# Interconnection Feasibility Study Report
# GIP-IR578-FEAS-R1

## Generator Interconnection Request 578
## 30 MW Battery Energy Storage System Facility
## Pictou County, NS

2021-04-19

Control Centre Operations
Nova Scotia Power Inc.

# Executive summary

This Feasibility Study report (FEAS) presents the results of a Feasibility Study Agreement for the connection of a 30 MW Battery Energy Storage System (BESS) facility interconnected to the NSPI system as Energy Resource Interconnection Service (ERIS).

This project is listed as Interconnection Request #578 in the NSPI Interconnection Request Queue and will be referred to as IR578 throughout this report. The proposed Commercial Operation Date is 2022/08/26.

The Interconnection Customer (IC) identified a 138 kV bus at 50N-Trenton as the Point Of Interconnection (POI). This BESS facility will be interconnected to the POI via a ~700 m long 138 kV transmission line from the Point of Change of Ownership (PCO).

There are two long-term firm Transmission Service Requests (TSR) that have established Queue position and are in the System Impact Study (SIS) stage, with a requested in-service date of 2025/01/01. These requests, TSR411 (800 MW from NB to NS) and TSR412 (500 MW from NFLD to NS), are expected to alter the configuration of the Transmission System in Nova Scotia As a result, the following notice has been posted to the OASIS site[1]:

> *Effective January 19th, 2021, please be advised that the completion of advanced-stage Interconnection Studies under the Standard Generator Interconnection Procedures (GIP) may be delayed pending the outcome of the Transmission Service Request (TSR) 411 and 412 System Impact Studies, which are expected to identify significant changes to the NSPI transmission system. The expected completion date for these studies is December 31, 2021. Feasibility Studies initiated prior to the completion of these TSR System Impact Studies will be performed based on the current system configuration.*

There are no concerns regarding increased short circuit levels or voltage flicker. The increase in short circuit level is still within the capability of associated breakers. The minimum short circuit level at the Interconnection Facility's (IF) high side bus is 718 MVA.

Voltage flicker will not be an issue based on test data from a 50 Hz system. Voltage flicker for a 60 Hz system will be examined when data is made available for the SIS to confirm NSPI's requirements are met.

[1] OASIS Generation Interconnection Procedures; https://www.nspower.ca/oasis/generation-interconnection-procedures

The project design must meet NSPI interconnection technical requirements, which include aspects like frequency and voltage ride-through, reactive power and voltage control, active power control, power quality, and low temperature operation. Harmonics must meet the Total Harmonic Distortion requirements in IEEE 519.

Supplementary reactive power support for IR578 is required as it is unable to meet NSPI's ±0.95 net power requirements at the IF 138 kV bus. The Tesla Powerstages selected for IR578 have current-limited, bi-directional inverters capable of four-quadrant operation at nominal voltage; however, they are only capable of >0.99 pf at full output. Net power factor requirements are met when IR578's output levels are just below 27.5 MW. Supplementary reactive power support will be further investigated in the System Impact Study.

The 50N-Trenton POI for IR578 is not classified as NPCC BPS or NERC BES. Complete NPCC BPS status will be determined in the SIS transient testing.

The preliminary loss factor is calculated as 9.47% while discharging at the 50N-Trenton 138 kV bus POI. This preliminary loss factor excludes losses associated with the TPIF, ICIF transformer, and generation facility.

This study's power flow analysis did not identify any transmission contingencies inside Nova Scotia that violate thermal loading criteria. Charging scenarios were evaluated during light load and summer peak conditions, however winter peak charging was only evaluated during off-peak conditions following the day's winter peak. For example, if winter peak occurred at 18:00, charging was assumed to be several hours later, when the demand reaches its minimum for the day.

The necessary Network Upgrades required for ERIS operation are:

- P&C modifications at 50N-Trenton.

The present preliminary non-binding cost estimate for interconnecting IR578 to the 50N-Trenton 138 kV bus as Energy Resource is $2,377,287, which does not include any To Be Determined costs associated with SIS stability analysis. $2,157,287 of this amount is the TPIF costs, with the remainder as the Network Upgrade costs. These estimates include a 10% contingency. This estimate will be further refined in the SIS and Facilities (FAC) studies.

Note that the proposed transmission path from the POI to PCO requires more detailed engineering to provide a more accurate cost estimate due to the congestion and sharp turns. It is the customers responsibility to provide a suitable right of way for the transmission line. The right of way shall be registered in NSPI’s name.

The estimated time to construct the Network Upgrades and TPIF for ERIS operation is 18-24 months after the receipt of funds.

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# 1.0 Introduction

This Feasibility Study report (FEAS) presents the results of a Feasibility Study Agreement for the connection of a 30 MW Battery Energy Storage System (BESS) facility interconnected to the NSPI system as Energy Resource Interconnection Service (ERIS).

This project is listed as Interconnection Request (IR) #578 in the NSPI Interconnection Request Queue and will be referred to as IR578 throughout this report. The proposed Commercial Operation Date is 2022/08/26.

The Interconnection Customer (IC) identified a 138 kV bus at 50N-Trenton as the Point Of Interconnection (POI). This BESS facility will be interconnected to the POI via a ~700 m long 138 kV transmission line from the Point of Change of Ownership (PCO). Figure 1 shows the approximate location of the proposed IR578 site.

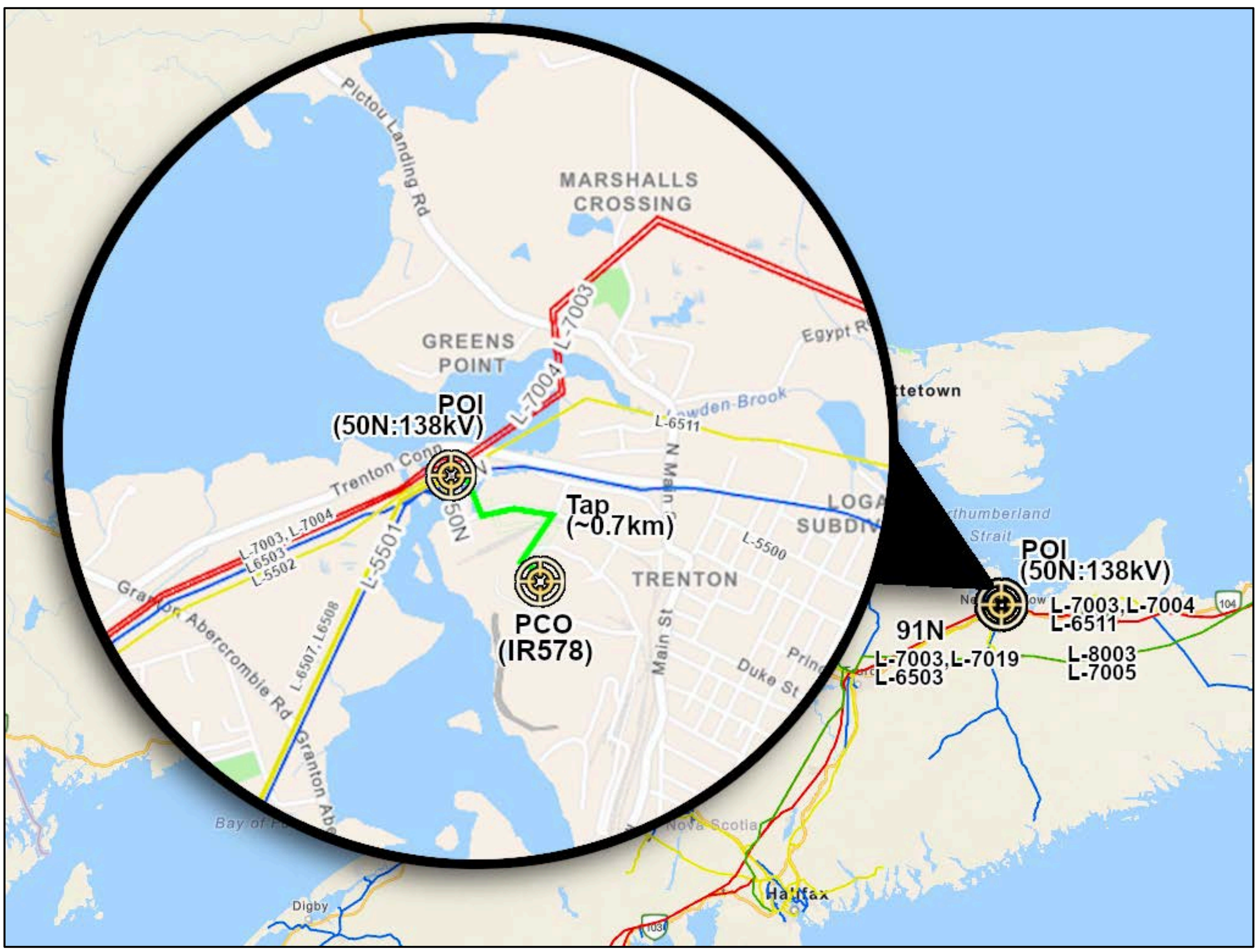


**Figure 1: IR578 approximate geographic location**

## 2.0 Scope

This Interconnection Feasibility Study's (FEAS) objective is to provide a preliminary evaluation of system impact and a high-level non-binding cost estimate of interconnecting the new BESS facility to the NSPI Transmission System at the designated location based on single contingency criteria. This assessment will identify potential impacts on transmission element loading, which must remain with their thermal limits. Any potential voltage criteria violations will be identified and addressed. Circuit breakers must be upgraded if the proposed facility increases the short-circuit duty of any circuit breakers beyond their rated capacity.

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

- 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.
- Identification of any thermal overload or voltage limit violations resulting from the interconnection and identify the necessary Network Upgrades to allow full output of the proposed facility.
- Description and high-level non-binding estimated cost of and time to construct the facilities required to interconnect the generating facility to the transmission system.

This FEAS does not include a complete determination of facility changes/additions required to increase the system transfer capabilities that may be required to the transmission system 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 in order to ascertain the final cost estimate to the interconnect the generating facility.

## 3.0 Assumptions

This FEAS is based on technical information provided by the IC. The POI and configuration are studied as follows:

1. ERIS per section 3.2 of the Generation Interconnection Procedures (GIP).
2. Commercial Operation date: 2022/08/26.
3. The Interconnection Facility consists of 616 Tesla Powerstage batteries, capped at 30 MW total. These Powerstages are grouped in blocks of 22 per Tesla Megapack, with two Megapacks per padmount unit. Each padmount unit has a single 3.0 MVA

generator step up transformer. The padmount units are connected via a single feeder to a 42.5/57.5/70.0 MVA substation step-up transformer.

4. The feeder circuit impedance was assumed to be negligible, due to the short distance *(padmounts were spaced at 17 m),*
5. The IC identified a 138 kV bus at the 50N-Trenton substation as the POI. This study will use 1113 ACSR Beaumont rated at 100ºC for the 700m transmission line between 50N and the IC substation. The IC initially proposed 1272 ACSR Bittern, however it is not NSPI stocked and may require reinforced structures. More detailed preliminary engineering is required at a later stage to determine the final transmission line design.
6. Preliminary data provided by the IC for the substation step-up transformer and padmount transformers:
   6.1. The substation step-up transformer was modelled as 1x (one) 138 kV (wye) - 34.5 kV (delta) transformer rated at 42.5/57.5/70 MVA, with a positive sequence impedance of 10.5% at 42.5 MVA and 30.0 X/R ratio.
   6.2. The padmount transformers were modelled as an equivalent transformer based off 14x (fourteen) 34.5 kV (delta) - 0.48 kV (grounded wye) 3.0 MVA transformers, with a 5.75% positive impedance at 3.0 MVA and 10.8 X/R ratio.
7. The Tesla Powerstages are the 480 VAC, 70 kVA nameplate variant. A 1.2 PU fault current is used for short circuit analysis, from the Tesla Application Note supplied by the IC.
8. The BESS charge/discharge rate is 30 MW.
9. Discharging occurring in light load, summer peak, and winter peak conditions.
10. Charging occurs in light load and summer peak conditions. During the winter season, charging only occurs in minimal load conditions several hours after winter peak.
11. The FEAS analysis is based on the assumption that IRs higher in the Generation Interconnection Queue and OATT Transmission Service Queue that have a completed System Impact Study or have a System Impact Study in progress will proceed, as listed in Section 4.0: Project queue position.

## 4.0 Project queue position

All in-service generation is included in this FEAS.

As of 2021/02/18, the following projects are higher queued in the Advanced Stage Interconnection Request Queue and are included in this study's base cases:

- IR426: GIA executed
- IR516: GIA executed
- IR540: GIA executed
- IR542: GIA executed
- IR557: SIS complete

- IR569: GIA executed
- IR568: GIA executed
- IR566: GIA executed
- IR574: SIS in progress

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

- TSR 411: Accepted application
- TSR 412: Accepted application

The two TSRs have an expected 2025 in service date and system studies to determine required upgrades to the NS Transmission System are currently in progress. As a result, the following notice has been posted to the OASIS site[2]:

> *Effective January 19th, 2021, please be advised that the completion of advanced-stage Interconnection Studies under the Standard Generator Interconnection Procedures (GIP) may be delayed pending the outcome of the Transmission Service Request (TSR) 411 and 412 System Impact Studies, which are expected to identify significant changes to the NSPI transmission system. The expected completion date for these studies is December 31, 2021. Feasibility Studies initiated prior to the completion of these TSR System Impact Studies will be performed based on the current system configuration.*

## 5.0 Short circuit

IR578 will not impact 50N-Trenton and neighbouring breaker's interrupting capability based on this study's short circuit analysis. Analysis was performed using PSS/e 34.7, classical fault study, flat voltage profile at 1.0 PU voltage, and 3LG faults.

The interrupting capability of the neighbouring 138 kV circuit breakers is at least 3,500 MVA and the short circuit levels in the area before and after this development are provided in Table 1: *Short circuit levels, 3-ph, in MVA.*

[2] OASIS Generation Interconnection Procedures; https://www.nspower.ca/oasis/generation-interconnection-procedures

**Table 1: Short circuit levels, 3-ph, in MVA**

| Location | IR578 not in service | IR578 in service | Post % increase |
|---|---|---|---|
| **2022, max generation, all facilities in service** | | | |
| POI (50N-Trenton):138 | 2,991 | 3,034 | 1% |
| IF:138 | 2,841 | 2,884 | 1% |
| **2022, min generation, all facilities in service** | | | |
| POI (50N-Trenton):138 | 1,426 | 1,469 | 3% |
| IF:138 | 1,391 | 1,434 | 3% |
| **2022, min generation, L6503 OOS** | | | |
| POI (50N-Trenton):138 | 1,169 | 1,212 | 4% |
| IF:138 | 1,145 | 1,188 | 4% |
| **2022, min generation, 79N-T81 OOS** | | | |
| POI (50N-Trenton):138 | 727 | 770 | 6% |
| IF:138 | 718 | 761 | 6% |

Further short circuit analysis will be performed in the SIS and will also examine Short Circuit Ratio (SCR) under minimum short circuit level conditions.

## 6.0 Voltage flicker & harmonics

The IC supplied manufacturer test data for a 50 Hz system, with $P_{st}$ and $P_{lt}$ values meeting NS Power's voltage flicker requirements. Voltage flicker for a 60 Hz system will be examined when data is made available for the SIS. A summary is listed in Table 2: Flicker requirements.

**Table 2: Flicker requirements**

| | $P_{st}$ | $P_{lt}$ |
|---|---|---|
| NS Power's requirements | ≤ 0.25 | ≤ 0.35 |
| Manufacturer-supplied 50 Hz test data *(12 samples)* | Max: 0.17<br>Min: 0.12<br>Avg: 0.14<br>90th: 0.17 | 0.14 |

The generator must meet IEEE Standard 519-2014 limiting voltage Total Harmonic Distortion *(all frequencies)* to no higher than 1.5% with no individual harmonic exceeding 1.5% on 138 kV.

## 7.0 Thermal limits

The steady state contingencies evaluated in this study demonstrate IR578 does not require Network Upgrades beyond the POI to operate at its full load/source capacity of 30 MW under ERIS. This is with the assumption charging is not performed during winter peak conditions. During winter season, charging is assumed to occur several hours after the day's peak, during the day's minimal load conditions.

Power flow analysis was performed for generation dispatches under system light load, summer peak load, and winter peak load conditions. Dispatch was also selected to represent import and export scenarios for flows associated with the existing Maritime Link transmission service reservation.

The base cases used in this study are shown in Table 3: Base case dispatch. Transmission connected wind generation facilities were typically dispatched at approximately 40%, with some low and high wind scenarios included.

Three scenarios for each case was examined for the Light Load (LL), Summer Peak (SP), and Winter Peak (WP) cases:

- IR578 off.
- IR578 charging at 30 MW.
- IR578 discharging at 30 MW.

Both Light Load and Summer Peak cases tested charging at the same system load levels as discharging. Winter Peak cases had charging performed at off-peak load dispatch, following daytime peak in that period. For example, if winter peak occurred at 18:00, the charging base case would reflect system load at off-peak conditions several hours later.

**Table 3: Base case dispatch**

| Case name | NS load | Wind | NS/NB | ML | CBX | ONI | ONS | M @ H | H fr |
|---|---|---|---|---|---|---|---|---|---|
| LL01 | 767 | 196 | 500 | -475 | 537 | 642 | 107 | 240 | 323 |
| LL02 | 767 | 29 | 0 | -330 | 350 | 365 | 310 | 156 | 255 |
| LL03 | 767 | 196 | -200 | 100 | 3 | 64 | 232 | -7 | 82 |
| SP01 | 1,469 | 196 | 500 | -475 | 1,039 | 1,223 | 626 | 555 | 498 |
| SP02 | 1,469 | 469 | 500 | -475 | 818 | 1,097 | 546 | 436 | 352 |
| SP03 | 1,469 | 196 | 500 | 0 | 731 | 933 | 336 | 427 | 298 |
| SP04 | 1,469 | 196 | 0 | -475 | 662 | 712 | 622 | 358 | 263 |
| SP05 | 1,469 | 196 | -300 | -475 | 452 | 459 | 667 | 247 | 216 |
| SP06 | 1,469 | 196 | -300 | 100 | 204 | 423 | 631 | 151 | 89 |
| WP01 | 2,192 | 323 | 330 | -330 | 1,024 | 1,222 | 744 | 573 | 476 |
| WP02 | 2,192 | 294 | 150 | -330 | 1,068 | 1,231 | 936 | 606 | 511 |
| WP03 | 2,192 | 196 | 0 | -330 | 976 | 1,111 | 941 | 550 | 454 |
| WP04 | 2,192 | 196 | -100 | -330 | 864 | 1,032 | 938 | 487 | 389 |
| WP05 | 2,192 | 489 | 330 | 0 | 915 | 1,138 | 691 | 532 | 426 |

Note 1: All values are in MW.
Note 2: CBX (Cape Breton Export) and ONI (Onslow Import) are Interconnection Reliability Operating Limit (IROL) defined interfaces.
Note 3: Wind refers to transmission connected wind only.

The POI for IR578 is at a facility that constitutes part of the Onslow Import (ONI) transmission interface. This can also have interactions with the Cape Breton Export (CBX) transmission interface. Both the ONI and CBX have an Interconnection Reliability Operating Limit associated with them.

SP01, WP01, and WP02 cases represent the system with generation dispatched near ONI corridor limits. IR578 is added to displace generation east of Onslow and in Cape Breton. Winter Peak cases WP02, WP03, and WP04 also have higher Onslow South (ONS) flows, which require higher levels of connected dynamic reserve in the Metro area.

Table 4 lists the ratings for the 138 kV transmission lines associated with the study. Overall line ratings are limited to the lesser of the conductor's thermal rating and the associated protection/equipment ratings.

**Table 4: Transmission line ratings**

**NSPI Transmission Line Ratings** Last Updated: 2020-09-01

| LINE | STATION | CONDUCTOR | | | | BREAKER | SWITCH | CURRENT TRANSFORMER | | | | | | TRIP MVA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | RELAYING | | | FULL SCALE METERING | | | |
| | | Type | Maximum Operating Temp. (Celsius) | SUMMER RATING 25 DEG (MVA) | WINTER RATING 5 DEG (MVA) | 100% Name-plate | 100% Name-plate | Ratio | R.F. | MVA | Ratio | R.F. | MVA | |
| L-6503a | 50N Trenton | ACSR 1113 Beaumont | 100 | 320 | 363 | 287 | 287 | 1000 | 2 | 287 | 1000 | 1 | 554 | 589 |
| | 49N/51N Michelin Granton | | | | | | 404 | | | | NA | | | |
| L-6503b | 51N Michelin Granton | ACSR 1113 Beaumont | 85 | 287 | 335 | | 404 | | | | NA | | | |
| | 1N Onslow | | | | | 478 | 287 | 1200 | 2.5 | 717 | 1200 | 1 | 665 | 449 |
| L-6507 | 50N Trenton | AACSR 795 Drake | 75 | 216 | 261 | 287 | 287 | 1200 | 2 | 574 | 1200 | 1 | 346 | 652 |
| | 79N Hopewell | | | | | 478 | 287 | 1200 | 2 | 574 | 1200 | 1 | 346 | 652 |
| L-6508 | 50N Trenton | ACSR 795 Drake | 75 | 216 | 261 | 278 | 278 | 1200 | 2 | 574 | 1200 | 1 | 346 | 652 |
| | 79N Hopewell | | | | | 478 | 287 | 1200 | 2 | 574 | 1200 | 1 | 346 | 652 |
| L-6511 | 93N Glen Dhu | ACSR 556.5 Dove | 60 | 140 | 184 | 478 | 478 | 800 | 2 | 382 | 800 | 2 | 441 | 895 |
| | 50N Trenton | | | | | 287 | 287 | 600 | 2 | 287 | 800 | 1 | 231 | 895 |

# 8.0 Voltage control

NS Power requires ±0.95 net power factor requirement at the HV terminals of the ICIF substation in addition to producing/absorbing reactive power at all production levels up to its full rated output.

IR578's Tesla Powerstages use current-limited, bi-directional inverters, capable of full four-quadrant operation at nominal voltage; however, they are only capable of >0.99 power factor at full output. As a result, supplementary reactive support will be required at the low voltage terminals of the Interconnection Transformer to meet NS Power's requirements. The power capability curve for a single Powerstage is shown in Figure 2: Single Powerstage power capability curve.

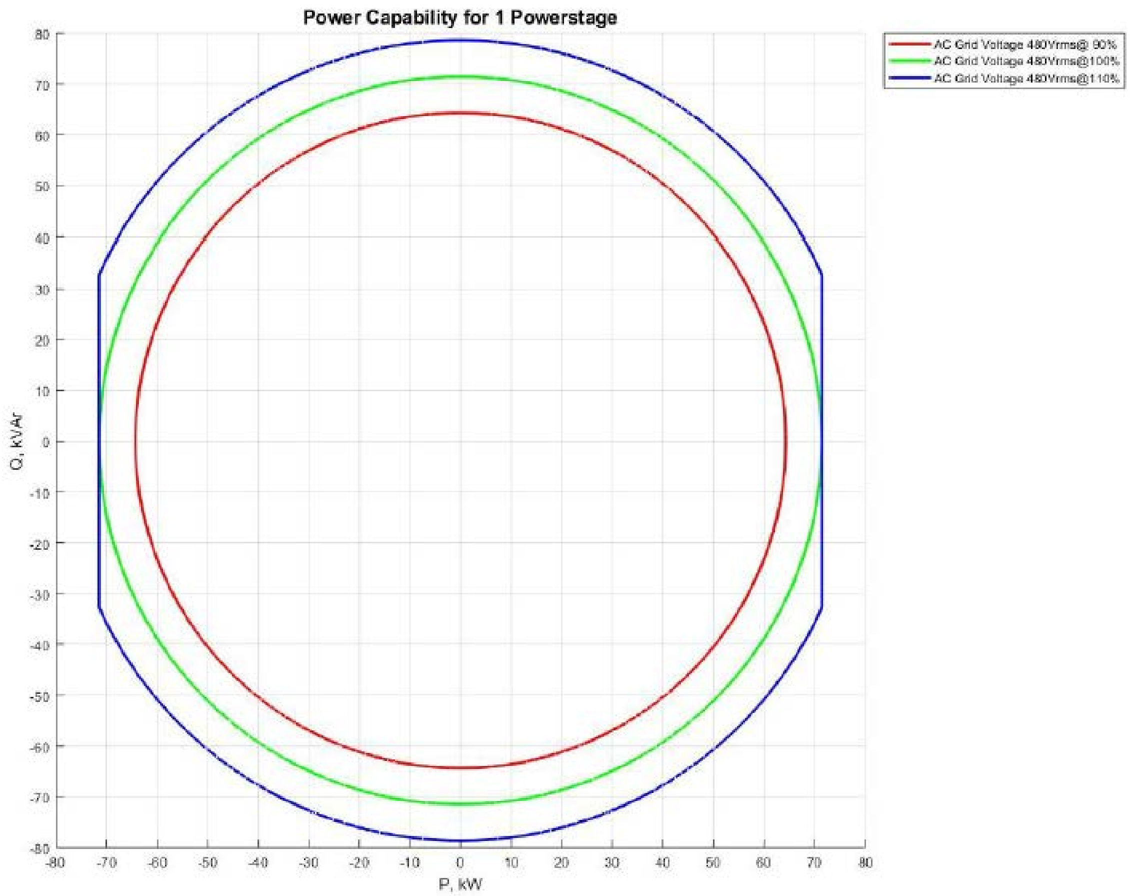


**Figure 2: Single Powerstage power capability curve[3]**

[3] Tesla Megapack Interconnection Data; Supplied by the IC.

Net power factor requirements for supplying VARs are met when the batteries are operating just below 27.5 MW *(11.99 MVAR supplied from the machine with 8.93 MVAR calculated at the high side of the ICIF transformer).* Table 5 lists the power factor calculated at the high side of the ICIF transformer for output levels from 30 MW to 25 MW, in 0.5 MW increments.

**Table 5: Power factor at battery output levels 30 MW - 25 MW**

| Machine terminals | | High side of ICIF transformer (supplying VARs) | | | High side of ICIF transformer (absorbing VARs) | | | Net power factor requirements met? |
|---|---|---|---|---|---|---|---|---|
| MW | MVAR | MW | MVAR | pf | MW | MVAR | pf | |
| 30.00 | 0.00 | 29.82 | -3.35 | 0.994 | 29.82 | -3.35 | 0.994 | no |
| 29.50 | 5.45 | 29.33 | 2.24 | 0.997 | 29.31 | -8.96 | 0.956 | no |
| 29.00 | 7.68 | 28.83 | 4.52 | 0.988 | 28.81 | -11.25 | 0.931 | no |
| 28.50 | 9.37 | 28.33 | 6.25 | 0.977 | 28.30 | -13.00 | 0.909 | no |
| 28.00 | 10.77 | 27.83 | 7.68 | 0.964 | 27.80 | -14.44 | 0.887 | no |
| 27.50 | 11.99 | 27.33 | 8.93 | 0.951 | 27.30 | -15.70 | 0.867 | no |
| 27.00 | 13.08 | 26.84 | 10.04 | 0.937 | 26.80 | -16.83 | 0.847 | yes |
| 26.50 | 14.06 | 26.34 | 11.04 | 0.922 | 26.29 | -17.84 | 0.827 | yes |
| 26.00 | 14.97 | 25.84 | 11.64 | 0.912 | 25.79 | -18.79 | 0.808 | yes |
| 25.50 | 15.80 | 25.34 | 11.68 | 0.908 | 25.29 | -19.65 | 0.790 | yes |
| 25.00 | 16.58 | 24.85 | 11.72 | 0.904 | 24.79 | -20.45 | 0.771 | yes |

Supplementary reactive power support will be further investigated in the System Impact Study.

A centralized controller will be required, which continuously adjusts the individual battery reactive power output within the plant capability limits and regulates the voltage at the low voltage terminal of the ICIF transformer. The voltage controls must be responsive to voltage deviations, be equipped with a voltage setpoint control, and have facilities that will slowly adjust the setpoint over several (5-10) minutes to maintain reactive power within the individual batteries' capabilities. Details of the specific control features, control strategy, and settings will be reviewed and addressed in the SIS.

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

This facility must have voltage ride-through capability as detailed in Figure 2 of NERC Standard PRC-024-2 Attachment 2. The SIS will examine the battery/plant capabilities and controls in detail to specify options, controls, and additional facilities that are required to achieve low voltage ridethrough.

## 9.0 System security

Transmission System Elements may be required to meet NPCC[4] Bulk Power System (BPS) and NERC[5] Bulk Electric System (BES) requirements.

NPCC BPS criteria is performance based, and currently the 138 kV bus at 50N-Trenton is not designated NPCC BPS. The SIS will complete NPCC BPS determination for IR578 and determine if the BPS status of any existing NSPI substations is impacted.

NERC BES criteria uses a bright line approach Expected facilities required for interconnection. IR578 does not meet any of the five BES inclusion criteria and will not be designated NERC BES.

Table 6 summarizes the BPS/BES status of neighbouring system elements.

**Table 6: BPS & BES classification of neighbouring elements**

| Neighbouring element classification | NPCC BPS | NERC BES |
|---|---|---|
| L6503 | yes | yes |
| L6507 | yes | yes |
| L6508 | yes | yes |
| L6511 | no | no |
| 50N-G5 (Trenton 5) & 50N-GT5 | no | yes |
| 50N-G6 (Trenton 6) & 50N-GT6 | no | yes |

## 10.0 Expected facilities required for interconnection

The following facilities are required to interconnect IR578 to the NSPI system via the 138 kV bus at 50N-Trenton as ERIS:

1) **Network Upgrades:**
   a) P&C modifications at 50N-Trenton.
2) **Transmission Provider's Interconnection Facilities (TPIF):**
   a) A 138 kV breaker, associated switches, and substation modifications.
   b) A 138 kV transmission line built to NSPI standards from the 50N-Trenton 138 kV bus to the IR578 substation.

[4] Northeastern Power Coordination Council.
[5] North American Electric Reliability Corporation.

c) Control and communications between the ICIF and the NSPI SCADA and protection system.

**3) Interconnection Customer's Interconnection Facilities (ICIF):**

a) Facilities to provide ±0.95 power factor when delivering rated output (30 MW) at the 138 kV bus when voltage is operating between ±5% of nominal. Rated reactive power shall be available through the full range of real power output, from zero to full power.

b) Centralized controls for voltage setpoint control for the low side of the ICIF transformer. Fast acting control is required and will include a curtailment scheme, which will limit/reduce total load/output from the facility, upon receipt of a telemetered signal from NSPI's SCADA system.

c) NSPI to have supervisory and control of this facility, via the centralized controller. This will permit the NSPI System Operator to raise/lower the voltage setpoint, change the status of reactive power controls, change the real/reactive power remotely. NSPI will also have remote manual control of the load curtailment scheme.

d) When not at full output, the facility shall offer over-frequency and under-frequency control with a deadband of ±0.2 Hz and a droop characteristic of 4%. The active power controls shall also have the capability to react to continuous control signals from the NSPI SCADA system's Automatic Generation Control (AGC) system to control tie-line fluctuations as required.

e) Real-time telemetry will include MW, MVAR, bus voltages, curtailment state, and state of charge.

f) Voltage ridethrough capability as detailed in Figure 2 of NERC Standard PRC-024-2 Attachment 2. As well as operation within NSPI's continuous nominal voltage range *(0.95 to 1.05 VPU)* and during stressed *(contingency)* conditions *(0.90 to 1.10 VPU)*.

g) Frequency ridethrough capability in accordance with NERC Standard PRC-024 and NPCC Standard PRC-006-NPCC-2. The facility shall have the capability of riding through a rate of change of frequency of 4 Hz/s as well as continuous operation in the 59.5 Hz to 60.5 Hz frequency range.

h) Facilities for NSPI to execute high speed rejection of generation and load (transfer trip), if determined in the SIS. The plant may be incorporated in SPS runback or load reject schemes.

i) The facility must use equipment capable of closing a circuit breaker with minimal transient impact on system voltage and frequency *(matching voltage within ±0.05 PU and a phase angle within ±15°)*.

j) Operation at ambient temperatures as low as -30ºC.

## 11.0 NSPI Interconnection Facilities and Network Upgrades cost estimate

The present high level, non-binding, cost estimate, excluding HST, for the IR578's Energy Resource Interconnection Service is shown in Table 7: ERIS cost estimate. This estimate assumes there is adequate space for new equipment and modifications. This does not include any TBD costs addressing any stability issues identified at the SIS stage based on dynamic analysis.

Note that the proposed transmission corridor requires more detailed design work that is not in scope for this FEAS. Below are a few highlighted issues that could significantly impact the estimate for this project:

- The requirement for easements and structure relocations.
- The proposed conductor, 1272 ACSR Bittern, is not a standard NPSI conductor size and may require reinforced structures. 1113 ACSR Beaumont was used for estimation purposes in this project.
- The 50N-Trenton substation is congested and issues with implementation may be discovered. No major issues were found in this preliminary review, however detailed design could potentially find issues resulting in increased scope.

**Table 7: ERIS cost estimate**

| Item | Network Upgrades | Estimate |
|---|---|---|
| I | P&C modifications at 50N-Trenton. | $200,000 |
| | Sub-total | **$200,000** |

| | TPIF | Estimate |
|---|---|---|
| I | Modifications at 50N-Trenton, including a new 138kV breaker, switches and associated equipment. | $1,200,000 |
| II | Transmission line from 50N-Trenton to the PCO. | $470,311 |
| III | P&C relaying equipment. | $100,000 |
| IV | NSPI supplied RTU. | $59,171 |
| V | Teleprotection and SCADA communications via overhead fibre from 50N-Trenton. | $131,688 |
| | Sub-total | **$1,961,170** |

| Determined costs | |
|---|---|
| Subtotal | $2,161,170 |
| Contingency (10%) | $216,117 |
| Total of determined cost items | $2,377,287 |

| Item | To Be Determined costs | Estimate |
|---|---|---|
| I | Preliminary engineering estimation for the transmission line from 50N-Trenton to the PCO. | TBD (SIS) |

The estimated time to construct the Network Upgrades and Transmission Provider's Interconnection Facilities is 18-24 months after receipt of funds.

# 12.0 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 NS Area Interchange bus. This methodology reflects the load centre in and around 91H-Tufts Cove. A negative loss factor reflects a reduction in system losses.

With IR578 in service and discharging, the loss factor is calculated as 9.47% at the POI. This preliminary loss factor excludes losses associated with the TPIF, ICIF transformer, and generation facility.

**Table 8: 2022 loss factor while discharging**

| | Discharging (MW) |
|---|---:|
| IR578 @ POI | 30.00 |
| TC3 w/ IR578 | 72.98 |
| TC3 w/o IR578 | 100.14 |
| Delta | 2.84 |
| 2022 loss factor | 9.47% |

# 13.0 Preliminary scope of subsequent SIS

The SIS will be conducted in accordance with the GIP with the assumption that all appropriate higher-queued projects will proceed, and the facilities associated with those projects are installed. It will provide a more comprehensive assessment, based on NSPI, NPCC, and NERC criteria, of the technical issues and requirements to interconnect the proposed facility as requested.

The assessment will consider, but not be limited, to the following:

- Contingency analysis for both steady state and system stability.
- Ride-through and operation following a contingency (n-1 operation).
- The minimum transmission additions/upgrades that are necessary to permit operation of this generating facility, under all dispatch conditions, catering to, at a minimum, the first contingencies listed below.
- Options and ancillary equipment that the customer must install to control flicker, voltage and ensure that the required ride-through capability.
- Identify guidelines and restrictions applicable following a first contingency (curtailments, etc.).
- Loss Factor.
- Determination of BPS designation.
- Changes to SPS schemes required for operation of this generating facility
- Under-frequency load shedding.
- Facilities that the customer must install to meet the requirements of the GIP.

Parameters for a generic model must be supplied for transient analysis in PSS/e.

The SIS will determine the facilities required to operate this facility at full capacity, withstand the contingencies as defined by NPCC/NERC and identify any restrictions that must be placed on the system following a first contingency loss. The SIS will be conducted with the assumption that all projects higher queued will proceed and the facilities associated with those projects are installed.

Any changes to SPS schemes required for operation of this generating facility, in addition to existing generation and facilities that can proceed before this project, will be determined by the SIS as well as any required additional transmission facilities. The determination will be based on NERC[6] and NPCC[7] 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.

Nova Scotia Power
Transmission System Operations
2021/03/26

[6] NPCC Directory #1: *Design and Operation of the Bulk Power System*

[7] NERC Reliability Standard TPL-001-4: *Transmission Operations*