

ONTARIO POWER GENERATION	Document Number: SAB10064	Revision: REV 9	Page: 1 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

SIR ADAM BECK 1 GS

G3 Upgrade - New Runner & Generator Rewind

Project Number: SAB10064

Niagara Plant Group

SCI #: NPG-08707.021-0001

	Document Number: SAB10064	Revision: REV 9	Page: 2 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

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G3 Upgrade - New Runner & Generator Rewind

SAB10064

1. RECOMMENDATION

Approval is recommended for the release of \$24,057k (CAP), including a preliminary release of \$650k, to rehabilitate and upgrade Sir Adam Beck 1 (SAB1) G3. Work will include a generator rewind and an upgraded runner resulting in improved unit efficiency and a maximum continuous rating (MCR) increase of approximately 9 MW. This project is a sustaining investment required to ensure continued reliable operation of G3 and to maximize the use of water available from the Niagara River when the third tunnel is placed in-service.

The rehabilitated G3 unit is expected to produce 59 GWh annually, including an incremental increase of 13 GWh due to the installation of higher capacity stator windings, a Johnson Valve sleeve, and more efficient runner and transformer.

This sustaining investment is consistent with the approved Life Cycle Plan (LCP) for SAB1 and OPG's objective of continuing to increase clean, renewable generation from its existing fleet of hydroelectric assets.

\$000's	LTD 2010	2010	2011	2012	2013	Total
Currently Released	650					650
Requested Now (This Release)			3,426	19,222	759	23,407
Future Funding Required						
Total Project Costs	287	11	3,778	19,222	759	24,057
<u>Investment Type</u>	<u>Class</u>	<u>NPV</u>	<u>IRR</u>	<u>LUEC</u>	<u>Discounted Payback</u>	
Sustaining	17	26,654 (using SEV's)	14.3% (using SEV's)	\$47.65 / MWh	12 years (using SEV's)	

Funding:

- A developmental release was approved on October 15, 2009 for \$650k
- The funding for the project is included in the Niagara Plant Group's annual business plan
- Capital funding of \$29,400k was included in the rate application EB-2010-0008

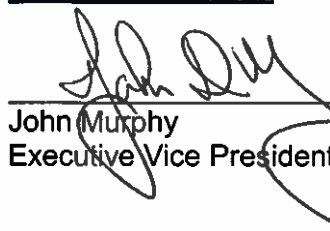
ONTARIO POWER GENERATION	Document Number: SAB10064	Revision: REV 9	Page: 3 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

2. SIGNATURES

Submitted by:

 19 JAN 11
Mike Martelli Date
Plant Group Manager, Niagara Plant Group

Recommended by:

 3 Feb 2011
John Murphy Date
Executive Vice President - Hydro

Finance Approval:

 Date
Donn Hanbidge
Senior Vice President and
Chief Financial Officer

Line Approval:

 27 Feb 2011
Tom Mitchell Date
President and CEO

	Document Number: SAB10064	Revision: REV 9	Page: 4 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

3. BACKGROUND AND ISSUES

Sir Adam Beck 1 (SAB1) GS is a ten unit 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) are 25Hz generators and were decommissioned in 2009. The approved LCP for SAB1 considered the water available to the station, including that provided by the third Niagara Tunnel, and concluded that an eight unit configuration will optimize the water available to the station and the corresponding station revenues. The LCP established an orderly program of unit rehabilitation involving G7, G9, G10 and G3 for SAB1. G7 was rehabilitated and placed in service in 2009 and G9 was rehabilitated and placed in service in December 2010. In 1970 SAB1 G3 was converted from 25 Hz to 60 Hz and upgraded to a 55 MVA machine.

SAB1 G3 was originally placed in service in 1922 and has not had a major rehabilitation since 1985. Hydroelectric units of this type normally require overhauls on a 25-30 year cycle to ensure reliable operation and to maintain revenue. In the rate regulation submission case number EB-2007-0905, OPG laid out a schedule whereby SAB1 units would be rehabilitated in order G7, G9, G10 then G3. A decision was made in April of 2009 to rehabilitate G3 ahead of G10, due to the condition of the stator core. G10's stator core was known to be acceptable for extended service while the condition of the core for G3 was unknown and a significant potential source of operational risk.

A condition assessment was completed by Hydro Engineering Division (HED) on G3 in August 2010. The assessment report indicated that the following components are at end of life:

- Surface air coolers
- Bearing coolers
- Stator windings
- Excitation system
- 15 kV bus and insulators
- Main output transformer
- Switches
- Protection and control system

The report recommended: a major overhaul of the turbine and related equipment, a major generator overhaul which included rewinding the stator, replacement of many main output power delivery system components, refurbishment of the excitation system, replacement of the main output transformer and modernization of the unit protections and controls. The existing excitation system does not meet current IESO requirements for reactive power capability, response time and ceiling levels. Many of the end-of-life components including the exciter, switches and bus work are original 1920's vintage equipment.

Based on previous rehabilitation and upgrade work completed on both units G7 and G9 at SAB1, there is an opportunity to replace the runner and install a Johnson Valve sleeve increasing the overall efficiency and energy production from the unit. The Johnson Valves were original station equipment installed in the 1920's. The sleeve is installed in

	Document Number: SAB10064	Revision: REV 9	Page: 5 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

the enlarged section of the penstock which reduces turbulent flow and thereby increases unit efficiency by 4 GWh for G3.

The runner on G3 is suitable for extended service, based on the Engineering condition assessment, however; replacement of the runner on G3 is justified because of the significant efficiency and capacity gains that can be achieved. The runner design used for G3 will be the same design used on both G7 and G9. The new runner will increase unit MCR by approximately 9 MW, and represents approximately 8 GWh of the total 13 GWh of incremental energy that will be generated by upgrading G3. Replacing the runner represents \$ million of the total project costs and provides excellent value to the ratepayer as the LUEC is approximately \$26/MWh, the NPV is \$11M and the payback period is approximately 8 years.

The total estimated cost for the recommended upgrade alternative is \$24.1M. This is \$5.3M less than the previous cost estimate used in both the 2010 – 2014 Business Plan and the EB-2010-0008 Payment Amounts submission for 2011 and 2012 to the Ontario Energy Board. The reduced costs are primarily due to the favourable condition of the generator found during the Engineering condition assessment of the unit. The G3 generator is expected to last for another 30 to 40 years with just a rewind and major overhaul work. During previous unit upgrades on G7 and G9 the generator needed to be replaced which significantly increased project costs.

Business Objectives:

Rehabilitate or overhaul G3 to provide 30 years of reliable service in the most cost effective manner possible to sustain the capacity of the eight unit (SAB1) station recommended by the approved Life Cycle Plan. Where it is cost effective, introduce both unit efficiency and capacity increases to expand the ability of existing hydroelectric generation to meet demand. Ensure that adequate generation capacity is available at Sir Adam Beck Generating Complex to maximize the use of water that will be delivered by the third Niagara Tunnel.

ALTERNATIVES & ECONOMIC ANALYSIS

Base Case (Do Nothing):

Do Nothing. (\$0k Capital)

This alternative does not address the increasing risk of equipment failure on G3. There were a number of systems that were identified as end-of-life during the engineering assessment. There is a risk of general cooling failures, bearing failures, excitation system failure in addition to numerous other electrical system failures on G3 due to the age and condition of the equipment. Not making appropriate sustaining investments to correct these conditions and deficiencies will lead to increasing unit unreliability and lost production. This alternative does not address the stated business objective and is not consistent with the approved Life Cycle Plan for SAB1.

	Document Number: SAB10064	Revision: REV 9	Page: 6 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

- This alternative is not recommended.

Alternative 1:

Rewind Generator and Replace Turbine Runner (\$24,057k Capital)

This alternative upgrades the existing generator and runner MCR from 55 MVA (46 MW) to 63.25 MVA (55 MW). A new, efficient runner will be installed, the turbine will be rehabilitated and a liner installed in the Johnson valve. This alternative includes performing miscellaneous safety and ergonomic improvements to work areas and equipment associated with the G3 unit. An Uprate Study to establish the maximum electrical and mechanical limits of the unit up to 68.5 MVA, 61.65 MW will be performed. If the unit can be successfully up-rated, additional generation of 5 GWh annually may be possible. With appropriate maintenance and overhauls, the expected service life of the components is 50 years.

This alternative is recommended because it provides the most cost effective manner in which the unit reliability will be restored and maintained for the next 30 years while delivering an additional 13 GWh of incremental energy annually. This alternative delivers the most preferable NPV and provides the best overall value to the Ratepayer of all of the alternatives considered. Performing safety and ergonomic upgrades will improve the work environment and reduce health and safety risks to workers. Performing an Uprate Study will ensure maximum utilization of the upgraded unit based on the existing scope of work.

- This is the recommended alternative

Alternative 2:

Replace Generator and Turbine (\$39,954k Capital)

This alternative replaces the 46 MW generator with a new 61.6 MW generator. A new, efficient runner would be installed, the turbine would be rehabilitated and a liner installed in the Johnson valve. This alternative includes performing miscellaneous safety and ergonomic improvements to work areas and equipment associated with the G3 unit. The scope of work for this alternative is the same as the rehabilitation work recently completed on G7 and G9 at SAB1. With appropriate maintenance and overhauls, the expected service life of the components is 50 years.

This alternative is rejected because improvement in unit performance resulting from the replacement of the generator does not yield enough incremental generation to justify the extra expenditure. The 50 year NPV for this alternative is over \$6M lower than the recommended alternative despite additional incremental generation of 5 GWh annually. A full generator replacement is not required and there are few benefits that would result from this significant expenditure.

- This is not the recommended alternative

	Document Number: SAB10064	Revision: REV 9	Page: 7 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

Alternatives Considered But Rejected:

1. Minor Overhaul

This option involves repairing only the equipment that requires immediate attention. It does not include upgrading the generator, the installation of a new runner, or overhauling the turbine. The expected reliable service life is only 5 years where 30 years of reliable service is required to meet the business objectives. This option does not make full use of the water that will be provided by the third tunnel. This alternative also does not address the stated business objectives and is not consistent with the approved LCP. Furthermore, pursuing this alternative does not provide the best value to the Ratepayer as this alternative ignores the value enhancing investments in the Johnson Valve sleeve and runner.

2. Major Overhaul

This option involves making necessary repairs to existing equipment and overhauling the turbine. It does not include upgrading the generator or the installation of a new runner. The expected reliable service life is only 15 years where 30 years of reliable service is required to meet the business objectives. Since many of the unit components are at end of life there is no guarantee of reliable long term performance of the generator. This option does not make full use of the water that will be provided by the third tunnel. This alternative does not address the stated business objectives and is therefore rejected. Furthermore, pursuing this alternative does not provide the best value to the Ratepayer as this alternative ignores the value enhancing investments in the Johnson Valve sleeve and runner.

Financial Analysis:

\$ Millions	Base Case	Alternative 1 (recommended)	Alternative 2 (Not recommended)
Project Cost	0	24.06	39.95
NPV (after tax)	0	26.65	20.56
IRR %	0	14.3	10.4
Discounted Payback (Yrs)	n/a	12	18

The financial analysis was based on a 50 year study period. Major overhauls are included 30 years into the study for both alternatives considered.

Annual generation for G3 is expected to be 59 GWh; 88% of which is expected to be delivered during the winter peak. MCR for G3 is expected to increase to 55 MW providing an incremental increase of approximately 9 MW over the previous unit configuration.

	Document Number: SAB10064	Revision: REV 9	Page: 8 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

Net Present Value (NPV) calculations have used forecast market prices of electricity (SEV's) 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 2010 rate submission for the rate years 2011 and 2012.

The breakeven levelized unit energy cost (LUEC) over 50 years for this project is \$47.65/MWh. This is significantly lower than the OPA's published prices of \$122/MWh for waterpower projects over 10MW under the Feed in Tariff (FIT) program. The impact on regulated rates to recover the cost of this project is estimated to be approximately 0.2%.

THE PROPOSAL

Results to be Delivered

Completing this project will result in the following:

1. 30 years of reliable service for G3
2. An upgraded runner providing increased efficiency () and greater unit capacity (9 MW)
3. A more efficient main output transformer ()
4. Increased unit MCR (9 MW)
5. Increased overall generation from the unit (13 GWh incremental annual generation)
6. Improved unit control
7. Improved work conditions
8. Excitation system will meet IESO requirements for reactive power capability and response

Execution Phase Work Overview

The work to be done in this stage will include the execution of the Project Execution Plan based on the project scope. The general scope of work for the project is as follows:

1. Upgrade existing generator and runner MCR from 55 MVA (46 MW) to 63.25 MVA (55 MW)
2. Perform an overhaul of the turbine system components
3. Upgrade the electrical output systems associated with the generator to 68.5 MVA
4. Perform miscellaneous safety and ergonomic improvements to work areas and equipment associated with the G3 unit
5. Perform an Uprate Study to establish maximum electrical and mechanical limits of the unit up to 68.5MVA, 61.65 MW

A draft Project Execution Plan (PEP) identifying scope, schedule and cost has been developed for this project. A final PEP will be in place prior to the mobilization of the contractor.

	Document Number: SAB10064	Revision: REV 9	Page: 9 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

A comprehensive scope of work can be found in the Execution Phase Project Charter and the detailed Sir Adam Beck 1 – G3 Upgrade Scope of Work document.

Electricity Grid and System Connection Requirements

A Customer Impact Assessment (CIA) will be initiated by OPG and completed by Hydro One based on the scope of work for the project. A System Impact Assessment (SIA) will also be requested by OPG and completed by the IESO based on the scope of work.

Execution Phase Work Milestones

- Award Installation and Major Equipment Procurement contracts – **September 2011**
- In-service the upgraded unit – **December 2012**

Labour Strategy

Trades work assignment has been completed via the Chestnut Park Accord (CPA) Addendum based on recommended alternative scope of work.

Project Management

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

6. QUALITATIVE BENEFITS

Sustainable Development

Since Hydroelectric generation is a renewable source of energy, the loss of a hydroelectric generating unit will increase the environmental impact of meeting Ontario's electricity demands. This will potentially necessitate the supply of energy from other less sustainable sources; therefore, increasing the reliability and production of SAB1 will potentially reduce the environmental impact of meeting Ontario's electricity demands.

Station Enhancement

Upgrades performed on the unit such as the modernization of the excitation system, unit protections and controls will improve the unit response and ensure compliance with Electricity market rules. This will enhance the overall station performance.

Health and Safety Issues

The work will be completed in a manner that ensures G3 and associated equipment will be compliant with all current corporate and provincial health and safety standards. Efforts will also be made to ensure that any new equipment installed is ergonomic. Enhancements such as upgraded lighting will improve the work environment and reduce health and safety risks to workers.

Environmental Issues

An Environmental Assessment is not required for this project as the scope of this upgrade does not extend the operational parameters for SAB1 past the parameters associated with the original 10 unit station configuration.

ONTARIO POWER GENERATION	Document Number: SAB10064	Revision: REV 9	Page: 10 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

7. RISK ANALYSIS

Risk Type	Issue Category	Description		
Cost	Description	Final Execution Phase cost is higher than estimated		
	Consequences	Release funding insufficient to complete work		
	Mitigating Activity	RQE is based on recent G7 and G9 projects as well as recent DeCew Falls GS2 overhauls. A contingency allowance is included in the estimate		
	Before Mitigation	Medium Risk	After Mitigation	Low Risk
Scope	Description	Planned Execution Phase scope of work not complete		
	Consequences	Could lead to cost overruns		
	Mitigating Activity	Detailed scope provided for Execution Phase work is based on condition assessment of existing equipment. Stakeholders' requirements and expectations have been obtained upfront. A PEP will be completed prior to project execution.		
	Before Mitigation	Medium Risk	After Mitigation	Low Risk
Scope	Description	Generator stator core is in poor condition		
	Consequences	Stator core requires replacement		
	Mitigating Activity	The decision to rewind the generator is based on recommendations derived from the core assessment, testing, inspection, maintenance records, history and sound engineering judgment		
	Before Mitigation	High Risk	After Mitigation	Low Risk
Performance	Description	Expected unit performance after the upgrade may not be achieved		
	Consequences	Unit operation does not meet operational targets		
	Mitigating Activity	Runner and Johnson Valve efficiency improvement targets are based on OEM model testing. MCR and MVA targets are based on unit assessment and engineering data. The performance targets stated are conservative.		
	Before Mitigation	High Risk	After Mitigation	Low Risk
Schedule	Description	Delay in completion of construction will result in lost generation revenue.		
	Consequences	Reduced revenue.		
	Mitigating Activity	Preliminary estimates of hours required to complete the work are based on recent G7 and G9 projects as well as recent DeCew Falls GS2 overhauls. Scheduled outage provides a float and is longer than the obtained estimates		
	Before Mitigation	High Risk	After Mitigation	Low Risk
Schedule	Description	Delays in delivery of long-lead items		
	Consequences	Delays in the start-up of installation work. This can delay the completion of construction work resulting in lost generation revenue		
	Mitigating Activity	Delivery estimates are based on recent G7 and G9 projects as well as recent experiences in the hydro fleet		
	Before Mitigation	Medium Risk	After Mitigation	Low Risk

ONTARIO POWER GENERATION	Document Number: SAB10064	Revision: REV 9	Page: 11 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

Risk Type	Issue Category	Description		
Quality	Description	Poor quality of workmanship		
	Consequences	Poor equipment/ unit reliability after return to service and possible damage to equipment and personnel. Equipment/ unit operation does not meet operational targets		
	Mitigating Activity	Include onsite quality assurance monitor during construction and support from the manufacturer during commissioning period. Develop and follow site inspection plans to ensure quality		
	Before Mitigation	High Risk	After Mitigation	Medium Risk
Regulatory	Description	Delays in obtaining outage approval		
	Consequences	Delay in start of construction work		
	Mitigating Activity	Prior approval and condition guarantee will be obtained for the outage from Hydro One and IESO		
	Before Mitigation	Medium Risk	After Mitigation	Very Low Risk
Environment	Description	Hazardous material may exist in obsolete equipment		
	Consequences	Improper disposal of hazardous material		
	Mitigating Activity	NPG Environmental policies will be followed		
	Before Mitigation	Medium Risk	After Mitigation	Low Risk
Health & Safety	Description	Risk of Injury to workers		
	Consequences	Worker Injury		
	Mitigating Activity	NPG Safety policies will be followed		
	Before Mitigation	Low Risk	After Mitigation	Very Low Risk
Health & Safety	Description	Hazardous material may exist in obsolete equipment		
	Consequences	Exposure to hazardous material		
	Mitigating Activity	NPG Safety policies will be followed		
	Before Mitigation	Low Risk	After Mitigation	Very Low Risk
Health & Safety	Description	Working near live equipment		
	Consequences	Worker Injury due to electrical shock		
	Mitigating Activity	Minimum clearances will be maintained		
	Before Mitigation	High Risk	After Mitigation	Low Risk
Other	Description	Lag time between delivery of large components and installation		
	Consequences	Storage space issues		
	Mitigating Activity	Prior arrangement and coordination between Projects and Production will need to be made to store equipment in the powerhouse area		
	Before Mitigation	Medium Risk	After Mitigation	Low Risk

ONTARIOPOWER GENERATION	Document Number: SAB10064	Revision: REV 9	Page: 12 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

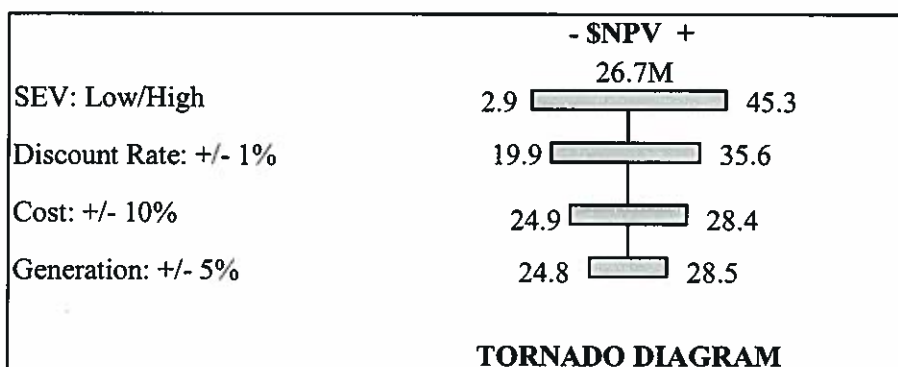
Graphical Representation of Risk using a Tornado Diagram:

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

SEV
 Discount Rate
 Capital Cost
 Generation

A Tornado diagram has been constructed to assess the 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 all NPV's are positive and project economics are fairly robust.

This project is most sensitive to the set of system economic values (SEV's) used in the analysis. If SEV's are low, than the economics of this project are less positive, but still attractive. If high SEV's are used, this project looks extremely attractive yielding a very high NPV and a quick payback. Base SEV's are used in the Financial Analysis delineated on page 7 and 8.

If the uprate study proves that the machine is capable of 68 MVA with a capacity of 61 MW than additional generation of 5 GWh would be expected annually. The corresponding NPV for the project would be \$30.4 million or \$3.7M more than the stated project NPV of \$26.7M.

ONTARIO POWER GENERATION	Document Number: SAB10064	Revision: REV 9	Page: 13 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

8. POST IMPLEMENTATION REVIEW

A simplified Post Implementation Review Report will be submitted by the Asset Management department 12 to 18 months after G3 is placed in service. Due to difficulties scheduling the Gibson test and outages to facilitate the cavitation inspection, the PIR completion deadline may be extended. The following table provides the criteria for this PIR.

Type of PIR		Target Project In Service date	Target PIR Completion date	
Simplified		2012	2013/2014	
Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
1. MCR	45.9 MW	55 MW	Unit Metering	SAB1 Production
2. Apparent Power	55 MVA	63 MVA	Unit Metering	SAB1 Production
3. Runner and Johnson Valve Efficiency Improvements	1986 Gibson Test	██████ to ██████ efficiency improvement over 1986 Gibson Test ██████ expected improvement with +/- 2% error on Gibson Test)	Gibson Test	NPG Asset/Projects
4. Runner Cavitation	N/A	As per model testing results (cavitation guarantee is 59 MW)	Visual Inspection	NPG Asset/Projects



Document Number:
SAB10064

Revision:
REV 9

Page:
14 of 15

SIR ADAM BECK 1 GS
 G3 UPGRADE - NEW RUNNER & GENERATOR REWIND
 SCI# NPG-08707.021-0001



HYDROELECTRIC
 Summary of Estimate (k\$)

Date: 30-Nov-10
 Estimate #: SAB10064-01

Facility Name: **Beck 1 GS**
 Project Title: **G3 Upgrade, New Runner and Generator Rewind**

Estimated Cost Distribution (k\$)

Years	2010	2011	2012	2013	TOTAL	%
Engineering & Project Mgmt	8	200	764	75	1,047	4.4
Permanent Material						
Consultant			450		450	1.9
Construction/Installation						
- OPG	174	25	123	30	352	1.5
- Others						
Interest	5	53	1,151	30	1,239	5.1
Contingency						
TOTAL	298	3,778	19,222	759	24,057	100.0

- Notes:
- Schedule: Start date: Oct-11
 In-Service Date(s): Dec-12 **100.0%**
 (include % for partial in-service)
 - Interest and Escalation rates are based on current allocation rates provided by Corporate Accounting
 - Includes Removal cost of: \$ 200 k in 2011
 - Incl. Definition Phase costs of: N/A

Prepared by:

 Project Engineer

Approved by:

 Gord Allan
 Project Manager

	Document Number: SAB10064	Revision: REV 9	Page: 15 of 15
	SIR ADAM BECK 1 GS G3 UPGRADE - NEW RUNNER & GENERATOR REWIND SCI# NPG-08707.021-0001		

APPENDIX 1

Assumptions

Financial Model

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

Project Cost Assumptions:

1. Overall project cost estimates were heavily based on G7 and G9 rehabilitations where appropriate
2. The cost for a new generator has increased significantly (approximately \$■■■■) from the G7 contract price (which also allowed the purchase of the G9 generator)
3. Estimates for the generator rewind were based heavily on actual labour requirements from SAB2 overhaul work
4. Quotes from suppliers of major components were used if available
5. Costs for other components and labour were based on costs for similar work carried out in the past with appropriate escalators applied
6. Competitive bids can be received for the work to be contracted out

Financial Assumptions:

7. Discount rate of 7%
8. The new generator and associated equipment will have a useful service life of 50 years
9. Extensive overhauls will be carried out after 30 years of service
10. For Alternative 1 a generator replacement is assumed to be required after 30 years of service
11. Costs for overhauls are built into the stream of cash flows for the analysis on both alternatives 1 and 2
12. SEV's will be used for financial analysis

Project Life Assumptions:

13. The project can start immediately after approval
14. The project can be completed and the generator can be commissioned by the end of Q4 2012
15. The useful service life of both the alternatives is 50 years
16. The study period used for the analysis is 50 years

Energy Production Assumptions:

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

Operating Cost Assumptions:

21. There will be minimal incremental operating costs associated with the upgraded G3 unit