

**Interconnection Feasibility Study Report
GIP-IR787-FEAS-R0**

**Generator Interconnection Request 787
210 MW Wind Generating Facility
Guysborough County, NS**

January 23, 2025

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer (IC) submitted a Network Resource Interconnection Service (NRIS) Interconnection Request, referred to as IR787 for a proposed 210 MW wind generation facility interconnected to the NSPI Transmission System, with a Commercial Operation Date of 31/12/2027. The Point of Interconnection (POI) requested by the customer was L-7004.

There are 19 transmission Interconnection Requests in the Advanced Stage Transmission and Distribution Queue ahead of IR787 that must be included in the study models for IR787.

In addition, there is a long-term firm Transmission Service Reservation (TSR) that must be accounted for: 550 MW from New Brunswick to Nova Scotia (TSR411).

TSR411 is a long-term firm point-to-point Transmission Service Reservation and a Facilities Study is 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 was posted to the OASIS site at <https://www.nspower.ca/oasis/generation-interconnection-procedures>:

Due to ongoing development discussions and engineering studies, the Transmission System Network Upgrades identified as part of Transmission Service Request #411 will not be included in the System Impact Study (SIS) Analysis for Generator Interconnection Procedures (GIP) Study Groups #32 to #35. GIP Study Group #32 to #35 analysis will be limited to the 2024 Transmission System configuration plus any material Network Upgrades identified in higher queued projects.

As of the date of this IR 787 FEAS, the Facility Study for TSR 411 has not been finalized. As such, the Transmission System Network Upgrades identified as part of Transmission Service Request #411 have not been included in this FEAS.

This study assumes that the addition of generation from IR#787 will displace coal-fired generation in eastern Nova Scotia for NRIS.

A few post-contingency thermal loading violations occur due to IR#787 on transmission line L-7004. The following upgrades are proposed if RAS modifications are possible and permitted by the Northeast Power Coordinating Council:

- Modifications to Limited Impact RAS (Group 3)
- Modifications to Type 1 RAS (Group 5 & 6)

If RAS modifications are not permitted then the following upgrades are proposed:

- Upgrade winter thermal rating of L-6515-1 (3.25 km) from 172 MVA at 50°C to 187 MVA at 60°C
- Upgrade winter thermal rating of L-6515-2 (46 km) from 172 MVA at 50°C to 187 MVA at 60°C
- Upgrade winter thermal rating of L-7004 (125 km) from 337 MVA at 70°C to 365 MVA at 80°C
- Upgrade winter thermal rating of L-7019 (29.6 km) from 379 MVA at 85°C to 408 MVA at 100°C

The minimum short circuit level at the Interconnection Facility 34.5kV bus is 620 MVA with and IR#787 off-line, resulting in a Short Circuit Ratio (SCR) of 3.0. The minimum short circuit level is 464 MVA with L-7004 (3C substation to IR787 POI) out of service, resulting in a SCR of 2.2. These conditions must be discussed with the wind turbine manufacturer to determine if the equipment can operate, or if modifications are required.

Data provided by the IC indicates that IR787 will be utilizing the Nordex N163/6.X WECS(wind energy conversion systems). Based on supplied interconnection data and assumptions, IR787 does not meet the net power factor requirement of +0.95 at the high voltage side of Interconnection Facility. The adequacy of reactive power supply will be further investigated in the System Impact Study as specific details of the collector circuits become available.

To connect IR787 as NRIS with RAS modifications, the preliminary non-binding cost estimate for interconnecting 210 MW to NSPI's transmission system is \$27,375,000, including a 25% contingency. However, if RAS modifications are not available the preliminary non-binding cost estimate to connect IR787 increases to \$185,150,313, including 25% contingency.

In this estimate, \$12,375,000 (including 25% contingency) of the amount represents Network Upgrade costs which are funded by the Interconnection Customer, but which are eligible for refund under the terms of section 11.4 of the *Standard Generator Interconnection and Operating Agreement (GIA)*. The remainder of the costs are fully funded by the Interconnection Customer.

The preliminary cost estimate does not include any supplemental reactive power devices that are required to meet the NSPI power factor and/or inertia requirements. It also does not include costs to address any potential stability issues identified at the SIS stage based on dynamic analysis, or costs related to findings of the electromagnetic transient (EMT) analysis.

It is anticipated that additional equipment, such as a synchronous condenser, will be required to meet the inertia requirements stated in section 7.6.7 of the TSIR or as posted on the OASIS site in the "Generation Interconnection Procedures section". Any costs associated with such equipment are the responsibility of the Interconnection Customer. The Interconnection Customer must indicate as part of their design submitted at the SIS stage how they intend to meet the inertia requirement.

The estimated time to construct the Transmission Providers Interconnection Facilities and Network Upgrades is 24-36 months after receipt of funds and cleared right of way from the customer. These estimates will be further refined in the System Impact Study and the Facilities Study.

It should also be noted that IR787's maximum capacity is larger than Nova Scotia's standard source loss contingency of 168MW (Pt Aconi). This may require the purchase of additional reserve by the IC over the amount required by NS Power during periods when IR787 output is above 168MW. The requirement for additional reserve would be eliminated by use of two 230kV spur lines from IR787 to the POI and use of a four-breaker ring bus so that the largest source loss would be reduced to 105 MW. Reserve will be further explored in the SIS.

1 Introduction

The Interconnection Customer (IC) submitted a Network Resource Interconnection Service (NRIS) Interconnection Request for a proposed 210 MW wind generation facility interconnected to the NSPI transmission system, with a Commercial Operation Date of 31/12/2027. The Point of Interconnection (POI) requested by the customer was at L-7004, approximately 1 km from the 100C substation.

The IC signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI transmission system dated August 12th, 2024, and this report is the result of that Study Agreement. This project is listed as Interconnection Request 787 in the NSPI Interconnection Request Queue and will be referred to as IR787 throughout this report.

Figure 1 shows the proposed geographic location of IR787 in relation to the NSPI transmission system.



Figure 1: IR787 Site Location

Figure 2 shows a not to scale simplified one-line diagram of the transmission system configuration in NS.

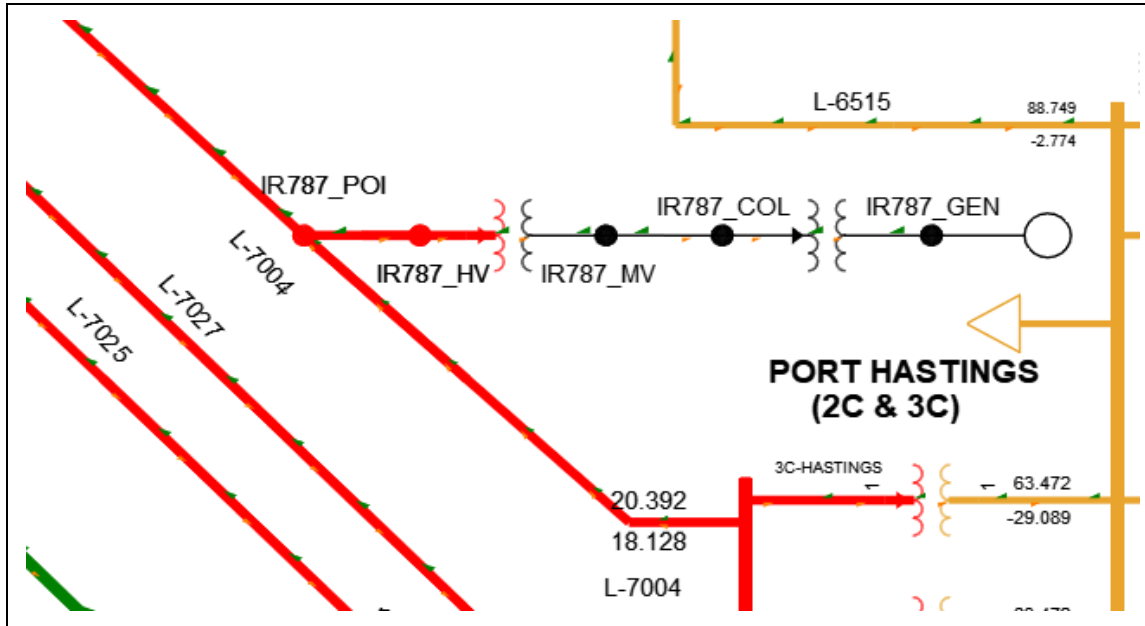


Figure 2: IR787 POI

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.

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 will be 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 identified short circuit issues associated with IR787. Expected minimum short circuit capability will also be identified for the purpose 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 the transmission elements. Voltage violations occur when the post-contingency transmission bus voltage is outside the range of +/-10% of the nominal voltage.

- 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 IR787 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 are studied as follows:

1. NRIS per section 3.2 of the Generation Interconnection Procedure (GIP).
2. Commercial operation date: 31/12/2027.
3. The Interconnection Customer Interconnection Facility (*ICIF*) consists of 30 Nordex N163/6.X WECS each rated at 7 MW for a total of 210 MW connected to 8 collector circuits operating at a voltage of 34.5 kV.
4. The POI at L-7004 is categorized as a Bulk Power System (BPS) and Bulk Electric System (BES) and will therefore require interconnection via a three-breaker ring bus with protection and full compliance with NPCC/NERC criteria and standards, in accordance with Table 8 of the TSIR.
5. The ICIF will require the construction of an approximately 12 km 230 kV transmission spur line from the POI to the IC 230 kV/34.5 kV transformers. The IC will be responsible for providing the Right-of-Way for the transmission line.
6. 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.

7. Preliminary data was provided by the IC for the substation transformer. The four substation transformers are rated at 35/47/58 MVA and modeled with a positive-sequence impedance of 8.5% on 35 MVA, wye-wye-delta Ground winding configuration with +/- 10% on-load tap changer. The transformer was modeled with an assumed X/R ratio of 20.
8. Preliminary data was provided by the IC for the generator step-up (GSU) transformers. Each GSU transformer is rated at 7.9 MVA with an impedance of 8.5%, delta-wye Ground winding configuration.
9. Detailed collector circuit data was not provided, so typical data ($R+jX = 0.01+j0.04$ pu, with $B = 0.099$ pu charging susceptance on system base 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.
10. Generation Interconnection Queue and OATT Transmission Service Queue requests that have completed a System Impact Study, or that have a System Impact Study in progress, are assumed to proceed as listed in Section 4 below.
11. It is required that the wind turbines are equipped with a “cold weather option” suitable for delivering full power under expected Nova Scotia winter environmental conditions according to section 7.6.9 of the TSIR.
12. Planning criteria meeting NERC Standard TPL-001-5 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.
13. Transmission line ratings used in this study are listed in Appendix A: Transmission line ratings

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 December 3rd, 2024, the following projects are higher queued in the Advanced Stage Interconnection Request Queue and are committed to the study base cases:

- IR516: GIA Executed
- IR542: GIA Executed
- IR574: GIA Executed
- IR598: GIA Executed
- IR597: GIA Executed
- IR664: GIA Executed
- IR662: GIA Executed
- IR670: FAC Complete
- IR671: FAC in Progress
- IR669: GIA Executed
- IR668: GIA Executed
- IR618: GIA Executed
- IR673: GIA Executed
- IR675: FAC Complete
- IR677: GIA in Progress
- IR697: SIS in Progress
- IR686: SIS in Progress
- IR739: SIS in Progress
- IR742: SIS in Progress

The power system base cases for the feasibility study includes all transmission connected IRs in the GIP queue up to and including IR742 with the exceptions of IR686 as it's SIS was not sufficiently advanced when IR787 was initiated.

In addition, TSR-411 is included in the queue, which reflects the study of long-term firm Transmission Service Reservation (TSR) from New Brunswick to Nova Scotia. If approved by the NSUARB, the TSR is expected to be in service in 2028 and a system study is currently underway to determine the required upgrades to the Nova Scotia transmission system. This has not been included in the feasibility study and the following notice is posted to the OASIS site:

Due to ongoing development discussions and engineering studies, the Transmission System Network Upgrades identified as part of Transmission Service Request #411 will not be included in the System Impact Study (SIS) Analysis for Generator Interconnection Procedures (GIP) Study Groups #32 to #35. GIP Study Group #32 to #35 analysis will be limited to the 2024 Transmission System configuration plus any material Network Upgrades identified in higher queued projects.

As of the date of this IR 787 FEAS, the Facility Study for TSR 411 has not been finalized. As such, the Transmission System Network Upgrades identified as part of Transmission Service Request #411 have not been included in this FEAS.

5 Short-Circuit Duty / Short Circuit Ratio

The NS Power design criteria for maximum system fault capability (3-phase, symmetrical) is 5,000 MVA (21 kA) on 138 kV systems and 10,000 MVA (25 kA) on 230 kV systems.

The fault current characteristic for the Nordex N163/6.X WECS is given as 3.36 times rated current, or $X'd = 0.298$ per unit on machine base MVA.

Short circuit analysis was performed using PSS®E for a classical fault study, 3LG and flat voltage profile at 1.0 p.u. The short-circuit levels in the area before and after this development are provided below in Table 1.

Table 1: Short-Circuit Levels (Classical fault study, flat voltage profile)

Location	IR787 not in service	IR787 in service	Post MVA increase	Post % Increase	Short Circuit Ratio (SCR) Without IR787
Max generation, all facilities in service (MVA)					
IR787_POI (230 kV)	1,882	2,225	343	18%	9.0
IR787_HV (230 kV)	1,525	1,883	358	23%	7.3
IR787-MV (34.5 kV)	792	1,251	459	58%	3.8
Min generation, all facilities in service (MVA)					
IR787_POI (230 kV)	1,133	1476	343	30%	5.4
IR787_HV (230 kV)	993	1352	359	36%	4.7
IR787-MV (34.5 kV)	620	1078	458	74%	3.0
Min generation, L-7004 (3C to POI) Out of Service (MVA)					
IR787_POI (230 kV)	702	1044	342	49%	3.3
IR787_HV (230 kV)	645	1003	358	56%	3.1
IR787-MV (34.5 kV)	464	922	458	99%	2.2

Inverter-based generation installations often have a minimum Short Circuit Ratio (SCR) for proper operation of converters and control circuits. The minimum short circuit ratio at the IR 787 34.5kV bus was found to be 3.0 with all facilities in service and IR787 offline. This falls to 2.2 with L-7004 (3C to POI) out of service. More detailed EMT analysis is required if IR787 proceeds to the SIS stage.

The IC should consult the wind turbine manufacturers to determine if the equipment can operate or if any modifications for lower SCR conditions are required. The impact of the low SCR will be further examined when detailed data for the machine is made available for the SIS.

Note that Section 7.4.15 of NSPI's TSIR states:

System short circuit level may decline over time with changes to transmission configuration and generation mix. The Generating Facility shall be able to accommodate these changes.

6 Voltage Flicker and Harmonics

Voltage flicker will be examined when data is made available for the SIS.

NSPI’s voltage flicker requirements are:

- (Short term flicker severity) $P_{st} \leq 0.35$
- (Long-term flicker severity) $P_{lt} \leq 0.25$

The generator must meet *IEEE Standard 519-2014 Voltage distortion limits* for all frequencies or Total Harmonic Distortion (THD) to no higher than 1.5% with no individual harmonic exceeding 1.0% on 230 kV.

7 Load Flow Analysis

The load flow analysis was completed for Summer Peak Load (SP) and Winter Peak Load (WP) scenarios with varying dispatch cases intended to cover a broad range of operating conditions. Two scenarios were examined for each case:

- Pre-IR787 cases ending with “-A”: IR787 off.
- Post-IR787 cases ending with “-B”: IR787 dispatched at 210 MW under NRIS designation.

Table 2 includes the list of cases considered, along with a brief description.

Table 2: Case Scenario Details

Case Name	Description
Summer Peak Cases	
C_SP_00	System under normal conditions
C_SP_01	System with low nearby generation (generators at ~25% output)
C_SP_02	System with medium nearby generation (generators at ~50% output)
C_SP_03	System with high nearby generation (generators at ~100% output)
Winter Peak Cases	
C_WP_00	System under normal conditions
C_WP_01	System with low nearby generation (generators at ~25% output)
C_WP_02	System with medium nearby generation (generators at ~50% output)
C_WP_03	System with high nearby generation (generators at ~100% output)

Figure 3 shows the relevant corridors on the NSPI transmission system. The arrow by each corridor shows the power flow direction of positive values.

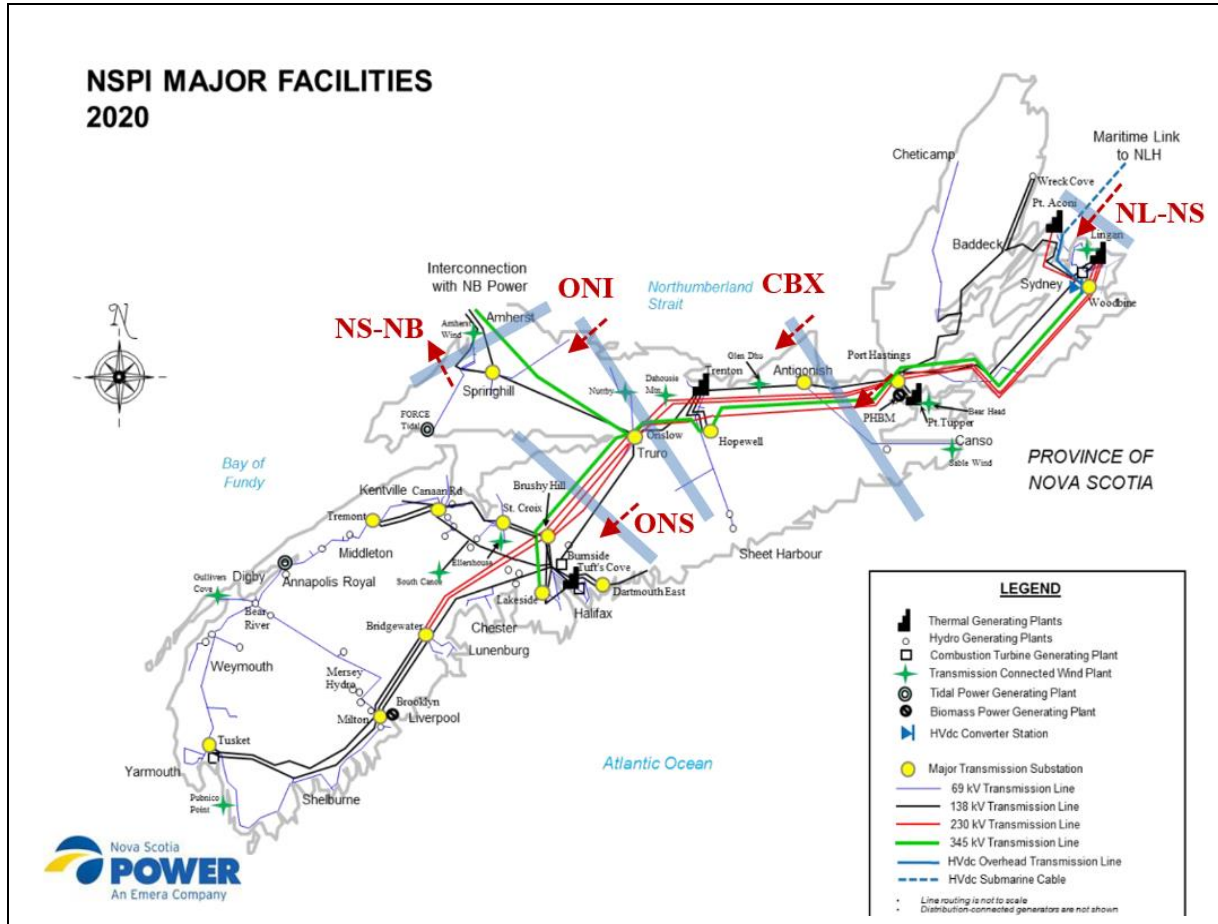


Figure 3: Relevant Transmission Interface

Table 3: Dispatch Cases for IR787

Case	IR787 Output (MW)	Total Wind Generation (MW)	System Load (MW)	NS→NB (MW)	ONS (MW)	CBX (MW)	ONI (MW)	NL→NS (MW)
Summer Peak Cases								
C_SP_00-A	0	236	1346	149	383	509	616	330
C_SP_00-B	210	446	1337	149	383	330	616	330
C_SP_01-A	0	269	1346	181	383	509	647	330
C_SP_01-B	210	479	1337	181	383	330	648	330
C_SP_02-A	0	370	1346	277	383	509	745	330
C_SP_02-B	210	581	1337	277	383	330	744	330
C_SP_03-A	0	574	1346	463	383	510	933	330
C_SP_03-B	210	784	1337	463	383	330	934	330
Winter Peak Cases								
C_WP_00-A	0	236	2219	0	763	738	930	170
C_WP_00-B	210	446	2210	0	763	690	930	170

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C_WP_01-A	0	269	2219	31	763	738	961	170
C_WP_01-B	210	479	2210	31	763	690	961	170
C_WP_02-A	0	371	2219	127	763	739	1057	170
C_WP_02-B	210	581	2210	127	764	692	1058	170
C_WP_03-A	0	574	2219	311	764	739	1243	170
C_WP_03-B	210	784	2210	311	764	694	1244	170

Single contingencies were applied at the 345 kV, 230 kV, 138 kV, and 69 kV voltage levels for the above system conditions with and without IR787. Automated analysis searched for violations of emergency thermal ratings and emergency voltage limit for each contingency. Contingencies studied are listed in Table 4.

Table 4: Contingencies List

Contingencies Studied				
88S_L-7014	67N-705	103H_L-6038	20V-T1	5S_L-6549
88S_L-7021	67N-706	103H-T81	20V-503	3S_L-6539
88S_L-7022	67N-710	103H-T61	20V-504	3S_bus
88S-710	67N-712	103H-T63	20V-401	5S_L-6537
88S-711	67N-713	103H-B61	102V-L5060	2S_L-6516
88S-712	1N_L-6613	103H-B62	102V-T51	5S-606
88S-713	1N_L-6503	103H-881	102V-GT1	5S-607
88S-714	1N_L-6001	103H-600	17V-L6051	2S-513
88S-715	1N-T1	103H-608	17V-L6011	1C-G2
88S-720	1N-T4	103H-681	17V-L5014	48C-G1
88S-721	1N-T65	89S-G1	17V-L4046	50N-G5
88S-722	1N-C61	91H_L-5049	17V-L4045	50N-G6
88S-723_G0	1N-B61	91H_L-5012	17V-SHUNT	50N-L-6511
88S-723_G8	1N-B62	91H_L-5041	17V-T2	91H-G3
88S-T71	1N-600	91H-T62	17V-T63	91H-G4
88S-T72	1N-601	91H-T11	17V-T1	91H-G5
88S-G2	1N-613	91H-511	17V-612	91H-G6
88S-G3	50N-15500	91H-516	17V-611	104W-G1
88S-G4	50N-15501	91H-521	17V-563	110W-T62
101S_ML-POLE1	50N-15502	91H-523	17V-512	104H-600
101S_ML-POLE2	50N-16503	91H-621	17V-519	50W, 50W-B3_OL
101S_ML-BIPOLE	50N-16511	91H_L-6042	17V-505	50W, 50W-615_OL
101S-T81	50N-16507	91H-613	101V-L6004-a	9W, 9W-T2_OL
101S-T82	50N-16508	91H-604	101V-L6053	50W, 50W-B3
101S_L-7011	50N-GT6	91H_L-6007	101V-601	50W, 50W-615

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101S_L-7011_G1	50N-GT5	91H-605	101V-602	9W, 9W-T2
101S_L-7012	50N-T12	91H-606	101V-603	67N-811_G0
101S_L-7012_G2	50N-T8	91H-607	IR379-GT	79N_L-8003_G0
101S_L-7015	50N-LOAD1	91H_L-6014	IR372-GT	67N-811_G5
101S-701	50N-LOAD2	91H-608	IR379-TX	79N_L-8003_G5
101S-702	50N-614	91H-609	IR372-TX	79N_L-8003_G6
101S-703	50N-607	91H-611	110W-661	67N-811_G6
101S-704	50N-604	91N-701	13V L-5531	67N_L-8001_NSX1
101S-705	50N-513	91N-702	13V L-5532	67N-814_NSX1
101S-706	50N-508	91N-703	13V 13V-B51	67N_L-8001_NSX2
101S-711	50N-500	91N-B71	13V L-5533	67N-814_NSX2
101S-712	120H_L-7008	99W-708	51V 51V-B61	67N_L-8001_NSI
101S-713	120H_L-7009	99W-709	51V-601	67N-814_NSI
101S-811	120H_L-6005	99W-T71	51V-T62	67N_L-8001_G0
101S-814	120H_L-6010	99W-T72	51V 51V-B52	67N-814_G0
101S-816	120H_L-6011	99W-L5545-a	51V 51V-T61	DCT_L-7003][L-7004_G3
3C_L-7003	120H Open L-6051	99W-L5546	51V 51V-T61_OL	67N-711_G3
3C_L-7004	120H L-6051	99W-L6531	51V-L5053	3C_L-7005_G3
3C-T71	120H_L-6016	99W-L6006	9W, L-5535	3C-710_G3
3C-T72	120H-T71	99W-L6025	9W 9W-B53	3C-720_G3
3C-711	120H-T72	99W-L6002	9W 9W-B52	DCT_L-7003][L-7004_G0
3C-712	120H-SVC	99W-L7009	9W L-5027	67N-711_G0
3C-713	120H_L-7018	99W-L7008	30W 30W-T62	3C_L-7005_G0
3C-714	120H-710	99W-601	30W 30W-B51	3C-710_G0
3C-715	120H-711	99W-601-IR664	50W L-6020	3C-720_G0
3C-716	120H-712	99W-T62	50W L-6024	79N-T81_G0
2C_L-6515	120H-713	99W-602	50W L-6048	101S_L-8004_G0
2C_L-6516	120H-714	99W-602-IR664	50W 50W-B4	101S-812_G0
2C_L-6517	120H-715	99W-T61	50W L-5541	101S-813_G0
2C_L-6518	120H-716	99W-T61-IR664	50W L-5530	79N-T81_G5
2C_L-6523	120H-720	99W-T62-IR664	50W L-5539	101S_L-8004_G5
2C_L-6537	120H-621	99W-SHUNT	50W 50W-B2	101S-812_G5
2C_B61	120H-622	99W-545	50W IR597	101S-813_G5
2C_B61_SPS	120H-623	99W-501	50W 50W-T53	79N-T81_G6
2C_B62	120H-624	99W-562	50W L-5540	101S_L-8004_G6
2C_L-6537_SPS	120H-625	3W-B53	113H-601	101S-812_G6
2C_B62_SPS	120H-626	3V-L4049	113H-L6043	101S-813_G6
47C_B1	120H-627	3V-L5035	132H-602	51V, L-5025_SPS

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47C_B2	120H-628	3V-G1	132H-603	13V, L-5026_SPS
47C_B3	120H-629	3V-G2	132H-605	11V, 11V-B51_SPS
47C_B4	90H-L6002-1	22V-L5033	132H-606	51V, 51V-B51_SPS
47C_B5	90H-L6009-2	43V-L6012	132H-L6044	51V, L-5025
47C_B6	90H-L-6008	43V-L6013	132H-L6040	13V, L-5026
47C_B7	90H-L6003	43V-L6054	132H-L6055	11V, 11V-B51
4C_L-6552	90H-L5003-2	43V-L6015	1H-603	51V, 51V-B51
4C_T63	90H-L5004-1	43V-50VLoad	1H-L-6035	IR670-B
4C_T2	90H-T1	43V-L6052	74N-600	IR618-B
4C_620	90H-C61	43V-L5017	74N-L6536	IR668-B
4C_621	90H-C51	43V-L5022	74N-L6514	IR787-B
4C_622	90H-611	43V-L5021	74N-L5029	
4C_623	90H-608	43V-T62	74N-L5058	
79N_L-6507	90H-605	43V-604	15V-B51	
79N_L-6508	90H-602	43V-T61	15V-L5050	
67N_L-8002	90H-612	43V-B61	15V-L5538	
67N_L-7019	90H-609	43V-B62	92V-B51	
67N_L-7001	90H-606	43V-SHUNT	DCT_L-5039][L-6033	
67N_L-7002	90H-603	43V-B51	DCT_L-7009][L-8002	
67N-T81	90H-610	43V-505	DCT_L-6011][L-6010	
67N-T82	90H-607	43V-562	DCT_L-6010][L-6005	
67N-T71	90H-604	43V-503	DCT_L-6005][L-6016	
67N-812	90H-601	43V-506	DCT_L-7008][L-7009	
67N-813	90H-503	41V-L4048	DCT_L-6507][L-6508	
67N-701	90H-506	41V-L4047	DCT_L-7021][L-6534	
67N-702	90H-501	41V-407	DCT_L-6033][L-6035	
67N-703	103H_L-6008	79V-L5015	85S_L-6545	
67N-704	103H_L-6033	79V-L5016	5S_L-6538	

8 Overload Results

8.1 NRIS

Table 5 below shows the contingencies that cause overloads due to IR787. Note that Rate 2 is the 15-minute emergency rating of a transmission line and is equal to 110% of the line MVA rating. Post contingency line overloads of up to 110% of the normal line rating are permitted where it can be demonstrated that operator action can relieve the overload within 15 minutes.

Table 5: Results

ID	Item	Highest Overload (% of Rate 2)	Case	Contingency
1	L-6515-1	104.0%	c_wp_03-B.sav <u>c_wp_03-B.sav</u>	101S_L-8004_G0 <u>101S-813_G0</u>
2	L-6515-2	101.4%	c_wp_03-B.sav <u>c_wp_03-B.sav</u>	101S_L-8004_G0 <u>101S-813_G0</u>
3	L-7004 (91N to POI)	107.9 %	c_sp_03-B.sav <u>c_wp_03-B.sav</u> c_wp_03-B.sav c_wp_03-B.sav	79N-T81_G0 <u>79N-T81_G0</u> 101S_L-8004_G0 101S-813_G0
4	L-7019	108.0 %	c_sp_03-B.sav c_sp_03-B.sav c_sp_03-B.sav <u>c_wp_03-B.sav</u> c_wp_03-B.sav c_wp_03-B.sav	79N-T81_G0 101S_L-8004_G0 101S-813_G0 <u>79N-T81_G0</u> 101S_L-8004_G0 101S-813_G0

Each of the violations caused by IR787 should be addressable with modifications to existing RASs. However, if RAS modifications are not possible then the following actions are required.

1. Upgrade winter thermal rating of L-6515-1 (3.25 km) from 172 MVA at 50°C to 187 MVA at 60°C
2. Upgrade winter thermal rating of L-6515-2 (46 km) from 172 MVA at 50°C to 187 MVA at 60°C
3. Upgrade winter thermal rating of L-7004 (125 km) from 337 MVA at 70°C to 365 MVA at 80°C
4. Upgrade winter thermal rating of L-7019 (29.6 km) from 379 MVA at 85 °C to 408 MVA at 100 °C

9 Reactive Power and Voltage Control

In accordance with the *Transmission System Interconnection Requirements* Section 7.6.2, IR787 must be capable of delivering reactive power for a net power factor of at least +/- 0.95 of rated capacity to the high side of the plant interconnection transformer(s); the rated reactive power is required for all active power levels from 0% to 100%. IR787 is also required to have an on-load tap changer for the substation interconnection transformer to manage the medium voltage so the WECS stay in their optimal reactive power output range. Reactive power can be provided by the asynchronous generator or by continually acting auxiliary devices such as STATCOM and synchronous condensers. When the wind speed is below the switch-on speed for the wind turbine, no reactive power is consumed or fed in, and thus Q is 0 unless the “STATCOM” function module is included. The Interconnection Customer Supplied the P-Q diagram that can be shown in Figure 4.

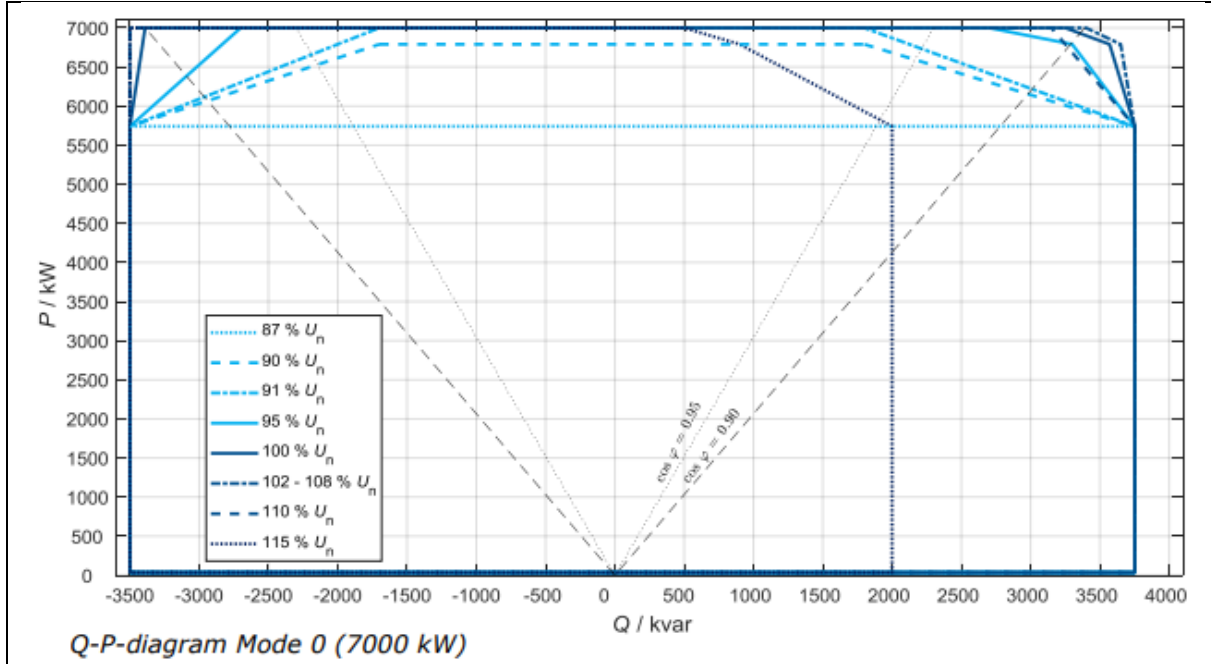


Figure 4: P-Q Diagram

The power factor analysis is conducted using a SMIB (Single Machine Infinite Bus) case for IR787 is shown in Figure 5 and Figure 6.

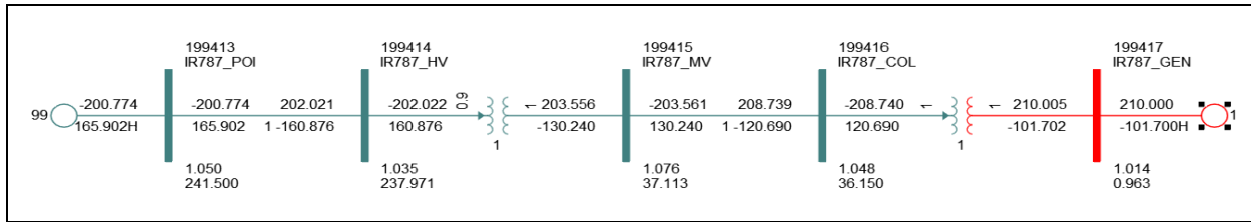


Figure 5: Leading Power Factor Analysis

Table 6: Leading Power Factor Analysis Results

IR787 MW	IR787 Mvar	Tx HV MW	Tx HV Mvar	Tx HV MVA	Tx HV PF
210	-101.7	202.021	-160.876	258.3	0.78

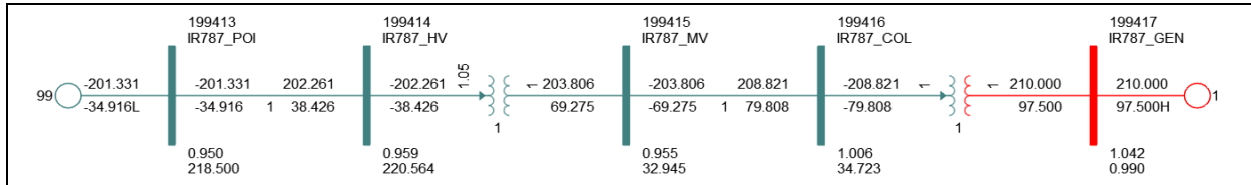


Figure 6: Lagging Power Factor Analysis

Table 7: Lagging Power Factor Results

IR787 MW	IR787 Mvar	Tx HV MW	Tx HV Mvar	Tx HV MVA	Tx HV PF
210	97.5	202.261	38.426	205.9	0.98

Based on the available data, the facility fails to meet the lagging power factor requirements. However, because this analysis is based on preliminary transformer data and assumed collector circuit models, reactive capability will be confirmed in the SIS when detailed design is submitted.

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 can slowly adjust the set-point over several (5-10) minutes to maintain reactive power within the individual generator 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)*.

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.

10 System Security / Bulk Power Analysis

The interconnection with L-7004 is part of the NPCC Bulk Power System (BPS). As such, all protection systems associated with IR787 must comply with NPCC Directory 4 System Protection Criteria.

BPS testing following NPCC's A-10 classification of bulk power system elements will be performed in the SIS to confirm if IR787 will be BPS categorized.

It should also be noted that IR787's maximum capacity is larger than Nova Scotia's standard source loss contingency of 168MW (Pt Aconi). This may require the purchase of additional reserve by the IC over the amount required by NS Power during periods when IR787 output is above 168MW. The requirement for additional reserve would be eliminated by the use of two 230kV spur lines from IR787 to the POI with a four-breaker ring bus station so that the largest source loss would be reduced. Reserve will be further explored in the SIS.

Since L-7004 is currently classified as part of the NERC Bulk Electric System (BES), it is also subject to the applicable NERC Reliability Criteria.

As IR787 has dispersed generation totaling more than 75 MVA, Inclusion I4 of the NERC BES Definition applies; each generator and systems designed for delivering that aggregate capacity to the POI classified are categorized as BES elements.

11 Expected Facilities Required for Interconnection

The following facility changes will be required to connect IR787 to the NSPI transmission system at the POI at L-7004.

11.1 NRIS with RAS Modifications

Required Network Upgrades:

1. Three Circuit Breaker Ring Bus station
2. Protection and control equipment & modifications at 3C and 91N substation.
3. Modification to Limited Impact RAS (Group 3)
4. Modification to Type 1 RAS (Group 5 & 6)

Required Transmission Provider's Interconnection Facilities (TPIF):

1. Construct a total of 12 km, 230kV, 556 ACSR (Dove) transmission spur line between the L-7004 POI and the Interconnection Customer's Interconnection Facility.
2. Supervisory, control, and communications between the wind farm and NSPI SCADA system (to be specified).

Required Interconnection Customer's Interconnection Facilities (ICIF):

1. 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. Rated reactive power shall be available through the full range of real power output, from zero to full power.
2. Centralized controls for voltage setpoint control for the low side of the ICIF transformer. Fast acting control is required and will include a curtailment scheme, which will limit/reduce total output from the facility, upon receipt of a telemetered signal from NSPI's SCADA system.
3. NSPI to have supervisory and control of this facility, via the centralized controller. This will permit the NSPI System Operator to raise/lower the voltage setpoint, change the status of reactive power controls, change the real/reactive power remotely.
4. When curtailed, the facility shall offer over-frequency and under-frequency control with ± 0.2 Hz deadband and 4% droop characteristic. The active power controls shall also react to continuous control signals from the NSPI SCADA system's Automatic Generation Control (AGC) system to control tie-line fluctuations as required.
5. The facility shall align with section 7.6.7 *Inertia Response – WECS* as posted on the OASIS site in the *Generation Interconnection Procedures* Section
6. Voltage ride-through capability as described in the NS Power TSIR.

7. Frequency ride-through capability in accordance with the NS Power TSIR. The facility shall have the capability of riding through a rate of change of frequency of 4 Hz/s.
8. Facilities for NSPI to execute high speed generation rejection (transfer trip), if determined in the SIS. The plant may be incorporated in RAS runback or load reject schemes.
9. Operation at ambient temperatures as low as -30°C. The IC shall also provide icing models and conduct icing studies for their facility.

11.2 NRIS Without RAS Modifications

Required Network Upgrades:

1. Three Circuit Breaker Ring Bus station
2. Protection and control equipment & modifications at 3C and 91N substation.
3. Upgrade winter thermal rating of L-6515-1 (3.25 km) from 172 MVA at 50°C to 187 MVA at 60°C
4. Upgrade winter thermal rating of L-6515-2 (46 km) from 172 MVA at 50°C to 187 MVA at 60°C
5. Upgrade winter thermal rating of L-7004 (125 km) from 337 MVA at 70°C to 365 MVA at 80°C
6. Upgrade winter thermal rating of L-7019 (29.6 km) from 379 MVA at 85°C to 408 MVA at 100°C

Required Transmission Provider's Interconnection Facilities (TPIF):

1. Construct a total of 12 km, 230kV, 556 ACSR (Dove) transmission spur line between the L-7004 POI and the Interconnection Customer's Interconnection Facility.
2. Supervisory, control, and communications between the wind farm and NSPI SCADA system (to be specified).

Required Interconnection Customer's Interconnection Facilities (ICIF):

1. 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. Rated reactive power shall be available through the full range of real power output, from zero to full power.
2. Centralized controls for voltage setpoint control for the low side of the ICIF transformer. Fast acting control is required and will include a curtailment scheme, which will limit/reduce total output from the facility, upon receipt of a telemetered signal from NSPI's SCADA system.
3. NSPI to have supervisory and control of this facility, via the centralized controller. This will permit the NSPI System Operator to raise/lower the voltage setpoint, change the status of reactive power controls, change the real/reactive power remotely.
4. When curtailed, the facility shall offer over-frequency and under-frequency control with ± 0.2 Hz deadband and 4% droop characteristic. The active power controls shall also react to continuous control signals from the NSPI SCADA system's Automatic Generation Control (AGC) system to control tie-line fluctuations as required.
5. The facility shall align with section 7.6.7 Inertia Response – WECS as posted on the OASIS site in the Generation Interconnection Procedures Section
6. Voltage ride-through capability as described in the NS Power TSIR.

7. Frequency ride-through capability in accordance with the NS Power TSIR. The facility shall have the capability of riding through a rate of change of frequency of 4 Hz/s.
8. Facilities for NSPI to execute high speed generation rejection (transfer trip), if determined in the SIS. The plant may be incorporated in RAS runback or load reject schemes.
9. Operation at ambient temperatures as low as -30°C. The IC shall also provide icing models and conduct icing studies for their facility.

12 NSPI Interconnection Facilities and Network Upgrade Cost Estimate

The high level, non-binding, present day cost estimate, not including HST, for IR787's Interconnection Service is shown in Table 8 and Table 9. This estimate assumes there is adequate space for new equipment and modifications. This does not include any to-be-determined costs to address any stability issues identified at the SIS stage, based on dynamic analysis. Note that this cost estimate is subject to change based on higher queued projects.

12.1 NRIS with RAS Modifications

Table 8: NRIS Cost Estimate with RAS Modifications

Item	TPIF	Estimate
1	12 km radial line (POI to TPIF substation)	\$ 12,000,000
	Contingency (25%)	\$ 3,000,000
	Sub-total	\$ 15,000,000

	Network Upgrades	Estimate
1	Three Circuit Breaker Ring Bus station	\$ 9,000,000
2	Protection and control equipment & modifications at 3C and 91N substation	\$ 500,000
3	Modifications to Limited Impact RAS (Group 3)	\$ 200,000
4	Modifications to Type 1 RAS (Group 5 & 6)	\$ 200,000
	Contingency (25%)	\$ 2,475,000
	Sub-total	\$ 12,375,000

Determined costs	
Total of determined cost	\$ 27,375,000

12.2 NRIS Without RAS Modification

Table 9: NRIS Cost Estimate

Item	TPIF	Estimate
1	12 km radial line (POI to TPIF substation)	\$ 12,000,000

	Contingency (25%)	\$ 3,000,000
	Sub-total	\$ 15,000,000

	Network Upgrades	Estimate
1	Three Circuit Breaker Ring Bus station	\$ 9,000,000
2	Protection and control equipment & modifications at 3C and 91N substation	\$ 500,000
5	Upgrade winter thermal rating of L-6515-1	\$ 1,316,250
6	Upgrade winter thermal rating of L-6515-2	\$ 18,630,000
7	Upgrade winter thermal rating of L-7004	\$ 86,250,000
8	Upgrade winter thermal rating of L-7019	\$ 20,424,000
	Contingency (25%)	\$ 34,030,062.5
	Sub-total	\$ 170,150,313

Determined costs	
Total of determined cost	\$ 185,150,313

13 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 (TC) as the NS Area Interchange bus. This methodology reflects the load centre in and around 91H-Tufts Cove. A negative loss factor reflects a reduction in system losses.

The loss factor is calculated using the data given in Table 10 and equation (01)

Table 10: Loss Factor Calculation

Name	Value
IR787 nameplate	210 MW
TC with IR787	276.4 MW
TC without IR787	470 MW
loss factor	7.81 %

$$Loss\ factor = \frac{(IR787\ nameplate + TC_{3\ with/IR787}) - TC_{3\ without/IR787}}{IR787\ nameplate} \quad (01)$$

14 Preliminary scope of subsequent SIS

The following provides a preliminary scope of work for the subsequent SIS for IR787.

The SIS will include a more comprehensive assessment of the technical issues and requirements such as confirming that the IC’s design meets the TSIR’s inertia requirements to interconnect

generation as requested. It will include contingency analysis, system stability, transient stability, ride through capability, 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 response, frequency response, control interactions with other IBR facilities, 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 notice on OASIS provides additional clarification on the SIS model requirements:

To be eligible for inclusion in the Interconnection System Impact Study stage, and thereby advance the Interconnection Request's initial Queue Position, the Interconnection Customer must meet the progression milestone requirements of Section 7.2 of the GIP at least ten (10) Business Days prior to the Interconnection System Impact Study commencement date. For clarity, item 7.2 (i) – provision of a detailed stability model for the generator(s) shall mean:

- *Provision of PSSE and PSCAD models in compliance with documents NSPI-TPR-015-2: PSSE and PSCAD Model Requirements, and*
- *Provision of test data demonstrating model testing in compliance with NERC, NPCC and NSPI criteria. NSPI-TPR-014-1: Model Quality Testing lists the minimum requirements that will be performed by NSPI. Additional testing may be performed to assess compliance with all applicable criteria. Any test not meeting the minimum NSPI requirements will be documented in the MQT report to the IC.*

The following outline provides the minimum scope that must be complete 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.

- Facilities that the customer must install to meet the requirements of the GIP and the TSIR.
- 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.
- Guidelines and restrictions applicable to first contingency operation (curtailments etc.).
- Under-frequency load shedding impacts.

The SIS will assess system contingencies such that the system performance will meet the following criteria:

- Table 1 “Planning Design Criteria” of NPCC Directory 1.
- Table 1 “Steady State & Stability Performance Planning Events” of NERC TPL001-5.
- NSPI System Design Criteria, report number NSPI-TPR-003-5.

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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 NPCC¹ and NERC² criteria as well as NSPI guidelines and good utility practice. The SIS will also determine the contingencies for which this facility must be curtailed.

Appendix A: Transmission line ratings

NSPI Transmission Line Ratings														Last Updated: 2024-10-01		
LINE	STATION	CONDUCTOR						BREAKER	SWITCH	CURRENT TRANSFORMER			PROTECTION			
		TYPE	MAX OPERATING TEMP. (°C)	HOT SEASON RATING 25°C (MVA)	WARM SEASON RATING 5°C (MVA)	COOL SEASON RATING 5°C (MVA)	COLD SEASON RATING 5°C (MVA)			100% NAME PLATE (MVA)	100% NAME PLATE (MVA)	RELAYING			FULL SCALE METERING	
										Ratio	R.F.	MVA	Ratio	R.F.	MVA	
L-7004	3C Pt. Hastings EHV	ACSR 556 Dove	60	238	318	318	318	797	797	800	2	637	1000	T	462	710
	91N Dalhousie Mountain							797	797	800	2.5	797	800	R	797	710
L-7005	3C Pt. Hastings EHV	ACSR 1113 Beaumont	70	417	523	523	523	797	797	800	2	637	1000	1	462	656
	67N Onslow EHV							797	797	800	2	637	800	1	385	597
L-7003	3C Pt. Hastings EHV	ACSR 556 Dove	60	238	318	318	318	797	797	800	2	637	1000	1	462	550
	67N Onslow EHV							797	797	800	2	637	1000	1	462	550
L-7019	91N Dalhousie Mountain	ACSR 556 Dove	70	277	345	345	345	797	797	800	2.5	797	800	2.5	797	3155
	67N Onslow EHV							797	797	800	2	637	1000	1	462	2382
L-6515a	2C Pt. Hastings	ACSR 556.5 Dove	50	114	172	172	172	287	287	1200	2	574	1200	2	574	651
	100C Cape Porcupine								143			NA				
L-6515b	100C Cape Porcupine	ACSR 556.5 Dove	50	114	172	172	172		143				NA			
	4C Lochaber Rd.							478	143	600	2.5	358	600	T	173	652

¹ NPCC criteria are set forth in its Reliability Reference Directory #1 *Design and Operation of the Bulk Power System*

² NERC transmission criteria are set forth in *NERC Reliability Standard TPL-001-5*