[redacted]

**Bremner Trio Small Hydro Project**

# Interconnection System Impact Study

Report #: T&S Planning 2016-019

May 2016

British Columbia Hydro and Power Authority

## Acknowledgements

This report was prepared and reviewed by T&D, Interconnection Planning and approved by both Interconnection Planning and Transmission Generator Interconnections.

 

## Revision Table

| Revision Number | Date of Revision | Revised By |
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## Executive Summary

[redacted] the Interconnection Customer (IC), proposed to develop the Bremner Trio Small Hydro Project in the Upper Harrison area in British Columbia to deliver electric energy to BC Hydro (BCH) through the BCH 2008 Clean Power Call (CPC). This generating project was studied in 2010, and the study results were documented in the SIS report (ASP2010-T047) and the FS report (TGI-2010-A117-FS-R1).

Recently, the IC has revised the plant design and the units' parameters in a new submission for Bremner and Trio Small Hydro project. The IC proposed to install two 25 MW units and one 3.5 MW unit instead of the IC's originally proposed two 10 MW and two 12.5 MW units. The total power injection to BC Hydro system is 49.5 MW at the point of interconnection (POI), BC Hydro's Upper Harrison Terminal substation (UHT). A short IC's owned 360 kV transmission line named 3L8 is to connect the IC's station BTR to UHT. The proposed Commercial Operation Date (COD) is July 1, 2016, however this is not achievable and BC Hydro is working with the IC to determine a revised COD for the Interconnection Facilities. A system impact re-study is required due to the changes.

To interconnect the Bremner Trio Small Hydro Project and its facilities into the BCH Transmission System at the POI, the updated System Impact Study (SIS) has identified the following issues and requirements:

- Under the system normal condition, 2L90 may become overloaded during some generation and load scenarios. To prevent the overloading, generation restriction at BCH's Bridge River #1 and #2 power plants will be needed. In addition, generation shedding in the area including the Bremner Trio Small Hydro generating project is required to mitigate the facility overloading and/or instabilities under various contingencies.
- One 360 kV circuit breaker and associated switching facilities are required to create a line termination position at UHT for connecting 3L8. An expansion from the existing UHT substation fence line is required to accommodate the interconnection of this project.
- A current differential protection will be used for the protection of the short line 3L8 and the high voltage side of the BTR transformer. The existing transmission lines 3L2 and 3L5 line protections will need to be modified at associated substations: BRT, ROS and UHT.
- The IC is required to provide the required telemetry and status information, which is to be reported to BCH's Fraser Valley Office and Southern Interior Office.
- Fibre optic termination equipment and modems at UHT will be required. Function upgrades associated with system controls, SCADA, and EMS will be required at BCH's Fraser Valley Office and Southern Interior Office.

The non-binding good faith cost estimate for interconnection Network Upgrades required to interconnect the proposed project to the BCH Transmission System is $7.42 million. The cost for Revenue Metering works of this project is $0.124 million. The estimated time to construct the Network Upgrades required to interconnect the project to the BCH Transmission System is 12-18 months from the project approval.

# Table of Contents



# 1. Introduction

The project reviewed in this System Impact Study report is as described in Table 1 below.

**Table 1: Summary Project Information**

| | | |
|---|---|---|
| Project Name | Bremner Trio Small Hydro Project (re-study) | |
| Interconnection Customer (IC) | [redacted] | |
| Point of Interconnection (POI) | BCH's UHT substation | |
| IC Proposed COD | July 1, 2016 | |
| Type of Interconnection Service | NRIS ☒ | ERIS ☐ |
| Maximum Power Injection (MW) | 49.5 (Summer) | 49.5 (Winter) |
| Number of Generator Units | 3 | |
| Plant Fuel | Hydro | |

[redacted] the Interconnection Customer (IC), proposes to develop the Bremner Trio Small Hydro Project. The project consists of two generating stations (Bremner Creek and Trio Creek) in the Upper Harrison area in British Columbia that will deliver electric energy to BC Hydro (BCH). The project was awarded an Electricity Purchase Agreement (EPA) through the BCH 2008 Clean Power Call (CPC).

This generating project was studied in 2010, and the SIS report (ASP2010-T047) and the FS report (TGI-2010-A117-FS-R1) were issued to the customer. Recently, the IC revised the plant design and the units' parameters in a new submission for Bremner and Trio Small Hydro project on November 04, 2015.

The Point of Interconnection (POI) is at UHT. The proposed commercial operation date (COD) is July 1, 2016, which cannot be met.

The Bremner Creek generating station will be connected to a customer-owned 138 kV / 360 kV transformer station (BTR) via a 17 km customer-owned 138 kV transmission line. BRT will then connect to BCH's Upper Harrison Terminal (UHT) via a very short customer owned 360 kV transmission line 3L8. Trio Creek generating station will be connected to the Bremner Creek generating station via a 6 km customer-owned 138 kV transmission line. The proposed maximum power to be injected into the BCH system from the project is 49.5 MW, which includes:

- Bremner Creek generating station consisting of one 28.275 MVA unit with the rated power factor of 0.9 lagging and 0.95 leading, and
- Trio Small Creek generating station consisting of two units with 28.319 MVA and 3.889 MVA respectively with the rated power factor of 0.9 lagging and 0.95 leading.

In the previous studies, it was planned that the transmission line 2L90 from Bridge River

Terminal (BRT) to Kelly Lake Station (KLY) would be upgraded and put in service before the original COD of this generating project, but the upgrade project was later delayed and generation restriction at BCH's Bridge River plants was chosen to mitigate the transmission constraints. In this re-study, the thermal ratings of the existing 2L90 were used and the same mitigating strategy has been used.

Figure 1 shows the one line diagram of the Bremner Creek generating station, the Trio Creek generating station, and the connection to UHT.

Figure 2 shows the regional transmission system with the interconnection of Bremner-Trio Small Hydro.

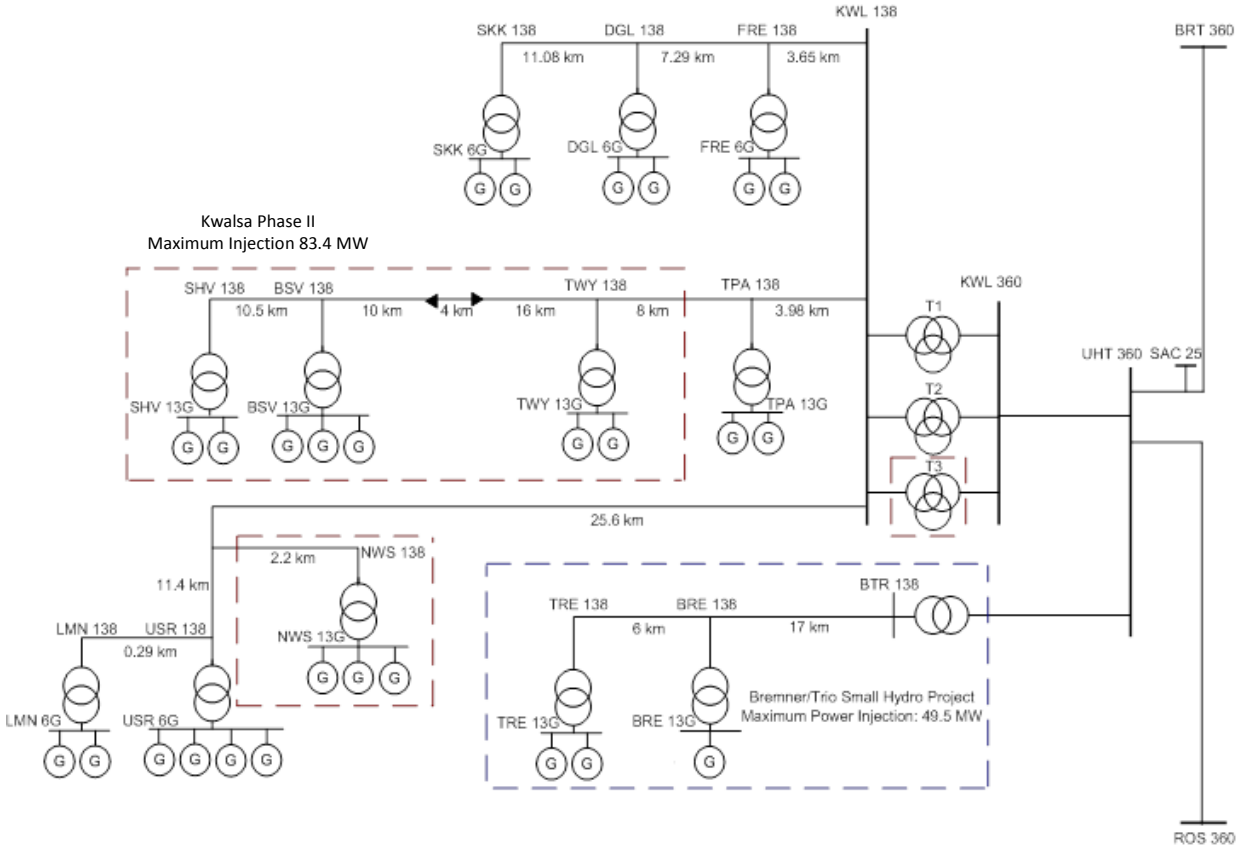



Figure 1 – Bremner Trio Small Hydro Project One Line Diagram and Interconnection to UHT (new design)

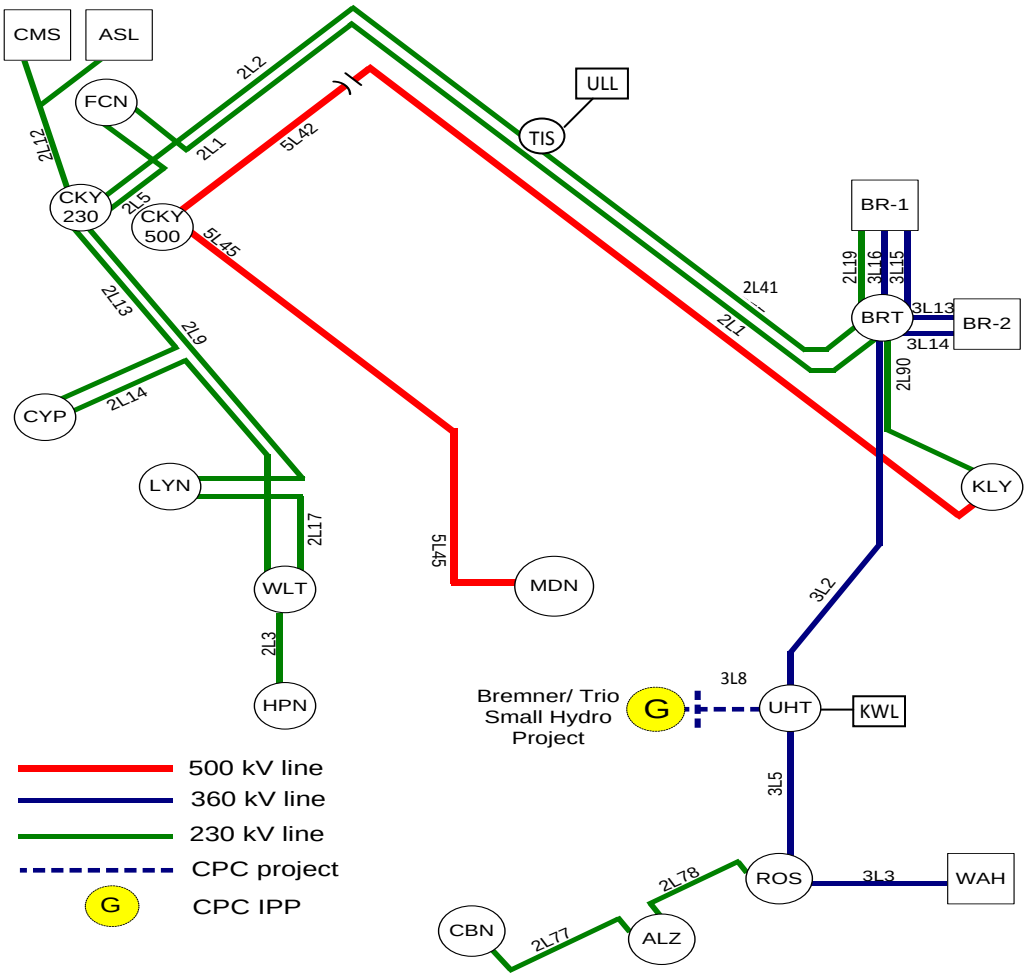



Figure 2 – Bridge River Regional Transmission System with the interconnection of Bremner-Trio Small Hydro

## 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. This study will identify constraints and Network Upgrades required for the reliable operation of the Transmission System.

## 3. Terms of Reference

This study investigates and addresses the voltage and overloading issues of the transmission networks in the vicinity of the Bremner Trio Small Hydro Project 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 remedial action scheme requirements. BCH planning methodology and criteria are used in the studies.

The SIS does not investigate the operating restrictions and other factors for the 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 bulk transmission system is not included in the 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 subsequent Interconnection Facilities Re-Study report for this project.

For any individual project that has its own staging developments, the impacts of the staging developments are not considered in the SIS. Only the final stage has been studied.

## 4. Assumptions

The power flow conditions studied are base cases that include generation, transmission facilities, and load forecast representing the queue position applicable to this project. Applicable seasonal conditions and the appropriate study years for the study horizon are also incorporated. BC Hydro 2016 light summer and heavy summer system configuration and load/generation conditions were selected and modelled in the cases used for this study. Facilities with higher queue priority are also represented in these cases.

The study is based on the latest model, data, and information received from the Interconnection Customer (IC) on November 04, 2015.

## 5. System Studies

### 5.1 Transmission Planning Study

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.

Transmission Planning study has concluded the following:

- Under the system normal condition (N-0), in both light summer and heavy summer load scenarios, and during high generation outputs in the CKY/BRR/UHT/WAH areas, 2L90 would be overloaded severely.
- With reduced generation outputs from the BCH's Bridge River Plants BR1 and BR2, the loading on 2L90 will decrease. It has been observed that the total output from BR1 and BR2 would need to be reduced down to zero in the light summer load case to avoid overloading 2L90 under system normal. In heavy summer load cases, the output from BR1&BR2 would need to be reduced as well but less severe than in the light summer

load case.

- 2L90 could be opened when overloaded for operational purposes. Under this operating condition, the system connectivity would be weakened and significant generation reduction at BR1 and BR2 would still be required to avoid overloading other transmission elements such as the ROS 360 kV transformer T1.
- Under various system contingencies, generation shedding in the area including this generating project is required to mitigate the facilities thermal overloading and/or instabilities.

## 5.2 Analytical Studies

The IC proposed to install two 25 MW units and one 3.5 MW unit. If the smallest unit is on line only, an abrupt opening of the UHT end of the tie line 3L8 could result in severe temporary over voltage (TOV). The expected instantaneous over-voltages would be limited only by Surge Arresters located at line terminals of the line 3L8 and on the 13.8 kV bus of the generating plant.

It is recommended that

- all local and remote supervisory (i.e. non-protection related) trips to the tie line circuit breakers at UHT will initiate tripping the IC's T1 at BTR to avoid potential TOVs damage to the UHT line terminal Surge Arresters.
- 288 kV IEC class 4 line terminal Surge Arresters are added at the UHT new line terminal position to protect line terminal equipment.

For the case of islanded configuration following an abrupt opening of the BTR end of the 138kV line with only smaller generator unit (3.5MW) in service, it is advised a transfer trip facility to be implemented to disconnect the generator before the line is disconnected from BTR/UHT. This recommendation action is only to protect the customer equipment and it is responsibility of the customer to assess the risk/benefit of its implementation.

## 5.3 Fault Analysis

The short circuit analysis for the System Impact Study is based upon the latest BC Hydro system model, which includes project equipment and impedances provided by the 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 the IC upon request.

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

## 5.4 Station upgrades

One 360 kV line termination and associated facilities will be added at UHT to accommodate the interconnection of this generating project. An approximate 10-15m expansion south east from the existing UHT substation fence line is required.

The IC proposed to build its 360 kV transformer station BTR immediately adjacent to UHT. However, the proposed location "immediately adjacent to UHT" is unacceptable. The BTR station will need to be set back from the existing South East UHT fence line by approximately 40m. This 40m buffer is required in order to enable both the present stage expansion for Bremner Trio interconnection and the future expansion of UHT.

## 5.5 Transmission Line Upgrade Requirements

No line upgrade work has been identified in this study.

## 5.6 Protection and Control

### 5.6.1 Protection

- Current differential primary/secondary (PY/SY) protection using SEL-487B-1 bus protection relays are required to protect the short 360 kV line 3L8 and the bus section at UHT. The differential protection will cover up to the transformer HV bushing at BTR.
- In addition to providing two bushing CTs of 360/138kV transformer HV for UHT bus protection, the IC shall provide appropriate redundant protections for 360/138kV transformer (fault clearing time <=5cycle), 138kV lines and 138/13.8kV transformers (fault clearing time <=8cycle). As the circuit breakers at UHT serve the high voltage breakers for IC's 360/138kV transformer, the IC is required to implement the transformer's tripping and isolating scheme in accordance with BCH's standards.
- The IC shall also provide entrance protection, power quality protection, out-of-step protection and protections for all station equipment at Bremner and Trio generating stations as per the latest BCH 60 kV to 500 kV Technical Interconnection Requirements (TIR) for Power Generators.
- On manual opening of UHT 3L8, BCH will trip IC's 360/138kV transformer by tripping the transformer's 138kV breaker to avoid potential TOVs damage to UHT line terminal Surge Arrester. Refer to Analytical Studies at 5.2.

### 5.6.2 Control

- The IC will provide SCADA data reporting to the control centers in accordance with the TIR, including required telemetry and status information, which should be available to the Energy Management System (EMS) at the nearest suitable BC Hydro site with appropriate telecom facilities. Continuous communications or broadband IP satellite from the IC sites to BC Hydro control centers is acceptable provided the performance objective stated in the TIR is met.

- The IC's telemetry and status will be routed to the appropriate Data Collection Platform (DCP). BC Hydro control centers are required to reconfigure the existing equipment to accommodate the new facilities, include the generator into the network model, and add the new telemetry and alarm points.
- The IC is responsible for providing a communications link for remote interrogation of the PPIS equipment by BCH servers. Alternative communications include IP cellular modem, IP satellite, BCH WAN (where appropriate) and are subject to BCH review and approval.
- Minor work will be required by BC Hydro to re-commission telemetry, alarms, and remote access at UHT.

### 5.7 Telecommunications

To support the PY/SY differential protection on 3L8 and the generation shedding scheme, the IC is to arrange for the supply and installation of dual route aerial and/or underground 48 strand single mode all-dielectric support structure (SM ADSS) cable between UHT and BTR. The associated connection devices will be installed at both terminal stations.

One continuous SCADA circuit to FVO/SIO for carrying BTR SCADA to the BCH's system, and one PPIS power quality monitoring circuit from UHT to BCH's Edmonds office (EDM). One metering circuit is needed from BTR to EDM.

Refer to Appendix B for the telecom block diagram.

### 5.8 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 BC Hydro practice for generating plants so that the generators will not trip for normal ranges of voltages and frequencies.

### 5.9 Black Start Capability

BC Hydro does not require the proposed project to have black start (self-start) capability.

### 5.10 Cost Estimate and Schedule

The non-binding good-faith cost estimate for interconnection Network Upgrades required to interconnect the proposed project to BC Hydro Transmission System is $7.42 million. The Revenue Metering cost estimated for this project is $0.124 million for an assumed two metering point, which will be paid directly by the IC.

It is expected that the BC Hydro work can be completed in 12-18 months from project approval, and thus the IC proposed COD date as July 1, 2016 cannot be met.

The estimate is based on these key assumptions:

- All engineering work will be executed by BC Hydro engineers;
- Project management will be executed by BC Hydro's project management;
- Construction work will be done by outside contractors;
- No cost for property purchase or First Nations consultation is included in the estimate.

# 6 Revenue Metering

Two Revenue Metering options are considered below:

Option 1: Single point of metering on the primary side of the main transformer T1 at BTR.
Option 2: Two points of metering, one each on the primary side of the transformer in the Bremner and Trio generating facility respectively.

In order to finalize the metering option, the IC will work with BCH to determine the required Revenue Metering configuration in accordance with the EPA and associated agreements. Specific metering information is provided in the table below.

| | |
|---|---|
| **Point-of-Metering** | Option 1: Primary side (360 kV) of the main power transformer T1 in BTR.<br>Option 2: Primary side (138 kV) of the main power transformers in the respective generating stations. |
| **Voltage Transformers** | Option 1: 3 x VTs (L-Grd) – 360/1.732-120-120V (or 115 -115 V) (to be supplied by the IC)<br>Option 2: 3 x VTs (L-grd) – 138/1.732 -120-120V (or 115 -115 V) (to be supplied by the IC), each for Bremner and Trio facilities. |
| **Current Transformers** | Option 1: 3 x CTs 50x100-5-5A (To be supplied by the IC)<br>Option 2: 3 x CTs 100x200-5-5A (To be supplied by the IC), each for Bremner and Trio facilities |

Refer to Appendix C for Revenue Metering Requirements.

# 7 Conclusions and Discussion

To interconnect the Bremner Trio Small Hydro Project and its facilities into the BCH Transmission System at UHT, this System Impact Study has identified the following issues and requirements:

- One 360 kV circuit breaker and associated switching facilities are required to build a line termination position at UHT Substation for connecting the IC's circuit 3L8.
- An expansion from the existing UHT substation fence line is required to accommodate the interconnection of the Bremner Trio generating facilities. In addition, the BTR substation is required to be set back from the existing South East UHT fence line in order

to enable both the present stage expansion for Bremner Trio interconnection and the future expansion of UHT.

- Under the system normal condition, 2L90 may become overloaded during some generation and load scenarios. To prevent the overloading, generation reduction at the existing Bridge River #1 and #2 power plants will be needed. In addition, generation shedding in the area including this generating project is required to mitigate the facility thermal overloading and/or instabilities under various contingencies.
- The existing transmission lines 3L2 and 3L5 line protection modifications will be required at associated substations BRT, ROS and UHT.
- The IC is required to provide the required telemetry and status information, which is to be reported to BCH system control centers FVO and SIO.
- Functional upgrades associated with system controls, SCADA, and EMS will be required at BCH system control centers FVO and SIO.
- Islanded operation of IPP is not allowed. Power quality protection is required to prevent/mitigate possible islanded operation.

# Appendix A: Generator, Excitor and Governor Models

**Generator Model (GENTPJU1):**
[G1B Unit Rating: 28.275 MVA, 13.8 kV, 25.448 MW, +0.9/-0.95 PF, $R_a$=0.0030 (pu)]
[G1T Unit Rating: 28.319 MVA, 13.8 kV, 25.487 MW, +0.9/-0.95 PF, $R_a$=0.0027 (pu)]
[G2T Unit Rating: 3.889 MVA, 13.8 kV, 3.50 MW, +0.9/-0.95 PF, $R_a$=0.006 (pu)]

| Unit | $T'_{do}$ | $T''_{do}$ | $T'_{qo}$ | $T''_{qo}$ | $H_{GT}$ | D | $X_d$ | $X_q$ | $X'_d$ | $X'_q$ | $X''_d$ | $X''_q$ | $X_l$ | S(1.0) | S(1.2) | $K_{IS}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G1B | 3.743 | .031 | .022 | .081 | 1.66 | 0.0 | 1.399 | .740 | .275 | .740 | .204 | .202 | .103 | 0.120 | 0.401 | 0.0 |
| G1T | 4.091 | .038 | .027 | .096 | 1.51 | 0.0 | 1.433 | .719 | .268 | .719 | .200 | .198 | .100 | 0.119 | 0.411 | 0.0 |
| G2T | 2.325 | .016 | .024 | .042 | 0.8 | 0.0 | 1.406 | .775 | .302 | .775 | .228 | .223 | .115 | 0.019 | 0.335 | 0.0 |

**Exciter Model (ESAC8B) Settings:**

| Unit | $T_R$ | $K_P$ | $K_I$ | $K_D$ | $T_D$ | $K_A$ | $T_A$ | $V_{RMAX}$ | $V_{RMIN}$ | $T_E$ | $K_E$ | $E_1$ | $S_{E1}$ | $E_2$ | $S_{E2}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G1B | .005 | 98.7 | 109.4 | 23.4 | 0.0 | 1.0 | .004 | 5.19 | 0.0 | 0.46 | 1.0 | 3.79 | 0.015 | 5.05 | 0.028 |
| G1T | .005 | 94.8 | 98.6 | 23.7 | 0.0 | 1.0 | .004 | 5.51 | 0.0 | 0.46 | 1.0 | 4.01 | 0.015 | 5.35 | 0.030 |
| G2T | .005 | 59.6 | 90.7 | 9.7 | 0.0 | 1.0 | .004 | 4.67 | 0.0 | 0.24 | 1.0 | 3.40 | 0.015 | 4.53 | 0.028 |

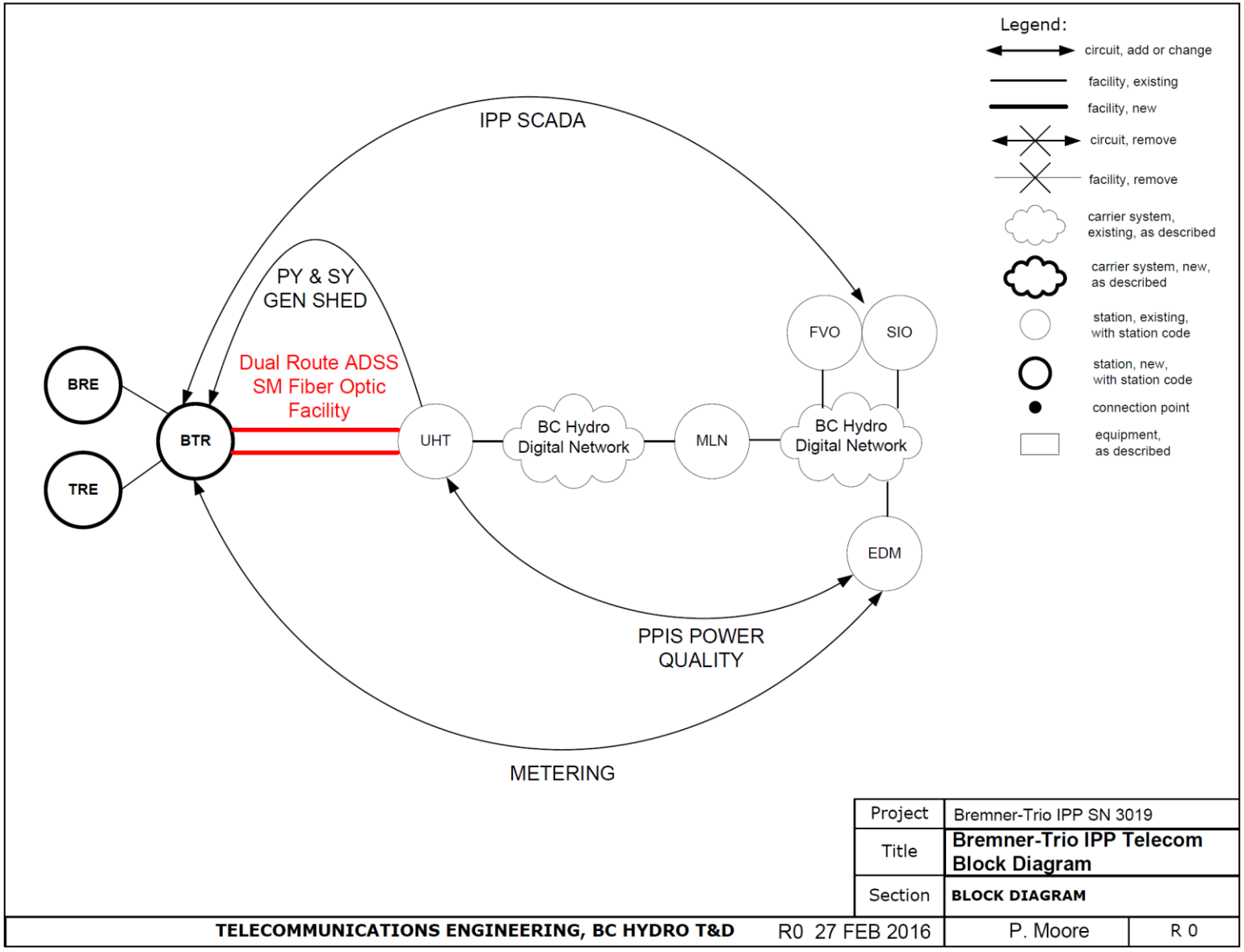
**Governor Model and Settings*:**

| Unit | R | r | $T_r$ | $T_f$ | $T_g$ | VELM | $G_{MAX}$ | $G_{MIN}$ | $T_W$ | $A_t$ | $D_{turb}$ | $q_{NL}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |

* No model and data & settings have been submitted – but not essential for the purpose of the study.

## Appendix B: Telecom Block Diagram



# Appendix C: Revenue Metering Related Telecommunications Requirements

Requirements to the IC:
Provide a communication channel to bring PG customer load consumption and power generation data from PG customer substation xxx to BC Hydro MV-90 server. The data will be downloaded to MV-90 server once a day.

The Point of Metering (POM) shall have a dedicated communications line (landline or alternative technologies e.g. cellular, fiber optic, microwave, satellite etc. subject to BCH approval) available for revenue metering use only. If there is digital cell phone coverage for data, BCH will supply the wireless communications. In this case, there will an incremental cost for the PG. BCH MV-90 Server must be able to access and download data from the revenue meters remotely as they do when they dial in a site using a standard phone line (wireless or landline). For more details, please, refer to Section 8 of BCH Revenue Metering Requirements for Complex Metering

**Revenue Metering Requirements:**

The remote read load profile revenue metering should be in accordance with the BC Hydro Requirements for Complex Revenue Metering. The latest version of this document is published at BC Hydro webpage under Forms and Guides. The revenue metering responsibilities and charges (Power generator (PG) and BCH) shall be in accordance with Section 10 (10.1 and 10.2). For details about the specific responsibilities, see table on pages.23-25.

Revenue class meters (main and backup) approved and sealed by Measurement Canada (MC) will be installed to register the energy delivered and received from the power generator. The meters will be supplied and maintained by BC Hydro. The main meter will be leased by BCH to the PG. As per federal regulations, the meter will be periodically removed and re-verified in a MC authorized laboratory. Main and backup bi-directional load profile interval meters are required to measure the power received and the power delivered (by BCH to the PG) during each 30 minute time period. The meters will be programmed for 5 minutes interval and will be remotely read each day by BCH/ABSU Enhanced Billing Group using MV-90;

The CTs and VTs used on the metering scheme will be supplied by the Power Generator and should be of a model/type approved by Measurement Canada. A 3-element metering scheme with 3 CTs and 3 VTs connected L-N (Grd) shall be used. The CTs and VTs must be pre-approved by BC Hydro's Revenue Metering Department. The PG should send an email to BCH RMSM stating the model/maker/ratio/MC approval numbers, etc. A list of approved models is available at Measurement Canada (MC) website

under "Notice of Approval Database Section". For Stand-Alone VTs and CTs, the H1 terminal of the VTs shall be connected on the BC Hydro side of the CTs.

If the impedance and losses between the POM and the PODR are significant, the meters will be programmed to account for the **line and/or transformer losses** between the POM and PODR. The PG or its consultant shall provide the line parameters data and the power transformer testing data to BC Hydro as applicable.

During the planning phase, BCH Revenue Metering department should be contacted to discuss the specifics of the project. The applicant should send drawings to BCH Revenue Metering Department showing the 1-line diagram (SLD) and informing the planned metering scheme, communication scheme, meter cabinet location, as well as any other metering related document. BC Hydro's Revenue Metering department can be contacted via email: metering.revenue@bchydro.com.

For a complete list of the information needed in the design stage, see below:

**Information required in the detailed design stage includes:**

1. Length of secondary cables
2. Single Line Diagram showing CTs, VTs, cabinets, all generating stations connecting to the POI
3. Identify whether revenue metering cabinets are indoors or outdoors - implication on whether cabinets need to be insulated
4. Communication medium contemplated to relay revenue metering data
5. 3-line diagram of the interconnection of the revenue metering CT & VT
6. Scaled Site Plan showing the relative location of the meter cabinet to the CT & VT (drawing showing the footprint for the sub)
7. Private power line parameters data and/or the power transformer testing data signed and stamped by a professional engineer (if applicable)
8. A set of manufacture switchgear drawings showing the installation of the revenue metering CT & VT (ensure the installation of the metering CT & VT complies with section 5.4 of BCH Requirements for Remotely Read Load Profile Revenue Metering, published at BCH website)
9. A simplified version of the lockout access steps to the revenue metering CT & VT (if applicable)
10. Location of the Meter Cabinet and verification of dedicated 120V AC 15A circuit for the meter cabinet - as per section 6.4 of BCH requirements
11. Contact name/phone on site for equipment/material delivery.
12. Mailing Address for the site (normal mailing address)
13. Interconnection Customer Billing Information
14. Operational Site Access for BC Hydro Meter Tech (for metering installation, maintenance, etc.)