intensive during outages for Mechanical Maintenance and IMS resources
- Waiting for inspection results to determine growth rates, based on the long lead time of materials, may result in the worst case scenario of having no viable spares for units that require replacement.

Alternative 3: Purchase two identical spindles with 2MW efficiency gain

This alternative includes the purchase two identical spindles (like for like) as those currently in use, except with an improved blade design which may offer a 2 MW per unit capacity improvement. This alternative offers an existing and proven design, reduced lead time, and somewhat lower costs relative to the preferred alternative. However, this spindle design has not been produced since the 1980s, and therefore also includes some manufacturing risks, which would result in schedule delays.

This alternative is not recommended since the purchase of two upgraded turbines is more economic than purchasing two like for like spares. The financial evaluation shows that, over the remaining life of the station, the value of potential additional production of an upgrade is significantly more than the difference in upfront costs.

Pros

- Offers a proven like for like replacement.
- Marginal MW gain
- Shorter lead time than other upgrade alternatives
- No additional engineering modifications

Cons

Type 3 Business Case Summary

Project #: Project # 13-83668
Document #: P-BCS-41110-00001
Project Title: Pickering High Pressure Turbine Spares, Full Execution Release

Alternative 3: Purchase two identical spindles with 2MW efficiency gain

- Up front capital cost and marginal MW increase does not provide as significant a financial benefit
- Has not been constructed since the 1980s. Knowledgeable people in the design and assembly process are no longer available. There is OPEX from original assembly documents that describe assembly failures requiring re-work, scrap and schedule delays.

Alternative 4: Purchase only one upgraded spare

This alternative includes purchasing only a single upgraded High Pressure Turbine Module as compared to two spares in the preferred alternative. This alternative was considered for primarily for financial reasons, for example, where two spares could not be funded due to budget constraints. However, this is not recommended since it will not fully address the risks of operating with cracked spindles.

Pros:

- Reduces the capital expenditure when compared to the preferred alternative

Cons:

- If all assumptions (cracks exist in uninspected units) are valid will not eliminate risk to station

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

k$	LTD	2017	2018	2019	2020	Total
Currently Released	0					0
Requested Now		1,650	3,300	8,250	10,175	23,375
Future Required						0
Total Project Cost	0	1,650	3,300	8,250	10,175	23,375
Ongoing Costs						
Grand Total						23,375

Estimate Class:	Class 3	**Estimate at Completion:**	23,375
NPV:	-2,284	**OAR Approval Amount:**	23,375

Additional Information on Project Cash Flows (optional):

The project cash flows are based on budget quality estimates and project milestones provided by the OEM.

Part E: Financial Evaluation

k$	Preferred Alternative – 2 Upgraded Spares	Base Case – Status Quo	2 Like For Like Spares	Single Upgraded Spare	
Project Cost	23,375	0	17,973	12,650	
NPV	-2,284	N/A	-10, 072	N/A	
Other (e.g. IRR)					

Summary of Financial Model Key Assumptions or Key Findings:

The negative NPV is the outcome a least cost analysis and includes the cost of the spare turbines and benefits of additional production if they are installed. The preferred alternative has an NPV that is 7,778 k$ higher than a like for like replacement.

The key assumptions for the financial analysis are as follows:

- The assumed MW gain for upgraded HP Module is 8 MW (Preferred Alternative). Currently, Preliminary Engineering is taking place under Pickering base OM&A. When the formal proposal is issued it is expected that 8MW or greater will be guaranteed as the OEM has full control over spindle and cylinder design and manufacture.
- The cost per upgraded HP module is based on pricing provided by OEM on August 10, 2017. The financial evaluation assumes price $11,500k per HP module or $10,625k if two are purchased. A 10% contingency has been applied to the purchase price.
- The Base Case (Status Quo) assumes Unit 5 and Unit 8 require re-inspection every 2.5 years until end of life with an incremental OM&A cost of $132k per inspection. However, it does not consider the possibility of forced outages due to failure of the turbine.
- The assumed MW gain for an identical spindle is 2MW (Alternative 3). This will be validated by the OEM if the alternative is considered further. This optimistic estimate is expected to be lower as the OEM cannot control the clearances of the equipment currently in operation. A lower MW gain would reduce the NPV for this alternative.
- The costs to refurbish the existing spares (3911A/3885A) apply equally to all alternatives. Therefore, they have not been included in the financial evaluation.

Part F: Qualitative Factors

Purchasing two upgraded High Pressure Turbine Modules addresses the risk of having turbine spindles fail on an in-service unit resulting in a lengthy unit outage, associated production losses, and potential reputational damage to OPG.

It is prudent for OPG to establish a position in the OEM supply chain and cancel the order if necessary if the future inspections do not validate the expected condition of the turbines.

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	There is a risk that that project costs could be higher than assumed for the preferred alternative	The estimate is based on OEM budget quality quotations. Class 3 estimates allow up to 30% deviation. A 10% contingency was applied to purchase price.	Low	Medium
Scope	There is a risk that inspections are favourable on all units and no additional spares are required	The purchase agreement will include cancellation penalties that will minimize OPG's financial risk	Low	Medium
Schedule	There is a risk that delivery does not meet 2019 outage schedule	The purchase agreement will include milestone dates that must met by vendor. Penalty and exit terms will be included in the agreement.	Low	Medium
Resources	There is currently no team in place to manage such a large complex purchase	Engaging base resources (Minor Modifications) to support project	Medium	Medium
Quality/ Performance	There is a risk that the upgraded turbines do not deliver the expected performance.	The terms and conditions have not been finalized at this time. However, it is expected that these deliverables will be included in the purchase contract. Warranty clauses will also be included.	Low	Low

Type 3 Business Case Summary

Project #: Project # 13-83668
Document #: P-BCS-41110-00001
Project Title: Pickering High Pressure Turbine Spares, Full Execution Release

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Technical	There is a risk that the preliminary engineering requires substantial plant interface changes to accommodate new design	This will be determined prior to issuing a PO to the OEM for purchase through preliminary Engineering already underway. If any changes are required, then the costs will be re-evaluated and a BCS re-submitted. However, based on the OPEX from Point Lepreau, it is not expected any changes will be required.	Low	High

Additional Risk Analysis:

N/A

Part H: Post Implementation Review (PIR) Plan

Type of PIR Report	Target In-Service or Completion Date	Target PIR Completion Date
Simplified PIR	2020-02-25	2020-06-30

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Gross Megawatt (MW) Output as measured by station gross MW output meter will be monitored over time to assess bulk MW increase	540MW	548MW	Based on Station output meters	Performance Engineering

Part I: Definitions and Acronyms

PO – Purchase Order
OEM – Original Equipment Manufacturer
HP – High Pressure
MW – Mega Watts
IMS – Inspection Maintenance Services

This page is intentionally left blank

Type 3 Business Case Summary

Project #: Project # 13-83668 Document #: P-BCS-41110-00001
Project Title: Pickering High Pressure Turbine Spares, Full Execution Release

For Internal Project Cost Control

OPG Confidential
OPG-FORM-0076-R005

Type 3 Business Case Summary

Project #: Project # 13-83668
Document #: P-BCS-41110-00001
Project Title: Pickering High Pressure Turbine Spares, Full Execution Release

Appendix A: Summary of Estimate						
Project Number:	Project # 13-83668					
Project Title:	Pickering High Pressure Turbine Spares					
k$	**2017**	**2018**	**2019**	**2020**	**Total**	**%**
OPG Project Management						
OPG Engineering (including Design)						
OPG Procured Materials	1,500	3,000	7,500	9,250	21,250	90%
OPG Other						
Design Contract(s)						
Construction Contract(s)						
EPC Contract(s)						
Consultants						
Other Contracts/Costs						
Interest						
Subtotal	**1,500**	3,000	7,500	9,250	**21,250**	**90%**
Contingency	150	300	750	925	2,125	10%
Total	**1,650**	**3,300**	**8,250**	**10175**	**23,375**	**100%**

Notes			
Project Start Date	August 24, 2017	**Total Definition cost** (excludes unspent contingency for Nuclear)	$0K
Target In-Service (or AFS) Date	June 2019 (1st Unit) Feb. 2020 (2nd Unit)	**Contingency included in this BCS** (Nuclear only)	$2,125K
Target Completion Date	June 2020	**Total contingency released plus contingency in this BCS** (Nuclear only)	$2,125K
Escalation Rate	2.9%	**Total released plus this BCS without contingency** (Nuclear only)	$21,250K
Interest Rate	N/A	**Total released plus this BCS with contingency** (Nuclear only)	$23,375K
Removal Costs	N/A	**Estimate at Completion** (includes only spent contingency for Nuclear)	$21,250K

Prepared by:		Approved by:	
John Fagan Station Engineering, Pickering	October 30/17 Date 2017-10-10	G. Bugden Greg Bugden Manager, Performance Engineering Project Sponsor/Manager	OCT 30/17 Date 2017-10-10

Type 3 Business Case Summary

Project #: Project # 13-83668 Document #: P-BCS-41110-00001
Project Title: Pickering High Pressure Turbine Spares, Full 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 Choose an item. (by year including contingency)						Future	Total Project Estimate
			2017	2018	2019	2020	2021	2022		
Execution	Full	Sept. 2017	1,650	3,300	8,250	10,175				23,375

Project Variance Analysis

k$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management					
OPG Engineering (including Design)					
OPG Procured Materials			21,250		This BCS represents the first funding request.
OPG Other					
Design Contract(s)					
Construction Contract(s)					
EPC Contract(s)					
Consultants					
Other Contracts/Costs					
Interest					
Subtotal			**21,250**		
Contingency			2,125		
Total			**23,375**		

Appendix C: Financial Evaluation Assumptions

Key assumptions used in the financial model of the Project are:

The key assumptions for the financial analysis are as follows:

- The project cash flows are based on budget quality estimates and project milestones provided by the OEM.
- The costs to refurbish the existing spares (3911A/3885A) apply equally to every alternative. Therefore, they have not been included in the financial evaluation.
- It has been assumed that Unit 1 and Unit 4 are currently clear of any indication of cracks and therefore should not require replacement. However, if future inspections indicate that Unit 1 and Unit 4 turbines require replacement, then additional spares may need to be purchased.
- The assumed MW gain for an upgraded high pressure Module is assumed to be 8 MW (Preferred Alternative). Preliminary Engineering is currently taking place. When the formal proposal is issued it is expected that 8MW or greater will be guaranteed as the OEM has full control over spindle and cylinder design and manufacture.
- The cost per upgraded high pressure module is based on pricing provided by OEM on August 10, 2017. The financial evaluation assumes price $11,500k per HP module or $10,625k if two are purchased. A 10% contingency has been applied to the purchase price.
- The Base Case (Status Quo) alternative assumes Unit 5 and Unit 8 require re-inspection every 2.5 years until end of life with an incremental OM&A cost of $132k per inspection. However, the alternative does not consider the possibility of forced outages due to failure of the turbine.
- The assumed MW gain for an identical spindle is 2MW (Alternative 3). This will be validated by the OEM if the alternative is considered further. This optimistic estimate is expected to be lower as the OEM cannot control the clearances of the equipment currently in operation. A lower MW gain would reduce the NPV for this alternative.
- The financial evaluation assumes System Economic Values provided by Corporate Finance and the projected capacity factors of Unit 7 and Unit 5.

Appendix D: References

SF171127497 "PNGS HP Modernization Proposal" rev 1