ONTARIO POWER GENERATION

Records File Information:
Retention Permanent

OPG Confidential
OPG-FORM-0076-R006*

Business Case Summary

Project #	BK1 84185	**Controlled Doc #**	NF20-PLAN-08707.021-0032
Project Title	SAB1 – G1/G2 Replacement		
Facility	Sir Adam Beck I G.S.	**Investment Classification**	Value Enhancing
Project Level (Scalability)	A	**Financial Classification**	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others: [if applicable]
Release: Gate and Project Phase	☐ Choose an item. G0☐: Initiation ☐ Choose an item. G1☐: Choose an item.		☐ Choose an item. G2☐: Definition ☒ Full G3☐: Execution
Estimate Class (overall project)	Class 2	**Target Project Completion Date**	2022-12-31

Recommendation

We recommend the release of $87.7M, including $6M of contingency. A previous Development Phase BCS released $32.0M including $2.2 M of contingency, bringing the full project release to $119.7M, including $8.2M of contingency.

This release is to fund the procurement and installation of two new generating units (G1 & G2) at Sir Adam Beck I GS (SAB1), specifically:

- Installation of new generator, exciter, transformer, buswork, breakers, switches and protection & control systems for each unit.
- Replacement of all turbine components between the remaining embedded concrete draft tube and scrollcase.
  - New turbine, turbine shaft, headcover, stay vanes, discharge ring, turbine bearing, draft tube extension, wicket gates, gate arms, links and control ring and governor system for each unit.
- Refurbishment of the three G2 Headgates (refurbishment of G1 headgates was done in FEED phase to facilitate inspections of the penstocks).

The proposed units will have a nameplate of 56.4 MW each, for a total of 112.8 MW of new generation at SABI.

Investment Cash Flows

$K	LTD	2019	2020	2021	2022	2023	2024	Future	Total
Previous releases (Cap)		24,832	327						25,158
Previous releases (OM&A)		3,865							3,865
Current request (Cap)	-	(3,329)	45,815	40,611	7,498				90,595
Current request (OM&A)	-	90							90
Total released to date	**-**	**25,457**	**46,141**	**40,611**	**7,498**	**-**	**-**	**-**	**119,708**
Future required	-								-
Total Project Cost	**-**	**25,457**	**46,141**	**40,611**	**7,498**	**-**	**-**	**-**	**119,708**
Ongoing Costs	-								
					Gate:	**G3**	**OAR Approval:**		$119,708 K

Approvals	Signatures	Date
The recommendation, including the identified ongoing costs, if any, represents the best option to meet the validated business need.		
Recommended by: Project Sponsor Michael Martelli President, Renewable Generation		22 October 2019
I concur with the business decision as documented in this BCS.		
Finance Approval: John Mauti Chief Finance Officer & SVP Finance		22/10/19
I confirm that this investment/project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.		
Line Approval per OAR 1.1: Ken Hartwick President & Chief Executive Officer		Oct 23/19

Project #: BK1 84185
Project Title: SAB1 – G1/G2 Replacement
Document #: NF20-PLAN-08707.021-0032

OPG Confidential
OPG-FORM-0076-R006

Business Case Summary

EXECUTIVE SUMMARY – Project Overview

Business Need:

Execution of this project will increase the capacity of the SAB1 generating station's supply of clean, renewable, cost effective generation in accordance with the mandate of OPG and consistent with the 2017 Long Term Energy Plan. This is an opportunity to replace the G1 and G2 units and increase the peaking capacity of renewable energy in the Province prior to the closure of the Pickering Nuclear GS and the upcoming Sir Adam Beck2 GS overhauls. It will leverage existing facilities and infrastructure at the Beck Complex to provide increased operational flexibility at a lower cost alternative to constructing greenfield generation (i.e. new combined cycle thermal station).

Summary of Preferred Alternative:

- Removal of existing 25 Hz G1 and G2 units and all associated equipment.
- Installation of new generator, exciter, transformer and protection & control systems for each unit.
- Replacement of turbine components between the remaining embedded concrete draft tube and scrollcase (new turbine, turbine shaft, headcover, stay vanes, discharge ring, turbine bearing, draft tube extension, wicket gates, gate arms, links and control ring) and governor system for each unit.
- Procurement and site installation of headworks and tailrace stoplogs for isolation during G1/G2 construction.
- Refurbishment of G1 and G2 Headgates.
- Inspection and repairs of remaining embedded components (penstocks, scrollcase & draft tubes).
- Replacement of electrical and control components on the SAB1 Powerhouse cranes.

The project will be funded as Capital, with the exception of G1 and G2 removals, which will be funded as OM&A.

Current Project Status:

The project is currently in Definition phase. Detailed engineering design is 75% complete, and the existing G1/G2 units and associated equipment have been removed from SAB1. The penstock, scrollcase and draft tube inspections have been completed. Approximately $3.8M in long lead procurement has been authorized and was included in the $32.0M Definition phase release. The Target Price for execution phase was negotiated in Q1 2019 and based on additional information through Definition phase and discovery work on embedded components, is expected to increase by $13.8M. Overall project cost estimate is $119.7M.

Key Risks:

The project is completely replacing the G1 and G2 units but is relying on 100 year old embedded components. Specifically, penstocks, scroll cases and draft tubes. These components have been thoroughly examined during the Definition phase (after removal of the old G1/G2 units) and issues have been identified with the penstocks and scrollcase flanges. Repair estimates have been received and have been included as an allowance in the project estimate. The residual risk of discovery work is low.

SAB1 has limited workspace, and many planned and in-flight projects. The G1/G2 Project coordinates weekly integration meetings at the management level, as well as trades level, including contractors to minimize disruptions and interference between projects. Integration with other projects will continue to be a risk to the project in execution phase, but it will be mitigated in the same fashion.

The project is also dependant on the Hydro One (HONI) switchyard replacement project. This project is currently replacing the end of life switchyard (E-bus), which is fully within the generating station building envelope, as well as increasing ampacity on the circuits for the additional G1/G2 generation. Key milestones from the HONI project schedule have been incorporated into the overall G1/G2 schedule for integration and interface management.

Business Need

For Project Level A or B

Execution of this project will increase the capacity of the SAB1 generating station's supply of clean, renewable, cost effective generation in accordance with the mandate of OPG and consistent with the 2017 Long Term Energy Plan. Replacing SAB1 G1/G2 will increase the peaking capacity of renewable energy in the Province prior to the closure of the Pickering Nuclear GS and the upcoming SAB2 GS overhauls. The Project leverages existing facilities and infrastructure at the Beck Complex to provide increased operational flexibility at a lower cost alternative to constructing greenfield generation (i.e. new combined cycle thermal station). Outside of peaking, G1/G2 will also be able to use additional water which will be available at the SAB Complex during the 31 planned overhauls at SAB1, SAB2 and PGS between 2023 and 2041.

The energy and capacity at the SAB complex were modeled with and without G1/G2 and the Pump Generating Station (PGS) diffuser flaps available, using 100 years of historical rivers flows. The models also took into account winter and summer (tourist) flows diverted from the Niagara River to the Complex for generation (diversion flows).

G1/G2 peaking capacity can be utilized when diversion flows are above 1,600 cms (occurs approximately 50% of time during peak summer hours). In contrast, PGS Diffuser Flaps peaking capacity is available when diversion flows are less than 1,600 cms. When diversion flows are lower, the PGS diffuser flaps (currently being re-instated) will provide an additional 180 cms of flow to G1 & G2. The combination of replacing G1/G2 units and re-instating the PGS diffuser flaps (4

Project #: BK1 84185
Project Title: SAB1 – G1/G2 Replacement
Document #: NF20-PLAN-08707.021-0032

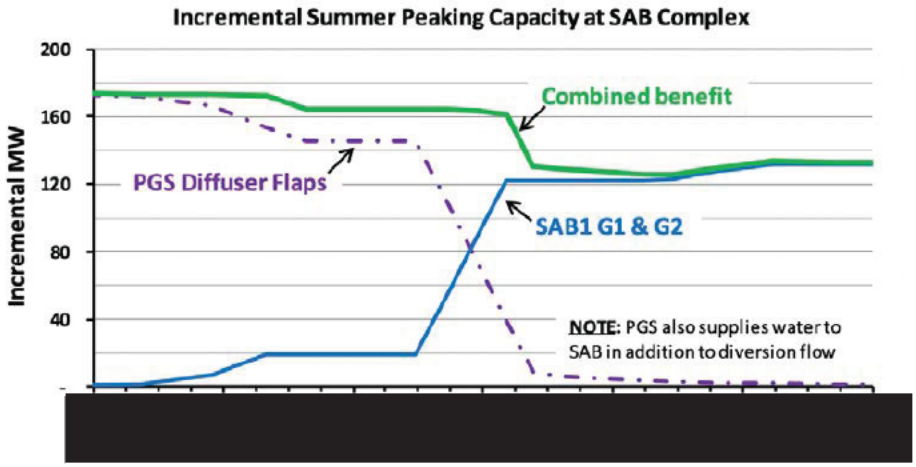
OPG Confidential
OPG-FORM-0076-R006

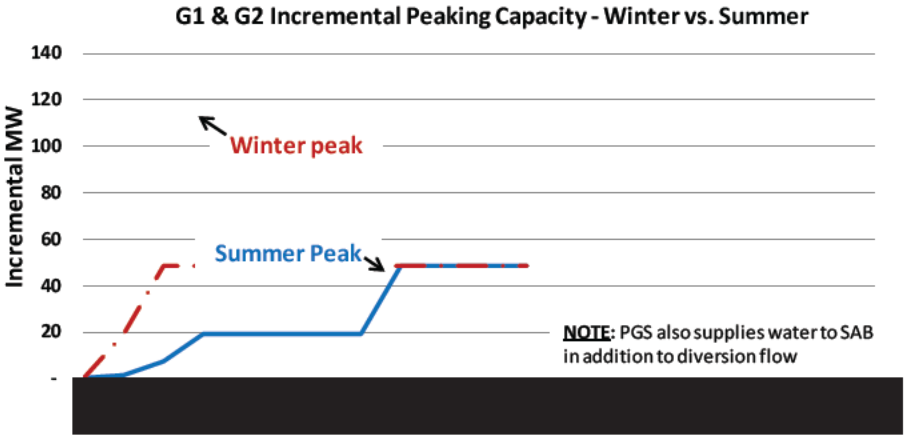
Business Case Summary

Business Need	For Project Level A or B

of 6 completed to-date) provides at least 125 MW of peaking capacity under all anticipated flow conditions. Based on the past 100 years of available summer diversion flows, G1/G2 will provide an average of 76 MW of peaking generation.

System Economic Values (SEVs) were used to value incremental energy and summer peaking capacity. Results show that G1/G2 in combination with the use of PGS Diffuser Flaps has a $144M net present value (NPV) over 75 operating years. See graphs below for the model output of the anticipated incremental summer peaking capacity at SAB complex.





[redacted]

[redacted]

Preferred Alternative:	**Convert G1 & G2 to 60 Hz 56.4 MW Units**	For Project Level A, B or C

Description of Preferred Alternative

The Preferred Alternative meets the business needs with the most effective MW output and provides reduced project risk and on-going maintenance costs. Restoring G1 and G2 to service will make use of existing assets and infrastructure at the Beck Complex and provide a source of low-cost green energy while increasing operational flexibility of the electricity system.

The preferred alternative includes the following scope:

Project #: BK1 84185
Project Title: SAB1 – G1/G2 Replacement
Document #: NF20-PLAN-08707.021-0032

OPG Confidential
OPG-FORM-0076-R006

Business Case Summary

Preferred Alternative:	**Convert G1 & G2 to 60 Hz 56.4 MW Units**	For Project Level A, B or C

Description of Preferred Alternative

- Removal of existing 25 Hz units G1 and G2 and associated equipment.
- Installation of new generator, exciter, transformer and protections and control systems for each unit.
- Replacement of the turbine components between the remaining embedded concrete draft tube and scrollcase (new turbine, turbine shaft, headcover, stay vanes, discharge ring, turbine bearing, draft tube extension, wicket gates, gate arms, links and control ring) and governor system for each unit.
- Procurement of forebay and tailrace stop logs to provide isolation during the project, they will become station spares at the end of the project.
- Refurbishment of the six G1 & G2 headgates (3 per unit).
- Inspection and repairs of remaining embedded components (penstocks, scrollcase & draft tubes).
- Replacement of electrical and control components on the SAB1 Powerhouse cranes.

Contracting and Procurement Strategies were developed with the key objectives of controlling cost and schedule growth, sharing risks/opportunities with the Contractor and ensuring the Contractor will meet the Project deliverables within the project deadlines. The project consists of two phases:

Phase 1 (Previous Release):

- Phase 1 consists of the front-end engineering design (FEED), procurement of long lead time items, dismantling of the old units, and technical assessment of the water conveyance structures and existing concrete foundation of the stator to help mitigate the risk of discovery work during execution (Phase 2). The work started in December 2018 (with a Limited Notice to Proceed to the successful proponent) and will be substantially completed by March 2020.
- A fixed price or "lump sum" strategy was chosen mainly due to the well-defined project deliverables on the dismantling and design scope. The engineering design is considered core work for the Contractor.

Phase 2 (This Release):

- Phase 2 will consist of the fabrication and installation of new G1 & G2 units. The work is scheduled to start in July 2020, with in-service dates for G2 in Q4 2021 and G1 in Q1 2022.
- A blend of target and fixed price was selected for Phase 2, as it best meets the key objectives of controlling procurement costs of major equipment which has minimal risks under fixed price. Project scope with more substantial risk can be subjected to additional planning under a target price model. During execution, the Contractor will be incentivized to find cost effective project delivery methods and disincentivized to allow excessive cost grown. This approach has been used with success on many projects of similar size, scope and complexity across OPG.
- The installation of G1/G2 is expected to proceed as "Owner Only", similar to the unit dismantling and removal work done in Phase 1.

A Project Management Plan (PMP) has been completed for the project and a Testing and Commissioning Plan will be completed by December 2019.

Regulatory Approvals

An Ontario Waterpower Association Class Environmental Assessment was completed for the project in February 2018. It was required due to the planned capacity upgrades exceeding the "grandfathered" capacity of the SAB1 GS.

Cultural Heritage Research and Cultural Heritage Recommendation Reports were completed in July 2018 for the SAB1 GS. Units 1 and 2 were listed as having Provincial heritage attributes due to the fact they were listed in the 1992 Federal heritage designation. A Strategic Conservation Plan (SCP) for SAB1 GS was initiated, and a Heritage Impact Analysis (HIA) was completed in March 2019 for the removal of the original G1 & G2 units. The HIA was accepted by Ministry of Tourism, Culture and Sport (MTCS).

Both a System Impact Assessment (SIA) and a Connection Impact Assessment (CIA) were completed in October 2015 for G1/G2. The SIA allows the IESO to assess the impacts of the new connection to the IESO Controlled Grid (ICG) and identify fault limits. The SIA was also needed for Hydro One to complete a CIA to incorporate SAB1 G1/G2 return to service into their projects. OPG signed a Connection Cost Recovery Agreement (CCRA) with Hydro One in May 2018 for $7.5 M. The CCRA released funding for Hydro One to perform ampacity upgrades attributed to G1 and G2 in the switchyard (E bus) and to connect G1 and G2 to the transmission grid.

Constraints:

- The SAB1 Powerhouse is only set up to manage one major overhaul at a time; coordination will be required with Production for the use of the overhead crane during execution and for laydown areas.
- Niagara Parkway is classified as a controlled access highway and requires a "Heavy or Oversized Load" permit when transporting heavy or oversized loads. Load restrictions may apply during spring seasons.

Project #: BK1 84185
Project Title: SAB1 – G1/G2 Replacement
Document #: NF20-PLAN-08707.021-0032

OPG Confidential
OPG-FORM-0076-R006

Business Case Summary

Preferred Alternative:	**Convert G1 & G2 to 60 Hz 56.4 MW Units**	For Project Level A, B or C

Description of Preferred Alternative

- Entrance road to SAB1 (Glen Access Road) off Niagara Parkway has limitation on size and length of trucks due to space constraints.
- Coordination is required with Hydro One to ensure the required 115 kV "E" Bus upgrades are completed by Q1 2021 to avoid the critical path and allow for G1/G2 to be connected to the system.

Key assumptions and risks include:

- This project, combined with the PGS diffuser flaps project currently in execution, will provide the grid with 125 MW of reliable peaking capacity under all anticipated flow conditions.
- Major water conveyance and control structures (penstocks, scroll cases, draft tubes, headgates) will not require full replacements. $9M in allowances ($1M for penstock repairs and $8M for scroll case flange repair/replacement) has been included in the overall project estimates based on the results of the Definition phase engineering assessment of these components and budgetary estimates from suppliers for repairs.

Deliverables:	**Associated Milestones (if any):**	**Target Date:**
Previous Releases (for Phase 1):		
Runner and Turbine Development and Model Testing	Start Runner Design and Modelling Test Engineering design for runner (CFD) complete Runner modelling and testing complete	Complete Complete Complete
Early procurement of runner ($1.4 M)	Start procurement of runner	Complete
Procurement of headworks and tailrace sectional service gates to provide isolation during the project	Delivery of tailrace sectional gates Delivery of headworks sectional gates	Complete Complete
Dismantling and removal of existing 25 Hz Units 1 & 2	Completion of G2 removal Completion of G1 removal	Complete Complete
Inspection and refurbishment of G1 intake headgate	G1 intake gate refurbishment complete	Complete
Contractor submission of revised Target Cost (for Phase 2)	Contractor submission of revised Target Cost	Oct. 31, 2019
FEED Phase (Detailed Engineering) complete	Substantial completion - Phase 1 (FEED) milestone	Mar. 17, 2020
Current release (for Phase 2):		
SAB1 North and South Powerhouse Crane electrical and controls replacement	Powerhouse Crane electrical upgrades complete	Jul 31, 2020
Hydro One switchyard (E-Bus in the SAB1 GS) connection and ampacity upgrades for Units 1 and 2	G2 connection complete G1 connection complete	Oct. 31,2020 Apr. 30, 2021
Installation of new generator, exciter, transformer, buswork, breakers, switches, and protections and control systems for Unit 1 and Unit 2 Start of Installation	Contractor mobilization for Phase 2 Unit G2 Available for Service (AFS) Unit G1 Available for Service (AFS)	Jul. 6, 2020 Oct. 28, 2021 Mar. 7, 2022
Project Close out	Close out completed	Dec. 31, 2022

Alternative 2:	**Base Case – Cancel Project**	For Project Level A, B or Value-Enhancing

Not recommended. This alternative would close down the project.

Pros:

- None.

Cons:

- The alternative would require a write off of costs incurred to date.
- Does not improve peaking capacity in the Province.
- Cancelling the project would not align with water availability as a result of 31 planned overhauls at SAB1, SAB2 and PGS between 2023 and 2041. Beginning in 2022, OPG plans to refurbish one generating unit at SAB2 each year for 16 years. If the 25 Hz generators are converted to 60 Hz in that time, they will make up for the lost generation as the other generators are taken offline to be refurbished. This would reduce the overall production of hydroelectric power from the Niagara hydro stations during this overhaul period.

Alternative 3:	**Delay Work for Preferred Alternative (Replacing G1/ G2) until Pickering Closure 2025**

Not recommended. This alternative would delay the project with a re-start date of 2025. In-service would be delayed until 2028. This option used a Rate of Inflation Increase Calculation of 2%/Yr (The Bank of Canada inflation-control target range is 1 to 3 %).

Pros:

- The short-term costs of replacing the units could be deferred by delaying the work. Depending on the provincial demand for electricity in the early 2020s, the delayed approach may better align with the needs of the grid. The NPV for this alternative is lower than the recommended alternative ($53 M vs $62M), and this alternative would forgo the operating flexibility described below.

Cons:

- Delaying the work would not align with water availability as a result of planned overhauls at SAB1 and SAB2. From 2021/22 (proposed in-service in recommended alternative) to the proposed 2028 in-service date in this scenario, 8 overalls are planned at the SAB complex. Excess water not being used at SAB2, would be used by G1/G2 in the recommended alternative.

Alternative 4:	**Convert only one unit (G2) to 60 Hz 56.4 MW (MCR)**

Not recommended. This alternative would convert only Unit G2.

Pros:

- This approach would replace one generator unit and its associated components. OPG would deliver added value by proceeding with at least one unit.

Cons:

- This approach has a lower NPV ($36M vs $62M) versus replacing both units due to lose of economies of scale, and lower overall peaking capacity. Engineering, project management and many other base costs remain the same regardless if one or two units are replaced.
- Proceeding with only one unit prevents OPG from maximizing the hydroelectric power production from the SAB Complex during the overhaul period of 2022 to 2041.

Key Risk Assessment — For Project Level A, B or C

Risk Class	Description of Risk	Response Type/ Actions/Final TCD	For Additional Review	Residual Ranking
Cost	Increase in project cost during Execution	Mitigate: • Contracting strategy uses Target Cost model with locked in labour and equipment rates, as well as disincentives for cost overruns • Auditing of submitted invoices • Water conveyance structures and unit foundations inspected during Phase 1	No	Low

Project #: BK1 84185
Project Title: SAB1 – G1/G2 Replacement
Document #: NF20-PLAN-08707.021-0032

OPG Confidential
OPG-FORM-0076-R006

Business Case Summary

Key Risk Assessment			For Project Level A, B or C	
Risk Class	**Description of Risk**	**Response Type/ Actions/Final TCD**	**For Additional Review**	**Residual Ranking**
Schedule	Interference or delays from other projects (e.g. G5 overhaul, Hydro One) in the station and conflicts arising from shared space or resource equipment	Mitigate: • Project Site Manager to monitor potential impacts and provide coordination between work groups • Craning operations require transfer of control between work groups • Offsite storage of unit components. Will be local but arrive at site "just in time"	No	Medium
Quality	Upon final commissioning, the results yield less than acceptable vibrations due to hydraulic imbalances (e.g. roping or cavitation) or a large operational "rough zone" and must be corrected	Mitigate: • Detailed model testing was performed • Air emission allowance in specs • Operational zone clearly specified	No	Low
Schedule	Hydro One infrastructure not completed in time to allow G1 and G2 to connect to the system resulting in commissioning/operating delays	Mitigate: • CCRA signed with Hydro One with connections milestones 6 months ahead of when required for testing • OPG SPOC to monitor	No	Low
Quality	After model testing, contractual performance targets are not met during Gibson testing	Mitigate: • LDs, cost disincentive for not meeting the performance requirement.	No	Low
Industrial Safety	Injury to OPG or Contractor staff	Transfer: • Replacement of Units 1 and 2 will be "Owner-Only" where the Contractor shall perform all Work and shall fulfill the role of "Constructor" in accordance with the Ontario Occupational Health and Safety Act (OHSA) and its regulations. OPG will act as "Owner" as per the OHSA. • Standard construction risks, which are to be managed by following OHSA regulations	No	Low

Additional Risk Analysis — For Project Level A or B

The project is recommending using the P90 results from the Monte Carlo analysis for calculating the project contingency. ($5.9M in cost risk and $2.3M in schedule risks. $8.2M in total).

The project identified 10 discrete risks that were significant in nature. Three of those risks are related to the 100 year old embedded components (penstocks, scroll cases and draft tubes) that the project is planning to re-use. As part of the Definition phase, the penstocks and draft tubes were both inspected and will require minor repairs. However, based on detailed inspections, the scrollcase flanges will require significant repairs or replacement. These 3 risks were removed from the Monte Carlo Analysis and based on budgetary quotes, an allowance of $12M has been held in the project estimates ($3M allowance for Penstock repairs and $8M allowance for scrollcase flange replacements).

As a result of the Monte Carlo Analysis, $8,169K will be held in contingency for schedule delays, unknown unknowns and other discrete risks.

We are confident the remaining contingency is sufficient given the old G1/G2 units are fully removed, there are no remaining sub surface risks and engineering design is 75% complete.

Project #: BK1 84185
Project Title: SAB1 – G1/G2 Replacement
Document #: NF20-PLAN-08707.021-0032

OPG Confidential
OPG-FORM-0076-R006

Business Case Summary

Financial Evaluation		For Project Level A, B (with multiple feasible alternatives) or Value-Enhancing		
$M	Preferred Alternative Convert G1 & G2 to 60 Hz 56.4 MW Units	Base Case (Cancel Project)	Alternative 3 Delay Preferred Alternative to 2026 Start	Alternative 4 Convert ONLY G2 to 60 Hz 56.4 MW Unit
Project Cost	119.7	0	134.7	74.8
NPV (based on 76MW G1/G2 peaking only)	62	0	53	36

Analysis of Financial Evaluation – Key Assumptions and Key Results:

Economic analysis performed by OPG Finance Investment Planning. Key findings include:

- All alternatives (except cancellation) have positive NPV, with the Preferred Alternative being the most economic.
- Peaking capacity value is the most critical component of NPV.

Qualitative Factors For Project Level A or B

- The project will increase available renewable energy to the Ontario grid, reducing the environmental impact of meeting Ontario's electricity demand.
- The project will leverage existing facilities and infrastructure at the Beck Complex to provide increased operational flexibility and a lower cost alternative to constructing greenfield generation.
- Complete replacement of the old units instead of retrofitting components provides increased unit reliability, easier integration with existing embedded components with less risk of design not working with existing equipment, and higher efficiencies with new technology.
- Outside of peaking capacity, G1/G2 will also be able to use additional water which will be available at the SAB Complex during the 31 planned overhauls at SAB1, SAB2 and PGS between 2023 and 2041.

Post Implementation Review (PIR) Plan (refer to OPG-PROC-0056)

Type of PIR Report	Comprehensive PIR	**PIR Completion Date**	Dec. 2022

PIR KPIs	Current Baseline	Target Result	How to measure?	Who will measure?
Unit Vibration and hydraulic stability	Industry Standards	Listed in detail in the technical specification and EPC with penalties to vendor for non-performance	Vibration testing during testing/commissioning	Machine Dynamics & Component Integrity (MDCI)
Turbine Power @ 91.0m net head	57,500 kW (per EPC)	57,500 kW	Performance testing during commissioning after in-service.	Engineering Technical Services - Performance & Testing Group (ETS P&T)
Transformer Losses	Per EPC – 192kW	192kW	Performance testing during commissioning after in-service.	Engineering Technical Services - Performance & Testing Group (ETS P&T)
Hydraulic Performance	57,500 kW at 68 m3/s. (per constraint in Tech Spec, and guaranteed output in EPC)	57,500 kW at 68 m3/s.	Gibson Test to be performed 6 – 1 year)	Specialized team including US Army Corps of Engineers and OPG Engineering

Project #: BK1 84185
Project Title: SAB1 – G1/G2 Replacement
Document #: NF20-PLAN-08707.021-0032

OPG Confidential
OPG-FORM-0076-R006

Business Case Summary

APPENDICES

Appendix A1: Summary of Estimate - Total Project Cost										
Project Number:	**BK184185**									
Project Title:	**SAB1 G1 G2 Replacement Project**									
$K	**LTD**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Future**	**Total**	**%**
Project Mgmt		2,299	4,855	4,569	2,209				13,932	12%
Inspection		301							301	0%
Engineering		5,196	2,866	2,594	766				11,422	10%
Procurement		5,131	12,784	13,586	-				31,502	26%
Construction		10,881	18,440	10,935	512				40,768	34%
Commissioning									-	0%
Closeout									-	0%
Contractor Fee		244	3,004	3,144	1,008				7,400	6%
Subtotal	-	24,052	41,950	34,828	4,496	-	-	-	105,326	88%
Outside WBS									-	0%
Contingency		1,000	2,390	2,390	2,390				8,170	7%
Subtotal w/ Contingency	-	25,052	44,340	37,218	6,886	-	-	-	113,496	95%
Interest		406	1,801	3,393	613				6,212	5%
Other									-	0%
Total	**-**	**25,457**	**46,141**	**40,611**	**7,498**	**-**	**-**	**-**	**119,708**	**100%**
Removal Costs (incl. above)		3,955							3,955	3%

Appendix A2: Summary of Estimate – Notes			
Escalation Rate	2%	**Interest Rate (going-forward)**	4.4%

Project #	Date (YYYY-MM-DD)	Description	Amount	%
BK184185	10/28/2021	Unit 2 in Service	56,855	49%
BK184185	3/7/2022	Unit 1 in Service	56,855	49%
BK184185	12/31/2022	Close-out	2,045	2%
Total			115,754	100%

Prepared by:		Reviewed and Endorsed by:	
Dave Bonell	11OCT19	Michael Martelli	October 22, 2019
RG - PMO	Date	President Renewable Generation	Date
Project Manager		Project Sponsor	

Project #: BK1 84185
Project Title: SAB1 – G1/G2 Replacement
Document #: NF20-PLAN-08707.021-0032

OPG Confidential
OPG-FORM-0076-R006
Business Case Summary

APPENDICES (Continued)

Appendix C: Financial Evaluation Assumptions For Project Level A, B (with multiple feasible alternatives) or Value-Enhancing

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

Project Capital Costs:

(1) Estimate for construction based on competitive bids and historical records for similar work

(2) Contingency is 11.34% or $8.170 M for the remaining project estimate (minus allowances, contingency and interest) of $72.7M.

Financial/Economic:

(1) Corporate Tax Rate: 25%

(2) CCA Rate: 8% - assumes that full CCA benefit can be claimed in any given year

(3) After-tax WACC: 7% - estimate for OPG's long-term Weighted Average Capital Cost (WACC)

(4) Annual Escalation (CPI): 2%

Project Life:

(1) Unit G2 In-service by Oct. 2021

(2) Unit G1 In-Service by Feb. 2022

(3) Forecast length: 75 years

Energy Production:

(1) Station output modelled with linear cms to MW curves; different slopes used up to an efficiency point and up to max capacity

(2) Diffuser flaps rehabilitated on all 6 Pump Generation Station (PGS) units, increases output by 30 cms/unit and 4 MW/unit

(3) Station specifications assume G1 & G2 converted to 56.4 MW units, and assume all existing PGS, SAB1 and SAB2 units are operating

Operations, Maintenance & Administration (OM&A) Expenses and Sustaining Capital:

(1) Annual fixed OM&A: 0.15 $M/Unit ($2018)

(2) GRC: 14.4 $/MWh

(3) Major Overhaul Costs: 30 $M/Unit ($2018)

(4) Major Overhaul Frequency: 25 years – units are out of service for the full year during major overhaul

Station Outages:

(1) PGS unit outages: 365 day outage every 15 years – station outage schedule provided by Plant Operations, PGS unit outage more frequent due to pumping and generating functions

(2) SAB1 unit outages: 365 day outage every 25 years

(3) SAB2 unit outages: 365 day outage every 25 years

ONTARIO POWER GENERATION

Records File Information:
Retention Permanent

OPG Confidential
OPG-FORM-0077-R002*

Project Over-Variance Approval

Project #	BK1 84185	**Controlled Doc #**	NF20-PLAN-08707.021-0007
Project Title	SAB1 – G1/G2 Replacement		
Facility	Sir Adam Beck I G.S.	**Investment Classification**	Value Enhancing
Project Level (Scalability)	A	**Financial Classification**	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others: [if applicable]
Release: Gate and Project Phase	☐ Over-variance G0 : Initiation ☐ Over-variance G1 : Choose an item		☐ Over-variance G2 : Definition ☒ Over-variance G3 : Execution
Estimate Class (overall project)	Class 2	**Target Project Completion Date**	Dec-2022

Recommendation

The purpose of this submission is to request approval for an additional $8.2M to address the additional cost to replace the SAB1 G1 & G2 scroll cases while maintaining an adequate contingency to complete the Sir Adam Beck 1 (SAB1) G1 & G2 Replacement Project.

The full release BCS of $119.7M, including $8.2M of contingency was approved in November 2019. This variance release will bring the full project release to $127.9M, including $9M of contingency.

Investment Cash Flows

$K	LTD	2019	2020	2021	2022	2023	2024	Future	Total
Previous releases		25,457	46,141	40,611	7,498				119,708
Current request	-		8,200						8,200
Total released to date	-	25,457	54,341	40,611	7,498	-	-	-	**127,908**
Future required	-								-
Total Project Cost	-	25,457	54,341	40,611	7,498	-	-	-	**127,908**
Ongoing Costs	-								
					Gate:	**G3**	**OAR Approval:**		$127,908 K

Project Overview

The project includes the replacement of two mothballed 25Hz generating units at Sir Adam Beck GS with two new 60 Hz units. The existing (100-year-old) embedded components including penstocks, scroll cases and draft tubes were intended to be re-used by the project.

Significant defects were discovered within the scroll cases once the units were disassembled. Over $4.7M of contingency was spent assessing the condition of the scroll cases and attempting to find a suitable in-situ weld repair, however, the casting defects were much worse than initially thought so the decision was made to abandon the repair option and replace the scroll case in each unit.

Total Project Estimate Variance Explanation

The original full BCS included $8.2M in contingency plus an $11M allowance for potential penstock and scroll case repairs. To date, $18.4M of this $19.2M has been committed to the following:

- penstock repairs estimated at $1M
- scroll case replacements is estimated at $10.2M
- $1.5M in engineering change requests during the design phase
- $1M in COVID-19 impacts
- $4.7M in the initial scroll case response

The G1 and G2 scroll case castings were made in 1919 using a "first of a kind" casting technology. Although there were defects in the castings, (voids 6" to 24" long) the scroll cases performed well without incident for

Project #: BK1 84185
Project Title: SAB1 – G1/G2 Replacement
Document #: NF20-PLAN-08707.021-0007

OPG Confidential
OPG-FORM-0077-R002

Project Over-Variance Approval

Total Project Estimate Variance Explanation

over 90 years. However, the capacity of the new units will increase from 40MW to 57M thereby subjecting this equipment to much higher stresses during normal operation and unit trips. With the number and size of defects in the cast steel, and the inability to effectively repair the defects to a high level of technical confidence, the decision was made to replace the scroll case in each unit thus providing a higher certainty of safe operation for the 75-year design life.

Return on Investment & Project Schedule

The full release BCS had a Net Present Value (NPV) of $62M based on a $119.7M release with an Internal Rate of Return (IRR) of 11.07%. With the requested increase in funding to $127.9M, the NPV of the project drops slightly to $57M assuming the entire release is spent, with an IRR of 10.58%.

The project has been re-baselined, to compensate for the install of the new scroll cases as well as significant (3-4 month) COVID-19 related delays on key components being manufactured in Brazil, Italy, Mexico and China.

- G2 in-service has moved from Oct 14, 2021 to March 11, 2022.
- G1 in-service has moved from Feb 25, 2022 to July 22, 2022.

Risk Analysis

- The adjusted full project cost of $127.9M will restore the P90 confidence based on execution phase risk included in the Monte-Carlo analysis.
- The discrete risks included in the calculation include;
  - site congestion
  - unit vibration
  - hydraulic imbalances
  - commissioning delays
  - turnover issues to operations
  - HydroOne estimate accuracy

Project #: BK1 84185
Project Title: SAB1 – G1/G2 Replacement
Document #: NF20-PLAN-08707.021-0007

OPG Confidential
OPG-FORM-0077-R002

Project Over-Variance Approval

Appendix A1: Summary of Estimate - Total Project Cost										
Project Number:	**BK184185**									
Project Title:	**SAB1 G1 G2 Replacement Project**									
$K	**LTD**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Future**	**Total**	**%**
Project Mgmt		2,299	4,855	4,569	2,209				13,932	11%
Inspection		301							301	0%
Engineering		5,196	2,866	2,594	766				11,422	9%
Procurement		5,131	12,784	13,586	-				31,502	25%
Construction		10,881	26,640	10,935	512				48,968	38%
Commissioning									-	0%
Closeout									-	0%
Contractor Fee		244	3,004	3,144	1,008				7,400	6%
Subtotal	-	24,052	50,150	34,828	4,496	-	-	-	113,526	89%
Outside WBS									-	0%
Contingency		1,000	2,390	2,390	2,390				8,170	6%
Subtotal w/ Contingency	-	25,052	52,540	37,218	6,886	-	-	-	121,696	95%
Interest		406	1,801	3,393	613				6,212	5%
Other									-	0%
Total	-	**25,457**	**54,341**	**40,611**	**7,498**	-	-	-	**127,908**	**100%**
Removal Costs (incl. above)		3,955	2,900						6,855	5%

Project #	Date (YYYY-MM-DD)	Description	Amount	%
BK184185	2022-03-11	Unit 2 in Service	59,504	49%
BK184185	2022-07-22	Unit 1 in Service	59,504	49%
BK184185	2022-12-31	Close-out	2,045	2%
Total			121,053	100%

Prepared by:		**Reviewed and Endorsed by:**	
Dave Bonell RG - PMO Project Manager	Aug 4, 2020 Date	Don Gagnon VP Eng & Technical Services Project Sponsor	Aug 28, 2020 Date

Approvals	**Signatures**	**Date**
Recommended by: Project Sponsor Michael Martelli President Renewable Generation		7 Oct 20.
Finance Approval: John Mauti Chief Finance Officer & SVP Finance		7 Oct /20
Line Approval per OAR 1.1: Ken Hartwick President & Chief Executive Officer		Oct 7/2020

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