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Bull River Solar Farm Project

Interconnection Feasibility Study

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This System Impact Study report was prepared by: Terence Munroe, Interconnection Planning

Reviewed by: Eric Tse, Interconnection Planning

Approved by: Robert Pan, Manager, Interconnection Planning

Contributors in the respective disciplines:

[redacted]

[redacted] Feb 17, 2017

Terence Munroe, Interconnection Planning

[redacted]

[redacted]

Steven Small, Stations Planning

[redacted]

[redacted]

Ming Lu, Transmission Line Design

[redacted]

[redacted]

Tony Jiao, Protection Planning

[redacted]

[redacted]

Parker Moore, Telecom Planning

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EXECUTIVE SUMMARY

[redacted] the Interconnection Customer (IC), is proposing to develop the Bull River Solar Farm facility (BRSX) to inject energy into the BC Hydro (BCH) system. The solar energy project, capable of producing up to 15 MW of power, will be located in the East Kootenay area of British Columbia.

This report identifies the required system modifications at a preliminary level for interconnecting the solar farm to the BCH system. The BRSX facility is proposed to be connected via a tap connection on to circuit 60L289 between BCH's Cranbrook Station (CBK) and Aberfeldie Generating Station (ABN). The Point of Interconnection (POI), located at the tap point, will be at a distance approximately 2.2 km west from ABN. The maximum power injection from BRSX into the BCH system at the POI is 15 MW and the proposed Commercial Operation Date (COD) is June 15, 2018.

This feasibility study of the BRSX project interconnection to the BCH Transmission System at the proposed POI has resulted in the following conclusions and requirements:

- No unacceptable voltage conditions in the transmission system were observed due to the BRSX solar farm facility under pre and post - contingency steady state scenarios;
- Transmission circuit 60L289 (CBK – ABN) can be overloaded during the summer months for pre-contingency (N – 0) system normal conditions. Post-contingency (N-1) steady state transmission element overloads were observed on circuits 60L289, 60L294, and 60L282;
- The present rating of circuit 60L289 is required to be uprated to a higher operating conductor temperature in order to accommodate the BRSX project under system normal conditions;
- Replacement of existing 60L289 line protection relays at CBK and ABN stations will be required to implement a hybrid current differential and Permissive Over-reaching Transfer Trip (POTT) protection scheme on 60L289;
- Primary (PY) and Standby (SY) WECC Class-2 telecommunication circuits are required with new installation of All Di-electric Support Structure (ADSS) fibre optic cable between BRSX and ABN sites. Upgrade of an existing microwave link is required for implementing the telecommunication circuits between CBK – ABN and CBK – BRSX;
- Replacement of the existing transformer at BCH's Wardner Station (WAR) is required to incorporate the protection scheme on 60L289 which will likely involve a station expansion;
- Islanded operation with existing BCH customers is not arranged for the Bull River Solar project. Power Quality protection (i.e. under and over voltage/frequency protection) is required at the BRSX facility. The capability to receive anti-islanding Direct Transfer Trips (DTTs) from BCH terminals will be required to remove the IC's generation source to minimize any potential impacts to BCH customers under islanding conditions.
- The IC is required to follow the requirements as applicable in the BCH document, "60 kV to 500 kV Technical Interconnection Requirements for Power Generators" that pertains to this type of asynchronous generation source (i.e. solar).

Mitigation methods of the IC's transformer energization inrush current may also be needed and will be studied in greater detail at the next System Impact Study (SIS) stage.

The non-binding good faith cost estimate for the above Network Upgrades necessary to interconnect the proposed project to the BCH Transmission System for a maximum injection of 15 MW is $5.17M. The estimated time to implement the identified Network Upgrades is 12 – 18 months.

The above estimate and schedule do not include the work associated with Revenue Metering nor does it include the work required within the IC's facilities. The IC is required to provide PY and SY 60L289 line protection at its terminal which must be the same as that used for the replacement of BCH's 60L289 line protection. The IC's protection must be in accordance with "60 kV to 500 kV Technical Interconnection Requirements for Power Generators."

Additional Network Upgrade requirements may be identified in the SIS or Facilities Study (FS) stages. The Interconnection SIS and FS reports 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 project reviewed in this Interconnection Feasibility Study report is as described in Table 1 below.

Table 1: Summary Project Information

Project Name	Bull River Solar Farm	
Interconnection Customer	[redacted]	
Point of Interconnection	2.2 km from ABN station via a tap connection	
IC Proposed COD	June 15, 2018	
Type of Interconnection Service	NRIS ☒	ERIS ☐
Maximum Power Injection at POI (MW)	15 (Summer)	15 (Winter)
Number of Inverter Units	250	
Plant Fuel	Solar	

[redacted] the Interconnection Customer (IC), is proposing to develop a 15 MW solar generating facility in the East Kootenay area of British Columbia.

The Bull River Solar Station (BRSX) will have a total of 250 inverters, where a single inverter has a rated maximum apparent power of 66 kVA and a rated active power output of 60 kW. Each inverter unit is connected to a DC network consisting of fourteen (14) photovoltaic circuits. The 250 inverters are distributed over two feeders with 160 inverters allocated onto one feeder and 90 inverters allocated on the second feeder. The maximum power (15 MW) generated from all 250 inverter units will first be stepped up to the 34.5 kV level through step-up transformers and then to the 60 kV system through a proposed 15 MVA, 60 kV (Y-gnd) / 34.5 kV (Δ) station transformer unit. The power will be transmitted through a short IC owned 0.1 km, 60 kV transmission line (designated as 60LXXX) via a tap connection on the BCH circuit, 60L289, between Cranbrook station (CBK) and Aberfeldie Generating Station (ABN). The Point of Interconnection (POI) will be located at this tap point which is at a distance of around 2.2 km from ABN or 2.0 km from Wardner Station (WAR). The IC's proposed maximum power injection into the BCH system at the POI, after losses, is around 15 MW. The proposed Commercial Operation Date (COD) for this project is June 15, 2018.

The IC proposed 60 kV transformer appears inadequate to deliver the 15 MW maximum power injection at the proposed POI while meeting the reactive power requirements for a solar/wind farm. The customer is requested to review its 60 kV transformer rating before moving to the system impact study stage, and to ensure that the transformer will be capable of delivering the proposed 15 MW injection.

Aberfeldie Generating Station (ABN – 25 MW) is a summer peaking station which historically operates close to its maximum continuous ratings during the summer months. During this high output, active power flows on 60L289 are predominantly in the direction towards CBK station.

There are two tapped load stations on circuit 60L289, the customer owned Bull River Mineral Station (BRM) and BCH's Wardner Station (WAR). BRM mine is presently shut down and has very low load levels. WAR station load levels are also low and it supplies ABN and BRM stations with its single feeder through the existing three (x3) single phase, 833 kVA, 67.3 kV (Y-gnd) / 11.95 kV (Y-gnd) transformers.

The Elko Generating Station (ELK – 12 MW), located at the end of circuit 60L294 (ABN – ELK), is no longer operational.

Appendix A illustrates the East Kootenay electrical system with the proposed IC connection in the area.

2.0 STUDY PURPOSE AND SCOPE

The Feasibility Study is a preliminary evaluation of the system impact and cost of interconnecting the proposed project to the BCH Transmission System. The study scope is restricted to power flow and short circuit analysis and investigates potential system constraints associated with the interconnection of the proposed project.

3.0 TERMS OF REFERENCE

This study investigates voltage and overloading issues of the transmission networks in the vicinity as a result of the proposed interconnection. BCH planning methodology and criteria in compliance with the North America Reliability Corporation (NERC) Mandatory Reliability Standards are used in the studies.

The Feasibility Study does not include stability analysis, harmonic mitigation, or electro-magnetic transient analysis. Operating restrictions and other factors for possible second contingency outages are not studied at this stage either. Subsequent system impact/facilities studies and internal network studies will determine the requirements for reinforcements or operating restrictions/instructions for the above mentioned types of events.

4.0 STUDY ASSUMPTIONS

The study is carried out based on the latest data and information submitted by the IC in September 2016 and the latest BC Hydro Interconnection Queue information. Reasonable assumptions are made to complete the study and the report, whenever such information is unavailable.

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 2018 summer and winter system configurations were selected for this study.

The following assumptions were applied to the feasibility study base cases:

- Existing plants (i.e. ABN) and higher priority queued projects in the East Kootenay area were included in the study;
- Elko Generating Station (ELK) was not included in the study (i.e. ELK = 0 MW).

Appendix B contains the power flow single line drawing reflecting the electrical orientation of the project within the BCH system. Appendix C provides other study assumptions.

5.0 STUDY RESULTS AND REQUIRED UPGRADES

The 15 MW BRSX facility is proposed to be interconnected to the BCH system through a short line tap connection onto circuit 60L289 (CBK – ABN). With all elements in service (system normal or pre-contingency) during the summer months, transmission circuit 60L289 can be overloaded due to the injection of 15 MW of power from the IC's facilities under steady state conditions. This pre-contingency overload is expected when power (at any level) is imported from Alberta (AB) into BC. At any transfer level between AB and BC (import and export), steady state post-contingency (N-1) transmission element overloads are expected on circuits:

- 60L289 for loss of 60L294 or 60L282;
- 60L289, 60L294 or 60L282 for loss of 2L113

The 60L289 circuit, presently rated at 30 MVA, is required to be uprated in order to address the overload concern under system normal conditions. Based on a high-level review at this study stage, a higher rating of 56 MVA is achievable by addressing clearance violations on circuit 60L289 with the replacement of specific wood pole structures. The higher rating is expected to remove some of the thermal overload concerns under single-contingency scenarios. Any single contingency overloads that are largely pre-existing issues will be addressed with existing operational measures.

For the successful integration of the BRSX station to the BCH system, the existing 60L289 line protection relays at CBK and ABN terminals are required to be replaced by SEL-411L relays. 60L289 will be protected by a hybrid protection scheme which includes a 3-terminal zero sequence current differential protection for ground faults and a 2-terminal Permissive Over-reaching Transfer Trip scheme (POTT) for phase to phase faults. For this, Primary (PY) and Standby (SY) WECC Class-2 64 kbps synchronous circuits are required between stations:

- CBK and ABN
- CBK and BRSX
- BRSX and ABN

To implement the synchronous circuits between ABN and BRSX, new installation of All Di-electric Support Structure (ADSS) fiber optic cable will be required. This will include the replacement of specific wood pole structures between ABN and BRSX. To incorporate the synchronous circuits between CBK – ABN and CBK – BRSX, the upgrade of an existing microwave link will be required.

In order to implement the above hybrid protection scheme on 60L289, the BC Hydro station work is as follows:

- Replace the existing three (3) single phase 67.3 kV (Y-gnd) / 11.9 kV (Y-gnd) transformers at Wardner station (WAR) with a single three phase 7.5 MVA, 64.5 kV (Δ) / 25.2 / 12.6 kV (Y-gnd) transformer. A station expansion at WAR will likely be needed to accommodate the replacement;
- Replace transformer fuse 60D1 at WAR for protection coordination purposes;
- Remove existing voltage regulator and bypass disconnect switches.

The IC is required to provide PY and SY 60L289 line protection at its terminal which must be the same as that used for the replacement of BCH's 60L289 line protection. In addition to 60L289 line protection, the IC is also required to provide Power Quality protection (i.e. under and over voltage / frequency protection) in accordance with BC Hydro's "60 kV to 500 kV Technical Interconnection Requirements for Power Generators" and to receive anti-islanding Direct Transfer Trips (DTTs) signals from BCH line terminals. The DTT requirements will be studied in greater detail at the next SIS stage.

Mitigation of the IC's transformer energization inrush current may be required to avoid potential voltage sag and power quality impacts on other BCH customers. At the next SIS stage, BCH will review and provide comments on the IC's proposed solution/configuration to meet the power quality requirements.

At this study stage, there are no Remedial Action Schemes (RAS) or special protection and control facilities specified to address or mitigate potential issues that may be identified as a result of future stage studies.

Please note that the above conclusions are based on the steady state power flow study results. Other system performance measures such as transient stability, transient overvoltage, etc., have yet to be determined. Those issues will be dealt with in the System Impact Study stage and may identify the need for additional network upgrades. Equipment that may be determined during future stage studies is not included in the cost estimate nor considered in the estimated schedule provided in the next section.

6.0 COST ESTIMATE AND PROJECT SCHEDULE

Table 2 below lists the facilities and system upgrades required in the BCH system to interconnect the proposed project to the system. It also provides a non-binding good faith cost estimate for the Network

Upgrades that would be the responsibility of the IC. The estimate and schedule do not include the work associated with Revenue Metering nor does it include the work required within the IC's facilities.

Table 2: Cost Estimate for the Required System Upgrades

Work Definition	**Facilities**	Estimated Cost
Stations, Transmission Line, P&C, and Telecommunication	Replacement of existing transformer at WAR. Replacement of existing protection at CBK and ABN sites with associated telecommunication upgrades. Replacement of wood pole structures on 60L289.	
	Estimated Interconnection Network Upgrade Cost:	**$5.17M**

The estimated time to implement the Network Upgrades required to interconnect the project to the BCH system is indicated in Table 3 below. This estimate assumes subsequent study work has been completed and a Standard Generator Interconnection Agreement has been executed.

Table 3: Estimated Project Schedule

0 - 6 months	☐	36 - 42 months	☐
6 -12 months	☐	42 -48 months	☐
12- 18 months	☒	48- 54 months	☐
18 - 24 months	☐	54 - 60 months	☐
24 – 30 months	☐	60 – 66 months	☐
30 - 36 months	☐	66 – 72 months	☐

7.0 CONCLUSIONS & DISCUSSION

This feasibility study of the BRSX project interconnection to the BCH Transmission System at the proposed POI has resulted in the following conclusions and requirements:

- The existing rating of circuit 60L289 is required to be uprated to accommodate the BRSX project under system normal conditions. This present rating of 30 MVA (50°C) can be increased to 56 MVA (90°C) which will involve the replacement of specific wood pole structures on 60L289 to address clearance violations;
- Replacement of existing 60L289 line protection relays will be required at CBK and ABN stations to implement a hybrid protection scheme which includes a 3-terminal zero sequence current

differential protection for ground faults and a 2-terminal Permissive Over-reaching Transfer Trip scheme (POTT) for phase to phase faults.

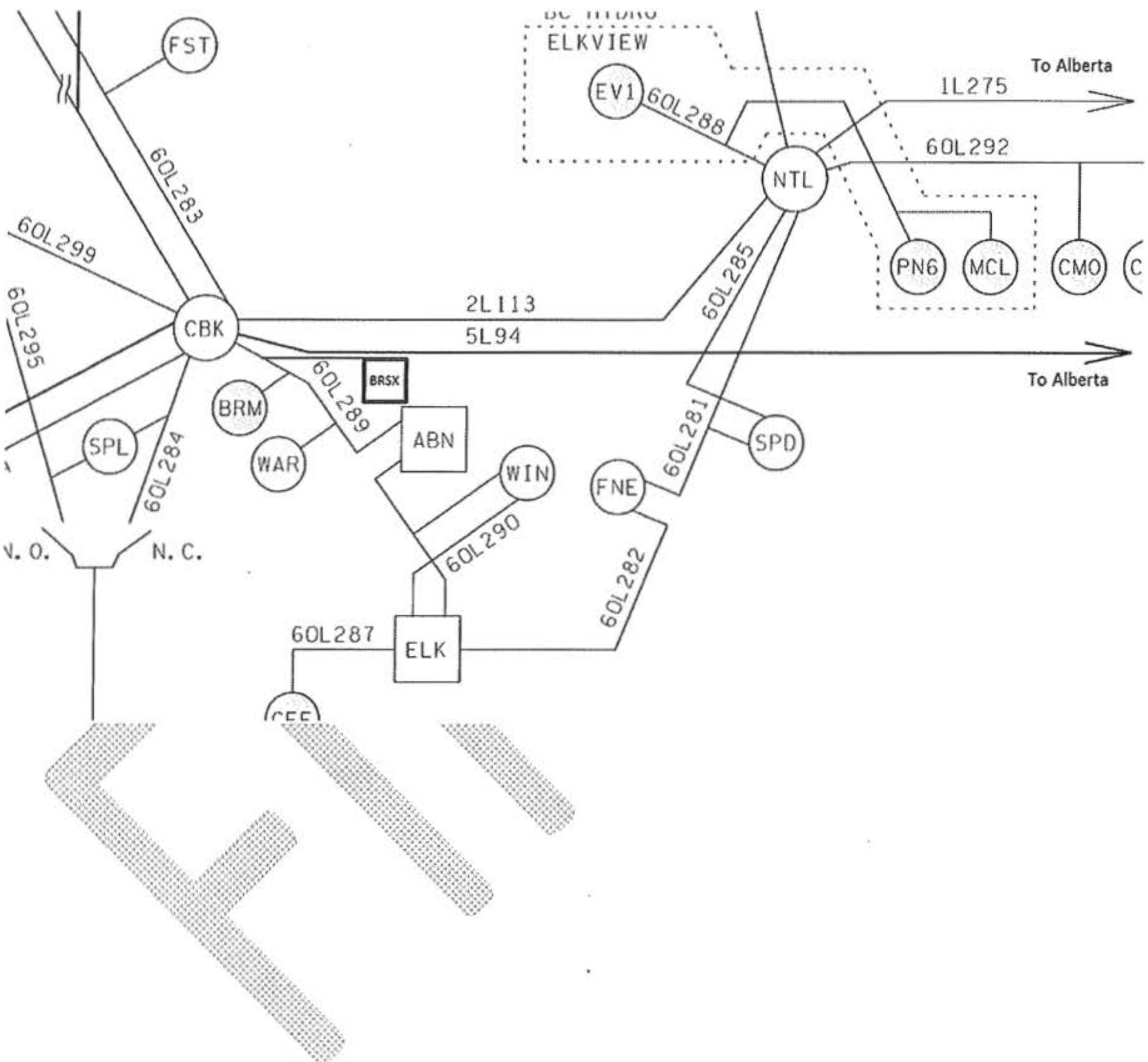
- Primary (PY) and Standby (SY) WECC Class-2 64 kbps synchronous data circuits will be required. New installation of ADSS fibre optic cable will be required on 60L289 between ABN and BRSX sites which will include the replacement of existing pole structures. The upgrade of an existing microwave link will be required to implement the data circuits between CBK – ABN and CBK – BRSX;
- Replacement of the existing transformer at Wardner Station (WAR) is required to incorporate the protection scheme on 60L289 which will likely involve a station expansion;
- Islanded operation with existing BCH customers is not arranged for the Bull River Solar project. Power Quality protection and the capability to receive DTT signals from BCH terminals will be required at BRSX.

The non-binding good faith cost estimate for the above Network Upgrades necessary to interconnect the proposed combined project to the BCH Transmission System for a maximum injection of 15 MW is \$5.17M. The estimated time to implement the identified Network Upgrades is 12 – 18 months.

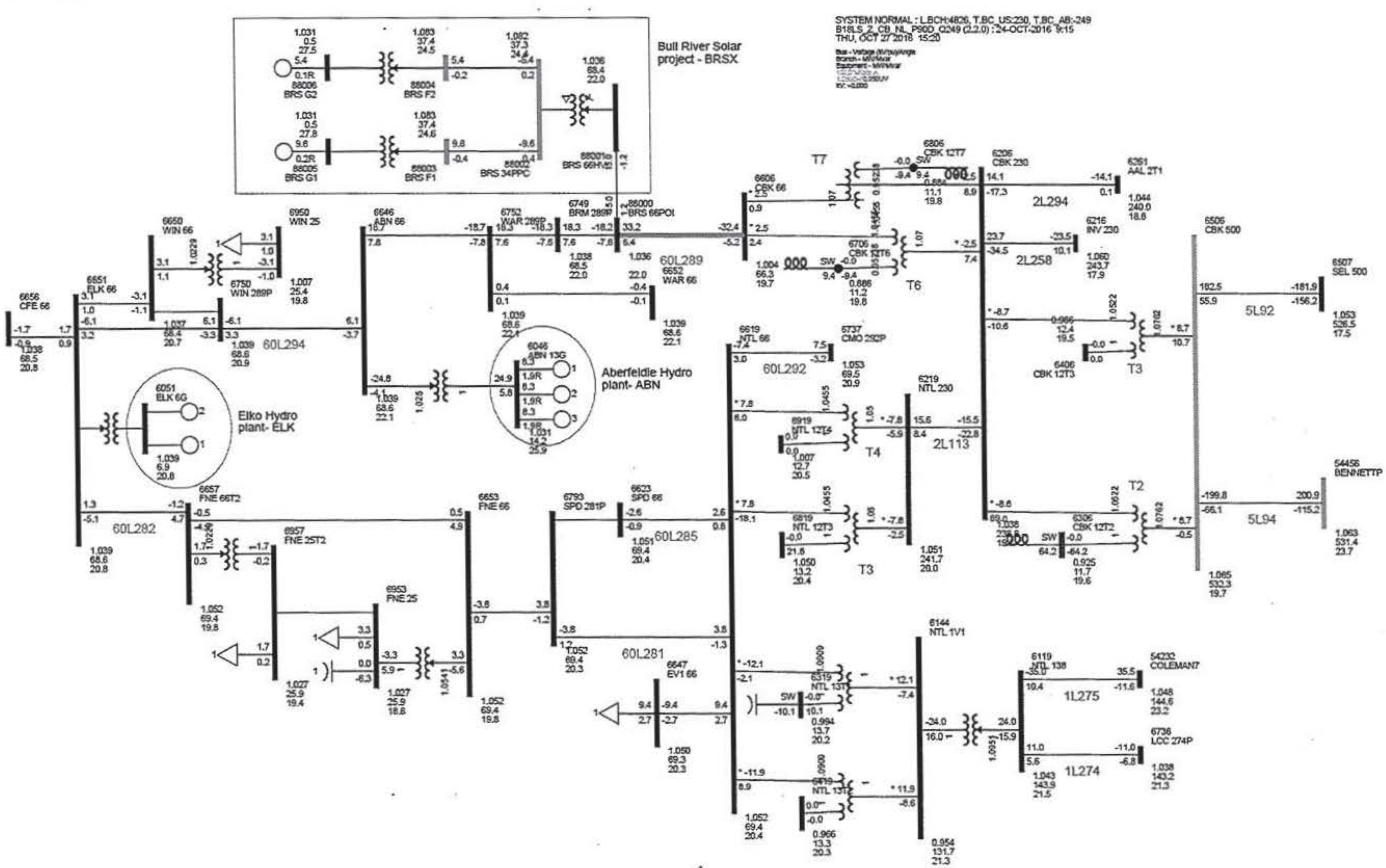
Additional Network Upgrade requirements may be identified in the SIS or Facilities Study (FS) stages. The Interconnection SIS and FS reports will provide greater details of the Interconnection Network Upgrade requirements and associated cost estimates and estimated construction timeline for this project.

When the solar farm advances to the next study stage, the IC will need to ensure that the solar farm design will meet the interconnection requirements. The interconnection requirements for a solar farm should be comparable to those for a wind farm as stated in BCH's "60 kV to 500 kV Technical Interconnection Requirements for Power Generators". Specifically, the solar farm will need to be capable of operating at a leading/lagging power factor of 0.95 when injecting 15 MW at the POI, regulating the POI voltage, and meeting the low voltage ride through requirements.

APPENDIX A – PROJECT ELECTRICAL MAP



APPENDIX B – SINGLE LINE DIAGRAM



APPENDIX C – OTHER ASSUMPTIONS

Assumptions related to the BCH transmission system:

Power Flow

Power flow study is based upon the base case that includes generation, transmission facilities, and load forecast representing the queue position applicable to the study of this project. Applicable seasonal conditions and the appropriate number of study years for the study horizon have also been incorporated.

Short Circuit

Short circuit study is based upon the complete short circuit model of BC Hydro System including contributions from the interconnecting utilities and private power generators. The model not only includes the existing facilities but also all those under construction.

Financial and Estimating Assumptions

Cost estimates are based on an order of magnitude assumption and are non-binding and provided in good faith. The cost estimate included in this report does not and cannot account for a variety of issues not under the control of BCH including, but not limited to:

- The impact of additional equipment required as the result of more detailed studies;
- Actual equipment specified during engineering design;
- Fluctuations in costs over time;
- First Nation considerations;
- Property-related costs and issues;
- Any Certificate of Public Convenience and Necessity (CPCN) required from the British Columbia Utilities Commission (BCUC);
- Physical space constraints in network facilities.