



FOR GENERATIONS



Moose Lake Wind Project

Interconnection System Impact Study

Report no.: T&S Planning 2016 - 076

November 2016

British Columbia Hydro and Power Authority

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Acknowledgements

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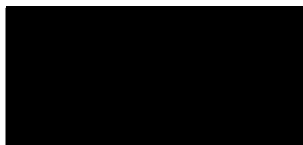
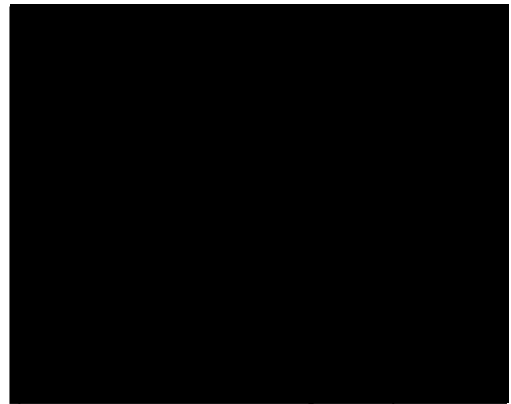
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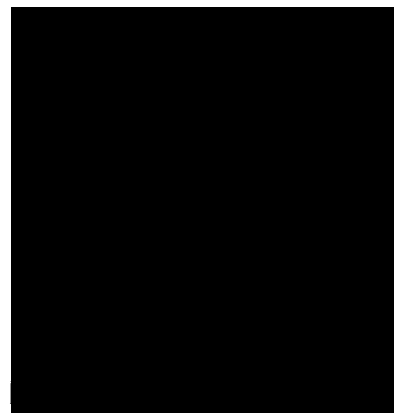
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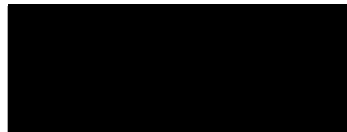
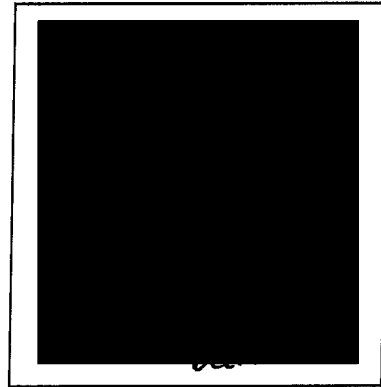


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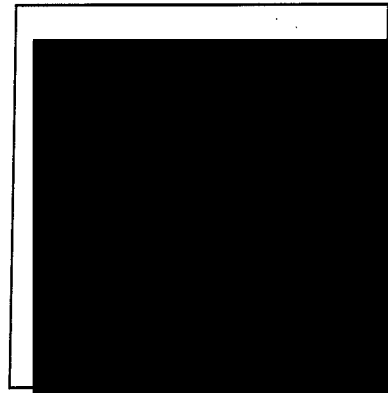




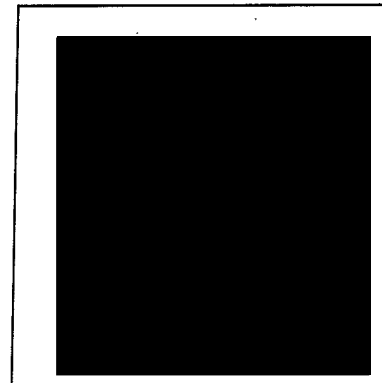
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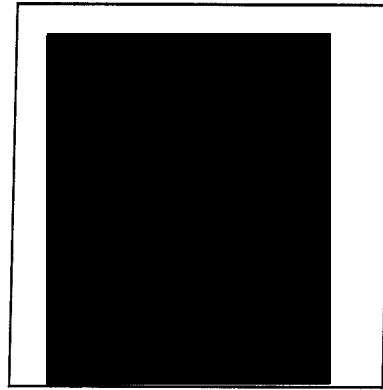


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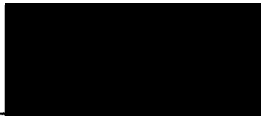
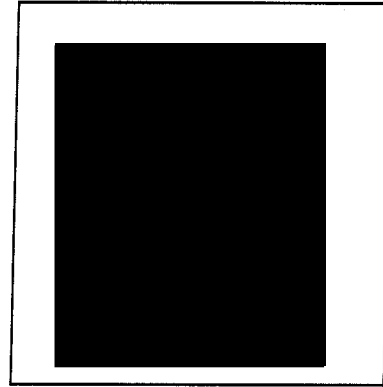




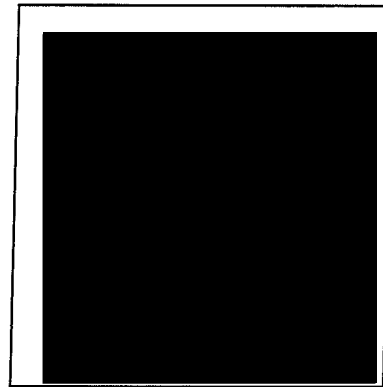
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Executive Summary

██████████, 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 four (Enercon – E126 Type 4) wind turbine units delivering a maximum of 15 MW into the BCH system. The power generated from the turbines at the collector station will be transferred through an IC owned 7.7 km long 34.5 kV circuit and stepped up to the 230 kV level through a 240/34.5 kV transformer in the Moose Lake Wind Station (MLW) owned by the IC. MLW will be located adjacent to and southeast of BCH's Meikle Terminal Switching Station (MKT). The IC's facilities will be connected to the BCH 230 kV system via a short 0.2 km line tap onto circuit 2L337 which runs between MKT and Tumbler Ridge Station (TLR). The Point of Interconnection (POI) will be at a distance of 0.2 km from MKT which is a recently built station for a higher queued wind farm project. The maximum power injection into the BCH system at the POI, after internal losses and loads, is 15 MW. The proposed Commercial Operation Date (COD) for this project is July 31, 2017.

This System Impact Study (SIS) is a re-study of the Moose Lake Wind project where a previous SIS was completed in 2015 and documented in a study report (T&S Planning 2015 – 069). The project was previously proposed with five (Vestas V112 – Type 4) turbines where the generated power was stepped up through a 240/34.5 kV transformer located close to the turbines and transferred via an IC-owned 9.4 km long 230 kV circuit to a line terminal position at MKT.

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, this SIS has identified the following conclusions and requirements:

1. Revision of existing line protection and installation/modification of control and telecommunication required;
2. Transmission line upgrades will involve modification to the existing circuit 2L337 and to the existing shielding and counterpoise;
3. No unacceptable transmission element 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, transient stability, and analytical studies 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) was 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 Moose Lake Wind project to participate in the scheme.
6. Islanded operation is not arranged for the Moose Lake Wind project. A Direct Transfer Trip (DTT) is required to trip the IC's 230 kV entrance breaker when any islanding scenario occurs. The IC is responsible for equipping adequate anti-islanding protection (i.e. under/over frequency and

voltage protection) to isolate the wind turbines from the BCH system under abnormal system conditions, in the event that the DTT signal fails.

A non-binding good faith cost estimate and timeline was previously provided to the IC in the study report T&S Planning 2015 – 069. Due to the change in application and scope of this project, that previous estimate and timeline is no longer valid. The Interconnection Facilities Study report will provide greater details of the recently changed Interconnection Network Upgrade requirements with the associated cost estimate and estimated construction timeline for this project. The work required within the IC's facilities and Revenue Metering costs are not part of the Interconnection Network Upgrades.

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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)	0.2 km from MKT station on circuit 2L337	
IC Proposed COD	July 31, 2017	
Type of Interconnection Service	NRIS <input checked="" type="checkbox"/>	ERIS <input type="checkbox"/>
Maximum Power Injection (MW)	15 (Summer)	15 (Winter)
Number of Generator Units	4	
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 project was previously studied in 2015 and the System Impact Study (SIS) results are documented in the study report, T&S Planning 2015 – 069.

The previous application consisted of five (Vestas V112 – Type 4) turbines where the generated power was stepped up through a 240/34.5 kV transformer located close to the turbines and transferred via an IC-owned 9.4 km long 230 kV circuit into a line terminal position at BC Hydro's Meikle Terminal Switching Station (MKT). The IC has changed their previous application as described below.

The Moose Lake Wind Project consists of a total of 4 wind turbine units on a single feeder, each with a capacity of 3.95 MW each. All 4 wind turbines are Enercon – E126 units proposed with Type 4 technology (i.e. Full Converter Units). The total power generated from all 4 turbine units will be collected via a single 34.5 kV feeder at a 34.5 kV bus. From the 34.5 kV collector bus, the power will be transmitted through an IC owned 7.7 km long 34.5 kV circuit and stepped up to the 230 kV voltage level through a 33.2 MVA, 240/34.5 kV (high side Y-gnd) station transformer located within the Moose Lake Station (MLW). This IC owned station, MLW, will be adjacent to and southeast of BCH's MKT station which is a recently built station for connecting a higher queued wind project. The IC's facilities will be connected to the BCH 230 kV system via a short 0.2 km line tap connection onto circuit 2L337. The Point of Interconnection (POI) for the MKL project is at a distance of 0.2 km from MKT on circuit 2L337. The wind farm's maximum allowable power injection into the BCH system, after losses and internal loads, is 15 MW. The proposed Commercial Operation Date (COD) for this project is July 31, 2017.

Due to the recent addition of the switching station MKT, the circuit 2L313 between Sukunka (SNK) and Tumbler (TLR) stations 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.

In the Peace area, two major transmission upgrade projects have been proposed: Site C generating station addition and the Peace Region Electricity Supply (PRES) project.

The Site C generating station is to be built in the North Peace area and will be connected to the 500 kV system at BCH's Peace Canyon Generating Station (PCN) through two 500 kV lines, 5L5 and 5L6. 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 is to build a double circuit 230 kV transmission line from Site C to Shell Groundbirch (SGB). This study reviewed the interconnection performance for both pre- and post- PRES system scenarios.

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

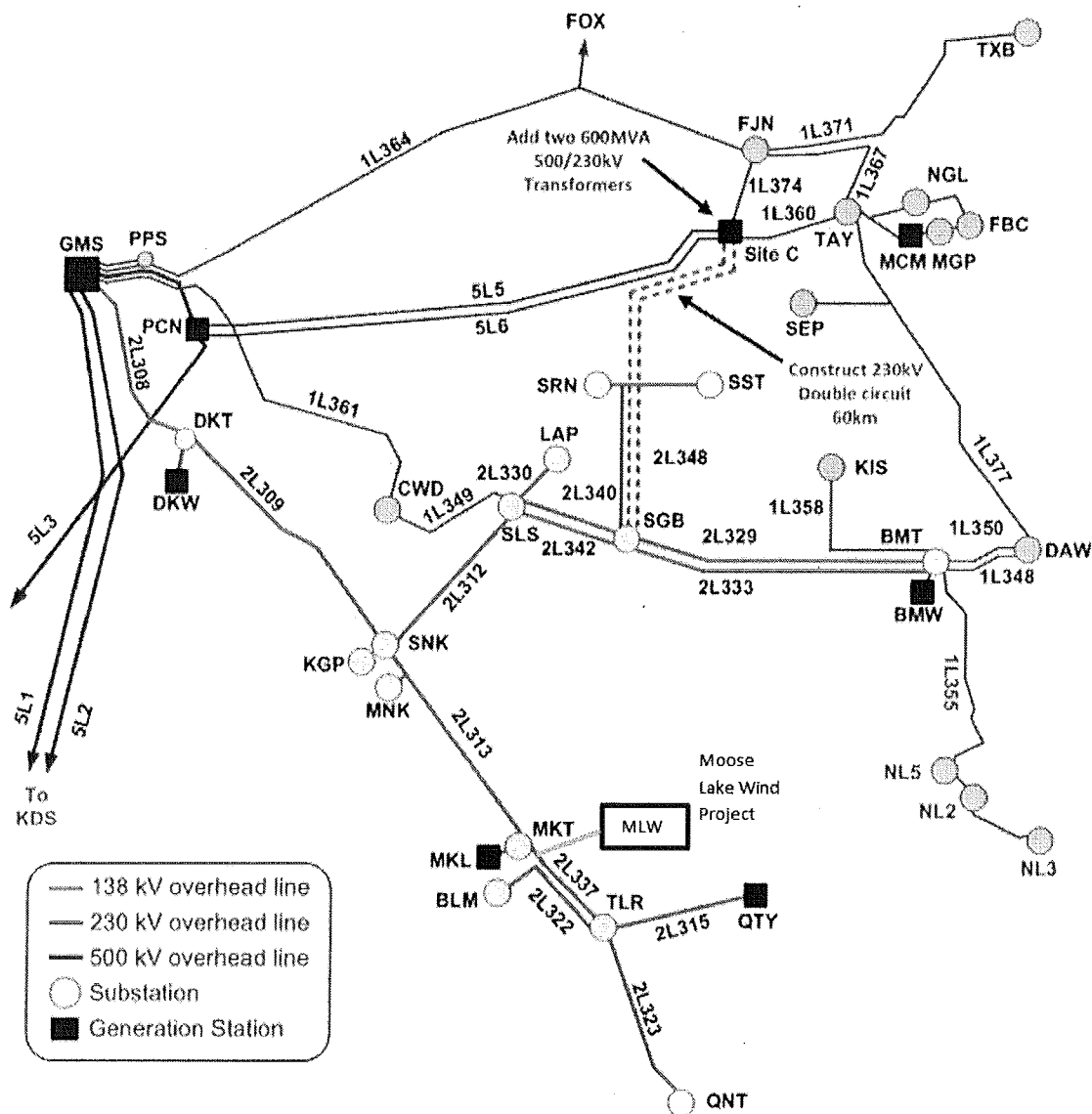


Figure 1: Peace Region one line diagram with Moose Lake Wind project (MLW) connection

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), 2023 Heavy Winter (HW), 2024 Heavy Summer (HS) and Light Summer (LS) power flow base cases were selected for this study. The IC's latest data submission, as of August 2016, has been used in this study. It is assumed that the Enercon Farm Control Unit (FCU) will limit the maximum active power into the POI at 15 MW. It is assumed that the ground grids between MKT and MLW stations will be connected for protection purposes.

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.

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 15 MW from MLW and high levels of area generation, no transmission element overloads or unacceptable voltage conditions were identified due to the MLW 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 an additional 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. However, a marginal overload condition can still occur on 2L312 with PRES in service.

There were no unacceptable steady state bus voltage conditions/violations in the transmission system observed for any of the studied scenarios.

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 Moose Lake Wind project was based on the IC's data submission plus any additional assumptions where the IC's data was incomplete or inappropriate. 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 15 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 15 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) that requires the Moose Lake Wind project to participate.

5.4 Analytical Studies

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

A separate generation interconnection SIS study determined that a higher priority queued 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 the 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 shown 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 D-VAR 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 15 MW of power injection. The results of this new study are summarized in Appendix B – Table B.2.

After analyzing the impact of the new 15 MW MLW wind farm, the critical contingency of 2L308 does not lead to the tripping of the nearby existing wind farm. All the existing and proposed wind farms are able to ride through the fault and recover full power after the fault.

There is a need to revisit that nearby existing wind farm's D-VAR STATCOM settings during the Moose Lake (and higher queued proposed project's) commissioning testing to validate with that customer if an updated set of parameters is required to be in place.

The Analytical Studies results and recommendations are as follows:

- No adverse system performance has been observed with the inclusion of the Moose Lake 15MW project ;
- Random energization of the IC's 230 kV transformer at Moose Lake Station could produce voltage sags around 5%. This voltage sag at the POI is acceptable;

- Extend the existing Peace Region anti-islanding scheme to trip the IC's 230 kV entrance circuit breaker when opening of 2L337 at MKT or other islanding status occurs for the Moose Lake IPP;

This assessment is based on the proponent's application of the Enercon-E126 Type 4 wind turbine. However, if a different wind turbine technology or manufacturer is selected during the next project phase, the present results will have to be revisited to assess their validity.

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

The line tap from the IC's station, MLW, to the BCH circuit 2L337 (MKT – TLR) will need to be designed and constructed as a three pole overhead flying tap.

The existing overhead shield wires and buried counterpoise wires are placed on two separate pole lines, one on each side of circuit 2L337, in order to provide shielding requirements. This same shielding and counterpoise arrangement must be instituted in the IC's tap to provide the same protection.

The total installation will require modification to the existing 230 kV circuit and to the existing shielding and counterpoise. The preliminary design/layout of the tap will determine if any structure change-outs on circuit 2L337 are required to accommodate the flying tap or shielding.

In addition, the location where the IC's 34.5 kV circuit crosses and parallels the BCH 230 kV circuit, 2L337, will have to be reviewed to make sure that issues related to ground fault dissipation and induction are mitigated.

5.7 BCH Station Upgrades or Additions

There is no station work required in order to interconnect the MLW project to the BCH 230 kV system via a tap connection.

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 of the IC's 230 kV bus will be included within the primary and standby protection for circuit 2L337. The Current Transformers (CTs) associated with the IC's 230 kV entrance circuit breaker will be connected to the existing protection relays for 2L337 at the MKT terminal. 2L337 protection at the MKT terminal will trip the existing breakers at MKT as well as the MLW 230 kV entrance breaker. The IC will provide breaker failure protection of its 230 kV entrance circuit breaker. It is assumed that the ground grids between MKT and MLW stations will be connected.

Protection work required by BCH:

- Modify existing protection settings for circuits 2L313 (SNK – MKT), 2L337 (MKT – TLR), and 2L339 (MKT – MKL);
- Provide revised protection settings of 2L337 (MKT – TLR) to the IC;
- Review the IC's power quality protection and entrance protection;
- Modify the existing Peace Region Gen-shedding RAS scheme, for anti-islanding protection of MLW, by tripping the IC's 230 kV entrance circuit breaker when manual opening of 2L337 at MKT or other islanding scenarios (as described in earlier sections) occur;

Protection work required by the IC:

- 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";

Control work required by BCH:

- The IC's telemetry, status and meteorological information sent to MKT will be routed to the BCH Data Collection Point (DCP) site;
- Re-configure the Front End Processors (FEPs) at the DCP site and update the existing database and displays at the BCH Control Centres to accommodate the addition of the IC's facilities;

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:

- Primary (PY) and Standby (SY) WECC Class 2 channel required between GMS and MKT for anti-islanding Direct Transfer Trip (DTT) of MLW;
- The IC is responsible for transporting a 9.6 kbps SCADA circuit from MLW to MKT.

Telecommunication work required by BCH:

- Connect the anti-islanding circuits to GMS facing MKT;
- Install one rack and fiber patch panel at MKT and terminate the fibre from MLW;
- Install an SI-TECH RS232 over fiber line driver and connect MLW SCADA OFF WSN circuit at the MKT DACS. Install one NetGuardian unit.
- Terminate the MLW SCADA circuit on the WSN front end processor.

Telecommunication Work required by the IC:

- Terminate the MLW-MKT fiber;
- Connect the RTU to a fibre modem facing MKT.

5.10 Islanding

Islanded operation is not arranged for this project. If an islanding scenario occurs, a Direct Transfer Trip (DTT) will be required to trip the IC's 230 kV entrance breaker and isolate the wind farm from a system security operation (anti-islanding) point of view. Additional anti-islanding protection (i.e. under/over frequency and voltage) will also be required at the wind farm to detect abnormal system conditions and subsequently isolate the generation units from the BCH system in the event the DTT signal fails.

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

Due to the change in application and scope of this project, the previous estimate and timeline provided to the IC in the study report T&S Planning 2015 – 069 is no longer valid. The Interconnection Facilities Study report will provide greater details of the recently changed Interconnection Network Upgrade requirements with the associated (non-binding good faith) cost estimate and estimated construction timeline for this project. The work required within the IC's facilities and Revenue Metering costs are not part of the Interconnection Network Upgrades.

6 Revenue Metering

Specific metering information is provided in Table 4. 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.

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

The estimated cost for installation of BCH Revenue Metering will be provided in the FS report, 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 C for more information. The cost for installation of BCH Revenue Metering is not included in the Network Upgrades.

Table 4: Revenue Metering Specific Information

Metering Voltage (kV)	230kV
Max Current	37.7 Amps @ 230 kV
Primary Voltage Point-of-Metering	230 kV on the primary side of the main transformer in MLW customer station
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)

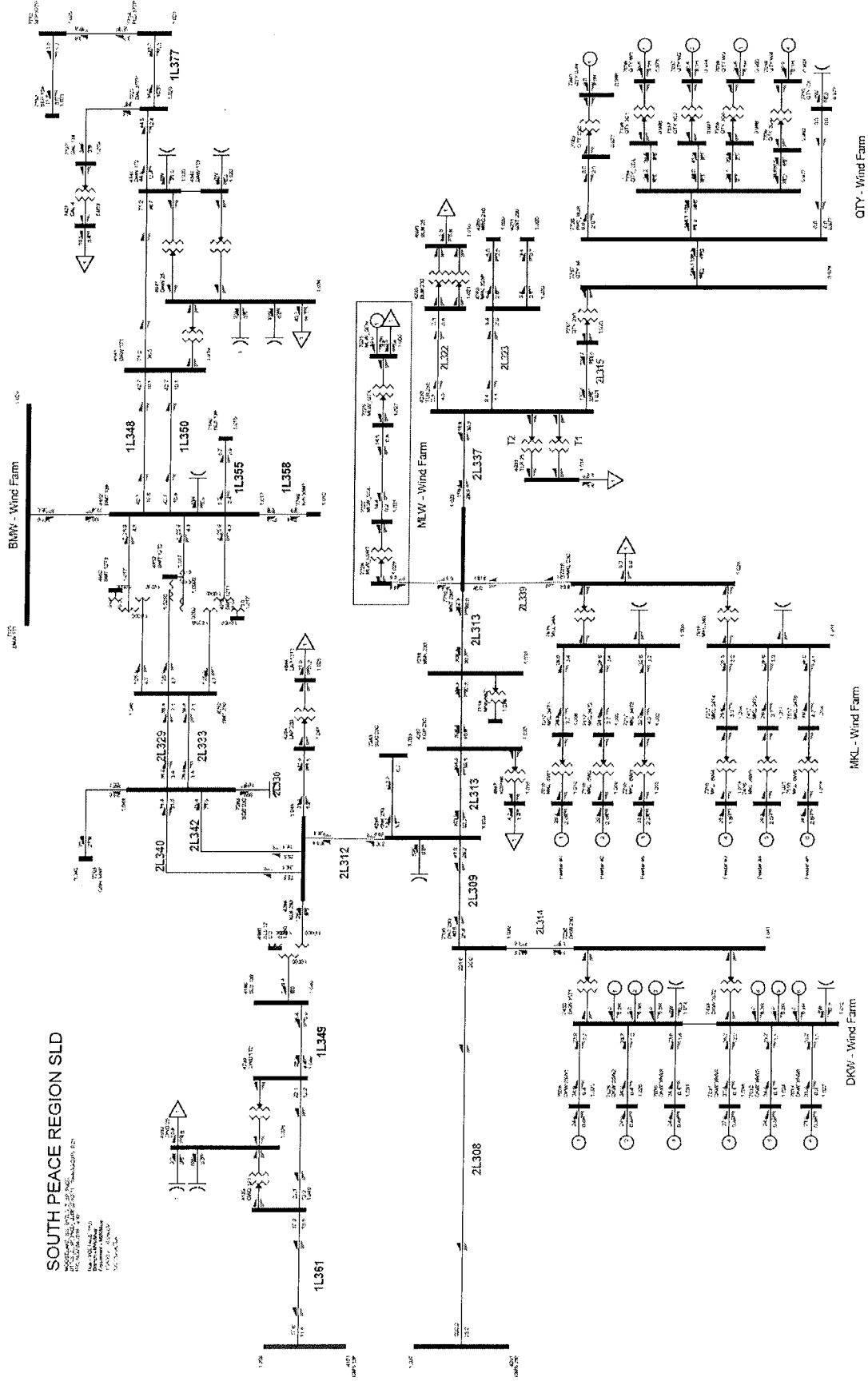
7 Conclusions and Discussions

To interconnect the Moose Lake Wind Project and its facilities to the BCH system, this System Impact Study (SIS) has identified the following conclusions and requirements:

1. Revision of existing line protection and installation/modification of control and telecommunication required;
2. Transmission line upgrades will involve modification to the existing circuit 2L337 and to the existing shielding and counterpoise;
3. No unacceptable transmission element 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, transient stability, and analytical studies 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) was 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 Moose Lake Wind project to participate in the scheme.
6. Islanded operation is not arranged for the Moose Lake Wind project. A Direct Transfer Trip (DTT) is required to trip the IC's 230 kV entrance breaker when any islanding scenario occurs. The IC is responsible for equipping adequate anti-islanding protection (i.e. under/over frequency and voltage 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 and timeline was previously provided to the IC in the study report T&S Planning 2015 – 069. Due to the change in application and scope of this project, that previous estimate and timeline is no longer valid. The Interconnection Facilities Study report will provide greater details of the recently changed Interconnection Network Upgrade requirements with the associated cost estimate and estimated construction timeline for this project. The work required within the IC's facilities and Revenue Metering costs are not part of the Interconnection Network Upgrades.

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							
DRY, BMWW QTY and Meikle (MKL) in service with full generation and low load condition							
Case #	System condition	Case Summary					
		a) Meikle2_z16hw.sav			b) Meikle2_171s.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	1,4,5		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, BMW 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 – 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.)

