BC Hydro
Power smart

[redacted] Kootenay Canal Generating Station Control Upgrade Project

Interconnection System Impact Study

[redacted]

BCH Interconnection Queue #: 350

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Acronyms

The following are acronyms used in this report.

ALH Arrow Lakes Hydro Generating Station
BRD Brilliant Dam Generating Station
BRX Brilliant Expansion Generating Station
BTS Brilliant Terminal Substation
COD Commercial Operation Date
COR Corra Lynn Generating Station
ERIS Energy Resource Interconnection Service
FBC FortisBC
FVO Fraser Valley Office
IC Interconnection Customer
KCL Kootenay Canal Generating Station
LBO Lower Bonnington Generating Station
NERC North American Electric Reliability Corporation
NLY Nelway Substation
NRIS Network Resource Interconnection Service
OATT Open Access Transmission Tariff
OO Operating Order
POI Point of Interconnection
PSS Power System Stabilizer
RAS Remedial Action Scheme
SEL Selkirk Substation
SIS System Impact Study
SLC South Slocan Generating Station
TIR BC Hydro 60 kV to 500 kV Technical Interconnection Requirements for Power Generators
UBO Upper Bonnington Generating Station
WAN Waneta Generating Station
WECC Western Electricity Coordinating Council

Executive Summary

[redacted] Generation, the Interconnection Customer (IC), requests a system impact study (SIS) for the Kootenay Canal Generating Station (KCL) Control Upgrade Project. This project will replace all excitation systems and governors of the four existing KCL generating units. The project's Commercial Operation Date (COD) is December 30, 2027.

KCL has four synchronous generators, each rated at 147 MVA, 13.8 kV and 0.9 power factor. The IC also plans to upgrade the generators with larger ones in the near future. However, the generator upgrade project is not included in this SIS scope.

The SIS has identified the following conclusions and requirements:

- With adequate generation shedding specified in Operating Order (OO) 7T-34, the system performance with the KCL Control Upgrade Project is acceptable under system normal and contingency conditions. No system upgrade is identified in this SIS.
- The shedding requirement for the existing KCL G1 to G4 units is applicable to the KCL G1 to G4 after the KCL Control Upgrade Project.
- The upgraded excitation systems can provide marginal positive impact to the dynamic performance of the transmission system.

It can be expected that some Protection & Control supporting work and field coordination will be needed during the project commissioning, and the associated cost will be a part of the overall KCL Control Upgrade Project budget.

1 Introduction

[redacted] Generation, the Interconnection Customer (IC), requests a system impact study (SIS) for Kootenay Canal Generating Station (KCL) Control Upgrade Project. BC Hydro's internal queue number of this project is 350, which is different from the external queue number shown on www.bchydro.com. This project will replace all excitation systems and governors of the four KCL generating units. The generators are connected to the KCL 230 kV bus via the customer owned disconnects (2D1, 2D2, 2D3 and 2D4) and stepup transformers. The project's Commercial Operation Date (COD) is December 30, 2027.

The project reviewed in this SIS is summarized in Table 1-1 below.

Table 1-1: Project Information

Project Name	Kootenay Canal Generating Station (KCL) Control Upgrade Project	
Interconnection Customer	[redacted]	
Point of Interconnection	The KCL 230 kV bus	
IC Proposed COD	December 30, 2027	
Type of Interconnection Service	NRIS ☒	ERIS ☐

KCL has four synchronous generators, each rated at 147 MVA, 13.8 kV and 0.9 power factor. The IC also plans to upgrade the generators with larger generatos in the near future. The generator upgrade project is not included in this SIS scope.

KCL is directly connected to Selkirk Substation (SEL) through two 230 kV transmission lines, 2L295, and 2L299. KCL is also connected to FortisBC (FBC) owned Brilliant Terminal Substation (BTS) through 2L288, and BTS is connected to SEL through 2L289. SEL has three 500 kV lines to connected to bulk system and is a strong point of the transmission system.

KCL and the adjacent area is a generation resource rich area. There are four FBC operated generation stations, South Slocan Generating Station (SLC), Upper Bonnington Generating Stations (UBO), Lower Bonnington Generating Station (LBO) and Corra Lynn Generating Station (COR), with approximate 220 MW total generation capacity connected to KCL via 60L225 and 60L227. The four-generating stations also supply the local loads within their 60 kV system.

There are also three generation stations, Brilliant Dam Generating Station (BRD), Arrow Lakes Hydro Generating Station (ALH) and Brilliant Expansion Generating Station (BRX) with approximate 465 MW total generation capacity connected to BTS. Waneta Generation Station (WAN) with 480 MW generation capacity is connected to Nelway Substation (NLY) through 2L277. WAN is also looped back to BTS through 62L and 77L.

KCL and the adjacent transmission system is descripted in Figure 1-1 below.

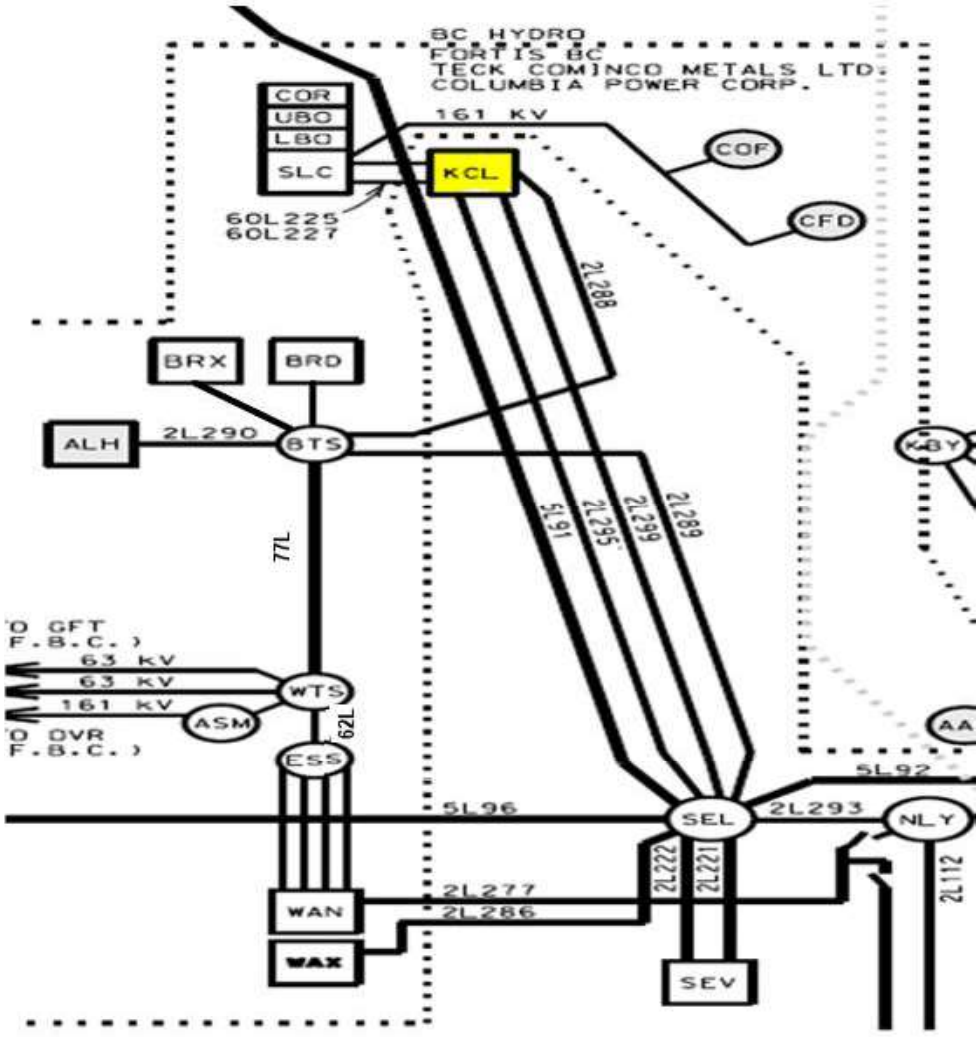

Figure 1-1: KCL and Adjacent Transmission System

2 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 per BCH's Open Access Transmission Tariff (OATT). This study will identify any constraints and suggest network upgrade options to obtain adequate performance for reliable operation of the transmission system.

The SIS is performed in compliance with the North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council (WECC) reliability standards, and the BCH transmission planning criteria, specifically:

- NERC standards: FAC-002-3 and TPL-001-4;
- WECC criteria: TPL-001-WECC-CRT-3.2;
- BC Hydro's 60 kV to 500 kV Technical Interconnection Requirements for Power Generators per FAC-001-3;
- BCH's TAP FAC-002-3 Study Guide.

3 Scopes of Study

This study investigates and addresses the voltage and overloading issues of the transmission system in the vicinity of the KCL project for the long term planning horizon as a result of the proposed control upgrade at KCL. Studies completed include steady-state studies, dynamics studies and short circuit analysis to evaluate system performance, as well as protection coordination, operation flexibility, telecom requirements and high level remedial action scheme (RAS) requirements. BCH planning methodology and criteria are used in the studies as stated in Purpose of Study.

Pursuant to FAC-002-3, BC Hydro has taken the necessary measures to assess the potential reliability impact on the FBC system, including monitoring the part of FBC system that is adjacent to the proposed control upgrade. The study result pertaining to the FBC system will be shared and coordinated with FBC upon completion of this SIS.

4 Assumptions and Conditions

- The study cases are established based upon the IC's submission dated Nov. 3, 2021.
- BC Hydro 2028 light summer and heavy summer load base cases are used in this study. To establish the base cases, the following assumptions are used:
  - Generations in the South Interior East areas are set to their maximum.
  - Firm transfer of the intertie exchanges with the US and Alberta systems is used.
  - Higher queue interconnection projects are included in the study models.
- The fault clearing times and generation shedding times used in this SIS are listed in Table 5-2 of Section 5.2.

5 System Studies and Results

5.1 Steady State Study

Since this project only upgrades KCL generating units' excitation systems and governors, the KCL generation capacity has not been changed for this SIS. It is expected that there is no incremental load flow impact on the transmission system. Power flow analysis under system normal (N-0 or P0) together with single and multiple contingencies specified in TPL-001-4 were performed to evaluate whether KCL Control Upgrade Project would cause any adverse impact in the nearby area.

Some of the contingencies can cause transmission system overloads. The existing South Interior generation shedding RAS will be relied on to resolve the overloading issues under various contigencies. The generation shedding RAS requirements for the existing KCL G1 to G4 units are applicable to the units after the KCL Control Upgrade Project.

It has been concluded that with KCL Control Upgrade Project, there will be no overloading or unacceptable voltage profiles in the transmission system under the studied load and generation conditions with adequate generation shedding specified in OO 7T-34.

Below Table 5-1 shows the loading and voltage profiles of the concerned transmission elements under system normal condition (N-0 or P0). Power flow results under contingency conditions are not presented in the table because with adequate generation shedding there is no concern with these conditions.

Table 5-1: Power Flow Results Under System Normal Condition

Cases	System Condition	Line rating and loading (percentage)				Bus Voltage		
		2L295 Rating (MVA) Summer: 427.3	2L299 Rating (MVA) Summer: 427.3	2L289 Rating (MVA) Summer: 450	2L277 Rating (MVA) Summer: 440.5	KCL 230 kV (pu)	BTS 230 kV (pu)	SEL 230 kV (pu)
2028 Light Summer	System Normal	72 %	71 %	84 %	47 %	238	235.4	234.4
2028 Heavy Summer	System Normal	70 %	70 %	80 %	42 %	238.1	235.2	234.6

5.2 Transient Stability Study

Transient stability simulations were performed on the 2028 light summer load scenarios for single and multiple contingencies in accordance with the TPL-1-004 planning standard. The stability simulation cases used the existing South Interior generation shedding RAS where necessary.

With adequate generation shedding RAS specified in OO 7T-34, system stability performance with the KCL Control Upgrade Project was shown to be acceptable.

The excitation systems can provide marginal positive impact to the transmission system dynamic performance compared with the existing ones. It is expected that the new excitation systems can support larger size generators in future.

A few selected transient stability study results are listed in Table 5-2 below.

Table 5-2: Selected Transient Stability Study Results for 2028 Light Summer Cases

NERC TPL-001-4 Category	Cases	Contingencies	Fault Loca ions	Fault Clearing Time (Cycles)		Generation Shedding Time (Cycles)	Generation Shedding Required	Transient Stability
				Close End	Far End			
P1	1	2L289	At SEL end	6	7	12	yes	Acceptable
	2	2L295/2L299	At KCL end	6	7	12	yes	Acceptable
P6	3	2L295 (with 2L289 already out of service)	At KCL	6	7	12	yes	Acceptable
P7	4	2L295 & 2L299	At SEL end	6	7	12	yes	Acceptable
Extreme events	5	2L295 & 2L299 & 2L289	At SEL end	6	7	12	yes	Acceptable
	6	2L295 & 2L299 & 2L289 (with 2L277 already out of service)	At SEL end	6	7	12	yes	Acceptable

5.3 Reliability Impact to Adjacent Utilities

The reliability impact of the proposed interconnection to FBC was assessed in accordance with FAC-002-3. During the study, the performances of nearby FBC system, including FBC owned/operated power plants connected to BTS, KCL and WAN, were monitored. The pre-existing generation shedding schemes that would be applied to FBC owned/operated generators as described in OO 7T-34 were considered. No unacceptable performance is observed in the FBC system.

5.4 Analytical Studies

No concerns or issues are identified in the Analytical Studies for the replacement of excitation system and governors on KCL G1 to G4 units.

5.5 Fault Analysis

The short circuit analysis for the SIS is based upon the latest BC Hydro system model, which includes project equipment and impedances provided by the IC. Thevenin impedances for the near-term system conditions and the ultimate fault levels at POI are not included in this report but will be made available to the IC upon request.

5.6 Remedial Action Scheme

No new RAS function is required. The shedding requirement for the existing KCL G1 to G4 units is applicable to the units after the KCL Control Upgrade Project.

In addition, the KCL G1-G4 power system stabilizer (PSS) settings are required to be re-tuned and confirmed before the commissioning of the new KCL excitation systems and governors.

5.7 Station Upgrade Requirements

No Stations Planning work is required for this project.

5.8 Protection, Control and Telecommunications

No Protection, Control and Telecommunication work is required in the transmission system for this project. It is expected that there will be some Protection & Control supporting work during the project commissioning.

6 Cost Estimate and Schedule

The expected Protection & Control supporting work for this project is assumed to be a part of the overall KCL Control Upgrade Project budget and will be done during the generator commissioning process, along with the required coordination with FVO and field personnel as well as the PSS tuning study before commissioning.

7 Conclusions

With adequate generation shedding specified in OO 7T-34, the system performance after the KCL Control Upgrade Project is acceptable under system normal and contingency conditions. No system upgrade is identified in this SIS.

The shedding requirements for the existing KCL G1 to G4 units are applicable to the G1 to G4 after the KCL Control Upgrade Project.

The upgraded excitation system can provide marginal positive impact to the dynamic performance of the transmission system.

Appendix 1: Power Flow and Dynamic Models and Data

KCL Step Up transformer T1-T4 data

T1 90/156 MVA, 230.1/13.8 kV, Impendence HL Z1=8.16%

T2 90/156 MVA, 230.1/13.8 kV, Impendence HL Z1=7.99%

T3 100/135/170 MVA, 230.1/13.8 kV, Impendence HL Z1=8.82%

T4 100/135/170 MVA, 230.1/13.8 kV, Impendence HL Z1=8.92%

KCL G1-G4 generator, exciter, compensator, stabilizer, governor models and parameters

Generator G1-G4 each: Unit Rating 147 MVA, 132.3 MW, 13.8 kV; +0.9, -0.9 pf and Ra= 0.00378 pu

Table A-1 PSS/E Generator Model: GENTPJU1

Unit	Model	T'do	T"do	T'qo	T"qo	H	D	Xd	Xq	X'd
G1-4	GENTPJU1	6.85	0.031	0	0.4	4.43	0	0.783	0.503	0.195
		X'q	X"d	X"q	Xl	$S_{G1.0}$	$S_{G1.2}$	K_{is}		
		0.503	0.172	0.172	0.08	0.08	0.245	0.12		

Table A-2 PSS/E Excitation System Model: EXST1

Unit	Model	TR	Vimax	Vimin	Tc	Tb	Ka	Ta	VRmax
G1-4	EXST1	0.0103	99	-99	1	1	150	0.003	6.771
		VRmin	Kc	Kf	Tf				
		-6.361	0.05	0	1				

Table A-3 PSS/E Power System Stabilizer Model: PSS2B

Unit	M	N	T_{W1}	T_{W2}	T_6	T_{W3}	T_{W4}	T_7	K_{S2}	K_{S3}
G1-4	5	1	5.0	5.0	0.0	5.0	0.0	5.0	0.4798	1.0
	T_8		T_9	K_{S1}	T_1	T_2	T_3	T_4	T_{10}	T_{11}
	0.2841		0.1393	7.0	0.0758	0.0371	0.0459	0.0153	0.0	0.0
	V_{Si1MAX}		V_{Si1MIN}	V_{Si2MAX}	V_{Si2MIN}	V_{STMAX}	V_{STMIN}			
	99		-99	99	-99	0.1	-0.1			

Table A-4 PSS/E Turbine-Governor Model: HYG3U1

Unit	Model	Rgate	Relec	Tt	Td	K2	Ki	Kd	Tf	Kg
G1-4	HYG3U1	0.0	0.04	0.2	0.05	1.1	0.6	0	0.1	2
		Tp	Vel open	Vel close	Pmax	Pmin	db	Gv1	Pgv1	Gv2
		0.1	0.063	-0.078	1	0	0.0	0.13	0	0.3
		Pgv2	Gv3	Pgv3	Gv4	Pgv4	Gv5	Pgv5	Gv6	Pgv6
		0.18	0.5	0.46	0.7	0.74	0.9	0.92	1.0	1.0
		H0	qnl	Tw	At	Dturb	Trate	Db1h	Err1	Db1l
		1.0	0.13	2.3	1.2	0.13	145.4	0.0	0.0	0.0

Table A-5 Voltage Regulator Voltage Compensating Model: COMP

Unit	Rc	Xc
G1-4	0.0	0.05