Interconnection Feasibility Study

[redacted]

Mount Mabel Wind Energy Project

Report No: T&S Planning 2015-054

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British Columbia Hydro and Power Authority

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

Revision Table

Revision Number	Date of Revision	Revised By

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EXECUTIVE SUMMARY

[redacted], the Interconnection Customer (IC), proposes to develop the Mount Mabel Wind Energy Project in the Thompson/Okanagan area of British Columbia to deliver electric energy to BC Hydro (BCH). This project consists of 24 Vestas V110 2 MW Type 3 wind turbines, installed in groups of 8 in three clusters.

The IC proposes to connect this project via a customer owned short line (0.1 km) onto the existing 138 kV circuit 1L243 between BCH's Nicola (NIC) and Highland (HLD) substations. The Point of Interconnection (POI) is on 1L243, 32 km from HLD. The maximum power injection from this project is about 46.5 MW. The proposed Commercial Operation Date (COD) for this project is January 1, 2018.

This report documents the preliminary 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 Mount Mabel Wind Energy project and its facilities to the BCH system through a tap point on 1L243, this Feasibility Study (FeS) has identified the following conclusions and requirements:

1. The tap connection for the IC's project would be acceptable with revised line protections. WECC Class 2 PY & SY 64 kbps synchronous circuits between NIC and HLD, NIC and MMW, and HLD and MMW would be needed to support the revised line protections, and microwave links between NIC, HLD, and Mount Mabel Wind station (MMW) would be implemented.
2. A disconnect at the POI would be added by BCH to connect the IC's tap line. It would be used to isolate the IC's facilities from the BCH system.
3. No abnormal voltage condition in the Transmission System under system normal and N-1 conditions due to the interconnection of Mount Mabel wind farm has been observed in the power flow analysis.
4. No overload in the Transmission System under system normal and single contingency conditions due to the interconnection of Mount Mabel wind farm has been observed in the power flow analysis.
5. Islanded operation is not planned for Mount Mabel Wind farm. The wind farm is to be isolated from the Transmission System when 1L243 (NIC-HLD) is out of service.
6. The IC shall provide entrance protection, power quality protection and line protection in accordance with the "60 kV to 500 kV BC Hydro Technical Interconnection Requirements for Power Generators". Wind Farm's protection should disconnect itself from the Transmission System once an islanding situation is detected.
7. The good faith non-binding cost estimate to complete BCH Network Upgrades required for the Mount Mabel Wind Farm connection is $3.713M, with an accuracy range of +100% to -35%. The Cost to implement the requirements on the IC's side is not part of this estimate.
8. These upgrades can be expected to be completed in approximately 18 months after the Standard Generation Interconnection Agreement (SGIA) is executed and the implementation phase funding is approved.

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1.0 INTRODUCTION

[redacted], the Interconnection Customer (IC), is proposing to develop the Mount Mabel Wind Energy Project in the Thompson-Okanagan area of British Columbia. The project consists of three different sites and uses a total of 24 Vestas V110 type 3 wind turbines, 2 MW each. The wind turbines will be installs in groups of 8 in three clusters. The maximum generation capacity in each cluster is 16 MW, and the proposed maximum power injection into the BCH system is 46.5 MW.

The Interconnection Customer (IC) will built three 34.5 kV feeders to connect the clusters to a common collector station. The lengths of these equivalent feeders are 4.6 km, 6.1 km and 11.2 km respectively. Mechanically switched reactive device in a range of -2/+6 MVAR is installed at the 34.5 kV collector bus for additional reactive support. It is expected that reactive device will be specified in details during the System Impact Study stage.

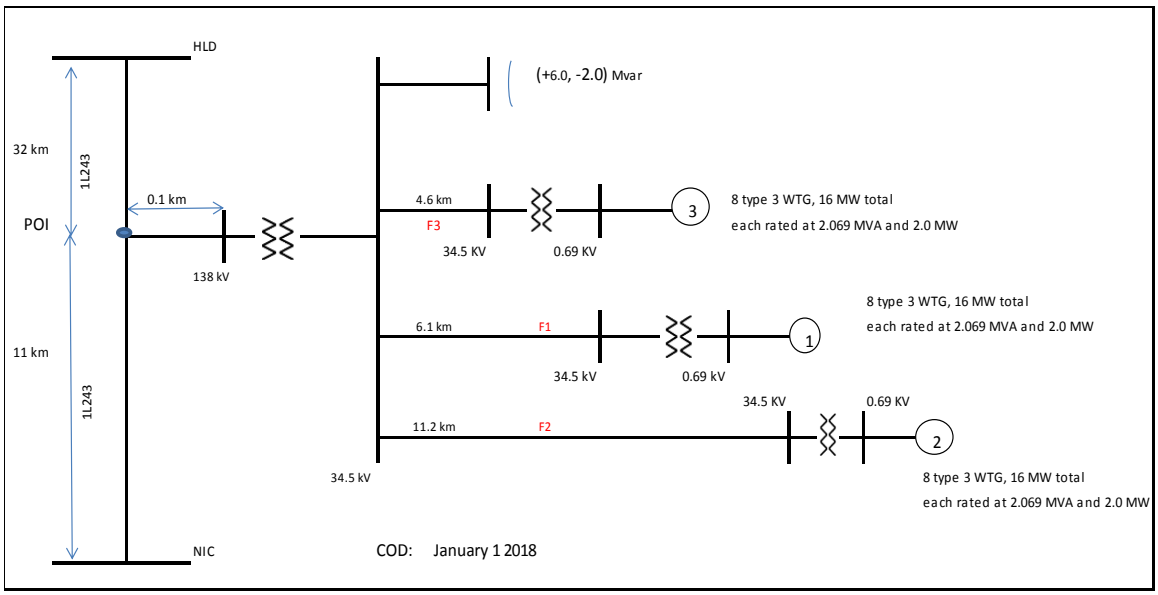
At the collector station, voltage is stepped up from 34.5 kV to 138 kV for transmission purpose. The IC builds a 0.1 km 138 kV overhead tap line to connect its Mount Mabel Wind station (MMW) to the Point of Interconnection (POI) on 1L243 (Nicola-Highland, or NIC-HLD). The POI is a new tap on the existing 1L243, 32 km from BCH Highland substation (HLD), or 11 km from Nicola substation (NIC). With the proposed line tap connection onto 1L243, the existing line protections will need to be reviewed.

The propose Commercial Operation Date (COD) is January 1, 2018.

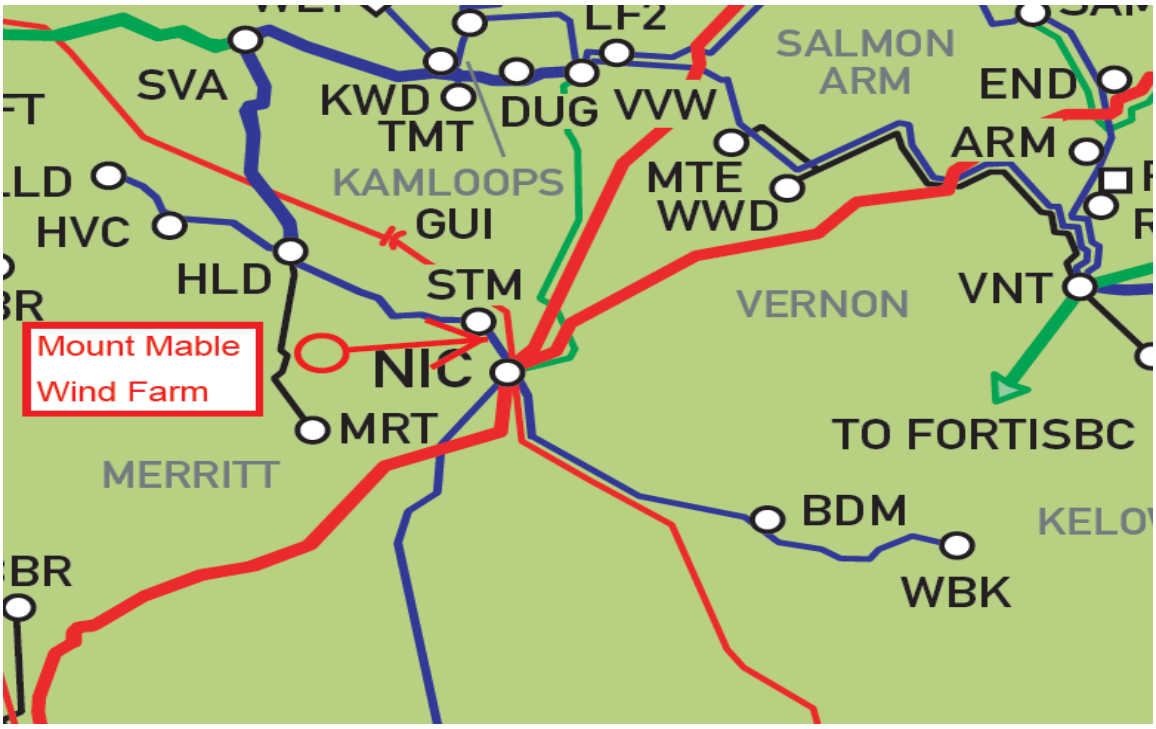
Table 1: Project Information Summary

Project Name	Mount Mabel Wind Energy Project	
Proponent Name	[redacted]	
Point of Interconnection	Tap on 1L243 between Nicola and Highland	
Applicant Proposed COD	January 1, 2018	
Type of Interconnection Service	NRIS ☒	ERIS ☐
Maximum Power Injection (MW)	46.5 (Summer)	46.5 (Winter)
Number of Generator Units	Twenty four 2MW Vestas V110 type 3 wind turbines	
Plant Fuel	Wind	

The following diagram shows the layout of the wind farm:



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



2.0 PURPOSE OF STUDY

The purpose of this feasibility study is to assess the impact of interconnecting Mount Mabel Wind Farm to BCH Transmission System at a preliminary level. This study identifies constraints and Network Upgrades required for interconnecting Mount Mabel Wind Farm to the transmission grid such that their performance is compliant with the North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council (WECC) reliability standards, and the BCH transmission planning criteria.

3.0 TERMS OF REFERENCE

This feasibility study investigates and addresses the overloading, voltage deviation issues of the transmission network in the South Interior region as a result of integrating Mount Mabel Wind Farm. Topics studied include equipment thermal loading and rating requirements, and protection requirements. BCH planning methodology and criteria are used in the studies.

Transient stability, Electro Magnetic Transient (EMTP) studies and Revenue Metering requirements will be done in the System Impact Study, if requested by the IC.

The requirements described in this Feasibility Study Report may be further augmented with additional requirements that are discovered in the later study stages.

4.0 ASSUMPTIONS

This Feasibility Study was carried out based on the model, data and information submitted by the IC in May 2015. Reasonable assumptions are made to complete the study whenever such information is unavailable.

1. BCH 2018 summer light load and 2018/19 winter heavy load system configuration and load/generation patterns are used in the study. Higher queue interconnection projects are included in these power flow models.
2. A -2/+6 Mvar mechanically switched reactive device, referred to as a "Power Factor Filter" by the IC, is installed at the 34.5 kV wind farm collector bus for additional reactive support.
3. The wind turbines are set to control the voltage of Mount Mabel 138 kV station.

5.0 FEASIBILITY STUDIES AND RESULTS

Power flow and short circuit studies were carried out to evaluate the feasibility of the proposed interconnection. Studies were also performed to determine the protection, control and communication requirements.

5.1 Steady State Power Flow Studies

The load flow single line diagrams for 2018 summer light load and 2018 winter heavy load condition case are shown in Appendix A of this report.

A series of pre and post contingency power flow analysis are performed to confirm that area voltages and facility loadings are within acceptable performance limits under steady state and single contingency conditions. Study results concluded that the findings are within BCH planning criteria.

The following tables show the power flow results:

2018 Summer Light Load Case:
Station Voltages

	Voltages at nearby stations for Summer Light Load Condition							
	NIC500	NIC230	NIC138	HLD138	VVW230	WBK138	MMW138	MMW-COL
Sys Normal, before MMW	1.073	1.073	1.022	1.007	1.054	0.99		
Sys normal, with MMW	1.074	1.075	1.026	1.011	1.056	0.995	1.028	1.061
1L203	1.074	1.075	1.025	1.005	1.057	0.994	1.026	1.062
1L243	1.073	1.073	1.022	0.995	1.052	0.990		
2L265	1.075	1.077	1.028	1.011	1.030	0.997	1.028	1.054
5L87	1.065	1.067	1.020	1.005	1.047	0.994	1.022	1.057
NIC 500/230 TX2	1.074	1.074	1.026	1.011	1.055	0.995	1.028	1.058
NIC230/138 TX5	1.074	1.074	1.026	1.011	1.055	0.995	1.028	1.058
SVA230/138 TX1	1.074	1.075	1.026	1.009	1.054	0.994	1.027	1.063

MMW	Mount Mabel Wind station
1L203	Circuit between Highland and Savona (HLD-SVA)
1L243	Circuit between Nicola and Highland (NIC-HLD)
2L265	Circuit between Nicola and Valley View (NIC-VVW)
5L87	Circuit between Nicola and Kelly (NIC-KLY)

2018 Summer Light Load Case:
Circuit Loadings as % of MVA Rating

Circuit Loading as a percentage of MVA rating for Summer LightLoad Condition					
	1L243 (NIC-MMW tap)	1L243 (MMW tap-HLD)	1L203 (HLD-SVA)	1L205 (HLD-SVA)	2L265 (NIC-VVW)
Rating (MVA)	170.7	170.7	170.7	120.7	318.7*
Sys Normal, without MMW	36.1	36	10.5	13.9	26.4
Sys normal, with MMW	17.2	41.5	8.7	11.6	26.1
1L203	16.9	42.3		17.7	25.9
1L243			25.9	34.4	32.7
2L265	27.7	53.0	10.0	13.5	
5L87	29.1	53.4	9.3	12.6	32.4
NIC 500/230 TX2	13.2	37.9	9.1	12.0	25.2
NIC230/138 TX5	13.1	37.9	9.1	12.0	25.2
SVA230/138 TX1	18.0	42.8	7.6	10.2	26.9

* 2L265 rating is limited by a CT setting of 800A

2018 Winter Heavy Load Case:
Station Voltages

	Voltages at nearby stations for Winter Heavy Load Condition							
	NIC500	NIC230	NIC138	HLD138	VVW230	WBK138	MMW138	MMW-COL
Sys Normal, before MMW	1.054	1.051	1.024	0.994	1.015	0.945		
Sys normal, with MMW	1.055	1.053	1.028	0.998	1.018	0.945	1.025	1.056
1L203	1.055	1.053	1.027	0.992	1.019	0.944	1.023	1.059
1L243	1.053	1.05	1.023	0.973	1.004	0.939		
2L265	1.056	1.057	1.031	1	0.862	0.946	1.025	1.045
5L87	1.039	1.037	1.024	0.993	0.997	0.941	1.021	1.057
NIC 500/230 TX2	1.055	1.049	1.023	0.997	1.015	0.939	1.022	1.058
NIC230/138 TX5	1.055	1.049	1.023	0.997	1.015	0.939	1.022	1.058
SVA230/138 TX1	1.055	1.053	1.027	0.994	1.015	0.944	1.024	1.06

2018 Winter Heavy Load Case:
Circuit Loadings as % of MVA Rating

Circuit Loading as a percentage of MVA rating for Winter Heavy Load Condition					
	1L243 (NIC-MMW tap)	1L243 (MMW tap-HLD)	1L203 (HLD-SVA)	1L205 (HLD-SVA)	2L265 (NIC-VVW)
Rating (MVA)	220.6	220.6	191.2	151.8	318.7*
Sys Normal, before MMW	45.8	45.7	9.9	11.8	
Sys normal, with MMW	29.6	49.9	8.9	10.6	55.8
1L203	29.4	50.2		16.0	55.6
1L243			33.0	39.1	68.5
2L265	49.9	70.2	17.0	20.4	
5L87	40.8	60.9	10.9	13.1	64.2
NIC 500/230 TX2	22.4	42.6	9.7	11.5	53.6
NIC230/138 TX5	22.4	42.6	9.8	11.5	53.6
SVA230/138 TX1	32.5	52.9	7.7	9.2	56.1
	* 2L265 rating is limited by a CT setting of 800A				

5.2 Transient Stability Study

Transient Stability is not performed as part of a Feasibility Study.

5.3 Fault Analysis

The short circuit analysis is based upon the latest BCH system model, which includes project equipment and impedances provided by the IC. The model included higher queued projects and planned system reinforcements but excluded lower queued projects. Thevenin impedances, including the ultimate fault levels at POI, are not included in this report but will be made available to the IC upon request.

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

5.4 Analytical Studies

Analytical Study is not performed as part of a Feasibility Study.

5.5 Transmission Line Upgrades

No transmission line upgrade requirement has been identified.

5.6 BCH Station Upgrades or Additions

Install a new tap structure on 1L243. A disconnect switch is required at the 1L243 tap to connect the IC's short 138 kV line. Addition requirements can be identified when transient stability and EMTP studies are performed as part of the System Impact Study.

Based on this Feasibility Study, there is no additional BCH's station work identified.

5.7 Protection & Control and Telecommunications

BCH Protection Requirements:

- Protection upgrades to NIC and HLD terminals of 1L243 to type SEL-411L line current differential relays.
- WECC Class 2 telecom is required between NIC, HLD, and Mount Mabel Wind Station.
  - Provide WECC Class 2 64 kbps synchronous circuits between NIC and HLD for "1L243 PY DIGITAL TELEPROT" and "1L243 SY DIGITAL TELEPROT". Physical interface shall be C37.94 optical over multimode fibre using ST connectors.
  - Provide WECC Class 2 64 kbps synchronous circuits between NIC and MMW for "1L243 PY DIGITAL TELEPROT" and "1L243 SY DIGITAL TELEPROT". Physical interface shall be C37.94 optical over multimode fibre using ST connectors.
  - Provide WECC Class 2 64 kbps synchronous circuits between HLD and MMW for "1L243 PY DIGITAL TELEPROT" and "1L243 SY DIGITAL TELEPROT". Physical interface shall be C37.94 optical over multimode fibre using ST connectors.

Mount Mabel Protection Requirements:

- Mount Mabel IPP terminal will be required to have SEL-411L line current differential relays for 1L243 protection. BCH will supply high level settings for Mount Mabel IPP terminal.
- The IC shall provide entrance protection, power quality protection and line protection in accordance with the "60 kV to 500 kV BC Hydro Technical Interconnection Requirements for Power Generators".

Telecom Requirement:

At Hamilton Microwave Repeater station**:**

- Perform a tower analysis and upgrade if required
- Install a mixed mode asynchronous 7 GHz microwave radio waveguide and antenna facing MMW

At Highland station:

- Install a microwave tower.
- Install a mixed mode asynchronous 7 GHz microwave radio, waveguide and antenna facing MMW.
- Establish a passive reflector at this sight, facing MSV and HLD.
- Install PY and SY Teleprotection circuits from NIC to MMW, Depending on the DACS, four (4) RFL FSUs will be required to convert from C37.94 to V.35.

At Mount Savona Microwave Repeater station:

- Perform a tower analysis and upgrade if required.
- Install a mixed mode asynchronous 7 GHz microwave radio, waveguide and antenna facing HLDP1.

At Nicola station:

- Install PY and SY Teleprotection circuits from MMW and HLD, four (4) RFL FSUs will be required to convert C37.94 to V.35.

A telecom Block diagram is attached in appendix D

At Mount Mabel Station (MMW) (work to be performed by the IC)

- Install a microwave tower.
- Install a mixed mode asynchronous 7 GHz radio, waveguide and antenna facing HAM
- Install a dehydrator.
- Install two DC-DC 48V converters off the station battery, of -48VDC power system with at least 8hours battery backup.
- Install a DACS compatible at the T1 and DS0 level with the DACS equipment at HLD and NIC.
- Install one PY and one SY Teleprotection circuits from NIC and HLD. Depending on the DACS, four (4) RFL FSUs may be required to convert from C37.94 to V.35.
- Install a SCADA circuit to FVO via the BC Hydro Telecom network.

5.8 Islanding

Islanded operation is not arranged for Mount Mabel Wind Farm. Mount Mabel Wind Farm shall be disconnected from the Transmission System when an islanding situation is detected.

5.9 Black Start Capability

BCH does not require the proposed Mount Mabel Wind farm 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.

5.10 Cost Estimate and Schedule

The good faith non-binding cost estimate to complete BCH Network Upgrades required for the Mount Mabel Wind Farm connection is $3.7 million.

The network upgrades identified in this report can be expected to be completed in approximately 18 months after the SGIA is executed and the implementation phase funding is approved.

The Interconnection Facilities Study report that follows the completion of System Impact study will provide more detail of the work to be performed.

6.0 REVENUE METERING

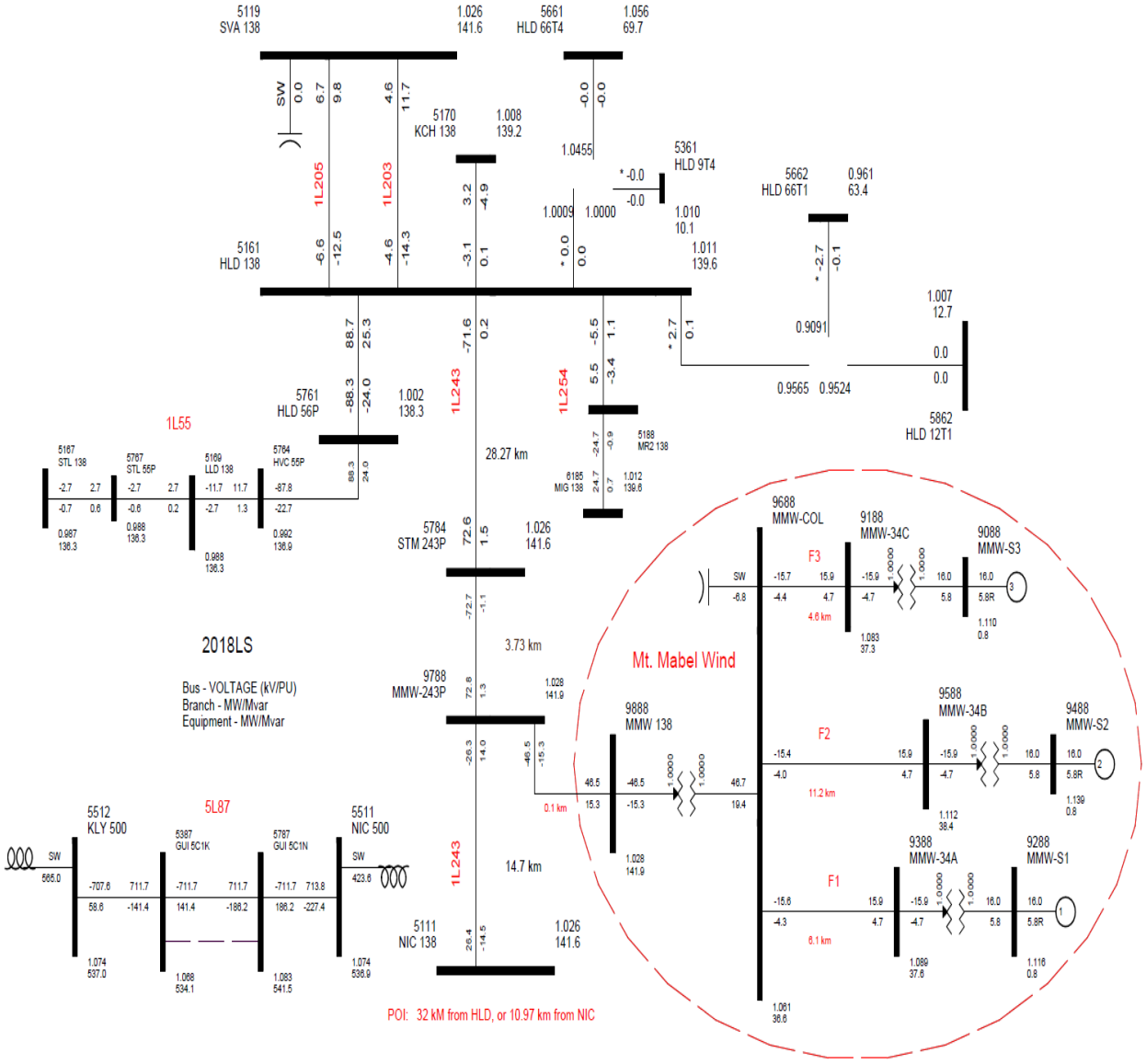
Revenue metering requirements will be determined during the System Impact Study.

7.0 CONCLUSIONS & DISCUSSION

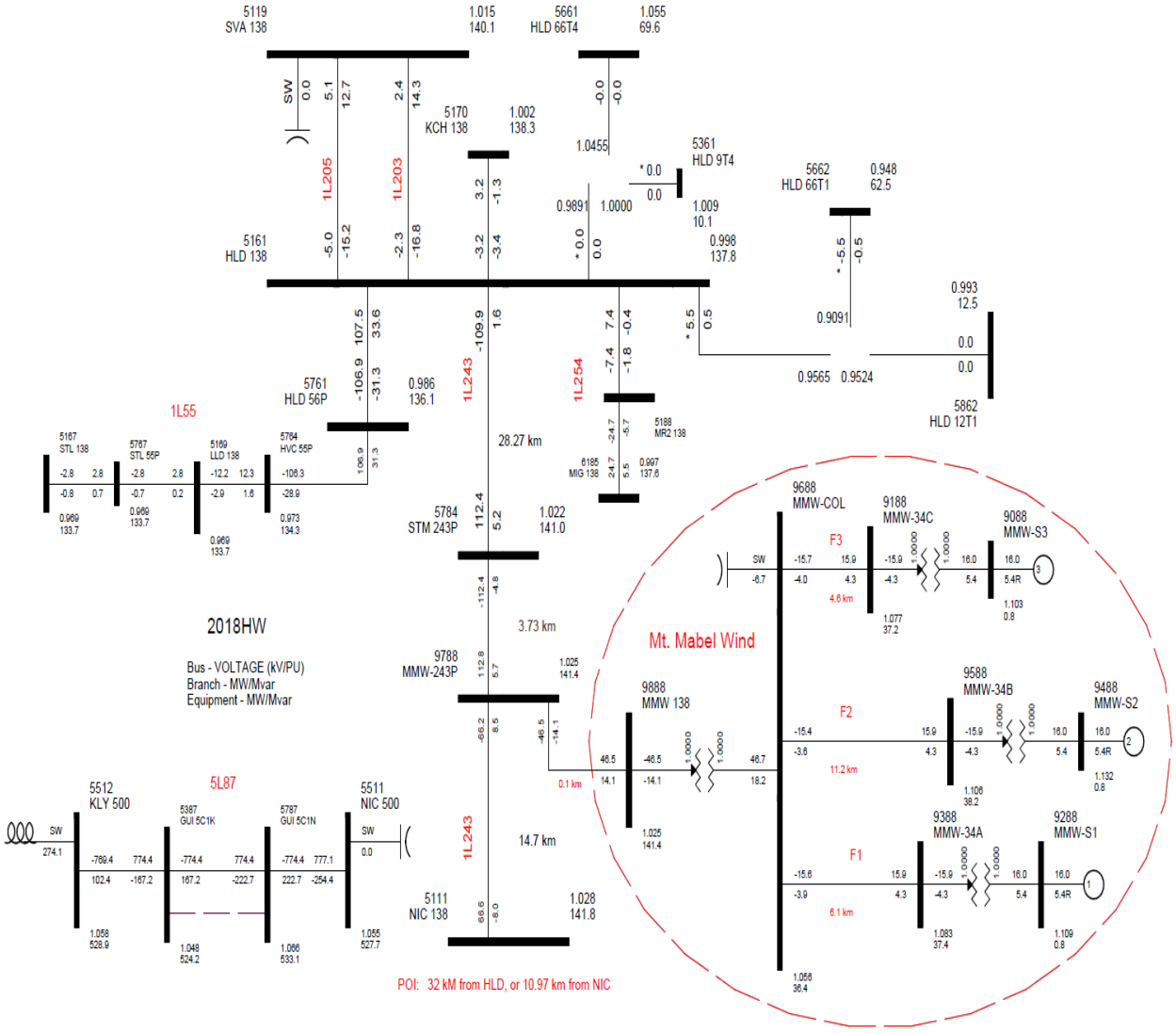
- In power flow studies, Mount Mabel Wind Farm was not observed to cause any equipment overload and voltage violation under single contingencies. No transmission element upgrade has been identified.
- There is sufficient capacity on circuit 1L243 (NIC-HLD) to accommodate the connection of the proposed Mount Mabel Wind Farm.
- A disconnect at the POI would be added by BCH to connect the IC's tap line. It would be used to isolate the IC's facilities from the BCH system.
- 1L243 line protection relays at NIC and HLD will need to be replaced. The IC is required to install the same protection relay at its MMW station. BCH will provide the setting of the relays at MMW.
- WECC Class 2 PY & SY 64 kbps synchronous circuits between NIC and HLD, NIC and MMW, and HLD and MMW would be needed to support the revised line protections, and microwave links between NIC, HLD, and Mount Mabel Wind station (MMW) would be implemented.
- Additional interconnection requirements may be identified during a System Impact Study stage.

APPENDIX A – Area Single-line Diagram

Summer Light Load Condition:



Winter Heavy Load Condition:



APPENDIX B – Communication Block Diagram