



BC Hydro

John Hart Replacement Project

Interconnection System Impact Study

Report No. TGI-2011-JHN-SIS-R1

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EXECUTIVE SUMMARY

BC Hydro Generation, the Interconnection Customer (IC), proposes to replace the existing John Hart generating facility with a new plant rated at 138MW delivered by three 46 MW units, located in Campbell River, British Columbia. The new plant (JHN) will be connected to the existing John Hart Switchyard (JHT). The proposed maximum power injection into the BCH system is 138 MW in winter and 126 MW in summer. The incremental power injection above the present value is 12 MW in winter and 0 MW in summer. The proposed Commercial Operation Date (COD) is October 31, 2016.

This report documents the evaluation of the system impact of interconnecting the proposed generating facilities and identifies the required system modifications to obtain acceptable system performance with the interconnection of the proposed John Hart Replacement project. The project will replace the existing six (6) generators with three (3) new 13.8 kV units rated 51.1 MVA each.

To interconnect the John Hart Replacement project and its facilities to the BCH Transmission System at the POI, this System Impact Study (SIS) has identified the following issues and requirements:

- The 132 kV circuits between JHT and Dunsmuir (DMR) substations are thermally constrained during high generation outputs in North Vancouver Island (North VI) before the John Hart Replacement project in place. The constraints, due largely to a major industrial load having been decommissioned in the area, can be mitigated with the existing operating measures until a long term transmission solution is determined and in place.
- No additional overload or voltage issues have been identified due to the addition of this project, and there were no instability issues under single system contingencies. The JHN generating units may be required to participate in an area generation shedding/runback scheme on either a temporary or a permanent basis depending on the long term transmission solution selected. Thus, the IC needs to allow for receipt of such shedding/runback signals. It is noted that there are significant dam safety, public safety and fishery issues associated with this project and they will be taken into consideration when assessing JHN generating units for participation in an area generation shedding/runback scheme.
- New Primary (PY) and Standby (SY) protection for 3 buses at JHT substation.
- The non-binding good faith cost estimate for Interconnection Network Upgrades required to interconnect the proposed project to the BCH Transmission System is \$600 K.
- The estimated time to construct the Interconnection Network Upgrades is 12 months.

The Interconnection Facilities Study report will provide greater details of the Interconnection Network Upgrade requirements and associated cost estimates and estimated construction timeline for this project.

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1.0 INTRODUCTION

The generating project reviewed in this Interconnection System Impact Study (SIS) report is as described in Table 1 below.

Table 1: Summary Project Information

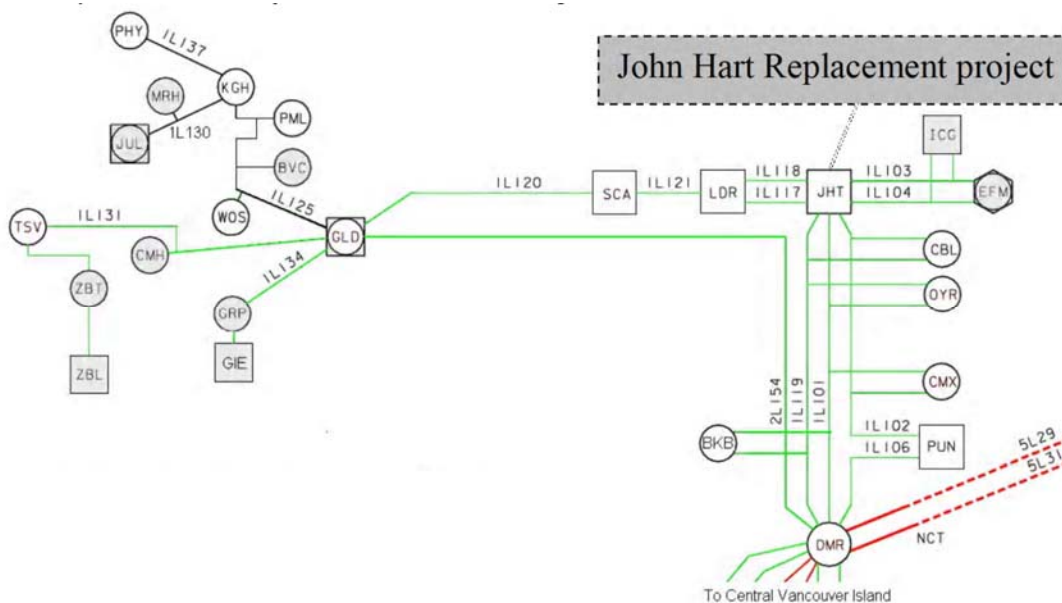
Project Name	John Hart Replacement Project (JHN)	
Interconnection Customer	BC Hydro Generation	
Point of Interconnection	John Hart substation (JHT)	
IC Proposed COD	31 October 2016	
Type of Interconnection Service	NRIS <input checked="" type="checkbox"/>	ERIS <input type="checkbox"/>
Maximum Power Injection (MW)	126 MW (Summer)	138 MW (Winter)
Number of Generator Units	3	
Plant Fuel	Hydro	

BC Hydro Generation, the Interconnection Customer (IC), proposes to replace the existing John Hart Generating station with the John Hart Replacement project (JHN). This project consists of three (3) new 13.8 kV units rated 51.1 MVA each. The new plant will be connected to the existing John Hart switchyard. The Point of Interconnection (POI) is the John Hart substation (JHT).

The proposed maximum power injection into the BCH system is 138 MW in Winter and 126 MW in Summer, 12 MW higher in Winter than the existing generating facilities. The proposed Commercial Operation Date (COD) is October 31, 2016.

Figure 1 below shows the connection of the John Hart Replacement project to the BCH Transmission System. The project interconnection single-line diagram can be found in Appendix A.

Figure 1 – The John Hart Replacement Project Interconnection Diagram



2.0 PURPOSE OF STUDY

The purpose of this SIS is to assess the impact of the interconnection of the proposed project on the BCH Transmission System. This study will identify constraints and Network Upgrades required for interconnecting the proposed generating project in compliance with the NERC/WECC reliability standards and the BC Hydro transmission planning criteria.

3.0 TERMS OF REFERENCE

This study investigates and addresses the voltage and overloading issues of the transmission networks in North Vancouver Island (North VI) as a result of the proposed interconnection. Topics studied include equipment thermal loading and rating requirements, system transient stability and voltage stability, transient over-voltages, protection coordination, operation flexibility, telecom requirements and high level requirements for local area protection schemes (LAPS). BCH planning methodology and criteria are used in the studies.

The SIS does not investigate operating restrictions and other factors for possible second contingency outages. Subsequent internal network studies will determine the requirements for reinforcements or operating restrictions/instructions for those kinds of events. Impact to the BCH bulk Transmission System is not reviewed in this interconnection SIS and will be covered in a separate study.

The work necessary to implement the network improvements identified in this SIS report will be described in greater detail in the Interconnection Facilities Study report for this project.

4.0 ASSUMPTIONS

The power flow conditions studied include generation, transmission facilities, and load forecasts representing the queue position applicable to this project. Applicable seasonal conditions and the appropriate study years for the study horizon are also incorporated. The 2016 heavy winter, 2017 heavy summer and 2017 light summer load flow base cases were selected for this study.

For the proposed John Hart Replacement project, the study is based on the model and data information provided by the IC in the Generator Interconnection Data Form. Additional assumptions are made to complete the study and the report, whenever such information is unavailable.

IPP's and load customers with higher queue positions have been modeled into the base case. The key customer projects include:

- Green Island Energy (GRP) project – 90 MW to be connected at 132 kV GRP substation;
- Two projects from the 2008 Clean Power Call – Kokish River Hydro project (KKS) for 45 MW and Cape Scott Wind Farm (Phase 1) project (CSS) for 99 MW; and
- Elk Falls (EFM) – previously a major industrial load in the area that has since shut down.

The existing 132 kV system is thermally constrained between John Hart (JHT) and Dunsmuir (DMR) during high outputs of the existing and higher-queued future generation in the area. The constraints, largely due to a major industrial load decommissioned in the area, can be mitigated with present operating measures before a long term transmission solution is implemented. The identification of a preferred long term option to resolve the constraint is outside the scope of this interconnection study. In this study, it is assumed that the present operating measures will continue to alleviate the overloading issues until a long-term solution is determined.

5.0 SYSTEM STUDIES

Power flow, short circuit and transient stability studies were carried out to evaluate the impact of the proposed interconnection. Studies were also performed to determine the protection, control and communication requirements and to evaluate possible over-voltage issues.

5.1 Steady State Pre-Outage Power Flows

Pre-outage power flows are prepared to assess the impact of the proposed interconnection using three basic system load conditions:

1. 2016 winter peak load;
2. 2017 summer light load;
3. 2017 summer peak load and

defined generation conditions.

With North VI generators all operating at Maximum Continuous Ratings (MCRs), the steady-state power flow studies have indicated:

- no voltage violations were observed;
- no additional circuits were overloaded due to the proposed incremental power injection, and the existing overloading conditions will be exacerbated insignificantly; and
- depending on the long-term transmission option and its implementation date for the thermally constrained circuits between JHT and DMR, the John Hart Replacement project may be required to participate in area generation shedding schemes on either a temporary basis (i.e. assuming a system capacity upgrade is implemented) or on a permanent basis (i.e. assuming generation reduction is used to resolve the constraints). It is noted that there are significant dam safety, public safety and fishery issues associated with this project and they will be taken into consideration when assessing JHN generating units for participation in an area generation shedding/runback scheme.

Table 2 below provides the power flow study results for the proposed interconnection with the area generators running at the MCRs.

Table 2: Steady-state Pre-outage Power Flow Study Results

System Load Condition	Contingency	John Hart injection at POI (MW)	Bus Voltages (in per unit)			Power flow Loading (% of rating)							
			JHT 132	DMR 132	GLD 132	2L154	1L120	1L121	1L117	1L119	1L101	1L102	1L106
With no John Hart Replacement Project													
2017 LS	None	126	1.06	1.06	1.05	62	11	19	21	106	105	109	95
2017 HS	None	126	1.06	1.06	1.05	57	11	21	23	107	103	114	84
2016 HW	None	126	1.04	1.06	1.07	35	5	21	20	86	75	101	43
With John Hart Replacement Project in													
2017 LS	None	126	1.06	1.06	1.05	62	11	19	21	106	105	109	95
2017 HS	None	126	1.06	1.06	1.05	57	11	21	23	107	103	114	84
2016 HW	None	138	1.04	1.06	1.07	35	4	20	21	87	77	102	44

Note: LS: light summer load; HW: heavy winter load; HS: heavy summer load

5.2 Power Flow Based First Contingency Study

Power flow based single contingency (N-1) studies have been conducted to check if the post-disturbance performance including bus voltage deviation and facility loading meets the planning criteria under different system load conditions including heavy winter, heavy summer and light summer.

With North VI generators all operating at MCR level, loadings above the ratings (up to 163% of rating) will occur on the remaining 132 kV lines from JHT to DMR after a single contingency of 2L154, 1L119, 1L101 or 1L102. The overload will be less severe but not yet mitigated to acceptable levels if north VI generation level is reduced to Effective Load Carrying Capability (ELCC) level. Such N-1 scenario overload problems exist with the generation at ELCC level before the John Hart Replacement project comes into service. Thus, further generation reduction in the region is needed to remove the overloading concerns.

The studies have indicated that there is no additional transmission equipment over-loading due to the incremental power injection from the IC's project, and no voltage violation conditions were identified either.

The contingency study results based on 2016 heavy winter, 2017 heavy summer and 2017 light summer load cases are listed in Table 3.

Table 3: The Power Flow Study Results after Single Element Contingency

System Load Condition	Contingency	John Hart injection at POI (MW)	Bus Voltages (in per unit)			Power flow Loading (% of rating)								note
			JHT 132	DMR 132	GLD 132	2L154	1L120	1L121	1L117	1L119	1L101	1L102	1L106	
2017 LS Gen -MCR	2L154	126	1.05	1.06	1.08	/	65	61	45	128	128	132	117	1, 2
	1L101		1.05	1.06	1.04	72	35	6	14	144	/	151	128	2
	1L102		1.05	1.06	1.04	72	35	7	14	152	145	/	2	2
	1L119		1.05	1.06	1.04	71	34	7	14	/	144	154	130	2
2017 HS Gen -MCR	2L154	126	1.05	1.06	1.07	/	53	54	41	124	121	132	101	1, 2
	1L101		1.05	1.06	1.04	66	30	9	16	144	/	155	112	2
	1L102		1.05	1.06	1.05	66	30	9	16	158	143	/	3	2
	1L119		1.05	1.06	1.04	66	29	9	16	/	140	163	117	2
2016 HW Gen -MCR	2L154	138	1.04	1.06	1.07	/	31	33	27	94	84	110	73	1, 2
	1L101		1.04	1.06	1.06	41	21	13	16	115	/	137	61	2
	1L102		1.04	1.06	1.06	42	24	12	15	139	112	/	20	2
	1L119		1.04	1.06	1.06	41	21	13	16	/	104	150	66	2
2017 LS Gen -ELCC	2L154	126	1.05	1.06	1.08	/	78	67	48	128	120	134	116	2
	1L101		1.06	1.07	1.07	50	62	15	7	126	/	135	108	2
	1L102		1.06	1.07	1.07	50	62	16	7	135	128	/	2	2
	1L119		1.06	1.07	1.07	50	61	15	7	/	126	138	111	2
2017 HS Gen-ELCC	2L154	126	1.05	1.06	1.07	/	66	60	44	125	122	134	100	2
	1L101		1.06	1.06	1.06	44	56	13	9	127	/	139	93	2
	1L102		1.06	1.06	1.06	45	57	13	9	141	126	/	7	2
	1L119		1.06	1.06	1.06	44	55	12	9	/	122	147	98	2
2016 HW Gen-ELCC	2L154	138	1.04	1.06	1.08	/	45	38	30	95	85	111	51	2
	1L101		1.05	1.06	1.07	25	48	9	13	101	/	124	47	2
	1L102		1.04	1.06	1.07	26	51	10	13	126	98	/	23	2
	1L119		1.04	1.06	1.07	25	47	9	13	/	90	138	51	2

Notes:

1. Generation runback signal is sent to KKS and CSS to runback/trip the units for the contingency 2L154 to remedy overloads on 1L120 (GLD-SCA) and to mitigate the overloading on the 132 kV circuits south of JHT. This scheme will be implemented with the two Clean Power Call projects (Kokish River Hydro and Cape Scott Wind Farm). The runback/tripping effect has been reflected in the above table.
2. Before a long-term transmission solution is in place, the existing LAPS at JHT will be used as an operating measure to reduce generation output at ICG (Island Co-Gen, rated at 290 MVA) or trip the ICG unit. The LAPS will operate upon an overload condition on 1L101, 1L102 or 1L119 plus a high generation output from ICG is detected, which will bring the line loading within its thermal ratings and subsequently remove the overloading on 1L106.

5.3 Transient Stability Study

A series of transient stability studies under various system operating conditions including the heavy winter case and the light summer case have been performed. The model of the generating project was based on the IC's data submission plus additional assumptions where the IC's data was incomplete or inappropriate. The models and data values of the key components are shown in Appendix B.

There is no transient instability issue with N-1 contingencies due to the connection of the John Hart Replacement project. For other severe cases, such as N-1-1 contingencies (one facility already out of service and another facility contingency), the system performance will be reviewed in separate BCH internal studies. If the IC's generators, under the more severe conditions become unstable, the swing center of the instability could in some situations be in the generators' step up transformers. Slips detected in a transformer should trip the generator, and such a slip detection scheme will need to be implemented by the IC. For situations with slip centered in the JHT-DMR 132 kV lines, it is expected that the existing tripping of the lines by impedance based protection is satisfactory.

The transient stability study results for 2016 Heavy winter load conditions are summarized in the following Table 4.

Table 4: Transient Stability Study Results (Pre-outage condition: 2016 Heavy winter)

Case	Outage	3Φ Fault Location	Fault Clearing Time (Cycles)		John Hart Generator Max Rotor Swing (Deg.) (Delta $\delta = \delta_{max} - \delta_{initial}$)	Stability Performance	Comment
			Close End	Far End			
1	1L101 (JHT - DMR)	Close to JHT	8	9	53	Acceptable	
2	1L102 (JHT - DMR)	Close to JHT	8	9	48	Acceptable	
3	1L120 (GLD - SCA)	Close to GLD	8	9	13	Acceptable	
4	1L121 (SCA - LDR)	Close to SCA	8	9	46	Acceptable	
5	2L154 (GLD - DMR)	Close to GLD	8	7	11	Acceptable	

5.4 Islanding

Islanded operation is not arranged for this project. Power quality protection will be required at the generating units to detect abnormal system conditions such as under/over voltage and under/over frequency and subsequently trip the units. The settings of these protective relays must conform to existing BCH practice for generating plants so that the generator will not trip for normal ranges of voltages and frequencies.

5.5 Fault Analysis

The short circuit analysis for the System Impact Study is based upon the latest BCH system short circuit model, which includes project equipment and impedances provided by the successful IC. The model included higher queued projects and planned system reinforcements but excluded lower queued projects. Thevenin impedances, including the ultimate fault levels at POI, are not included in this report but will be made available to Interconnection Customers upon request.

BCH will work with the IC to provide accurate data as required during the project design phase.

5.6 Analytical Studies

No unacceptable temporary or transient over-voltage issues were identified.

5.7 Protection and Control & Telecommunications & Circuit Breakers

Protection, control and telecom requirements for the proposed IC project have been reviewed. The main items are summarized below:

John Hart Substation

- Provide new PY and SY protection for 1B1, 1B10 and 1B13 using SEL-487B relays. SEL-587Z relays will be considered at the time of application.

5.8 Black Start Capability

BCH does not require the proposed project to have black start capability.

If the IC desires their facilities to be energized from the BCH system, the IC is required to make the necessary arrangements with BCH as the Transmission Service Provider.

5.9 Transmission Line upgrade requirements

No Transmission line upgrades have been identified.

5.10 Additional BCH Station Upgrades or Additions

No Station upgrades or additions have been identified.

5.12 Cost Estimate and Schedule

The non-binding good faith cost estimate for the Interconnection Network Upgrades is \$600 K. The Interconnection Facilities Study report will provide more detailed information of the cost estimates.

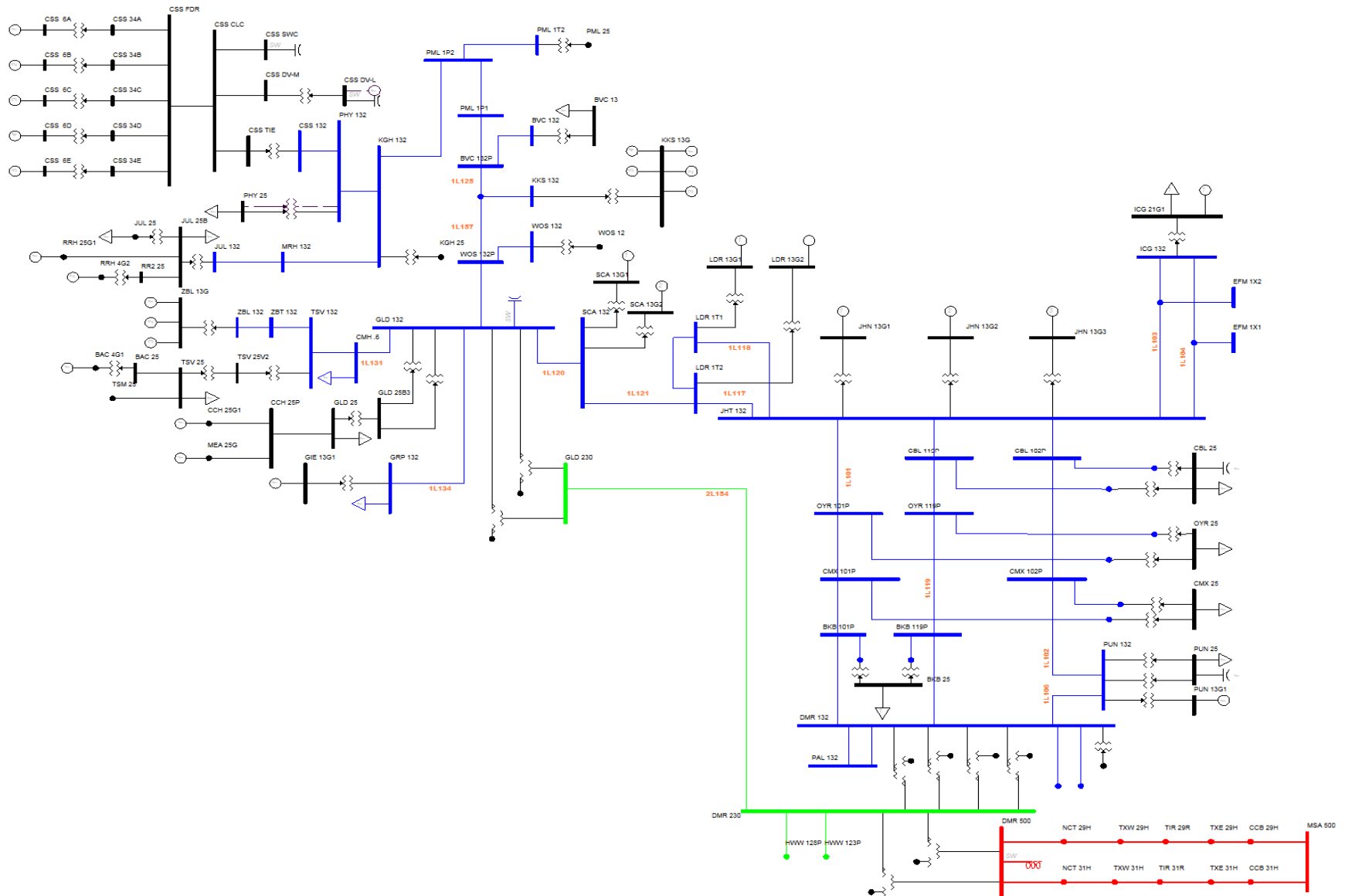
The estimated time to construct the Interconnection Network Upgrades is 12 months after the Standard Generation Interconnection Agreement is signed and the BCH capital project for the network upgrade is approved. A more detailed construction timeline will be provided in the Interconnection Facilities Study report.

6.0 CONCLUSION & RECOMMENDATIONS

In order to interconnect the John Hart Replacement project to the BCH Transmission System at the POI, this SIS has identified the following issues and requirements:

- The existing 132 kV circuits between JHT and Dunsmuir (DMR) substations are thermally constrained. The constraints can be mitigated with the existing operating measures until a long term transmission solution is determined and in place.
- Power flow studies indicate that with this replacement project in service the proposed incremental power injection will cause no additional overload or voltage issues and will only insignificantly exacerbate the existing overloading issues. The JHN generating units may be required to participate in an area generation shedding/runback scheme on either a temporary or a permanent basis depending on the long term transmission solution selected. Thus, the IC needs to allow for receipt of such shedding/runback signals.
- Stability studies indicated no transient instability issues with N-1 contingencies due to the addition of the project. Under more severe contingencies, the IC's generators may become unstable. Out of step protection is required and should be provided by the IC.
- New Primary (PY) and Standby (SY) protections for 3 buses at JHT substation.
- Power flow studies indicate that with this project in service, the incremental power injection will cause no additional overload or voltage issues and will only insignificantly exacerbate the existing overloading issues.
- The non-binding good faith cost estimate for Interconnection Network Upgrades required to interconnect the proposed project to the BCH Transmission System is \$600 K.
- The estimated time to construct the Interconnection Network Upgrades is 12 months.

APPENDIX A – PROJECT SINGLE LINE DIAGRAM



APPENDIX B – JOHN HART REPLACEMENT PROJECT PRODUCT and MODEL

The contents of this section have been removed due to the proprietary nature of the information.