# Interconnection Feasibility Study Report
# GIP-IR802-FEAS-R0

## Generator Interconnection Request 802
## 7 MW Solar Generating Facility
## Lunenburg County, NS

2025-02-13

Control Centre Operations
Nova Scotia Power Inc.

# Executive Summary

The Interconnection Customer (IC) submitted a Network Resource Interconnection Service (NRIS) Interconnection Request for a proposed 7 MW solar generation facility interconnected to the NSPI distribution system, with a Commercial Operation Date of 2026-06-30. The Point of Interconnection (POI) requested by the customer is the NSPI 12.5 kV distribution circuit 89W-302, approximately 3 km from 89W-Bridgewater East.

Preliminary Assessment indicated that NSPI must upgrade existing distribution facilities to accommodate this solar generation facility at the requested location. This feasibility study (FEAS) is to provide a preliminary evaluation of system impacts from interconnecting the proposed generation facility to the NSPI transmission system.

There are nineteen Transmission Interconnection Requests and twenty-one Distribution Interconnection Requests in the Advanced Stage Queue that are higher queued than IR802. In addition, there is a long-term firm Transmission Service Reservation *(TSR)* that must be accounted for: 550 MW from New Brunswick to Nova Scotia *(TSR411)*.

TSR411 is expected to be in service in 2028 and a system study is currently underway to determine the associated upgrades to the Nova Scotia transmission system. These upgrades are expected to materially alter the configuration of the transmission system in Nova Scotia. As a result, the following notice was posted to the OASIS site at https://www.nspower.ca/oasis/generation-interconnection-procedures:

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

This study assumes that the addition of generation from IR802 will displace coal-fired generation in eastern Nova Scotia for NRIS.

Interconnection with NSPI 12.5kV distribution circuit 89W-302 will not require any new transmission interconnection facility to the generation facilities. IR802 generator is not considered as a NERC Bulk Electric System (BES) element, or part of Nova Scotia Bulk Power System (BPS).

At the time of this study, the SIS associated with higher queued project IR739 was not complete. IR739 models were included in the base cases for IR802, and where overloads were identified as a result of both the IR739 and IR802 generation, the contributions of both projects were identified.

With the interconnection of IR802 and higher queued IR739, the study shows up to 177% overload on 99W-T72 under various contingency conditions with a 4% increase caused by the interconnection of IR802. Thermal overloads on 99W-T71 and L-7009 are also found to increase by 4% after interconnection of IR802. The overloads associated with higher queued IR739 will be mitigated by the network upgrades and the area Automatic Action Scheme (AAS) revisions

associated with that project. Without IR739 (i.e., if the project is withdrawn), IR802 alone would not cause thermal overloads on L-7009, 99W-T71 or 99W-T72.

The study shows that the flow on L-5535 will exceed its summer nominal ratings (up to 101%) under certain system normal conditions with the addition of both IR 739 and IR802, and post-contingency overload is up to 140%. These overloads are mostly associated with IR739, but are slightly worsened post IR802 project with 1% increase. Without IR739, IR802 alone would not cause thermal overload on L-5535.

The addition of IR802 7MW solar generation will cause reverse flow into the transmission system through the substation transformer 89W-T51 and potentially 99W-T61 if 69kV line L-5545 is out of service. The NSPI protection and control systems should be modified accordingly. No violations of voltage criteria for transmission facilities were found for IR802.

Data provided by the IC indicated that IR802 will be utilizing Sungrow SG350HX string inverter. Based on the provided impedances of the transformers, existing collector circuit length and typical collector circuit impedances, IR802 would be able to meet the net power factor of +0.95 to -0.95 at the generator step-up transformer 12.5 kV bus. As specific details of the collector circuits become available, the adequacy of reactive power supply will be further investigated in the System Impact Study. It is required that the proposed Sungrow SG350HX string inverter models should meet the requirement to produce full Mvar capability down to zero MW output.

IR802 was not found to adversely impact the short-circuit capabilities of existing circuit breakers. It is assumed that the project design meets NSPI requirements for low-voltage ride-through and voltage control. Harmonics must meet the Total Harmonics Distortion provisions of IEEE 519. Voltage flicker will be further examined when data for the machine is made available. The minimum short circuit level at the 12.5 kV of generator step-up transformer (POI) is 54 MVA with all lines in service which corresponds to a short-circuit ratio of 7.7.

The preliminary value for the unit loss factor is calculated as 2.9% at the POI at 89W-302.

The preliminary non-binding transmission cost estimate for interconnecting 7 MW to the POI at 89W-302, including the cost of the protection upgrades at 89W substation is $891,000. In this estimate, $550,000 of the amount represents Network Upgrade costs which are funded by the Interconnection Customer, but which are eligible for refund under the terms of the GIP. The remainder of the costs are fully funded by the Interconnection Customer. These estimates do not include costs associated with distribution systems or IC's Interconnection Facilities.

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# 1 Introduction

The Interconnection Customer (IC) submitted a Network Resource Interconnection Service (NRIS) Interconnection Request for a proposed 7 MW solar generation facility interconnected to the NSPI distribution system, with a Commercial Operation Date of 2026-06-30. The Point of Interconnection (POI) requested by the customer is the NSPI 12.47 kV distribution circuit 89W-302, approximately 3 km from 89W-Bridgewater East.

The IC signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI system dated 2024-07-16, and this report is the result of that Study Agreement. This project is listed as Interconnection Request 802 (previously as IR764), in the NSPI Interconnection Request Queue and will be referred to as IR802 throughout this report.

Figure 1 shows the proposed geographic location of IR802 in relation to the NSPI transmission system.

**Figure 1 IR#802 Site Location**

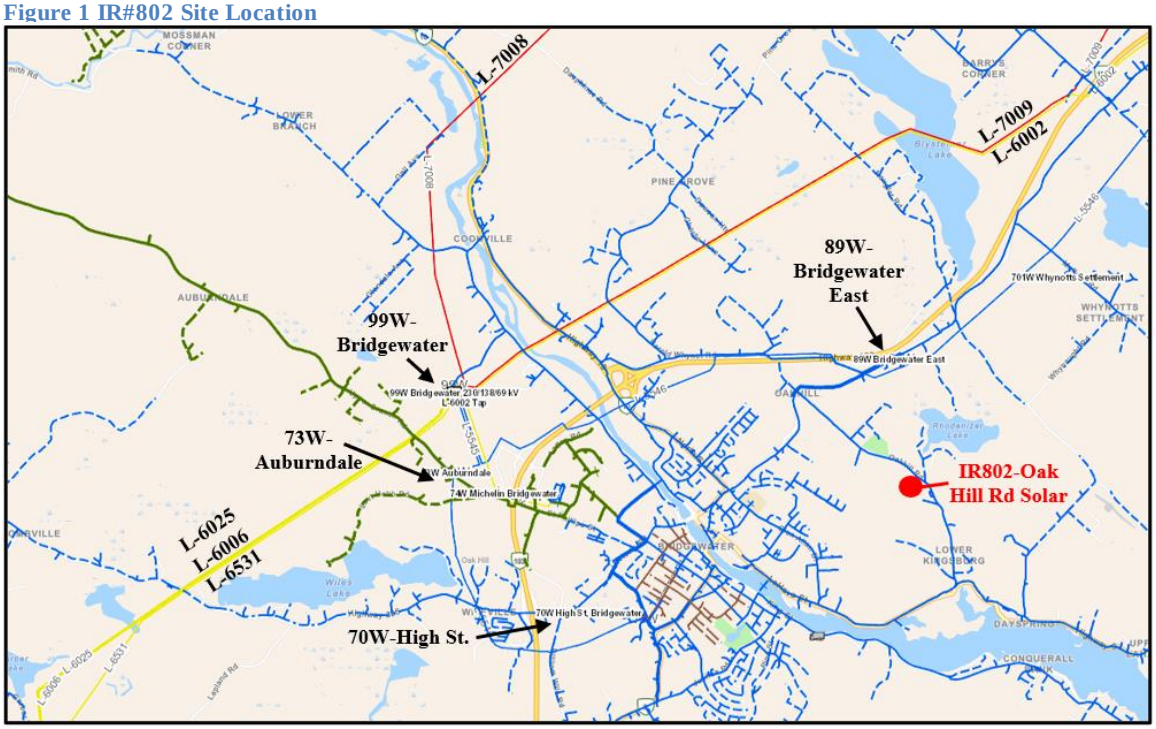



Figure 2 shows the circuit breaker configuration of transmission lines in the vicinity of the POI. Figure 3 shows the distribution circuit and proposed generator site.

**Figure 2 Circuit Breaer Configuration near POI**

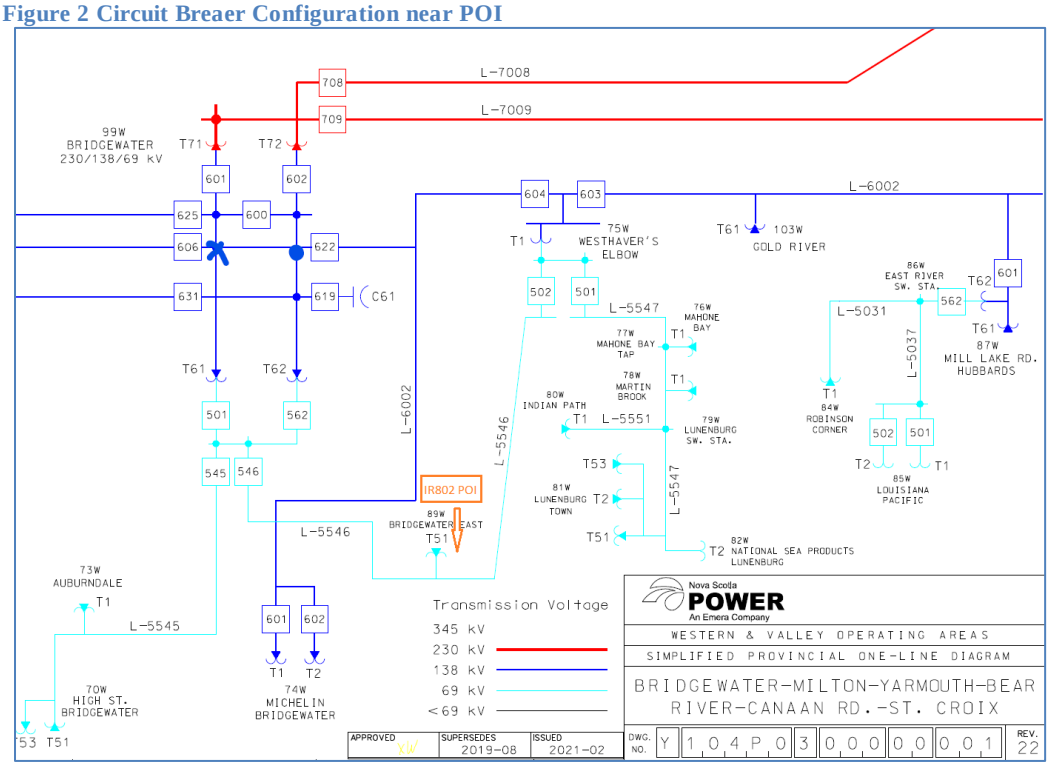
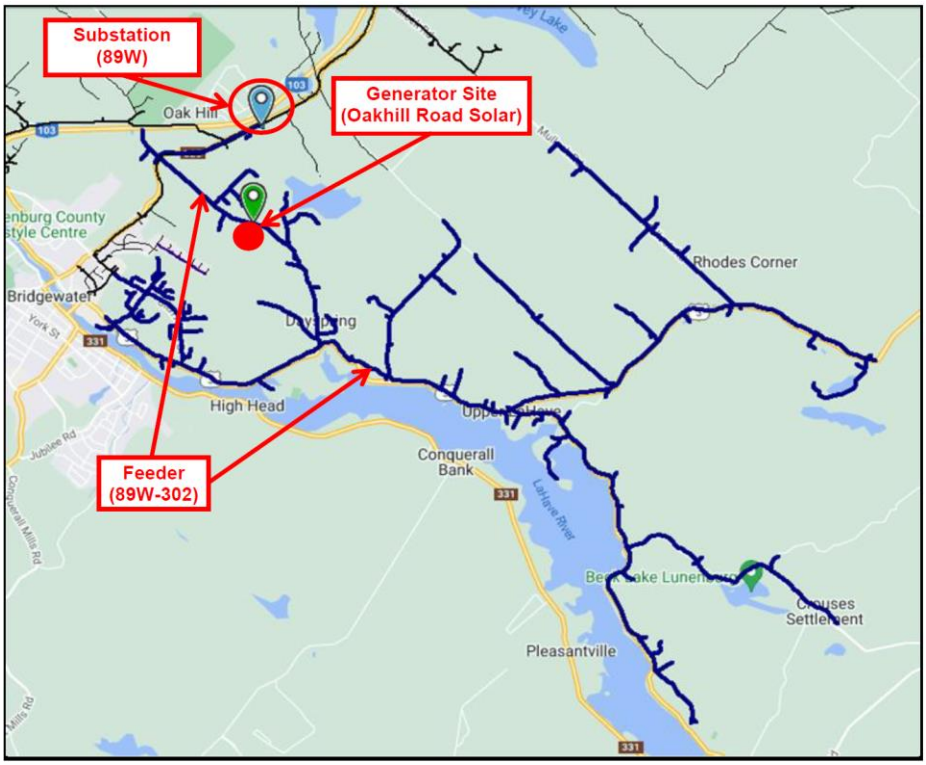



**Figure 3 Distribution Circuit and Generator Site**



# 2 Scope

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

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

- Preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the interconnection, and any network upgrades necessary to address the short circuit issues associated with the IR. 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.

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

- For comparative purposes, the impact of IR802 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 interconnect the generating facility.

# 3 Assumptions

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

1. NRIS as per section 3.2 of the Generator Interconnection procedures (GIP).

2. Commercial Operation date 2026-06-30.

3. The Interconnection Customer Interconnection Facility (ICIF) consists of up to 28 Sungrow String Inverter SG350HX, each rated at 0.32 MVA; capped at a total of 7 MW, connected to collector circuits operating at a voltage of 12.47 kV.

4. The Point of Interconnection (POI) is identified on distribution circuit 89W-302 therefore no new transmission interconnection facilities are required to connect IR802 to the NSPI system.

5. 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 generator 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 solar 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.

6. Preliminary data was provided by the IC for the IC substation interconnection facility. The positive-sequence impedance of three 12.47/0.8kV generator step-up (GSU) transformers are each rated at 5.5% on 3.2 MVA with an assumed X/R ratio of 8. These GSUs have a delta (HV) -wye (LV) winding configuration with +/-2x2.5% tap changer.

7. Preliminary assessment indicated that IR802 requires 0.1 km extension of 336 aluminum line section of 89W-302. With the network upgrade 89W-302 impedance is explicitly modeled as 0.5408+j0.8437 p.u. (R+jX) with 0.000020 p.u. charging (B) on system base 100 MVA.

8. The existing transformer 89W-T51 is rated at 15/20/25 MVA and modeled with a positive-sequence impedance of 8.15% on 15 MVA with an assumed X/R ratio of 30. 89W-T51 has a delta (HV)- grounded wye (LV) winding configuration with +/-10% on-load tap changer with 32 steps.

9. There is existing wind generation of 4MW on distribution circuit 89W-303. This wind generation is modeled with the following parameters:

    - The wind generation is modelled as an equivalent generator representing two Repower MM92 turbines, rated at 2.05MW each with total output capped at 4MW.

    - GSU is rated at 5.75% on 2.5 MVA with an assumed X/R ratio of 8. This GSU has a grounded wye (HV) - grounded wye (LV) winding configuration with +/-2x2.5% tap changer.

    - Distribution circuit 89W-303 from the wind generation to 89W is modelled with impedance of 0.6502+j0.9985 p.u. (R+jX) with 0.000024 p.u. charging (B) on system base 100 MVA.

10. It is assumed that IR802 generation meets IEEE Standard 519 limiting total harmonic distortion (all frequencies) to a maximum of 5% with no individual harmonic exceeding 3% for 69 kV.

11. Generation in a higher queue position, except for the interconnection requests that are electrically remote from IR802, are modeled in the base cases.

12. Planning criteria meeting NERC Standard TPL-001-5 *Transmission System Planning Performance Requirements* and NPCC Directory 1 *Design and Operation of the Bulk Power System* as approved for use in Nova Scotia by the Utility and Review Board, are used in evaluation of the impact of any facility on the Bulk Electric System.

13. The rating of transmission facilities in the vicinity of IR802 are shown in Table 1 and Table 2.

**Table 1: Rating of Transmission Lines**

| Line | Conductor | Design Temp | Limiting Element | Summer Rating Normal/Emergency MVA | Winter Rating Normal/Emergency MVA |
|---|---|---|---|---|---|
| L-7008 | ACSR 1113 Beaumont | 70ºC | CT | 398.0/437.8 | 398.0/437.8 |
| L-7009 | ACSR 795 Drake | 50ºC | Conductor | 223.0/245.3 | 340.0/374.0 |
| L-6006 | ACSR 795 Drake | 50ºC | Conductor | 135.0/148.5 | 205.0/225.5 |
| L-6025 | ACSR 1113 Beaumont | 70ºC | CT | 200.0/220.0 | 200.0/220.0 |
| L-6531 | ACSR 556.5 Dove | 50ºC | Conductor | 110.0/121.0 | 165.0/181.5 |
| L-5545a | ACSR 556.5 Dove | 50ºC | Conductor/Trip MVA | 55.0/57.0 | 57.0/57.0 |
| L-5545b | ACSR 4/0 Penguin - 336.4 Linnet | 50ºC | Conductor/Switch | 31.0/34.1 | 45.0/48.0 |
| L-5546 | ACSR 2/0 Quail | 50ºC | Conductor | 23.0/25.3 | 34.0/37.4 |

| Table 2: Rating of Transformers | | |
|---|---|---|
| Transformer | Normal Rating / Max. Loading | |
| | Summer MVA | Winter MVA |
| 99W-T71 | 200/240 | 200/240 |
| 99W-T72 | 200/240 | 200/240 |
| 99W-T61 | 100/110 | 100/110 |
| 89W-T51 | 25/27.5 | 25/33.25 |

# 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 2025/01/29, the following projects are higher queued in the Advanced Stage Interconnection Request Queue and are committed to the study base cases:

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

The following projects have been submitted to the Transmission Service Request (TSR) Queue:

- TSR411: SIS in progress
- TSR412: Withdrawn

TSR-411 is a long-term firm point-to-point transmission service reservation in the amount of 550 MW from New Brunswick to Nova Scotia; The TSR is expected to be in service in 2028 and a system study is currently underway to determine the required upgrades to the Nova Scotia transmission system. 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.*

# 5 Short-Circuit Duty / Short Circuit Ratio

The maximum expected (design) short-circuit level is 5,000 MVA (21 kA) on 138kV systems and 3,500 MVA (31.5 kA) on 69 kV system. The fault current characteristic for this Sungrow String Inverter SG350HX is assumed as 1.1 times rated current, or X'd = 0.9091 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 3.

**Table 3: Short-Circuit Levels. IR802 on 89W-302 Three-phase MVA (1)**

| Location | Without IR802 | With IR802 |
|---|---|---|
| All transmission facilities in service | | |
| POI on 89W-302 (12.5kV) | 81 (2) | 91 (2) |
| 89W Bridgewater East (12.5kV) | 166 (2) | 175 (2) |
| 89W Bridgewater East (69kV) | 694 | 703 |
| 99W Bridgewater (69kV) | 812 | 819 |
| 99W Bridgewater (138kV) | 1994 | 2003 |
| 99W Bridgewater (230kV A) | 1548 | 1551 |
| 99W Bridgewater (230kV B) | 1791 | 1794 |
| 50W Milton (69kV) | 629 | 630 |
| 50W Milton (138kV) | 1578 | 1581 |
| Minimum Conditions (PA, LG1, ML In-Service) | | |
| 89W Bridgewater East (69kV), all lines in-service | 284 | 294 |
| POI on 89W-302 (12.5kV), all lines in-service | 54 | 65 |
| 89W Bridgewater East (69kV), L-6025 open at 99W | 284 | 294 |
| POI on 89W-302 (12.5kV), L-6025 open at 99W | 54 | 65 |

| | | |
|---|---|---|
| 89W Bridgewater East (69kV), T72 open at 99W | 265 | 274 |
| POI on 89W-302 (12.5kV), T72 open at 99W | 54 | 65 |

(1) Classical fault study, flat voltage profile
(2) The maximum current produced by the existing wind generation on 89W-303 is assumed approximately 20MVA based on IR290 Distribution SIS report.

The interrupting capability is at least 10000 MVA for the 230kV circuit breakers, 6000 MVA for the 138 kV circuit breakers and 2500 MVA for 69 kV circuit breakers at 99W-Bridgewater. At 50W-Milton, the interrupting capability is at least 3500 MVA for the 138kV circuit breakers and 2000 MVA for the 69kV circuit breakers. As such, the interrupting rating 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. Based on the calculated short circuit levels, the short circuit ratio would be 7.7 at the 12.5kV Interconnection Facility of the IR802 substation with all lines in service and IR802 offline. The short circuit ratio remains at 7.7 with L-6025 or T72 open at 99W-Bridgewater.

# 6 Voltage Flicker and Harmonics

Flicker coefficient information was not provided for the Sungrow String Inverter SG350HX machine. Voltage flicker will be further examined when data for the machine is made available.

The generating facility 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 69 kV.

# 7 Load Flow Analysis

At the time of this study, the SIS associated with higher queued project IR739 was not complete. IR739 models were included in the base cases for IR802, and where overloads were identified as a result of both the IR739 and IR802 generation, the contributions of both projects were identified.

The load flow analysis was completed for generation dispatches under system summer peak, summer shoulder, spring light load and winter peak load conditions which are expected to stress the Western-Valley areas. 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. Winter peak load conditions was scaled to 92% of system peak winter load to correlate with solar generation peak output

during winter, as the peak solar output will occur in early afternoon, rather than at system peak at 7pm.

For these cases, transmission connected wind generation facilities were dispatched between 19% and 100% of their rated capability. All interface limits were respected for base cases.

Two scenarios were examined for each of the Light Load (*LL*), Shoulder Season (*SH)*, Summer Peak *(SP)*, and Winter Peak (*WP*) cases:

- Pre-IR802 cases ending with "-1": IR802 off.
- Post-IR802 cases ending with "-2": IR802 dispatched at 7 MW under NRIS designation.

**Table 4: Base Cases for IR802**

| Case | NS Base Load | IR802 | 89W Load | West wind | Valley Wind | NS / NB | ML | CBX | ONS | ONI | Valley import | Western import | Valley export | West Valley import |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - | - | - | - | - | | - | - | L8004, L7003, L7004, L7005, L6515) | *(L8002, L7001, L7002, L7018, L6001)* | *(L8003, L7003, L7019, L7005, L6503)* | *(L6054, L6011, L6051)* | *(L7008, L7009)* | *(L5532, L5535, L5025)* | *(L5022, L5532, L5535, L6013, L6015)* |
| c_ll01-1 | 550 | 0 | 3.24 | 353 | 69 | 329 | -396 | 203 | -58 | 228 | 70 | -344 | -2 | 21 |
| c_ll01-2 | 550 | 7 | 3.24 | 353 | 69 | 328 | -396 | 197 | -64 | 222 | 70 | -350 | -2 | 21 |
| c_ll02-1 | 544 | 0 | 3.24 | 353 | 344 | 330 | 0 | -190 | -451 | -164 | -120 | -378 | 42 | -22 |
| c_ll02-2 | 544 | 7 | 3.24 | 353 | 344 | 330 | 0 | -196 | -458 | -171 | -120 | -384 | 42 | -22 |
| c_ll03-1 | 577 | 0 | 3.24 | 60 | 58 | 349 | -475 | 479 | 344 | 650 | 100 | 44 | -12 | 32 |
| c_ll03-2 | 577 | 7 | 3.24 | 60 | 58 | 349 | -475 | 472 | 337 | 644 | 99 | 37 | -12 | 32 |
| c_sh01-1 | 995 | 0 | 6.37 | 353 | 78 | 149 | -316 | 205 | 187 | 329 | 123 | -297 | -6 | 41 |
| c_sh01-2 | 995 | 7 | 6.37 | 353 | 78 | 149 | -316 | 199 | 181 | 323 | 123 | -303 | -6 | 41 |
| c_sh02-1 | 995 | 0 | 6.37 | 353 | 344 | 150 | -140 | -107 | -191 | -48 | -61 | -320 | 36 | -1 |
| c_sh02-2 | 995 | 7 | 6.37 | 353 | 344 | 150 | -140 | -113 | -198 | -54 | -61 | -327 | 36 | -1 |
| c_sh03-1 | 1029 | 0 | 6.37 | 60 | 58 | 151 | -316 | 669 | 610 | 753 | 160 | 95 | -30 | 65 |
| c_sh03-2 | 1029 | 7 | 6.37 | 60 | 58 | 151 | -316 | 662 | 603 | 746 | 160 | 88 | -30 | 65 |
| c_sp01-1 | 1372 | 0 | 9.79 | 353 | 344 | 329 | -168 | -104 | 88 | 181 | 12 | -288 | -8 | 55 |
| c_sp01-2 | 1372 | 7 | 9.79 | 353 | 344 | 329 | -168 | -110 | 81 | 174 | 12 | -294 | -8 | 55 |
| c_sp02-1 | 1366 | 0 | 9.79 | 353 | 329 | 329 | -475 | 326 | 363 | 535 | 135 | -150 | -25 | 72 |
| c_sp02-2 | 1366 | 7 | 9.79 | 353 | 329 | 329 | -475 | 319 | 356 | 528 | 135 | -157 | -25 | 72 |
| c_sp03-1 | 1406 | 0 | 9.79 | 60 | 79 | 329 | -475 | 770 | 786 | 958 | 198 | 144 | -28 | 75 |
| c_sp03-2 | 1406 | 7 | 9.79 | 60 | 79 | 329 | -475 | 763 | 779 | 951 | 198 | 137 | -28 | 75 |
| c_sp04-1 | 1382 | 0 | 9.79 | 353 | 83 | 329 | -475 | 434 | 496 | 667 | 165 | -252 | -6 | 53 |
| c_sp04-2 | 1382 | 7 | 9.79 | 353 | 83 | 329 | -475 | 427 | 489 | 661 | 165 | -258 | -6 | 53 |
| c_wp01-1 | 2106 | 0 | 15.81 | 353 | 344 | 329 | -170 | 19 | 360 | 384 | 71 | -236 | -18 | 87 |
| c_wp01-2 | 2106 | 7 | 15.81 | 353 | 344 | 329 | -170 | 14 | 356 | 379 | 71 | -242 | -18 | 87 |
| c_wp02-1 | 2090 | 0 | 15.81 | 353 | 344 | 329 | -330 | 249 | 603 | 626 | 136 | -195 | -17 | 87 |
| c_wp02-2 | 2090 | 7 | 15.81 | 353 | 344 | 329 | -330 | 242 | 596 | 619 | 136 | -202 | -17 | 87 |
| c_wp03-1 | 2144 | 0 | 15.81 | 353 | 82 | 151 | -330 | 818 | 612 | 874 | 196 | -199 | -19 | 89 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| c_wp03-2 | 2144 | 7 | 15.81 | 353 | 82 | 151 | -330 | 811 | 606 | 867 | 196 | -206 | -19 | 89 |
| c_wp04-1 | 2144 | 0 | 15.81 | 60 | 73 | 150 | -475 | 1071 | 849 | 1110 | 222 | 147 | -24 | 94 |
| c_wp04-2 | 2144 | 7 | 15.81 | 60 | 73 | 150 | -475 | 1063 | 842 | 1103 | 221 | 140 | -24 | 94 |

For NRIS analysis, this FEAS added IR802 and displaced coal-fired generation in Cape Breton, reducing Cape Breton Export (CBX) transfers and Onslow Import (ONI) transfers. Single contingencies were applied at the 230 kV, 138 kV and 69 kV voltage levels for the above system conditions with IR802 interconnected to the POI at 89W-302. Automated analysis searched for violations of emergency thermal ratings and emergency voltage limits for each contingency. Contingencies studied are listed in Table 5.

**Table 5: PSSE Contingency List**

| Transmission Line | Transformer / Bus | Circuit Breaker Failure | Double Circuit Tower |
|---|---|---|---|
| L-7008, L-7009, L-5545, L-5546, L-6531, L-6006, L-6025, L-6002, SHUNT (*138 kV*) | 99W- T61, T62, T71, T72 B71, B72, B51 | 99W: 708, 709, 600, 501, 545, 546, 562 | L-7008+ L-7009 L-7009+ L-8002 |
| L-6012, L-6013, L-6054, L-6015, L-6052, L-5017, L-5022, L-5035, L-5019, 50V-Load (*138kV*), | 43V- T61, T62, B51, C61 | 43V: 604, 613, 505, 562, 503, 506, 501, 502, 504, IR737: 601 | L-5016+ L-6012 |
| L-6051, L-6011, L-5014, L-5060, L-5015, L-5016 | 17V-T2, T63, T1, C51, B2 | 17V: 610, 612, 611, 563, 512, 519, 505 | |
| L-5025*, L-6053, L-6004 | 51V- T61*, B51*, B52, B61 | 101V:601, 602 | |
| L-5531, L-5532*, L-5026* | 13V- B51, 11V-B51* | | |
| L-6002, L-6009, L-6008, L-6004, L-6003, L-5003, L-5004 | 90H- T1 | 90H: 611, 608, 605, 604, 602, 612, 609, 606, 603, 610, 607, 601, 503, 506, 501 101H: 600; IR671:601 | |
| L-6005, L-6010, L-6011 | 120H- T71, T72 | 120H: 710, 711, 712, 713, 714, 715, 716, 720, 621, 622, 623, 624, 626, 627, 628, 629 | L-6005+ L-6016 L-6011+ L-6010 L-6005+ L-6016 |
| L-6042, L-6007, L-6014, L-5049, L-5012, L-5041 | 91H-T62, T11, | 91H: 621, 613, 603, 604, 605, 606, 607, 608, 609, 611, 516, 521, 523 | |

| Table 5: PSSE Contingency List | | | |
|---|---|---|---|
| **Transmission Line** | **Transformer / Bus** | **Circuit Breaker Failure** | **Double Circuit Tower** |
| L-6020, L-6024, L-6025, L-6048, L-5541, L-5530, L-5539, L-5540 | 50W-T53, B3, B4, B2, IR597 | 50W: 615, 600, 514, 517 | |
| L-6021, L-5535, L-5027 | 9W-T2, T63, B52, B53 | 9W: 500 | |
| | 30W-T62, B51 | | |

*Indicates contingency was studied with/without RAS action

With the interconnection of IR802, the study shows up to 177% overload on 99W-T72 under various contingency conditions. The pre-existing overload is found to be 174%, with a 4% overload increase caused by the interconnection of IR802. Thermal overloads on 99W-T71 and L-7009 are also found to increase by 4% after interconnection of IR802. These overloads are pre-existing issues due to higher queued projects in the study area, which will be mitigated by the network upgrades and the area Automatic Action Scheme (AAS) prior to IR802. Without these higher queued projects, IR802 alone would not cause thermal overload on L-7009, 99W-T71 or 99W-T72.

The study shows that the flow on L-5535 will exceed its summer nominal ratings (up to 101%) under certain system normal conditions and post-contingency overload is up to 140%. These overloads are pre-existing issues due to a higher queued project in the study area, and slightly worsened post IR802 project with 1% increase. Without the higher queued project, IR802 alone would not cause thermal overload on L-5535.

The thermal overloads increased by over 3% due to IR802 are summarized in Table 6.

| Table 6 Contingency Results in Highest Overload | | | | |
|---|---|---|---|---|
| **Line / Transformer** | **Line Segment** | **Highest Overload** | **Case** | **Contingency** |
| 99W-T71 | 99W Bridgewater | 176% (pre-existing, 3.6% increase by IR802) | ll01, ll02, sh01, sh02, sp01, sp04 | 120H-715, 120H-716, 120H_L-7008, 99W-708, 99W-B71, 99W-L7008, 99W-T72 |
| 99W-T72 | 99W Bridgewater | 177% (pre-existing, 3.6% increase by IR802) | ll01, ll02, sh01, sh02, sp01, sp04 | 120H-712, 120H-713, 120H_L-7009, 99W-709, 99W-B72, 99W-L7009, 99W-T62, 99W-T71, DCT_L-7009][L-8002 |

| | | | | |
|---|---|---|---|---|
| L-7009 | 120H Brushy – 99W Bridgewater | 172% (pre-existing, 3.5% increase by IR802) | ll01, ll02, sh01, sh02, sp01 | 120H-715, 120H-716, 120H_L-7008 |

The load supplied by 89W substation is studied at 3.2-15.8 MW during periods of light to peak load. There is also an existing 4 MW wind generation facility on 89W-303 distribution circuit. With the addition of IR802 7MW solar generation, reverse flow into the transmission system is anticipated through the substation transformer 89W-T51, and potentially through 99W-T61 during periods where L-5545 is out of service. The protection and control systems at 89W and 99W should be modified accordingly.

# 8 Reactive Power and Voltage Control

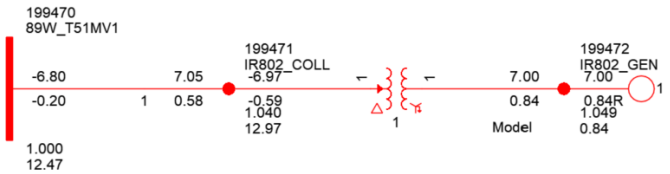
In accordance with the *Transmission System Interconnection Requirements* Section 7.6.2, IR802 must be capable of delivering reactive power at a net power factor of at least +/- 0.95 of rated capacity to the high side of the generator pad mount transformer(s). Reactive power can be provided by the asynchronous generator or by continually acting auxiliary devices such as STATCOM, DSTATCOM or synchronous condenser, supplied by the Interconnection Customer. It also requires that rated reactive power shall be available through the full range of real power output of the Generating Facility, from zero to full power.

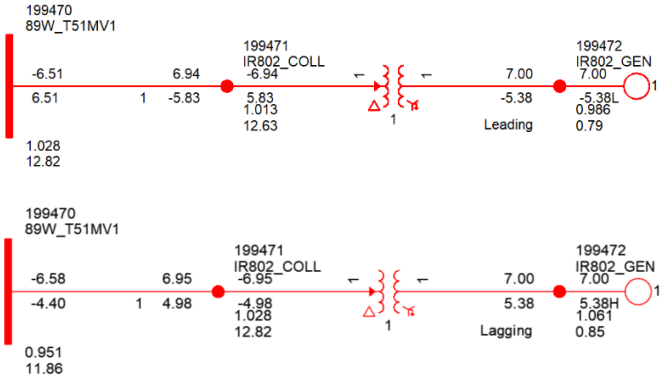
There was no detailed manufacture technical data available for this project. The information provided by IC (Appendix 1 to GIP) indicated that the Sungrow String Inverter SG350HX has a rated MVA of 0.32 MVA with a power factor of 0.80 lagging and leading (+/- 0.192 Mvar per inverter).

The analysis shown in Figure 4 indicates that IR802 is able to meet the full-load reactive power requirement. The model shows that with 28 SG350HX Inverter units operating at a total 7 MW and 5.38 Mvar (maximum), the delivered power to the high side of the generator step-up transformers is 6.95 MW and 4.98 Mvar, or a power factor of 0.81 with inverter terminal voltage at 1.06 p.u.

This configuration would be able to meet the leading power factor requirement of -0.95 at the high side of generator step-up transformer while the inverters are operating at a total of 7 MW and -5.38 Mvar (power factor of 0.79) at a terminal voltage of 0.99 p.u.

**Figure 4: Power Factor Analysis (Top: Model, Middle: Leading, Bottom: Lagging)**






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 generator reactive power output within the plant capability limits and regulates the voltage at the 12.5 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 generator's 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 or voltage droop must be provided.

In accordance with the *Distribution Interconnection Requirements for Generating Facilities Greater than 100 kW* Section 6.17, IR 802 must be capable of controlling voltage and operating at a fixed, preset power factor. The controller's voltage set-point shall be adjustable throughout the range of 95- 105% of rated terminal voltage. IR802 shall be capable of providing dynamic reactive power compensation (dynamic Volt/VAr operation), it shall be able to consume reactive power in response to an increase in line voltage and produce reactive power in response to a decrease in line voltage.

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 89W-T51 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

IR802 is requested to connect into the 12.5 kV distribution systems, it's not categorized as part of the Nova Scotia Bulk Power System (BPS) or NERC Bulk Electric System (BES).

# 10 Expected Facilities Required for Interconnection

The following transmission facility changes will be required to connect IR802 to the NSPI distribution system at a POI on 89W-302 under NRIS:

**a. Required Network Upgrades**

- Modification of NSPI protection systems at 89W-Bridgewater East and 99W-Bridgewater

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

- Add 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 generator step-up Transformer when the voltage at that point is operating between 95 and 105 % of nominal. This study shows that Sungrow String SG350HX Inverter is able to meet this requirement. It's also required that it meets 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 12.5 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.
- Facility capable of controlling voltage and operating at a fixed, preset power factor. The controller's voltage set-point shall be adjustable throughout the range of 95- 105% of rated terminal voltage.

- Facility capable of providing dynamic reactive power compensation (dynamic Volt/VAr operation), it shall be able to consume reactive power in response to an increase in line voltage and produce reactive power in response to a decrease in line voltage.
- Low voltage ride-through capability as per Section 7.4.1 of the Nova Scotia Power Transmission System Interconnection Requirements (TSIR).
- 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.
- Operation at ambient temperature of -30°C.

# 11 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

Estimates for NSPI Transmission Interconnections Facilities and Network Upgrades for interconnecting 7 MW solar energy at the 12.5 kV POI on 89W-302 are included in Table 7.

**Table 7: Transmission System Cost Estimate NRIS @ POI 89W-302**

| Item | Network Upgrades | Estimate |
|---|---|---|
| 1 | Modification of protection systems to 89W-Bridgewater East and 99W-Bridgewater | $500,000 |
| | Sub-total for Network Upgrades | $500,000 |
| **Item** | **TPIF Upgrades** | **Estimate** |
| 2 | NSPI P&C relaying equipment | $100,000 |
| 3 | NSPI supplied RTU | $60,000 |
| 4 | Tele-protection and SCADA communications | $150,000 |
| | Sub-total for TPIF Upgrades | $310,000 |
| | **Total Upgrades** | **Estimate** |
| | Network Upgrades + TPIF Upgrades | $810,000 |
| | Contingency (10%) | $81,000 |
| | Total (Incl. 10% contingency and Excl. HST) | $891,000 |

The preliminary non-binding transmission cost estimate for interconnecting 7 MW at the POI at 89W-302 under NRIS is $891,000 including a contingency of 10%. In this estimate, $500,000 (plus 10% contingency) of the amount represents Network Upgrade costs which are funded by the Interconnection Customer, but which are eligible for refund under the terms of the GIP.

These estimates do not include costs associated with distribution system or the IC's interconnection facilities. These estimates do not include costs to address any stability issues that may be identified at later stage.

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

# 12 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 IR802 in service, losses in the winter peak case total 94.0 MW. With IR802 in service at the POI of 89W-302, displacing generation at 91H, the system losses total 94.2 MW – an increase of 0.2 MW. The power delivered to the 89W-302 is 6.97 MW, therefore the loss factor is calculated as 0.2/6.97 = 2.9%.

# 13 Issues to be addressed in SIS

The following provides a preliminary scope of work for the subsequent SIS for IR802.

The SIS will include a more comprehensive assessment of the technical issues and requirements to interconnect generation as requested. 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 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 *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 accomplish the SIS, the following statement posted on the NSPI OASIS Generation Interconnection site[1] clarifies the SIS model requirements:

> *To be eligible for inclusion in the Interconnection System Impact Study stage, and thereby advance the Interconnection Request's initial Queue Position, the Interconnection Customer must meet the progression milestone requirements of Section 7.2 of the GIP at least ten (10) Business Days prior to the Interconnection System Impact Study commencement date. For clarity, item 7.2 (i) – provision of a detailed stability model for the generator(s) shall mean:*
> *Provision of PSSE and PSCAD models in compliance with documents NSPI-TPR-015-2: PSSE and PSCAD Model Requirements, and*
> *Provision of test data demonstrating model testing in compliance with NERC, NPCC and NSPI criteria. NSPI-TPR-014-1: Model Quality Testing lists the minimum requirements that will be performed by NSPI. Additional testing may be performed to assess compliance with all applicable criteria. Any test not meeting the minimum NSPI requirements will be documented in the MQT report to the IC. NSPI-TPR-015-2: PSSE and PSCAD Model Requirements and NSPI-TPR-014-1: Model Quality Testing will undergo revision as the grid evolves and performance criteria changes. The most up to date version will be provided as they become available.*

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.

A thorough assessment will be provided to ensure that the facilities will meet applicable NSPI, NPCC and NERC transmission design criteria.

[1] https://www.nspower.ca/oasis/generation-interconnection-procedures
[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-001-5*

In addition, the SIS will include a distribution system impact study (DSIS) to determine the distribution interconnection requirements and upgrades associated with IR802.

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Nova Scotia Power
Transmission System Operations
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