Interconnection Feasibility Study Report
GIP-IR630-FEAS-R3

Generator Interconnection Request 630
40 MW Solar Generating Facility
Halifax County, NS

2022-04-11

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer (IC) submitted an Interconnection Request (IR#630) for Network Resource Interconnection Service (NRIS) for a proposed 40 MW solar generation facility interconnected to the NSPI transmission system, with a Commercial Operation Date of 2023-07-01. The Point of Interconnection (POI) requested by the customer is the 87H-Musquodoboit Harbour on the 138kV line L-6043. L-6043 runs radially from 113H-Dartmouth East and ends at 87H-Musquodoboit Harbour, with a substation 126H-Porters Lake tapped in the middle of the line. The proposed Interconnection Customer's Interconnection Facility (ICIF) is given to be approximately 2.2 km away from the POI at the 87H-Musquodoboit Harbour substation.

There are six transmission and three distribution Interconnection Requests currently in the Advanced Stage Transmission and Distribution Queue that must be included in the study models for IR#630. 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#630 will displace coal-fired generation in eastern Nova Scotia for NRIS.

Interconnection with L-6043 at 87H-Musquodoboit Harbour will require a "Direct line tap with protection". It is required that the ICIF will include a circuit breaker to at the 138kV side of the ICIF station step-up transformer. IR#630 will not be designated as NERC BES element.

The assessment of the POI on the 138kV line L-6043 indicated that no violations of thermal loading and voltage criteria would occur due to IR#630.

Data provided by the IC indicates that IR#630 may not be able to meet reactive requirements without additional reactive support. Based on the Delta PV M250HV – 0.25 MW inverters, typical impedances of the transformers, IC provided collector circuit length, and typical collector circuit impedances, IR#630 will not meet the net power factor of +0.95 to -0.95 at the high voltage side of Interconnection Facility while operating at full rated power. The adequacy of reactive power supply will be further investigated in the System Impact Study as specific details of the collector

circuit are supplied. It is noted that the proposed Delta M250HV model is not capable of full reactive power control down to zero MW.

IR#630 was not found to adversely impact the short-circuit capabilities of existing circuit breakers. Although flicker coefficients were not provided for the proposed inverters, voltage flicker is not expected to be a concern for this project on its own. It is assumed that the project design meets NSPI requirements for low-voltage ride-through, reactive power and voltage control. Harmonics must meet the Total Harmonics Distortion provisions of IEEE 519. The minimum short circuit level at the Interconnection Facility 138kV bus is 640 MVA with all lines in service and IR#630 off-line, resulting in a 6.46 short-circuit ratio.

The preliminary value for the unit loss factor is calculated as -1.3% at the POI on L-6043. Losses associated with the IC facilities (collector circuits, transformers) are excluded from this calculation.

The preliminary non-binding cost estimate for interconnecting 40 MW to the POI on L-6043 as NRIS, including the cost of line protection upgrade incorporating transfer-trip is $2,266,000. 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, $150,000 of the amount (plus 10% contingency) represents Network Upgrade costs which are funded by the IC, but eligible for refund to the IC under the terms of the GIP. The remainder of the costs are fully funded by the IC.

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

Table of Contents

1 Introduction

The Interconnection Customer (IC) submitted an Interconnection Request for Network Resource Interconnection Service (NRIS) for a proposed 40 MW solar generation facility interconnected to the NSPI transmission system, with a Commercial Operation Date of 2023-07-01.

The Point of Interconnection (POI) requested by the customer is the 87H-Musquodoboit Harbour on the 138kV line L-6043. L-6043 runs radially from 113H-Dartmouth East and ends at 87H-Musquodoboit Harbour, with a substation 126H-Porters Lake tapped in the middle of the line. The proposed Interconnection Customer's Interconnection Facility (ICIF) is given to be approximately 2.2 km away from the POI at the 87H-Musquodoboit Harbour substation.

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 630 in the NSPI Interconnection Request Queue and will be referred to as IR#630 throughout this report.

Figure 1 shows the proposed geographic location of IR#630 in relation to the NSPI transmission system.

Figure 1 IR#630 West Petpeswick Rd 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)

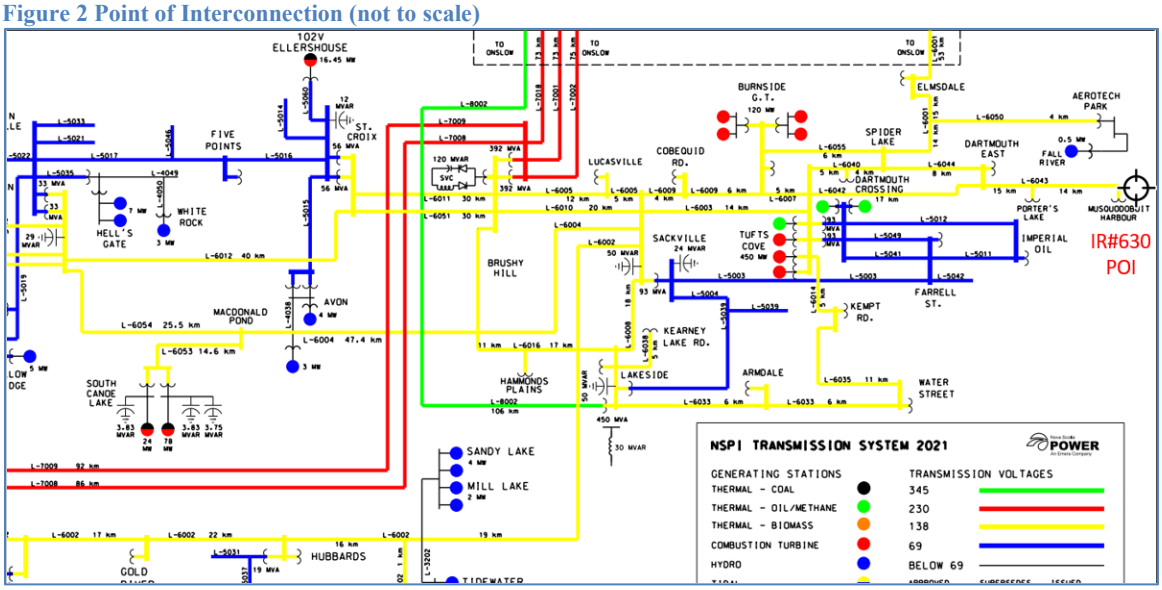
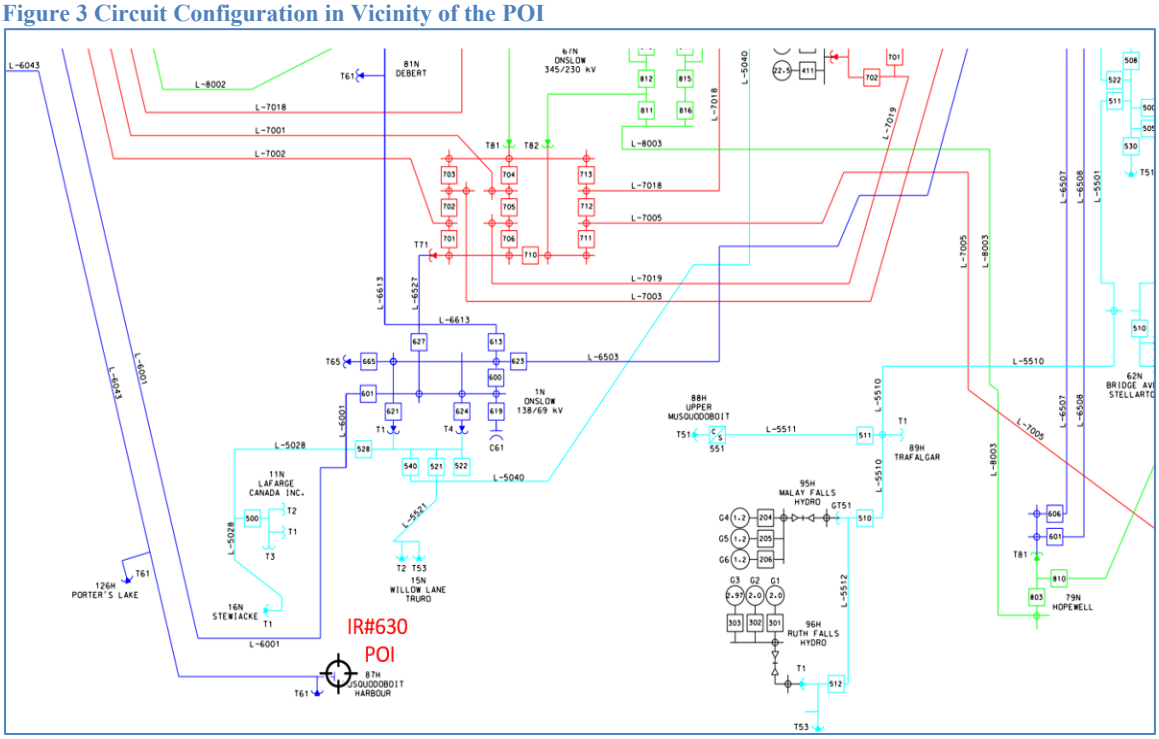


Figure 3 Circuit Configuration in Vicinity of the POI



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 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#630. 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#630 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

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

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.

Applicable planning criteria as approved for use in Nova Scotia by the Nova Scotia Utility and Review Board are used in evaluation of the impact of any facility on the Bulk Electric System.

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 per section 3.2 of the Generator Interconnection Procedures (GIP).

2. Commercial Operation date 2023-07-01.

3. The Interconnection Customer Interconnection Facility (ICIF) consists of 160 Delta M250HV solar PV Inverter units, each rated at 0.25 MW, 800V; capped at a total of 40 MW, connected to ten collector circuits operating at a voltage of 34.5kV.

4. As L-6043 is a radial 138kV non- Bulk Power System line, in accordance with Table 8 of the NSPI Transmission System Interconnection Requirements, the tap point will be a “Direct line tap with 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 2.2 km 138kV transmission line extended from the POI to the IC 138kV/34.5kV transformers. The IC will be responsible for providing the Right-of-Way for the lines. Detailed line data was not provided, so it was assumed as same as L-6043 with 556.5 Dove conductor and 70°C.

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 IC substation 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 138kV/34.5kV 30/40/50 MVA station transformer. The substation

step-up transformer was modeled with a positive-sequence impedance of 9.0% on 30 MVA with an X/R ratio of 45. The IC indicated that this Interconnection Facility step-up transformer has a grounded wye-delta winding configuration with +/-5% fixed (off-load) tap changer. The impedance of each inverter step-up transformer was given as 7% on 4 MVA with an assumed X/R ratio of 11.4.

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. It is assumed that the solar units are suitable for 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#630 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-7001	795 Drake	60°C	Conductor	298/328MVA	383/421MVA
L-7002	795 Drake	100°C	Cond/CT	447/492MVA	462/508MVA
L-7018	2x 795 Drake	60°C	CT Ratio	462/508MVA	462/508MVA
L-6040	556.5 Dove	70°C	Conductor	163/179MVA	201/221MVA
L-6042	556.5 Dove	70°C	Conductor	163/179MVA	201/221MVA
L-6044	795 Drake	100°C	CT Ratio	231/254MVA	231/254MVA
L-6043	556.5 Dove	70°C	Cond/CT	163/179MVA	200/220MVA
L-6055	795 Drake	100°C	Cond/Switch	268/295MVA	287/316MVA
L-6001	556.5 Dove	60°C	Conductor	140/154MVA	184/202MVA
L-6503	1113 Beaumont	100°C	Cond/CT	287/316MVA	287/316MVA
L-6613	1113 Beaumont	100°C	Switch	287/316MVA	287/316MVA
L-5028	336.4 Oriole	50°C	CT Ratio	18/20MVA	18/20MVA
L-5040	336.4 Linnet	70°C	Conductor	41/45MVA	60/66MVA

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 2022-01-10, 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#630 are six transmission and three 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 5,000 MVA (21 kA) on 138kV systems and 10,000 MVA (25 kA) on 230kV systems. The fault current characteristic for the Delta PV Inverter M250HV - 0.25 MW is assumed as 1.0 times rated current, or X'd = 1.0 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. V. The short-circuit levels in the area before and after this development are provided below in Table 2 (L-6043 POI).

Table 2: Short-Circuit Levels. IR#630 on L-6043 Three-phase MVA (1)

Location	Without IR#630		With IR#630	
	MVA	X/R	MVA	X/R
Maximum Generation: All transmission facilities in service				
Interconnection Facility (138kV)	826	5.71	863	5.96
87H-Musq. Harb. (138kV, POI)	866	5.78	903	6.02
113H-Dartmouth East (138kV)	2331	9.99	2367	10.12
Minimum Conditions (PA1, LG1, ML In-Service)				
Interconnection Facility (138kV), all lines in-service	640	6.46	677	6.82
87H-Musq. Harb. (138kV, POI)	664	6.55	700	6.91
113H-Dartmouth East (138kV)	1278	10.65	1315	10.91

(1) Classical fault study, flat voltage profile

The maximum short-circuit level at 138kV bus of 113H-Dartmouth East with IR#630 on-line, is 2367 MVA. The interrupting capability of the 138kV circuit breakers is 6000 MVA at 113H-Dartmouth East. As such, the interrupting ratings at these substations will not be exceeded by this development on its own.

Inverter-based generation installations often have a minimum Short Circuit Ratio (SCR) for proper operation of converters and control circuits. Delta PV documentation has not indicated the minimum Short Circuit Ratio of the Delta PV Inverter M250HV. Based on the calculated short circuit levels in Table 2, the minimum short circuit ratio would be 6.46 at the 138kV Interconnection Facility of the IR#630 substation with all lines in service and IR#630 off-line.

6 Voltage Flicker and Harmonics

Flicker coefficient information was not provided for the Delta PV M250HV – 0.25 MW Solar Inverter. As a result, Voltage flicker will be further examined when data for the machine is made available for the SIS.

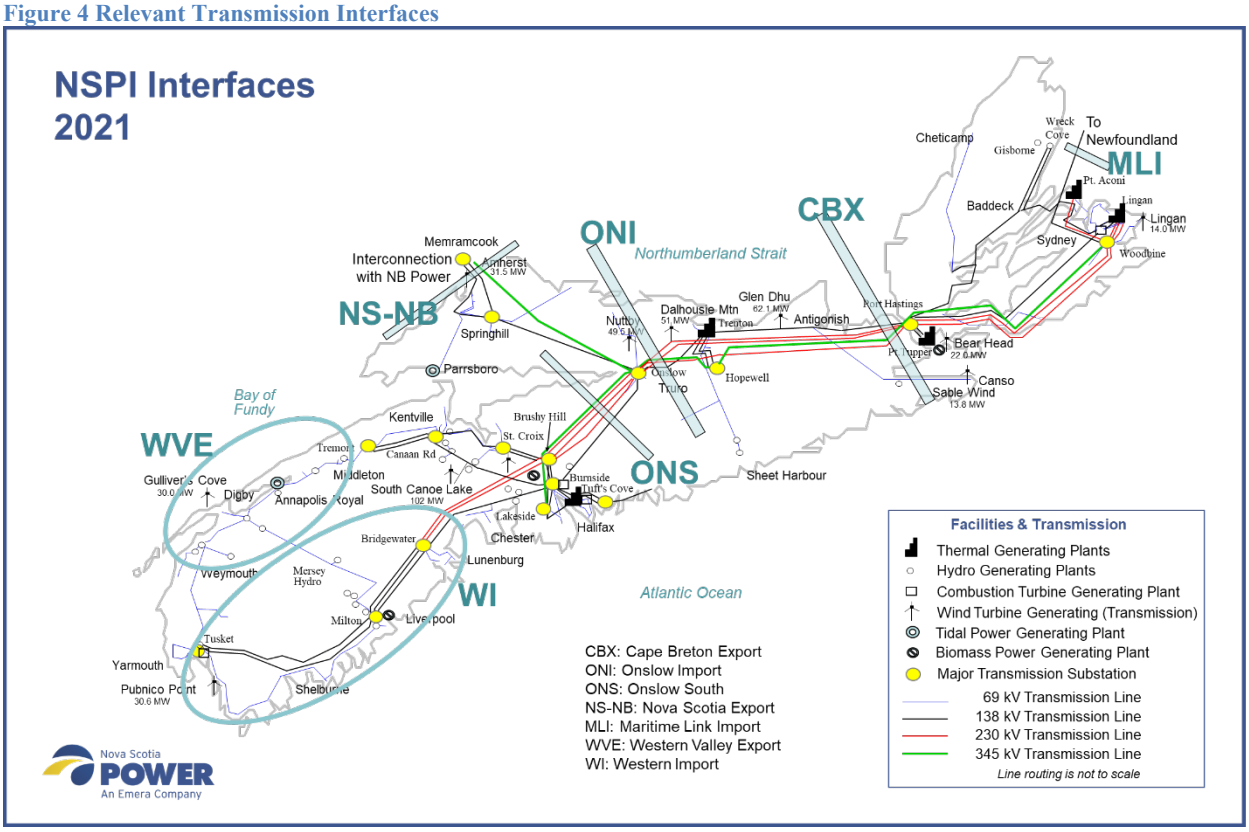
Total harmonic distortion (THD) for the Delta M250HV solar PV inverters is indicated less than 3% at nominal apparent power. The inverter is expected to meet IEEE Standard 519-2014 limiting voltage Total Harmonic Distortion (all frequencies) to a maximum of 2.5%, with no individual harmonic exceeding 1.5% on 138kV.

7 Load Flow Analysis

The load flow analysis was completed for generation dispatches under winter peak load conditions, summer low-hydro and spring high-hydro load conditions. Generation dispatch was also chosen to represent import and export scenarios that consider expected flows from the existing transmission service reservation associated with the Maritime Link, and scenarios where Maritime Link imports displace NS thermal generation.

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

Figure 4 Relevant Transmission Interfaces



Transmission connected wind generation facilities were typically dispatched at approximately 40%, with some low and high wind scenarios included. 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#630	Wind
SP02-1	0	900	140	250	38	33	43	0	259
SP02-2	0	900	140	210	38	33	43	40	259
SP04-1	333	1400	20	386	-9	73	9	0	356

Table 3: Base Case Dispatch (MW)									
Case	NS-NB	LOAD	HYDRO	ONS	WVE	WI	MER	IR#630	Wind
SP04-2	333	1400	20	346	-9	73	9	40	356
W02-1	180	2200	127	880	7	134	20	0	420
W02-2	180	2200	127	840	7	134	20	40	420
S – Summer/Spring W - Winter Peak; MER – Mersey Hydro; LOAD – Excludes PHP									

For NRIS analysis, this FEAS added IR#630 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#630 interconnected to the POI on L-6043. Automated analysis searched for violations of emergency thermal ratings and emergency voltage limits for each contingency. Contingencies studied are listed in Table 4.

Table 4 Contingency List			
Transmission Line	**Transformer / Bus**	**Circuit Breaker Failure**	**Double Circuit Tower**
L-7014, L-7021, L-7022	88S: T71, T72	88S: 710, 711, 713, 690, 721, 722, 723*	L-6534 + L-7021
L-7011, L-7012, L-7015, L-8004*	101S: T81, T82	101S: 701, 702, 703, 704, 705, 706, 711, 712, 713, 811, 812*, 813*, 814, 816	
L-6515, L-6516, L-6537*	2C: B61, B62	4C: 620, 621, 622, 623	
L-7003, L-7004, L-7005, L-7019	3C-T71, 3C-T72	3C: 710, 712, 713, 715, 716, 711, 714	L-7003+L-7004* Canso Causeway
L-6503, L-6613	1N: B61, B62	1N: 600, 613	
L-8001*, L-8002	67N: T71, T81	67N: 701, 702, 7-3, 705, 711, 712, 713, 811*, 812, 813, 814*, 815*	L-7003+L7004 Trenton area
L-6507, L-6508, L-8003*	79N: T81*	79N: 601*, 606*, 803*, 810*	
L-6537, L-6538*, L-6539, L-6516	91N: B71	91N: 701, 702, 703 5S: 606, 607	

*Indicates contingency was studied with/without RAS action

Load Flow contingencies associated with the Primary & Secondary Transmission System and the Electrically Remote Transmission System share the following post contingency requirements:

- All system elements must be within 110% of their thermally limited ratings (assuming system operator action can resolve the overload in < 10 minutes)
- Steady state bus voltage must remain within 90% - 110% of nominal voltage following correction by automatic tap changers.
- Any Pre/Post contingency voltage change at buses must be < 10% prior to tap changer action

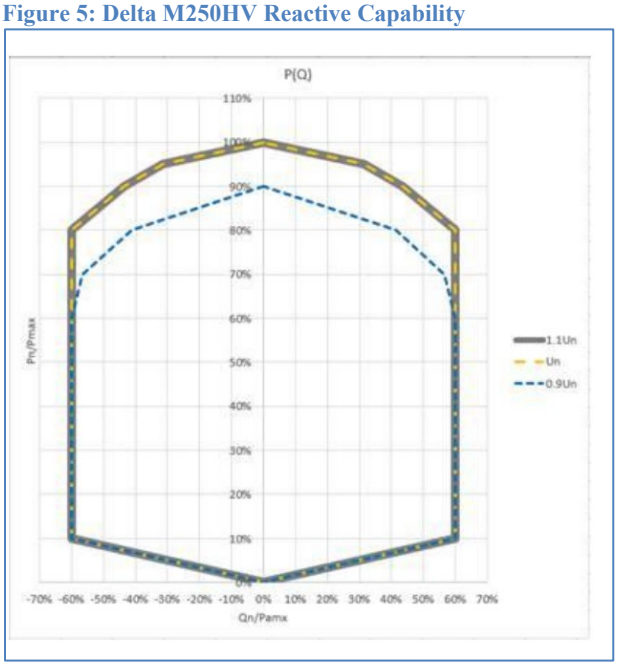
The results for the load flow analysis were acceptable with no criteria violations in any of the dispatch cases considered. As a result, IR#630 does not require Network Upgrades beyond the POI to operate at its full source capacity of 40 MW under NRIS.

8 Reactive Power and Voltage Control

In accordance with the *Transmission System Interconnection Requirements* Section 7.6.2, IR#630 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 40 MW, this translates into a reactive capability of 13 Mvar leading and lagging.

The PQ curve provided by the IC indicates that the Delta PV M250HV – 0.25 MW has a unity power factor when the real power output reaches its max at a terminal voltage of 1.0 p.u., which means the reactive power capability is zero when IR#630 operates in rated 40MW. When real power drops to 10%~80% of the Pmax, the reactive power capability reaches to its maximum of 60% of Pmax. Figure 5 shows how reactive capability varies with voltage and real power output. It is noted that this unit is not capable of reactive power control down to zero MW.

Figure 5: Delta M250HV Reactive Capability



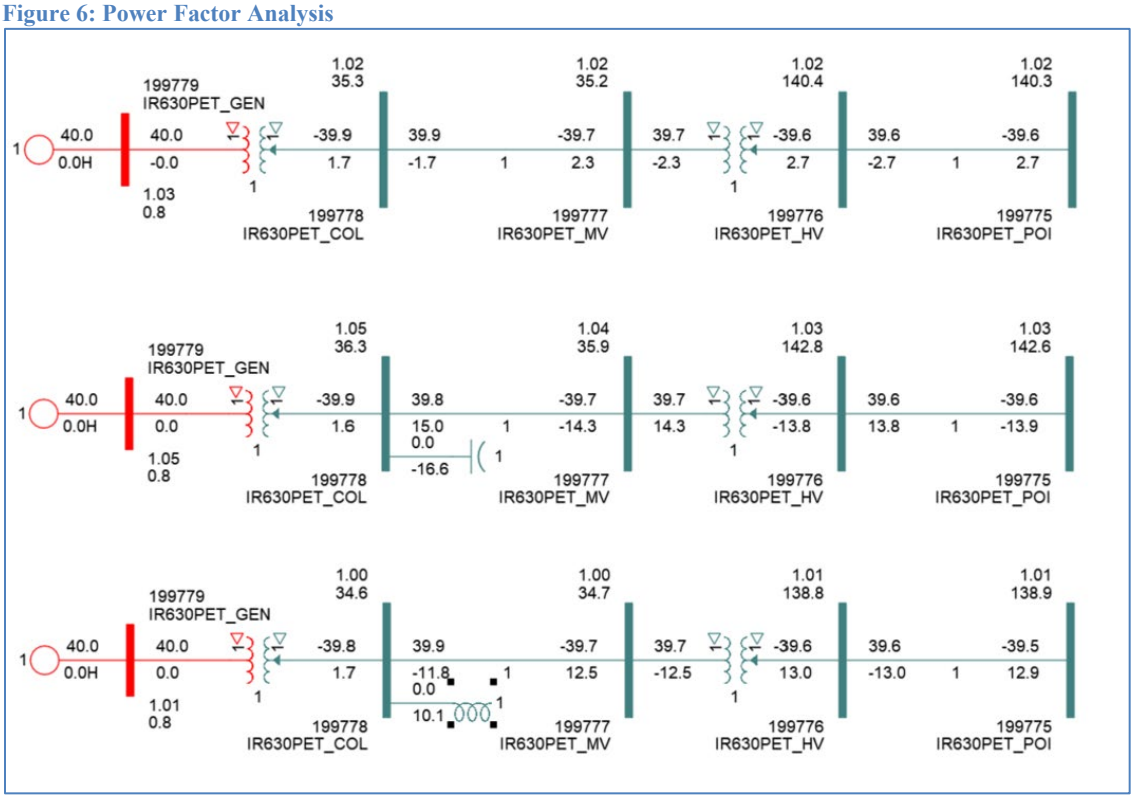
Analysis shown in Figure 6 shows that IR#630 may not be able to meet the full-load reactive power requirement and may require additional reactive support device such as

STATCOM, DSTATCOM or synchronous condenser, supplied by the Interconnection Customer.

The model shows that with 160 solar inverter units operating at a total of 40 MW and 0 MVar, the delivered power to the high side of the ICIF transformers is 39.6 MW and -2.7 MVar, or a power factor of -0.9998 with solar inverter terminal voltage at 1.0 p.u.

This configuration would not be able to meet the lagging power factor requirement of 0.95 or leading power factor requirement of -0.95 at the high side of ICIF transformer while operating at full load. The IC is responsible for meeting this requirement by providing power factor correction as described in the Nova Scotia Power Transmission System Interconnection Requirements (TSIR). It is assumed that the reactive power device is installed at 34.5 kV collector system, and the study showed the minimum range of +15/-10 MVAr is required.

Figure 6: Power Factor Analysis



Because this analysis is based on preliminary transformer data and assumed collector circuit models, reactive capability will be confirmed in the SIS.

A centralized controller will be required which continuously adjusts individual inverter 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 inverters 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 inverter and its excitation. Line drop compensation, voltage droop, control of separate switched capacitor banks must be provided.

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

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

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

9 System Security / Bulk Power Analysis

Transmission System Elements may be required to meet NPCC Bulk Power System (BPS) and NERC Bulk Electric System (BES) requirements.

Presently the 138kV buses at the 113H-Dartmouth East and the 87H-Musquodoboit Harbour substations are not part of the Nova Scotia Bulk Power System (BPS). As such, IR#630 does not meet any of the five BES inclusion criteria, therefore it will not be designated NERC BES element. However, this will be further evaluated during the SIS phase.

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#630 in service, losses in the winter peak case total 86.2 MW. With IR#630 in service at the POI of L-6043, displacing generation at 91H, and not including losses associated with the IR#630 Generation Facilities or TPIF Interconnection Facilities, system losses total 85.7 MW, a decrease of 0.5 MW. The model shows power delivered to the POI is 39.6 MW, therefore the loss factor is calculated as -0.5/39.6 = -1.3%.

11 Expected Facilities Required for Interconnection

The following facility changes will be required to connect IR#630 to the NSPI transmission system at a POI on L-6043 under NRIS:

a. Required Network Upgrades

- Modification of NSPI protection systems on L-6043 at 113H-Dartmouth East including a transfer trip to the IR#630 generation for any combinations of islanding conditions.

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

- Construct a total of 2.2 km transmission line between the POI at 87H on L-6043 and the Interconnection Customer's Interconnection Facility. This line would be built to NSPI's 138kV standards. The IC will be responsible for providing the Right-of-Way for the lines.
- Add control and communications between the solar plant and NSPI SCADA system (to be specified).

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

- One 138kV circuit breaker at the 138kV side of the ICIF station transformer.
- 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. The data provided for this study showed the Delta M250HV solar inverters did not meet this power factor requirement and it did not meet the requirement that rated reactive power be delivered from zero to full rated real power.
- 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.

12 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

Estimates for NSPI Interconnections Facilities and Network Upgrades for interconnecting 40 MW solar energy at the 138kV POI at 87H on L-6043 are included in Table 5 under NRIS.

Table 5 Cost Estimate NRIS @ POI L-6043

Item	Network Upgrades	Estimate
1	Modification of NSPI protection systems on L-6043 at 113H-Dartmouth East, including Transfer trip scheme to the IR#630 generation for any combinations of islanding conditions	$150,000
	Sub-total for Network Upgrades	$150,000
Item	**TPIF Upgrades**	**Estimate**
1	Construct a total of 2.2 km transmission line between the POI at 87H on L-6043 to the ICIF, with IC responsible for providing Right-Of-Way	$1,100,000
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	$1,910,000
	Total Upgrades	**Estimate**
	Network Upgrades + TPIF Upgrades	$2,060,000
	Contingency (10%)	$206,000
	Total (Incl. 10% contingency and Excl. HST)	$2,266,000

The preliminary non-binding cost estimate for interconnecting 40 MW at the POI at L-6043 under NRIS is $2,266,000 including a contingency of 10%. Of this amount, $150,000 (plus 10% contingency) 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 cost estimate does not include any reactive power devices that are potentially required to meet the NSPI power factor requirements. It also does not include TBD costs to address any stability issues identified at the SIS stage based on dynamic analysis.

The estimated time to construct the Transmission providers Interconnection Facilities and the Network Upgrades 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#630. 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 SIS will consider but not be limited to the following:

- Correct models of the entire facility from the POI to the IC substation and IR#630 facility including the collector circuits.
- 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.
- The minimum transmission additions/upgrades that are necessary to permit operation of this Generating Facility, under all dispatch conditions, meeting NPCC and NERC criteria.
- Guidelines and restrictions applicable to first contingency operation (curtailments etc.).

- Under-frequency load shedding impacts.
- Metro Dynamic Reactive Reserves requirement, thermal and voltage assessment for increasing Onslow South if IR#630 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 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 IR#630 control system to coordinate with other facilities in the transmission system and to ensure fault ride through.

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.

Nova Scotia Power
Transmission System Operations
2022-04-11

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