Interconnection Feasibility Study Report

GIP-IR613-FEAS-R1

Generator Interconnection Request IR613

60 MW Wind Generating Facility

Location Amherst, Cumberland County, NS

2021-11-02

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer (IC) submitted an Interconnection Request (IR613) for Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS) for a proposed 60 MW wind generation facility interconnected to NSPI transmission system, with a Commercial Operation Date of December 1, 2024. The Point of Interconnection (POI) requested by the customer is line L-6535. The generation will consist of eleven Enercon E-160 EP5-E3 FT wind turbines.

This feasibility assessment is conducted with IR613 generation to be used in NS and not for exporting outside NS and to displace the planned phased out coal generation in Cape Breton as per NSPI's generation plan. If IR613 were to displace non-coal generation in Halifax, then major system upgrades associated with increasing Onslow South corridor and Metro Dynamic Reactive Reserve could be required and are not accounted for in this feasibility assessment.

Based on the information provided by the IC, this feasibility assessment provides the following findings:

- IR613 rated output, serving both NRIS and ERIS, does not violate thermal or voltage criteria when displacing planned phased out coal generation in Cape Breton and not generation in Halifax, NS (the Onslow South power flow level is maintained at the existing level).
- Voltage flicker and harmonic levels will be studied in System Impact Study (SIS).
- The 34.5kV/690V transformer impedances and ratings were not provided. The SIS will acquire the correct model and parameters for the study.
- IR613 will likely require power factor correction or mitigation measure to meet NSPI's power factor requirement when it delivers reactive power to the power system. This needs to be examined in subsequent SIS.
- The minimum Short Circuit Ratio (SCR) at 34.5 kV bus is 3.9 to be confirmed by SIS. It should be discussed with Enercon to ensure that the wind turbines can operate at this SCR level.
- The estimated loss factor for IR613 is 8.2% at rated output.
- The high level cost estimate, for either services NRIS or ERIS, in 2021 Canadian dollars, for IR613 connection as per the IC's POI is $7,881,500 which includes 10% contingency and excludes HST. The alternate high level cost estimate would be $2,436,500 if the POI were to move to 92N-Armherst substation and the IC substation were to move adjacent to 92N-Amherst substation.
- This feasibility assessment is completed without accounting for TSR411 and TSR412 which could significantly alter the results of this assessment

IR613 will be required to meet NSPI's Generator Interconnection Procedure (GIP) and Transmission System Interconnection Requirements (TSIR). This feasibility assessment will be further subjected to the subsequent SIS and Facility Study which will determine the final system requirements and upgrades for IR613.

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1.0 Introduction

The Interconnection Customer (IC) submitted an Interconnection Request (IR613) for Network Resource Interconnection Service (NRIS) for a proposed 60 MW wind generation facility interconnected to the NSPI transmission system, with a Commercial Operation Date of December 1, 2024.

IR613 Feasibility Study agreement, IR #613 Feasibility Study Agreement - Amherst 2 v1 signed.pdf, signed by the IC on 09/01/2021 states that the Point of Interconnection (POI) will be on L-6535 and the service as NRIS/ERIS.

The IC also provided a pdf document, IR613_AmherstII_60MW_ReceivedIR.pdf, with title "Interconnection Request Appendix 1 to GIP" signed by the IC on June 6, 2021 and by NSPI on June 25, 2021. The document contains the following information:

- NRIS, 60 MW, Eleven Enercon E-160 EP5-E3 FT wind turbines, Amherst, NS
- Individual wind turbine rating:
    - 6.2 MVA, 690 V, Power Factor 0.899
    - Short Circuit 1.2 p u
    - Max 5.56 MW
- Substation step-up transformer:
    - 50/83 MVA
    - 138 kV/34.5 kV plus Tertiary
    - Winding HV Wye, LV Delta, and Tertiary Wye.
    - Positive impedance Z1 of 9% on 50 MVA and X/R of 29.5
- Electrical one-line showing:
    - The IC's substation step-up transformer:
        - 50/66/83 MVA, +/- 10% OLTC, Z=9%
        - 138kV/34.5kV transformer with HV grounded wye, LV grounded wye, Tertiary delta.
    - Two collector circuits. Feeder 1 has 6 wind turbines and Feeder 2 has 5 wind turbines.
    - No information on the impedances of the collector circuits provided
- Technical data sheet on E-160 EP5 E3 FT wind turbines
    - P 5.56 MW, Q +/-2.7 MVAR, S 6.2 MVA
    - 690 V, Inom 4,652 A, Irated 5,188 A, Ikmax 5,600 A for short circuit

The information provided on the 138kV/34.5 kV transformer configuration is conflicting. Since the configuration indicated on the electrical one-line is consistent with NSPI's TSIR, which states "The winding configuration for a Generating Facility with medium voltage collector circuit and multiple generators is generally grounded-wye on the high side and grounded-wye on the low sided, with a delta tertiary winding", the transformer configuration as indicated on the electrical one-line will be used in this assessment.

The IC's email communication to NSPI on August 12, 2021 provided the revised POI to L-6535 as shown on Figure 1, about 1.7 km from 92N-Amherst. However, subsequent to the meeting with the IC on December 19, 2021 to review version R0 of this report, the IC asked to move the IC substation adjacent to the existing 92N-Amherst for the alternative POI. This report revision R1 reflects the IC's request.

Figure 1: POI Location

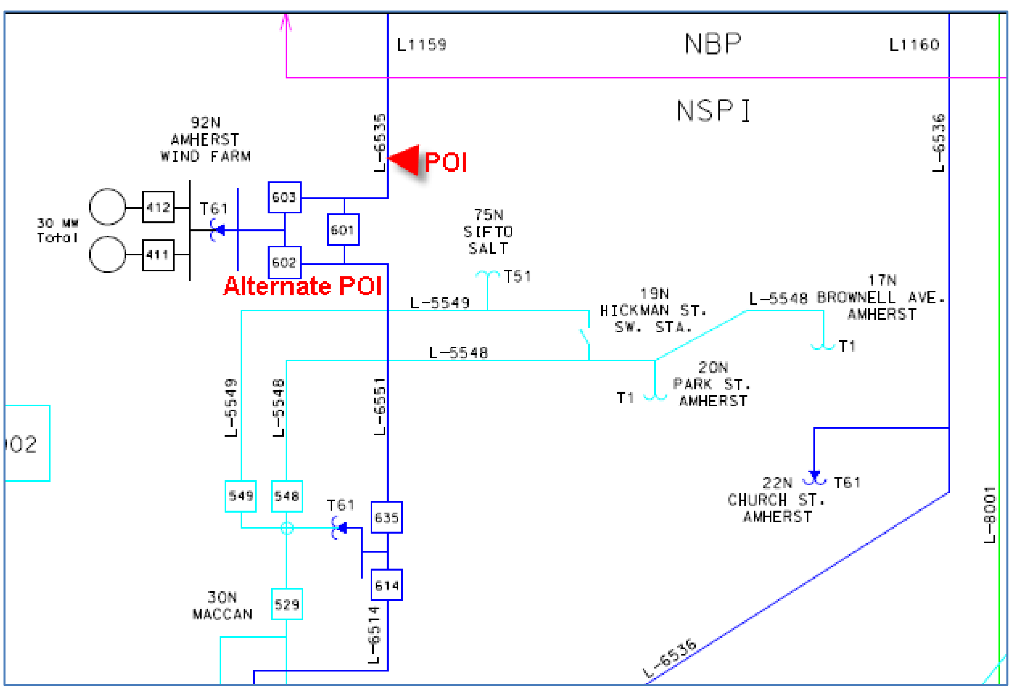

Figure 2 POI electrically (not to scale)

2.0 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 circuit breakers beyond their rated capacity, the circuit breakers must be upgraded.

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 the short circuit issues associated with the IR.
- 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.
- Preliminary description and high-level non-binding estimated cost to construct the facilities required to interconnect the generating facility to the transmission system.

This FEAS is based on a power flow and short circuit analysis and does not include a complete determination of system and 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 interconnect the generating facility.

Applicable planning criteria 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.

3.0 Assumptions

3.1 System Assumptions

As mentioned in section 4.0 Projects with Higher Queue Positions, TSR411 and TSR412 are not included in this feasibility assessment of IR613.

The power flow cases used for this feasibility assessment contain only transmission connected generating facilities.

3.2 Project Assumptions

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

1. Network Resource Interconnection Service (NRIS) type per the Generator Interconnection procedures (GIP). The IR613 generation is for used in NS and not for export outside NS and displaces the planned phased out coal generation in Cape Breton and not generation in Halifax, NS.
2. Commercial Operation Date of December 1, 2024.
3. The Interconnection Facility is modelled based on the information provided by the IC as per section 1.0 Introduction.
4. 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.
5. The information on collector circuits was not adequate for estimating the equivalent impedances, so assumed values were used. The subsequent SIS can obtain the details from the IC and do the correct modelling of the collector circuits at that time.
6. 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, with the exception of TSR411 and TSR412 as discussed earlier in the report.
7. 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.
8. It is the IC’s responsibility that the new facility will meet all requirements of NSPI’s GIP and NSPI’s Transmission System Interconnection Requirements.

4.0 Projects with Higher Queue Positions

All in-service generation is included in the FEAS.

Figure 3 shows the GIP queue, link https://www.nspower.ca/docs/default-source/pdf-to-upload/nspi-combined-interconnection-request-queue.pdf?sfvrsn=d112e57b_9, at the start of this assessment.

Combined T/D Advanced Stage Interconnection Request Queue

Publish Date: *Tuesday, August 03, 2021*

Nova Scotia POWER An Emera Company

Queue Order*	IR #	Request Date DD-MMM-YY	County	MW Summer	MW Winter	Interconnection Point Requested	Type	Inservice date DD-MMM-YY	Revised Inservice date	Status	Service Type	IC Identity
1 -T	426	27-Jul-12	Richmond	45	45	47C	Biomass	01-Jan-17	01/09/2018	GIA Executed	NRIS	N/A
2 -T	516	05-Dec-14	Cumberland	5	5	37N	Tidal	01-Jul-16	31/05/2020	GIA Executed	NRIS	N/A
3 -T	540	28-Jul-16	Hants	14.1	14.1	17V	Wind	01-Jan-18	31/10/2023	GIA Executed	NRIS	N/A
4 -T	542	26-Sep-16	Cumberland	3.78	3.78	37N	Tidal	01-Jan-19	01/11/2021	GIA Executed	NRIS	N/A
5 -D	557	19-Apr-17	Halifax	5.6	5.6	24H	CHP	01-Sep-18		SIS Complete	N/A	N/A
6 -D	569	26-Jul-19	Digby	0.6	0.6	509V-302	Tidal	01-Mar-21	30/07/2021	GIA Executed	N/A	N/A
7 -D	568	21-May-19	Cumberland	2	2	22N-404	Solar	01-Sep-20	01/09/2021	GIA Executed	N/A	N/A
8 -D	566	16-Jan-19	Digby	0.7	0.7	509V-301	Tidal	31-Jul-19	29/01/2021	GIA Executed	N/A	N/A
9 -T	574	27-Aug-20	Hants	58.8	58.8	L-6051	Wind	30-Jun-23		FAC in Progress	NRIS	N/A

Nova Scotia Power - Interconnection Request Queue: Page 1 of 2

ERIS - Energy Resource Interconnection Service
NRIS - Network Resource Interconnection Service
N/A - Not Applicable

T - Transmission Interconnection Request
D - Distribution Interconnection Request

*** Note: Queue reflects current list of IR's which have established an advanced queue position per GIP/DGIP Section 4.1**

Queue Order*	IR #	Request Date DD-MMM-YY	County	MW Summer	MW Winter	Interconnection Point Requested	Type	Inservice date DD-MMM-YY	Revised Inservice date	Status	Service Type	IC Identity
10-D	595	11-Mar-21	Halifax	0.1	0.1	1H-454	Battery	11-Jan-21		SIS Complete	N/A	N/A
11-T	598	13-May-21	Cumberland	2.52	2.52	37N	Tidal	01-Dec-22		SIS in Progress	NRIS	N/A
12-D	604	07-Jun-21	Cape Breton	0.45	0.45	11S-303	Solar	15-Jan-22		SIS in Progress	N/A	N/A
13-D	603	31-May-21	Cumberland	0.4	0.4	22N-404	Solar/Battery	16-Feb-22		SIS in Progress	N/A	N/A
14-D	600	27-May-21	Halifax	0.6	0.6	99H-312	Solar/Battery	02-Mar-22		SIS in Progress	N/A	N/A

Figure 3: GIP Queue

The following projects are higher queued in the Advanced Stage Interconnection Request Queue and are committed to the study:

- 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 in Progress
- IR595: SIS Complete
- IR598: SIS in Progress
- IR604: SIS in Progress
- IR603: SIS in Progress
- IR600: SIS in Progress

Figure 4 shows the Transmission Service Request (TSR) queue, link https://www.nspower.ca/docs/default-source/test/transmission-service-studies-feb-18-2020.pdf?sfvrsn=5a5228ea_2, at the start of this assessment.

OATT Transmission Service
Queued System Impact Studies
Active June 15, 2021

Project	Date & Time of Service Request	Project Type	Project Location	Requested In-Service Date	Project size (MW)	Status
TSR 400	July 22, 2011	Point to Point	NS-NB	May 2019	330	System Upgrades in Progress
TSR 411	January 19, 2021	Point to Point	NB-NS	Jan 1, 2025	800	SIS In Progress
TSR 412	January 19, 2021	Point to Point	Woodbine-NS	Jan 1, 2025	500	SIS In Progress
TSR 413	April 14, 2021	Network	Antigonish NS	Jan 1, 2022	8.792	Accepted Application

Figure 4: TSR Queue

TSR400 has a firm export from NS to NB of 150 MW in winter and 330 MW in summer. This is a “through NS” export from NL via the Maritime Link (ML) HVDC to the NS and NB border, and NS does not carry the operating reserve for it. The sink entity will be responsible for that reserve. Loss of ML HVDC under this condition, NS will cut the 150 MW or 330 MW “through NS” export.

Regarding TSR411 and TSR412, they 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.*

5.0 Short-Circuit Duty / Short Circuit Ratio

The maximum (design) expected short-circuit level is 5,000 MVA on 138 kV systems.

Short circuit analysis is based on ASPEN One-Liner v14.4 short circuit case that is maintained and updated by NSPI system protection department for short circuit calculations. The case is imported into PSSE version 33.12.1 and the short circuit analysis is performed in PSSE with higher queued projects and IR613 added to the PSSE models.

IR613 short circuit capability used for this assessment is based on the information provided by the IC as per section “1.0 Introduction”.

The short circuit calculations are based on three-phase-fault and flat voltage profile at one per unit voltage.

Minimum generation has only the Maritime Link, Point Aconi, Lingan 1, and Trenton 6 in NS in service under the present system operating requirements. In NB, only the nuclear plant Point Lepreau and the large coal plant Belledune in service.

Table 1 shows maximum and minimum short circuit levels at 410N-memramcook, 92N-Amherst, and IR613 POI.

Maximum generation system normal	410N Memramcook	92N-Amherst	IR613 POI	Unit
IR613 Off	2,313	1,161	1,171	MVA
IR613 On	2,358	1,220	1,232	MVA

Table 1: Maximum generation short circuit level system normal

The interrupting capability of the 138 kV circuit breakers at 138 kV substations is at least 3,500 MVA, much higher than the maximum short circuit levels at these locations with IR613 being on-line, hence IR613 will not incur any breaker upgrades at these substations.

As for the minimum short circuit level, Table 2 shows minimum short circuit levels at IR613 POI, 34.5 kV bus and 690 V equivalent generator terminal bus.

Minimum generation system normal	IR613 POI	IR613 34.5 kV	IR613 Terminal	Unit
IR613 Off	904	293	219	MVA
IR613 On	966	367	301	MVA

Table 2: Minimum generation short circuit level system normal

Table 3 shows minimum short circuit levels at IR613 POI, 34.5 kV bus and 690 V equivalent generator terminal bus with L-6535 out of service between IR613 POI and

410N-Memramcook. These fault levels are lower than the values with L-6535 out of service between IR613 POI and 92N-Amherst.

Minimum generation with L-6535 Out (section from IR613 to Memramcook)	IR613 POI	IR613 34.5 kV	IR613 Terminal	Unit
IR613 Off	516	234	184	MVA
IR613 On	578	308	265	MVA

Table 3: Minimum generation short circuit level with L-6613 out

Table 3 system three phase short circuit (with IR613 off-line) at the POI 138 kV is 516 MVA and short circuit level at 34.5 kV is 234 MVA. Hence, the short circuit ratio (SCR) for IR613 at 34.5 kV level is 234/60 = 3.9 which is less than the minimum required SCR of 5 based on the information provided by the IC. Therefore, the IC needs to discuss with the wind turbine manufacturer for the design of the wind turbines to operate properly at this SCR. In addition, the subsequent system impact study will verify the final SCR.

6.0 Voltage Flicker and Harmonics

The voltage flicker and harmonics can’t be determined due to lack of information at this time. Hence, the subsequent SIS can obtain the required information and to determine if the requirements are met.

7.0 Thermal Limits

7.1 NS Load Forecast

At the time of this assessment for IR613, the latest NSPI corporate load forecast available was in the “2021 Ten Year System Outlook” report issued by NS Power June 30, 2021. The load forecast for the year 2031 has NS system peak forecast of 2,262 MW with a firm peak of 2,057 MW. The total net system load includes system losses but excludes power plant station service loads.

The winter peak load for NS is modeled based on the above load forecast.

7.2 IR613 Model

Based on the information provided by the IC, the following was determined and modelled for IR613:

1. The POI on L-6535 is modelled at 1.7 km from 92N-Amherst substation.

2. The IC's 138 kV to 34.5 kV substation is modelled adjacent to the POI.

3. The 138 kV to 34.5 kV transformer is modelled based on 9% positive impedance on 50 MVA base rating and X/R of 29.5. The nominal rating is modelled as 83 MVA.

4. The 34.5 kV to 690 V transformer is not provided. For the purpose of this feasibility assessment, it is modelled based on assumed values of 9.9% positive impedance and 1% resistance on 7 MVA base rating. The equivalent 34.5kV/690V transformer for the wind farm is modelled as 9.9% positive impedance and 1% resistance on the nominal rating of 77 MVA.

5. The equivalent generator for the 11 wind turbines is modelled based on the information provided by the IC for each wind turbine of 5.56 MW, 6.2 MVA and +/-2.7 MVAR with the total output of 60 MW at 690 V.

6. The information on collector circuits was not adequate for estimating the equivalent impedances, so assumed values were used. The subsequent SIS can obtain the details from the IC and do the correct modelling of the collector circuits at that time.

7.3 IR613 Steady State Analysis Result

This feasibility assessment is completed based on IR613 output being used in NS, not for exporting outside NS, and displacing the planned phased out coal generation in Cape Breton as per NSPI's present plan and guidelines for these feasibility assessments. The guidelines include all wind farms in NS to be dispatched at full outputs in two seasons, winter peak and summer peak. System light load dispatches are only required in the western/valley area of NS.

The present NB to NS firm import is zero. The base cases are dispatched with NB to NS at 142.5 MW to allow ten minute reserve delivery from NB to NS.

The present NS to NB firm export is 150 MW in winter season and 330 MW in non-winter season. The base cases are dispatched with NS to NB at 320 MW in winter peak and 500 MW in summer peak to allow for the ten minute reserve delivery from NS to NB.

In order to maintain ONS or CBX power flow within the existing established operating limits, ten minute operating reserve from NS to NB may need to come from Burnside units. In addition, these units can be dispatched as synchronous condensers as needed to meet the Metro Dynamic Reactive Reserve requirements.

For each system dispatch chosen, a steady state analysis is performed and checked for the system performance with IR613 off-line and with IR613 on-line at full output in order to determine any thermal overload or voltage violation directly caused by IR613.

A number of system dispatch cases were created based on the above conditions using PSSE software version 33.12.1. The power flows of various interfaces inside and outside NS are displayed in Table 4.

Case Name	NB to NS	NB to PEI	NB to NE	NL to NS	NB to HQ	CBX	ONI	ONS	TC	TR	LG	PA	BS	IR 613	Trans Wind
C01a_WP_R1.sav	142.5	150	0	475	-928	869	948	975	84	165	266	185	0	0	489
C01b_WP_R1.sav	142.5	150	0	475	-928	807	890	975	84	165	202	185	0	60	549
C02a_WP_R1.sav	-320	250	0	475	-928	1237	1273	833	110	150	495	189	100	0	489
C02b_WP_R1.sav	-320	250	0	475	-928	1170	1213	833	110	150	425	189	100	60	549
C03a_SP_R1.sav	142.5	150	-800	475	-785	426	426	532	0	0	155	168	0	0	489
C03b_SP_R1.sav	142.5	150	-800	475	-785	366	368	532	0	0	93	168	0	60	549
C04a_SP_R1.sav	-500	236	-800	475	-785	841	973	430	0	157	371	190	100	0	489
C04b_SP_R1.sav	-500	236	-800	475	-785	778	913	430	0	157	304	190	100	60	549

Table 4: Power system cases

Applicable contingencies in NS and some contingencies in NB around Memramcook substation were simulated in steady state for the above cases. These contingencies are shown in Table 5. For load flow, 67N-815 contingency is the same as L-8001 contingency and 67N-816 contingency is the same as L-8003 contingency due to the empty node between 67N-815 breaker and 67N-816 breaker. In NS, system normal uses Rate A and N-1 contingencies use Rate B, whereas in NB, system normal uses Rate A and N-1 contingencies use Rate C. Contingencies marked with * denotes applicable in service SPS may be armed.

Contingencies in NS and NB				
101S_701	120H_710	30N_B61	67N_706	90H_608
101S_702	120H_711	30N_T61	67N_710	90H_609
101S_703	120H_712	3C_711	67N_713	90H_611
101S_704	120H_713	3C_712	67N_811*	90H_612
101S_705	120H_714	3C_713	67N_812	90H_T1
101S_706	120H_715	3C_714	67N_813	91H_511
101S_711	120H_716	3C_715	67N_814	91H_513
101S_712	120H_690	3C_716	67N_T71	91H_516
101S_713	120H_SVC	3C_T71	67N_T81	91H_521
101S_811	120H_T71	3C_T72	67N_T82	91H_523
101S_812*	120H_T72	3C710*	67N711*	91H_603
101S_813*	132H_602	3C690*	67N712*	91H_604
101S_814*	132H_603	3S_T1	70037004*	91H_605

Contingencies in NS and NB				
101S_816	132H_605	47C_602	70087009Sep	91H_606
101S_T81	132H_606	47C_603	74N_B61	91H_607
101S_T82	1C_689	47C_674	74N_T61	91H_608
103H_600	1C_B61	47C_T63	79N-T81*	91H_609
103H_608	1C_B62	47C_T64	85S_B61	91H_611
103H_681	1C_G2	47C_T65	85S_G1	91H_613
103H_881	1N_600	47C_T67	88S_710	91H_621
103H_B61	1N_601	49N_600	88S_711	91H_T11
103H_B62	1N_613	4C_T2	88S_712	91H_T62
103H_T81	1N_B51	4C_T63	88S_713	91H_TC3
104H600	1N_B52	50N_500	88S_714	91N_701
108H_600	1N_B61	50N_604	88S_715	IR613_POI
108H_B1	1N_B62	50N_B55	88S_690	L-5003
108H_B3	1N_C61	50N_B57	88S_721	L-5011
113H_600	1N_T1	50N_G6	88S_722	L5012
120H_621	1N_T4	50N_T12	88S_723*	L-5014
120H_622	2CB61WC1	50N_T8	88S_G4	L-5015
120H_623	2CB62WC1	50NB61G6	88S_T71	L-5016
120H_624	2S_513	50NB62G5	88S_T72	L-5017
120H_625	2S_600	67N_701	89S_G1	L-5019
120H_626	2S_B64	67N_702	90H_602	L-5020
120H_627	2S_B65	67N_703	90H_603	L1108
120H_628	2S_T1	67N_704	90H_604	L1142
120H_629	L-5534	L6012	L6523	L1108
L-5021	L-5535	L6013	L6531	L1142
L-5022	L-5536	L6014	L6535 92N-IR613	L1143
L-5023L5053	L-5537	L6015	L6535 410N-IR613	L1148-L1151*
L-5024	L-5538	L6016	L6536	L1157
L-5025	L-5539	L6020	L6537*	L1190
L-5026	L-5541	L6021	L6538	L1190-L1215
L-5027	L-5546	L6024	L6539	L1244
L-5028	L-5547L5551	L6025	L6551	L3004
L-5029L5030	L-5548	L6033	L6552	L3006
L-5032L5004	L-5549	L60335039	L6613	L3013
L-5033	L-5550L5582	L60336035	L7001	L3017_3019
L-5035	L-5559L5579	L6035	L7002	Lepreau
L-5036	L-5560	L6038	L7003	ME1-10
L-5037L3031	L-5561L5565	L6040	L7004	ME1-11
L-5039	L-5563	L60406042	L7005*	ME1-12

Contingencies in NS and NB				
L-5040	L-5564L5576	L6042	L7008	ME1-13
L5041	L-5571	L6043	L7009	ME1-14
L-5042	L-5573L5575	L6044	L7011	ME1-15
L5049	L-5580	L6047	L7012	ME1-16
L-5054	L6001	L6048	L7014	ME1-6
L-5058	L6002_90H	L6051	L7015	ME1-7
L-5500	L6002_99W	L6052	L7019	ME1-8
L-5501	L6003	L6053	L7021	ME1-9
L-5502	L60036007	L6054	L70216534	ME3-1*
L-5505	L60036009	L6055	L7022	ME3-2*
L-5506	L6004	L6503	L8001*	ME3-3*
L-5507L5508	L6005	L6507	L8002	Mem_T3
L-5511	L60056010	L65076508	L80027009	
L-5512	L60056016	L6508	L8003*	
L-5521	L6006	L6510	L8004*	
L-5524	L6007	L6511	ML_2Poles	
L-5527A	L6008	L6514	ML_Pole1	
L-5527B	L6009	L6515	ML_Pole2	
L-5530	L6010	L6516	PHP	
L-5531	L60106011	L6517	90H_605	
L-5532	L6011	L6518	90H_606	
L-5533L5581	2S_T2	67N_705	90H_607	

Table 5: Contingencies in NS and NB studied

The load flow results show that, when IR613 rated output is used in NS and displaces the planned phased out coal generation in Cape Breton as per NSPI's generation plan, IR613 operating at full output does not violate thermal limit criteria.

8.0 Voltage Limits

The load flow results show that, when IR613 rated output is used in NS and displaces the planned phased out coal generation in Cape Breton as per NSPI's plan, IR613 operating at full output does not violate voltage criteria.

Regarding power factor, NSPI requires IR613 to meet +/-0.95 on the high voltage side of the IC substation transformer.

Figure 5 shows power factor on the high voltage side of the IC substation transformer when IR613 generates maximum reactive power output. Table 6 shows that IR613 does not meet NSPI's required power factor of +0.95 or less, hence IR613 will require power factor correction. This will be further examined in the SIS as the collector circuit impedances were not provided for this feasibility assessment and assumed values were used.

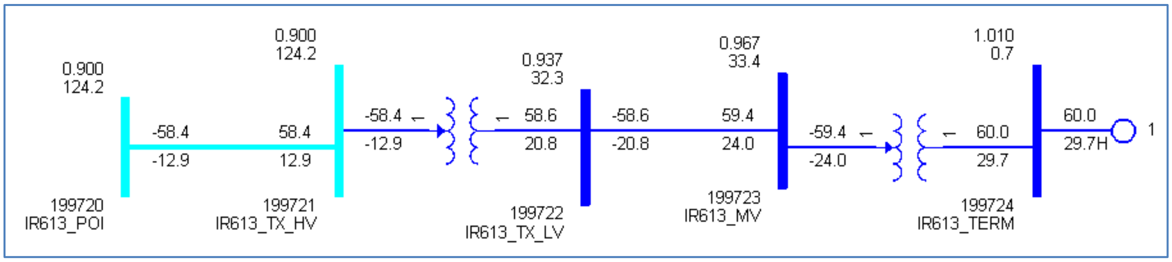

Figure 5 Power Factor with Qmax

IR613 Max MW	IR613 Max MVAR	Tx HV MW	Tx HV MVAR	Tx HV Power Factor
60.0	29.7	58.4	12.9	0.976

Table 6: Power factor with Qmax

Figure 6 shows power factor on the high voltage side of the IC substation transformer when IR613 absorbs maximum reactive power output. Table 7 shows that IR613 meets NSPI's required power factor of -0.95 when it absorbs reactive power from the system. This will be further examined in the SIS as the collector circuit impedances were not provided for this feasibility assessment and assumed values were used.

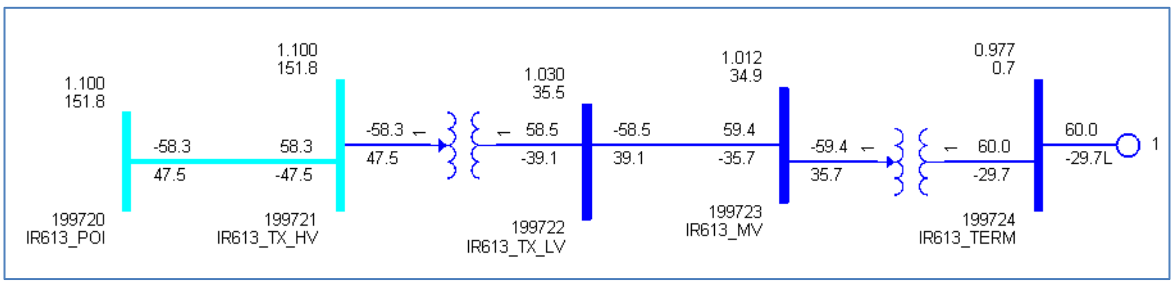

Figure 6 Power Factor with Qmin

IR613 Max MW	IR613 Max MVAR	Tx HV MW	Tx HV MVAR	Tx HV Power Factor
60.0	-29.7	58.3	-47.5	0.775

Table 7: Power factor with Qmin

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 (Please refer to

NSPI's TSIR). 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 NSPI's TSIR. The SIS will state specific options, controls and additional facilities that are required to achieve this.

9.0 System Security / Bulk Power Analysis

L-6535 is not on NSPI's BPS (Bulk Power System) list or BES (Bulk Electricity System) list. However, it forms part of the intertie transmission corridor between NS and NB with existing transfer limits/constraints. As per the Table 8 of NSPI's TSIR, connection to these lines will require "three breaker ring bus with protection". The existing 92N-Amherst wind farm connected to L-6535/L6551 on this corridor has a three breaker ring bus. The SIS will determine the BPS and BES status of IR613.

10.0 Loss Factor

The Loss Factor calculation is based on the peak load case and is used only for comparison purposes. The winter peak load flow case is run with and without the new facility in service, while keeping 91H-Tufts Cove Generator 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 for IR613 is shown in Table 8:

Loss Factor	
Description	**MW**
IR613 On	60
TC3 with IR613 On	104.5
TC3 with IR613 Off	159.6
IR613 Loss Factor	+8.2%

Table 8: Loss factor

11.0 Expected Facilities Required for Interconnection

The following facility changes will be required to connect IR613 to L-6535.

L-6535 is not presently on NSPI's Bulk Power System list or Bulk Electricity System list, but it forms part of NS-NB intertie transmission corridor with existing transfer limits. As required by NSPI's "Transmission System Interconnection Requirements", dated February 25, 2021, Version 1.1, connection to these lines requires a three breaker ring bus. This is evidenced by the existing connection of 92N-Amherst wind farm with a three breaker ring bus to L-6535.

a. Required Network Upgrades

- Modification of NSPI protection systems at 410N-Memramcook and 92N-Amherst on line L-6535.
- Install a new 138kV substation complete with 3 breaker ring bus at the POI to L-6535 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):

- Install 138 kV jumpers from NSPI Interconnection Facility substation at the POI to the IC substation.
- Add P&C, 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. Please refer to NSPI's TSIR for additional requirements such as primary frequency responses (curtailed and un-curtailed), full reactive power capability over active power range and voltage/frequency ride through.

- 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 Nova Scotia Power Transmission System Interconnection Requirements (TSIR) document.
- 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 SPS run-back schemes.
- Automatic Generation Control to assist with tie-line regulation.
- The facility must meet NSPI's TSIR as published on the NSPI OASIS site at https://www.nspower.ca/oasis/standards-codes.

12.0 Facilities and Network Upgrades Cost Estimate

The cost estimates for NSPI Interconnection Facilities (IF) and Network Upgrades for interconnecting IR613, for either services NRIS or ERIS, to L-6535 are shown in Table 9. Please note that this cost estimate is high level, non-binding in 2021 Canadian dollars. This does not include additional costs to be identified by the subsequent SIS and Facility Study.

Item	Network Upgrades	Estimate
I	P&C modifications at 410N-Memramcook and 92N-Amherst for L-6535	$400,000
II	The breaker ring bus 138 kV substation at POI	$6,250,000
	Sub-total for Network Upgrades	$6,650,000
Item	**TPIF Upgrades**	**Estimate**
I	Install jumpers from NSPI IF substation to IC substation	$200,000
II	P&C relaying equipment	$100,000
III	NSPI supplied RTU	$65,000
IV	Tele-protection and SCADA communications	$150,000
	Sub-total for TPIF Upgrades	$515,000
Item	**Total Upgrades**	**Estimate**
	Network Upgrades + TPIF Upgrades	$7,165,000
	Contingency (10%)	$716,500
	Total (Incl. 10% contingency and Excl. HST)	$7,881,500

Table 9: POI cost estimate

An alternate POI cost estimate, which has an overall lower total cost, involves moving the

POI to 92N-Ahmerst substation and the IC substation adjacent to 92N-Ahmerst substation. This alternate POI option will avoid the cost of a new three breaker ring bus substation at the POI on L-6535 and a new 138 kV spur line, about 1.7 km, from the POI to 92-Amherst substation. This alternative option requires adding a fourth 138 kV node at 92N-Amherst substation. In this case, the 4th breaker addition will be network upgrade and there is no 138 kV spur line from the alternate POI to the IC substation. This cost estimate is shown Table 10.

Item	Network Upgrades	Estimate
I	P&C modifications at 92N-Amherst for new node	$200,000
II	Add a new 138 kV node and a new spur line termination to existing three breaker ring bus at 92N-Amherst	$1,700,000
	Sub-total for Network Upgrades	$1,900,000
Item	**TPIF Upgrades**	**Estimate**
I	As IC asked to assume IC substation to be adjacent to 92N-Amherst substation with no 138 kV line extension.	$0
II	P&C relaying equipment	$100,000
III	NSPI supplied RTU	$65,000
IV	Tele-protection and SCADA communications	$150,000
	Sub-total for TPIF Upgrades	$315,000
Item	**Total Upgrades**	**Estimate**
	Network Upgrades + TPIF Upgrades	$2,215,000
	Contingency (10%)	$221,500
	Total (Incl. 10% contingency and Excl. HST)	$2,436,500

Table 10: Alternate POI cost estimate

13.0 Preliminary Scope of the SIS

The following provides a preliminary scope of work for the subsequent SIS for IR613. 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, low voltage ride-through, frequency ride-through, and power factor to meet NSPI TSIR requirements. The SIS will be conducted in accordance with the GIP with the assumption that all appropriate higher-queued projects will proceed and the facilities associated with those projects are installed.

The following outline provides the minimum scope that must be complete in order to assess the impacts. It is recognized the actual scope may deviate, to achieve the primary objectives. The SIS will consider but not be limited to the following:

1) Correct models of the entire facility from the POI to the IC substation and IR613 facility including the collector circuits.
2) Facilities that the customer must install to meet the requirements of the GIP and NSPI's latest version of "Transmission System Interconnection Requirements", informally referred to as NSPI's Grid Code.
3) The minimum transmission additions/upgrades that are necessary to permit operation of this Generating Facility, under all dispatch conditions, meeting NPCC and NERC criteria.
4) Guidelines and restrictions applicable to first contingency operation (curtailments etc.).
5) Under-frequency load shedding impacts.
6) Metro Dynamic Reactive Reserves requirement, thermal and voltage assessment for increasing Onslow South if IR613 is required to displace generation at Tufts Cove instead of the planned phased out coal generation in Cape Breton as per NSPI's present generation plan.

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 latest revision as approved by NS-UARB.
- Table 1 "Steady State & Stability Performance Planning Events" of NERC TPL-001-x latest revision as approved by NS-UARB.
- NSPI System Design Criteria, report number NSPI-TPR-003-4 latest revision as approved by NSPI and submitted to NS-UARB.

Additionally, electromagnetic transient study may be required to account for IR613 control system to coordinate with other facilities in the transmission system and to ensure fault ride through.

Any changes to SPS schemes required for operation of this generating facility, in addition to existing generation and facilities that can proceed before this project, will be determined by the SIS as well as any required additional transmission facilities. The determination will be based on all NERC and NPCC criteria approved by the UARB 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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