Interconnection Feasibility Study Report

GIP-555-FEAS-R1

System Interconnection Request #555

100.8 MW Wind Generating Facility

Lunenburg County (L-6002)

2017-03-31

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer (IC) submitted an Interconnection Request (IR#555) for Network Resource Interconnection Service (NRIS) for a proposed 100.8 MW wind generation facility interconnected to the NSPI transmission system, with a Commercial Operation Date of 2020-09-30. The Point of Interconnection (POI) requested by the customer is on the 138 kV transmission line L-6002, at or near the 87W-Hubbards substation. Alternatively, Energy Resource Interconnection Service (ERIS) is proposed at the same POI.

The Generation Interconnection Procedures do not confer any rights to receive transmission service, which must follow the procedures of the NSPI Open Access Transmission Service. Preceding IR#555 is a long-term firm transmission service reservation in the amount of 330 MW from Nova Scotia to New Brunswick, as well as two transmission Interconnection Requests ahead of IR#555 which are considered in this study.

NRIS for IR#555 is expected to honour the long term firm reservation for delivery of 330 MW to the NS-NB border, plus delivery of between 172 MW and 220 MW of operating reserve to NB Power in accordance with reserve sharing agreements (Transmission Reservation Margin). This combination can result in a total transfer of 650 MW. The NRIS study identified a number of transmission contingencies inside Nova Scotia and New Brunswick which would violate thermal loading, voltage support, and uncontrolled separation criteria. Significant upgrades to the NS-NB interconnection would be necessary to support these levels of transfer, as identified in the *Nova Scotia Power 10 Year System Outlook*.

The alternative request to study ERIS addressed the issues associated with the NS-NB transfer limits. That is, IR#555 displaced an equivalent level of import from the Maritime Link to allow it to operate within the long-term firm reservation amount of 330 MW from NS to the NB border.

The assessment of 100.8 MW on the primary POI on the 138 kV line L-6002 indicated that there would be no issues with thermal overloads or voltage criteria violations local to the POI. L-6002 operates in a number of modes, depending on the status of 230 kV circuits between 120H-Brushy Hill and 99W-Bridgewater. L-6002 is normally operated as a radial circuit out of 90H-Sackville, but is connected through to 99W-Bridgewater whenever L-7008 or L-7009 is out of service. All configurations of L-6002 were studied without issue.

To provide for NRIS, upgrades would be necessary for the transmission system were identified:

- The line L-6613 from 1N-Onslow to 74N-Springhill is planned to be built in 2017-2018, but the switchgear was not planned to be changed. IR#555 will require switches at the 1N-Onslow end of L-6613 and the switchgear at the 74N-Springhill end must be uprated.
- To prevent voltage collapse in the Springhill-Amherst area, a 50 Mvar Static Var Compensator.

Although normally outside the scope of a feasibility study for the NSPI system, a contingency in New Brunswick (loss of the 345kV line from Memramcook to Salisbury) was found to overload the Memramcook 345 kV transformer in summer. This should be addressed by NB Power in the transmission service request studies under its OATT.

The alternate study for ERIS confirmed that no transmission upgrades were necessary to support a total NS firm export of 330 MW, plus reserve sharing with NB Power.

Data provided by the IC indicates that IR#555 should be able to meet this requirement without additional reactive support. Based on the provided rated power factor of the 4.2 MW Enercon E-141 EP4-FT (0.875), and the provided impedances of the transformers, supplementary reactive support probably will not be needed. This will be further investigated in the System Impact Study.

No concern regarding short-circuit or voltage flicker was found for this project on its own, provided that the project design meets NSPI requirements for low-voltage ride-through, reactive power range and voltage control system. Harmonics must meet the Total Harmonics Distortion provisions of IEEE 519.

The preliminary value for the unit loss factor is calculated to be -1.8% for 100.4 MW on L-6002 if metered at the POI and -0.7% if metered at the 138kV substation for IR#555, neglecting collector circuit and transformer losses. Losses were found to be sensitive to the generation dispatch at 91H-Tufts Cove. This means that the radial circuit from the Interconnection Substation to the POI were calculated to be about 1%.

Minimum short circuit levels at the POI were calculated at 590 MVA with all lines in-service and 304 MVA with one line out of service. However, adding the impedance of the radial circuit, minimum short circuits could be as low as 266 MVA, resulting in a Short Circuit Ratio of 2.66. These values should be communicated to the generator designers for control design. This project does not add enough fault current to affect the fault clearing duty of existing circuit breakers.

The POI on L-6002 is not considered Bulk Power System (BPS), and therefore the Interconnection Substation does not need to be designed to meet the requirements of NPCC Directory 4 *System Protection Criteria*.

The preliminary non-binding cost estimate for interconnecting 100.8 MW onto L-6002 via the new 19 km radial circuit would be $14,322,000 interconnection facility cost (including the cost of the radial 138kV line) and an additional $8,360,000 in network upgrades to support incremental transmission export capability for NRIS. For the option of ERIS, the interconnection cost would be the same $14,322,000 with no additional network upgrade cost. All cost estimates include a contingency of 10% and they will be further refined in the System Impact Study and the Facility Study.

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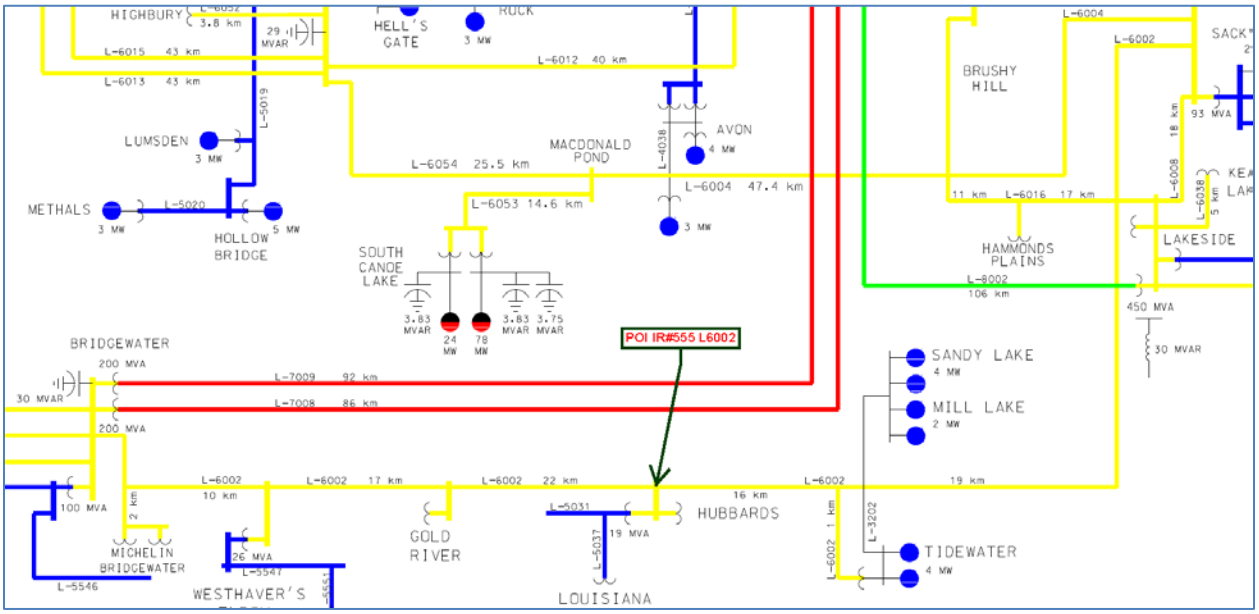
1 Introduction

The Interconnection Customer (IC) submitted an Interconnection Request (IR#555) for Network Resource Interconnection Service (NRIS) for a proposed 100.8 MW wind generation facility interconnected to the NSPI transmission system, with a Commercial Operation Date of 2020-09-30. The Point of Interconnection (POI) requested by the customer is on the 138 kV transmission line L-6002 at or near the existing 87W-Hubbards Wind, as shown in Figure 1.

Alternatively, the IC has requested that the projected be studied as Energy Resource Interconnection Service (ERIS).

Figure 1 Point of Interconnection (not to scale)



The Interconnection Customer (IC) signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI transmission system dated 2017-03-10, and this report is the result of that Study Agreement. This project is listed as Interconnection Request #555 in the NSPI Interconnection Request Queue, and will be referred to as IR#555 throughout this report.

2 Scope

This Interconnection Feasibility Study (FEAS) consists of a power flow and short circuit analysis. Based on this scope, the FEAS report shall provide the following information:

1. Preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the interconnection;
2. Preliminary identification of any thermal overload or voltage limits violations resulting from the interconnection;
3. Preliminary description and high level non-bonding estimated cost of facilities required to interconnect the Generating Facility to the Transmission System and to address the identified short circuit and power flow issues.

The Scope of this FEAS includes modeling the power system in normal state (with all transmission elements in service) under anticipated load and generation dispatch conditions.

In accordance with Section 3.2.2.2 of the Standard Generation Interconnection Procedures (SGIP), "the Interconnection Study for NR Interconnection Service shall assure that the Interconnection Customer's Generating Facility meets the requirements for NR Interconnection Service and as a general matter, that such Generating Facility's interconnection is also studied with the Transmission Provider's Transmission System at peak load, under a variety of severely stressed conditions, to determine whether, with the Generating Facility at full output, the aggregate of generation in the local area can be delivered to the aggregate of load on the Transmission Provider's Transmission System, consistent with the Transmission Provider's reliability criteria and procedures".

In accordance with Section 3.2.1.2 of Standard Generation Interconnection Procedures (GIP), as approved by the UARB on February 10, 2010, the FEAS for ERIS consists of short circuit/fault duty, steady state (thermal and voltage) analyses. The short circuit/fault duty analysis would identify direct Interconnection Facilities required and the Network Upgrades necessary to address short circuit issues associated with the Interconnection Facilities. The steady state studies would identify necessary upgrades to allow full output of the proposed Generating Facility and would also identify the maximum allowed output, at the time the study is performed, of the interconnecting Generating Facility without requiring additional Network Upgrades. It is therefore assumed that transmission interfaces limits will not be exceeded to avoid system upgrades in an ERIS study.

A more detailed analysis of the technical implications of this development will be included in the System Impact Study (SIS) report. The SIS includes system stability analysis, power flow analysis such as single contingencies (including contingencies with more than one common element), off-nominal frequency operation, off-nominal voltage operation, low voltage ride through, harmonic current distortion, harmonic voltage distortion, system protection, special protection systems (SPS), automatic generation

control (AGC) and islanded operation. The impacts on neighbouring power systems and the requirements set by reliability authorities such as Northeast Power Coordinating Council (NPCC), North American Electric Reliability Corporation (NERC), and NSPI will be addressed at that time and will include an assessment of the status of the Interconnection Facility as a Bulk Power System element. The SIS may identify and provide a non-binding estimate of any additional interconnection facilities and/or network upgrades that were not identified in this FEAS.

An Interconnection Facilities Study follows the SIS in order to ascertain the final cost estimate to interconnect the generating facility.

In accordance with Section 2.4 of the SGIP, "Nothing in this GIP shall constitute a request for transmission service or confer upon an Interconnection Customer any right to receive transmission service". Transmission Service is subject to the requirements of the Nova Scotia Power Inc. Open Access Transmission Tariff (OATT).

This study does not examine the effects of increased wind generation on the overall operation and security of the NSPI power system. The most recent Integrated Resource Plan indicated that the maximum amount of wind generation which the NSPI system could accept without significant reinforcement of the ties with other systems was about 600 MW, which has currently been exceeded with the recent Community Feed-In Tariff (COMFIT) Program.

3 Assumptions

This FEAS is based on the technical information provided by the Interconnection Customer. The Point of Interconnection (POI) and configuration is studied as follows:

1. Network Resource Interconnection Service type, with an alternate request to study Energy Resource Interconnection Service type, per section 3.2 of the SGIP.

2. Commercial Operation date 2020-09-30.

3. The Interconnection Facility consists of 100.8 MW net generation with 24 (alternatively 12) units of 4.2 MW Enercon E-141 EP4-FT Wind Turbines on three collector circuits. These are classified as Type 4 Wind Energy Conversion Systems using full IGBT inverter technology.

4. The IC indicated that the POI is on the 138 kV transmission line L-6002 near 87W-Hubbards substation. The IC has indicated that the Interconnection Customer's Generating Facility is remote from the POI, connected with a new 19 km radial 138kV circuit. The radial circuit is indicated by the IC to be constructed using 556.5 kcmil Dahlia AAC conductor. Electrical characteristics for this new line were calculated using data from the *Aluminum Electrical Conduct Handbook* by the Aluminum Association. NSPI standard H-Frame structure dimensions were used.

5. The generation technology used must meet NSPI requirement for reactive power capability of at least 0.95 capacitive to 0.95 inductive at the HV terminals of the IC Substation Step Up transformer. It is also required to have high-speed Automatic Voltage Regulation to maintain constant voltage at the designated voltage control point during and following system disturbances as determined in the subsequent System Impact Study. The designated voltage control point will either be the low voltage terminals of the wind farm transformer, or if the high voltage terminals are used, equipped with droop compensation controls. It is assumed that the generating units are not de-rated in their MW capability when delivering the required reactive power to the system.

6. Preliminary data was provided by the IC for the IC substation step-up transformers. Modeling for the primary interconnection point was conducted with a 138 kV-34.5 kV 66/88/110 MVA Interconnection Facility transformer with a positive sequence impedance of 7,5% and an X/R ratio of 32. The IC indicated that this Interconnection Facility transformer has a grounded wye-grounded wye with a delta tertiary winding configuration with +/-10% off-load tap changer. The impedance of generator step-up transformers is assumed to be 6% on 4.8 MVA with an assumed X/R ratio of 7.5.

7. Collector circuit data was not provided, so typical data was assumed with the understanding that the net output of the plant will be impacted by losses through transformers and collector circuits.

8. The FEAS analysis is based on the assumption that IR's higher in the Generation Interconnection Queue and OATT Transmission Service Queue that have completed a System Impact Study, or that have a System Impact Study in progress will proceed, as listed in Section 4 below.

9. It is assumed that the wind turbines are equipped with a "cold weather option" suitable for delivering full power under expected Nova Scotia winter environmental conditions. The data sheet supplied with the application provided a winter rating based on an ambient temperature of 0°C, which would not be considered suitable for Nova Scotia.

10. The IC has indicated that this project is intended for export from Nova Scotia, and as such, there will be no adverse impact on Native Load Customers in the form of out-of-merit dispatch costs, compromised reliability, or any ancillary services outside the requirements of the NSPI OATT.

11. Planning criteria meeting NERC Standard TPL-001-4 *Transmission System Planning Performance Requirements* and NPCC Directory 1 *Design and Operation of the Bulk Power System* as approved for use in Nova Scotia by the Utility and Review Board, are used in evaluation of the impact of any facility on the Bulk Electric System.

12. It is assumed that all committed transmission upgrades associated with the Maritime Link have been completed.

4 Projects with Higher Queue Positions

All in-service generation is included in the FEAS.

As of 2017-03-30 the following projects are higher queued in the Interconnection Request Queue and OATT Transmission Service Queue, and have the status indicated.

Interconnection Requests -Included in FEAS

- All distribution connected generation qualified under the COMFIT program
- IR #426 GIA Executed, in-service
- IR #507 GIA Executed
- IR #516 GIA Executed
- IR #540 GIA in Progress
- IR #542 SIS in Progress

Interconnection Requests –Not Included in FEAS

- IR #514 FEAS complete
- IR #543 Load FAC in progress
- IR #549 FEAS in progress
- IR #550 FEAS in progress
- IR #551 FEAS in progress
- IR #552 FEAS in progress

OATT Transmission Service Queue– Included in FEAS

- TSR-400 Long Term Firm Point to Point, under construction

OATT Transmission Service Queue– Not included in FEAS

- TSR-401 Point to Point Application Complete
- TSR-402 Network, Application Complete
- TSR-403 Point to Point, Application Complete
- TSR-404 Network, Application Complete
- TSR-405 Network, Application Complete
- TSR-406 Network, Application Complete

Only Transmission Service Request TSR400 and Interconnection Requests IR#516 and IR#542 are expected to have an impact on IR#555.

If any of the higher-queued projects included in this FEAS are subsequently withdrawn from the Queue, the results of this SIS may require updating or a re-study may be necessary. The re-study cost incurred as a result of the withdrawal of the higher-queued project shall be the responsibility of the Interconnection Customer that withdraws the higher queued project.

5 Objective

The objective of this FEAS is to provide a preliminary evaluation of the system impact and the high-level non-binding cost estimate of interconnecting the 100.8 MW generating facility to the NSPI transmission system at the designated location. The assessment will identify potential impacts on the loading of transmission elements, which must remain within their thermal limits. Any potential violations of voltage criteria will be identified and addressed. If the proposed new generation increases the short-circuit duty of any circuit breakers beyond their rated capacity, the circuit breakers must be upgraded. Single contingency criteria[1] are applied for both NRIS and ERIS assessments.

This FEAS is based on a power flow and short circuit analysis and does not include a complete determination of facility changes/additions required to increase system transfer capabilities that may be required to the Bulk Power System to meet the design and operating criteria established by NPCC and NERC or required to maintain system stability. These requirements will be determined by the subsequent interconnection System Impact Study (SIS).

Although this FEAS is not meant to constitute a System Impact Study for Transmission Service under the OATT, it is acknowledged that this project is intended for export from Nova Scotia and will be studied in two ways; the first will assume that the output from IR#555 will not displace any firm transactions and will be incremental to established transfer levels (NRIS), the second will assume that the anticipated transfer limit between Nova Scotia and New Brunswick in 2020 is honoured (ERIS).

[1] A Single Contingency is defined by NPCC as "A single event, which may result in the loss of one or more elements".

6 Short-Circuit Duty / Short Circuit Ratio

The maximum (design) expected short-circuit level is 5000 MVA on 138 kV systems. The short-circuit levels in the area before and after this development are provided below in Table 6-1 for the designated POI (L-6002). Because the generator type for IR#555 is Type 4, the fault characteristics are given as only slightly greater than full load current, or X'd = 1.0 per unit.

The maximum short-circuit level at the POI on L-6002 with IR#555 off-line will be 1172 MVA in 2022. With IR #555 on-line the short-circuit level will increase to 1254 MVA at the POI. Similarly, under minimum generation conditions, the short circuit level will be 875 MVA with all lines in-service, and 381 MVA with the line from POI to 50N-Trenton out of service. This translates into minimum Short Circuit Ratio of between 3.8 and 8.8 for the 100.8 MW option and double that for the 50.4 MW alternative.

Table 6-1: Short-Circuit Levels. IR555 on L-6002 Three-phase MVA (1)

Location	Without IR #555	With IR #555
All transmission facilities in service		
Point of Interconnection	1311	1402
90H-Sackville 138kV	3660	3718
74W-Westhavers Elbow	1504	1536
Minimum Conditions		
IR#555 138kV site	266 line out	416 lines in
Point of Interconnection	304 line out	590 lines in

(1) Classical fault study, flat voltage profile

The interrupting capability of the 138 kV circuit breakers is at least 5000 MVA at 90H-Sackville. The circuit breaker at 87W-Hubbards transformer is rated 5000 MVA, and the circuit breakers at 75W-Weshavers are rated at 3500 MVA. As such, the interrupting ratings will not be exceeded by this development on its own. IR#551 does not add appreciable fault duty to local circuit breakers.

The minimum short circuit level with all lines in service at IR#555 138kV substation is 416 MVA, however with the configuration of L-6002 connected through to 99W-Bridgewater (operating with L-7008 out) could result in short circuit level as low as 266 MVA. The generator manufacturer should be made aware of the potential minimum Short Circuit Ratio of 2.6 for control system design.

7 Voltage Flicker and Harmonics

Due to the lack of flicker coefficient information on the Enercon E-141 Wind Turbines, this study assumes the same flicker data as for the Enercon E-82 machine. Type 4 wind turbines are not expected to result in appreciable voltage flicker at minimum generation conditions. Therefore voltage flicker should not be a concern for this project.

The generator is expected to meet IEEE Standard 519-1992 limiting voltage Total Harmonic Distortion (all frequencies) to a maximum of 1.5%, with no individual harmonic exceeding 1.5% on 138 kV, and a maximum of 1.5% THD and no individual harmonic exceeding 1% on 230 kV.

8 Thermal Limits

This facility is requested to be interconnected via a new substation s to the existing 138 kV transmission line L-6002 at or near the 87W-Hubbards substation as shown in Figure 1. There is currently only a single line tap at 87W-Hubbards which would need to be developed into a four-breaker ring bus. Alternately, a new three-breaker ring bus could be developed at POI away from 87W-Hubbards. A ring bus is required because the proposed new radial circuit to IR#555 is more than 10% of the length of line L-6002.

L-6002 is designed and insulated for 138 kV (insulator strings, phase spacing, conductor height), using 556.5 ACSR Dove conductor. The section of L-6002 between 87W-Hubbards and 90H-Sackville has a conductor design temperature of 100°C, but is limited to 143 MVA by the rating of the in-line switches at the 87W-Hubbards end. The section if L-6002 between 87W-Hubbards and 99W-Bridgewater has a conductor design temperature of 50°C which limits the line rating in summer, and switches that limit the line in winter. Table 8.1 summarizes the transmission line ratings in the vicinity of IR#555.

Table 8.1 Local Transmission Element Limits

Line	Conductor	Design Temperature	Limiting Element	Summer Rating Normal/Emergency	Winter Rating Normal/Emergency
L-6002a	556.5 Dove	100°C	Switch	143/157	143/157
L-6002b	556.5 Dove	50°C	Conductor/Switch	110/121	143/157
L-7008	1113 Beaumont	70°C	Relaying	398/438	398/438
L-7009	795 Drake	50°C	Conductor	223/245	340/374
L-5003	556.5 Dove	50°C	Conductor/Switch	55/61	72/79

IR#555 was modeled as a new wind farm interconnected at the 87W-Hubbards substation via a 19 km radial circuit terminated with the wind farm facility, which has its own station transformer, collector circuits, and WECS units. This configuration would produce similar loading on existing circuits as if it was connected via a new three-breaker ring bus on L-6002.

It should be noted that L-6002 is normally open at 75W-Westhavers Elbow and therefore operates as a radial circuit between 103W-Gold River and 90H-Sackville. However whenever one of the 230kV circuits L-7008 or L-7009 are open between 120H-Brushy Hill and 99W-Bridgewater, line L-6002 is closed through from 90H-Sackville to 99W-Bridgewater.

Figure 2 shows the circuit breaker configuration in the part of the system between 87W-Hubbards and 99W-Bridgewater, Figure 3 shows the configuration of L-6002 in the 90H-Sackville area.

Figure 2 Western Breaker Configuration

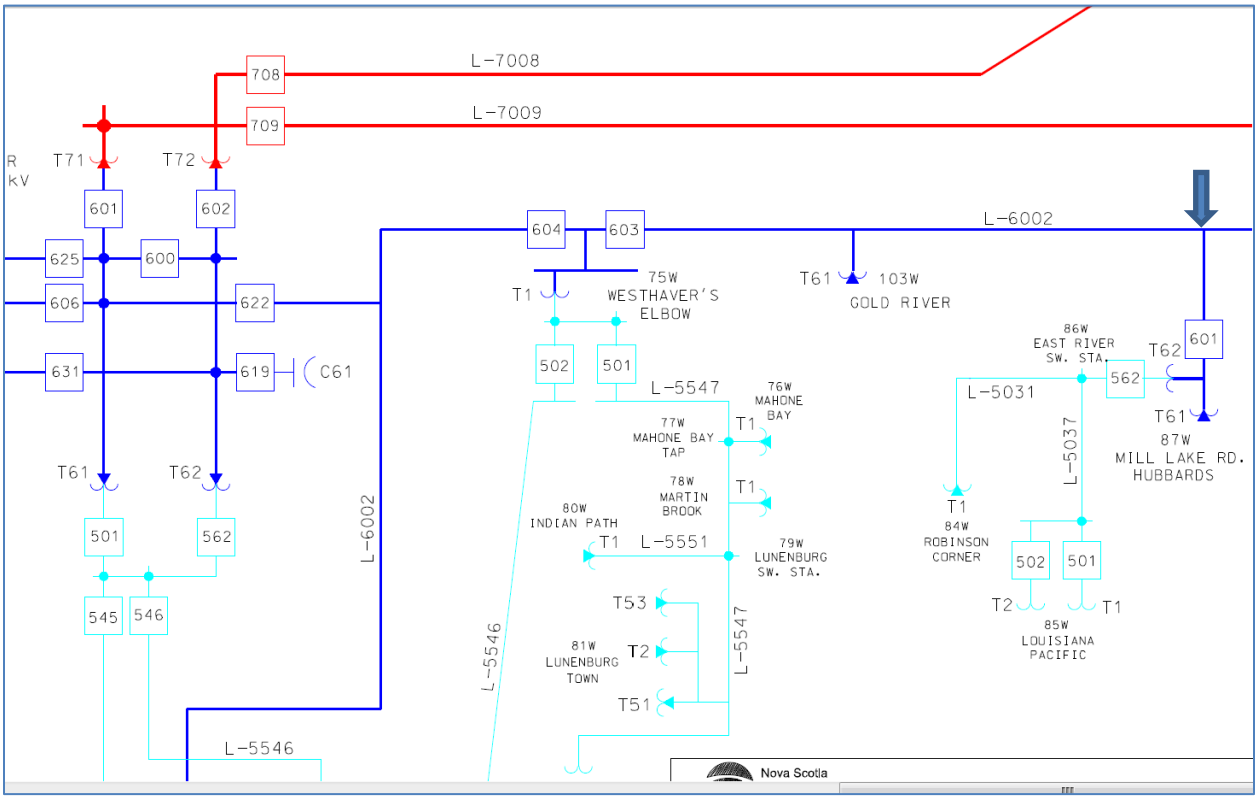
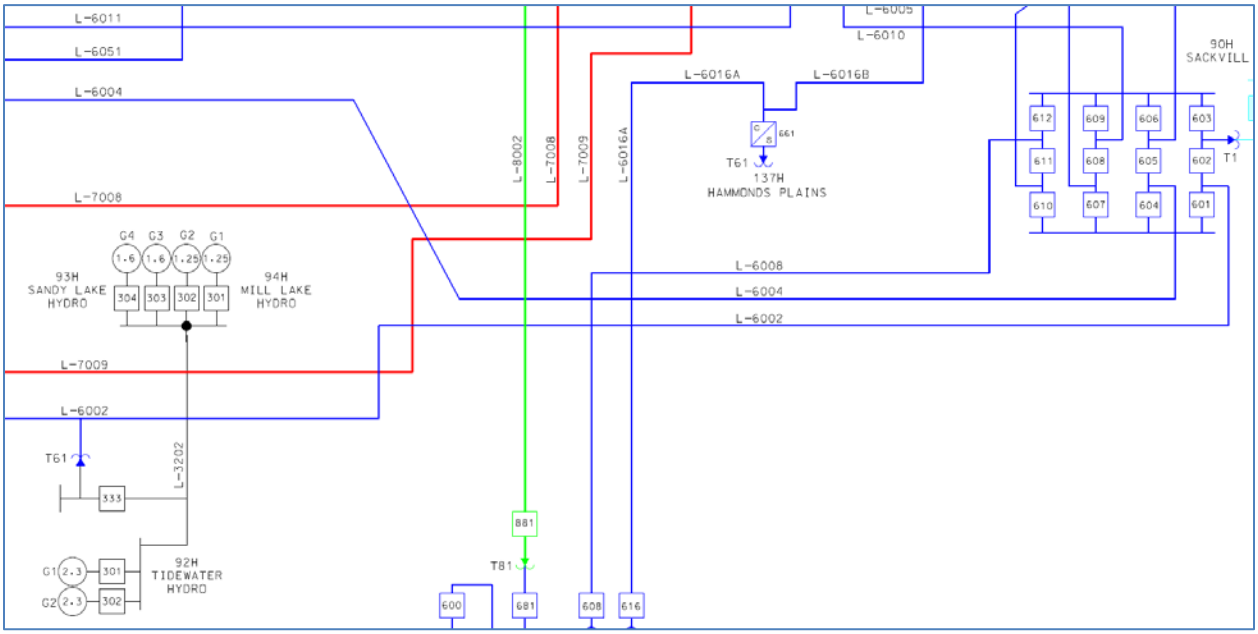


Figure 3 Metro Breaker Configuration



IR#555 as NRIS

With the system economically dispatched within present limits, the addition of 100.8 MW at the POI did not result in any issues of concern for loading of L-6002, L-7008 or L-7009 under any normal design contingency. With L-6002 in its normal configuration breaker 75W-603 is open and the POI would be radial to 90H-Sackville. In this configuration, line fault protection for L-6002 would send a transfer trip signal to IR#555 to prevent islanded operation with load. A transfer trip signal would also be sent for a fault on the new radial line from the POI to IR#555.

With L-7008 or L-7009 out of service, L-6002 is closed through from 90H-Sackville to 99W-Bridgewater (breaker 75W-603 is closed). For a fault on the section of L-6002 between the POI and 90H-Sackville, breakers at the POI would open and IR#555 would remain in service connected to 99W-Bridgewater.

Operational limits must apply to the situation where a 138kV bus at 90H-Sackville (90H-B1 or 90H-B2) are out of service. In that rare case, loss of the second bus would result in L-6002 connected through transformer 90H-T1 and L-5003 to 99H-Farrell St in Dartmouth, which is only rated at 60-80 MVA.

There is a long-term firm transmission reservation between Nova Scotia and New Brunswick (Transmission Service Request TSR-400) of 330 MW. Transmission upgrades are underway to permit the NS-NB transfer of 330 MW plus the delivery of between 172 MW and 220 MW of shared Operating Reserve in accordance with the NS-NB Interconnection Agreement for a total capability of between 502 MW and 550 MW.

As NRIS, IR#555 adds 100.8 MW (minus collector circuit losses) to the flow between Onslow and the New Brunswick border, resulting in a total export of between 600 MW and 650 MW, including the firm transmission reservation of 330 MW and the delivery of shared operating reserve to New Brunswick. While exporting high amounts of power from NS, the Export Power Monitor SPS (NPCC Type III) must be armed to quickly reject/runback up to 330 MW of generation in Nova Scotia to avoid overload of the parallel 138kV transmission, maintain synchronism between the NS and NB power systems, and avoid excess over-frequency operation of the NS power system. Loss of L-8001 (designated L-3025 on the New Brunswick side of the border) will activate this SPS for the following contingencies:

- Loss of L-8001/L-3025 for any reason
- Breaker failure of 67N-814 (L-8001, 67N-T81)
- Breaker failure at Memramcook NB (L-3006, L-8001/L-3025, ME-T3)

Loss of L-8001, even with activation of the Export Power Monitor SPS, resulted in L-6613, the new circuit to be constructed this year in association with TSR-400 reservation, to exceed its thermal rating with IR#555 NRIS plus TSR-400 and reserve delivery to NB. L-6613 is designed with the same conductor /characteristics as L-6503. If switchgear at 1N-Onslow and 74N-Springhill is uprated to 2000 A then the emergency rating of L-

6613 can be increased from the planned rating of 287 MVA to an emergency rating of 363/400 MVA (summer/winter).

A contingency on the NB side of the border (loss of L-3006) was found to result in exceeding the emergency rating of the Memramcook 345kV – 138kV transformer by 10%. This issue would normally be dealt with if a SIS is conducted by the NB Power System Operator in conjunction with a transmission service request into or through their system, in accordance with the NB Power OATT.

Winter peak load conditions were studied with the NS-NB firm export of 330 MW and the assumption that Maritime Link would be operated at no greater than 330 MW. Under these conditions, the reserve sharing commitment to New Brunswick was limited to 172 MW. Addition of IR#555 as NRIS results in a total export of 602 MW. Contingencies related to loss of L-8001 result in voltage collapse of the 138 kV intertie and separation from New Brunswick, even with SPS action and thermal uprating of L-6613. Reactive power support in the form of a 0-50 Mvar Static Var Compensator (SVC) would be required on the 138kV bus at 74N-Springhill

IR#555 as ERIS

As ERIS, transmission flows would respect existing transfer limits to avoid the need for transmission reinforcement. Therefore it was assumed that IR#555 formed part of the transmission reservation TSR-400 (330 MW firm) with reserve delivery to NB Power of 187 MW. Under this scenario, Maritime Link is dispatched at 374 MW, which still provides SPS run-back capability of 330 MW. The contingency loss of L-8001 requires SPS rejection/run-back of 330 MW resulting in line L-6613 loading to 100% of its emergency rating MVA, so it would not require switchgear uprating. Loss of L-3006 in New Brunswick brings flow on the Memramcook 345kV transformer to 102% of its summer emergency rating.

In the case of winter peak firm export of 330 MW plus reserve of 172 MW, no issues were identified as long as there was a sufficient generation in NS to run-back for SPS action.

9 Voltage Limits

This project, like all new generating facilities must be capable of providing both lagging and leading power factor of 0.95, measured at the HV terminals of the IC Substation Step Up Transformer, at all production levels up to the full rated load of 100.8 MW.

Data provided by the IC indicates that IR#555 would likely meet this requirement without additional reactive support. The data sheet provided was for the 4.2 MW Enercon E-141 EP4-FT WECS which states that the normal power factor range is 0.875 leading and lagging at the machine terminals. Depending on the characteristics of the collector circuits and given the impedances of the transformers, supplementary reactive support may be needed in the form of capacitor banks at the low voltage terminals of the Interconnection Transformer, or a mixture of Enercon model FT and FTQ WECS units. This will be further investigated in the System Impact Study.

A centralized controller will be required which continuously adjusts individual generator reactive power output within the plant capability limits and regulates the voltage at the 34.5 kV bus voltage. The voltage controls must be responsive to voltage deviations at the terminals of the Interconnection Facility substation, be equipped with a voltage set-point control, and also have the ability to slowly adjust the set-point over several (5-10) minutes to maintain reactive power within the individual generators capabilities. The details of the specific control features, control strategy and settings will be reviewed and addressed in the SIS, as will the dynamic performance of the generator and its excitation. Line drop compensation, voltage droop, control of separate switched capacitor banks must be provided.

The NSPI System Operator must have manual and remote control of the voltage set-point and the reactive set-point of this facility to coordinate reactive power dispatch requirements.

This facility must also have low voltage ride-through capability as per Appendix G of the Standard Generator Interconnection and Operating Agreement (GIA). The SIS will state specific options, controls and additional facilities that are required to achieve this.

The material provided by the IC indicates that the Enercon units are available with a STATCOM Reactive Power mode. It is recommended that the IC obtain an optional quote for this feature, as it may help to support system voltage and stability during high power transfer levels. The need for this feature will be further examined in the SIS.

10 System Security / Bulk Power Analysis

As NRIS this generating facility will increase loading on the Onslow Import interface (flow into Onslow from eastern Nova Scotia) which can be heavily loaded from the supply sources at Lingan, Point Aconi, Wreck Cove, Point Tupper and Trenton as well as imported power from the Maritime Link. This interface supports flow towards the load centre in Halifax and exports to New Brunswick and is therefore often congested, especially with transmission out of service for maintenance. Increased flow on this interface may require increased reactive support at Onslow and in the Halifax area or invoke facility additions that can reduce the reactive support requirements. This will be evaluated in the SIS.

The SIS will determine if any facility changes are required to permit the proposed higher transmission loadings while maintaining compliance with NERC/NPCC standards and in keeping with good utility practice.

As noted in Section 8, the transmission capacity between Nova Scotia and New Brunswick is limited to the long term firm transmission reservation associated with the Maritime Link, including the transmission capacity necessary to deliver reserve to NB Power under the Interconnection Agreement. There is some incremental capacity available, but not enough to support this NRIS application at the locations identified. The *Nova Scotia Power 10 Year System Outlook* is posted on the NSPI OASIS. Section 9.5 of that report discusses the characteristics of the NS-NB and notes “the timing and configuration of an expansion to the provincial intertie has yet to be determined”.

It is important to note that, without a second 345 kV transmission line between Nova Scotia and New Brunswick, export capability is dependent on the availability of sufficient generation in Nova Scotia to be rejected or run-back by SPS action. This means that for NS export up to 330 MW, the Maritime Link must be operating in import mode in excess of 330 MW or two thermal units at Pt. Aconi/Lingan must be operating at full load.

The POI on L-6002 would not be considered Bulk Power System (BPS), and therefore the Interconnection Substation does not need to be designed to meet the requirements of NPCC Directory 4 *System Protection Criteria*.

11 Expected Facilities Required for Interconnection

NRIS – 100.8 MW at POI on L-6002

The following facility changes are required to interconnect IR #555 at the proposed POI on L-6002:

1. A three-breaker ring bus development adjacent to the right-of-way of L-6002, designed for 138 kV. Circuit breakers must be rated 2000 A. Non-BPS
2. Proposed new 138 kV transmission line from the POI to IR#555 facility meets NSPI design standards.
3. Control and communications between the wind farm and NSPI SCADA system (to be specified).

Network Upgrades to provide NRIS service.

4. Upgrade switchgear for L-6613 to 2000 A at 1N-Onslow (switches only) and 74N-Springhill (breaker and switches).
5. Install 50 Mvar SVC at Springhill.

Alternate ERIS – 100.8 MW at POI on L-6002

The following facility changes are required to interconnect IR #555 at the proposed POI on L-6002:

6. A three-breaker ring bus development adjacent to the right-of-way of L-6002, designed for 138 kV. Circuit breakers must be rated 2000 A. Non-BPS
7. Proposed new 138 kV transmission line from the POI to IR#555 facility meets NSPI design standards.
8. Control and communications between the wind farm and NSPI SCADA system (to be specified).

Network Upgrades to provide ERIS service.

9. None.

Requirements for the Generating Facility

1. The radial branch line to a new Interconnection Substation would be designed for 138 kV and would be fully shielded for 1.0 km out of each substation. The Interconnection Substation would require a circuit breaker at high side of customer power transformer and protections as acceptable to NSPI. An RTU to interface with NSPI's SCADA, with telemetry and controls as required by NSPI.

2. Facilities to provide 0.95 leading and lagging power factor when delivering rated output at the HV terminals of the IC Substation Step Up Transformer when the voltage at that point is operating between 95 and 105 % of nominal. The functionality of Enercon STATCOM Reactive Power mode should be considered.
3. Centralized controls. These will provide centralized voltage set-point controls and are known as Farm Control Units (FCU). The FCU will control the 34.5 kV bus voltage and the reactive output of the machines. Responsive (fast-acting) controls are required. The controls will also include a curtailment scheme which will limit or reduce total output from the facility, upon receipt of a telemetered signal from NSPI's SCADA system.
4. NSPI to have control and monitoring of reactive output of this facility, via the centralized controller. This will permit the NSPI Operator to raise or lower the voltage set-point remotely.
5. Low voltage ride-through capability as per Appendix G to the Standard Generator Interconnection and Operating Agreement (GIA).
6. Real-time monitoring (including a Remote Terminal Unit) of the interconnection facilities. Local wind speed and direction, MW and Mvar, as well as bus voltages are required.
7. Facilities for NSPI to execute high speed rejection of generation (transfer trip) if determined in SIS. The plant may be incorporated into SPS run-back schemes.
8. Synthesized inertial response similar to the features of Enercon IE controls.
9. Automatic Generation Control to assist with tie-line regulation.
10. Operation at ambient temperature of -30°C

12 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

Estimates for NSPI Interconnections Facilities and Network Upgrades for interconnecting 100.8 MW wind energy as NRIS onto the identified POI on the 138 kV transmission system are included in Table 12-1. Estimates for the alternate ERIS 100.8 MW are included in Table 12-2.

Table 12-1: Cost Estimates identified from FEAS scope 100.8 MW on L6002 NRIS		
	Determined Cost Items	**Estimate**
NSPI Interconnection Facilities		
i	New transmission line POI to IR#555 site (19 km)	$5,320,000
ii	138 kV Single breaker bus primary equipment and control building at IR#555 site.	$1,700,000
iii	Site preparation for new substation at POI on L-6002	$1,000,000
iv	138 kV 3-breaker ring bus primary equipment and control building	$4,000,000
v	Protection, control	$300,000
vi	Protection modifications for remote sites	$200,000
vii	Communications	$500,000
	Subtotal	$13,020,000
	Contingency (10%)	$1,302,000
	Total Interconnection Facilities	$14,322,000
Network Upgrades (including increased tie capacity for NRIS)		
viii	Upgrade switchgear on L-6613 to 2000 A (1N and 74N)	$500,000
ix	50 Mvar SVC at 74N-Springhill	$7,000,000
x	Protection modifications	$100,000
	Subtotal	$7,600,000
	Contingency (10%)	$760,000
	Total Network Upgrades	$8,360,000
Totals		
xi	Total of Determined Cost Items	$22,682,000
	To be Determined Costs	
xii	System additions to address potential stability limits	TBD (SIS)
xiii	Memramcook transformer loading issue	TBD (NB Power SIS)

The preliminary non-binding cost estimate for interconnecting 100.8 MW at the POI on L-6002 at or near 87W-Hubbards would be $14,322,000 plus network upgrade cost of $8,360,000 for NRIS service, for a total cost of $22,682,000. All cost figures include a 10% contingency.

Table 12-2: Cost Estimates identified from FEAS scope 100.8 MW on L6002 ERIS		
	Determined Cost Items	**Estimate**
NSPI Interconnection Facilities		
i	New transmission line POI to IR#555 site (19km)	$5,320,000
ii	138 kV Single breaker bus primary equipment and control building at IR#555 site.	$1,700,000
iii	Site preparation for new substation at POI on L-6002	$1,000,000
iv	138 kV 3-breaker ring bus primary equipment and control building	$4,000,000
v	Protection, control	$300,000
vi	Protection modifications for remote sites	$200,000
vii	Communications	$500,000
	Subtotal	$13,020,000
	Contingency (10%)	$1,302,000
	Total Interconnection Facilities	$14,322,000
Totals		
viii	Total of Determined Cost Items	$14,322,000
	To be Determined Costs	
ix	System additions to address potential stability limits	TBD (SIS)

The preliminary non-binding cost estimate for interconnecting 100.8 MW at the POI on L-6002 as alternate ERIS would be $14,322,000 including a contingency of 10%.

12 Loss Factor

Injection of 100.8 MW of power at the POI, for delivery to NB border will be incremental to transmission system losses serving native load. To assist in the evaluation of the impact of the location of the POI, loss factors from the POI to the NS-NB border were calculated. This calculation does not include any losses from the generators to the POI (generator transformer, collector circuits, Interconnection Substation equipment:

- IR#555, 100.8 MW with POI on L-6002 excluding radial branch losses - Loss Factor -1.8%. This assumes that metering is compensated to the POI.
- IR#555, 100.8 MW with POI on L-6002 including radial branch losses - Loss Factor -0.7%. This assumes that metering is at the Interconnection Facility substation.

This means that, under certain dispatch conditions, injection of 100.8 MW at IR#555 can reduce system losses by 1-2 MW from the POI to the NS-NB border, or 0.5-1.0 MW from the interconnection substation to the NS-NB border. This result was most sensitive to generation dispatch at 91H-Tufts Cove.

13 Issues to be addressed in SIS

The following provides a preliminary scope of work for the subsequent SIS for IR#555. The SIS will include a more comprehensive assessment of the technical issues and requirements to interconnect generation as requested. It will include contingency analysis, system stability and ride through and operation following a contingency (N-1 operation). The SIS must determine the facilities required to operate this facility at full capacity, withstand any contingencies (as defined by the criteria appropriate to the location) and identify any restrictions that must be placed on the system following a first contingency loss. The SIS will confirm the options and ancillary equipment that the customer must install to control flicker, voltage and ensure that the facility has the required ride-through capability. The SIS will be conducted in accordance with the GIP with the assumption that all appropriate higher-queued projects will proceed and the facilities associated with those projects are installed.

The following outline provides the minimum scope that must be complete in order to assess the impacts. It is recognized the actual scope may deviate, to achieve the primary objectives.

The assessment will consider but not be limited to the following.

i. Facilities that the customer must install to meet the requirements of the GIP
ii. The minimum transmission additions/upgrades that are necessary to permit operation of this Generating Facility, under all dispatch conditions, catering to the first contingencies listed.
iii. Guidelines and restrictions applicable to first contingency operation (curtailments etc.)
iv. Under-frequency load shedding impacts

To complete this assessment the following first contingencies, as a minimum, will be assessed:

- L-8001/3025
- L-3006
- Memramcook 345/138 kV transformer
- L-6613
- L-6514
- L-6535/L-1159
- L-8001 & 67N-T81 (common circuit breaker)
- L-8002 & 67N-T81 (common circuit breaker)
- L-3006 & L-3025 & Memramcook 345/138 kV Tx (common breaker)
- L-3006 & L3017 (common breaker)
- 1N-B61 (bus fault)
- L-1108/1190 Common 138 kV structure

- Loss of 180 MW of load under peak load conditions
- Loss of largest generation source in NS
- Loss of Maritime Link

To complete this assessment the dynamics of the following first contingencies, as a minimum, will be assessed:

- 3 phase fault L-8001/3025 at 67N-Onslow, NS Import SPS operation (islanding)
- 3 phase fault L-8001/3025 at 67N-Onslow, NS Export SPS operation
- 3 phase fault L-3006 at Memramcook, NB SPS/UVLS operation (islanding)
- 3 phase fault L-3006 at Memramcook, NB Export SPS
- 3 phase fault L-3006 at Salisbury, NB SPS/UVLS operation (islanding)
- 3 phase fault L-8002 at 67N-Onslow
- SLG L-3017, drops L-3017&L-3006 (common CB), NB SPS/UVLS operation,
- SLG Memramcook T3, drops L-3006 (common CB), NB SPS/UVLS operation
- 3 phase fault 1N-Onslow 138 kV bus B61
- 3 phase fault on L7005 at 67N-Onslow

Any changes to SPS schemes required for operation of this generating facility, in addition to existing generation and facilities that can proceed before this project, will be determined by the SIS as well as any required additional transmission facilities. The determination will be based on NERC[2] and NPCC[3] criteria as well as NSPI guidelines and good utility practice. The SIS will also determine the contingencies for which this facility must be curtailed.

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[2] NPCC criteria are set forth in its Reliability Reference Directory #1 *Design and Operation of the Bulk Power System*
[3] NERC transmission criteria are set forth in *NERC Reliability Standards TPL-001, TPL-002, TPL-003*