Interconnection Feasibility Study Report
GIP-IR762-FEAS-R0

Generator Interconnection Request 762
16.8 MW Wind Generating Facility
Hants County, NS

September 10, 2024

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer (IC) submitted a Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS) Interconnection Request 762 for a proposed 16.8 MW wind generation facility interconnected to the NSPI Transmission System. The Commercial Operation Date was estimated to be 2027/06/24. The Point of Interconnection (POI) requested by the customer was IR673's 34.5kV MV bus. However, the Point of Interconnection, by definition, is where the Interconnection Facilities connect to the Transmission Provider's Transmission System. For the purpose of this study, IR762 shares the same Point of Interconnection as IR673 (transmission Line L-6054).

There are 22 transmission Interconnection Requests in the Advanced Stage Transmission and Distribution Queue ahead of IR762 that must be included in the study models for IR762.

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.*

This study assumes that the addition of generation from IR#762 will displace coal-fired generation in eastern Nova Scotia for both NRIS and ERIS.

Data provided by the IC indicates that IR762 will be utilizing the Enercon E-138 EP3 wind turbine generators (WTG). Based on supplied interconnection data and assumptions, IR762 by itself may 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 for both IR673 and IR762 become available.

NS Power notes that NERC standard PRC-029-1 is currently in development. As proposed, this standard will impose performance requirements for voltage and frequency ride through behaviour on inverter-based generating resources. It is anticipated that this standard will be applicable to the project currently under study. The Interconnection Customer is advised to consider the requirements of PRC-029-1 in their project design to ensure that their project can conform to these requirements. Conformance will be validated at the System Impact Study stage.

To connect IR762 as NRIS, the preliminary non-binding cost estimate for interconnecting 16.8 MW to NSPI's transmission system is $0.

The preliminary cost estimate does not include any supplemental reactive power devices that are potentially 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, 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 of the TSIR. 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.

In preparation for NERC's new Category 2 GO and Category 2 GOP entity designations, this IR will be categorized accordingly and is expected to register with NERC/NPCC and adhere to applicable the NERC and NPCC requirements.

1 Introduction

The Interconnection Customer (IC) submitted a Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection service (ERIS) Interconnection Request for a proposed 16.8 MW wind generation facility interconnected to the NSPI transmission system, with an estimated Commercial Operation Date of 2027/06/24. The Point of Interconnection (POI) requested by the customer was at IR673's 34kV MV bus, approximately 4.55 km from the 101V substation. However, the Point of Interconnection, by definition, is where the Interconnection Facilities connect to the Transmission Provider's Transmission System. For the purpose of this study, IR762 shares the same Point of Interconnection as IR673 (transmission Line L-6054).

The IC signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI transmission system dated 2024/05/15, and this report is the result of that Study Agreement. This project is listed as Interconnection Request 762 in the NSPI Interconnection Request Queue and will be referred to as IR762 throughout this report.

Figure 1 shows the proposed geographic location of IR762 in relation to the NSPI transmission system.

Figure 1: IR762 Site Location

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

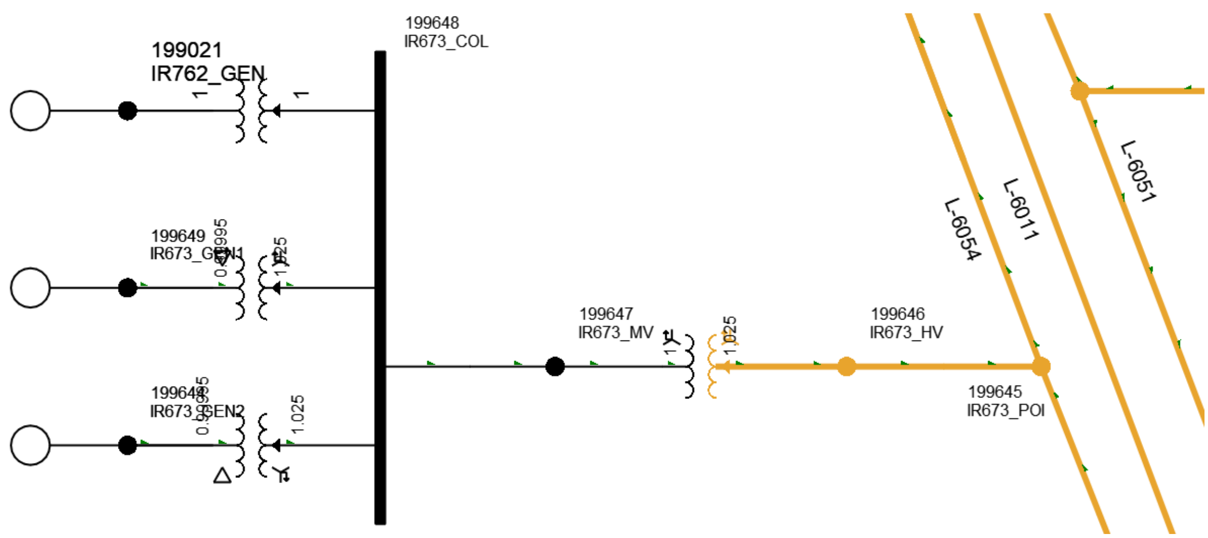

Figure 2: IR762 POI

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 IR762. 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 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* (TSIR).

- 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 IR762 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 and ERIS per section 3.2 of the Generation Interconnection Procedure (GIP).

2. Estimated Commercial operation date: 2027/06/24

3. The Interconnection Customer Generating Facility consists of 4 Enercon E-138 EP3 WTG each rated at 4.2 MW for a total of 16.8 MW connected to 1 collector circuits operating at a voltage of 34.5 kV.

4. The POI at L-6054 is not categorized as a Bulk Power System and will therefore not require compliance with applicable NPCC requirements

5. The POI at L-6054 is not categorized as a Bulk Electric System and will therefore not require compliance with applicable NERC requirements

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 substation transformer is rated at 34/45/57 MVA and modeled with a positive-sequence impedance of 7.5%, Wye-Delta-Wye Ground three winding configuration with +/-5% fixed load tap changer.

8. Preliminary data was provided by the IC for the generator step-up (GSU) transformers. Each GSU transformer is rated at 5 MVA with an impedance of 6.5%, +/-0.85 Power Factor, Delta-Wye Ground two winding configuration and assumed X/R ratio of 20.

9. Detailed collector circuit data was not provided, so typical data (R+jX = 0.021+j0.052 p.u, with B = 0.001 p.u charging susceptance on system base 100 MVA) was calculated 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 July 31, 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
- IR540: GIA Executed
- IR542: GIA Executed
- IR517: GIA in Progress
- IR574: GIA Executed
- IR598: GIA Executed
- IR597: GIA Executed
- IR647: GIA in Progress
- IR664: FAC Complete
- IR662: FAC Complete
- IR670: FAC Complete
- IR671: FAC in Progress
- IR669: GIA Executed
- IR668: GIA in Progress
- IR618: GIA in Progress
- IR673: GIA in Progress
- IR675: FAC Complete
- IR677: SIS 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 exception of IR686, IR739 and IR742 as the SIS were not sufficiently advanced when IR762 was initiated and/or as they are considered electrically remote from IR762.

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.*

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 this Enercon E-138 EP3 WTG is given as 1.05 times rated current, or X'd = 0.9524 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	IR762 and IR673 not in service	IR762 and IR673 in service	Post % Increase	Short Circuit Ratio (SCR) Without IR762
Max generation, all facilities in service (MVA)				
IR762_POI (138 kV)	1,330	1,429	7%	26.4
IR762_HV (138 kV)	1,317	1,416	8%	26.1
IR762-MV (34.5 kV)	337	466	38%	6.7
Min generation, all facilities in service (MVA)				
IR762_POI (138 kV)	740	837	13%	14.7
IR762_HV (138 kV)	736	833	13%	14.6
IR762-MV (34.5 kV)	281	405	44%	5.6
Min generation, L-6054-1 Out of Service (MVA)				
IR762_POI (138 kV)	513	610	19%	10.2
IR762_HV (138 kV)	511	608	19%	10.1
IR762-MV (34.5 kV)	241	365	51%	4.8

Ratings of breakers in adjacent substations were also reviewed and it was determined that no breaker upgrades or replacements were required. 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 based on both IR673 and IR762 generation (50.4MW) is 5.6 with all facilities in services, IR762 offline and IR673 offline. This falls to 4.8 with L-6054-1 Out of service. More detailed EMT analysis is required if IR762 proceeds to the SIS stage.

The IC should consult the wind turbine manufacturers to determine 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 2.5% with no individual harmonic exceeding 1.5% on 138 kV.

7 Load Flow Analysis

The load flow analysis was completed for Spring Minimum Load (SML), Summer Shoulder Load (SSH), Summer Peak Load (SUM) and Winter Peak Load (WIN) Scenarios with varying dispatch scenarios intended to cover a broad range of operating conditions.

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

Table 2: Case Scenario Details

Case Name	Description
SML_00 (Base Case)	Case under normal conditions with IR762 off
SML_01	Case under normal conditions with IR762 on max output
SML_02	Case with nearby generation on max output with IR762 on max output
SML_03	Case with nearby generation on max output with IR762 off
SSH_00 (Base Case)	Case under normal conditions with IR762 off
SSH_01	Case under normal conditions with IR762 on max output

Case Name	Description
SSH_02	Case with nearby generation on max output with IR762 on max output
SSH_03	Case with nearby generation on max output with IR762 off
SUM_00 (Base Case)	Case under normal conditions with IR762 off
SUM_01	Case under normal conditions with IR762 on max output
SUM_02	Case with nearby generation on max output with IR762 on max output
SUM_03	Case with nearby generation on max output with IR762 off
WIN_00 (Base Case)	Case under normal conditions with IR762 off
WIN_01	Case under normal conditions with IR762 on max output
WIN_02	Case with nearby generation on max output with IR762 on max output
WIN_03	Case with nearby generation on max output with IR762 off

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

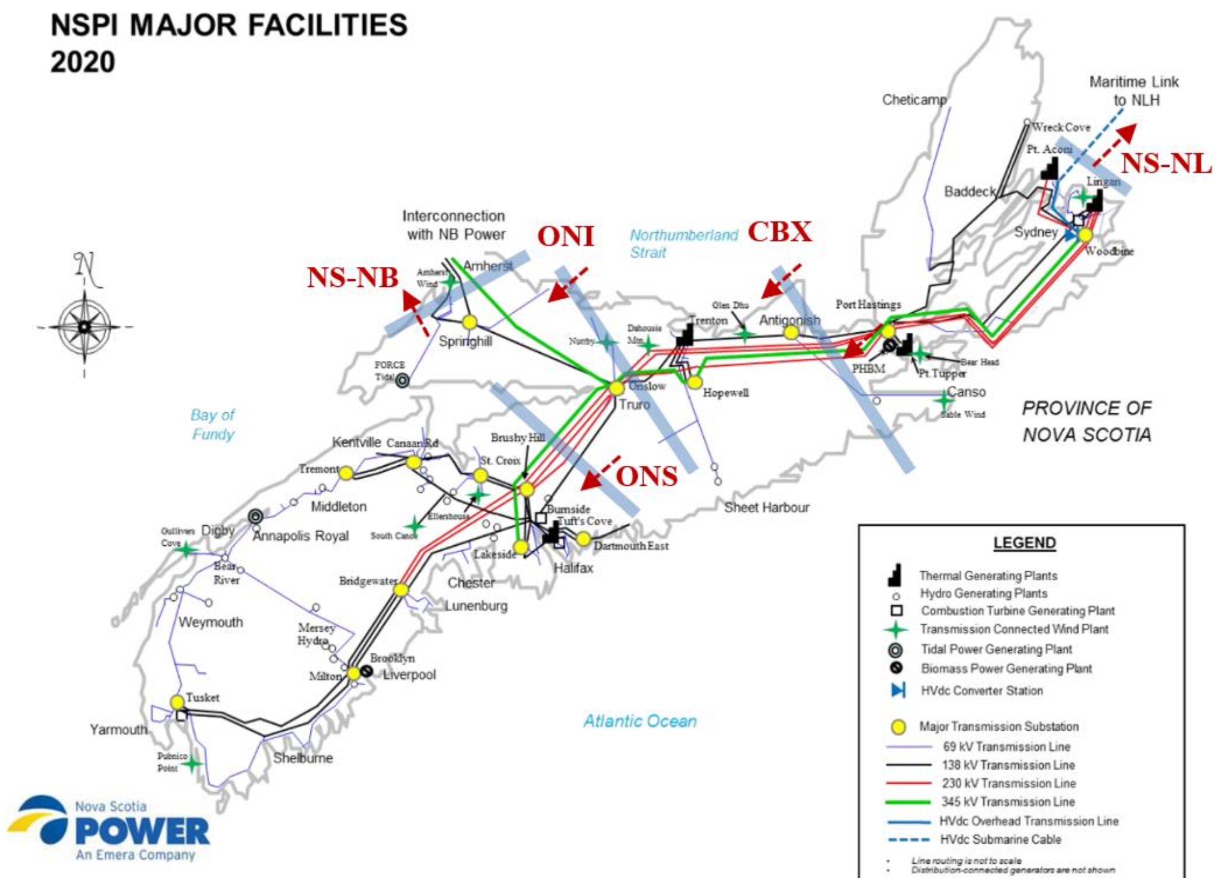

Figure 3: Relevant Transmission Interface

Table 3: Dispatch Cases for IR762

Case	IR762 Output (MW)	System Load (MW)	NS→NL (MW)	NS→NB (MW)	ONI (MW)	CBX (MW)	ONS (MW)
SML_00	0	722	170	168	69	40	-111
SML_01	16.8	705	170	168	53	24	-127
SML_02	16.8	894	170	339	54	25	-298
SML_03	0	909	170	339	69	40	-283
SSH_00	0	1195	330	152	370	292	164
SSH_01	16.8	1178	330	152	353	274	147
SSH_02	16.8	1366	330	328	354	276	-29
SSH_03	0	1382	330	328	370	292	-14
SUM_00	0	1528	330	150	616	509	383
SUM_01	16.8	1511	330	150	600	492	366
SUM_02	16.8	1699	330	329	601	493	186
SUM_03	0	1715	330	329	616	509	202
WIN_00	0	2296	170	0	930	738	763
WIN_01	16.8	2277	170	0	912	720	746
WIN_02	16.8	2466	170	184	914	738	562
WIN_03	0	2483	170	184	930	738	578

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 IR762. 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-l5500	91H-516	17V-611	104W-G1
88S-G4	50N-l5501	91H-521	17V-563	110W-T62
101S_ML-POLE1	50N-l5502	91H-523	17V-512	104H-600
101S_ML-POLE2	50N-l6503	91H-621	17V-519	50W, 50W-B3_OL
101S_ML-BIPOLE	50N-l6511	91H_L-6042	17V-505	50W, 50W-615_OL
101S-T81	50N-l6507	91H-613	101V-L6004-a	9W, 9W-T2_OL
101S-T82	50N-l6508	91H-604	101V-L6053	50W, 50W-B3
101S_L-7011	50N-GT6	91H_L-6007	101V-601	50W, 50W-615
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	DCT_L-7003][L-7004_G3
47C_B2	120H-628	3V-G1	132H-603	67N-711_G3
47C_B3	120H-629	3V-G2	132H-605	3C_L-7005_G3
47C_B4	90H-L6002-1	22V-L5033	132H-606	3C-710_G3
47C_B5	90H-L6009-2	43V-L6012	132H-L6044	3C-720_G3
47C_B6	90H-L-6008	43V-L6013	132H-L6040	DCT_L-7003][L-7004_G0
47C_B7	90H-L6003	43V-L6054	132H-L6055	67N-711_G0
4C_L-6552	90H-L5003-2	43V-L6015	1H-603	3C_L-7005_G0
4C_T63	90H-L5004-1	43V-50VLoad	1H-L-6035	3C-710_G0
4C_T2	90H-T1	43V-L6052	74N-600	3C-720_G0
4C_620	90H-C61	43V-L5017	74N-L6536	79N-T81_G0
4C_621	90H-C51	43V-L5022	74N-L6514	101S-812_G0
4C_622	90H-611	43V-L5021	74N-L5029	101S-813_G0
4C_623	90H-608	43V-T62	74N-L5058	79N-T81_G5
79N_L-6507	90H-605	43V-604	15V-B51	101S_L-8004_G5
79N_L-6508	90H-602	43V-T61	15V-L5050	101S-812_G5
67N_L-8002	90H-612	43V-B61	15V-L5538	101S-813_G5
67N_L-7019	90H-609	43V-B62	92V-B51	79N-T81_G6
67N_L-7001	90H-606	43V-SHUNT	DCT_L-5039][L-6033	101S_L-8004_G6
67N_L-7002	90H-603	43V-B51	DCT_L-7009][L-8002	101S-812_G6
67N-T81	90H-610	43V-505	DCT_L-6011][L-6010	101S-813_G6
67N-T82	90H-607	43V-562	DCT_L-6010][L-6005	51V, L-5025_SPS
67N-T71	90H-604	43V-503	DCT_L-6005][L-6016	13V, L-5026_SPS
67N-812	90H-601	43V-506	DCT_L-7008][L-7009	11V, 11V-B51_SPS
67N-813	90H-503	41V-L4048	DCT_L-6507][L-6508	51V, 51V-B51_SPS

67N-701	90H-506	41V-L4047	DCT_L-7021][L-6534	51V, L-5025
67N-702	90H-501	41V-407	DCT_L-6033][L-6035	13V, L-5026
67N-703	103H_L-6008	79V-L5015	85S_L-6545	11V, 11V-B51
67N-704	103H_L-6033	79V-L5016	5S_L-6538	51V, 51V-B51

8 Overload Results

Table 5 below shows the contingencies that cause overloads due to IR762. Note that Rate 2 is the 15-minute emergency rating of a transmission line and is equal to 110% of the line MVA rating.

Table 5: Results

ID	Item	Highest Overload (% of Rate 2)	Case	Contingency
1	Transmission Line: L-6004	105.1	SML_02	43V-T62 & 43V-B62 & **43V-562**

For this specific study, consideration was given to the following:

- Lines L-6004 and L-6054 are assumed to be upgraded to permit 100C maximum conductor operating temperature per IR673 System Impact Study.
- Subsequent overloading of L-6004 and L-6054 to 105% of their emergency rating will only occur when all wind generation connected to these lines is generating near 100% output and a breaker for one of these lines opens at 90H-Sackville (L-6004) or 43V-Canaan Road (L-6054).
- Under these wind conditions, line ratings would increase such that there would not be an overload condition due to the cooling provided by the wind.
- In the unlikely event of a line overload following the above contingencies, operator action could easily be taken to remotely curtail the output of IR762.

As a result, reconductoring and/or rebuilding of lines L-6004 and L-6054 to increase the ratings of these lines was not deemed necessary.

It should also be noted that the IC's substation transformer for IR673 will be overloaded with the addition of IR762's 16.8 MW up to 118% during high wind conditions where the facility is also delivering or consuming reactive power.

9 Reactive Power and Voltage Control

In accordance with the *Transmission System Interconnection Requirements* Section 7.6.2, IR762 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*). Reactive power can be provided by the asynchronous generator or by continually acting auxiliary devices such as

STATCOM, synchronous condenser, etc. Supplied by the Interconnection Customer, The P-Q diagram can be shown in Figure 4.

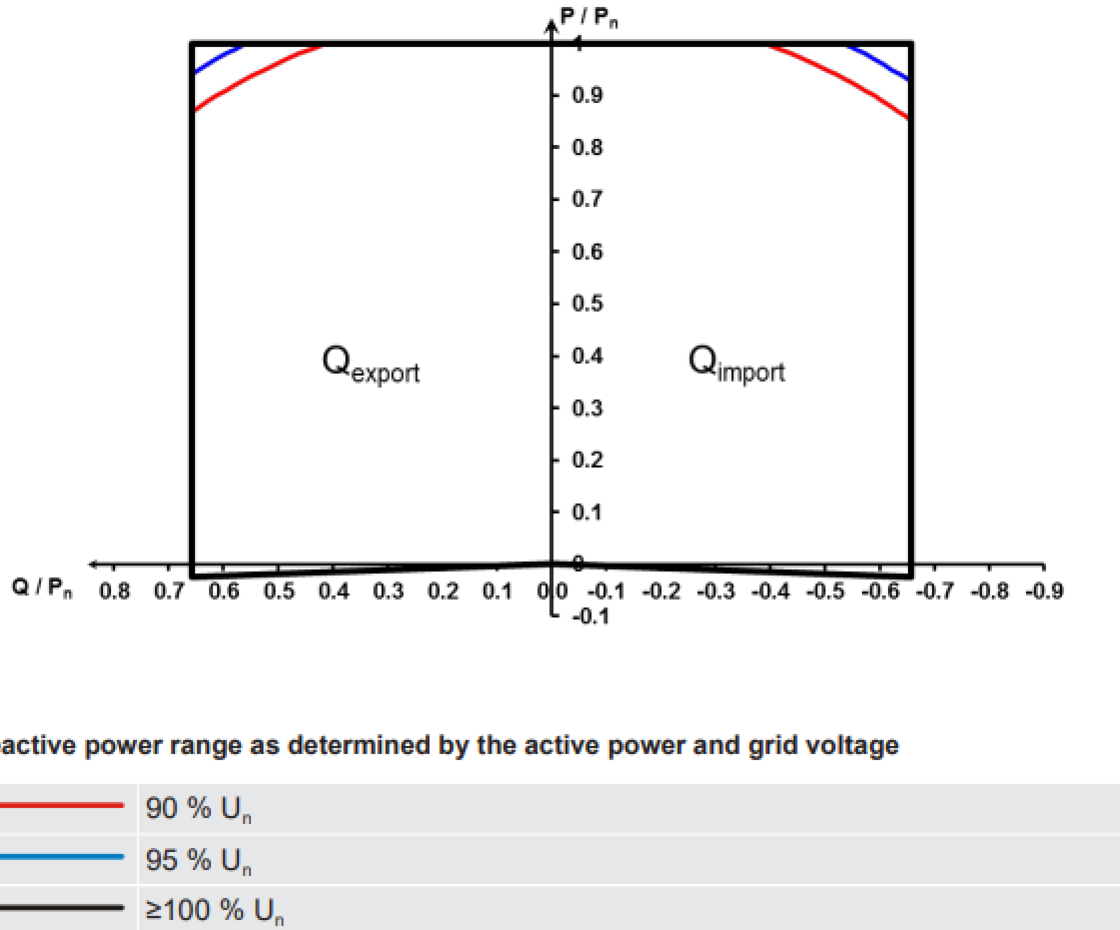

Figure 4: P-Q Diagram

The power factor analysis is conducted using a SMIB (Single Machine Infinite Bus) case for IR762 is shown in Figure 5.

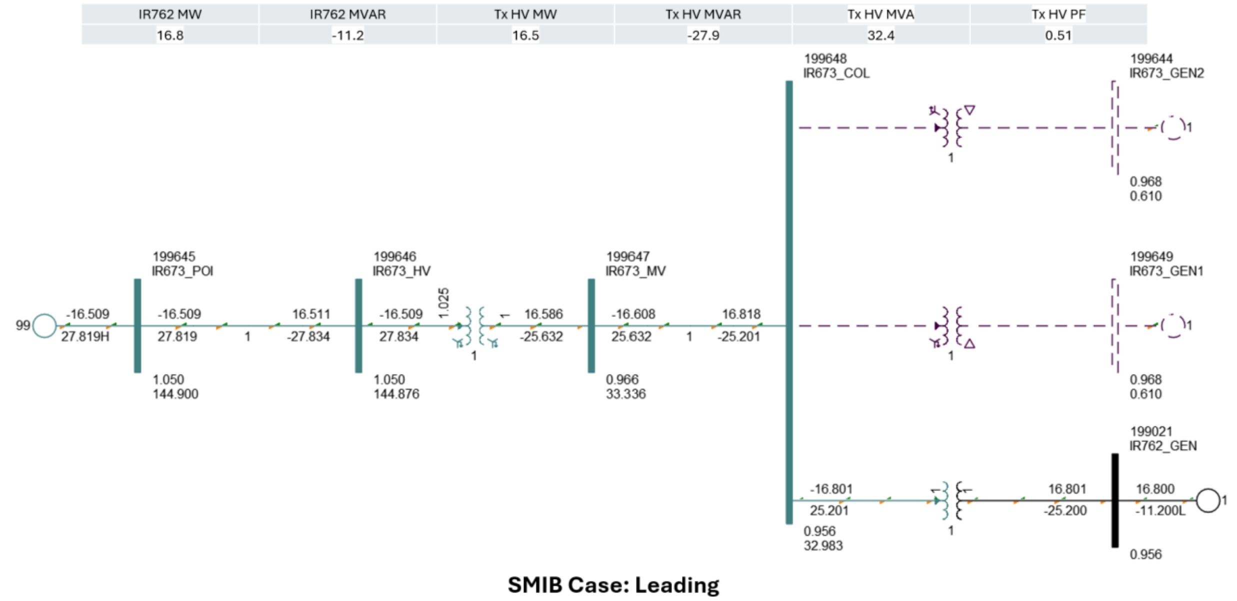

Figure 5: Leading Power Factor Analysis

Table 6: Leading Power Factor Analysis Results

IR762 MW	IR762 MVAR	Tx HV MW	Tx HV MVAR	Tx HV MVA	Tx HV PF
16.8	-11.2	16.5	-27.9	32.4	0.51

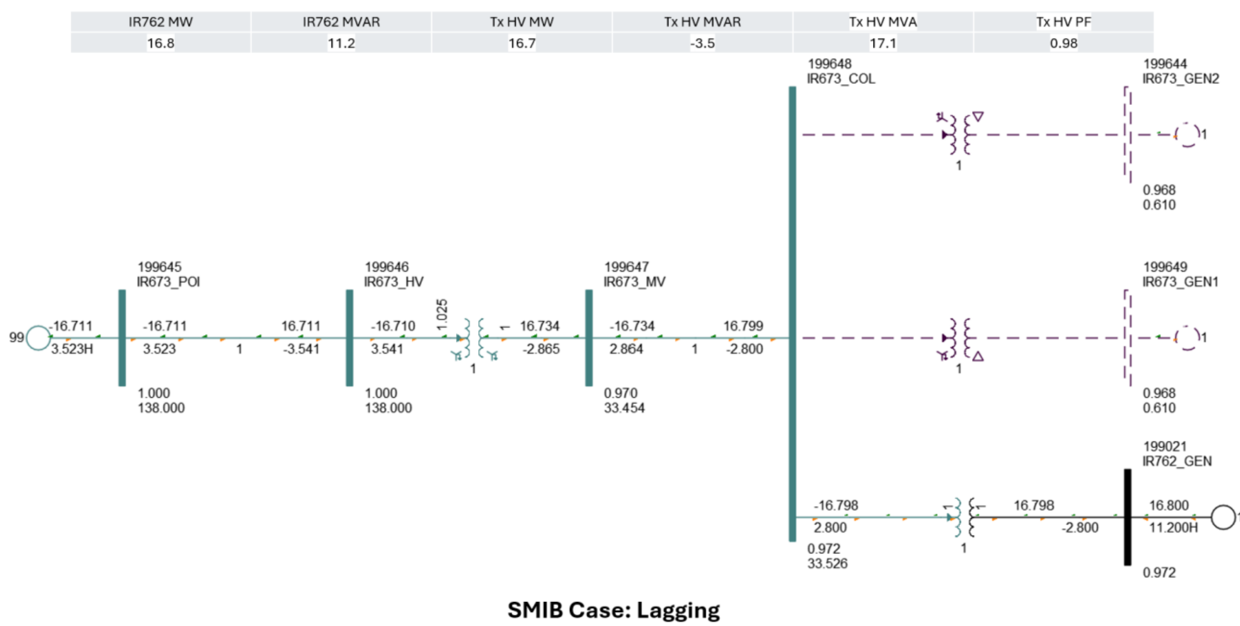

Figure 6: Lagging Power Factor Analysis

Table 7:Lagging Power Factor Analysis Results

IR762 MW	IR762 MVAR	Tx HV MW	Tx HV MVAR	Tx HV MVA	Tx HV PF
16.8	11.2	16.7	-3.5	17.1	0.98

This analysis shows that IR762 does not meet the lagging power factor requirement of 0.95. Since 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 coordinated and integrated with IR673's facility controls 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 IR673's collector circuit is not part of the NPCC Bulk Power System (BPS). As such, all protection systems associated with IR762 do not need to comply with NPCC Directory 4 System Protection Criteria.

Since IR673's collector circuit is not classified as part of the NERC Bulk Electric System (BES), it also is not subject to the applicable NERC Reliability Criteria.

On March 19, 2024, NERC filed with FERC a proposed revision to its Registry Criteria to include owners and operators of non-BES IBRs that are interconnected to the BPS and have a material aggregate impact on BES reliability. To address the impact on reliability, the revised Generator Owner (GO) and Generator Operator (GOP) Registry Criteria would include owners and operators of non-BES IBRs that either have or contribute to an aggregate nameplate capacity of greater than or equal to 20 MVA, connected through a system designed primarily for delivering such capacity to a common point of connection at a voltage greater than or equal to 60 kV (i.e., Category 2 GO and Category 2 GOP).

In preparation for NERC's new Category 2 GO and Category 2 GOP entity designations, this IR will be categorized accordingly and is expected to register with NERC/NPCC and adhere to applicable the NERC and NPCC requirements.

11 Expected Facilities Required for Interconnection

The following facility changes will be required to connect IR762 to the NSPI transmission system at the POI at L-6054.

11.1 NRIS

Required Network Upgrades:

1. None

Required Transmission Provider's Interconnection Facilities *(TPIF)*:

1. If IR762 is an expansion of IR673, there are no additional TPIF costs. If IR762 is a separate company under the same ownership as IR673, there are still no additional TPIF costs, and the ICIF remains the same as for IR673, although it could not be sold to an independent party at a later date. However, if IR762 is a new project under an independent company from IR673, the ICIF cannot be shared. IR762 will require its own substation transformer but may share the TPIF associated with IR673, provided that it contributes 50% of the TPIF cost, which will be refunded to IR673.

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, and 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 support short-duration frequency deviations by providing inertia response equivalent to a Synchronous Generator with an inertia factor (H) of at least 3.0 MW-s/MVA for
6. a period of at least 10 seconds.
7. Voltage ride-through capability as described in the NS Power TSIR.
8. 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.
9. 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.
10. Operation at ambient temperatures as low as -30ºC. The IC shall also provide icing models and conduct icing studies for their facility.
11. NS Power notes that NERC standard PRC-029-1 is currently in development. As proposed, this standard will impose performance requirements for voltage and frequency ride through behaviour on inverter-based generating resources. It is anticipated that this standard will be applicable to the project currently under study. The Interconnection Customer is advised to consider the requirements of PRC-029-1 in their project design to ensure that their project can conform to these requirements. Conformance will be validated at the System Impact Study stage.

11.2 ERIS

Required Network Upgrades:

1. None

Required Transmission Provider's Interconnection Facilities *(TPIF)*:

1. If IR762 is an expansion of IR673, there are no additional TPIF costs. If IR762 is a separate company under the same ownership as IR673, there are still no additional TPIF costs, and the ICIF remains the same as for IR673, although it could not be sold to an independent party at a later date. However, if IR762 is a new project under an independent company from IR673, the ICIF cannot be shared. IR762 will require its own substation transformer but may share the TPIF associated with IR673, provided that it contributes 50% of the TPIF cost, which will be refunded to IR673.

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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 l
3. mit/reduce total output from the facility, upon receipt of a telemetered signal from NSPI's SCADA system.
4. 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.
5. 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
6. ontrol (AGC) system to control tie-line fluctuations as required.
7. The facility shall support short-duration frequency deviations by providing inertia response equivalent to a Synchronous Generator with an inertia factor (H) of at least 3.0 MW-s/MVA for a period of at least 10 seconds.
8. Voltage ride-through capability as described in the NS Power TSIR.
9. 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.
10. 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.
11. Operation at ambient temperatures as low as -30ºC. The IC shall also provide icing models and conduct icing studies for their facility.
12. NS Power notes that NERC standard PRC-029-1 is currently in development. As proposed, this standard will impose performance requirements for voltage and frequency ride through behaviour on inverter-based generating resources. It is anticipated that this standard will be applicable to the project currently under study. The Interconnection Customer is advised to consider the requirements of PRC-029-1 in their project design to ensure that their project can conform to these requirements. Conformance will be validated at the System Impact Study stage.

12 NSPI Interconnection Facilities and Network Upgrade Cost Estimate

The high level, non-binding, present day cost estimate, including HST, for IR762's Interconnection Service is shown in *Table 6 NRIS Cost Estimate* and *Table 7 ERIS Cost Estimate*. These estimates assume 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 Cost Estimate

Table 8: NRIS Cost Estimate

Item	TPIF	Estimate
	If IR762 is an expansion of IR673, there are no additional TPIF costs. If IR762 is a separate company under the same ownership as IR673, there are still no additional TPIF costs, and the ICIF remains the same as for IR673, although it could not be sold to an independent party at a later date. However, if IR762 is a new project under an independent company from IR673, the ICIF cannot be shared. IR762 will require its own substation transformer but may share the TPIF associated with IR673, provided that it contributes 50% of the TPIF cost, which will be refunded to IR673.	$ 0
	Contingency (25%)	$ 0
	Sub-total	$ 0

	Network Upgrades	Estimate
	Contingency (25%)	$ 0
	Sub-total	**$ 0**

Determined costs	
Total of determined cost	**$ 0**

12.2 ERIS Cost Estimate

Table 9:ERIS Cost Estimate at 27.4% of Maximum Output

Item	TPIF	Estimate
	If IR762 is an expansion of IR673, there are no additional TPIF costs. If IR762 is a separate company under the same ownership as IR673, there are still no additional TPIF costs, and the ICIF remains the same as for IR673, although it could not be sold to an independent party at a later date. However, if IR762 is a new project under an independent company from IR673, the ICIF cannot be shared. IR762 will require its own substation transformer but may share the TPIF associated with IR673,	$ 0

	provided that it contributes 50% of the TPIF cost, which will be refunded to IR673.	
	Contingency (25%)	$ 0
	Sub-total	$ 0

Determined costs	
Total of determined cost	$ 0

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 (TC3) 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 8 and equation (01)

Table 10: Loss Factor Calculation

Name	Value (MW)
IR762 nameplate	16.8
TC3 with IR762	128.8
Total Losses with IR762	76.7
TC3 without IR762	145.9
Total Losses without IR762	77.0
Total Losses Delta	-0.3
Loss factor	-1.79%

$$Loss\ factor = \frac{(IR762_{\ nameplate} + TC3_{with/IR762}) - TC3_{without/IR762}}{IR762_{\ nameplate}} \qquad (01)$$

14 Preliminary scope of subsequent SIS

The following provides a preliminary scope of work for the subsequent SIS for IR762.

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.

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

NPCC[1] and NERC[2] criteria as well as NSPI guidelines and good utility practice. The SIS will also determine the contingencies for which this facility must be curtailed.

[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*

Appendix A: Transmission line ratings

L-6011	120H Brushy Hill	ACSR 556.5 Dove	100	215	242	478	478	800	2	382	800	1	231	670
	17V St. Croix					287	287	600	2	287	600	1	173	1171
L-6015	43V Canaan Road	ACSR 556.5 Dove	100	215	242	478	287	600	2	287	600	1	173	405
	51V Tremont					478	287	800	2	382	800	2	441	774
L-6012	17V St. Croix	ACSR 556.5 Dove	100	215	242	287	287	800	2	287	800	1	231	865
	43V Canaan Rd.					598	287	600	2	287	600	1		456
L-6004	90H Sackville	ACSR 556.5 Dove	75	174	210	478	287	800	2	382	800	1	231	473
	101V MacDonald Pond					478	478	800	2	382	800	2	231	741
L-6054	101V MacDonald Pond	ACSR 556.5 Dove	75	174	210	478	478	800	2	382	800	2	382	1543
	43V Canaan Rd					598	287	600	2	287	600	1	166	1212
L-6013	43V Canaan Rd.	ACSR 556.5 Dove	100	215	242	597	287	600	2	287	600	1	173	507
	51V Tremont					478	287	800	2	382	800	2	441	774
L-6015	43V Canaan Road	ACSR 556.5 Dove	100	215	242	478	287	600	2	287	600	1	173	405
	51V Tremont					478	287	800	2	382	800	2	441	774