BC hydro
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Wartenbe Wind Farm Project

Interconnection Feasibility Study

Report No: T&S Planning 2017-048

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British Columbia Hydro and Power Authority

ACKNOWLEDGEMENTS

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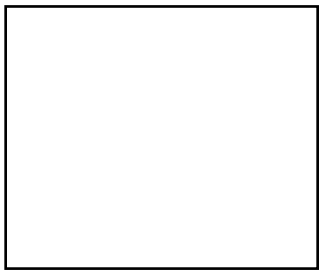

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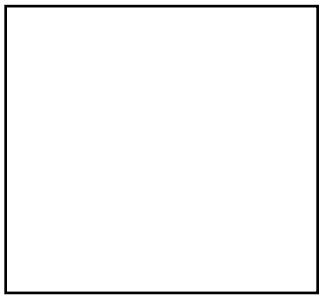

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EXECUTIVE SUMMARY

[redacted] the Interconnection Customer (IC), is proposing to develop a 15 MW wind farm facility, Wartenbe Wind Farm (the project), in the Peace Region of British Columbia. The IC will install 5 (Vestas V117) turbines with a rated capacity of 3 MW each. All the 5 turbines are type 4 machines. The IC's proposed Point of Interconnection (POI) for the project is on the 138 kV line, 1L349, at a distance of about 100 m from Sundance Lakes Substation (SLS). The project's power injection into BC Hydro system at the POI is 14.9 MW. The Commercial Operation Date (COD) originally proposed by the IC for the project is December 31, 2018, and the IC updated the COD to December 31, 2019 during the period of writing this report. A feasibility study was requested by the IC to assess, at a preliminary level, the system impacts on the BC Hydro transmission system by connecting the project.

This feasibility study of interconnecting the project to the BC Hydro Transmission System at the proposed POI has resulted in the following conclusions and requirements:

- No transmission element thermal overloads or unacceptable voltage conditions were observed in the power flow simulations due to the project interconnected into the system under system normal (N-0) scenarios.

- Before the project comes into service, loss of 2L308 (N-1) will result in thermal overloading of the 138 kV lines 1L349, 1L361, 1L367, 1L377 and the 230 kV line 2L312, and loss of 2L312 will result in thermal overloading of 2L308. An existing generation shedding Remedial Action Schemes (RAS) is in place and an update of the RAS has been planned to address those overloading concerns under single contingences. The additional 14.9 MW power injection from the project (to be added in December, 2019) will aggravate the above overloading concerns for loss of 2L308 (N-1) and the generation RAS will be adequate to mitigate the concerns. The project is not expected to be included into the Peace Region generation shedding RAS, however this will need to be reviewed and confirmed in the System Impact Study (SIS) stage.

- The overloading conditions observed in the 2019 system configuration would be greatly reduced in the 2024 system configuration with the inclusion of the Site C project and Peace Region Electricity Supply (PRES) project. Still, loss of 2L308 (N-1) will result in thermal overloading of the 230 kV line 2L312 and vice versa. This thermal overloading problem is not due to the project connection and can be mitigated adequately by the generation shedding RAS.

- The IC's 138 kV substation ground grid is required to be connected with the ground grid of BC Hydro's SLS to facilitate modification of the line protection stated below.

- The current transformers on the customer side of the Wartenbe 138 kV entrance circuit breaker will be connected to the existing SLS 1L349 protection relays. The SLS 1L349 primary and standby protection will trip SLS 1L349 line circuit breaker as well as customer entrance 138 kV circuit breaker.
- The Customer will provide power quality protection that complies with BC Hydro requirements as applicable in the BC Hydro document, "60 kV to 500 kV Technical Interconnection Requirements for Power Generators".
- The IC is required to follow the requirements as applicable in the BC Hydro document, "60 kV to 500 kV Technical Interconnection Requirements for Power Generators" that pertains to wind generators.

The non-binding good faith cost estimate for the above Network Upgrades necessary to interconnect the proposed project to the BC Hydro Transmission System for a maximum injection of 14.9 MW is $1.321 million. The estimated time to implement the identified Network Upgrades is 12 – 18 months after the implementation funding is approved.

The above estimate and schedule do not include the work associated with Revenue Metering nor does it include the work required within the IC's facilities. Additional network upgrade requirements may be identified in the SIS or Facilities Study (FS) stages. The interconnection SIS and FS reports will provide greater details of the Interconnection Network Upgrade requirements and associated cost estimates and estimated construction timeline for this project.

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1.0 INTRODUCTION

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

Table 1: Summary of Project Information

Project Name	Wartenbe Wind Farm	
Interconnection Customer	[redacted]	
Point of Interconnection	On 1L349 at a distance of about 100 m from Sundance Lakes Substation (SLS)	
IC Proposed COD	December 31, 2019	
Type of Interconnection Service	NRIS ☒	ERIS ☐
Maximum Power Injection (MW)	14.9 (Summer)	14.9 (Winter)
Number of Generator Units	5	
Plant Fuel	Wind	

[redacted] the Interconnection Customer (IC), is proposing to develop a 15 MW wind farm facility named Wartenbe Wind Farm (the project) in the Peace Region of British Columbia. This IC's name is different from that in its data submission, and the name change from EDF EN Canada Inc. was requested by this customer during finalizing this report. The IC will install 5 (Vestas V117) turbines with a rated capacity of 3 MW each. All the 5 turbines are type 4 machines. The project's power injection into BC Hydro system is 14.9 MW. The Commercial Operation Date (COD) originally proposed by the IC for the project is December 31, 2018. The IC updated the COD to December 31, 2019 during the period of writing this report.

The IC originally proposed two options of connecting the project into the BC Hydro system. The first option was a tap connection onto the line 2L312 and the second option was a terminal connection on the 230 kV bus at Sundance Lakes Substation (SLS). The tap connection (first option) was considered as unacceptable since the line 2L312 is a critical facility to supply the area customers prior to a transmission reinforcement project (PRES as described below) in service. The second option of connecting the 15 MW wind farm to the SLS 230 kV bus was not a desirable option from economical aspect. Upon BC Hydro's suggestion, the IC proposed a tap connection on the 138 kV line 1L349, about 100 m from SLS. The IC's wind turbines will be connected through an about 11 km 34.5 kV feeder to the IC's 138 kV substation, which is located close to SLS approximately 100 m apart.

In the Peace Region the line 1L349 connects SLS westward to Chetwynd substation (CWD) which is connected to G. M. Shrum Generating Station (GMS) through 1L361. The SLS is also connected to BC Hydro's 230 kV Sukunka (SNK) substation through a 30.5 km 230 kV line 2L312.

The SNK substation is connected back to GMS through two radially connected 230 kV lines named 2L309 and 2L308. SLS is connected eastward to Shell Groundbirch Switching Station (SGB) through two parallel 230 kV lines, named 2L340 and 2L342. Figure 1 and Figure 2 describe the geographic layout of the project connections and its adjacent transmission system before and after the Site C project's transmission system and Peace Region Electricity Supply (PRES) project are completed in 2024. As these two projects will have significant changes to the area transmission system, it is necessary to study the project's impact under both the 2019 and 2024 system configurations.

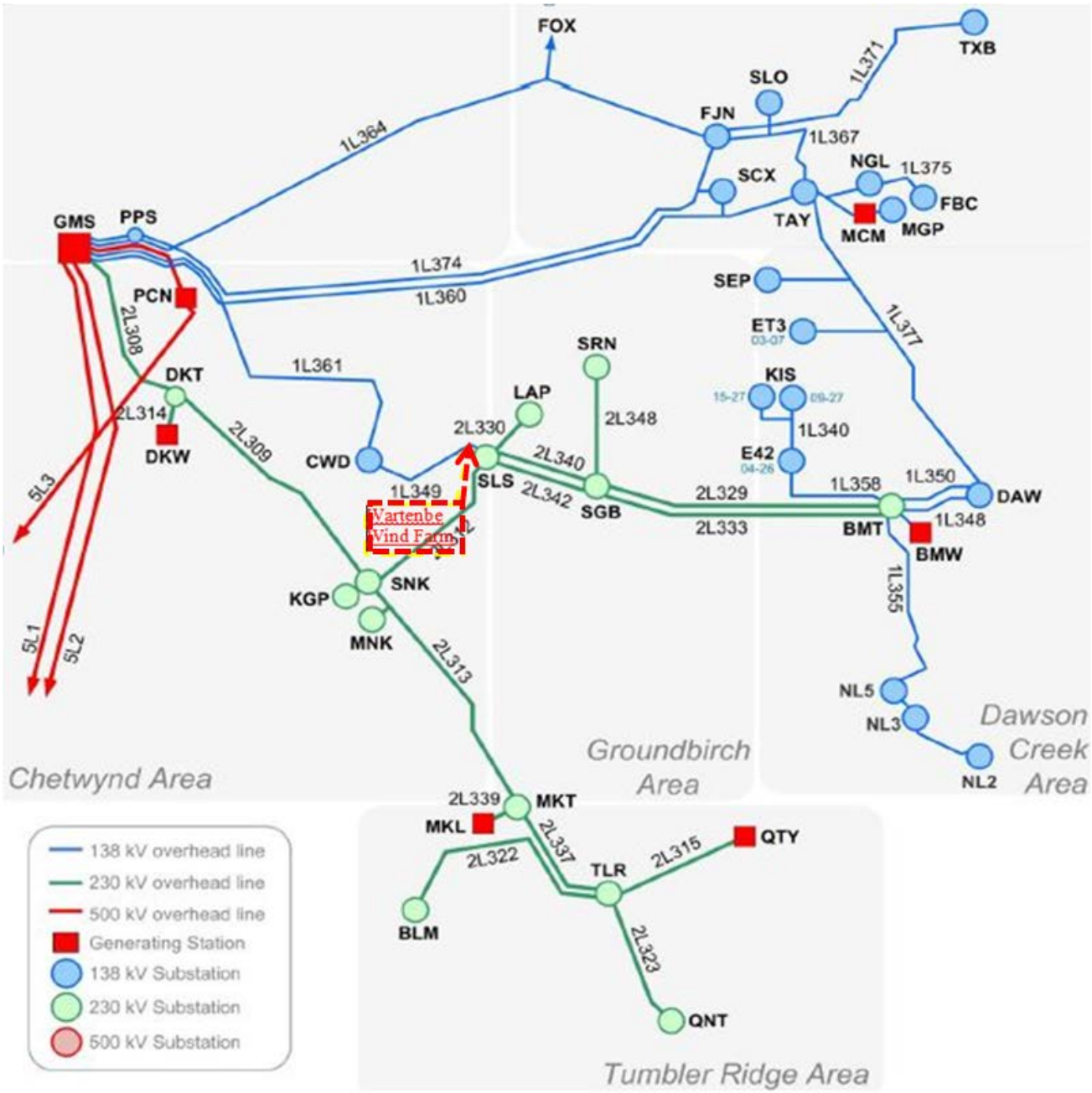

Figure 1: Geographic diagram of the project connections and its adjacent transmission system (Prior to Site C and PRES)

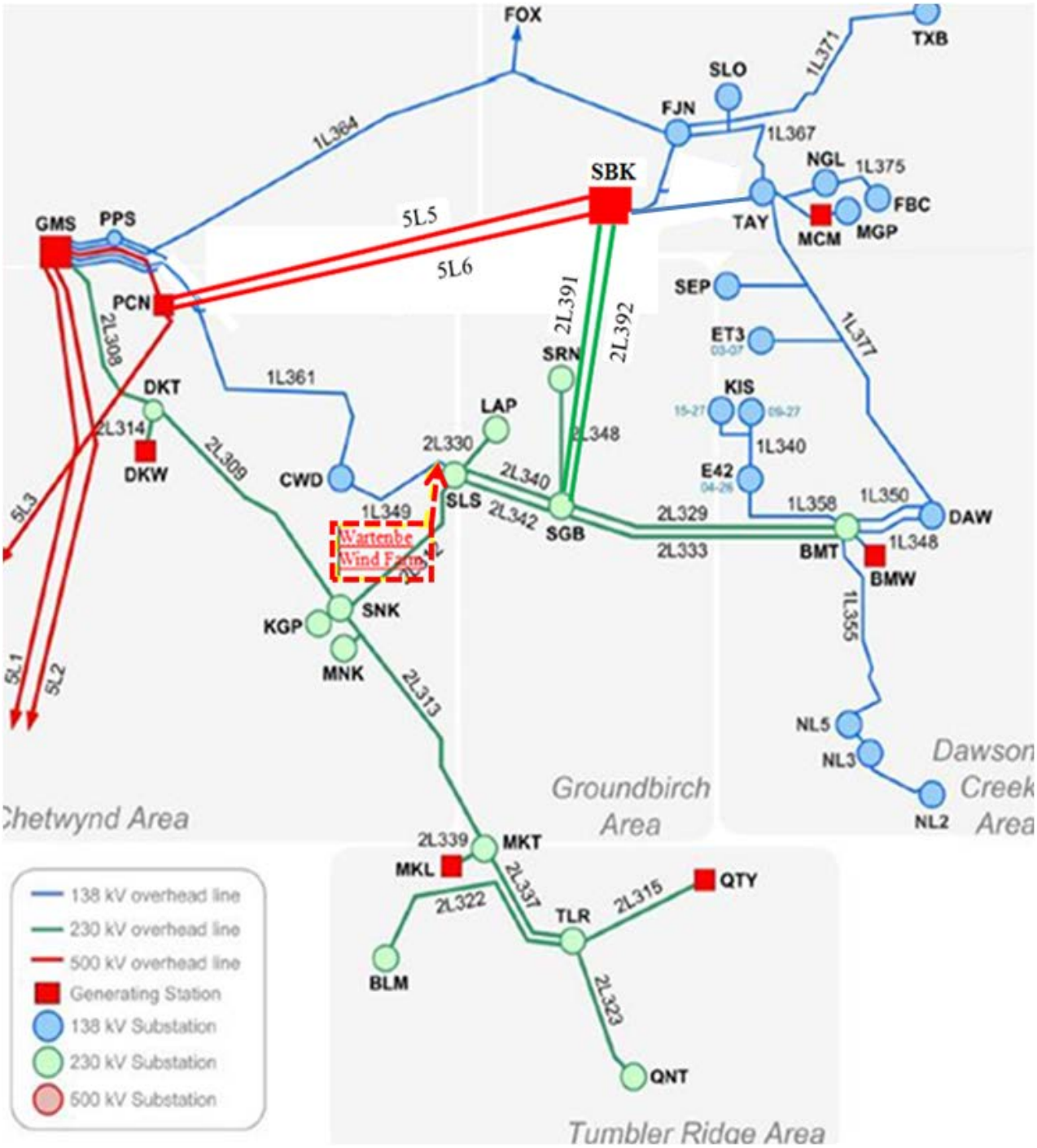

Figure 2: Geographic diagram of the project connections and its adjacent transmission system (after Site C and PRES)

2.0 STUDY PURPOSE AND SCOPE

The Feasibility Study is a preliminary evaluation of the system impact and cost of interconnecting the proposed project to the BC Hydro Transmission System. The study scope is restricted to power flow and short circuit analysis and investigates potential system constraints associated with the interconnection of the proposed project.

3.0 TERMS OF REFERENCE

This study investigates voltage and thermal overloading issues of the transmission network in the vicinity as a result of the proposed interconnection. BC Hydro planning methodology and criteria in compliance with the North America Reliability Corporation (NERC) Mandatory Reliability Standards are used in the studies.

The Feasibility Study does not include stability analysis, harmonic mitigation, or electro-magnetic transient analysis. Operating restrictions and other factors for possible second contingency outages are not studied at this stage either. Subsequent system impact/facilities studies and internal network studies will determine the requirements for reinforcements or operating restrictions/instructions for the above mentioned types of events.

4.0 STUDY ASSUMPTIONS

The study is carried out based on the latest data and information submitted by the IC on July 12, 2017 and the latest BC Hydro Interconnection Queue information. Reasonable assumptions are made to complete the study and the report, whenever such information is unavailable. The power flow cases studied include generation, transmission facilities, and load forecasts representing the queue position applicable to this project. Applicable seasonal conditions and the appropriate study years for the study horizon are also incorporated. The 2019 and 2024 summer and winter system configurations were selected for this study.
In the study cases the local generating plant outputs are listed in Table 2 below.

Table 2: Peace Region generation outputs used in this study

Peace Region IPP Generation Levels		
	Plant	Generation Output (MW)
1	Dokie Wind Farm (DKW)	144
2	Quality Wind Farm (QTY)	142
3	Bear Mountain Wind Farm (BMW)	102
4	Meikle Wind Farm (MKL)	185
5	Moose Lake Wind Farm (MLW)	15
6	Zonnebeke Wind Farm (ZBW)	30
7	South Peace Wind Farm (SPW)	45
8	Septimus Creek Wind Farm (SCW)	15
9	Babcock Ridge Wind Farm (BKW)	15
10	Seven Mile Wind Farm	15
11	McMahon Cogeneration Plant	100

Appendix A provides additional study assumptions.

5.0 STUDY RESULTS AND REQUIRED UPGRADES

5.1 Power Flow Study Results

Pre-contingency (N-0) and post-contingency (N-1) power flow analyses were performed to evaluate whether the project connection would cause any adverse impacts in the nearby areas.

Under system normal conditions (N-0), with selected generation outputs in the Peace Region, no thermal overloading or unacceptable voltage conditions on transmission elements have been observed.

Before the project comes into service, loss of 2L308 (N-1), will result in the thermal overloading of the 138 kV lines 1L349, 1L361, 1L367, 1L377 and the 230 kV line 2L312 with 2019 system configuration under light and heavy summer load scenarios. Under the above mentioned load conditions loss of 2L312 will result in overloading of 2L308. Under the heavy winter load

condition only 1L377 will be overloaded for loss of 2L308. The overloading problems can be mitigated adequately by the existing generation shedding Remedial Action Scheme (RAS) and its planned update in the Peace Region. The additional 14.9 MW power injection from the project will aggravate the overloading concerns for loss of 2L308 and the generation shedding RAS can adequately address the overloading concerns. The Wartenbe project is not expected to be included in the Peace Region generation shedding RAS, however this will need to be reviewed and confirmed in a future System Impact Study (SIS).

The existing overload concerns observed in the 2019 system configuration would be greatly reduced with the 2024 system configuration after the Site C project's transmission system and PRES projects are completed in 2024. Loss of 2L308 (N-1) will result in thermal overloading 2L312 only and vice versa. This thermal overloading problem is not due to the project connection and can be mitigated adequately by the generation shedding RAS in the Peace Region.

Under system normal configuration, tripping a major load in the Peace Region did not result in any observable overloading or abnormal voltage condition.

5.2 Substation Upgrade Requirements

The IC's 138 kV substation will be built about 100 m from SLS and its ground grid is required to be connected with the ground grid of SLS. No other station work has been identified for this project at this stage.

5.3 Protection and Control Requirements

Current transformers (CTs) on the customer side of Wartenbe's 138 kV entrance circuit breaker will be connected to the existing SLS 1L349 protection relays. SLS 1L349 protection will trip SLS 1L349 line circuit breaker, as well as the customer entrance 138 kV circuit breaker.

BC Hydro will provide revised settings of SLS/CWD 1L349 protections.

The Customer will provide power quality protection that complies with BC Hydro requirements as listed in BC Hydro's "60 kV to 500 kV Technical Interconnection Requirements for Power Generators".

The Customer will also comply with all the protection requirements as listed in BC Hydro's "60 kV to 500 kV Technical Interconnection Requirements for Power Generators".

BC Hydro will review Customer power quality protection and entrance protection.

6.0 COST ESTIMATE AND PROJECT SCHEDULE

Table 3 below lists the key facilities and system upgrades required in the BC Hydro system to interconnect the proposed project to the system. It also provides a non-binding good faith cost estimate for the Network Upgrades that would be the responsibility of the IC. The estimate and schedule do not include the work associated with Revenue Metering nor does it include the work required within the IC's facilities.

Table 3: Cost Estimate for the Required System Upgrades

Work Definition	Facilities	Estimated Cost
Stations, Transmission Line, Protection & Control	Tap connection at the POI on 1L349; Ground grid connection; Protection works for connecting Wartenbe.	
Estimated Interconnection Network Upgrade Cost:		**$1.321 m**

The non-binding good faith cost estimate for the above Network Upgrades necessary to interconnect the proposed project to the BC Hydro Transmission System for a maximum injection of 14.9 MW is $1.321 million.

The estimated time to implement the Network Upgrades required for interconnecting the project to the BC Hydro system is 12 – 18 months after the implementation funding is approved.

The above estimates were developed upon a number of key assumptions, which are available upon request. Two of those are listed below:

- The distance between SLS and the Wartenbe Wind Farm substation is about 100 m;
- No cost of any telecom work has been included;

7.0 CONCLUSIONS & DISCUSSION

The conclusions and requirements from this feasibility study of interconnecting the project to the BC Hydro Transmission System at the proposed POI are summarized below.

Interconnecting the project into the system would not result in any transmission element thermal overloads or unacceptable voltage conditions under system normal (N-0) scenarios.

The additional 14.9 MW power injection from the project will aggravate the existing overloading concerns on some transmission lines in Peace Region for loss of 2L308 (N-1) and an existing generation RAS would be adequate to mitigate the concerns.

The overloading conditions observed in the 2019 system configuration would be greatly reduced in the 2024 system configuration with the inclusion of the Site C project's transmission system and Peace Region Electricity Supply (PRES) projects.

The IC's 138 kV substation ground grid is required to be connected with the ground grid of BC Hydro's SLS to facilitate the modification of the SLS 1L349 primary and standby protection to trip SLS 1L349 line circuit breaker, as well as the customer entrance 138 kV circuit breaker.

Additional Network Upgrade requirements may be identified in the SIS or Facilities Study (FS) stages. The Interconnection SIS and FS reports will provide greater details of the Interconnection Network Upgrade requirements and associated cost estimates and estimated construction timeline for this project.

When the wind farm advances to the next study stages, the IC will need to ensure that the wind farm design will meet the interconnection requirements as stated in BC Hydro's "60 kV to 500 kV Technical Interconnection Requirements for Power Generators". Specifically, the wind farm will need to be capable of operating in a range of 0.95 leading to 0.95 lagging power factor as measured at the POI when injecting 14.9 MW into the system, regulating the POI voltage, and meeting the low voltage ride through requirements.

APPENDIX A

The cost estimate included in this report does not and cannot account for a variety of issues not under the control of BC Hydro including, but not limited to:

- The impact of additional equipment required as the result of more detailed studies;
- Actual equipment specified during engineering design;
- Fluctuations in costs over time;
- First Nation consultations;
- Property-related costs and issues;
- Any Certificate of Public Convenience and Necessity (CPCN) required from the British Columbia Utilities Commission (BCUC);
- Physical space constraints in network facilities.