[redacted]

Moose Lake Wind Project

Interconnection System Impact Study

Report no.: T&S Planning 2015 - 069

December 2015

British Columbia Hydro and Power Authority

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Executive Summary

[redacted], the Interconnection Customer (IC), is proposing to develop the Moose Lake Wind Project in the Peace Region of British Columbia to deliver electric energy to BC Hydro (BCH). The wind farm will consist of a total of 5 (Vestas Type 4) wind turbine units with a total installed capacity of 15 MW. The Point of Interconnection (POI) is at BCH's Meikle Terminal Switching Station (MKT), which is a new station being built in order to connect a higher queued wind farm project. An IC owned 9.4 km, 230 kV transmission line will be used to connect the IC's 230 kV Moose Lake Wind station (MLWX) to the POI. The maximum power injection into the BCH system at the POI, after internal losses and loads, is 14.5 MW. The proposed Commercial Operation Date (COD) for this project is December 01, 2016.

This System Impact Study (SIS) assumes that the Meikle Terminal Switching Station (MKT) will be in service prior to the interconnection of the Moose Lake Wind project.

This report documents the evaluation of the system impact of interconnecting the proposed generating facility and identifies the required system modifications to obtain acceptable system performance with the interconnection of the proposed project. To interconnect the Moose Lake Wind project and its facilities to the BCH system at MKT, this SIS has identified the following conclusions and requirements:

1. Addition of one transmission line termination and one 230 kV dead tank breaker (with Independent Pole Operation) along with associated equipment is required;
2. Installation of new and modification of existing protection, control, and telecommunication work is required;
3. No unacceptable transmission equipment overloads were observed due to Moose Lake Wind project under system normal conditions (no contingency);
4. No unacceptable voltage conditions in the transmission system were observed in the power flow and transient stability simulations due to the Moose Lake Wind project for pre-contingency and N – 1 contingency scenarios;
5. For the initial in-service years, thermal overloading on circuits 2L312 (SNK – SLS), 1L349 (SLS – CWD), and 1L377 (DAW – TAY) were observed for the loss of circuit 2L308 (GMS – DKT) during light load conditions. A generation runback Remedial Action Scheme (RAS) has been proposed with a separate project to address the overloads and it is not necessary for the subject wind farm to participate in the scheme.
6. Random energization of the 230kV 33MVA transformer at Moose Lake Station could produce voltage sags up to 11% at the POI which exceeds the maximum allowable voltage sag as per BCH's "60 kV to 500 kV Technical Interconnection Requirements for Power Generators.". It is the IC's responsibility to have some technique in place for meeting the above requirement;
7. Application of area sacrificial Surge Arrestors (SAs), rated at 180 kV with disconnecting capability, is recommended at the MLWX line terminal;
8. Islanded operation is not arranged for the Moose Lake Wind project which can occur when circuit 2L308/2L309 and 2L312 or 2L313/2L337 is lost for protective or non-protective tripping. A Direct Transfer Trip (DTT) to disconnect MLWX is required to mitigate a temporary overvoltage concern under islanding situations. The IC is responsible for equipping adequate

anti-islanding protection to trip the wind turbines under abnormal system conditions, in the event that the DTT signal fails.

A non-binding good faith cost estimate for the identified Interconnection Network Upgrades is $5.0 million with an accuracy range of -35%, +100% and the estimated time to implement after project approval is 18 months. The work required within the IC's facilities and Revenue Metering costs are not part of the Interconnection Network Upgrades. The Interconnection Facilities Study report will provide greater details of the Interconnection Network Upgrade requirements with the associated cost estimate and estimated construction timeline for this project.

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1. Introduction

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

Table 1: Summary of Project Information

Project Name	Moose Lake Wind Project	
Interconnection Customer	[redacted]	
Point of Interconnection (POI)	Meikle Wind Terminal Station – MKT	
IC Proposed COD	Dec 1, 2016	
Type of Interconnection Service	NRIS ☒	ERIS ☐
Maximum Power Injection (MW)	14.5 (Summer)	14.5 (Winter)
Number of Generator Units	5	
Plant Fuel	Wind Farm	

[redacted], the Interconnection Customer (IC), is proposing to develop a 15 MW wind generating facility near Tumbler Ridge in the Peace Region.

The Moose Lake Wind Station (MLWX) consists of a total of 5 wind turbine units on a single feeder, each with a capacity of 3.0 MW each. All 5 wind turbines are Vestas units, proposed with Type 4 technology, i.e. Full Converter Units. The total power (15 MW) generated from all 5 turbine units will be collected via a single 34.5 kV feeder at a 34.5 kV bus. From the 34.5 kV bus, the power is stepped up to the 230 kV system through a 33.2 MVA, 240/34.5 kV (high side Y-gnd) station transformer unit. The power will then be transmitted through an IC owned 9.4 km, 230 kV transmission line into BC Hydro's (BCH's) Meikle Terminal Switching Station (MKT) which is a new station to be built for connecting a higher queued wind project. MKT, which is located 23 km from Tumbler Ridge Station (TLR), is the official Point of Interconnection (POI) for the Moose Lake Wind project. The farm's maximum power injection into the BCH system, after losses and internal loads, is 14.5 MW. The proposed Commercial Operation Date (COD) for this project is December 01, 2016.

Due to the addition of the switching station MKT, the present circuit 2L313 SNK-TLR will be sectionalized into two 230 kV lines, one between SNK and MKT which is still designated as 2L313 and one between MKT and TLR which is designated as 2L337. The scheduled in-service date of MKT is in late 2016.

To serve some higher priority queued loads that are expected in the South Peace area mainly between BCH's Chetwynd (CWD) and Dawson (DAW) stations, two major transmission upgrade projects have been proposed: Dawson Creek/Chetwynd Area Transmission (DCAT) project and the Peace Region Electricity Supply (PRES) project.

A new 230 kV station Sundance (SLS) is being built at the existing intersection of 2L312 (SNK – LAP) and 1L358 (BMT – CWD). The existing 138 kV circuit from SLS to CWD will be renamed 1L349. A 230 kV double circuit will be built from SLS to BMT and DAW. The 230 kV section from BMT – DAW will be operated at the 138 kV level. The two existing 138 kV lines, 1L358 (section from SLS – BMT) and 1L362 (BMT – DAW) will be decommissioned. The scheduled COD for the DCAT project is sometime in 2015.

PRES, formerly known as GMS-Dawson-Creek-Area-Transmission (GDAT) project, will reinforce the Peace Region transmission system and provide N – 1 supply capability to customers. This project is in the identification stages and there are a number of system reinforcement alternatives that have been considered. The leading technical alternative, assuming Site C comes into service in 2023, is to build a double circuit 230 kV transmission line from Site C to Shell Groundbirch (SGB).

Figure 1 below illustrates the reconfigured Peace Region electrical system after the DCAT and PRES upgrades as well as the proposed IC connection at the 230 kV MKT station.

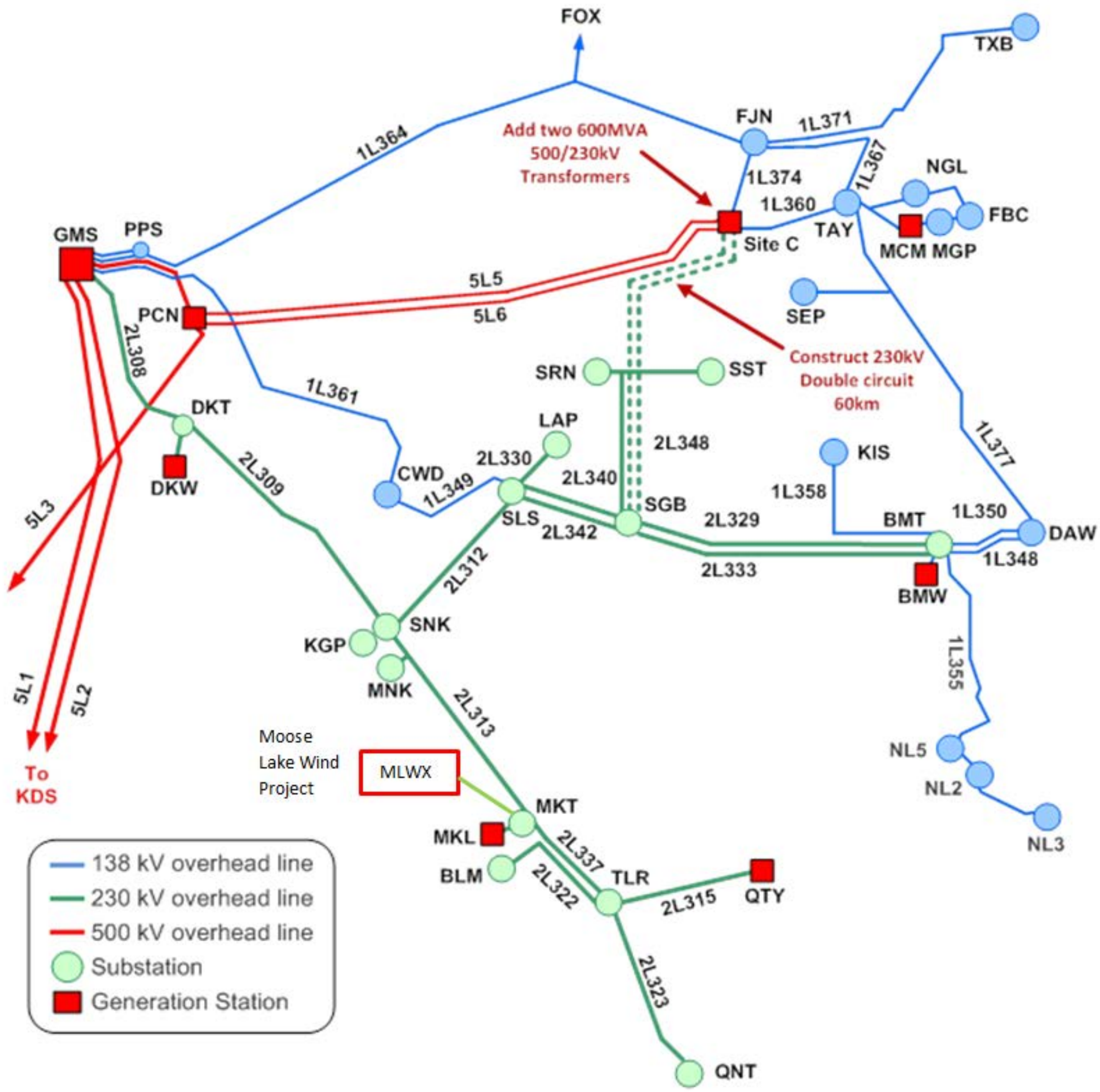


Figure 1: Peace Region one line diagram with Moose Lake Wind project (MLWX) connection and DCAT and PRES upgrades included

2. Purpose of Study

The purpose of this SIS is to assess the impact of the proposed interconnection on the BCH Transmission System. This study will identify constraints and Network Upgrades required for interconnecting the proposed generating project in compliance with the North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council (WECC) reliability standards and the BCH transmission planning criteria.

3. Terms of Reference

This study investigates and addresses the overloading, voltage deviation, and stability issues of the transmission network in the Peace Region as a result of the proposed interconnection for system normal and single contingency conditions. The studied topics include equipment thermal loading and rating requirements, system transient stability and voltage stability, transient over-voltages, potential harmonic resonances, 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 network studies will determine the requirements for reinforcements or operating restrictions/instructions for those types of events.

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

4. Assumptions

The studied power flow conditions include generation, transmission facilities, and load forecasts representing the BCH interconnection queue position applicable to this project. Applicable seasonal conditions and the appropriate study years for the study horizon are also incorporated. As a result, BC Hydro 2016 Heavy Winter (HW), 2017 Heavy Summer (HS) and Light Summer (LS) power flow base cases were selected for this study. The IC’s latest data submission, as of February 2015, has been used in this study.

5. System Studies and Results

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

5.1. Steady State Power Flows

Steady state pre-outage (N – 0) power flows were prepared and single element (N – 1) contingency studies were conducted. This was to determine if the pre-contingency and post-contingency performance, including bus voltage deviations and facility loading levels, met the NERC Mandatory Reliability Standards (MRS) and WECC/BCH transmission planning criteria.

Pre-contingency study results (i.e. all elements in-service) have indicated that with a maximum injection of 14.5 MW from MLWX and high levels of area generation, no transmission equipment overloads or unacceptable voltage conditions were observed due to the MLWX project both before and after the PRES project comes in service.

Before Site C and PRES projects are in service, single contingency (N – 1) study results have indicated thermal overloads on circuits 2L312 (SNK – SLS), 1L349 (SLS – CWD), and 1L377 (DAW – TAY) under the contingency of circuit 2L308 (GMS – DKT) for the 2017LS system configuration. This issue of the thermal overloads on the 138 kV system was identified in previous studies for higher queued projects and a generation shedding Remedial Action Scheme (RAS) was proposed to mitigate any potential thermal overload concerns for this N–1 contingency and other more severe system disturbances. It is not necessary for the subject wind farm to participate in the generation shedding RAS at this study stage.

After the PRES project comes in service, the Peace Region will have another 230 kV connection back to the 500 kV system. Loss of circuit 2L308 is not expected to cause any overloads on the 138 kV transmission system.

There were no unacceptable bus voltage conditions/violations in the transmission system observed.

A summary of the study results are shown below in Table 2:

Table 2: Power Flow Results

Base Case	Contingency	Bus voltages (p.u.)				Power flows (MW / % Amps)						
		GMS 230	SNK 230	TLR 230	SLS 230	2L308 @ GMS	2L309 @ SNK	2L312 @ SNK	1L349 @ SLS	1L361 @ GMS	1L377 @ DAW	1L367 @ TAY
2016 HW	All in-service	1.04	1.03	1.02	1.04	-189	49	227	30	-7	43	70
	2L308 (GMS - DKT)	1.04	1.02	1.02	1.04	n/a	-140	415	125	-93	130	120
	2L309 (DKT - SNK)	1.04	1.02	1.02	1.03	-140	n/a	276	55	-31	66	83
	2L312 (SNK - SLS)	1.03	1.02	1.02	1.03	-407	276	n/a	-88	121	-63	1
2017 LS	All in-service	1.04	1.03	1.02	1.04	-220	81	210	26	-18	45	37
	2L308 (GMS - DKT)	1.04	1.03	1.02	1.04	n/a	-140	431 (101% I)	138 (101% I)	- 115	147 (110% I)	96
	2L309 (DKT - SNK)	1.04	1.03	1.02	1.03	-140	n/a	291	68	-56	82	59
	2L312 (SNK - SLS)	1.04	1.03	1.02	1.04	-422	292	n/a	-83	100	-54	-26
2024 LS	All in-service	1.04	1.03	1.02	1.03	-192	52	239	14	-6	21	20
	2L308 (GMS - DKT)	1.04	1.03	1.02	1.03	n/a	-140	430 (~100% I)	38	-28	43	29
	2L309 (DKT - SNK)	1.04	1.02	1.02	1.03	-140	n/a	291	21	-12	27	22
	2L312 (SNK - SLS)	1.03	1.02	1.02	1.03	-421	291	n/a	-15	25	-6	7

Note:

Summer continuous rating of 1L349 is 133.6 MVA and winter continuous rating is 167.6 MVA
Summer continuous rating of 1L361 is 133.6 MVA and winter continuous rating is 143.4 MVA
Summer continuous rating of 1L367 is 124.3 MVA and winter continuous rating is 155.4 MVA
Summer continuous rating of 1L377 is 133.9 MVA and winter continuous rating is 174 MVA
Summer continuous rating of 2L312 is 420.3 MVA and winter continuous rating is 509.9 MVA

5.2. Transient Stability Study

A series of transient stability studies, under selected system operating conditions including the 2016 heavy winter and 2017 heavy summer and light summer load conditions, have been performed. The model of the generating project was based on the IC's data submission plus any additional assumptions where the IC's data was incomplete or inappropriate. The best available dynamic models, provided by respective manufacturers that represent the nearby wind farms in the area, were used at the time of the study.

Transient stability studies have been performed to assess the impact of 14.5 MW of maximum power injection from the Moose Lake Wind Project on the transmission network in the vicinity.

No transient instability phenomenon and transient voltage violations have been observed based on the studied scenarios and contingencies, and the wind farm was capable of riding through the faults. A summary of the system stability studies for the 2017 light summer load condition is shown in Table 3 below:

Table 3: Transient Stability Study Results for Moose Lake Wind injection of 14.5 MW (using 2017LS case)

Case	Outage	3Φ Fault Location	Fault Clearing Time (Cycles)		Max. Transient Voltage			IC Low Voltage Ride Through Performance	Min. Transient Voltage		
			Close End	Far End	SNK 230 kV	TLR 230 kV	SLS 230 kV		SNK 230 kV	TLR 230 kV	SLS 230 kV
1	2L308 (GMS – DKT)	Close to GMS	GMS 7	DKT 9	1.24	1.25	1.23	Acceptable	>0.95	>0.95	>0.95
2	2L308 (GMS – DKT)	Close to DKT	DKT 7	GMS 9	1.22	1.21	1.22	Acceptable	>0.95	>0.95	>0.95
3	2L309 (DKT – SNK)	Close to DKT	DKT 7	SNK 9	1.22	1.24	1.21	Acceptable	>0.95	>0.95	>0.95
4	2L309 (DKT – SNK)	Close to SNK	SNK 7	DKT 9	1.20	1.21	1.20	Acceptable	>0.95	>0.95	>0.95
5	2L312 (SNK – SLS)	Close to SNK	SNK 7	SLS 9	1.14	1.18	1.12	Acceptable	>0.95	>0.95	>0.95
6	2L312 (SNK – SLS)	Close to SLS	SLS 7	SNK 9	1.15	1.19	1.12	Acceptable	>0.95	>0.95	>0.95
7	TLR 25kV Fault	Close to TLR	TLR 35	N/A	1.14	1.16	1.15	Acceptable	>0.95	>0.95	>0.95

5.3 Remedial Action Scheme (RAS)

There is no Remedial Action Scheme (RAS) required for transient instability or steady state issues in order to interconnect the Moose Lake Wind project at this study stage.

5.4 Analytical Studies

This technical section presents the preliminary results and dynamic evaluation of the response of the Moose Lake Wind farm under critical contingencies and disturbances that are determined to be very severe.

A separate SIS study, for a higher priority queued proposed wind farm, determined that that wind farm caused nearby existing wind farms to exhibit sustained oscillations in voltage and power that propagated into the system. These oscillations occurred when a disturbance caused the voltage of a nearby existing farm to drop below a certain low voltage threshold when it is required to recover power into a weakened system post-fault and contingency. The results of that study carried out are show in Appendix B – Table B.1.

The most critical case analyzed corresponds to a multi-phase fault on 2L308. This contingency led to a high post-fault overvoltage that resulted in the tripping of the nearby existing wind farm. It is important to highlight that the [redacted] STATCOM associated with that nearby wind farm blocks during the contingency. This behavior reduces the dynamic reactive support of the nearby wind farms. In addition to that case, the cases described in Table B.1 (highlighted in yellow) evidenced large oscillations that damp out after a few seconds post-fault.

All the contingencies marked in red or yellow in Table B.1 were re-assessed after the inclusion of the Moose Lake Wind farm with 14.5 MW of power injection. The results of this new study are summarized in Appendix – Table B.2.

After analyzing the impact of the new 15 MW MLWX wind farm, the critical contingency of 2L308 does not lead to the tripping of the nearby existing wind farm. The Moose Lake Wind facility provides some additional reactive support lost during the blockage of the nearby wind farm's STATCOM. All the existing and proposed wind farms are able to ride through the fault and recover full power after the fault.

[redacted]

The Analytical results and recommendations are as follows:

- The inclusion of the Moose Lake 15 MW plant helps improving the overall system response under critical faults, by adding additional reactive power regulation capability;

- Other wind farm projects in the area generally perform acceptably during the contingencies studied, recovering full power into the weakened post-fault system with no unstable behaviour;
- The preliminary results indicate that the settings provided by the wind turbine manufacturer are acceptable and do not adversely affect the recovery of the other projects in the vicinity;
- It is important to note that the wind turbine models for this project are based on typical plant data (not approved by Vestas), and also do not include a plant voltage control model;
- Abrupt opening of 2L313 at SNK for no fault, resulting in Moose Lake Wind isolated with a 230kV subnetwork containing one or two other wind farms, can result in Temporary Over Voltages (TOVs). It is recommended to have delayed opening of 2L313 at SNK for all non-protective trips, and to send a DTT signal to trip circuit 2L346 (MKT – MLWX) at MKT;
- Random energization of the 230kV 33MVA transformer at Moose Lake Station could produce voltage sags up to 11% at the POI which exceeds the maximum allowable voltage sag. Therefore some technique, to reduce the inrush current, is required such as implementation of an independent pole circuit breaker with Point of Wave (POW) controller for transformer energization;
- Any outage of 2L308, 2L309 or 2L312 will require arming a generation shedding scheme to trip MLWX so that the wind farm does not remain operational in an islanded mode following a contingency on the remaining 230kV tie at SNK or GMS;
- For system and equipment back up security, in cases where misoperation and/or miscoordination of the generation shedding schemes occur and subsequent failure(s) of system Surge Arrestors (SAs) can occur randomly, application of area Sacrificial SAs with disconnecting capability is recommended at strategic locations. The sacrificial SAs are chosen at a lower level than those applied for equipment protection purposes to ensure they fail first due to thermal energy and thus avoid possible random and multiple failures. Furthermore, since the system must be restored quickly, the sacrificial SAs should be equipped with motor operated disconnects to isolate the failed SA. The suggested rating of the Sacrificial SAs for this 230 kV region with mostly 192 kV and 228 kV rated SAs is 180kV with maximum continuous rating of 245 kV.

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 IC. The model included higher priority interconnection queued projects and planned system reinforcements but excluded lower priority 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 Transmission Line Upgrades

There are no transmission line upgrades required in the BCH system for this project. The scope of work for BCH is limited to the IC's engineering review of the last span (of the customer owned line, 2L346) into MKT. It is the IC's responsibility to ensure that the MLWX transmission line/equipment ratings will be adequate to deliver the maximum injected power into the BCH system.

5.7 BCH Station Upgrades or Additions

In order to interconnect MLWX to the BCH 230 kV system, the following upgrades are required at the planned Meikle Terminal Switching Substation (MKT):

- Addition of one transmission line termination for MLWX connection with associated motorized line disconnect, surge arresters, and CVTs;
- Addition of one 230kV dead tank circuit breaker (2CB4) capable of Independent Pole Operation (IPO), suitable for -50deg C, with tank heaters and associated disconnect switch (2D2CB4);
- Addition of one disconnect switch (2D2CB3).

5.8 Protection and Control

Protection and control requirements for the proposed IC project are summarized below. Detailed requirements will be stated in the Facilities Study.

Protection work required by BCH:

- Provide relays for the MKT terminal and modify existing protection settings for circuits 2L313 (SNK – MKT), 2L337 (MKT – TLR), and 2L339 (MKT – MKL);
- Review the IC's power quality protection, entrance protection, and 2L346 (MKT – MLWX) protection at the IC's terminal;
- Modify the existing Peace Region Gen-shedding RAS scheme, for anti-islanding protection of MLWX, by tripping the IC-owned circuit, 2L346, at MKT when manual opening of 2L313 at SNK or other islanding scenarios (as described in earlier sections) occur;
- Provide guidance to the IC with the implementation of the line current differential protection scheme for 2L346 and provide the IC with core settings.

Protection work required by the IC:

- Provide redundant Primary (PY) and Standby (SY) WECC Class 2 Digital Telecommunication media for circuit 2L346 from MKT to MLWX for successful integration of line current differential protections;
- Provide power quality protection that complies with BC Hydro and WECC requirements in case an island is inadvertently formed as described in earlier sections. The Customer is required to comply with all the protection requirements as listed in BC Hydro's "60 kV to 500 kV Technical Interconnection Requirements for Power Generators;"
- The Customer shall apply some techniques to reduce the inrush current for voltage sag caused by transformer energization.

For the purpose of scoping, BC Hydro's standard line protection practice providing 100 ohms ground fault resistive coverage is assumed for the IC owned circuit, 2L346. It is also assumed that line current differential protection relays (primary and standby) will be used. The IC is required to consult BC Hydro for relay model numbers.

Control work required by BCH:

- Update the existing database and displays at the BCH Control Centres to accommodate the addition of the IC's facilities;
- Control work at MKT is required which includes, but not limited to, providing local/remote and backup control and alarms for new equipment and relays, 2L346 metering, and remote data access to the new relays.

Control work required by the IC:

- The IC is required to provide telemetry, status and meteorological information via a Distributed Network Protocol, Remote Terminal Unit/Intelligent Electronic Device (DNP3 RTU/IED) to the BC Hydro Control Centres as per the "60 kV to 500 kV Technical Interconnection Requirements (TIR) for Power Generators;"
- The IC is responsible for providing a continuously reporting channel to MKT station with appropriate telecom facilities. Broadband satellite communications is also an acceptable option.

It is assumed that BC Hydro Control centres will have no control over the IC's facilities.

5.9 Telecommunications

The telecommunication requirements for the proposed IC project are summarized below:

- PY and SY WECC Class 2 64 kbps synchronous circuits over fibre between MKT and MLWX;
- Interface is 1310 nm with ST connectors over single mode fibre;

- PY and SY WECC Class 1 DTT between GMS and MKT for anti-islanding of MLWX;
- The IC is responsible for transporting a 9.6 kbps SCADA circuit from MLWX to MKT.

A telecom block diagram is provided in Appendix C.

Telecommunication work required by BCH:

- Connect the anti-islanding circuits to GMS facing MKT;
- Terminate the fibre from MLWX;
- Connect the PY and SY relays to fibre strands facing MLWX;
- Connect the anti-islanding circuits to MKT facing GMS;
- Cross connect the SCADA circuit from fibre modem to a circuit on the MKT DACS facing WSN DCP.

Telecommunication Work required by the IC:

- Terminate the fibre to MKT;
- Connect the PY and SY relays to fibre strands facing MKT;
- Connect the RTU to a fibre modem facing MKT.

5.10 Islanding

Islanding is not arranged for this project. If an islanding scenario occurs, a direct transfer trip (DTT) will be required to isolate the wind farm from a system security operation (anti-islanding) point of view. Additional anti-islanding protection, in the event the DTT signal fails, will also be required at the wind farm to detect abnormal system conditions to subsequently trip the units.

5.11 Black Start Capability

BCH does not require the proposed project to have black start (self-start) capability. However, if the IC desires their facilities to be energized from the BCH system, the IC is required to apply for an Electricity Supply Agreement.

5.12 Cost Estimate and Schedule

The non-binding good faith cost estimate for the Interconnection Network Upgrades required to interconnect the proposed project to the BCH Transmission system at MKT is $5.0 million (including 20%

contingency and 2% annual inflation). An accuracy range of -35% to 100% is applied to this cost estimate. The estimate does not include:

- Any work required at the IC's facilities;
- Revenue Metering costs;
- First Nations consultation and accommodation;
- Outage and related disruptions.

It is expected that the BC Hydro work can be completed in approximately 18 months from project approval.

6 Revenue Metering

Specific metering information is provided in Table 6-1. The Point of Metering (POM) should be on the primary side (230 kV side) of the IC's main 230/34.5 kV power transformer. It can be installed either in/near the BCH MKT station, subject to space availability and other constraints, or in the MLWX customer substation.

Power Transformer is DELTA in the secondary; therefore 3-element metering cannot be used if metering is to be moved to the secondary side.

For both options 1 and 2 (refer Table 6-1), the CTs and VTs shall be the same rating as voltage and peak demand is the same. Therefore, costs for both the options will be similar.

The estimated cost for installation of BCH Revenue Metering is $67k, which does not include any costs for civil, structural, and electrical work of Revenue Metering. Only the BCH Revenue Metering tasks (i.e. field and engineering) are covered. Refer to Appendix F for more information. The cost for installation of BCH Revenue Metering is not included in the Network Upgrades.

Table 6-1: Revenue Metering Specific Information

Metering Voltage (kV)	230kV
Max Current	37.7 Amps @ 230 kV
Primary Voltage Point-of-Metering	230 kV in/near BC Hydro MKT station (option 1) 230 kV on the primary side of the main transformer in MLWX customer station (option 2)
Voltage Transformers	3 x VTs (L-Grd) – 230/1.73kV-120-120V (supplied by the IC; to be informed)
Current Transformers	3 x CTs- 50x100-5-5 A – Ratio – (supplied by the IC)

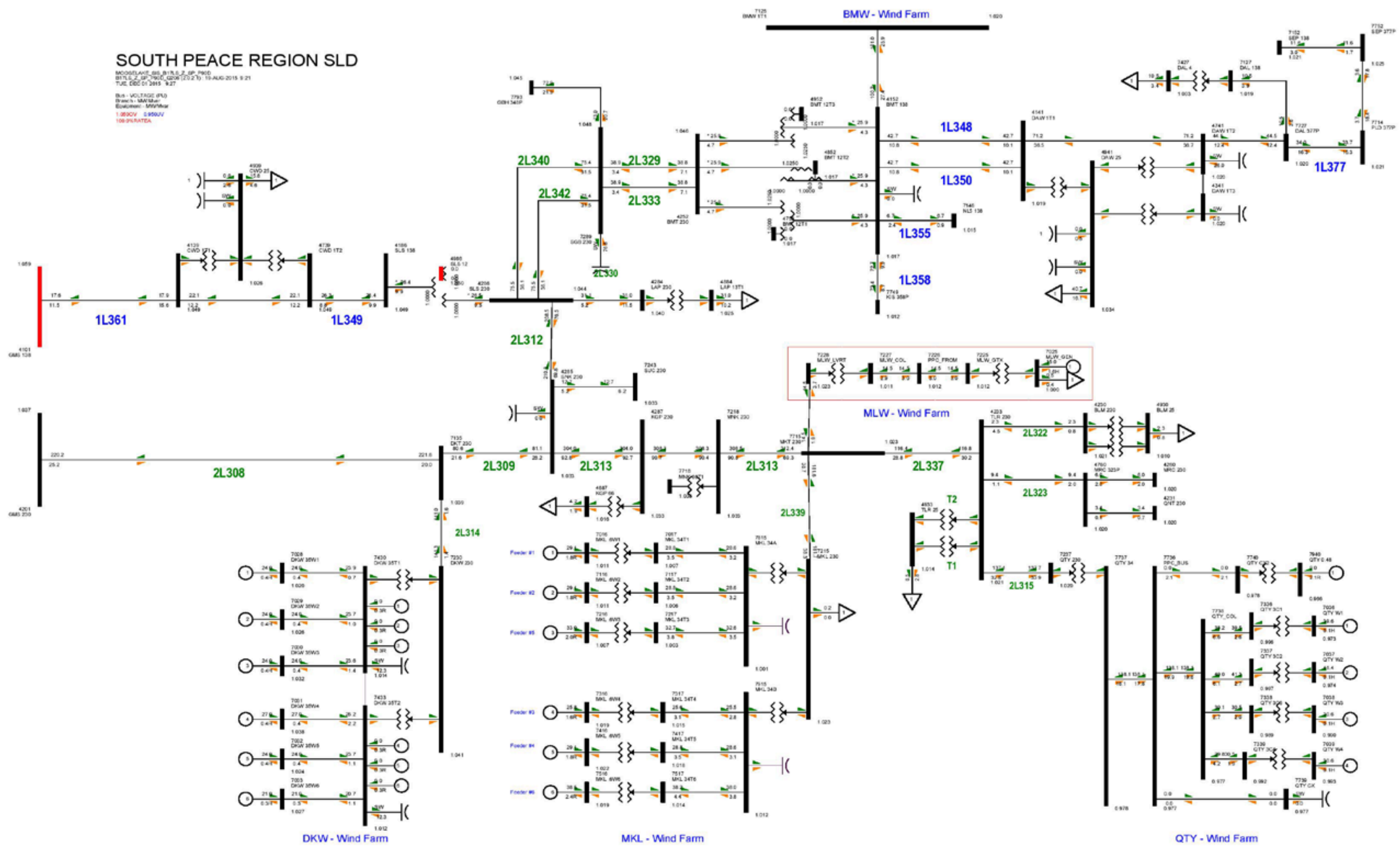
7 Conclusions and Discussions

To interconnect the MKL project and its facilities to the BCH system at MKT, this System Impact Study (SIS) has identified the following conclusions and requirements:

1. Addition of one transmission line termination and one 230 kV dead tank breaker (with Independent Pole Operation) along with associated equipment is required;
2. Installation of new and modification of existing protection, control, and telecommunication work is required;
3. No unacceptable transmission equipment overloads were observed due to Moose Lake Wind project under system normal conditions (no contingency) for both pre-PRES and post-PRES configurations and loading levels.;
4. No unacceptable voltage conditions in the transmission system were observed in the power flow and transient stability simulations due to the Moose Lake Wind project for pre-contingency and N – 1 contingency scenarios for pre/post PRES configurations and loading levels;
5. Before the PRES project comes into service, thermal overloading on circuits 2L312 (SNK – SLS), 1L349 (SLS – CWD), and 1L377 (DAW – TAY) were observed for the loss of circuit 2L308 (GMS – DKT) during 2017 LS load conditions. A generation runback Remedial Action Scheme (RAS) has been proposed to address the overloads, and the subject wind farm is not required to participate in the scheme. With PRES in service, the thermal overload concerns during the N-1 contingency are expected to be alleviated;
6. Random energization of the 230kV 33MVA transformer at Moose Lake Station could produce voltage sags up to 11% at the POI which exceeds the maximum allowable voltage sag as per BCH's "60 kV to 500 kV Technical Interconnection Requirements for Power Generators.". Therefore some technique, to reduce the inrush current, is required such as the implementation of an independent pole circuit breaker with Point of Wave (POW) controller;
7. Abrupt opening of 2L313 at Sukunka Switching Station (SNK), for either protective or non-protective conditions, requires the implementation of a Direct Transfer Trip (DTT) to disconnect MLWX with the existing intentional (1 cycle) delayed opening of 2L313 at SNK to avoid high Temporary Over Voltages (TOVs);
8. Any outage of 2L308, 2L309 or 2L312 will require arming a generation shedding scheme to trip MLWX so that the wind farm does not remain operational in an islanded mode following a contingency on the remaining 230kV tie at SNK or GMS;
9. Application of area sacrificial Surge Arrestors (SAs), rated at 180 kV with disconnecting capability, is recommended at the MLWX line terminal;
10. Islanded operation is not arranged for the Moose Lake Wind project which can occur when circuit 2L308/2L309 and 2L312 or 2L313/2L337 is lost for protective or non-protective tripping. The IC is responsible for equipping adequate anti-islanding protection to trip the wind turbines under abnormal system conditions.

A non-binding good faith cost estimate for the identified Interconnection Network Upgrades is $5.0 million with an accuracy of -35% and +100%, and the estimated time to implement after project approval is 18 months. The work required within the IC's facilities or installation of Revenue Metering is not part of the Interconnection Network Upgrades. The Interconnection Facilities Study report will provide greater details of the Interconnection Network Upgrade requirements with the associated cost estimate and estimated construction timeline for this project.

Appendix A – Area Single Line Diagram



Appendix B – Analytical Study Results

Table B.1: Original Summary of Contingency cases results for MKL wind PSCAD study

Meikel Wind Farm Transient Dynamic Response							
DKY, BMWM QTY and Meikle (MKL) in service with full generation and low load condition							
Case #	System condition	Case Summary					
		a) Meikle2_z16hw.sav			b) Meikle2_17ls.sav		
		Pass/Fail	SC MVA @ MKL 230kV POI	Notes	Pass/Fail	SC MVA @ MKL 230kV POI	Notes
1	Post DCAT: 3G on 2L308		580.86	2,3,4		457.63	3,4
2	Post DCAT: SLG on 2L308		580.86	1,4		457.63	4
3	Post DCAT: 3G on 2L309		578.11	1,4,5		456.53	3,4,5
4	Post DCAT: 3G on 2L312		847.4	1,4		809.94	1,4
5	Post DCAT: SLG on 2L312		847.4	1,4		809.94	1,4
6	Post DCAT: 3G on 1L361		1097.54	1,4,6		963.52	1,4
PINK	Problem case (May require mitigation)						
Yellow	Case exhibits undesirable behaviour, but may be acceptable						
GREEN	Acceptable Behaviour						

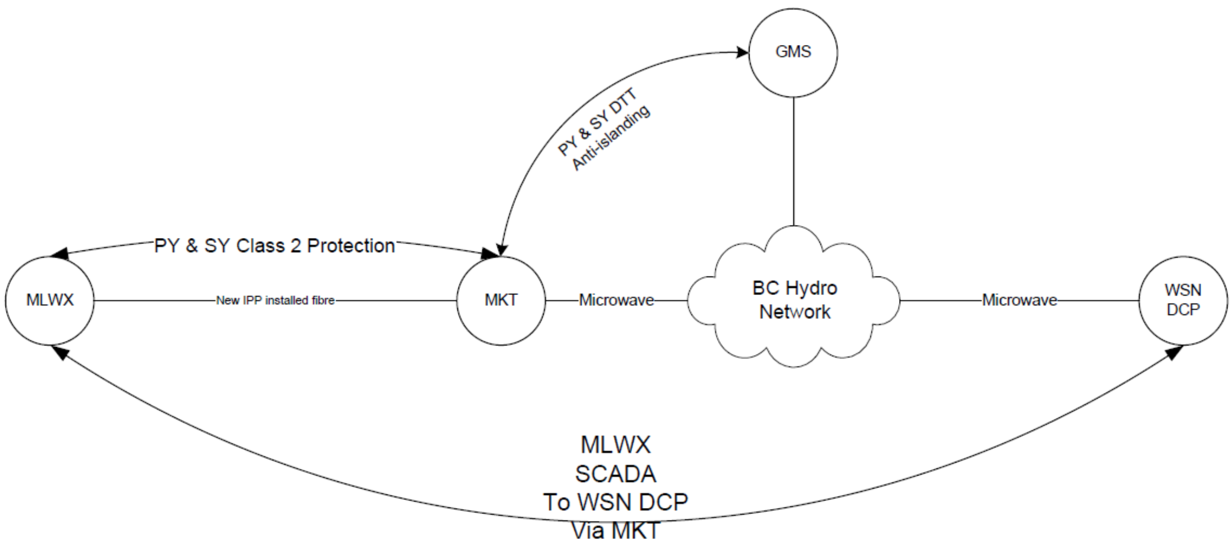
Note No.	Description
1	Normal operation
2	QTY wind trips due to overvoltage protection
3	QTY STATCOM blocked for aprox. 2s following fault clearing. STATCOM re-starts and continues providing reactive support after this period.
4	BMW trips off due to a hard coded 10 s tripping in the model (Simulation artifact, not real behaviour)
5	BMW over power after clearing the fault for 1 second
6	Strong voltage oscillations cause all reactive power controllers to activate. Damps after 5 seconds

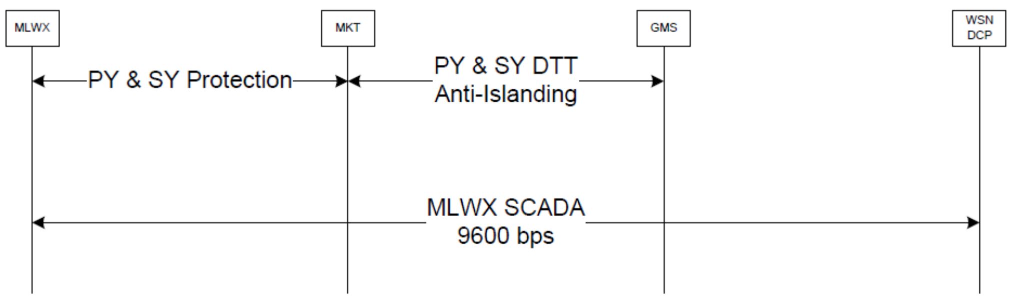
Table B.2 – Summary of contingency Cases after the inclusion of the new 15MW Moose Lake wind farm

Meikel Wind Farm Transient Dynamic Response							
DKY, BMWM QTY and Meikle (MKL) in service with full generation and low load condition + New 15 MW Wind Farm							
Case #	System condition	Case Summary					
		a) Meikle2_z16hw.sav			b) Meikle2_17ls.sav		
		Pass/Fail	SC MVA @ MKL 230kV	Notes	Pass/Fail	SC MVA @ MKL 230kV	Notes
1	Post DCAT: 3G on 2L308		580.86	2,3,4		457.63	3,4
2	Post DCAT: SLG on 2L308		580.86	1,4		457.63	4
3	Post DCAT: 3G on 2L309		578.11	1,4,5		456.53	3,4,5
4	Post DCAT: 3G on 2L312		847.4	1,4		809.94	1,4
5	Post DCAT: SLG on 2L312		847.4	1,4		809.94	1,4
6	Post DCAT: 3G on 1L361		1097.54	1,4,6		963.52	1,4
PINK	Problem case (May require mitigation)						
Yellow	Case exhibits undesirable behaviour, but may be acceptable						
GREEN	Acceptable Behaviour						

Note No.	Description
1	Normal operation
2	QTY wind trips due to overvoltage protection
3	QTY STATCOM blocked for aprox. 2s following fault clearing. STATCOM re-starts
4	BMW trips off due to a hard coded 10 s tripping in the model (Simulation artifact, not real behaviour)
5	BMW over power after clearing the fault for 1 second
6	Strong voltage oscillations cause all reactive power controllers to activate. Damps after 5 seconds

Appendix C – Telecom Block Diagram





Appendix D – Revenue Metering Requirements

Telecommunications for Revenue Metering - Power Generators:

When the Point(s)-of-Metering is (are) located at the customer(s) substation:

Power Generators:

A telecommunications channel is required for remote read/download data from the main and the backup meters. The design, supply and installation of the communications equipment shall be coordinated between BCH Revenue Metering, BCH Telecom, the Power Generator (PG) and the Telecommunications Service Provider. The PG should provide a terminal / connector inside the BCH meter cabinet. Where the POI is on a 69 kV voltage class or higher BC Hydro transmission system **and** where a conventional wire-line telephone is installed, Ground Potential Rise (GPR) protection shall be provided. Alternative technologies may be used, e.g. cellular, fiber optic, microwave, satellite etc. however these solutions must be discussed and approved by BCH before installation. BCH MV-90 Server must be able to access and download data from the 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 Requirements for Complex Revenue Metering published at the Revenue Metering webpage and at the BC Hydro external website.

Revenue Metering Input:

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

Primary Metering is required. A 3-element metering scheme with 3 CTs and 3 VTs connected L-N (Grd) will be used. Main and backup load profile interval meters are required to measure the power delivered. The meters will be programmed for 5 minute interval and will be remotely read each day by BCH/ABSU Enhanced Billing Group using MV-90; the POM shall have a dedicated communications line (landline or wireless BCH approved IP alternative) available for revenue metering use only. If there is digital cell phone coverage for data, BCH will supply the wireless communications.

The revenue class meters (main and backup) are Measurement Canada (MC) approved and will be supplied and maintained by BC Hydro. The MC approved revenue class instrument transformers (CTs and VTs units) are supplied by BCH (Stock items w/CAT ID).

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 customer or the consultant shall provide the line parameters (and/or power transformer) data signed and stamped by a professional engineer.

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, meter cabinet location, as well as any other related document. BC Hydro's Revenue Metering department can be contacted via email: metering.revenue@bchydro.com.

Information required in the 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.)

