ONTARIO POWER GENERATION

BUSINESS CASE SUMMARY

Pickering A Steam Generator Locking Tab Replacement 13 - 49248

Developmental Release Business Case Summary NA44-BCS-33115-00001-R000

1/ RECOMMENDATION:

We recommend a release of $1.2M (including contingency) to complete Preliminary Design of the preferred Steam Generator Locking Tab replacement option, develop a Full Release BCS, and generate a contract strategy for the Pickering A (Units 1 and 4) Locking Tab Replacement project by March 2008.

The business objective of this project is to avoid a significant forced outage due to a locking tab failure on the cold leg of the Heat Transport System. A Fitness for Service evaluation has indicated that the cold leg locking tabs have a minimum lifespan of 6.3 EFPYs. If a cold leg locking tab were to fail, it is speculated that it would cause significant damage to the Heat Transport System, potentially including some components of the reactor core (i.e. fuel bundles). A forced outage would then be required to repair the damage at a projected cost of $100M and duration of 90 days. More importantly, a locking tab failure could potentially affect OPG's standing with the CNSC and our Power Reactor Operating License (PROL). Beyond 6.3 EFPYs in service, justification for continued operation would be required for Units 1 and 4.

The deliverables of this project are:

- Complete a mini-field campaign to remove and re-install the SG Clamping Dogs in support of inspection by IMS during the P711 Outage
- Develop a new locking tab replacement option which will minimize/eliminate interference with routine maintenance activities as well as meet or exceed SG life expectancy
- Develop a new locking tab replacement option which will minimize project cost, schedule, and dose uptake
- Replace the locking tabs currently installed in Unit 1 and 4 steam generators (SG) with a new design prior to the calculated 6.3 year expected lifespan of the locking tabs (2010 and 2011)

Currently, preliminary work has been conducted to acquaint the project team with the project objectives and current field conditions. In addition, a number of locking tab replacement options are being reviewed to determine the most technically viable and cost effective.

As this project is related to Pickering A, there are no issues/opportunities with respect to the ongoing life extension assessment.

$000's (incl contingency)	Funding	LTD 2006	2007	2008	2009	2010	2011	Later	Total
Currently Released	None	-	-	-	-	-	-	-	-
Requested Now	Developmental	-	850	385					1,235
Future Funding Req'd	Full	-	-		520	7,675	7,905	400	16,500
Total Project Costs		-	850	385	520	7,675	7,905	400	17,735
Other Costs									-
Ongoing Costs									-
Grand Total		-	850	385	520	7,675	7,905	400	17,735
Investment Type: Sustaining		Class: OM&A		(IEV) Impact on Ec Value: $148M		IRR: 79.2%		Discounted Payback: 5.9	

Submitted By:

M. Arsenio
Director Projects & Modifications

25 June 2007
Date:

Finance Approval:

R. Lessel
Director Investment Management

June 25, 2007
Date:

Line Approval (Per OAR Element 1.1 Project in Budget):

M. Reid
Director Station Engineering Pickering A

June 27 2007
Date:

2/ BACKGROUND & ISSUES

Adverse Condition

The Steam Generator Divider Plate sealing skin modification was performed on Units 1, 4, 5-8 starting with Unit 4 in 2001 and finishing with Unit 7 in 2004. The primary purposes of this modification were to address Divider Plate bolt degradation as well as the steady increase in Reactor Inlet Header Temperature (RIHT) which was forcing several units to run derated. All the modifications were completed successfully as measured by the decrease in RIHT for each unit. The steam generator inspections conducted in Unit 5 during the P551 (Spring of 2005) Outage were the first to be done for the PNGS B units following installation of the sealing skin/locking tab modification. These inspections revealed that numerous pieces of locking tabs and divider plate sealing skin had broken off in the hot leg (inlet) side of the steam generators (refer to SCR P-2005-03243) due to high cycle fatigue cracking. Further inspections revealed that all 10 affected steam generators experienced locking tab failures, and 4 of 10 steam generators experienced divider plate skin failures. The root causes of this event were deemed to be insufficient design analysis for the new locking tabs and inadequate installation of the sealing skins to ensure proper seal. Subsequent steam generator inspections in Units 6 and 8 uncovered more broken locking tabs and sealing skins. It is expected that Unit 7 steam generators will exhibit the same adverse condition. There have been no locking tab failures observed in the cold leg (outlet) side of any steam generator inspected. [Note that Pickering A Units 1 and 4 have had no locking tab or skin failures to date but are considered vulnerable to similar failures found in Pickering B SGs.]

Required Repair

The sealing skin modification installed in the PNGS A units was similar to that of PNGS B, but not identical. Due to the Unit 5 event, PNGS A was obligated to review locking tab design installed in Units 1 and 4 in order to allow for continued operation of the units (refer to SCR P-2005-03370). An Engineering Assessment (NA44-33110) of the locking tabs installed in the PNGS A SGs was performed. In addition, steam generator inspections were conducted and showed that there had been no locking tab failures in the SGs. These two activities allowed for both PNGS A units to run for a period of 1.8 EFPYs since the sealing skin modification. The rationale for continued operation was due to the determination that hot leg tab failures can be tolerated from a reactor safety point of view. Cold leg tab failures were deemed unacceptable as they could produce debris of broken tabs flowing downstream and blocking flow to the fuel bundle which could result in fuel failure. Thus, a Fitness for Service Evaluation of cracked locking tabs for PNGS A and PNGS B (P-REP-33115-00001 R01) was conducted. This evaluation proved that cold leg locking tabs will not fail prior to 6.3 EFPY. Thus, replacement of the locking tabs must be completed prior to 6.3 EFPY or 2010 (U4) and 2011 (U1).

Similar Previous Replacement Campaigns

As mentioned, hot leg locking tab failures were first found in Unit 5. Upon this discovery, all of the sealing skins, locking tabs, and associated components in all Unit 5 steam generators (except for two steam generators which were previously modified in 1999 with a different design) and all Unit 6 steam generators in the following outage (Units 7 and 8 were delayed in order to re-evaluate the repair strategy) were replaced. These repair campaigns were costly, lengthy, and dose intensive:

Unit 5 – approximately $11M, 2 months, 33 Rem (10 steam generators)
Unit 6 – approximately $12M, 2 months, 65 Rem (12 steam generators)

The replacement strategy for PNGS A will focus on locking tab replacement (currently installed sealing skins will be retained), and minimizing cost, time, and dose.

3/ ALTERNATIVES AND ECONOMIC ANALYSIS

		Cost	Cost				
Revenue	(164.5)	-	-	(6.5)	-		
OM&A	(336.5)	(17.7)	(18.0)	(33.5)			
Capital	-	-	-	-			
NPV (after tax)	(157.2)	(9.1)	(9.2)	(18.3)			
Impact on Economic Value (IEV)	N/A	148.1	148.0	139.0			
IRR%	N/A	79.2%	79.2%	117.2%			
Discounted Payback (Yrs)	N/A	5.9	5.9	6.8			

Status Quo - Not Recommended

Status Quo is **not** a recommended option. The Fitness for Service evaluation conducted on the Locking Tabs proved that cold leg locking tabs have a minimum lifespan of 6.3 EFPYs. After 6.3 EFPYs in service, the risk of cold leg locking tab failure increases, thereby increasing the risk to reactor safety. If a cold leg locking tab were to fail, it is speculated that it would cause significant damage to the Heat Transport System, potentially including some components of the reactor core (i.e. fuel bundles). A forced outage would then be required to repair the damage at a projected cost of $100M and duration of 90 days. More importantly, a locking tab failure could potentially affect OPG's good standing with the CNSC and in turn OPG's Power Reactor Operating License (PROL). In addition, beyond 6.3 EFPYs in service, justification for continued operation would be required for Units 1 and 4.

Alternative 1 - Replace Locking Tabs with new design - Recommended

Replacing the current locking tabs installed in Units 1 and 4 with a new design will allow for the following (which are aligned with the project objectives):

- SGs to run until End of Life (EOL) without the possibility of locking tab failure
- Ability for maintenance to be conducted with minimal interference from the new design which will replace the current locking tabs
- Ability to remove and/or replace components of the new design with relative ease, if required
- Installation to be less complex, optimizing cost, schedule, and dose

The Locking Tab replacement option will be designed with a substantial amount of rigour as per CNE Directive 05-01. As this modification cannot be commissioned, qualification testing along with required analysis will be performed to ensure that the Locking Tab replacement option is robust and will not become Foreign Material.

This is the only alternative which achieves all of the project objectives and in doing so, is this least expensive and has the greatest Net Present Value (NPV).

Alternative 2 - Delay Project - Not Recommended

Delaying the Project is **not** a recommended option. When the Technical Operability Evaluation (TOE) was first generated, it was determined that all affected units (Units 1, 4, 5, 6, 7, 8) would only be able to operate for 1.8 EFPYs since installation of the locking tabs and sealing skins. OPG Projects pursued locking tab life extension and successfully increased the minimum tab life from 1.8 EFPYs to 6.3 EFPYs. If the project is delayed past 6.3 EFPYs, there is a risk of cold leg locking tab failure which increases over time. As in the Status Quo option, this risk of cold leg locking tab failure is very costly, and has very severe Reactor Safety consequences. There is a slight chance that locking tab failure can be tolerated from a reactor safety point of view beyond 6.3 EFPYs in

service, however justification for continued operation of Units 1 and 4 would be required.

Based on the current outage schedules for Units 1 and 4, the Locking Tab replacement will be conducted several months before the end of the minimum tab life (6.3 EFPYs). Thus, there is no benefit to having a separate outage specifically for the Locking Tab replacement, only a few months after the planned outage.

Alternative 3 – Replace Locking Tabs with Pickering B design - Not Recommended

Replacing the current locking tabs installed in Units 1 and 4 with a design similar to that of Pickering B (Units 5 and 6) is **not** a recommended option. Although this option allows the SGs to run until EOL without the possibility of locking tab failure, it does not meet all of the other project objectives previously outlined as is shown below:

- The locking tabs installed in Pickering B are welded on the Hot Leg side of the SG Primary Head and thus are not conducive to removal and/or replacement if required during maintenance activities.
- Due to the bolt configuration in the Pickering A SGs (i.e. uneven bolt spacing), installation of locking tabs similar to those in Units 5 and 6 would be quite difficult.
- Replacement of the Units 5 and 6 locking tabs during 2005 involved a tremendous amount of inspections and rework, and hence was costly, time consuming, and dose intensive.

In addition to the above, this option is more costly than Alternative 1. Therefore, replacing the locking tabs with a design similar to Pickering B is not recommended.

Alternative 4 – - Not Recommended

Alternative 5 – - Not Recommended

4/ THE PROPOSAL

A Developmental Release will be used for a mini-campaign (to remove and re-install Clamping Dogs) in support of P711 SG inspections, Preliminary Engineering, to create a contract strategy and complete a Phase 1 BCS.

A Full release will then be requested to:

- Perform the Detailed Engineering
- Award a labour contract (for both units)
- Perform all pre-installation activities for Unit 4 (i.e. workplan preparation, work permits, space allocation, etc.)
- Install, commission, and AFS the modification for Unit 4
- Revise Design Engineering documents as required (i.e. Design ECs, drawings, etc.) for Unit 1
- Start pre-installation activities for Unit 1
- Complete pre-installation activities for Unit 1
- Install, Commission, and AFS the modification for Unit 1
- Close-out the Project

Refer to Appendix C for a list of the project milestones.

5/ QUALITATIVE FACTORS

Successful implementation of the locking tab replacement project will eliminate the reactor safety risk inherent to the design of the current cold leg locking tabs. Ease of maintainability will be a consideration during the developrnent of the design.

Filed: 2013-09-27
EB-2013-0321
Ex. F2-3-3
Attachment 1 Tab 3

6/ RISKS

Description of Risk	Description of Consequence	Risk Before Mitigation	Mitigating Activity	Risk After Mitigation
Cost				
Objectives stated in the Developmental BCS will cost more	Unable to accomplish objectives or will require futher release of funds	**Low**	Clearly defined scope. Regular review of project expenditures. [redacted] contingency available.	**Low**
Scope				
Preliminary design results in an increase in scope	Change in scope resulting in changes in cost and schedule	**High**	Scope has clearly been identified through several meetings and a preliminary evaluation of design options.	**Medium**
Schedule				
Conflict between Boiler activities (Inspection and Locking Tab replacement)	Increase in Outage duration	**Medium**	Schedule will be optimized to ensure that work is conducted in parallel as much as possible. Divider Plate work has already been moved to 2010 and 2011 to mitigate interference with the Boiler Chemical Clean.	**Low**
Resources				
Lack of Design Engineering resources	Delay in Design deliverables	**Medium**	Design support has been committed to this project	**Low**
Technical				
Locking Tab replacement option does not satisfy all project objectives	Constructability and maintenance issues with design	**High**	OPG Design and Components and Equipment are actively working together to ensure that an acceptable option is selected. Qualification testing will be done to ensure constructability and maintability issues are addressed and eliminated if possible.	**Medium**

Locking Tab replacement option fails prior to end of SG life	Potential Foreign Material issue	**Medium**	Locking Tab replacement option will be designed with a substantial amount of rigour as per CNE Directive 05-01. Qualification testing along with required analysis will be performed to ensure that the Locking Tab replacement option is robust and will not become Foreign Material.	**Low**
Regulatory				
This modification does not require regulatory involvement or approval				
Environmental				
N/A				
Health & Safety				
N/A				
Investment				
Locking Tab replacement option interference with low row tube plugging	Removal of locking tab replacement components for low row tube plugging may require significant time and resources	**High**	OPG Design will determine the most viable locking tab replacement option taking into consideration the requirement for access to low row tubes when performing inspections or maintenance.	**Medium**

7/ POST IMPLEMENTATION REVIEW PLAN

Type of PIR:	Targeted Final AFS Date:	Targeted PIR Approval Date:	PIR Responsibility (Sponsor Title)
Simplified	Jun 2011	Jul 2015	Components & Equipment

Comments:

	Measurable Parameter	Current Baseline	Targeted Result	How will it be measured?	Who will measure it? (person / group)
1.	Installation of replacement component(s) during P1041 and P1111 outages	N/A	Components installed during respective outages	Schedule review	PNGS A Components & Equipment
2.	Reliable performance (100% non-failure) of components to end of SG/plant life.	6.3 EFPYs	Non-failure of components during life of SGs	1. Inspection of components during first and second SG inspection outages following replacement. 2. Confirmed non-failure at subsequent outages to end of SG life.	PNGS A Components & Equipment
3.					
4.					
5.					

Appendix "A" **Glossary** (acronyms, codes, technical terms)

- AFS: Available for Service
- CNSC: Canadian Nuclear Safety Commission
- EC: Engineering Change
- EFPY: Effective Full Power Year
- EOL: End of Life
- HTS: Heat Transport System
- NPV: Net Present Value
- RIHT: Reactor Inlet Header Temperature
- PNGS: Pickering Nuclear Generating Station
- PROL: Power Reactor Operating License
- SG: Steam Generator
- TOE: Technical Operability Evaluation

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BUSINESS CASE SUMMARY

Appendix "B"

Project Funding History

$ 000's			Previous Releases (incl contingency) Cumulative Values								
Release Type	Month	Year	2006	2007	2008	2009	2010	2011	2012	Later	Total
Developmental				850	385	520	7,675	7,905	400		17,735
											0
											0
											0
											0
											0
											0
											0
LTD Spent											0

Comments:

The Developmental Release will be used to cover the cost of a mini-campaign to support P711 SG inspections and complete ~40% of the design. The Full Release will be used to complete 100% of the design, install, commission, AFS the modification in Unit 4. Additionally, it will be used to prepare for Unit 1, install, commission, and AFS the modification in Unit 1, as well as complete Project Close-out.

Appendix "C"

Financial Model – Assumptions

Project Cost Assumptions:

For the majority of engineering and design work, overtime has been assumed to be 10%. For field personnel, overtime has been assumed to be 25%.

Financial Assumptions:

The rate of inflation estimated at 2% is consistent with Corporate guidelines.

Project / Station End of Life Assumptions:

Based on a memo to D. Power from P.R. Charlebois, "Pickering Units 1 & 4 End of Service Life Predictions for Establishing Book Value", January 12, 2006, we have assumed that Station End of Life for Units 1 and 4 will be in 2021, thus requiring replacement of the Locking Tabs during 2011 and 2010 respectively.

It is assumed that the Locking Tab replacement modification will be conducted during Fall 2010 for Unit 4 and Fall 2011 for Unit 1.

It is assumed that the majority of design work will be completed well before the 2009 outage milestone.

Energy Price / Production Assumptions

The price of energy is estimated based on Corporate System Economic Values. Production from each Pickering A unit is assumed to be 516 MW at a capacity factor of 80%.

Operating Cost Assumptions

N/A

Other Assumptions:

It is assumed that if a Cold Leg locking tab were to fail, it would cause damage to the Heat Transport System (HTS). The forced outage required to repair the HTS is assumed to cost $100M and be 90 days in duration.

The risk of Cold Leg locking tab failure is assumed to be 5% starting in 2011 (U4) and 2012 (U1) and increasing at a rate of 5% per year.

The probability of Cold Leg locking tab failure in Units 1 and 4 simultaneously is too low to be considered. If a failure were to occur in one unit, the 2nd unit would be shut down immediately.

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Attachment "A"

Project Cost Summary

$000's OM&A	LTD Prior Yr 2006	This Release 2007	This Release 2008	Future Release 2009	Future Release 2010	Future Release 2011	Future Release 2012	Later	Total
Project Management (OPG)	-	221	175	137	395	434	177		1,539
Engineering & Drafting (OPG)	-		160	86	157	168	96		666
Material	-	120			150	125			395
Installation - PWU, BTU	-	125		97	610	615	28		1,475
Contract - Design	-								-
Contract - Installation	-	234							
Contract - Other	-								
Installation - IMS	-								
Kinectrics	-								
Interest (Capital Project Only)									-
Project Costs (excl contingency)	-	700	335						-
General Contingency		150	50						
Specific Contingency									-
Project Costs (incl contingency)	-	850	385	520	7,675	7,905	400	-	17,735
2007-2011 Business Plan		300	100	500	7,100	7,100	300		15,400
Variance to Business Plan	-	400	235	(180)	75	105	-	-	635
Committed Cost									-
Inventory Write Off Required									-
Spare Parts / Inventory									-
Total Release (excl contingency)	-	700	335						-
Total Release (incl contingency)	-	850	385	520	7,675	7,905	400	-	17,735
Ongoing OM&A (non-project)									
Removal Costs (incl in above)									-

Basis of Estimate

Design Complete	Up to - 40%		Quality of Estimate	Conceptual + 60% to - 25%	
3rd Party Estimate	N/A	OPEX used	Yes	Lessons Learned	Yes
Reviewed by Sponsor	Yes	Budgetary Quote(s)	No	Phase 1 Actual Used	N/A
Similar Projects	Yes	Contracts in place	N/A	Competitive Bid	N/A

Variance to Business Plan:

The estimated variance(s) to the 2006-2010 Business Plan will be addressed through the portfolio management process. A PCRAF will be approved by May 2007.

Reviewed By:

Pejman Asgarpour
Project Manager

Date: APR/25/2007

Approved By:

Jerry Keto
Eng & Mods Manager (Strat IV)

Date: 16 April 2007

ONTARIO POWER GENERATION

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Attachment "B" **Project Variance Analysis**

OM&A	LTD N/A N/A	Choose One: Last BCS N/A N/A	Choose One: This BCS Sep N/A	Variance	Comments
Project Management (OPG)				0	
Engineering & Drafting (OPG)				0	
Material				0	
Installation – PWU, BTU				0	
Contract - Design				0	
Contract - Installation				0	
Contract - Other				0	
Kinectrics				0	
				0	
Interest (Capital Project Only)				0	
Project Costs (excl contingency)	**0**	**0**	**0**	**0**	
General Contingency				0	
Specific Contingency				0	
Project Costs (incl contingency)	**0**	**0**	**0**	**0**	
Committed Cost				0	
Inventory Write Off Required				0	
Spare Parts / Inventory				0	
Total Release (incl contingency)	**0**	**0**	**0**	**0**	
Total Release (excl contingency)	**0**	**0**	**0**	**0**	
Ongoing OM&A (non-project)				**0**	
Removal Costs (incl in above)				**0**	

Comments:

This project was identified in June 2005. Currently, conceptual funding is being used to perform minimal design work and to generate the Developmental BCS.

Attachment "C"

Key Milestones

Completion Date			Description
Day	Mth	Yr	
30	Apr	2007	BCS: Developmental Release Approved
30	Jun	2007	PSM: Plan Start Milestone
16	Oct	2007	SOI: Start of mini Field Campgain (P711 Clamping Dog Removal/Re-install)
30	Apr	2008	FR1: Full Release BCS Approved
15	Apr	2009	FD1: Final Design Complete (Unit 1 and Unit 4)
15	May	2009	MCA: Major Contracts Awarded
15	Apr	2010	SOI: Start of Installation (Unit 4)
30	Jun	2010	AFS: Available for Service Meeting (Unit 4)
31	Dec	2010	ECC: EC Close-out (Unit 4)
31	Mar	2011	SOI: Start of Installation (Unit 1)
15	Jun	2011	AFS: Available for Service Meeting (Unit 1)
27	Jun	2011	PCS: Close-out Starts
21	Dec	2011	PCM: Plan Complete Milestone

A Project Execution Plan (PEP) will be approved by Jul 2008

Comments:

All applicable milestones will be in accordance with N-PROC-MA-0013 (Planned Outage Management) as the locking tab replacement will be conducted during the 2010 and 2011 outages.