SIR ADAM BECK PUMP GENERATING STATION (SAB PGS) RESERVOIR REFURBISHMENT – DEFINITION PHASE - HDEV0028

1. RECOMMENDATION:

Approve the release of $9.3 M for Definition Phase work to assess and finalize the design for the refurbishment of the Sir Adam Beck Pump Generating Station (SAB PGS) reservoir.

OPG's economic assessment shows that there is substantial value, estimated at $470 million NPV (2011$), to the Ontario electricity system from continued operation of the SAB PGS.

A Concept Phase assessment has been completed and it concluded that sealing the base of the reservoir with a liner was the preferred option. Definition Phase work relating to refurbishment includes finalizing the design for a reservoir liner system, including assessing whether a partial, or full, liner system and which type of liner system will most cost-effectively allow the facility to continue to provide value to the Ontario electricity system over the next 50-100 years.

Request for this Current Release:	$ 9.3 M
Expenditure Type:	Capital
Release Type:	Definition Phase Release
Release Date:	Q3 2011
Completion Date:	Q4 2013
Investment Type - Refurbishment	Sustaining
Estimate Quality:	Release

Release History ($M)	Pre-2011	2011	2012	2013	2014	2015	Total
Previous Releases - Concept OM&A	1.5	2.0					3.5
Current Release - Definition Capital		3.5	3.5	2.3			9.3
Future Release - Execution Capital					131.5	143.0	274.5
Total Estimated Project Costs	**1.5**	**5.5**	**3.5**	**2.3**	**131.5**	**143.0**	**287.3**

The Execution Capital estimates are preliminary and reflect the AACE Class 4 standard with an expected accuracy of [redacted] to [redacted]. More accurate Class 3 estimates will be prepared during the Definition Phase.

The Definition Phase Refurbishment work will be done in conjunction with other work, if approved, to benefit from synergies, including work to assess the expansion of the reservoir. Business cases for the other work will be provided separately.

Managing the risks around the Project will be important in achieving success. To manage the risk, OPG has engaged an independent panel of international experts to provide technical advice to OPG on the project. Management believes that the issues and risks associated with this project are manageable.

2. SIGNATURES

Submitted by:

Carlo Crozzoli
VP, Hydroelectric Development — Date

Recommended by:

John Murphy — 14 Sept 2011
Executive Vice President, Hydro — Date

Finance Approval :

Donn Hanbidge — Sept 16/2011
SVP and Chief Financial Officer — Date

Line Approval :

Tom Mitchell — Sept 19, 2011
President & CEO — Date

3. SCOPE, BACKGROUND & ISSUES

3.1 Scope of Definition Phase

The scope of the Definition Phase of the refurbishment work is to finalize the design of a reservoir liner system, including assessing whether a partial, or full, liner system and which type of liner system will most cost-effectively allow the facility to continue to provide value to the Ontario electricity system over the next 50-100 years.

3.2 General Background

The SAB PGS is a six unit reversible pump-turbine plant capable of pumping water from the outlet of the tunnels and canal of the SAB complex, into a storage reservoir, and generating (174 MW) from that reservoir by discharging the stored water back into the SAB Complex head pond. The station was constructed between 1953 and 1957. It is the only pump generation station in Canada.

The SAB PGS supports the peaking operation of the SAB Complex. It stores water in off-peak times and uses it to generate during higher priced on-peak hours. Its operation is integrated with the Sir Adam Beck 1 (SAB1) and Sir Adam Beck 2 (SAB2) stations and water stored in the reservoir is used to generate peaking power at all three stations. As a result, the operation of SAB PGS provides a significant summer peaking value to the Ontario electricity system. The SAB PGS is also used to: 1) improve the overall efficiency of operations at the SAB Complex, 2) assist SAB1 and SAB2 in the provision of Automated Generation Control (AGC) services and Operating Reserve services to the Ontario electricity system.

3.3 Background Issues and Opportunities

The PGS Reservoir is comprised of a 7 km long rock-fill dyke, varying in height from 5 to 21 meters. The reservoir bottom is comprised predominantly of natural materials that provide a low-permeability blanket supplemented by an engineered natural clay blanket in certain areas.

The bedrock underlying the entire reservoir is thought to be characterized by open, interconnected, vertical and horizontal joints. Such joints could result in seepage from the reservoir over long distances and cause migration of fine grained soils into the open joints. Such bedrock characteristics could make the foundation and potentially the dyke itself susceptible to sinkhole formation which could potentially lead to dyke breach.

There is some uncertainty in the extent and nature of the jointing in the bedrock, which, if significant, could lead to more prevalent sinkhole development over time and the shutdown of the facility in the near term. Past performance combined with more recent observations indicates that further investigation is warranted at this time. The reservoir has performed satisfactorily over the last 50 years. A detailed investigation is now required to assess its performance and determine any potential mitigative measures to ensure its ongoing operations.

A Concept Phase analysis has been completed and assessed two main options for refurbishment:

1. Sealing the base of the reservoir with a liner.

2. Installation of a concrete cut off wall through the overburden soils and into the bedrock under most of the reservoir perimeter.

The assessment concluded that sealing the base of the reservoir with a liner was the preferred option because it is more cost effective and has less risk. The preferred option will be refined during Definition Phase by determining the extent of the liner and the type of liner.

4. DEFINITION PHASE ALTERNATIVES AND PRELIMINARY ECONOMIC ANALYSIS

I. Status Quo Alternative (leading to Potential Shutdown in 2014): Not Recommended

The status quo is not recommended. This alternative would result in the potential shutdown and removal of the SAB PGS from operations in the near future. An economic analysis shows that there is substantial value to the Ontario electricity system from continued operation of the SAB PGS. There is a substantial cost associated with shutting down the PGS and putting it in a safe state. Preliminary estimates indicate the cost could be $50 M.

II. Delay Definition Phase for the Project: Not Recommended

Delaying the Definition Phase work is not recommended. OPG's assessment shows that it is prudent to continue investigations into the geological condition of the site, including the extent and nature of the jointing in the bedrock under the reservoir. It is also prudent to further investigate potential mitigative measures, such as whether installation of a partial liner, or a full liner over the entire reservoir base, is warranted.

III. Proceed to the Definition Phase of the Refurbishment Work: Recommended Case

It is recommended that the work proceed to Definition Phase immediately to ensure that investigations into the geological conditions of the site and into potential mitigative measures are completed in a timely way.

Economics of Recommended Alternative:

The economic assessment shows that there is an approximately $470 M net present value to the Ontario electricity system based on OPG's evaluation of the capacity value and the peaking energy value of the ongoing operation of the SAB PGS, compared to the shut-down of the facility.

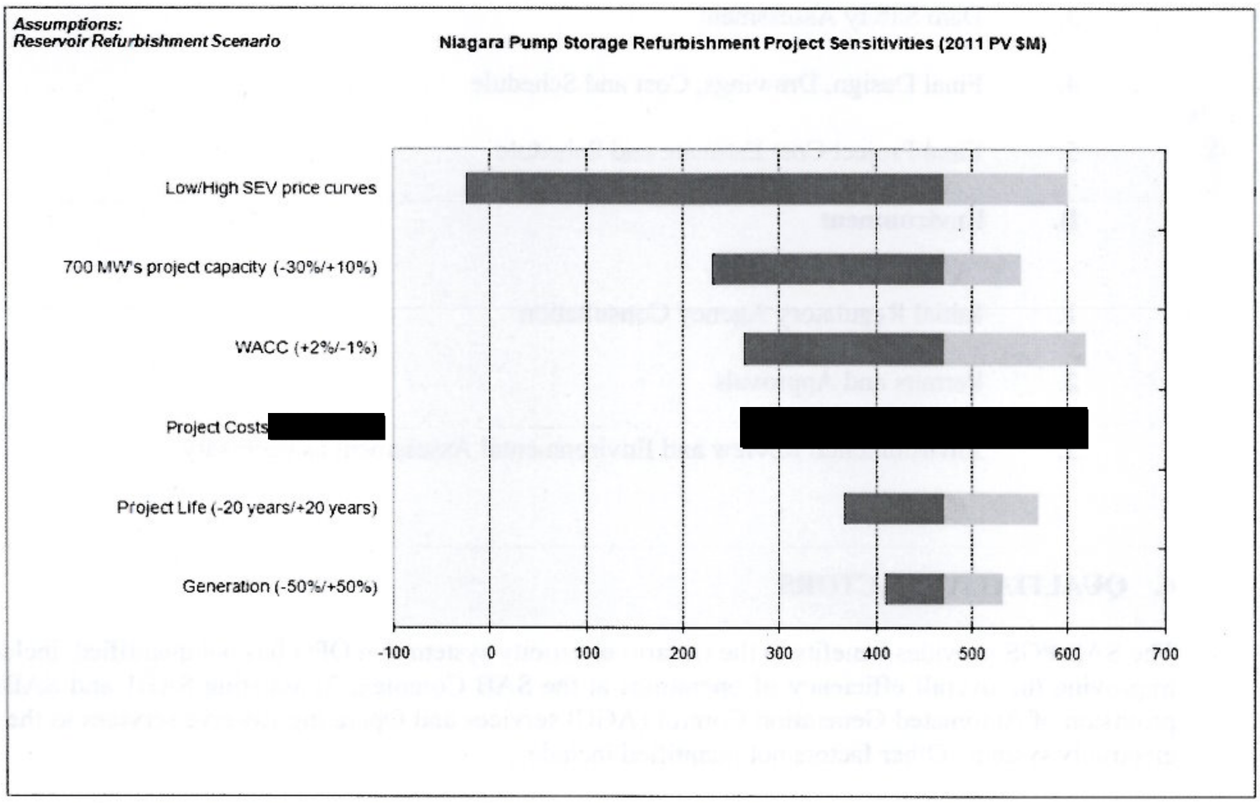
Net Present Value (NPV) calculations have used forecast market prices of electricity and System Economic Values for economic evaluation purposes. This demonstrates that the investment is beneficial to the electricity system.

The SAB PGS is a regulated hydroelectric asset and as such will receive the regulated rate for energy. The impact on regulated Hydro rates to recover the cost of this project is estimated to be approximately 2.5% in 2016, or about $1.3/MWh based on current assumptions.

The economic assessment is based on the estimated cost of an engineered liner over the base of the entire reservoir. At this preliminary stage of the project, cost estimates of Execution Phase work reflect the AACE Class 4 standard and therefore, have an expected accuracy of [redacted] to [redacted]

The results were tested for sensitivity to key inputs, as shown in the graph below. The sensitivity analysis shows that the expected economic value to the electricity system is insensitive to such key factors as the cost of the incremental work, project life, project capacity value, and electricity generation performance.

It is sensitive to electricity prices. An assumed low electricity price curve results in an estimated project NPV of about -$25 M, while a high price curve results in an estimated project NPV of about $600 M.



Key Assumptions used in the economic analysis are provided in Appendix A.

While at this preliminary stage of the project there are significant uncertainties associated with the assessment, the preliminary economic analysis shows that the Refurbishment work is economic when compared to the Status Quo alternative. Therefore, the analysis justifies moving to the Definition Phase for the Refurbishment work.

5. THE PROPOSAL

Definition Phase work relating to refurbishment includes finalizing the design for a reservoir liner system, including assessing whether a partial, or full, liner system and which type of liner system will most cost-effectively allow the facility to continue to provide value to the Ontario electricity system over the next 50-100 years.

Major tasks to be completed during the Definition Phase will include:

A. Engineering

1. Comprehensive Geotechnical Investigation
2. Preliminary Design, Drawings, Cost and Schedule
3. Dam Safety Assessment
4. Final Design, Drawings, Cost and Schedule
5. Final Project Cost Estimate and Schedule

B. Environment

1. Initial Regulatory Agency Consultation
2. Permits and Approvals
3. Environmental Review and Environmental Assessment as necessary

6. QUALITATIVE FACTORS

The SAB PGS provides benefits to the Ontario electricity system that OPG has not quantified, including: 1) improving the overall efficiency of operations at the SAB Complex, 2) assisting SAB1 and SAB2 in the provision of Automated Generation Control (AGC) services and Operating Reserve services to the Ontario electricity system. Other factors not quantified include:

Improving the Unit Efficiencies and Removing Operation Limitations on Existing PGS Units

OPG is assessing the potential to improve the efficiency of existing SAB PGS units through unit overhauls and runner replacement. OPG is also assessing the potential to improve operations by removing existing limitations on the units. The work has the potential to improve the benefit of the SAB PGS to the electricity system. Further work to assess the issues will be done during the Definition Phase of the Reservoir Refurbishment work and will be separately approved.

Refurbishment of SAB1 G1 and G2

SAB1 G1 and G2 were 25Hz units that were shut down in 2009. They have not been refurbished pending review of the business case. Analysis to date shows that refurbishment of the units could add about 110 MW of new capacity to the Beck Complex and could add to the value of the SAB PGS to the electricity system. Further work to assess the issues will be done during the Definition Phase of the Reservoir Refurbishment work and will be separately approved.

Wind and Solar Integration

Energy storage, including pumped storage, has been widely discussed in recent years due to its potential to assist in integrating intermittent renewables, such as wind and solar, into the electricity system and maximizing their contribution. There is the potential for additional value, including new sources of value to the electricity system for pumped storage in the future as the share of wind and solar increases in Ontario's electricity system. The Directive of February 17, 2011, from the Minister of Energy to the OPA to guide the OPA in development of the Plan requires the OPA to consider the potential for storage technologies.

In addition to the work described above, OPG is assessing expanding the volume of the reservoir which could provide additional benefits to the Ontario electricity system. Further work to assess expansion, if approved, will be done jointly with the reservoir refurbishment work to capture synergies and will be separately approved.

7. RISKS

A key risk for the work stems from the geological conditions at the site. To mitigate the risks OPG has engaged a qualified Owner's Representative to assist OPG through the remaining phases of the project, including developing and implementing a comprehensive geotechnical investigation of the site. In addition, OPG has engaged an independent panel of international experts to provide advice to OPG on the project. Overall, risks to the project fall into three main categories:

1. Technical Risks: e.g. the risk that unexpected findings from the planned geotechnical investigations result in delays and design changes.

2. Regulatory Risks: e.g. the risk that issues relating to regulatory requirements result in unexpected delays and costs.

3. Economic Risks: e.g. the risk that unexpected findings during the Definition Phase assessments lead to design changes that increase the cost of the project.

The top risks are included in Appendix B.

8. POST IMPLEMENTATION REVIEW (PIR) PLAN

Type of PIR	Target Definition Phase Completion Date	Target PIR Completion Date
Simplified	(31/Dec/2013)	(31/Mar/2014)

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)	When it will be measured
Quality assessment of the feasibility of the Project	N/A	Work is well managed and done to a high standard of quality.	Technical feasibility to be confirmed by Independent Panel	Independent Panel and Sponsor	At completion of Definition phase
Provincial and/or Federal Environmental Approvals	N/A	Receive all necessary approvals on schedule	Receive all necessary approvals on schedule	Project Team	At completion of Definition phase
Full Business Case Summary for OPG Board approval	N/A	Quality BCS prepared on schedule	Quality BCS prepared on schedule	Sponsor	At completion of Definition phase

APPENDIX A: Modeling Assumptions for Economic Analysis

Financial Model – Assumptions

Following are the key assumptions used during the modeling of the Project:

1. Definition Phase costs of $8.4M which includes [redacted] for contingency.
2. Interest during Construction (IDC) for Definition Phase of $0.9M
3. Execution Phase costs of $255.0M which includes [redacted] for contingency.
4. Interest during Construction (IDC) for Execution Phase of $19.5M.

Financial Assumptions:

1. For NPV calculations a Weighted Average Cost of Capital (WACC) of 7% was used.
2. Debt Rate of 6.75%.
3. Return on Equity (ROE) of 9.3%.
4. Debt Ratio of 53%.

Project Life Assumptions:

1. SAB PGS Reservoir life extended 50 years.

Energy Production Assumptions:

1. Average 50 years of production from the SAB PGS will be 128 GWh's.
2. Average 50 years of production from the Beck Complex resulting from the SAB PGS will be 728 GWh's.

Operating Cost Assumptions:

1. Average 50 years of pumping generation from the SAB PGS will be 178 GWh's.
2. Average 50 years of uplift charges of $1.4M (2011$'s) which include rural rate assistance, debt retirement charge and charging energy.
3. Average 50 years of pumping generation associated with the Beck Complex resulting from the SAB PGS will be 779 GWh's.
4. Average 50 years of standard and non standard OM&A of $4.5M (2011 $'s).
5. Average 50 years of sustaining capital expenditures of $7.1M (2011$'s).

Appendix B: Risk Register

Category	Risk	Contributing Factors	Mitigation / Monitoring / Refurbishment	Residual Risk
Site Investigation (Geotechnical)	Geotechnical investigations cause damage to existing clay liner, dyke or tongue (test-pitting/ drilling, etc.).	- Lack of experience and/or controls - Poor workmanship and materials - Compressed schedule - Working conditions (weather, temp., etc)	- Prepare and implement rigorous quality assurance program which includes engineering oversight over all field activities (including possible repairs) - Identify liner integrity and repair requirements in investigation plan - Monitor reservoir during re-filling activities and maintain frequent monitoring for first year of operation after work completed	Based on experience, the probability of a defect developing as a result of the investigation work is likely very low. However, if a defect develops it can be repaired in the future.
Site Investigation (Environmental)	Issues related to aquatic species relocation arise during dewatering process and cause delays to the geotechnical investigation.	- Greater number of fish and mussels found in the reservoir than anticipated - Discovery of species at risk	- Prepare detailed plans for aquatic species relocation - Retain contingent systems (additional personnel and equipment) for fish rescue and salvage operations will be available	If the relocation process takes longer than expected, available time for the geotechnical investigations would be reduced. This could result in an extension of the planned outage or a need to schedule another outage in 2012.
Site Investigation (Environmental)	Inability to dewater reservoir in specified timeframe (e.g sediment discharge exceeds allowable limits) causes delays to the geotechnical investigation.	- Existing reservoir conditions are likely to produce sediment laden water during complete reservoir drawdown.	- Utilize sediment control (flocculants, settling ponds, filter tubes, etc.) - Maintain a controlled drawdown rate	If the dewatering process takes longer than expected, available time for the geotechnical investigations would be reduced. This could result in an extension of the planned outage or a need to schedule another outage in 2012.
Construction	The reservoir bottom conditions are not as expected (e.g., soft bottom conditions, bedrock joints, sand seams, etc.) resulting in logistical issues, schedule delays, cost increase, and quality issues	- The geotechnical investigation may not detect all deficiencies in the overburden and bedrock	- Delineate and characterize sediment (bearing capacity) during site investigations - Invite general contractors to view reservoir in dewatered state - Install temporary working platforms - Allow sediment to be dried and removed prior to liner placement - Repair any deficiencies detected during construction	Additional cost and time may be required to repair any deficiencies detected during construction.
Construction	The dyke "tongue" does not exist in all areas or to extent expected, resulting in cost & schedule increases	- Lack of as-built verification/ records. - May be difficult to differentiate "tongue" material from surrounding material.	- Determine the extent of the "tongue" during the site investigations - Develop alternative designs to tie-in to dyke core.	Additional cost and time may be required for excavation work to tie-in to dyke core.
Regulatory	Cost Recovery	Recovery of project costs is subject to regulatory review before the Ontario Energy Board	Effective project management processes and execution	All such regulatory reviews include uncertainty and as such, some inherent risk.

Appendix C: Summary of Definition Phase Cost Estimates ($M)

	2011	2012	2013	Total
Internal Expenses	0.2	0.6	0.6	1.4
External Expenses	[redacted]			
Interest	[redacted]			
Escalation	0.0	0.1	0.1	0.1
Contingency	[redacted]			
Total Release	**3.5**	**3.5**	**2.3**	**9.3**

Prepared by:

Mahir Aydin — Sept 13, 2011
Project Manager — Date

Approved by:

Tim Gigliotti — Sept. 13, 20
Project Director, — Date