

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 1 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

SIR ADAM BECK 1 GS

G9 REHABILITATION

Project Number: SAB10047

Niagara Plant Group

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 2 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

SIR ADAM BECK 1 GS

G9 REHABILITATION

SAB10047

1. RECOMMENDATION

Approve the release of \$ 32.0 million (includes a previously approved developmental release of \$300k) for the replacement of the Sir Adam Beck 1 (SAB1) G9 generator with a new generator, the rehabilitation and upgrade of the turbine, the installation of a new runner, a liner in the Johnson valve and a new transformer and the upgrade of the associated electrical equipment. The upgraded G9 is scheduled to be commissioned and placed into service by the end of 2010.

The new G9 generator will have an electrical rating of 61.6 MW, increasing the installed capacity of the SAB1 Generating Station by 10.8 MW. The project has been incorporated into the station Life Cycle Plan. The rehabilitated and upgraded G9 will optimize energy production by efficiently utilizing the water available to the SAB complex, including water available from the Niagara Tunnel. The Pump Generating Station (PGS) will be used to shift energy from off-peak to on-peak, increasing capacity output of the SAB facility. The resulting incremental peaking capability for SAB1 is about 10 MW and incremental energy is 60.8 GWh per year. This incremental output has a market value of ~\$4 to 6 million (2008\$).

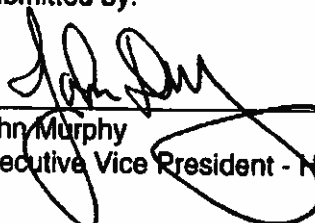
This project is consistent with OPG's objective of maintaining its assets and optimizing production from its existing hydroelectric generating assets. The project is identified in the current approved business plan in 2008, 2009 and 2010 and cash flows will be managed by the Plant group.

\$000s	LTD 2007	2008	2009	2010	Later	Total
Currently Released	0	300				300
Requested Now (This Release)		1,700	15,520	14,490		31,710
Future Funding Required						
Total Project Costs		2,000	15,520	14,490		32,010
<u>Investment Type</u>	<u>Class</u>	<u>NPV</u>	<u>IRR</u>		<u>Discounted Payback</u>	
Sustaining/Value Enhancing	17	17,600 (using SEVs)	11.0% (using SEVs)		16 years (using SEVs)	

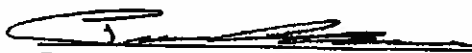
ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 3 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

2. SIGNATURES


Submitted by:


John Murphy
Executive Vice President - Hydro
Date 7 Aug 2008.

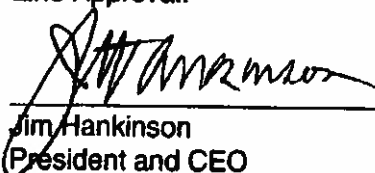
Recommended by:


Pierre Charlebois
Executive Vice President and
Chief Operating Officer
Date Aug 11/08

Finance Approval:


Donn Hanbidge
Senior Vice President and
Chief Financial Officer
Date August 10/08

Line Approval:


Jim Hankinson
President and CEO
Date Aug 21/08

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 4 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

3. BACKGROUND AND ISSUES

SAB 1 GS is a ten unit hydroelectric station located on the Niagara River. The units were placed in service during the years 1921 to 1930. Two of the units (G1 and G2) have 25 Hz generators and they are scheduled to be decommissioned in 2009. The SAB1 Life Cycle Plan considered the water available to the station, including that provided by the Niagara Tunnel, and concluded that an eight unit station will optimize the use of the water available to the station. An orderly program of unit rehabilitation involving G7, G9, G10 and G3 was proposed in the Life Cycle Plan. After the completion of the G7 conversion project currently underway, this G9 project and the Niagara Tunnel, the eight 60 Hz units at the station (G3 to G10) will have a total capacity of 427 MW and will have an annual energy production of approximately 2,149 GWh. This energy generates annual revenue of \$81.4 million at the proposed regulated rate of \$37.90/MWh but over \$100 million if valued at current market prices.

The G9 generator was installed in 1925 and converted to 60 Hertz in 1956. The 50.8 MW generator is in poor mechanical condition. It is currently limited to operating at a maximum of 70% wicket gate opening due to significant vibrations that occur at greater gate openings. Under this operating restriction, the maximum generator output is 37 MW. The bearing lubrication system is unreliable and prone to causing bearing failures. It is suspected that the upper guide bearing is partially wiped. The unit may fail at any time and it is possible that it may not be able to be brought back into service. The generator is at the end of its service life. Consideration has been given to correcting the problems with the generator, but this will require significant re-design and re-work within the physical constraints of the current generator. It is unlikely that a generator manufacturer other than the original designer would be prepared to undertake the major re-design required. It is expected that the cost of the re-design and the repairs will be significant compared to the cost of a new generator. Any attempt at undertaking the re-design and repairs will yield a unique repair with uncertain long term reliability.

When the SAB1 G7 generator was purchased from GE Hydro in 2007, OPG negotiated an option, valid until the end of 2008, to purchase a second, similar generator at the same base cost, modified by an escalator clause for the cost of labour and material. This represents an attractive option to OPG. GE Hydro has since been acquired by Andritz VA Tech and the takeover was concluded at the end of June, 2008. Discussions with Andritz VA Tech have been initiated and Andritz VA Tech has indicated that it will honour OPG's option for a second generator.

The installation of a new, larger G9 generator necessitates the replacement of associated electrical components. The existing rotating exciter has a "dead zone" and is not fully functional. A new static exciter is required to complement the new generator. Upgrades to the buswork and a new, larger capacity transformer are required to handle the increase in generator output.

The existing runner and turbine are physically unable to fully utilize the water available through the G9 water conveying structures. A new efficient runner and an upgrade to the turbine are required to utilize this water. It has been identified that there are significant

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 5 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

hydraulic losses through the G9 Johnson valve. A liner installed in the Johnson valve will reduce these losses.

4. ALTERNATIVES & ECONOMIC ANALYSIS

Base Case (Status Quo): Continue to Operate G9 in its Current Condition

This alternative does not address the fact that the unit is in poor condition, restricted to 70% wicket gate opening due to vibration problems and may have a partially wiped upper guide bearing. The unit may fail at any time and may not be able to be brought back into service, resulting in the total loss of generation from the unit.

- **This alternative is not recommended.**

Alternative 1:

Install a new 61.6 MW Capacity Generator, Transformer, Runner, Johnson Valve Liner and Upgrade the Turbine

This alternative replaces the end of life 50.8 MW G9 generator with a new 61.6 MW generator that optimizes the use of the water available. It includes a new exciter, new protections and controls and a new transformer. A new, efficient runner will be installed, the turbine will be rehabilitated and a liner installed in the Johnson valve. With regular maintenance, the useful service life of the components is expected to be 50 years or more.

- **This is the recommended alternative**

The following options were considered and rejected:

1. Repair the Existing Generator, Upgrade to 61.6 MW, Install a New Transformer, Runner, Johnson Valve Liner and Upgrade the Turbine

This option involves undertaking a major re-design and re-work of the generator. The upgrade of the generator, the installation of a new transformer and runner and the upgrade to the turbine would optimize the use of the available water. However, the generator re-work would be a unique rehabilitation and there will be a significant risk that the rehabilitation will not guarantee reliable long term performance of the generator. This option was rejected for technical reasons.

2. Repair the Existing Generator (50.8 MW), Install a New Runner and Overhaul the Turbine.

This option involves repairing, but not up-grading, the generator and installing a new runner and overhauling the turbine. The same problems identified in the option above would be present, with no guarantee of reliable long term performance of the generator. This option does not make full use of the available water. This option was rejected for technical and financial reasons.

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 6 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

Financial Analysis:

\$ Millions	Base Case	Alt 1 (recommended)
Project Cost	0	32.0
NPV (after tax)	0	17.6
IRR %	0	11.0
Discounted Payback (Yrs)	n/a	16

The financial evaluation assumes incremental peaking capability of 10 MW and annual energy of 60.8 GWh for G9. Generation estimates were developed using detailed water and energy modeling based on 80 years of historical Niagara River flows. Peaking capability is estimated based on the unit's average capacity factor during peak periods in the summer and winter seasons.

The Beck complex is often operated for operating reserve and paid through an Operating Reserve revenue stream. The financial evaluation calculations do not include this benefit as this value is determined at the time of operation and is dependant on system requirements and how the units are required to be operated.

Net Present Value (NPV) calculations have used forecast market prices of electricity for economic evaluation purposes. This demonstrates that the investment is prudent from a commercial perspective. However, this generator is part of OPG's regulated Hydroelectric assets and as such will receive the regulated rate for energy. This project was included in OPG's 2008 rate submission for the rate years 2008 and 2009.

The levelized unit energy cost (LUEC) over 50 years for this project is approximately \$54/MWh. This is significantly lower than published prices of \$110/MWh in OPA's standard offer for renewable energy projects. The impact on regulated rates to recover the cost of this project is estimated to be approximately 0.2%.

5. THE PROPOSAL

Results To Be Delivered:

The existing SAB1 G9 generator will be replaced with a new 61.6 MW generator and the turbine will be rehabilitated and upgraded. Also included are a new exciter, new protections and controls, upgraded buswork and a new transformer. The turbine rehabilitation will incorporate a new, efficient runner and greaseless bearings. A steel liner will be constructed inside the Johnson valve to reduce hydraulic losses.

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 7 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

The generator is scheduled to be commissioned by the end of 2010. The new generator will utilize the water made available to the Beck complex by the Niagara Tunnel and through the use of the Pump Generating Station. It will contribute 60.8 MWh annually to the station output. As well, it will increase the Beck complex's ability to provide operating reserve and provide assistance with managing excess baseload generation (EBG) on the system.

Runner

The existing runner is the original runner installed in 1925. It was last inspected in March 2007 and found to have some minor cavitation and pinholes in the stainless steel overlay.

The design, model development and model testing for new runners for SAB 1 GS have been completed as part of a runner replacement program. A new runner for G9 with an efficiency of approximately [REDACTED] can be supplied by the runner manufacturer.

Generator:

A new 61.6 MW capacity generator can be installed to match the maximum power output of a new runner.

With a new generator and new runner, G9 will have a high efficiency rating and will generally be one of the first units on / last units off at the station to maximize efficient generation.

Transformer

The existing 55 MVA transformer will be replaced with a new 68.5 MVA transformer to match the output of the generator.

Turbine Upgrade

The last significant amount of work on the G9 turbine was carried out in 1956 at the time of conversion to 60 Hertz. Stator repairs were made in 1974. The normal interval between major overhauls is 25 to 30 years and the turbine is overdue for rehabilitation. Modifications will be made to the turbine to increase the maximum output to approximately 61.6 MW, from the current 50.8 MW output. The scope will include the modification of the discharge ring and the installation of greaseless bushings. The upgraded turbine will maximize the efficient use of the available water.

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 8 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

Johnson Valve Liner

The G9 water conveying structures include a Johnson valve located at the end of the penstock. The internal components of the Johnson valve have been removed to address a concern that the valve could not be relied on to function safely. The ribs and projections remaining inside the valve casing cause significant hydraulic losses. A steel liner will be installed to create a smooth transition from the penstock to the scroll case, thereby reducing the hydraulic losses. Installation of the liner will also alleviate concerns regarding the long term integrity of the cast steel Johnson valve casing.

Other Major Items In Scope

The existing faulty rotating exciter will be replaced with a new static exciter to match the requirements of the new generator.

Upgrades to the generator output buswork and to the electrical connections to the Hydro One system will be made to handle the increase in generator output.

A System Impact Assessment by the IESO and a Customer Impact Assessment by Hydro One are required because the project will connect additional generation capacity (10.8 MW) to the Ontario Grid. The developmental release (approved) provides funding to carry out these studies.

Ongoing Operational and Maintenance Cost Impacts

The incremental effort to maintain the unit is minimal and will be managed in the Plant Group business plan. A unit overhaul after 25 years of operation has been included in the financial analysis.

Qualitative Factors

The Project was classified by OPG as Rehabilitation and therefore was presented to the Chestnut Park Accord Steering Committee for trades work assignment. The Committee assigned operation of the powerhouse overhead crane, inspection of scroll case and stay vane repairs, transformer testing and oil handling, and commissioning to the Power Workers Union. The balance of the work was assigned to the Building Trades unions.

Project activities will be conducted in accordance with Niagara Plant Group Environment, Health and Safety (EH&S) Management System

Project Management

A Project Management Plan identifying scope, schedule and cost has been developed for this project.

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 9 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

The project will be executed by the Niagara Plant Group Project Department.

Post Implementation Review (PIR)

A Post Implementation Review (PIR) will be conducted within 12 months of the date of the return to service of the unit.

The following unit performance parameters will be measured:

Turbine/ generator output: The Niagara Plant Group Production Department will verify that the generator output is 61.6 MW. Revenue metering equipment will be used to measure the output.

Runner performance: The runner performance with respect to cavitation will be assessed by the Niagara Plant Group Production Department and Hydro Engineering by making an inspection of the runner in accordance with the runner warranty details.

The Niagara Plant Group Project Department will review the project by comparing the planned cost and schedule milestones outlined in the Project Management Plan to the actual cost and schedule milestones.

6. QUALITATIVE BENEFITS

Qualitative Factors & Sustainable Energy Development:

- Sustained generation from an existing hydro generating station with a 10.8 MW increase in capacity (from 50.8 MW to 61.6 MW).
- Increased efficiency of water use due to the efficient runner, turbine upgrade and installation of the Johnson valve liner.
- Combining the generator replacement, electrical equipment replacement, runner replacement, turbine upgrade and Johnson valve liner installation into one outage reduces total outage time and avoids repetitive dismantling and assembly of the unit.

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 10 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

7. RISK ANALYSIS

Risk Category	Description of Risk	Description of Consequence	Risk Before Mitigation	Mitigating Activity	Residual Risk
Cost	Cost over-run / Cost under-run	Plant Group cash flow issues	medium	Estimates refined by obtaining budget quotes where possible	low to medium
Scope	Scope not complete, or accurate	Could lead to cost over/ under runs	low	Compared scope with similar project underway (G7)	low
Schedule	Delays to the delivery / installation of the generator	G9 return to service delayed	medium	Initiate discussions with preferred generator vendor to secure delivery schedule, commit to generator purchase as soon as possible	medium
Resources	Insufficient commissioning resources to complete critical tasks on schedule	G9 return to service delayed	medium	Where possible, schedule and complete activities throughout project life	low to medium
Technical and Quality Assurance	Incorporating new technology and equipment	Unproven technology or equipment may prove unacceptable	low	Where possible, apply OPG standards. Ensure adequate specifications and engineering reviews of proposals	low
	Poor quality components from unknown/ overseas suppliers	Detrimental to the long term performance of the component	medium	Arrange site surveillance, develop and follow inspection test plans to ensure quality	low
Generation	Inaccurate estimation of energy production from unit	Over estimate of energy production	medium	Use detailed water modeling incorporating 80 years of historical Niagara River flow	low
Regulatory	G9 not compatible with grid / system requirements	G9 not permitted to be connected to grid	low	Ensure applications to IESO and Hydro One are complete and accurate	low
Environmental	Spill	Reportable spill	low	Plant Group Environmental policies will be followed	low
Health & Safety	Unsafe working procedures	Worker injury	medium	Plant group Safety Policies will be followed	low

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 11 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

Cost Risk:

There is a medium to high level of confidence in the cost estimate for this project.

- The cost of the generator design/ supply/ install, the largest component of the project, is based on the purchase option obtained from GE Hydro at the time of the purchase of the SAB1 G7 generator. A defined escalation clause for labour and material will be applied to the G7 base cost. However, negotiations with Andritz VA Tech, the new owners of GE Hydro, for the purchase of the new generator have not been concluded.
- Preliminary price quotes have been obtained from the exciter, runner, transformer and Johnson valve liner suppliers in an effort to develop accurate cost estimates.
- Much of the work associated with the G9 project is similar to the work presently being undertaken on the G7 project. G9 project costs were developed with this knowledge.
- An overall contingency of [REDACTED] is included in the project cost estimate. The contingency has been determined by assessing the unique risk factors for each of the items in the estimate.

Schedule Risk:

- Discussions with Andritz VA Tech indicate that they will honour OPG's option to purchase a 61.6 MW generator similar to the SAB1 G7 generator currently being installed by GE. OPG has not concluded discussions with Andritz VA Tech regarding OPG's schedule for the installation of the generator. It is not known if the G9 generator can be slotted into the Andritz VA Tech manufacturing queue such that it can be manufactured and installed to meet the project schedule. If the Andritz VA Tech generator production plant is booked, the generator in-service date will be delayed.
- The project schedule is such that there may be numerous contractors on site at any given time, creating the possibility for interference. This concern will be managed by scheduling and coordinating site work appropriately.

Supply and Procurement Quality Assurance Risk:

- Supply Chain and Hydro Engineering will exercise due diligence and assess the capabilities of Andritz VA Tech prior to entering an agreement.
- Possible manufacture of runner and generator components overseas presents quality risks. Contracts for source surveillance will have to be put in to place. Inspection and test plans will be utilized to monitor the product quality throughout the manufacturing process.

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 12 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

- Quality assurance for the generator assembly at site will be addressed by hiring a Quality Control monitor to oversee the generator assembly.

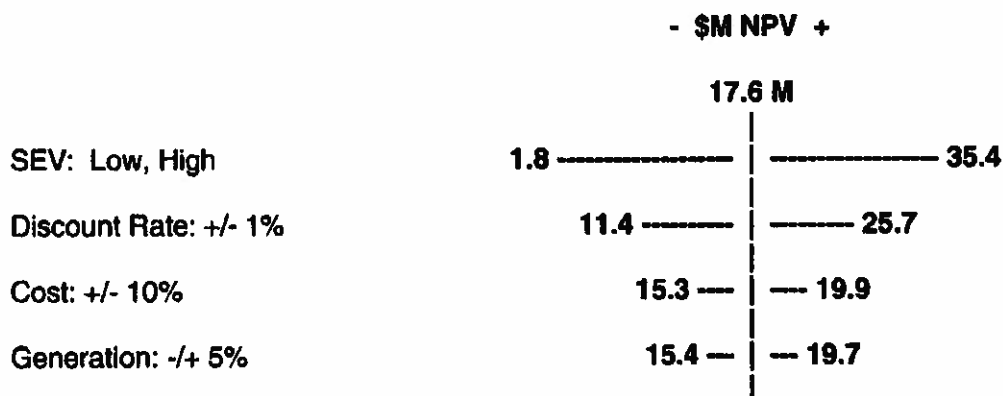
Graphical Representation of Risk using a Tornado Diagram:

The project is considered to be sensitive to the following variables:

SEV (forecast market prices)
 Discount Rate
 Capital Cost
 Generation

A Tornado diagram has been constructed to illustrate the impact on project NPV with the following variables and changes:

- Change to SEV: Low and High values
- Discount Rate: + / - 1%
- Project cost: + / - 10%
- Generation: - / + 5%



The result of the sensitivity analysis indicates that the project economics are fairly robust with the NPV remaining positive for the range of variables tested.

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 13 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

ONTARIOPOWER HYDROELECTRIC
 GENERATION Summary of Estimate

Date	July 15, 2008
Project #	SAB10047

Facility Name: Sir Adam Beck 1 GS

Project Title: G9 Rehabilitation

Years (k\$)	2008	2009	2010	2011	TOTAL	%
Project Mgmt.	75	500	594		1,169	3.7
Engineering						
Permanent Materials						
Construction/ Installation						
- Contractors						
Interest	25	540	1,477		2,042	6.4
Contingency						
TOTAL	2,000	15,520	14,490		32,010	100%

Notes: 1 Schedule Start date: September, 2008
 In-service dates:
 Generator December, 2010

2 Interest rate provided by Corporate Finance

3 Includes Removal Costs of: 1,100 k

4 Includes Definition Phase Costs of: 300 k

Prepared by:

Approved by:

Torben Frost
 Project Engineer

John Conlon
 Project Manager

ONTARIOPOWER GENERATION	Document Number: SAB10047	Revision: REV 0	Page: 14 of 14
	SIR ADAM BECK 1 GS G9 REHABILITATION		

APPENDIX 1

Assumptions

Financial Model

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

Project Cost Assumptions:

1. VA Tech will honour OPG's option to purchase a generator similar to G7 at the price negotiated in the contract with GE Hydro.
2. Quotes from suppliers of major components were used if available.
3. Costs for other components and labour were based on costs for similar work carried out in the past with appropriate escalators applied.
4. Competitive bids can be received for the work to be contracted out.

Financial Assumptions:

5. The July 2008 Hydro FE Model was used with a 2008 project start year.
6. The new generator and associated equipment will have a useful service life of 50 years.

Project Life Assumptions:

7. The project can start immediately after approval.
8. The project can be completed and the generator can be commissioned by December, 2010.

Energy Production Assumptions:

9. Energy forecasts were based on Niagara River flow models.
10. Existing outage plans can be followed.
11. Generation at the Beck plants can be maximized while adhering to the market dispatches.
12. Historical forced outage rates will be typical in the future.

Operating Cost Assumptions:

13. Other than a unit overhaul after 25 years of operation, there will be minimal incremental operating costs associated with the new generator.