BC Hydro
Power smart

[redacted]

Mount Mabel Wind Energy project

Interconnection System Impact Study

Report #: T&S Planning 2017-011

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British Columbia Hydro and Power Authority

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Revision Table

Revision Number	Date of Revision	Revised By

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Executive Summary

The Interconnection Customer (IC), [redacted] is proposing to build the Mount Mabel wind farm in the Nicola area within the South Interior region of British Columbia. The wind farm has a total of fifteen (x15) Vestas V126 type 4 wind turbines with a total capacity of 45 MW. The wind turbines, each with an individual capacity of 3 MW, will be installed in groups of five at three different sites. Each site will connect to the IC's collector station MMWX via an individual 34.5 kV feeder. The maximum output from each site will be 15 MW. The total maximum output from all the wind turbines is proposed to be 45 MW.

At the MMWX station, the power will be stepped up to the 138 kV level through a 66 MVA, 138 kV (Y-gnd) / 34.5 kV (Δ) transformer for transmission purposes. The IC will build a privately owned 0.1 km, 138 kV overhead line and transmit power into the BC Hydro (BCH) system via a tap connection onto line 1L243 between Nicola substation (NIC) and Highland substation (HLD). The proposed Point of Interconnection (POI) is on 1L243 at a distance of 20.4 km from BCH's Highland substation (HLD). The maximum power injection expected into the POI after losses is 43.5 MW.

To interconnect the Mount Mabel Wind Project and its facilities into the BCH Transmission System at the POI, this System Impact Study (SIS) has identified the following conclusions and requirements:

- Three 138 kV disconnect switches will be installed at the POI for implementing a tap connection of the Mount Mabel wind project into the BCH system;
- No abnormal bus voltages or transmission element overloading was observed in the system during steady state power flow studies under pre-contingency (N-0) system normal and (N-1) post-contingency conditions. No transient instability was observed in the area due to the addition of the Mount Mabel wind project following single system contingencies;
- A Direct Transfer Trip (DTT) signal to MMWX 138 kV circuit breaker, from either NIC or HLD stations, is recommended to prevent islanded modes of operation following protective or unintentional tripping of 1L243;
- Transformer energization inrush mitigation is required to meet the "60 kV to 500 kV BC Hydro Technical Interconnection Requirements (TIR) for Power Generators" regarding maximum allowable voltage dips;
- Existing line protection at NIC and HLD terminals of 1L243 is required to be upgraded to current differential protection using relay type SEL-411L. Mt. Mabel terminal will also be required to install a SEL-411L relay for line protection;

- Associated control work is required at NIC and HLD with the upgraded 1L243 line protection relays. The IC is required to provide telemetry, status and meteorological information to the BC Hydro Control Centers using appropriate telecom facilities.
- In order to implement the protection system upgrade requirement, WECC Class 2 Primary (PY) and Standby (SY) telecommunication channels are required between NIC, HLD, and Mt. Mabel terminals. This will be implemented using existing microwave facilities and new microwave facilities between specific sites;
- The IC shall meet the requirements in accordance with the TIR. Specifically, the Mount Mabel wind turbines are required to meet the Low Voltage Ride Through (LVRT) requirement, have capability to adequately control voltage at the POI and provide a range of ±0.95 PF as measured at the POI when generating at rated capacity.

The non-binding good faith cost estimate for the interconnection Network Upgrades required to interconnect the proposed project to the BCH Transmission System is $5.1 million. The estimated time to implement the identified Network Upgrades is in a range of 12 to 18 months.

The above estimate information has been revised to reflect the wind farm submission update made by the IC in April 2017 when the initial SIS report draft was sent to the IC for commenting. The key change in the submission update is the location of the IC's collector station MMWX, which has resulted in changing the telecommunication solution and also revising the Network Upgrades costs in this report.

The Facilities Study report will provide greater details of the Interconnection Network Upgrade requirements with the associated cost estimate and expected construction timeline for this project.

Table of Contents

1. Introduction

The project reviewed in this system impact study is as described in Table 1 below.

Table 1: Summary of Project Information

Project Name	Mount Mabel Wind Energy Project	
Proponent Name	[redacted]	
Point of Interconnection	Tap on 1L243 at a distance of 20.4 km from HLD	
Applicant Proposed COD	January 1, 2018	
Type of Interconnection Service	NRIS ☒	ERIS ☐
Maximum Power Injection (MW)	43.5 (Summer)	43.5 (Winter)
Number of Generator Units	Fifteen Vestas V126 (3 MW) type 4 turbines	
Plant Fuel	Wind	

The Interconnection Customer (IC), [redacted] is proposing to build the Mount Mabel wind farm in the Nicola area within the South Interior region of British Columbia. The wind farm has a total of fifteen (x15) Vestas V126 type 4 wind turbines with a total capacity of 45 MW. The wind turbines, each with an individual capacity of 3 MW, will be installed in groups of five at three different sites. Each site will connect to the IC's collector station MMWX via an individual 34.5 KV feeder. The maximum output from each site will be 15 MW. The total maximum output from all the wind turbines is proposed to be 45 MW.

At the MMWX station, the power will be stepped up to the 138 kV level through a 66 MVA, 138 kV (Y-gnd) / 34.5 kV (Δ) transformer for transmission purposes. The IC will build a privately owned 0.1 km, 138 kV overhead line and transmit power into the BC Hydro (BCH) system via a tap connection onto line 1L243 between Nicola substation (NIC) and Highland substation (HLD). The proposed Point of Interconnection (POI) is on 1L243 at a distance of 20.4 km from BCH's Highland substation (HLD). The maximum power injection expected into the POI after losses is 43.5 MW.

A higher priority queued project, Pennask and Shinnish Wind farm (30 MW) is presently being commissioned via a tap connection on the adjacent 138 kV circuit, 1L244 between Nicola (NIC) and Westbank Station (WBK) and was included in this Mount Mabel wind farm project study.

Figure 1 shows the layout of the Mount Mabel wind farm:

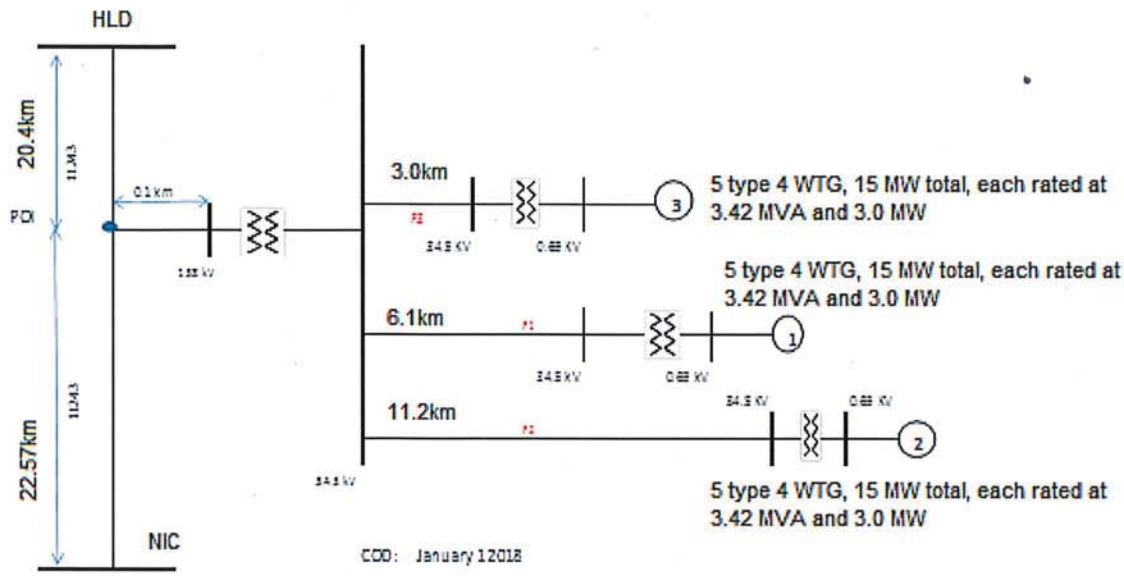

Figure 1: Layout of the Mount Mabel wind farm

The following diagram shows the geographic location of the project in the South Interior.

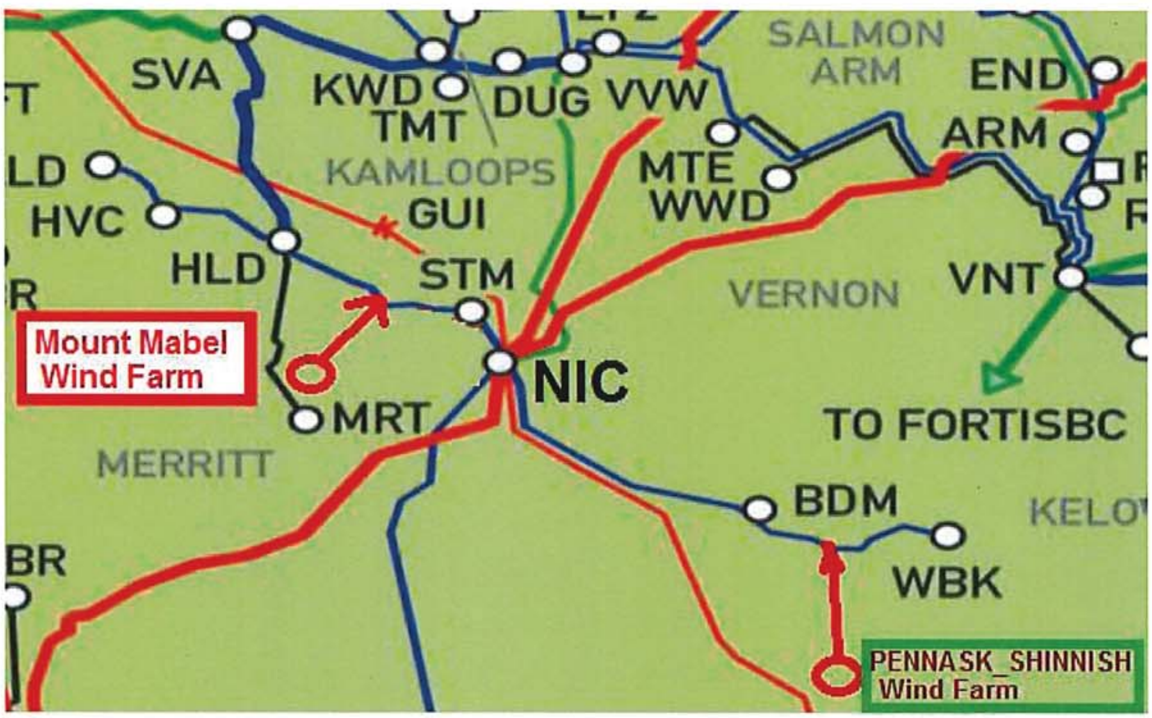

Figure 2: Geographical location of Mount Mabel and Pennask and Shinnish wind farms

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 suggest Network Upgrades options to obtain adequate performance for the reliable operation of the Transmission System, which is 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 voltage and overloading issues of the transmission networks in the vicinity of the Mount Mabel Wind Energy 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 (RAS) 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 interconnection Facilities Study report (FS) for this project.

4. Assumptions

This study is based on the data provided by the IC to BC Hydro in August 2016. In April 2017, the project's collector station location was updated in a new submission and the coordinates used in this study are assumed to be at [50: 17: 8.34 N (latitude) and 120: 35: 34.38 W (longitude)].

BCH 2019 heavy summer load and light summer load configurations as well as 2019/2020 heavy winter load system configurations with high generation patterns were used in the study. Higher priority queued interconnection projects were also included in the 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 interconnection.

5.1 Power Flow Study

Steady State N-0 and N-1 Power Flows

The power flow analyses were carried out for system normal (with every element in service) and N-1 contingency situations to assess this project's impact on the BCH system. The summary of voltages at key stations and the loading of nearby circuits for different system scenarios are listed below. Nearby existing units at Merritt Green (MIG) and Kwoiek Creek (KCH) generation stations were selected to be offline in order to adequately stress line 1L243.

With a maximum power output of 45 MW from the wind farm, there are no observed voltage violations or transmission equipment overloads either in the pre-contingency (N-0) or post-contingency (N-1) steady state scenarios.

Tables 5-1, 5-2, below show the voltage profile and circuit loadings for heavy summer load conditions.

Table 5-1: Voltage at nearby station for Heavy Summer Load Condition

Configuration	NIC500	NIC230	NIC138	HLD138	WBK138	VVW230	MMW138
System normal, prior to MMW	1.068	1.065	1.027	1.007	0.954	1.030	
System normal, with MMW	1.066	1.064	1.025	1.007	0.952	1.030	1.016
Loss of 1L203	1.066	1.063	1.023	0.997	0.950	1.029	1.010
Loss of 1L243	1.066	1.064	1.026	0.984	0.953	1.028	
Loss of 2L265	1.067	1.068	1.028	1.000	0.956	0.997	1.014
Loss of 5L87	1.058	1.057	1.019	1.002	0.946	1.026	1.011
Loss of NIC 500/230 TX2	1.066	1.060	1.022	1.006	0.949	1.028	1.014
Loss of NIC 230/138 TX5	1.066	1.063	1.023	1.006	0.950	1.029	1.015
Loss of SVA 230/138 TX1	1.066	1.064	1.025	1.004	0.952	1.029	1.014

Table 5-2: Circuit Loading as a percentage of MVA rating for Heavy Summer Load Condition

Configuration	1L243 (NIC-MMW tap)	1L243 (MMW tap-HLD)	1L203 (SVA-HLD)	1L205 (SVA-HLD)	2L265 (NIC-VVW)
Rating (MVA)	170.7	170.7	172.8	118.8	318.7*
System normal, prior to MMW	48	48	12	16	47
System normal, with MMW	31	57	10	14	46

Loss of 1L203	32	58		22	45
Loss of 1L243			35	48	55
Loss of 2L265	52	78	12	16	
Loss of 5L87	36	62	10	14	48
Loss of NIC 500/230 TX2	28	53	11	15	43
Loss of NIC 230/138 TX5	26	51	11	15	47
Loss of SVA 230/138 TX1	35	60	9	12	48

*2L265 rating is limited by a CT setting of 800A (318.7MVA)

Table 5-3 and Table 5-4 below show the voltage profile and circuit loadings for heavy winter load conditions.

Table 5-3: Voltage at nearby station for Heavy Winter Load Condition

Configuration	NIC500	NIC230	NIC138	HLD138	WBK138	VVW230	MMW138
System normal, prior to MMW	1.057	1.055	1.022	0.993	0.948	1.023	
System normal, with MMW	1.058	1.056	1.023	0.996	0.949	1.024	1.009
Loss of 1L203	1.058	1.055	1.021	0.982	0.946	1.023	1.002
Loss of 1L243	1.058	1.055	1.024	0.955	0.950	1.015	
Loss of 2L265	1.059	1.059	1.025	0.983	0.951	0.982	1.003
Loss of 5L87	1.042	1.041	1.009	0.983	0.934	1.009	0.996
Loss of NIC 500/230 TX2	1.058	1.053	1.020	0.995	0.946	1.022	1.008
Loss of NIC 230/138 TX5	1.058	1.056	1.021	0.995	0.947	1.023	1.008
Loss of SVA 230/138 TX1	1.058	1.055	1.020	0.991	0.945	1.021	1.006

Table 5-4: Circuit Loading as a percentage of MVA rating for Heavy Winter Load Condition

Configuration	1L243 (NIC-MMW tap)	1L243 (MMW tap-HLD)	1L203 (SVA-HLD)	1L205 (SVA-HLD)	2L265 (NIC-VVW)
Rating (MVA)	220.6	220.6	191.2	149.9	318.7*
System normal, prior to MMW	48	48	13	16	53

System normal, with MMW	35	55	12	14	52
Loss of 1L203	36	56		23	52
Loss of 1L243			41	49	66
Loss of 2L265	55	75	13	16	
Loss of 5L87	44	64	13	15	59
Loss of NIC 500/230 TX2	32	52	12	15	49
Loss of NIC 230/138 TX5	30	50	13	15	53
Loss of SVA 230/138 TX1	33	53	11	14	56

*2L265 rating is limited by a CT setting of 800A (318.7MVA)

Table 5-5 and Table 5-6 below show the voltage profile and circuit loadings for light summer load conditions.

Table 5-5: Voltage at nearby station for Light summer Load Condition

Configuration	NIC500	NIC230	NIC138	HLD138	WBK138	VVW230	MMW138
System normal, prior to MMW	1.075	1.074	1.024	1.013	0.983	1.047	
System normal, with MMW	1.076	1.075	1.024	1.014	0.983	1.047	1.019
Loss of 1L203	1.075	1.074	1.023	1.005	0.982	1.047	1.014
Loss of 1L243	1.076	1.074	1.024	1.000	0.983	1.046	
Loss of 2L265	1.076	1.077	1.026	1.005	0.984	1.002	1.015
Loss of 5L87	1.064	1.064	1.015	1.007	0.974	1.040	1.012
Loss of NIC 500/230 TX2	1.076	1.072	1.022	1.013	0.981	1.046	1.018
Loss of NIC 230/138 TX5	1.076	1.074	1.023	1.014	0.982	1.047	1.019
Loss of SVA 230/138 TX1	1.076	1.076	1.024	1.011	0.983	1.047	1.018

Table 5-6: Circuit Loading as a percentage of MVA rating for Light summer Load Condition

Configuration	1L243 (NIC-MMW tap)	1L243 (MMW tap-HLD)	1L203 (SVA-HLD)	1L205 (SVA-HLD)	2L265 (NIC-VVW)
Rating (MVA)	170.7	170.7	172.8	118.8	318.7*

System normal, prior to MMW	40	40	11	16	31
System normal, with MMW	23	48	9	13	30
Loss of 1L203	24	49		21	30
Loss of 1L243			30	41	37
Loss of 2L265	36	62	8	11	
Loss of 5L87	32	58	10	14	34
Loss of NIC 500/230 TX2	21	47	10	14	28
Loss of NIC 230/138 TX5	20	45	10	14	30
Loss of SVA 230/138 TX1	24	50	9	12	31

*2L265 rating is limited by a CT setting of 800A (318.7MVA)

5.2 Transient Stability Study

Transient stability simulations were conducted on 2019/2020 heavy winter and 2019 light summer load conditions. To account for the worst single contingency case scenarios, KCH (60 MW) and MIG (40MW) generators were placed online at high power output levels.

The study results demonstrated that the studied contingencies did not result in instability of the (non-islanded) generators in the region and system performance meets the BCH planning criteria. The simulation results show that PSS/E models representing the Mount Mabel wind turbines meet the Low Voltage Ride-through requirement as well as demonstrate acceptable voltage control capabilities at the POI.

The following tables show the transient stability simulation results of the 2019/2020 heavy winter load condition and 2019 light summer load condition.

Table 5-7: Transient stability simulation results for 2019 Light Summer Load

Case	Contingency	3-Ph Fault Location	Fault Clearing (Cycles)		Performance of the wind farm	POI Min Transient Voltage (p.u.)	Other Non-Islanded Units
			Near End	Far End			
1	2L265	NIC230	5	5	Acceptable	1.010	Acceptable
2	1L203	HLD138	7	7	Acceptable	0.97	Acceptable
3	5L87	NIC500	4	4	Acceptable	1.000	Acceptable
4	NIC 500/230 TX2	NIC500	5	5	Acceptable	1.010	Acceptable
5	NIC 230/138 TX5	NIC230	10	10	Acceptable	1.010	Acceptable
6	SVA 230/138 TX1	SVA 230	7	7	Acceptable	1.020	Acceptable

Table 5-8: Transient stability simulation results for 2019/2020 Heavy Winter Load

Case	Contingency	3-Ph Fault Location	Fault Clearing (Cycles)		Performance of the wind farm	POI Min Transient Voltage (p.u.)	Other Non-Islanded Units
			Near End	Far End			
1	2L265	NIC230	5	5	Acceptable	0.980	Acceptable
2	1L203	HLD138	7	7	Acceptable	0.960	Acceptable
3	5L87	NIC500	4	4	Acceptable	0.970	Acceptable
4	NIC 500/230 TX2	NIC500	5	5	Acceptable	0.980	Acceptable
5	NIC 230/138 TX5	NIC230	10	10	Acceptable	0.990	Acceptable
6	SVA 230/138 TX1	SVA 230	7	7	Acceptable	1.010	Acceptable

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 priority interconnection 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 Analytical Studies

Transformer Energization:

The worst expected transformer energization voltage dip of around 9% RMS for uncontrolled energization exceeded BCH's power quality requirements and therefore transformer energization inrush mitigation control is required for this application in order to avoid negative impacts to nearby existing customers near HLD and NIC. This can be achieved by implementation of Point On Wave control with flux calculation, Point On Wave with controlled opening/closing or by fast motorized disconnects with arcing horns.

Temporary Over Voltages (TOVS):

The following contingencies and switching were studied to assess the impact of the proposed Wind Farm to BCH system.

- Single Line-to-Ground (SLG) fault on 1L243 with 9 cycles clearing time by opening associated 138 kV circuit breakers (CBs) at both NIC and HLD ends;
- Two Line-to-Ground (LLG) fault on 1L243 with 9 cycles clearing time by opening associated 138kV CBs at both NIC and HLD ends;

- Three Line-to-Ground (3LG) fault on 1L243 with 9 cycles clearing time by opening associated 138kV CBs at both NIC and HLD ends;
- Two Line-to-Ground (LLG) Fault on 1L55 with 9 cycles clearing time by opening 138kV CB at HLD;
- Non-protective tripping of 1L243;

Based on the results, no severe TOVs has been observed under the above fault conditions. However, there is a slight temporary overvoltage for the scenario of unintentional tripping of 1L243. Therefore, it is recommended to have a direct transfer trip (DTT) from either NIC or HLD to the wind farm substation to minimize potential impact to existing customers during the period of islanded mode operation. This aligns with BC Hydro's standard practice for wind farm interconnections.

Frequency Scans:
The results demonstrate no significant frequency shift of natural resonances after interconnecting the wind farm. Harmonics metering at the wind farm substation is recommended because harmonics injection from the wind farm is not modelled in detail in this study.

In the Analytical Studies described above, the wind turbine models for the nearby Pennaska and Shinnish wind farm had been replaced with the PSCAD models for Enercon machines, and Pennask wind farm STATCOM was not modelled to adopt a conservative approach. The Pennask and Shinish wind farm uses the Savion products. However, the models for that project presently available to BCH are not compatible to the PSCAD models provided for this project and thus cannot be used for this study purpose. In this study, the surge arresters were not modelled unless TOV issues are identified. The approach will need to be reviewed when this project moves to the next study stage.

6. Upgrades for the Transmission Requirement

6.1 Remedial Action Scheme (RAS)

No additional RAS function is required to integrate the Mount Mabel Wind Project into the BC Hydro transmission system. An operational planning study will be required to update the South Interior generation shedding requirement for the accommodation of the power injection from this IC.

6.2 Station Upgrades Requirements

There are no BCH upgrade requirements for station equipment identified for this project.

6.3 Transmission Line Upgrade Requirements

For integrating a tap connection of the project onto 1L243 at the POI, a tap structure and three Disconnect Switches (DS) will be required where:

- one DS will be located between the POI and the IC's tie line;
- one DS located between the POI and the line segment toward HLD; and
- one DS located between the POI and the line segment toward STM;

Additional Right of Way (ROW) may be required to accommodate the tap connection.

There may be civil design work and a geotechnical survey associated with implementing new as well as updating existing microwave facilities as described in Section 6.5 (Telecommunications).

6.4 Protection and Control Requirement

Protection

- Existing line protection at NIC and HLD terminals will need to be upgraded for 1L243 to differential protection using SEL-411L relays. Mt. Mabel terminal will also be required to install similar line protection using SEL-411L relays. BCH will supply high level settings to the IC for the Mt. Mabel terminal.
- WECC Class 2 Primary (PY) and Standby (SY) telecommunication channels are required between NIC, HLD, and Mt. Mabel terminals to implement the protection upgrades.

Control

- Control work required at the Nicola and Highland BC Hydro substations associated with the new 1L243 line protection relays.
- The IC is required to provide a minimum 9600 bps continuous reporting channel for telemetry, status and meteorological information via Distributed Network Protocol 3 (DNP3) Remote Terminal Unit (RTU) / Intelligent Electronic Device (IED) to the BCH Control Center using appropriate telecom facilities per the Technical Interconnection Requirements (TIR) for Power Generators.
- At the request of BC Hydro the IC will be required to provide protection event records from the interconnecting line protection relays to BC Hydro under the following circumstances: a fault on interconnecting line, or a relay mis-operation for fault outside of interconnecting line.
- The IC is responsible for providing a communications link for remote interrogation of the line protection relays and Power Parameter Information System (PPIS) equipment by BCH servers. Communications and equipment selection is subject to BCH review and approval.

6.5 Telecommunications

Telecommunication facilities required for this project are summarized below:

- New microwave facilities are required at HLD to provide WECC Class 2 Primary (PY) and Standby (SY) 64 kbps synchronous C37.94 circuits between NIC and HLD stations;
- New and existing microwave facilities are required to provide WECC Class 2 Primary (PY) and Standby (SY) 64 kbps synchronous C37.94 circuits between HLD and MMWX stations and between NIC and MMWX stations;
- A 9600 bps SCADA circuit is required to transfer telemetry, status and meteorological data from MMWX to BC Hydro control centers; and
- Existing Power Line Carrier (PLC) circuits from the Savona (SVA) – HLD system are required to be transferred to the new microwave terminal at HLD.

The above telecommunication solutions have been concluded upon the new MMWX location that was changed by the IC in April 2017. With the new location, a microwave link to MMWX becomes superior over the fibre optical cable solution that was recommended with the originally proposed station location.

6.6 Cost Estimate and Schedule

The non-binding good-faith cost estimate for Interconnection Network Upgrades required to interconnect the proposed project to BCH Transmission System is $5.1 million.

Excluded from this estimate are:

- Outages and related disruptions for construction and commissioning;
- First Nations consultation and accommodation;
- Revenue Metering costs.

The non-binding estimated time for BCH to implement the identified Network Upgrades is in a range of 12 to 18 months from project approval.

7. Additional Requirements

7.1 Islanding Operation

Islanded operation is not arranged for this project. A Direct Transfer Trip (DTT) signal from either HLD or NIC terminals to MMWX is required to isolate the IC's facilities when an islanded scenario occurs. Power quality protection will be required at the wind farm to detect abnormal system conditions, such as under/over voltage and under/over frequency, and subsequently disconnect the wind farm from the system within a specified time. The settings of these protective relays must conform to existing BC Hydro practice for wind plants so that the turbines will not trip for normal ranges of voltages and frequencies as well as meet the LVRT requirements.

7.2 Black Start Capability

BC Hydro 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 (ESA).

8 Revenue Metering

One main Point of Metering (POM1) at the 138 kV voltage level is required on the primary side of the 138 kV / 34.5 kV power transformer. Additionally, three secondary POMs (POM2, POM3, POM4) at the 34.5 kV level are required on the low side of the power transformer to collect the transmitted power from each of the three sites. Since the main transformer secondary side is delta connected, the secondary metering shall be 2 element for each of the three 34.5 kV sites. Specific metering information is provided in Table 8-1. The loss compensation parameters will need to be calculated during implementation. Refer to Appendix for more detailed information.

The estimated Revenue Metering cost is $222k, and does not include any costs for civil, structural, and electrical work of Revenue Metering. Only included are the costs for the BCH Revenue Metering tasks, (i.e., field and engineering).

Table 8-1: Metering requirements for Mount Mabel wind farm project

Point-of-Metering	On the primary 138 kV side of the power transformer in the customer station (main POM) On the secondary 34.5 kV side of the power transformer (for three secondary POMs)
Voltage Transformers	3 x VTs (L-Grd) – 138,000/1.732-120-120V (to be confirmed and supplied by the IC) –POM1 6 x VTs (L-L) – 34,500-120V (to be confirmed and supplied by the IC) – 2 x VTs per site for POM2, POM3, POM4
Current Transformers	3 x CTs 200 - 5A (to be confirmed and supplied by the IC) – POM1 6 x CTs 300 - 5A (to be confirmed and supplied by the IC) – 2 x CTs per site for POM2, POM3, POM4

Note: Refer to Appendix or Revenue Metering Requirements.

9 Conclusions and Discussions

To interconnect the Mount Mabel wind project and its facilities into the BCH Transmission System at POI, this System Impact Study has identified the following issues and requirements:

- Three disconnect switches will be installed at the MMWX POI for interconnecting the Mount Mabel wind project into the BCH system;
- No abnormal bus voltages or transmission element overloading was observed in the system during steady state power flow studies under pre-contingency (N-0) system normal and (N-1) post-contingency conditions. No transient instability was observed in the area due to the addition of the Mount Mabel wind project following single system contingencies;
- A Direct Transfer Trip (DTT) signal to MMWX 138 kV circuit breaker, from either NIC or HLD stations, is recommended to prevent islanded modes of operation following protective or unintentional tripping of 1L243;
- Transformer energization inrush mitigation is required to meet the TIR requirements;
- Existing line protection at NIC and HLD terminals of 1L243 is required to be upgraded to current differential protection using relay type SEL-411L. Mt. Mabel terminal will also be required to install a SEL-411L relay for line protection;
- Associated control work is required at the Nicola and Highland BC Hydro substations with the upgraded 1L243 line protection relays. The IC is required to provide telemetry, status and meteorological information to the BC Hydro Control Centers using appropriate telecom facilities.
- In order to implement the protection system upgrade requirement, WECC Class 2 Primary (PY) and Standby (SY) telecommunication channels are required between NIC, HLD, and Mt. Mabel terminals. This will be implemented using existing microwave facilities and new microwave facilities between specific sites;

  The IC shall meet the requirements in accordance with the "60 kV to 500 kV BC Hydro Technical Interconnection Requirements (TIR) for Power Generators". The Mount Mabel wind turbines are required to meet the Low Voltage Ride Through (LVRT) requirement, have capability to adequately control voltage at the POI and provide a range of ±0.95 PF as measured at the POI when generating at rated capacity.

The non-binding good faith cost estimate for the interconnection Network Upgrades required to interconnect the proposed project to the BCH Transmission System is $5.1 million. The estimated time to implement the identified Network Upgrades is in a range of 12 to 18 months.

The Facilities Study report will provide greater details of the Interconnection Network Upgrade requirements and associated cost estimate and estimated construction timeline for this project.

Appendix

Revenue Metering Telecom Requirements and Revenue Metering Requirements:

Revenue Metering Telecom Requirements:

The 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 IC. 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 (the IC 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 IC. 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 IC) 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. The CTs and VTs must be pre-approved by BC Hydro's Revenue Metering Department. The IC 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. The revenue metering VT and CT secondary windings are not permitted to be shared with any other equipment therefore no other devices shall be connected to the revenue metering VT and CT secondary windings.

For generation applications, all instrument transformer compartment doors shall be **key interlocked** with a BC Hydro side disconnect device and a Power Generator side disconnect device(s). The key interlocks shall prevent opening instrument transformer compartment door(s) unless all disconnect devices are visibly open. *Where the POM is on the Power Generator side of the power transformer, the BC Hydro side disconnect device shall be on the BC Hydro side of the power transformer to insure no-load losses.* "

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 IC or its consultant shall provide the line parameters data and the power transformer testing data to BC Hydro.

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.)