Interconnection Feasibility Study Report
GIP-IR612-FEAS-R1

Generator Interconnection Request 612
20 MW Solar Generating Facility
Lunenburg County, NS

2022-04-14

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer (IC) submitted an Interconnection Request (IR#612) for Network Resource Interconnection Service (NRIS) or Energy Resource Interconnection Service (ERIS) for a proposed 20 MW solar generation facility interconnected to the NSPI transmission system, with a Commercial Operation Date of 2023-11-30. The Point of Interconnection (POI) requested by the customer is the 69kV line L-5546, with an alternate POI at the 69kV Substation 89W. L-5546 runs between 99W-Bridgewater and 75W-Westhaver's Elbow and it is currently operated with an open point at 89W-Bridgewater East substation. The proposed POI would be approximately 0.9 km from the 89W-Bridgewater East towards 75W direction. The alternate POI would only be considered if unexpected results not contemplated in the Scoping Meeting are found with the primary POI, which was found not to be the case for IR#612.

There are six transmission and six distribution Interconnection Requests currently in the Advanced Stage Transmission and Distribution Queue that must be included in the study models for IR#612. In addition, there is one long-term firm transmission service reservation in the amount of 550 MW from New Brunswick to Nova Scotia (TSR-411). This transmission service request is expected to be in service in 2025 and system studies are currently underway to determine the associated upgrades to the Nova Scotia transmission system. These upgrades are expected to materially alter the configuration of the transmission system in Nova Scotia. As a result, the following notice has been posted to the OASIS site at https://www.nspower.ca/oasis/generation-interconnection-procedures:

> *Effective January 19th, 2021, please be advised that the completion of advanced-stage Interconnection Studies under the Standard Generator Interconnection Procedures (GIP) may be delayed pending the outcome of the Transmission Service Request (TSR) 411 System Impact Study, which is expected to identify significant changes to the NSPI transmission system. The revised expected completion date for the study is February 28, 2022. Feasibility Studies initiated prior to the completion of the TSR System Impact Study will be performed based on the current system configuration.*

This study assumes that the addition of generation from IR#612 will displace coal-fired generation in eastern Nova Scotia for both NRIS and ERIS.

Interconnection with L-5546 around 89W-Bridgewater East substation will require a "Direct line tap with protection". It is required that the ICIF include a circuit breaker at the 69kV side of the ICIF station step-up transformer. IR#612 will not be designated as NERC BES element.

The assessment of the POI on the 69kV line L-5546 indicated that L-5546 could exceed its operating limit when the ambient temperature is higher than 30°C. No violations of voltage criteria were found for IR#612.

Data provided by the IC indicates that IR#612 would be able to meet reactive requirements without additional reactive support. As specific details of the collector circuits become available, the need for supplemental reactive power support will be further investigated in the System Impact Study.

No concern regarding high short-circuit level or voltage flicker was found for this project on its own, provided that the project design meets NSPI requirements for low-voltage ride-through, reactive power range and voltage control. Harmonics must meet the Total Harmonics Distortion provisions of IEEE 519. The minimum short circuit level at the Interconnection Facility 69kV bus is 280 MVA with all lines in service and IR#612 off-line, resulting in a Short Circuit Ratio of 8.08, which falls to 6.44 with alternate POI at 89W substation.

The preliminary value for the unit loss factor is calculated as -0.51% at the POI on L-5546. Losses associated with the IC facilities (collector circuits, transformers) are excluded from this calculation.

The preliminary non-binding cost estimate for interconnecting 20 MW to the POI on L-5546 as NRIS is $2,057,000. The cost estimates include a contingency of 10%, and this estimate will be further refined in the System Impact Study and the Facility Study. In this estimate, $700,000 of the amount (plus 10% contingency) represents Network Upgrade costs which are funded by the IC, but which are eligible for refund under the terms of the GIP. The remainder of the costs are fully funded by the IC.

The estimated cost for interconnection of IR#612 under ERIS is $1,397,000 including 10% contingency. Of this amount, Network Upgrade costs of $100,000 plus 10% contingency is funded by the IC but eligible for a refund under the terms of the GIP. Under ERIS, IR#612 would be limited to 15.6 MW under certain operating conditions.

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

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

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1 Introduction

The Interconnection Customer (IC) submitted an Interconnection Request for Network Resource Interconnection Service (NRIS) for a proposed 20 MW Solar generation facility interconnected to the NSPI transmission system, with a Commercial Operation Date of 2023-11-30. The Point of Interconnection (POI) requested by the customer is the 69kV circuit L-5546 towards 75W-Westhaver's Elbow substation, with an alternate POI at the 69kV 89W-Bridgewater East substation on the same 69kV circuit. L-5546 runs between 99W-Bridgewater and 75W-Westhaver's Elbow and it is currently operated with an open point at 89W-Bridgewater East substation. The proposed POI would be approximately 0.9 km from the 89W-Bridgewater East substation towards 75W direction. The alternate POI would be considered if unexpected results not contemplated in the Scoping Meeting are found with the primary POI, which was found not to be the case for IR#612.

The IC signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI transmission system, and this report is the result of that Study Agreement. This project is listed as Interconnection Request 612 in the NSPI Interconnection Request Queue and will be referred to as IR#612 throughout this report. The study is to include Energy Resource Interconnection Service (ERIS) as well as NRIS.

Figure 1 shows the proposed geographic location of IR#612 in relation to the NSPI transmission system.

Figure 1 IR#612 Whynotts Settlement Site Location

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

Figure 2 Point of Interconnection (not to scale)

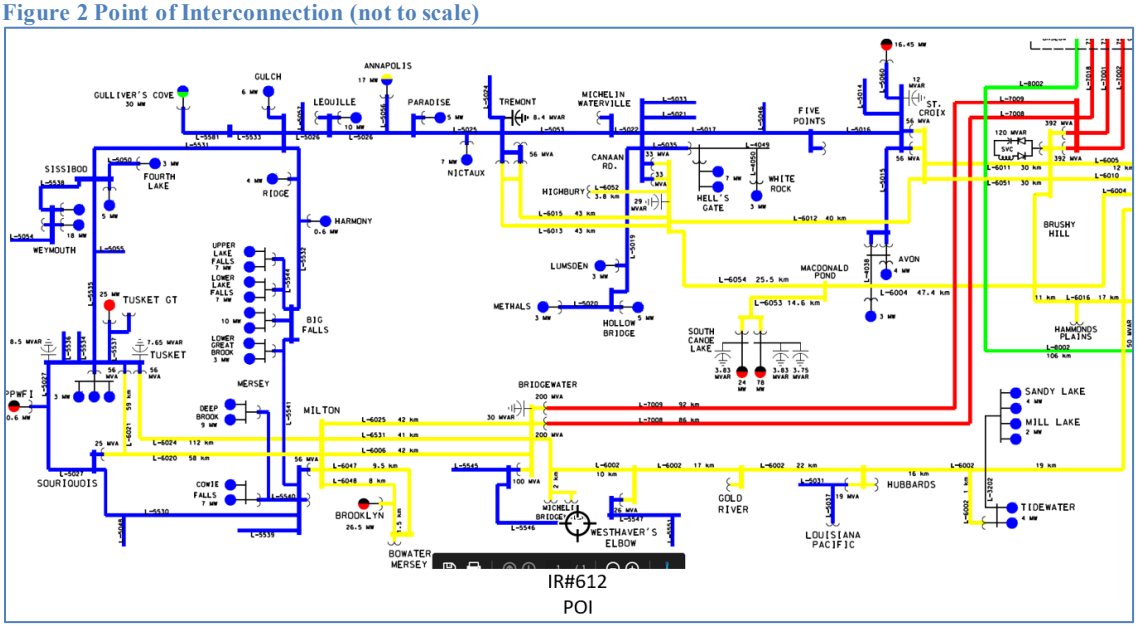
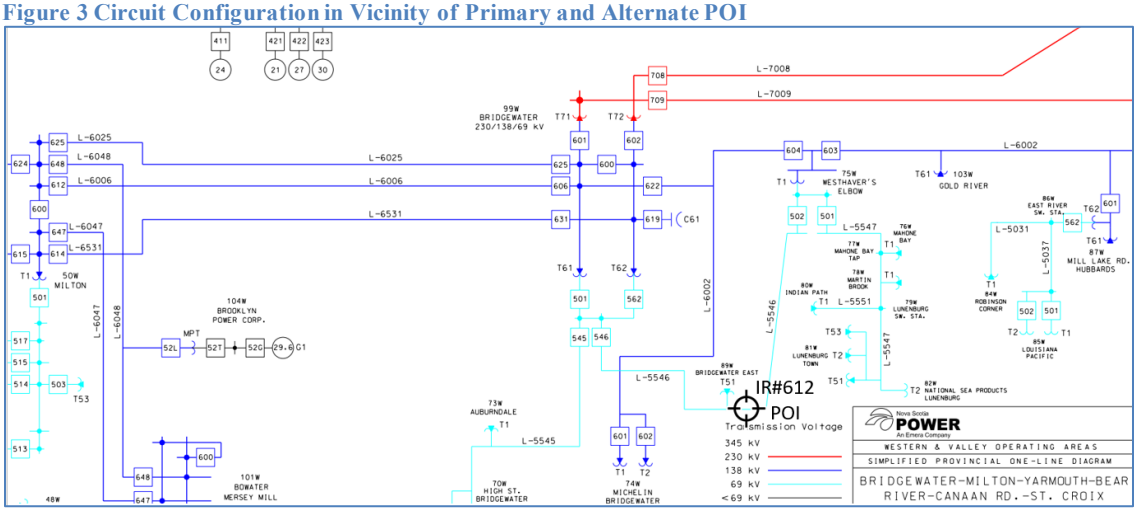


Figure 3 Circuit Configuration in Vicinity of Primary and Alternate POI



2 Scope

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

rated capacity, the circuit breakers must be upgraded. Single contingency criteria are applied.

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

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

- Preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the interconnection, and any network upgrades necessary to address the short circuit issues associated with IR#612. Expected minimum short circuit capability will also be identified for the purposes of Short Circuit Ratio analysis.

- Preliminary identification of any thermal overload or voltage limit violations resulting from the interconnection and identification of the necessary network upgrades to allow full output of the proposed facility. Thermal limits are applied to the seasonal (summer/winter) emergency ratings of transmission elements. Voltage violations occur when the post-contingency transmission bus voltage is outside the range of +/-10% of nominal voltage.

- Preliminary analysis of the ability of the proposed Interconnection Facility to meet the reactive power, power quality and cold-weather capability requirements of the NSPI *Transmission System Interconnection Requirements*[1].

- Preliminary description and high-level non-binding estimated cost and time to construct the facilities required to interconnect the generating facility to the transmission system.

- For comparative purposes, the impact of IR#612 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.

[1] transmission-system-interconnection-requirements (nspower.ca)

The ERIS study identifies necessary upgrades to allow full output of the proposed Generating Facility and the maximum allowed output, at the time the study is performed, of the interconnecting Generating Facility without requiring additional Network Upgrades.

3 Assumptions

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

1. NRIS and ERIS per section 3.2 of the GIP.

2. Commercial Operation date 2023-11-30.

3. The Interconnection Customer Interconnection Facility (ICIF) consists of 7 Solar inverter units; Sungrow SG3600UD, 3.6 MW, 600V, capped at a total of 20 MW, connected to 7 collector circuits operating at a voltage of 34.5kV.

4. As L-5546, where the proposed POI is tapped on, is currently non-Bulk Power System and has an open point at 89W substation, in accordance with Table 8 of the NSPI *Transmission System Interconnection Requirements* , it is assumed that the ICIF will include a Direct Line tap with Transfer Trip protection. It is required that the ICIF will include a circuit breaker to protect the IC substation step-up transformer.

5. The ICIF will require the construction of a 0.9 km 69kV transmission line extended from the POI to the IC 69kV/34.5kV transformers. The IC will be responsible for providing the Right-of-Way for the line. As detailed line data was not provided, it was assumed with Linnet 336 conductor. For the alternate POI, the line length will be 1.8 km.

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 ICIF station step-up 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 IC substation step-up transformer, consisting of one 69kV/34.5kV 22.4 MVA station transformer. The substation step-up transformer was modeled with a positive-sequence impedance of 37.5% on 100 MVA base with an X/R ratio of 19.6. The IC indicated that this Interconnection Facility step-

up transformer has a grounded wye-delta-wye winding configuration with +/-10% fixed (off-load) tap changer in (assumed) 8 steps. The impedance of each generator step-up transformer was given as 5.75% on 3.2 MVA with an X/R ratio of 8.

8. Detailed collector circuit data was not provided, so typical data (R+jX = 0.01+j0.04 p.u. on 100 MVA) was assumed with the understanding that the net real and reactive power output of the plant will be impacted by losses through transformers and collector circuits.

9. The FEAS analysis assumes 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.

10. Although the Interconnection Request document does not indicate what ambient temperature the winter rating is based on, it is assumed that the solar generating facility is capable of delivering full power under expected Nova Scotia winter environmental conditions of -30°C as per the NSPI *Transmission System Interconnection Requirements*.

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

12. The rating of transmission lines in the vicinity of IR#612 are shown in Table 1.

Table 1 Local Transmission Element Ratings

Line	Conductor	Design Temp	Limiting Element	Summer Rating Normal/Emergency	Winter Rating Normal/Emergency
L-7008	1113 Beaumont	70°C	CT Ratio	398/438 MVA	398/438 MVA
L-7009	795 Drake	50°C	Conductor	223/245 MVA	340/374 MVA
L-6002	556.5 Dove	50°C	Cond/Switch	110/121 MVA	143/157 MVA
L-6006	795 Drake	50°C	Conductor	135/149 MVA	205/225 MVA
L-6025	1113 Beaumont	70°C	CT Ratio	200/220 MVA	200/220 MVA
L-6531	556.5 Dove	50°C	Conductor	110/121 MVA	165/181 MVA
L-6021	336.4 Linnet	50°C	Switch	72/79 MVA	72/79 MVA
L-6020	336.4 Linnet	50°C	Conductor	82/90 MVA	121/133 MVA
L-6024	795 Drake	50°C	Switch	72/79 MVA	72/79 MVA
L-5535	2/0 Quail	50°C	Conductor	23/25 MVA	34/37 MVA
L-5532	4/0 Penguin/Quail	50°C	Conductor	23/25 MVA	34/37 MVA
L-5546	2/0 Quail	50°C	Conductor	23/25MVA	34/37MVA
L-5547	2/0 Quail	50°C	Conductor	23/25MVA	34/37MVA

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 2022-03-22, the following projects are higher queued in the Advanced Stage Interconnection Request Queue and are committed to the study base cases:

- IR426: GIA executed
- IR516: GIA executed
- IR540: GIA executed
- IR542: GIA executed
- IR574: GIA in progress
- IR598: FAC in progress

The following project has been submitted to the Transmission Service Request (TSR) Queue:

- TSR411: SIS in progress

Preceding IR#612 are six transmission and six distribution Interconnection Requests with GIA's executed. A long-term firm point-to-point transmission service reservation in the amount of 550 MW from New Brunswick to Nova Scotia (TSR-411). This transmission service request is 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:

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5 Short-Circuit Duty / Short Circuit Ratio

The maximum (design) expected short-circuit level is 3,500 MVA (29kA) on 69kV systems, 5,000 MVA (21 kA) on 138kV systems and 10,000 MVA (25 kA) on 230kV systems. The fault current characteristic for the Sungrow SG3600 Solar inverter units is given as 1.2987 times rated current, or X'd = 0.77 per unit.

Short circuit analysis was performed using PSS®E for a classical fault study, 3LG and flat voltage profile at 1.0 p.u. V. The short-circuit levels in the area before and after this development are provided below in Table 2 (L-5546 POI).

Table 2: Short-Circuit Levels. IR#612 on L-5546 Three-phase MVA (1)

Location	Without IR#612		With IR#612	
	MVA	X/R	MVA	X/R
Maximum Generation: All transmission facilities in service				
Interconnection Facility (69kV)	309	7.74	334	8.20
Tap point of L-5546 (69kV, POI)	320	9.53	344	10.0
75W-Westhaver's Elbow (69kV)	390	23.2	414	23.3
99W-Bridgewater (69kV)	637	22.6	639	22.9
Interconnection Facility (69kV, with alternate POI)	444	5.96	468	6.22
89W substation (alternate POI)	466	7.45	491	7.74
75W-Westhaver's Elbow (69kV, with alternate POI)	390	23.2	391	23.3
99W-Bridgewater (69kV, with alternate POI)	637	22.6	661	22.7
Minimum Conditions (PA1, LG1, ML In-Service)				
Interconnection Facility (69kV, with POI), all lines in-service	280	8.08	305	8.60
Tap point of L-5546 (69kV, POI)	289	9.83	313	10.3
Interconnection Facility (69kV, with alternate POI), all lines in-service	384	6.44	409	6.76
89W substation (with alternate POI)	401	7.94	425	8.30

(1) Classical fault study, flat voltage profile

The interrupting capability of the 69kV circuit breakers is at least 3500 MVA at 75W and 99W. As such, the interrupting ratings at these substations will not be exceeded by this development on its own.

The IC documentation has indicated that the minimum Short Circuit Ratio of the Sungrow SG3600UD inverter is 2.5. Based on the calculated short circuit levels, a POI on L-5546 and a 20 MW installation consisting of 7 units each 3.6 MVA, the minimum short circuit ratio would be 8.08 at the HV terminals of the IR#612 substation with all lines in service and IR#612 off-line. This falls to 6.44 with alternate POI at 89W substation.

6 Voltage Flicker and Harmonics

Flicker coefficient information was not provided for the Sungrow SG3600UD inverter Solar units, as a result, Voltage flicker will be further examined when data for the 3.6 MVA Sungrow SG3600UD machine is made available for the SIS.

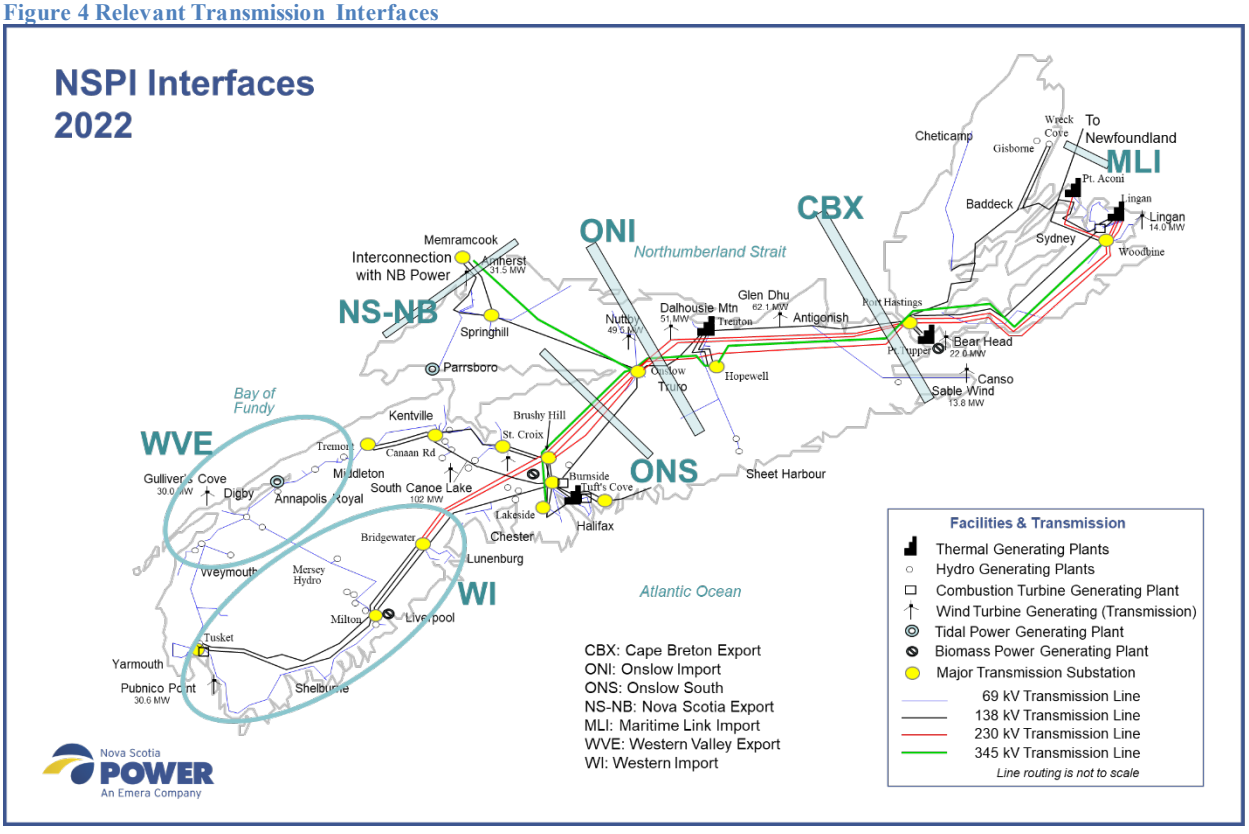
The generator is expected to meet IEEE Standard 519-2014 limiting voltage Total Harmonic Distortion (all frequencies) to a maximum of 5%, with no individual harmonic exceeding 3% on 69kV.

7 Load Flow Analysis

The load flow analysis was completed for generation dispatches under winter peak load conditions, summer peak low-hydro and spring high-hydro light load conditions expected to stress transfers in western NS and Annapolis Valley.

Figure 4 shows the relevant interfaces on the NSPI transmission system.

Figure 4 Relevant Transmission Interfaces



The Western region of Nova Scotia is sensitive to the balance between local load and hydro/wind generation. Hydro plants are likely to be at rated output during spring run-off conditions and are less likely to be so during the drier summer and fall months. The 10W-Tusket Gas Turbine plays an important role in ten-minute operating reserve which can be called upon at any time, so transmission capacity in the vicinity of IR#612 takes this into consideration.

The cases and dispatch scenarios considered are shown in Table 3.

Table 3: Base Case Dispatch (MW)

Case	NS-NB	LOAD	HYDRO	ONS	WVE	WI	MER	IR#612 Tap	L-6002	Wind
SP02-1	0	900	140	250	38	33	43	POI	Open	259
SP02-2	0	900	140	250	38	33	43	Alt-POI	Open	259
SP02-3	0	900	140	250	38	33	43	POI	Loop	259
SP02-4	0	900	140	250	38	33	43	Alt-POI	Loop	259
SP04-1	333	1400	20	386	-9	73	9	POI	Open	356
SP04-2	333	1400	20	386	-9	73	9	Alt-POI	Open	356
SP04-3	333	1400	20	386	-9	73	9	POI	Loop	356
SP04-4	333	1400	20	386	-9	73	9	Alt-POI	Loop	356
W02-1	180	2200	127	880	7	134	20	POI	Open	420
W02-2	180	2200	127	880	7	134	20	Alt-POI	Open	420
W02-3	180	2200	127	880	7	134	20	POI	Loop	420
W02-4	180	2200	127	880	7	134	20	Alt-POI	Loop	420

S – Summer/Spring W - Winter Peak; MER – Mersey Hydro; LOAD– Excludes PHP

For both NRIS and ERIS analysis, this FEAS added IR#612 and displaced an equivalent amount of coal-fired generation in Cape Breton. Single contingencies were applied at the 230kV, 138kV, and 69 kV voltage levels for the above system conditions with IR#612 interconnected to the POI on L-5546. Automated analysis searched for violations of emergency thermal ratings and emergency voltage limits for each contingency. Contingencies studied are listed in Table 4. It should be noted that a number of existing contingencies unrelated to IR#612 can result in the separation of the western transmission system and possible disconnection of IR#612.

Table 4 Contingency List

Transmission Line	Transformer / Bus	Circuit Breaker Failure	Double Circuit Tower
L-7008, L-7009	120H: T71, T72	120H: 715, 716, 712, 713	L-7008 + L-7009
L-6025, L-6006, L-6531	99W: B61, B62		
L-6024, L-6020, L-6021	50W: B2, B3, B4, T1		
L-5035	9W: B52 B53		
L-5025, L-5026	51V: B51, B62	1N: 600, 613	

NRIS Results
There is no significant contingency resulting in thermal overload in all cases above. However, it must be noted that L5546 is a 2/0 Quail conductor with a 50°C design temperature, which means that it is rated 23 MVA at ambient 25°C, but the rating drops to 19.7 MVA at 30°C and 15.6 MVA at 35°C, which are lower than the maximum output 20MW of IR#612. These ratings are for June at noon, where the solar panels will likely be at maximum output. Because L-5546 utilizes 2/0 Quail conductor for the entire line between 99W-Bridgewater and 75W-Westhaver's Elbow, this would be the same issue for the alternate POI at 89W.

The following options were examined:

1. Rebuild L-5546 between the POI and 75W-Westhaver's Elbow (6km) with Linnet 336 conductor at an estimated cost of $600,000 plus 10% contingency.
2. Increase the operating temperature of L-5546 from 50°C to 70°C at an estimated cost of $750,000 plus 10% contingency.

No contingencies resulted in a violation of voltage limit criteria under the assumption that the existing contingencies which result in western separation are excluded.

ERIS Results
To avoid the thermal limit violations encountered in the NRIS analysis, IR#612 could operate at up to 15.6 MW without the need for transmission limit upgrades, under certain operating conditions. This would be in addition to any other system conditions that require curtailment of solar energy resources.

8 Reactive Power and Voltage Control

In accordance with the *Transmission System Interconnection Requirements* Section 7.6.2, IR#612 must be capable of delivering reactive power at a net power factor of at least +/- 0.95 of rated capacity to the high side of the plant interconnection transformer. Reactive power can be provided by the asynchronous generator or by continually acting auxiliary devices such as STATCOM, DSTATCOM or synchronous condenser, supplied by the Interconnection Customer. Rated reactive power shall be available through the full range of real power output of the Generating Facility, from zero to full power. Based on the plant rating of 20 MW, this translates into a reactive capability of 6.6 MVar leading and lagging.

The information provided by the IC indicates that the Sungrow SG3600 Solar inverter has a rated power factor of 0.8 lagging and leading at 45°C with a maximum 3.6MVA apparent power. As each unit is capped to 2.86MW to achieve 20MW with seven units, this translates into a gross reactive power range of -15.3 MVar to +15.3 MVar. Figure 5.1 and 5.2 show how reactive capability varies with real power output and ambient temperature.

It is noted that this unit is capable of reactive power control down to zero MW only in Q(t) mode.

Figure 5.1: SG3600 Reactive Capability (Pf mode)

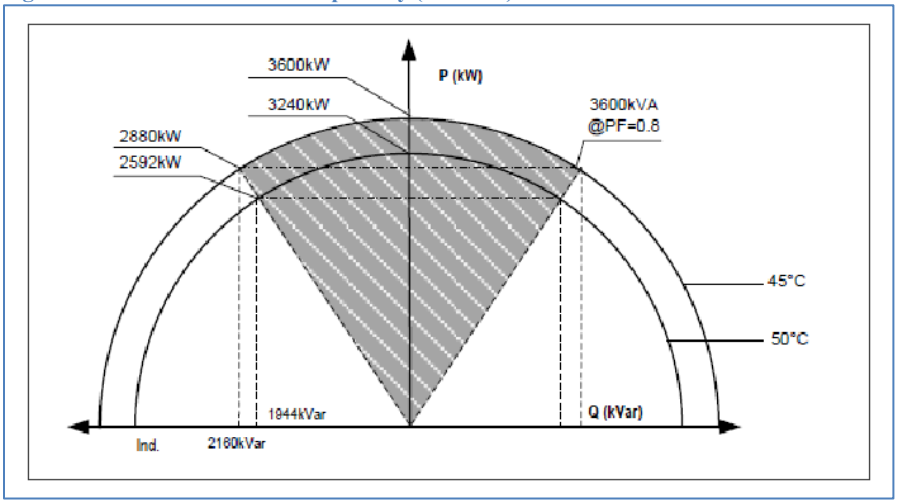
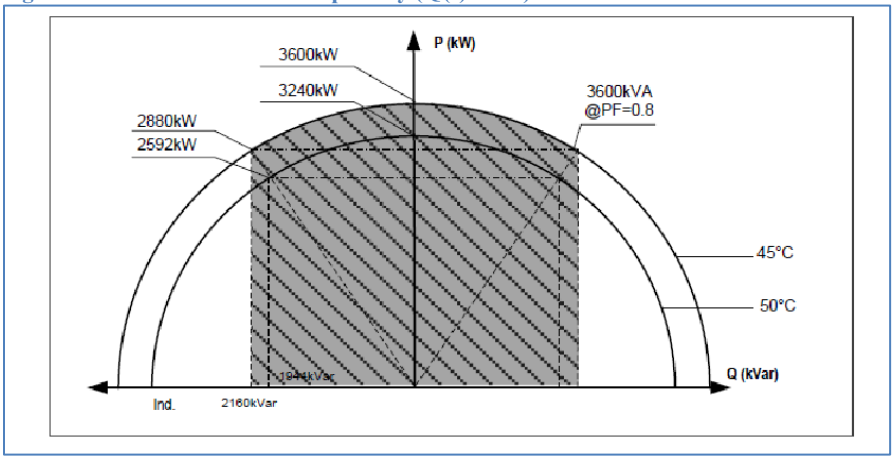
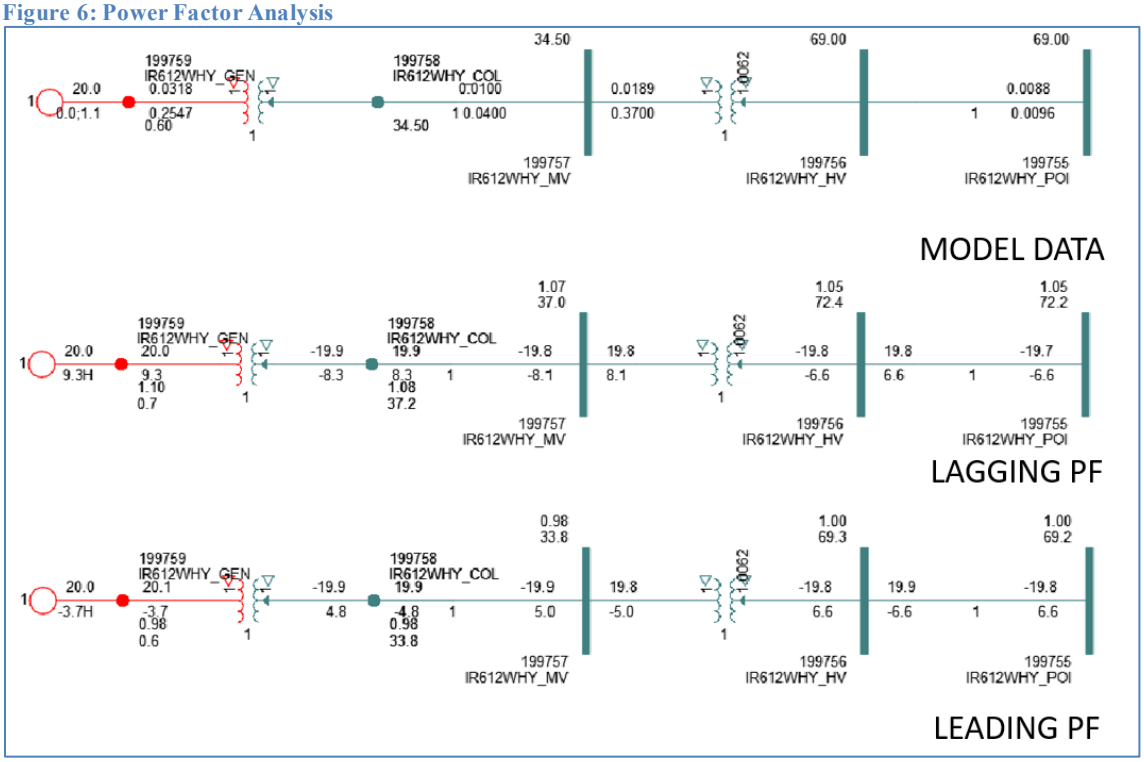


Figure 5.2: SG3600 Reactive Capability (Q(t)mode)



Analysis shown in Figure 6 shows that IR#612 would be able to meet this requirement without additional reactive support. The model shows that with 7 Sungrow SG3600 units operating at a total 20 MW and 9.3 Mvar at terminal voltage of 1.10 p.u., the delivered power to the high side of the ICIF transformer is 19.8 MW and 6.6 Mvar, or a power factor of 0.95. This configuration would also be able to meet the leading power factor requirement. The model shows that with 7 Sungrow SG3600 units operating at 20 MW and -3.7Mvar at a terminal voltage of 0.98 p.u., the delivered power to the high side of the ICIF transformer is 19.9 MW and -6.6 Mvar, or a power factor of -0.95.

Figure 6: Power Factor Analysis



Power factor behaviour is the same regardless of the POI on L-5546 radial towards to 75W or alternate POI towards 99W, because this analysis is based on preliminary transformer data and assumed collector circuit models. As specific details of the collector circuits become available, the need for supplemental reactive power support will be further investigated in the System Impact Study.

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

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

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

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

9 System Security / Bulk Power Analysis

The 69kV buses at the 75W-Westhaver's Elbow and the 99W-Bridgewater substations are not part of the Nova Scotia Bulk Power System (BPS), and IR#612 has dispersed generation totalling less than 75 MVA. Hence, the 34.5 kV bus and the 69kV bus of IR#612 would not be designated as NERC BES element.

It should be noted that IR#612 must be equipped with anti-islanding protection. Though it is assumed that the ICIF will include a Direct Line tap with Transfer Trip protection, the Transfer Trip protection will have to cover other contingencies resulting in IR#612 islanding, including L-6002 tripping from either 75W end or 99W end, or tripping of 99W-T61 or 99W-B61.

10 Loss Factor

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

Without IR#612 in service, losses in the winter peak case total 86.2 MW. With IR#612 in service at the POI of L-5546, displacing generation at 91H, and not including losses associated with the IR#612 Generation Facilities or TPIF Interconnection Facilities, system losses total 86.1 MW, a decrease of 0.1MW. The model shows power delivered to the POI is 19.7 MW, therefore the loss factor is calculated as -0.1/19.7 = -0.51%.

11 Expected Facilities Required for Interconnection

The alternate POI was not examined since the primary POI on L-5546 did not exhibit problems not foreseen in the project launching meeting.

The following facility changes will be required to connect IR#612 to the NSPI transmission system at a POI on L-5546:

11.1 NRIS Requirements:

a. Required Network Upgrades

- Rebuild L-5546 between the POI and 75W-Westhaver's Elbow (6km) with Linnet 336 conductor at an estimated cost of $600,000 plus 10% contingency.
- Modification of NSPI protection systems on L-5546 at 75W-Westhaver's Elbow and 99W-Bridgewater, including the addition of a transfer trip to IR#612, either 69kV side or 34.5kV side breaker of the substation step-up transformer, for any combinations of islanding conditions.

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

- Construct a 0.9km 69kV transmission line with Linnet 336 conductor between the POI on L-5546 and the Interconnection Customer's Interconnection Facility. This line would be built to NSPI's 69kV standards. The IC will be responsible for providing the Right-of-Way for the line.
- Add control and communications between the solar plant and NSPI SCADA system (to be specified).
- Add transmission line tap at POI (no breaker).

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

- One 69kV circuit breaker at the 69kV side of the ICIF station transformer.
- Centralized controls. These will provide centralized voltage set-point controls and are known as Farm Control Units (FCU). The FCU will control the 34.5 kV bus voltage and the reactive output of the machines. Responsive (fast-acting) controls are required. The controls will also include a curtailment scheme which will limit or reduce total output from the facility, upon receipt of a telemetered signal from NSPI's SCADA system.
- NSPI will have control and monitoring of reactive output of this facility, via the centralized controller. This will permit the NSPI Operator to raise or lower the voltage set-point remotely.
- Low voltage ride-through capability per Section 7.4.1 of the Nova Scotia Power Transmission System Interconnection Requirements.
- Real-time monitoring (including an RTU) and control of the interconnection facility, with telemetry including local solar plant MW and MVar, as well as bus voltages.
- Facilities for NSPI to execute high speed rejection of generation (transfer trip) if determined in SIS. The plant may be incorporated into RAS run-back schemes.
- Automatic Generation Control to assist with tie-line regulation.
- Operation at ambient temperature of -30°C.

11.2 ERIS Requirements:

The facility requirements for ERIS are the same as NRIS, except rebuilding L-5546 with Linnet 336 conductor. But IR#612 generation will be limited to 15.6 MW during summer time under certain operating conditions.

12 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

Estimates for NSPI Interconnections Facilities and Network Upgrades for interconnecting 20 MW wind energy at the 69kV POI at on L-5546 are included in Table 5 (NRIS) and Table 6 (ERIS).

Table 5 Cost Estimate NRIS @ POI on L-5546		
Item	**Network Upgrades**	**Estimate**
1	Rebuild L-5546 between the POI and 75W-Westhaver's Elbow (6km) with Linnet 336 conductor at an estimated cost of $600,000 plus 10% contingency.	$600,000
2	Modification of NSPI protection systems on L-5546 at 75W-Westhaver's Elbow and 99W-Bridgewater	$100,000
	Sub-total for Network Upgrades	$700,000
Item	**TPIF Upgrades**	**Estimate**
1	Construct a 0.9km 69kV transmission line with Linnet 336 conductor between the POI on L-5546 and the ICIF. The IC will be responsible for providing the Right-of-Way for the line.	$360,000
2	Direct line tap (no breaker)	$500,000
3	NSPI P&C relaying equipment	$100,000
4	NSPI supplied RTU	$60,000
5	Tele-protection and SCADA communications	$150,000
	Sub-total for TPIF Upgrades	$1,170,000
	Total Upgrades	**Estimate**
	Network Upgrades + TPIF Upgrades	$1,870,000
	Contingency (10%)	$187,000
	Total (Incl. 10% contingency and Excl. HST)	$2,057,000

Table 6 Cost Estimate ERIS @ POI on L-5546		
Item	**Network Upgrades**	**Estimate**
1	Modification of NSPI protection systems on L-5546 at 75W-Westhaver's Elbow and 99W-Bridgewater	$100,000
	Sub-total for Network Upgrades	$100,000
Item	**TPIF Upgrades**	**Estimate**
1	Construct a 0.9km 69kV transmission line with Linnet 336 conductor between the POI on L-5546 and the ICIF. The IC will be responsible for providing the Right-of-Way for the line.	$360,000
2	Direct line tap (no breaker)	$500,000
3	NSPI P&C relaying equipment	$100,000
4	NSPI supplied RTU	$60,000
5	Tele-protection and SCADA communications	$150,000
	Sub-total for TPIF Upgrades	$1,170,000
	Total Upgrades	**Estimate**
	Network Upgrades + TPIF Upgrades	$1,270,000
	Contingency (10%)	$127,000
	Total (Incl. 10% contingency and Excl. HST)	$1,397,000

The preliminary non-binding cost estimate for interconnecting 20 MW at the POI on L-5546 under NRIS is $2,057,000 including a contingency of 10%. Of this amount, $700,000 is for Network Upgrades, which are funded by the IC, but are eligible for refund under the terms of the GIA. The remainder of the costs are fully funded by the IC.

The preliminary non-binding cost estimate for interconnecting 20 MW at the POI on L-5546 under ERIS is $1,397,000 including a contingency of 10%. Of this amount, $100,000 is for Network Upgrades, which are funded by the IC, but are eligible for refund under the terms of the GIA. The remainder of the costs are fully funded by the IC.

Under ERIS, IR#612 will be limited to 15.6 MW under certain operating conditions.

These estimates do not include potential additional costs to address any stability issues identified at the SIS stage based on dynamic analysis.

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

13 Issues to be addressed in SIS

The following provides a preliminary scope of work for the subsequent SIS for IR#612. The SIS will include a more comprehensive assessment of the technical issues and requirements to interconnect generation as requested. It will include contingency analysis, system stability, ride through, and operation following a contingency (N-1 operation). The SIS must determine the facilities required to operate this facility at full capacity, withstand any contingencies (as defined by the criteria appropriate to the location) and identify any restrictions that must be placed on the system following a first contingency loss. The SIS will confirm the options and ancillary equipment that the customer must install to control flicker, voltage, frequency response, active power and ensure that the facility has the required ride-through capability. The SIS will be conducted in accordance with the GIP with the assumption that all appropriate higher-queued projects proceed, and the facilities associated with those projects are installed.

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

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

i. Facilities that the customer must install to meet the requirements of the GIP and the NSPI *Transmission System Interconnection Requirements*.

ii. The minimum transmission additions/upgrades that are necessary to permit operation of this Generating Facility, under all dispatch conditions, catering to the first contingencies listed.

iii. Guidelines and restrictions applicable to first contingency operation (curtailments etc.).

iv. Under-frequency load shedding impacts.

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

- L-8001
- L-8002
- L-7008
- L-7009
- Simultaneous loss of L-7008 + L-7009
- Buses at 50W and 99W
- Transformer 99W-T61
- Loss of largest generation source in NS
- Loss of Maritime Link

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

- 3 phase fault L-8001 with high NS import from NB (islanding)
- 3 phase fault L-8002 at 67N-Onslow
- Simultaneous SLG on L-7008 & L-7009 double circuit tower at 120H-Brushy Hill
- SLG fault on breaker 99W-600 or 50W-600, with load loss
- 3 phase fault on transformer 99W-T61

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 NERC[2] and NPCC[3] criteria as well as NSPI guidelines and good utility practice. The SIS will also determine the contingencies for which this facility must be curtailed.

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[2] NPCC criteria are set forth in its Reliability Reference Directory #1 *Design and Operation of the Bulk Power System*
[3] NERC transmission criteria are set forth in *NERC Reliability Standard TPL-001-4*