



**Interconnection Feasibility Study Report
GIP-IR610-FEAS-R1**

**Generator Interconnection Request 610
90 MW Wind Generating Facility
Antigonish County, NS**

2021-11-30

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer (IC) submitted an Interconnection Request (IR#610) for Network Resource Interconnection Service (NRIS) or Energy Resource Interconnection Service (ERIS) for a proposed 90 MW wind generation facility interconnected to the NSPI transmission system, with a Commercial Operation Date of 2024-12-31. The Point of Interconnection (POI) requested by the customer is the 230kV line L-7005, with an alternate POI on the 230kV line L-7003. L-7005 and L-7003 run between 67N-Onslow EHV and 3C-Port Hastings, and the proposed POI would both be approximately 16% of the distance from the 3C-Port Hastings end. The alternate POI will only be considered if unexpected results not contemplated in the Scoping Meeting are found with the primary POI.

There are four transmission and three distribution Interconnection Requests currently in the Advanced Stage Transmission and Distribution Queue that must be included in the study models for IR#610. In addition, there is one long-term firm transmission service reservation in the amount of 800 MW from New Brunswick to Nova Scotia (TSR-411), and one 500 MW long-term firm transmission service request from Newfoundland to Nova Scotia (TSR-412) that also must be accounted for. The two transmission service requests are expected to be in service in 2025 and system studies are currently underway to determine the associated upgrades to the Nova Scotia transmission system. These upgrades are expected to materially alter the configuration of the transmission system in Nova Scotia. As a result, the following notice has been posted to the OASIS site at <https://www.nspower.ca/oasis/generation-interconnection-procedures>:

Effective January 19th, 2021, please be advised that the completion of advanced-stage Interconnection Studies under the Standard Generator Interconnection Procedures (GIP) may be delayed pending the outcome of the Transmission Service Request (TSR) 411 and 412 System Impact Studies, which are expected to identify significant changes to the NSPI transmission system. The expected completion date for these studies is December 31, 2021. Feasibility Studies initiated prior to the completion of these TSR System Impact Studies will be performed based on the current system configuration.

This study assumes that the addition of generation from IR#610 will displace coal-fired generation in eastern Nova Scotia for both NRIS and ERIS.

The assessment of the POI on the 230 kV line L-7005 indicated that transmission upgrades would not be necessary to deliver 90 MW without exceeding emergency thermal ratings of equipment. No violations of voltage criteria were found for IR#610.

Since both L-7005 is classified as Bulk Power System, interconnection with that line will require a three-breaker 230kV ring bus. This new substation will be classified as Bulk Power System under NPCC criteria and Bulk Electric System under NERC criteria.

Data provided by the IC indicates that IR#610 may not be able to meet reactive requirements without additional reactive support. Based on the provided rated power factor of the Vestas V170 6 MW wind turbines, the provided impedances of the transformers and typical collector circuit impedances, approximately 12 Mvar of supplementary reactive support may be needed to meet the net power factor of +0.95 to -0.95 at the Interconnection Facility 230kV bus. As specific details of

the collector circuits become available, the need for supplemental reactive power support will be further investigated in the System Impact Study.

No concern regarding high short-circuit level 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. Harmonics must meet the Total Harmonics Distortion provisions of IEEE 519. Short Circuit Ratio is not likely to be an issue for inverter-based generation controls. The minimum short circuit level at the Interconnection Facility 230kV bus is 1198 MVA with all lines in service, and 555 MVA with L-7005 open between the POI and 3C-Port Hastings.

As the POI for IR#610 is part of the Nova Scotia Bulk Power System, protection at 3C-Port Hastings and 67N-Onslow must comply with NPCC Directory 4 requirements. The IR#610 Interconnection Customer substation at Upper Afton will also be classified as Bulk Power System, and therefore protection systems at that site also needs to meet NPCC BPS criteria, and also classified as part of the NERC Bulk Electric System (BES), subject to the applicable NERC Reliability Criteria. As IR#610 has dispersed generation totalling more than 75 MVA, each generator will also be classified as a BES element.

The preliminary value for the unit loss factor is calculated as +8.6% at the POI at L-7005. Losses associated with the IC facilities (collector circuits, transformers) are excluded from this calculation.

The preliminary non-binding cost estimate for interconnecting 90 MW to the POI on L-7005, including the cost of the three-breaker ring bus line connection and protection upgrades at each end of L-7005 is \$9,361,000. The cost estimates include a contingency of 10%, and this estimate will be further refined in the System Impact Study and the Facility Study. In this estimate, \$8,200,000 of the amount represents Network Upgrade costs which are funded by the Interconnection Customer, but which are eligible for refund under the terms of the GIP. The remainder of the costs are fully funded by the Interconnection Customer. The estimated time to construct the Transmission Providers Interconnection Facilities is 18-24 months after receipt of funds and cleared right of way from the customer.

Because the analysis did not uncover any unexpected issues, the alternate POI on L-7003 was not considered.

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1 Introduction

The Interconnection Customer (IC) submitted an Interconnection Request for Network Resource Interconnection Service (NRIS) for a proposed 90 MW wind generation facility interconnected to the NSPI transmission system, with a Commercial Operation Date of 2024-12-31. The Point of Interconnection (POI) requested by the customer is the 230kV circuit L-7005, with an alternate POI at the 230kV circuit L-7003. The proposed primary POI is in close proximity to the circuit L-7005, whereas the alternate POI is located 2.3 km from L-7003. The primary and alternate POI are approximately 25.9 km and 24.4 km respectively from the 3C-Port Hastings EHV substation.

The IC signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI transmission system dated 2021-08-09, and this report is the result of that Study Agreement. This project is listed as Interconnection Request 610 in the NSPI Interconnection Request Queue and will be referred to as IR#610 throughout this report. The study is to include Energy Resource Interconnection Service (ERIS) as well as NRIS.

Figure 1 shows the proposed geographic location of IR#610 in relation to the NSPI transmission system.

Figure 1 Upper Afton Site Location



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Figure 2 is a simplified one-line diagram of the transmission system configuration near the proposed POI. Figures 3 and 4 show the circuit breaker configuration of transmission lines in the vicinity of the POI.

Figure 2 Point of Interconnection (not to scale)

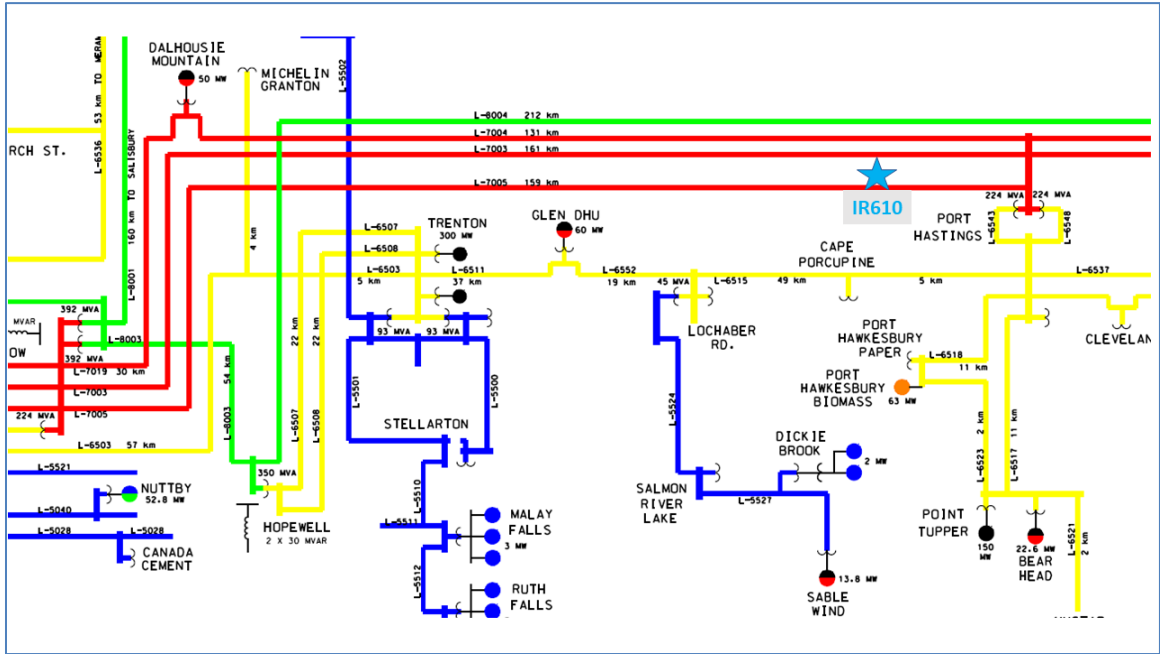


Figure 3 Circuit Configuration West of POI

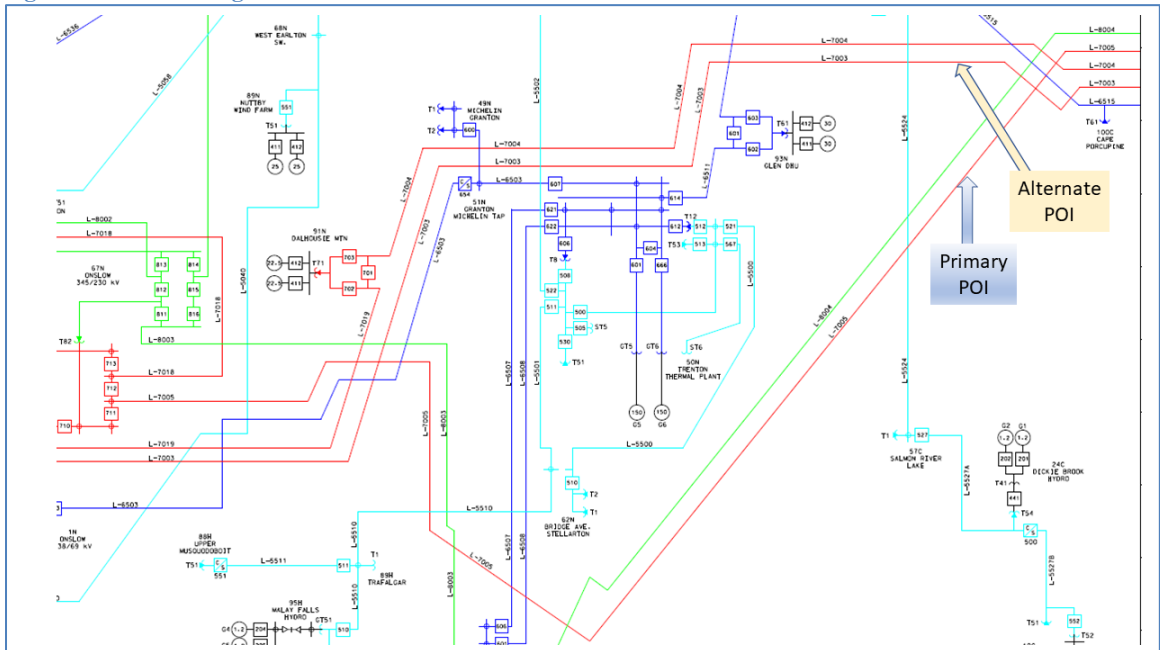
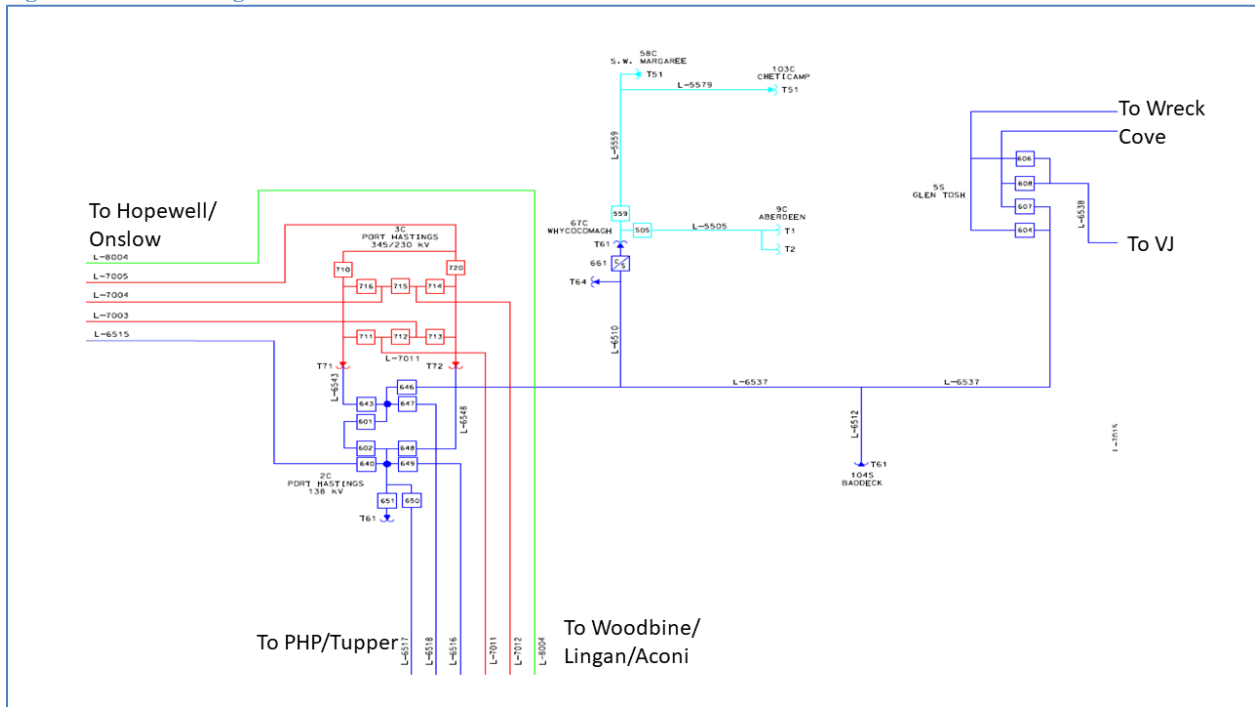


Figure 4 Circuit Configuration East of POI



2 Scope

The objective of this Interconnection Feasibility Study (FEAS) is to provide a preliminary evaluation of system impacts from interconnecting the proposed generation facility to the NSPI transmission system at the requested location. The assessment will identify potential impacts on transmission element loading, which must remain within their thermal limits. Any potential violations of voltage criteria will be identified and addressed. If the proposed generation increases the short-circuit duty of any existing circuit breakers beyond their rated capacity, the circuit breakers must be upgraded. Single contingency criteria are applied.

In accordance with Section 6.1 of the Generator Interconnection procedures (GIP), the alternate POI is only studied if the FEAS uncovers unexpected results not contemplated during the Scoping Meeting.

The scope of the FEAS includes the modelling of the power system in normal state (with all transmission elements in service) under anticipated load and generation dispatch conditions. A power flow and short circuit analysis is performed to provide the following information:

- Preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the interconnection, and any network upgrades necessary to address the short circuit issues associated with the IR. Expected minimum short circuit capability will also be identified for the purposes of Short Circuit Ratio analysis.
- Preliminary identification of any thermal overload or voltage limit violations resulting from the interconnection and identification of the necessary network upgrades to allow full output of the proposed facility. Thermal limits are applied to the seasonal (summer/winter) emergency ratings of transmission elements. Voltage violations occur when the post-contingency transmission bus voltage is outside the range of +/-10% of nominal voltage.
- Preliminary analysis of the ability of the proposed Interconnection Facility to meet the reactive power, power quality and cold-weather capability requirements of the NSPI *Transmission System Interconnection Requirements*¹.
- Preliminary description and high-level non-binding estimated cost and time to construct the facilities required to interconnect the generating facility to the transmission system.
- For comparative purposes, the impact of IC#610 on incremental system losses under standardized operating conditions is examined.

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 the system transfer capabilities that may be required to meet the design and operating criteria established by NSPI, the Northeast Power Coordinating Council (NPCC), and the North American Electric Reliability Corporation (NERC). These requirements will be determined by a more detailed analysis in the subsequent interconnection System Impact Study (SIS). An Interconnection Facilities Study (FAC) follows the SIS to ascertain the final cost estimate to the interconnect the generating facility.

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. NRIS and ERIS per section 3.2 of the GIP.
2. Commercial Operation date 2024-12-31.
3. The Interconnection Customer Interconnection Facility (ICIF) consists of up to 15 Wind Energy Converter System (WECS) units; Vestas V170, 6.0 MW, 720V, Type 4

¹ [transmission-system-interconnection-requirements \(nspower.ca\)](https://www.nspower.ca/transmission-system-interconnection-requirements)

- (full converter), capped at a total of 90 MW, connected to three collector circuits operating at a voltage of 34.5kV.
4. The proposed POI on L-7005 is considered Bulk Power System facilities and will therefore require three-breaker ring bus in accordance with Table 8 of the NSPI *Transmission System Interconnection Requirements*.
 5. The generation technology used must meet NSPI requirements 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 transformer, consisting of one 230kV/34.5kV 60/80/100 MVA station transformer. The substation step-up transformer was modeled with a positive-sequence impedance of 8.0% on 60 MVA with an X/R ratio of 40. The IC indicated that this Interconnection Facility step-up transformer has a grounded wye-delta-wye winding configuration with +/-10% on-load tap changer in (assumed) 32 steps. The zero-sequence impedance was given as 7.2% on 60 MVA. The impedance of each generator step-up transformer was given as 9.9% on 7.0 MVA with an assumed X/R ratio of 11.
 7. Detailed collector circuit data was not provided, so typical data ($R+jX = 0.01+j0.035$ p.u. on 100 MVA) was assumed with the understanding that the net real and reactive power 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.
 10. 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.
 11. The rating of transmission lines in the vicinity of IR#610 are shown in Table 1.

Line	Conductor	Design Temp	Limiting Element	Summer Rating Normal/Emergency	Winter Rating Normal/Emergency
L-6503	1113 Beaumont	85°C	Switchgear	287/315 MVA	287/315 MVA
L-6511	556.5 Dove	60°C	Conductor	140/154 MVA	184/202 MVA
L-6552	556.5 Dove	50°C	Conductor	110/121 MVA	143/157 MVA
L-6515	556.5 Dove	50°C	Conductor	110/121 MVA	143/157 MVA
L-7003	556.5 Dove	70°C ²	Conductor	275/302 MVA	345/379 MVA
L-7004	556.5 Dove	60°C	Conductor	233/246 MVA	307/338 MVA
L-7019	556.5 Dove	70°C	Conductor	273/303 MVA	345/379 MVA
L-7005	1113 Beaumont	70°C	CT Ratio	398/438 MVA	398/438 MVA

4 Projects with Higher Queue Positions

All in-service generation is included in the FEAS, except for Lingan Unit 2, which is assumed to be retired.

As of 2021-10-26, the following projects are higher queued in the Advanced Stage Interconnection Request Queue and are committed to the study base cases:

- IR426: GIA executed
- IR516: GIA executed
- IR540: GIA executed
- IR542: GIA executed
- IR557: SIS complete
- IR569: GIA executed
- IR568: GIA executed
- IR566: GIA executed
- IR574: FAC complete

The following projects have been submitted to the Transmission Service Request (TSR) Queue:

- TSR411: SIS in progress
- TSR412: SIS in progress

Preceding IR#610 are four transmission and three distribution Interconnection Requests with GIA's executed; one transmission IR with the FAC complete and one distribution IR with the SIS complete; a long-term firm point-to-point transmission service reservation in the amount of 800 MW from New Brunswick to Nova Scotia (TSR-411); and a 500 MW long-term firm transmission service request from Newfoundland to Nova Scotia (TSR-

² L-7003 is currently being uprated from a design temperature of 60°C to 70°C. This study assumed that the upgrade is complete before IR#610 is in service.

412). The two transmission service requests are expected to be in service in 2025 and system studies are currently underway to determine the required upgrades to the Nova Scotia transmission system. As a result, the following notice has been posted to the OASIS site at <https://www.nspower.ca/oasis/generation-interconnection-procedures>:

Effective January 19th, 2021, please be advised that the completion of advanced-stage Interconnection Studies under the Standard Generator Interconnection Procedures (GIP) may be delayed pending the outcome of the Transmission Service Request (TSR) 411 and 412 System Impact Studies, which are expected to identify significant changes to the NSPI transmission system. The expected completion date for these studies is December 31, 2021. Feasibility Studies initiated prior to the completion of these TSR System Impact Studies will be performed based on the current system configuration.

5 Short-Circuit Duty / Short Circuit Ratio

The maximum (design) expected short-circuit level is 5,000 MVA (21 kA) on 138kV systems and 10,000 MVA (25 kA) on 230kV system. The fault current characteristic for the Type 4 fully converted units is assumed to be 1.7 times rated current for up to 5 cycles, or $X'd = 0.589$ per unit.

Short circuit analysis was performed using PSS®E for a classical fault study, 3LG and flat voltage profile at 1.0 p.u. V. The short-circuit levels in the area before and after this development are provided below in Table 2 (L-7005 POI).

Table 2: Short-Circuit Levels. IR#610 (Type 4) on L-7005 Three-phase MVA ⁽¹⁾		
Location	Without IR#610	With IR#610
All transmission facilities in service		
Interconnection Facility (230kV)	2075	2187
3C-Port Hastings (230kV)	2875	2967
67N-Onslow (230kV)	4016	4065
Minimum Conditions (PA1, LG1, ML In-Service)		
Interconnection Facility (230kV), all lines in-service	1198	1311
Interconnection Facility (230kV), L-7005 open at 3C	555	667
Interconnection Facility (230kV), L-7005 open at 67N	1014	1126

(1) Classical fault study, flat voltage profile

The interrupting capability of the 230 kV circuit breakers at 67N-Onslow and 3C-Port Hastings is at least 10,000 MVA. As such, the interrupting ratings at this substation will

not be exceeded by this development on its own. Therefore IR#610 will not impact the circuit breakers in the terminal substations of L-7005.

Inverter-based generation installations often have a minimum Short Circuit Ratio (SCR) for proper operation of converters and control circuits. Based on the calculated short circuit levels, a POI on L-7005, and a 90 MW installation consisting of 15 units each 6 MVA, the short circuit ratio would be 13.3 at the HV terminals of the IR#610 substation with all lines in service and IR#610 off line. This falls to 6.2 with L-7005 open at 3C-Port Hastings, and 11.2 if L-7005 is open at 67N-Onslow.

The IC has indicated that SCR of 5 can allow standard control settings to be employed.

6 Voltage Flicker and Harmonics

Flicker coefficient information was not provided for the Vestas V170 – 6MW Wind Turbines, however, it is known that Type 4 wind turbines typically have a flicker coefficient of 2.0 - 2.4 at angle of 85°, which is about half that of Type 3 machines. Type 4 wind turbines are not expected to result in appreciable voltage flicker at minimum generation conditions. Voltage flicker will be further examined when data for the 6.0 MW Vestas V170 machine is made available for the SIS.

The generator is expected to meet IEEE Standard 519-2014 limiting voltage Total Harmonic Distortion (all frequencies) to a maximum of 1.5%, with no individual harmonic exceeding 1.5% on 230 kV.

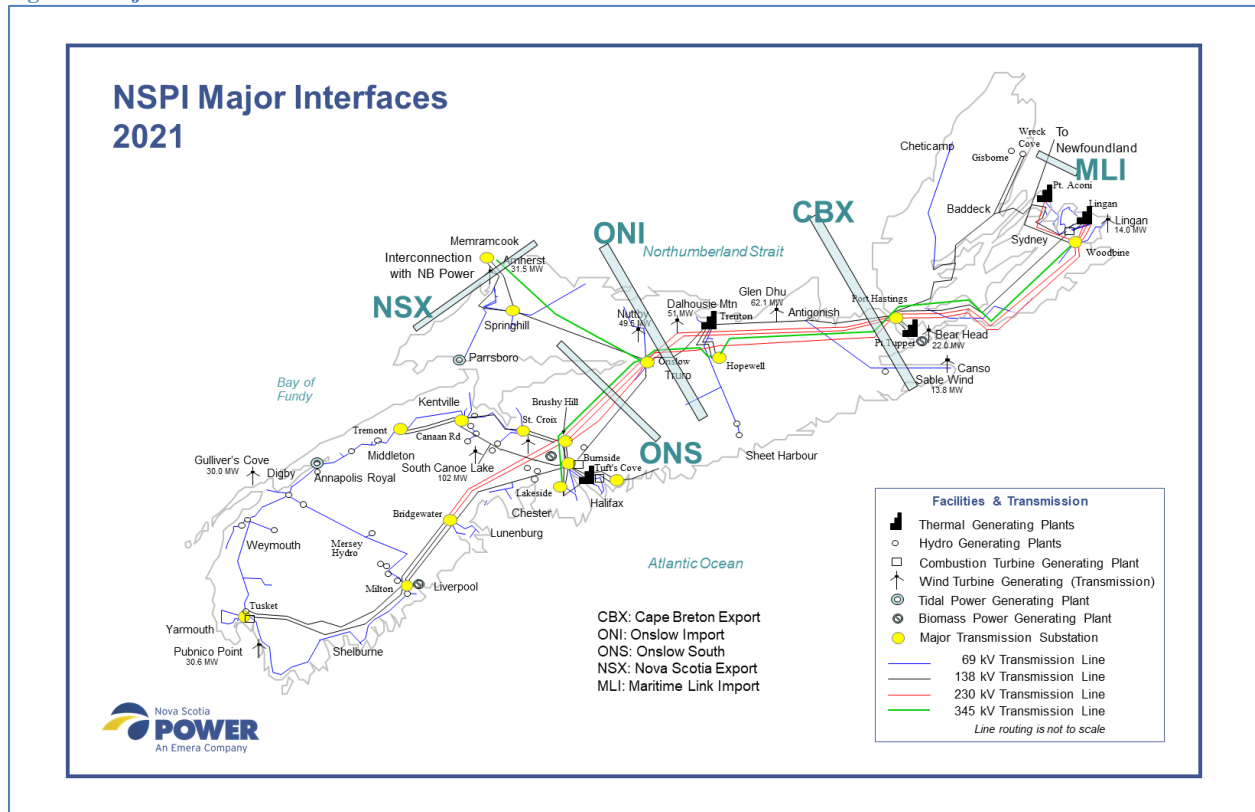
7 Load Flow Analysis

The load flow analysis was completed for generation dispatches under system summer peak load and winter peak load conditions, expected to stress the east-west corridor across the transmission interfaces Cape Breton Export (CBX) and Onslow Import (ONI). Generation dispatch was also chosen to represent import and export scenarios that consider expected flows from the existing transmission service reservation associated with the Maritime Link, and scenarios where Maritime Link imports displace NS thermal generation.

The major transmission interfaces/corridors relating to the IR#610 are shown in Figure 5. The nominal interface thermal limits are summarized in Table 3. NSPI relies on Remedial Action Schemes (RAS)³ approved by NPCC to maintain interface limits. These RAS are armed by system conditions and flow across the respective interfaces and react to pre-determined contingencies to rapidly reduce flow by either tripping generation in Cape Breton or running-back Maritime Link HVdc import.

³ Also referred to as Special Protection System (SPS)

Figure 5 Major Transmission Interfaces



Interface	NLI (1)	NSX (2)	CBX (3)	ONI	ONS (4)
Summer	475	330-500	875-1075	1075-1275	600-850
Winter	475	330-500	950-1150	1275	600-975

- (1) NLI is limited by simultaneous New Brunswick Import
- (2) NS import from NB is dependant on conditions in NB
- (3) Dependant on generation at Trenton and Point Tupper
- (4) Dependant on reactive power reserve in Metro

Transmission connected wind generation facilities were typically dispatched at approximately 40%, except in the vicinity of IR#610. There is high co-relation between wind plants in the Central Region between Port Hastings and Onslow, so it is reasonable to expect that these other wind plants would be near full output when IR#610 is at rated output. The cases and dispatch scenarios considered are shown in Table 4.

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Table 4: Base Case Dispatch (MW)								
Case	MLI	NS-NB	CBX	ONI	ONS	LIN	TRE	Wind
SP01	475	330	1050	1110	672	277	160	110
SP02	475	0	839	883	782	320	160	122
SP03	475	330	868	845	462	80	0	384
SP04	475	0	749	890	820	328	165	250
SP05	475	0	727	775	674	324	160	122
SP06	475	0	880	860	862	210	0	250
SP07	-100	-225	230	326	462	192	165	213
W01	320	150	950	1170	870	485	324	233
W02	475	150	1150	1211	921	485	165	218
W03	320	150	851	1063	792	486	324	235
W04	475	0	1150	1115	930	483	165	75
W07	-100	-172	259	503	555	232	324	412

S - Summer Peak W - Winter Peak LIN – Lingan Gen TRE – Trenton Gen

For NRIS analysis, this FEAS added IR#610 and displaced coal-fired generation in Cape Breton, reducing Cape Breton Export (CBX) transfers while maintaining Onslow Import (ONI) transfers. Single contingencies were applied at the 345 kV, 230 kV, and 138 kV voltage levels for the above system conditions with IR#610 interconnected to the POI on L-7005. Automated analysis searched for violations of emergency thermal ratings and emergency voltage limits for each contingency. Contingencies studied are listed in Table 5.

Table 5 Contingency List			
Transmission Line	Transformer / Bus	Circuit Breaker Failure	Double Circuit Tower
L-7014, L-7021, L-7022	88S: T71, T72	88S: 710, 711, 713, 720, 721, 722, 723*	L-6534 + L-7021
L-7011, L-7012, L-7015, L-8004*	101S: T81, T82	101S: 701, 702, 703, 704, 705, 706, 711, 712, 713, 811, 812*, 813*, 814, 816	
L-6515, L-6516, L-6537*	2C: B61*, B62	4C: 620, 621, 622, 623	
L-7003, L-7004, L-7005	3C-T71	3C: 710, 712, 713, 715, 716	L-7003 + L-7004*
L-6503, L-6613	1N: B61, B62	1N: 600, 613	

L-8001*, L-8002	67N: T71, T81	67N: 701, 702, 7-3, 705, 711, 712, 713, 811*, 812, 813, 814*, 815*	
L-6507, L-6508, L-8003*	79N: T81*	79N: 601*, 606*, 803*, 810*	
Line segments either side of POI	91N: B71	91N: 701, 702, 703	

*Indicates contingency was studied with/without RAS action

NRIS Results

The load flow results for all studied base cases with IR#610 operating at full output show all remaining system elements operating within 100% of their posted seasonal equipment emergency ratings, assuming that IR#610 displaced coal-fired generation in Cape Breton.

No contingencies resulted in a violation of voltage limit criteria.

The analysis indicated that IR#610 connected at the proposed POI (L-7005) meets criteria.

ERIS Results

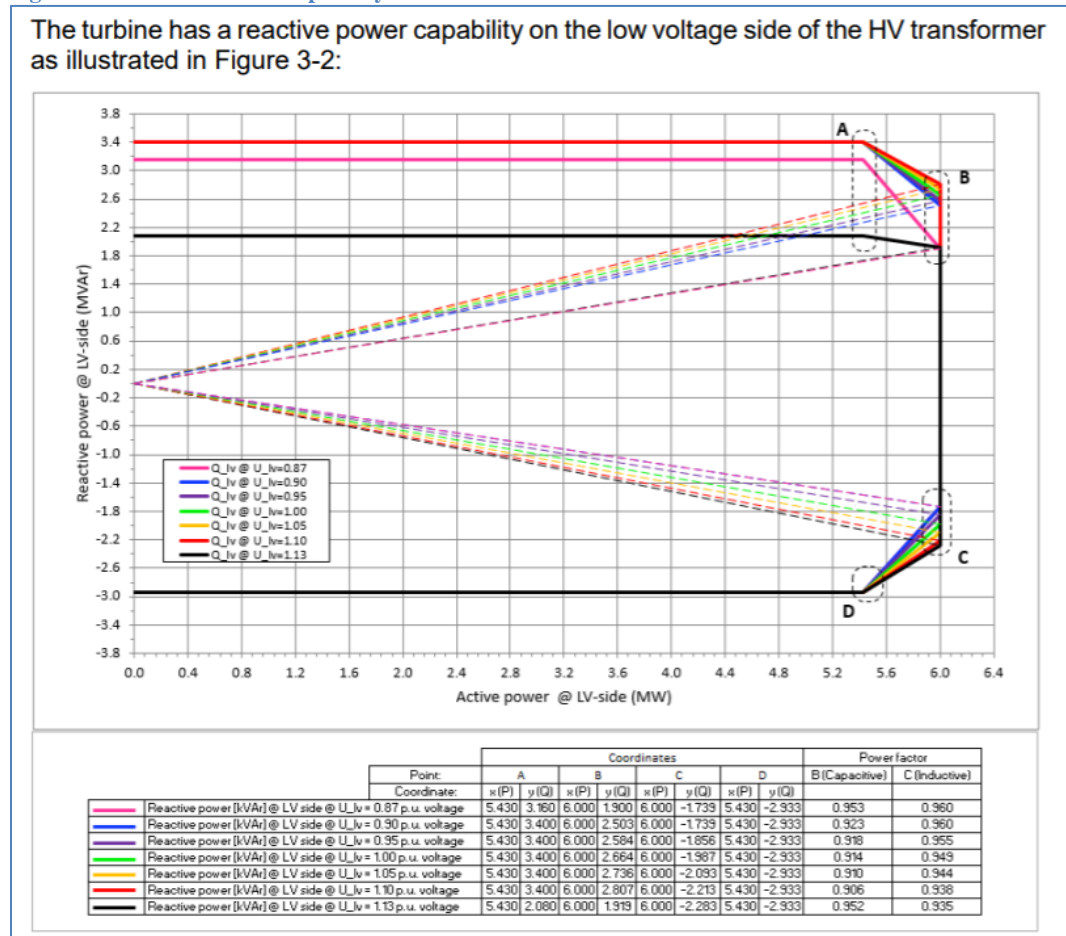
There is no difference between the requirements for ERIS versus NRIS.

8 Reactive Power and Voltage Control

In accordance with the *Transmission System Interconnection Requirements* Section 7.6.2, IR#610 must be capable of delivering reactive power at a net power factor of at least +/- 0.95 of rated capacity to the high side of the plant interconnection transformer. Reactive power can be provided by the asynchronous generator or by continually acting auxiliary devices such as STATCOM, DSTATCOM or synchronous condenser, supplied by the Interconnection Customer. Rated reactive power shall be available through the full range of real power output of the Generating Facility, from zero to full power. Based on the plant rating of 90 MW, this translates into a reactive capability of 29 Mvar leading and lagging, based on assumed collector circuit and transformer impedance.

The information (Figure 6) provided by the IC indicates that the Vestas V170 – 6 MW WECS have a rated power factor of 0.91 lagging at the machine terminal voltage of 1.05 p.u and 0.914 at a terminal voltage of 1.0 p.u.

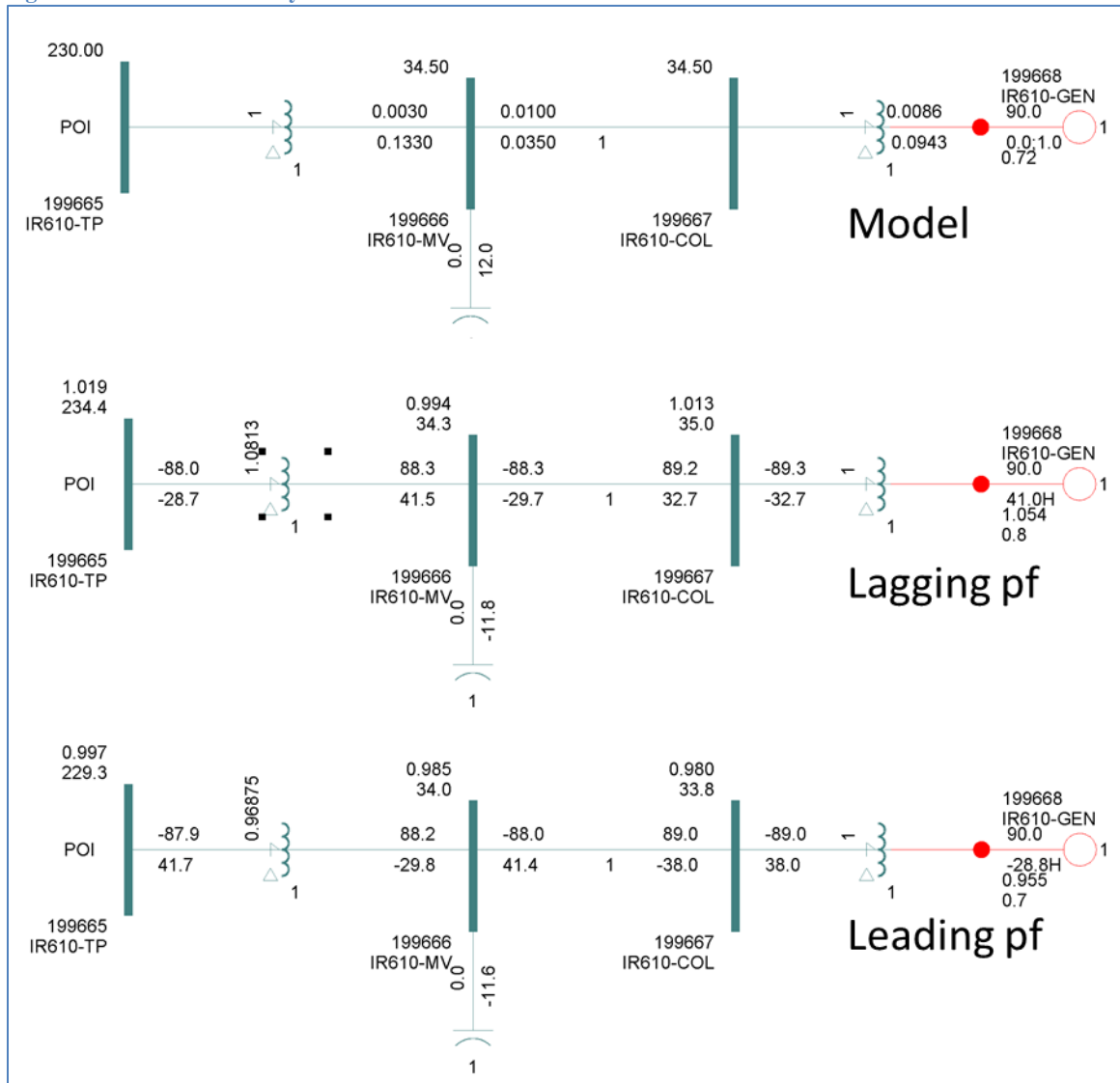
Figure 6: WECS Reactive Capability



Analysis shown in Figure 7 shows that IR#610 may not be able to meet this requirement without additional reactive support. The model shows that with 15 WECS units operating at a total 90 MW and 41.0 Mvar at terminal voltage of 1.05 p.u., the delivered power to the high side of the ICIF transformer is 88.1 MW and 17.8 Mvar, or a power factor of 0.98. To meet the requirement of 0.95, a fixed capacitor bank rated at 12 Mvar (or equivalent) would be required.

This configuration would be able to meet the leading power factor requirement while WECS are operating at 90 MW and -28.8 Mvar at a terminal voltage of 0.95 p.u.

Figure 7: Power Factor Analysis



Power factor behaviour is the same regardless of the POI. Because this analysis is based on preliminary transformer data and assumed collector circuit models, the size of the auxiliary reactive support will be confirmed in the SIS.

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.

Settings for the ICIF on-load tap-changer must be coordinated with plant voltage controller for long-term reactive power and voltage management at the POI.

9 System Security / Bulk Power Analysis

The 230kV buses at the 67N-Onslow EHV Substation and the 3C-Port Hastings Substation are already part of the Nova Scotia Bulk Power System (BPS). As such, all protection systems associated with the new three-breaker ring bus at the POI must comply with NPCC Directory 4 *System Protection Criteria*.

The 67N-Onslow EHV and the 3C-Port Hastings substations are also currently classified as part of the NERC Bulk Electric System (BES), subject to the applicable NERC Reliability Criteria. As IR#610 has dispersed generation totalling more than 75 MVA, Inclusion I4 of the NERC BES Definition would apply, and each generator would be classified as a BES element. The IR#610 230kV bus would be classified as a BES element, including the 230kV – 34.5kV transformer.

There are presently RAS L-7005 (Group 3) which will be impacted by the installation of a POI substation on that circuit. Modifications will be required to account for the fact that the POI would create two separate circuits. These RAS are classified as Type III, and the modifications may require approval by NPCC.

10 Expected Facilities Required for Interconnection

Because the analysis did not uncover any unexpected issues, the alternate POI was not considered.

The following facility changes will be required to connect IR#610 to the NSPI transmission system at a POI on L-7005:

10.1 NRIS Requirements:

a. Required Network Upgrades

- Modification of NSPI protection systems at 67N-Onslow EHV and 3C-Port Hastings.
- Modification of Type III SPS (Group 3)
- Install a new 230kV substation complete with 3 breaker ring bus at the POI at L-7005 and control and protection as acceptable to NSPI. A Remote Terminal Unit (RTU) to interface with NSPI's SCADA, with telemetry and controls as required by NSPI.

b. Required Transmission Provider's Interconnection Facilities (TPIF):

- Add control and communications between the wind farm and NSPI SCADA system (to be specified).

c. Required Interconnection Customer's Interconnection Facilities (ICIF)

- 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.
- 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.
- NSPI will 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.

- Low voltage ride-through capability per Section 7.4.1 of the Nova Scotia Power Transmission System Interconnection Requirements (TSIR).
- Real-time monitoring (including an RTU) of the interconnection facilities. Local wind speed and direction, MW and Mvar, as well as bus voltages are required.
- Facilities for NSPI to execute high speed rejection of generation (transfer trip) if determined in SIS. The plant may be incorporated into RAS run-back schemes.
- Synthesized inertial response controls within the WECS.
- Automatic Generation Control to assist with tie-line regulation.
- Operation at ambient temperature of -30°C.

10.2 ERIS Requirements:

The facility requirements for ERIS are the same as NRIS.

11 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

Because the analysis did not uncover any unexpected issues, only the costs associated with the POI on L-7005 are provided.

Estimates for NSPI Interconnections Facilities and Network Upgrades for interconnecting 90 MW wind energy at the 230kV POI at on L-7005 are included in Table 6.

Table 6 Cost Estimate NRIS or ERIS @ POI L-7005		
Item	Network Upgrades	Estimate
1	Three breaker ring bus 230 kV substation complete with P&C at NSPI TPIF substation, complete with P&C modifications to L-7005 at 3C-Port Hastings and 67N-Onslow.	\$8,000,000
2	Upgrades to Type III RAS Group 3 on L-7005	\$200,000
	Sub-total for Network Upgrades	\$8,200,000
Item	TPIF Upgrades	Estimate
1	NSPI P&C relaying equipment	\$100,000
2	NSPI supplied RTU	\$60,000
3	Tele-protection and SCADA communications	\$150,000
	Sub-total for TPIF Upgrades	\$310,000
Total Upgrades		Estimate
	Network Upgrades + TPIF Upgrades	\$8,510,000
	Contingency (10%)	\$851,000
	Total (Incl. 10% contingency and Excl. HST)	\$9,361,000

The preliminary non-binding cost estimate for interconnecting 90 MW at the POI at L-7005 under NRIS or ERIS is \$9,361,000 including a contingency of 10%. This does not include TBD costs to address any stability issues identified at the SIS stage based on dynamic analysis.

The estimated time to construct the Transmission providers Interconnection Facilities is 18-24 months after receipt of funds and cleared right of way from the IC.

12 Loss Factor

Loss factor is calculated by running the winter peak load flow case with and without the new facility in service while keeping 91H-Tufts Cove as the Nova Scotia Area Interchange bus. This methodology reflects the load centre in and around Metro.

Without IR#610 in service, losses in the winter peak case total 86.2 MW. With IR#610 in service at the POI of L-7005, displacing generation at 91H, and not including losses associated with the IR#610 Generation Facilities or TPIF Interconnection Facilities, system losses total 93.79 MW, an increase of 7.594 MW. The model shows power delivered to the POI is 88.3 MW, therefore the loss factor is calculated as $7.594/88.7 = +8.6\%$.

13 Issues to be addressed in SIS

The following provides a preliminary scope of work for the subsequent SIS for IR#610. 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, 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, frequency response, active power 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 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 and the NSPI *Transmission System Interconnection Requirements*.
- 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
- L-8004
- L-8003
- Transformer 79N-T81
- L-7005 either side of IR#610
- L-8004 & 79N-T81 (common circuit breaker)
- L-8004 & 101S-T81 (common circuit breaker)
- 1N-B61 (bus fault)
- L-7005 & 3C-T71 (common circuit breaker)
- Loss L-7003 & L-7004 (double circuit tower)
- 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-8004 at 101S-Woodbine, CBX and ONI, RAS armed
- 3 phase fault L-8003 at 67N-Onslow, ONI RAS armed
- 3 phase fault L-8001 with high NS import from NB (islanding)
- 3 phase fault L-8002 at 67N-Onslow
- Simultaneous SLG on L-7003 and L-7004 double circuit tower at 3C-Port Hastings
- SLG L-8003 at Onslow, drops 67N-T82, 345kV RAS Operation
- 3 phase fault at 79N-Hopewell, drops L-8003, 8004, bus, RAS operation
- 3 phase fault 1N-Onslow 138 kV bus B61

Any changes to RAS 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 NERC⁴ and NPCC⁵ 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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⁴ NPCC criteria are set forth in its Reliability Reference Directory #1 *Design and Operation of the Bulk Power System*

⁵ NERC transmission criteria are set forth in *NERC Reliability Standard TPL-001-4*