System Impact Study Report

Report GIP-IR662-SIS-R3

Generator Interconnection Request #662

50 MW Battery Energy Storage System Facility

Halifax County, NS

June 29, 2023

Control Centre Operations
Nova Scotia Power Inc.

Executive summary

The System Impact Study *(SIS)* for IR662 will be conducted in Part 1 and Part 2. Part 1, using Power System Simulator software, will determine the impacts of IR662 on the NSPI power system with respect to steady state, stability, short circuit, power factor, voltage flicker, bulk power system status, under-frequency operation, low voltage ride through and loss factor. Part 2 is in progress and will be issued separately from this document. It will use Electro Magnetic Transient software to determine IR662's impacts and control interactions when integrated with NSPI power system.

Part 1 system impacts will be assessed based on NSPI system design criteria, Generator Interconnection Procedure *(GIP)*, Transmission System Interconnection Requirements *(TSIR)*, applicable Northeast Power Coordinating Council *(NPCC)* planning criteria for Bulk Power System *(BPS)*, and applicable North American Electric Reliability Corporation *(NERC)* planning criteria for Bulk Electricity System *(BES)*.

This report presents the results of Part 1 of the System Impact Study *(SIS)* for IR 662 - a proposed 50 MW Battery Energy Storage System *(BESS)* facility interconnected to the NSPI system as Network Resource Interconnection Service *(NRIS)*. The Point of Interconnection *(POI)* is identified as the 138kV bus at 132H-Spider Lake substation. The proposed Commercial Operation Date is 2024/12/15.

IR662 consists of twenty SMA Sunny Central Storage 3800 battery storage inverters with 660V terminal voltage, each rated at 3.8 MW totaling 76.0 MW but capped at 50.0 MW. The voltage is stepped up to 34.5kV through ten pad-mounted transformers. The system is interconnected to the POI through one 34.5kV/138kV station transformer and a 150m 138kV transmission line.

The short circuit analysis shows that the maximum short circuit levels are far below 5,000 MVA for 138 kV with IR662 added into the power system at POI. IR662 short circuit contribution does not require any uprating of existing breakers in the transmission system. The minimum short circuit level at IR662 34.5 kV bus, with L-6055 out of service, is 431 MVA, which equates to a SCR of 8.6.

The IC has confirmed that the inverters battery system units can provide ±50.0 MVAr reactive power when delivering capped power at ±50.0 MW and have full ±50.0 MVAr reactive power capability at 0 MW real power. Therefore, IR662 meets the leading and lagging power factor requirement based on the preliminary information supplied. This should be re-evaluated once the detailed design information on transformer impedances and collector circuit design are finalized.

IR662 does not require any major Network Upgrades at 132H-Spider Lake and beyond to operate at request MW capability under NRIS. No issues were identified in the steady state or stability analysis that are attributed to IR662.

The facilities associated with IR662 are not designated as NPCC BPS as IR662 does not affect the BPS status of existing facilities. IR662 also does not qualify as NERC BES based on project size and interconnection voltage.

IR662 Under Frequency Ride Through capability was tested under dynamic simulation. The facility remained connected when system frequency deviation caused Under Frequency Load Shedding *(UFLS)* relays to activate. While charging, IR662 also assisted in frequency recovery by momentarily switching to discharging while system frequency was below nominal.

IR662 low voltage ride through *(LVRT)* capability was tested to cover expected system operating conditions in winter peak, summer peak and light load. The simulations showed that IR662 remained on-line with temporarily reduced power and ramped back to rated power during contingency and remained stable post contingency.

The loss factor calculation is based on a winter peak case with and without IR662 in service. The calculated loss factor is 0.1% at IR662's generator terminal *(660V)* and -0.7% at its 138kV ICIF bus. This means system losses on peak are slightly reduced when IR662 is discharging at 50 MW.

Due to the higher-queued project IR672's withdrawal from the Queue, a re-study on IR662 was performed for the steady state analysis, stability analysis, and NPCC-BPS testing with IR672 removed from the study. No other issues were identified in the steady state or stability analysis that are attributed to IR662. IR662 does not affect the BPS status of existing facilities.

It is concluded that the incorporation of the proposed facility into the NS Power transmission at the specified location has no negative impacts on the reliability of the NS Power grid, provided the recommendations provided in this report are implemented.

The following facility changes will be required to connect IR662 as NRIS to NSPI transmission system at the 132H POI-Spider Lake:

- Transmission Provider's Interconnection Facilities *(TPIF)*:
  - A 138 kV breaker, associated switches, and substation modifications at 132H-Spider Lake. This includes the 150m transmission line from the 132H POI to the IR662 PCO.
  - Protection modifications at 132H-Spider Lake.
  - Modifications to existing 132H-Spider Lake RTU.

- IC Interconnection Facility *(ICIF)*:
  - The facility must meet NSPI's TSIR as published on the NSPI OASIS site. The following requirements are items of note from the TSIR.

- Facilities to meet ±0.95 power factor requirement when delivering rated output *(50 MW)* at the 138 kV bus. Rated reactive power shall be available through the full range of real power output, from zero to full power.
- The ability to interface with the NS Power SCADA and communications systems to provide control, communication, metering, and other items to be specified in the forthcoming Interconnection Facilities Study.
- NSPI to have supervisory and control of this facility, via the centralized controller such as a plant control unit. This will permit the NSPI System Operator to raise/lower the voltage setpoint, change the status of reactive power controls, and change the real/reactive power remotely. NSPI will also have remote manual control of the load curtailment scheme.
- The centralized voltage controller to control the 34.5 kV bus voltage to a settable point and will control the reactive output of each inverter unit of IR662 to achieve this common objective. Responsive *(fast-acting)* controls are required. The setpoint for this controller will be delivered via the NS Power SCADA system. The voltage controller must be tuned for robust control across a broad range of SCR.
- Voltage flicker and harmonics characteristics as described in Section 3.3: Voltage flicker.
- Frequency ride through capability to meet the requirements in Section 2.3.8: Underfrequency operation.
- The ability to control active power in response to control signals from the NS Power System Operator and frequency deviations. This includes automatic curtailment to pre-set limits *(0%, 33%, 66% and no curtailment)*, over/under frequency control, and Automatic Generation Control *(AGC)* system to control tie-line fluctuations as required.
- 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%.
- Voltage ride through capability to meet the requirements in Section 2.3.9: Voltage ride-through.
- Real-time monitoring of the interconnection facilities including MW, MVAR, bus voltages, curtailment state, and state of charge.
- Operation at ambient temperatures as low as -30ºC.
- 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 ±15º)*.
- Facilities for NSPI to execute high speed rejection of generation and load *(transfer trip)*. The plant may be incorporated in SPS runback or load reject schemes.
- The facility must meet NSPI's TSIR as published on the NSPI OASIS site.

The total high level non-binding estimated cost in 2023 Canadian dollars for the new Transmission Provider's Interconnection Facilities *(TPIF)* is $1,870,000, which includes 10% contingency but excludes HST. The costs of all associated facilities required at the IC's substation and Generating Facility are in addition to this estimate. This cost excludes any additional costs or changes to be identified by the subsequent SIS Part 2 report and Facility Study as well as any cost associated with ICIF generating facility.

The IC will be responsible for acquiring the ROW *(Right-Of-Way)* for all the facilities. The right of way shall be registered in NSPI's name.

The non-binding construction tine estimate of NSPI Transmission Provider Interconnection Facilities is two years, but to be confirmed by the Facility Study.

Table of Contents

List of appendices

List of tables & figures

1.0 Introduction

The Interconnection Customer *(IC)* submitted an Interconnection Request *(IR)* to Nova Scotia Power Inc. *(NSPI)* for the connection of a 50 MW Battery Energy Storage System *(BESS)* facility interconnected to the NSPI system as Network Resource Interconnection Service *(NRIS)*. The proposed Commercial Operation Date is 2024/12/15.

The IC signed a System Impact Study *(SIS)* Agreement for this 50 MW Battery Energy Storage System *(BESS)* facility, and this report is the result of that Agreement. This project is listed as Interconnection Request #662 in the NSPI Interconnection Request Queue and will be referred to as IR662 throughout this report.

1.1 Scope

The Interconnection Customer *(IC)* identified a 138 kV bus at 132H-Spider Lake substation as the Point of Interconnection *(POI)*. This BESS facility will be interconnected to the POI via a 150 m long 138 kV transmission line from the Point of Change of Ownership *(PCO)*.

Figure 1: Proposed interconnection shows the approximate geographic location of the proposed IR662 site. *Figure 2: Proposed interconnection in one-line diagram* illustrates the electrical locations of IR662.

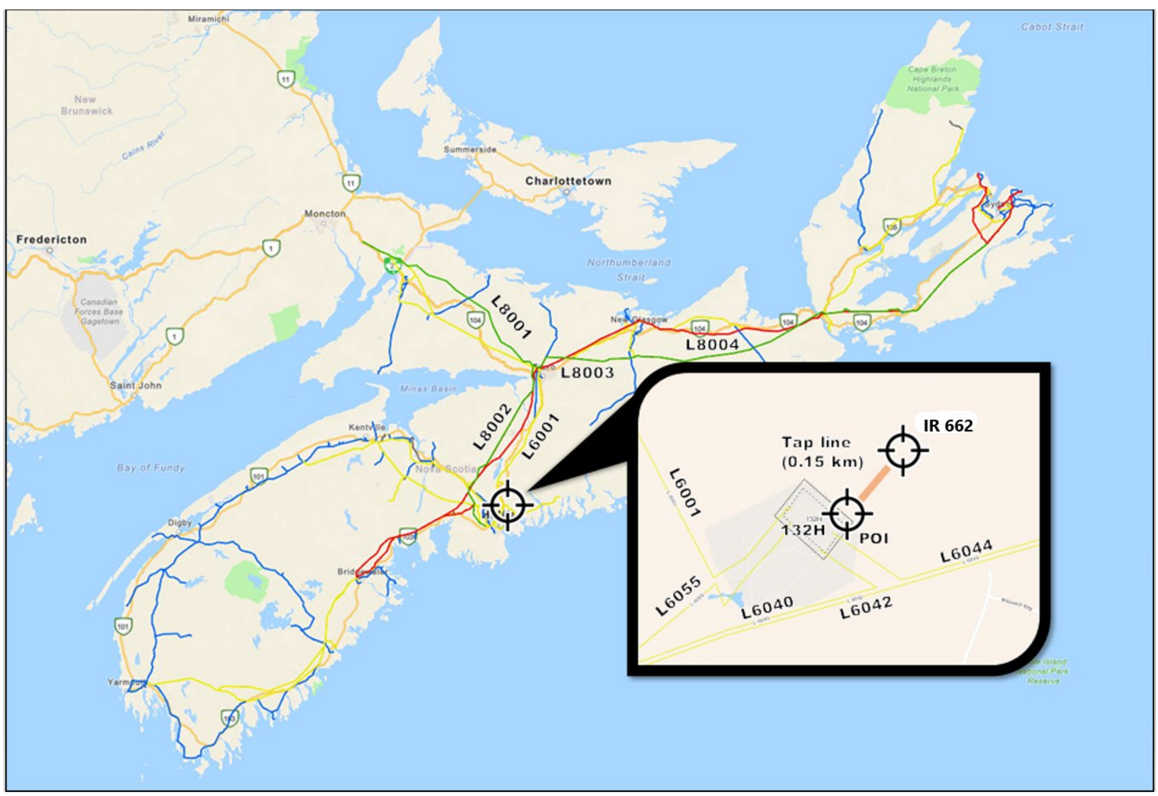


Figure 1: Proposed interconnection

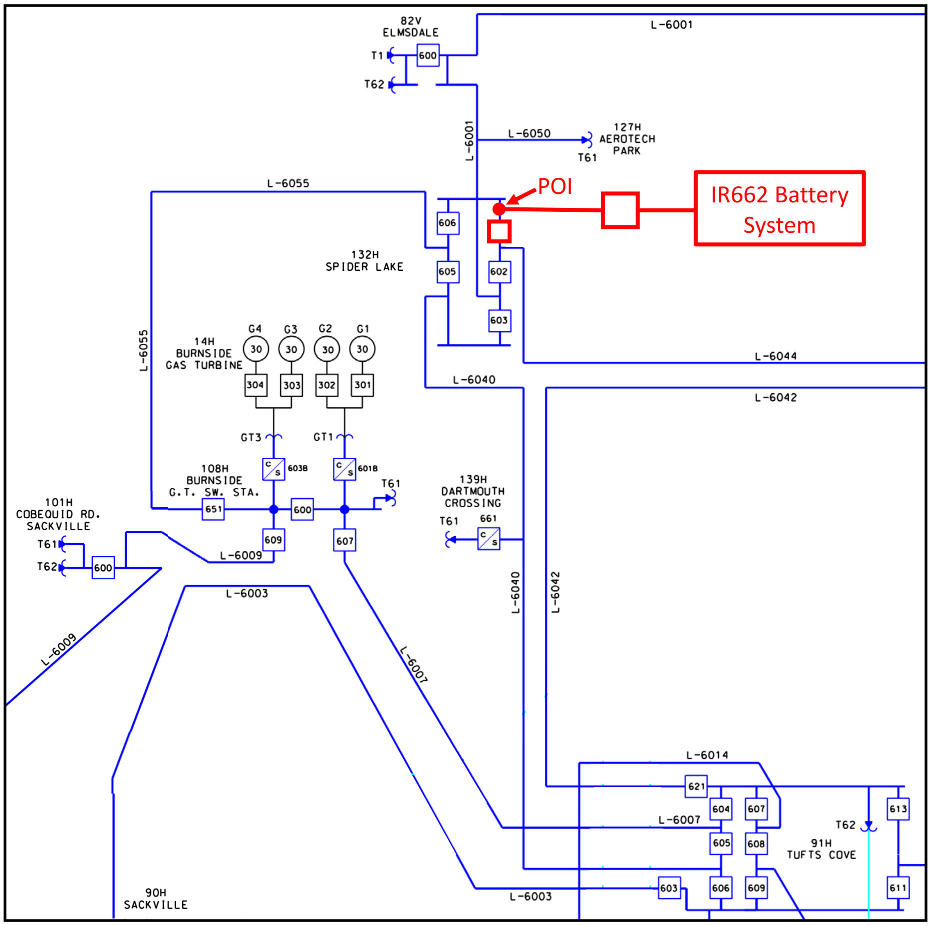


Figure 2: Proposed interconnection in one-line diagram

This report presents the results of the SIS with the objective of assessing the impact of the proposed generation facility on the NS Power Transmission System.

The scope of the SIS is limited to determining the impact of the IR662 generating facility on the NS Power transmission for the following:

- Short circuit analysis and its impact on circuit breaker ratings.
- Power factor requirement at the high side of the ICIF transformer.
- Voltage flicker.
- Steady state analysis to determine any thermal overload of transmission elements or voltage criteria violation.
- Stability analysis to demonstrate that the interconnected power system is stable for various single-fault contingencies.
- NPCC Bulk Power System *(BPS)* and NERC Bulk Electric System *(BES)* determination for the substation.
- Underfrequency operation.
- Low voltage ride through.
- Incremental system Loss Factor.
- Impact on any existing Special Protection Systems *(SPSs)*.

This report provides a high-level non-binding cost estimate of requirements for the connection of the generation facility to ensure there will be no adverse effect on the reliability of the NS Power Transmission System.

1.2 Assumptions

The study is based on technical information provided by the IC. The POI and configuration are studied with the following assumptions:

1. Network Resource Interconnection Service type with an in-service date of 2024-12-15.
2. The Interconnection Facility consists of 20 x 3.8MVA SMA SCS 3800 inverters, capped at 50 MW total:
   - 2.1. The inverter units are grouped in blocks of 7.6MVA with two SMA SCS 3800 units per block. Each block is connected to the collector circuits through one pad-mounted transformer.
   - 2.2. The total 20 battery inverter units and the 10 generator transformers were modeled as an equivalent lumped parameter generator connected to an equivalent transformer.
   - 2.3. This equivalent model was developed using the data provided by the Interconnection Customer. The manufacturer's dynamics data is included in *Appendix A: Generating facility dynamic* data of this report.
3. The SMA SCS 3800 inverters battery system units are the 660 VAC, 3800 kVA nameplate variant. A 1.0 PU fault current is used for short circuit analysis.
4. The 10 generator transformers *(660 V/34.5 kV)* were modeled as a single unit with an impedance of 7.5% on 75 MVA base with an assumed X/R ratio of 8.
5. The feeder circuit impedance was assumed to be negligible, due to the short distance from the power transformer.
6. The interconnection facility transformer was modeled as 138 kV *(wye)* to 34.5 kV *(wye)*, 60 MVA, with an impedance of 7.5% *(on 60 MVA Base)* and an X/R ratio of 40.
7. The IC identified the 138 kV bus B61 at the 132H-Spider Lake substation as the POI. This study will use 556 ACSR Dove conductor rated at 60ºC for the 150m transmission line between 132H and the IC substation.
8. NSPI's transmission line ratings as posted on NSPI's Intranet, including any projected line upgrades for the periods under study.
9. It is assumed that IR662 generation meets IEEE Standard 519 limiting total harmonic distortion *(all frequencies)* to a maximum of 2.5% with no individual harmonic exceeding 1.5% for 138 kV.
10. Generation in a higher queue position, as listed in Section 1.3, is modeled in the base cases.
11. The Maritime Link can be used as an SPS target.

1.3 Project queue position

All in-service generation facilities are included in the SIS.

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 and 33.

As of 2023/02/10, the following projects are higher queued in the Advanced Stage Interconnection Request Queue:

- IR426: GIA executed, 2018/09/01 in-service date.
- IR516: GIA executed, 2020/05/31 in-service date.
- IR540: GIA executed, 2023/10/31 in-service date.
- IR542: GIA executed, 2025/06/30 in-service date.
- IR557: SIS Complete, 2018/09/01 in-service date.
- IR517: GIA in progress, 2019/10/01 in-service date.
- IR569: GIA executed, 2022/02/24 in-service date.
- IR566: GIA executed, 2022/04/30 in-service date.
- IR574: GIA executed, 2025/09/30 in-service date.
- IR598: GIA executed, 2024/06/30 in-service date.
- IR604: GIA executed, 2023/03/30 in-service date.
- IR597: FAC in progress, 2023/08/31 in-service date.
- IR647: GIA in progress, 2023/12/31 in-service date.
- IR653: GIA executed, 2022/10/30 in-service date.
- IR654: GIA executed, 2022/09/20 in-service date.
- IR656: GIA in progress, 2022/12/31 in-service date.
- * IR672: SIS in progress, 2024/12/02 in-service date.
- IR662: SIS in progress, 2023/12/15 in-service date.

*IR672 was withdrawn 2023/04/19 and portions of this report were restudied accordingly.

If any higher-queued projects included in this SIS are subsequently withdrawn from the Queue, it may be necessary to update this SIS or perform a re-study.

2.0 Technical model

To facilitate the load flow analysis, the proposed 20 x 3.8MVA SMA SCS 3800 inverters battery system units is modelled as a single generator with a terminal voltage of 660 V. The voltage is stepped up to 34.5 kV with a single equivalent generator step-up transformer. This equivalent model is then stepped up to 138 kV via interconnection transformer.

The PSS®E model for load flow is shown in *Figure 3: PSS®E model* below. The equivalent 660 V/34.5 kV generator transformer was modeled to have an impedance of 7.5% on 75 MVA. The interconnection transformer was assumed to have 7.5% impedance on the 60 MVA rating with an X/R ratio of 40. The SIS results must be updated when actual nameplate data for transformers becomes available.

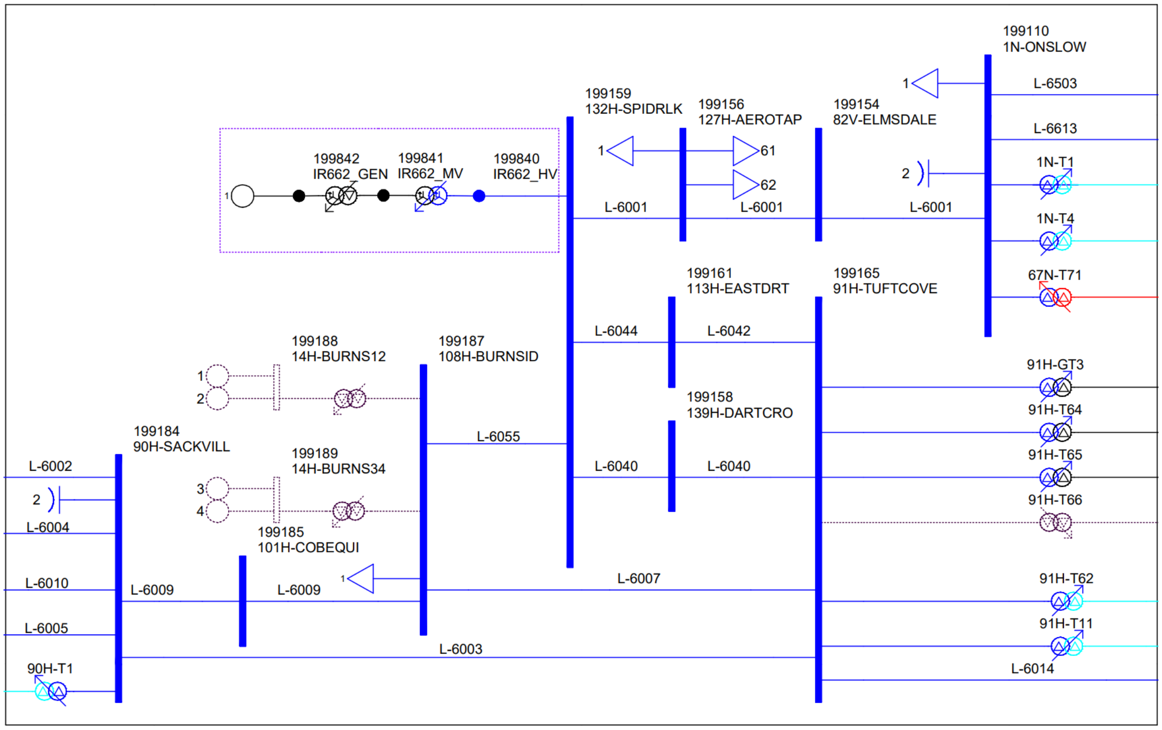


Figure 3: PSS®E model

2.1 System data

The "*2022 Load Forecast Report*", dated April 29, 2022, produced by NSPI, and submitted to Nova Scotia Utility and Review Board *(NSUARB)* was used to allocate the loads in NS. The winter peak load forecast for the near future is shown in *Table 1: Load forecast for study period*, with 2026 used for this study.

As for the summer peak and the light load forecast, their typical values are based on 67% and 35% respectively of the winter peak values.

Please note that the load forecast includes the power system losses but excludes the station service loads at power generating stations.

Table 1: Load forecast for study period

Forecast year	System peak	Interruptible contribution to peak	Firm contribution	Demand response	Growth %
2023	2,185	146	2,035	-4	0.9
2024	2,215	146	2,057	-12	1.4
2025	2,253	152	2,076	-24	1.7
2026	2,291	154	2,101	-36	1.7
2027	2,326	153	2,133	-39	1.5
2028	2,361	153	2,170	-39	1.5
2029	2,398	153	2,207	-39	1.6
2030	2,434	152	2,243	-38	1.5
2031	2,479	152	2,289	-38	1.9
2032	2,532	152	2,342	-37	2.1

2.2 Generating facility

IR662 will be equipped with twenty SMA SCS 3800 inverters battery system units, each rated at 3.8MW totaling 76 MW. However, the plant output will be capped to the 50 MW request.

The proposed BESS facility is assumed to be equipped with a SCADA-based central regulator which controls the individual generator reactive power output to maintain constant voltage at the ICIF substation. It is indicated by the IC that SMA SCS 3800 inverters battery system units are capable of a reactive power range of ±50 MVAr at ±50 MW real power output levels.

2.3 System model & methodology

Testing and analysis were conducted using the following criteria, software, and/or modelling data.

2.3.1 Short circuit

PSS®E 34.8, classical fault study, flat voltage profile at 1 PU voltage, and 3LG fault was used to assess before and after short circuit conditions. The 2026 system configuration with IR662 in service and out of service was studied, with comparison between the two.

2.3.2 Power factor

NSPI's TSIR *(Transmission System Interconnection Requirements, version 1.1, dated February 25, 2021)*, section 7.6.2 Reactive Power and Voltage Control requires *"The Asynchronous Generating Facility shall 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"* and *"Rated reactive power shall be available through the full range of real power output of the Generating Facility, from zero to full power"*. PSS®E was used to simulate high and low system voltage conditions to determine the machine capability in delivery/absorption of reactive power *(VAr)*.

2.3.3 Voltage flicker

Not applicable for battery energy storage system.

2.3.4 Generation facility model

Modelling data provided was provided by the IC for PSS®E steady state and stability analysis in this SIS. The 20 SMA SCS 3800 inverters battery system units and collector circuits were grouped as a single equivalent generator with an equivalent impedance line.

2.3.5 Steady state

Analysis was performed in PSS®E using Python scripts to simulate a wide range of single contingencies, with the output reports summarizing bus voltages and branch flows that exceeded established limits.

System modifications and additions up to 2026 were modelled to develop base cases to best test system reliability in accordance with NS Power, NPCC, and NERC design criteria.

Power flow was run with the contingencies on each of the base cases listed in Section 0 Voltage flicker is not calculated for IR662 as it is not applicable for BESS.

As for harmonics, NSPI requires IR662 to meet Harmonics IEEE-519 standard limiting Total Harmonic Distortion *(all frequencies)* to a maximum of 2.5%, with no individual harmonic exceeding 1.5% for 138 kV. The total harmonic distortion *(THD)* for SMA SCS 3800 inverters battery system is currently not available. If for some reason, in the actual installation, IR662 causes issues with voltage flickers or harmonics, then IR662 will be responsible for mitigating the issues.

Steady state analysis; with IR662 in and out of service to determine the impact of the proposed facility on the reliability of the NS Power grid.

2.3.6 Stability

Analysis was performed using PSS®E for the 2026 study year and system configuration. Light load, Fall, and Winter peak were studied for contingencies that provide the best measure of system reliability. Details on the contingencies studied are provided in Section 3.5 Stability analysis. The system was examined after the addition of IR662 to determine its impact.

Note all plots are performed on 100 MVA system base.

2.3.7 NPCC-BPS/NERC-BES

NS Power is required to meet reliability standards developed by the Northeast Power Coordinating Council *(NPCC)* and the North American Electric Reliability Corporation *(NERC)*. Both NPCC and NERC have more stringent requirements for system elements that can have impacts beyond the local area. These elements are classified as "Bulk Power System" *(BPS)*, for NPCC, and "Bulk Electric System" *(BES)*, for NERC.

2.3.7.1 NPCC BPS

NPCC's Bulk Power System *(BPS)* substations are subject to stringent requirements like redundant and physically separated protective relay and teleprotection systems. Determination of BPS status was in accordance with NPCC criteria document A-10: Classification of Bulk Power System Elements, 2020/03/27. The A-10 test requires steady state and stability testing.

The steady state test involves opening all elements connected to the bus under test in constant MVA power flow.

The stability test involves simulation of a permanent 3PH fault at the bus under test with all local protection out of service *(such as station battery failure)*, including high speed teleportation to the remote terminals. The fault is maintained on the bus for enough time to allow remote protection at surrounding substations to trip the lines to the faulted substation with the corresponding back-up protection times. The post-fault simulation is extended to 20 seconds.

A bus will be classified as part of the BPS if any of the following is observed during the steady state and/or stability tests:

- System instability that cannot be demonstrably contained with in the Area.
- Cascading that cannot be demonstrably contained within the Area.
- Net loss of source/load greater than the Area's threshold.

The NPCC A-10 Criteria document does not require rigorous testing of all buses. Section 3.4, item 2 states:

> *"...*
> *For buses operated at voltage levels between 50 kV and 200 kV, all buses adjacent to a bulk power system bus shall be tested. Testing shall continue into the 50-200 kV system until a non-bulk power system result is obtained, as detailed in Section 3.5. Once a non-bulk power system result is obtained, it is permitted to forgo testing of connected buses unless one of the following considerations shows a need to test these buses:*
> *- Slower remote clearing times.*
> *- Higher short-circuit levels.*
> *..."*

2.3.7.2 NERC BES

NERC uses Bulk Electric System *(BES)* classification criteria based on a "bright-line" approach rather than performance based like the NPCC BPS classification. The NERC

Glossary of Terms as well as the methodology described in the NERC Bulk Electric System Definition Reference was used to determine if IR662 should be designated BES or not.

2.3.8 Underfrequency operation

Underfrequency dynamic simulation is performed to demonstrate that NS Power's automatic Underfrequency Load Shedding *(UFLS)* program sheds enough load to assist stabilizing system frequency, without tripping IR662's generators.

This test is accomplished by triggering a sudden loss of generation by placing a fault on L-8001 under high import conditions.

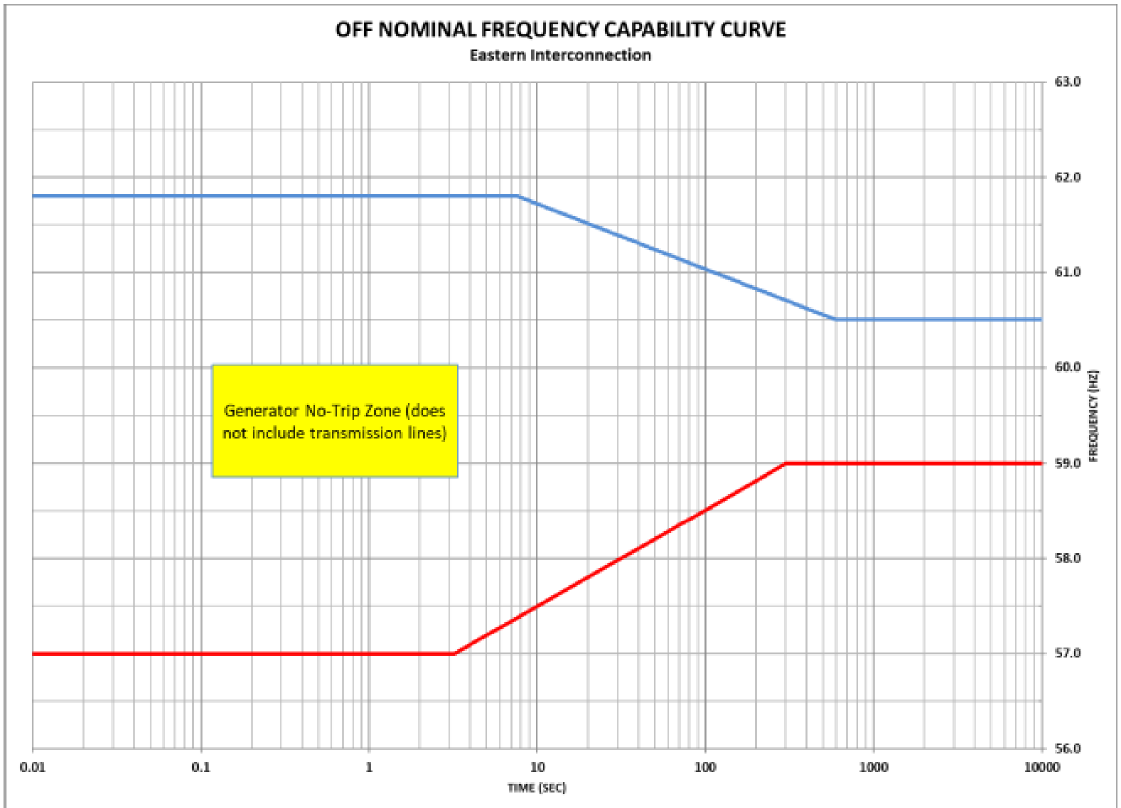
Nova Scotia is connected to the rest of the North American power grid by the following three AC transmission lines:

- L-8001 *(345kV)*
- L-6535 *(138kV)*
- L-6536 *(138kV)*

Under high import conditions, if L-8001, or, either of L-3025 and L-3006 in NB trips, an "Import Power Monitor" SPS will cross-trip L-6613 at 67N-Onslow to avoid thermal overloads on the 138kV transmission lines. This controlled separation will island Nova Scotia from the rest of the North American power grid. System frequency will be stabilized from the resulting generation deficiency through Under-Frequency Load Shedding *(UFLS)* schemes to shed load across Nova Scotia. IR662 is required to remain online and not trip under this scenario.

Other contingencies in New Brunswick and New England can also result in under-frequency islanded situation in Nova Scotia.

In addition to the test, IR662 must be capable of operating reliably for frequency variations in accordance with NERC Standards PRC-024-2 and PRC-006-NPCC-2 as shown in *Figure 4: Off-nominal frequency curve (PRC-024-2 and PRC-006-NPCC-2 combined)*. It shall have the capability of riding through a rate of change of frequency of 4Hz/s.



High Frequency Deviation		Low Frequency Deviation	
Frequency (Hz)	Time (Sec)	Frequency	Time
≥ 61.8	Instantaneous Trip	f ≥ 57.0 Hz	t ≤ 3.3 s
< 61.8 ≥ 60.5	$10^{(90.935 - 1.45713 * f)}$	f ≥ log(t) + 56.5 Hz	3.3s < t ≤ 300 s
< 60.5	Continuous Operation	f ≥ 59.0Hz	t > 300 s

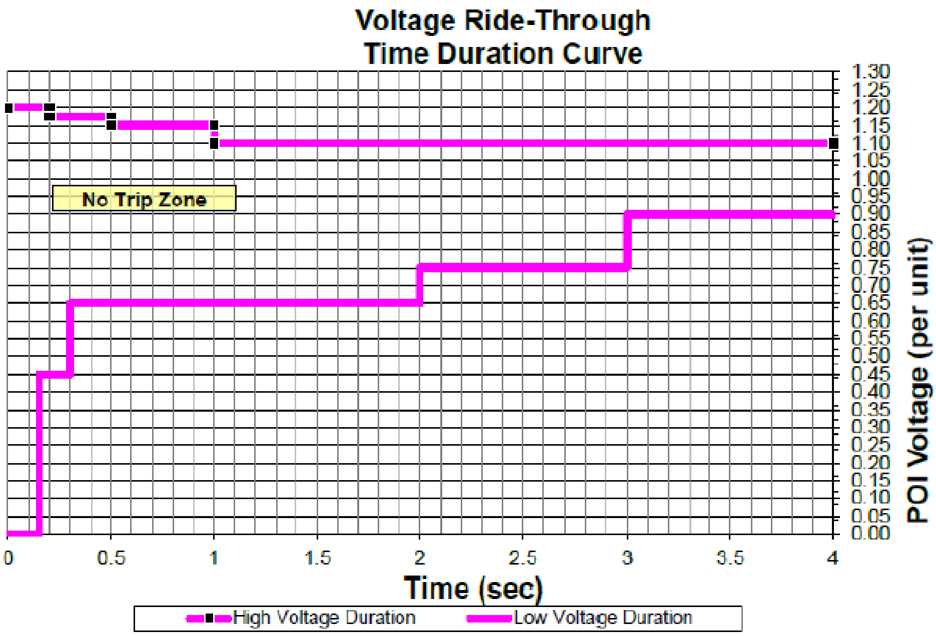
Figure 4: Off-nominal frequency curve *(PRC-024-2 and PRC-006-NPCC-2 combined)*

2.3.9 Voltage ride-through

IR662 must remain operational under the following voltage conditions:

- Under normal operating conditions: 0.95 PU to 1.05 PU
- Under stressed *(contingency)* conditions: 0.90 PU to 1.10 PU
- Under the voltage ride-through requirements in NERC Standard PRC-024-2, see *Figure 5: PRC-024-2 Attachment 2: Voltage ride-through requirements*.

VOLTAGE RIDE-THROUGH REQUIREMENTS



Low Voltage Ride-Through Data Points	
Bus Voltage at Point of Interconnection (pu)	**Duration (sec)**
< 0.45	0.15
< 0.65	0.30
< 0.75	2.00
< 0.90	3.00
High Voltage Ride-Through Data Points	
Bus Voltage at Point of Interconnection (pu)	**Duration (sec)**
≥1.200	Instantaneous trip permitted
≥1.175	0.2
≥1.150	0.5
≥ 1.100	1.00

Figure 5: PRC-024-2 Attachment 2: Voltage ride-through requirements

This test is performed by applying a 3-phase fault to the HV and MV buses of the ICIF for 9 cycles. IR662 should not trip for faults on the Transmission System or its collector circuits.

2.3.10 Loss factor

Loss factor was calculated by running the power flow using a standardized winter peak base case with and without IR662, while keeping 91H-Tufts Cove generation as the NS area interchange bus. The loss factor for IR662 is the differential MW displaced or increased at 91H-Tufts Cove generation calculated as a percentage of IR662's rated MW rating.

This methodology reflects the load centre in and around 91H-Tufts Cove and has been accepted and used in the calculation of system losses for the Open Access Transmission Tariff *(OATT)*. It is calculated on the hour of system peak as a means for comparing multiple projects but not used for any other purpose.

Because of the uncertainty the collector circuit design and transformer equipment specification, loss factors are provided at the generator terminal bus and the high side of the ICIF transformer.

3.0 Technical analysis

The results of the technical analysis are reported in the following sections.

3.1 Short circuit

Short circuit analysis was performed using PSS®E 34.8, classical fault study, flat voltage profile at 1 PU voltage, and 3LG faults. The short circuit levels in the area before and after this development are provided in *Table 2: Short circuit levels, three phase, MVA*.

The machine was modelled as instructed in the IC-supplied model user guide[1] with site-specific data provided by the IC. The transient and sub-transient reactance of 1.0 was used in the short circuit calculation for IR662 generator.

IR662 will not impact 132H-Spider Lake and neighbouring breaker's interrupting capability based on this study's short circuit analysis. The interrupting capability of the 138 kV circuit breakers at 91H-Tuft’s Cove and 108H-Burnside is at least 5,000 MVA. The NS Power design criteria for maximum system fault capability *(3-phase, symmetrical)* at the 138 kV voltage levels is 5,000 MVA.

[1] *SMA_SunnyCentral_ShortCircuitData.pdf*

Table 2: Short circuit levels, three phase, MVA

Table 2: Short-Circuit Levels, Three-phase MVA			
Location	**IR662 OFF**	**IR662 ON**	**Post % Increase**
Maximum generation, all transmission facilities in service			
132H-Spider Lake, 138kV *(POI)*	3026	3090	2.1%
91H-Tuft's Cove, 138 kV	3805	3860	1.4%
91H-Tuft's Cove, 69 kV	2207	2217	0.5%
108H-Burnside, 138 kV	3457	3508	1.5%
IR662 34.5kV	631	702	11.2%
Low Generation, all transmission facilities in service			
132H-Spider Lake, 138kV *(POI)*	1010	1074	6.4%
91H-Tuft's Cove, 138 kV	1058	1118	5.7%
91H-Tuft's Cove, 69 kV	756	785	3.8%
108H-Burnside, 138 kV	1044	1103	5.7%
IR662 34.5kV	446	516	15.8%
Minimum Conditions – low Generation, L-6055 out of service			
132H-Spider Lake, 138kV *(POI)*	939	1003	6.9%
IR662 34.5kV	431	502	16.4%

When L-6055 is out of service, the SCR[2] is calculated as 8.6 *(431 MVA / 50 MW)* at IR662's 34.5kV bus. Note that the minimum short circuit level on the 34.5kV bus can be greatly impacted by the impedance of the ICIF transformer and collector circuit impedance.

3.2 Power factor

IR662 must be capable of providing between 0.95 lagging to 0.95 leading net power factor at the high side of the ICIF transformer, at all production levels up to the full rate load.

The technical data provided by the IC specified a 138/34.5 kV transformer, with off-load tap changer, and ±5% taps; each tap step is assumed to be a value of 2.5% since the number of steps were not specified. The 34.5/0.66 kV generator step-up transformers were assumed to be supplied with ±5% taps.

The SMA SCS 3800 inverters battery system units PQ curves within normal voltage operation are shown in *Figure 6: Reactive power capability of the SCS 3800 UP at 25 °C under normal voltage operation* and *Figure 7: Reactive power capability of the SCS 3800 UP at 40 °C under normal voltage operation*. However, despite the reactive range indicated in Figure 6 and Figure 7, the IC has confirmed that the inverters battery system units can provide ±50.0 MVAr reactive power when delivering capped power at ±50.0 MW and have full ±50.0 MVAr reactive power capability at 0 MW real power.

[2] Short Circuit Ratio: a measure of system strength relative to the BESS facility size.

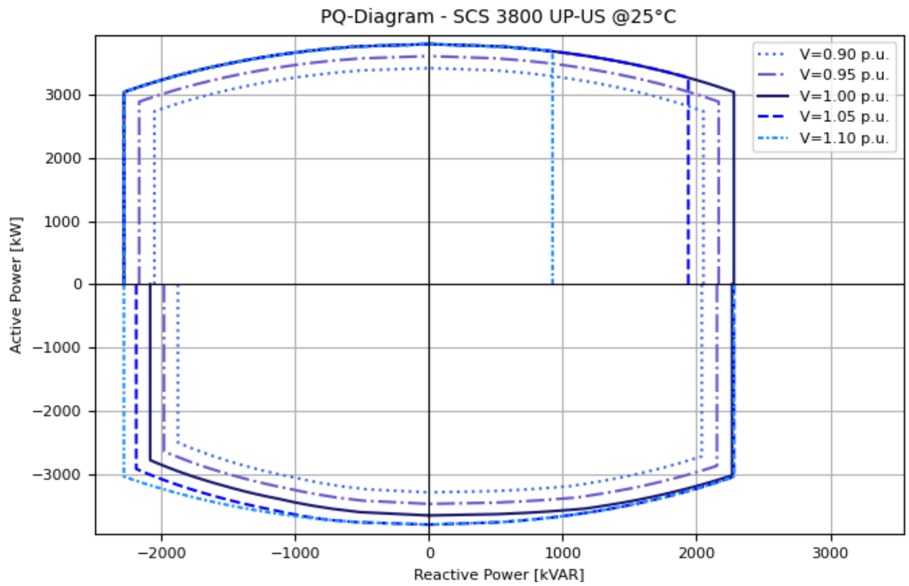


Figure 6: Reactive power capability of the SCS 3800 UP at 25 °C under normal voltage operation[3]

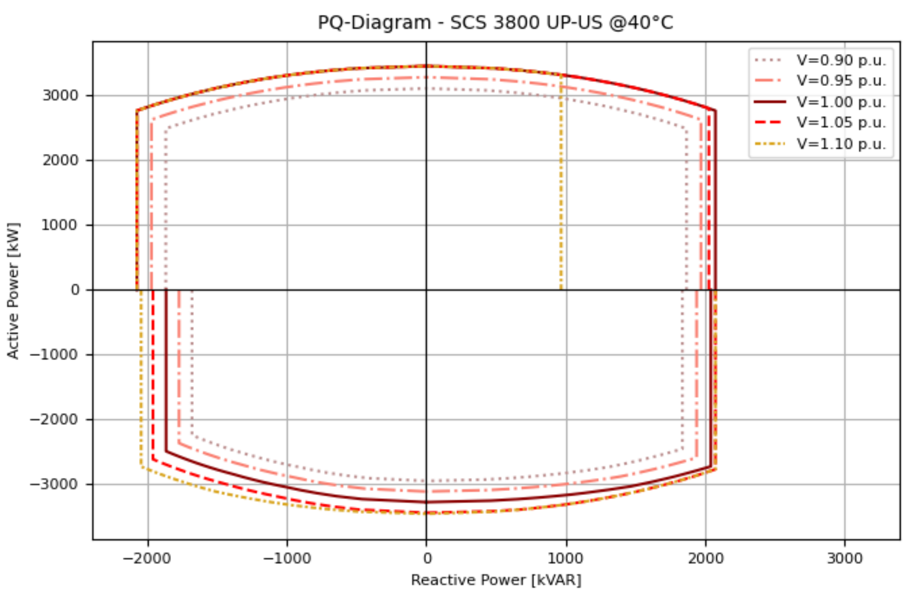


Figure 7: Reactive power capability of the SCS 3800 UP at 40 °C under normal voltage operation[4]

When IR662 generation is at capped 50.0 MW output and producing maximum 50.0 MVAr of reactive power, the real and reactive power delivered to the high side *(138kV)* of the ICIF transformer is 49.30 MW and 40.06 MVAr, respectively. This equates to a +0.776 power factor, meeting the existing +0.950 GIP requirement.

---

[3] *scs3800 25c 0.90vpu.pdf; scs3800 25c 0.95vpu.pdf; SCS3800 25c 1 vpu.pdf; scs3800 25c 1.05vpu.pdf; scs3800 25c 1.10vpu.pd*

[4] *scs3800 40c .90vpu.pdf; scs3800 40c .95vpu.pdf; SCS 3800 40c 1 vpu.pdf; scs3800 40c 1.05vpu.pdf; scs 3800 40c 1.10vpu.pdf*

When IR662 generation is at capped 50.0 MW output, while absorbing maximum 50.0 MVAr of reactive power, the real and reactive power delivered to the high side *(138 kV)* of the ICIF transformer is 49.16 MW and 62.00 MVAr, respectively. This corresponds to a -0.621 power factor, meeting the -0.950 GIP requirement.

The calculated reactive power consumption the IC's components when IR662 is at max MW output while producing or absorbing reactive power is listed in *Table 3: MVAr consumption at rated MW output*. Overall, IR662 meets both lagging and leading power factor requirement of NS Power. This should be re-evaluated once detailed design information on the transformers and collector circuits *(if any)* are available.

Table 3: MVAr consumption at rated MW output

Component	At max MVAr production	At max MVAr absorption
138/34.5 kV ICIF transformer*	5.42	6.54
34.5/0.66 kV generator step-up transformer equivalent *(tap setting 1.025)*	4.52	5.46

* Taps setting at 1.000 for max MVAr production and 0.95 for max MVAr absorption

3.3 Voltage flicker & Harmonics

Voltage flicker is not calculated for IR662 as it is not applicable for BESS.

As for harmonics, NSPI requires IR662 to meet Harmonics IEEE-519 standard limiting Total Harmonic Distortion *(all frequencies)* to a maximum of 2.5%, with no individual harmonic exceeding 1.5% for 138 kV. The total harmonic distortion *(THD)* for SMA SCS 3800 inverters battery system is currently not available. If for some reason, in the actual installation, IR662 causes issues with voltage flickers or harmonics, then IR662 will be responsible for mitigating the issues.

3.4 Steady state analysis

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

IR662 is located to the north of Halifax, connected via 138 kV to the Secondary Transmission System. IR662 is most notably impacted by the Onslow South *(ONS)* corridor which defines the interface flows into the load centre in Halifax via Truro. The ONS corridor includes line L8002, L7001, L7002, L7018, and L6001.

3.4.1 Base cases

The bases cases used for power flow analysis are listed in *Table 4: Power flow base* cases. One-line diagrams of each base case are presented in *Appendix B: Base case one-line diagrams*.

For these cases:

- Transmission connected wind generation facilities were dispatched between 19% and 100% of their rated capability.
- Light Load and Summer Peak cases tested charging at the same system load levels as discharging.
- For Winter Peak cases, charging was performed at off-peak hours of peak load dispatch *(91% of peak, based on measured load 4 hours after historical system peak)*.
- All interface limits were respected for base case scenarios.

Three scenarios were examined for each of the Light Load, Summer Peak, and Winter Peak cases:

- IR662 off.
- IR662 discharging at 50 MW under NRIS designation.
- IR662 charging at 50 MW.

In Light Load and Summer Peak cases, both IR662 charging and discharging are derived from the same IR662 off cases *(i.e.., ll01-1 and sp-02-1)*. In Winter cases, IR662 discharging is derived from Winter Peak cases *(i.e.., wp02-1)* and IR662 charging is based on off-peak hours of peak load dispatch *(i.e.., wp02-3)*.

Table 4: Power flow base cases

Case Name	NS Load	IR 662	Wind	NS/NB	ML	CBX	ONI	ONS
ll01-1	774	-	419	330	-475	385	413	82
ll01-2	768	50	419	330	-475	334	363	32
ll01-4	792	-50	419	330	-475	385	413	82
ll02-1	777	-	559	500	-475	346	403	-82
ll02-2	768	50	559	500	-475	296	353	-132
ll02-4	788	-50	559	500	-475	346	403	-82
ll03-1	783	-	419	330	-330	290	319	-11
ll03-2	783	50	419	330	-330	247	278	-53
ll03-4	783	-50	419	330	-330	290	319	-11
sp01-1	1,417	-	419	330	-475	770	887	498
sp01-2	1,417	50	419	330	-475	717	837	447
sp01-4	1,417	-50	419	330	-475	769	887	497
sp02-1	1,411	-	559	330	-475	768	913	543
sp02-2	1,411	50	559	330	-475	714	862	492
sp02-4	1,417	-50	559	330	-475	768	913	543
sp03-1	1,420	-	389	330	-475	927	1,064	693
sp03-2	1,420	50	389	330	-475	872	1,012	642
sp03-4	1,426	-50	389	330	-475	927	1,064	693
sp04-1	1,361	-	168	-108	-175	654	695	712
sp04-2	1,361	50	168	-108	-175	600	644	660
sp04-4	1,361	-50	168	-108	-175	654	695	711
sp05-1	1,392	-	559	330	-475	317	478	108
sp05-2	1,392	50	559	330	-475	316	429	58
sp05-4	1,408	-50	559	330	-475	445	604	233

Case Name	NS Load	IR 662	Wind	NS/NB	ML	CBX	ONI	ONS
sp06-1	1,420	-	419	330	-475	899	1,009	620
sp06-2	1,420	50	419	330	-475	844	958	568
sp06-4	1,426	-50	419	330	-475	899	1,009	620
sp07-1	1,392	-	419	-300	-300	190	256	498
sp07-2	1,392	50	419	-300	-300	181	237	479
sp07-4	1,392	-50	419	-300	-300	190	256	498
sp08-1	1,392	-	559	330	-370	192	335	-36
sp08-2	1,392	50	559	330	-370	192	286	-85
sp08-4	1,401	-50	559	330	-370	319	486	115
wp01-1	2,160	-	559	150	-320	887	1,139	885
wp01-2	2,160	50	559	150	-320	830	1,087	832
wp01-3	1,958	-	559	150	-320	699	974	736
wp01-4	1,958	-50	559	150	-320	699	974	736
wp02-1	2,145	-	559	0	-475	818	1,075	971
wp02-2	2,145	50	559	0	-475	760	1,021	917
wp02-3	1,952	-	559	0	-475	781	1,051	964
wp02-4	1,952	-50	559	0	-475	781	1,050	964
wp03-1	2,142	-	559	-170	-300	548	818	884
wp03-2	2,142	50	559	-170	-300	493	765	831
wp03-3	1,940	-	559	-170	-300	366	652	735
wp03-4	1,940	-50	559	-170	-300	366	652	735
wp04-1	2,160	-	559	186	-320	1,008	1,252	961
wp04-2	2,160	50	559	186	-320	950	1,199	907
wp04-3	1,967	-	559	187	-320	929	1,189	914
wp04-4	1,967	-50	559	186	-320	929	1,189	915
wp05-1	2,169	-	379	320	-475	1,028	1,239	786
wp05-2	2,169	50	379	320	-475	972	1,187	734
wp05-3	1,976	-	379	320	-475	949	1,177	741
wp05-4	1,976	-50	379	320	-475	949	1,177	741
wp06-1	2,151	-	559	150	-320	521	792	538
wp06-2	2,151	50	559	150	-320	468	741	487
wp06-3	1,958	-	559	150	-320	501	784	546
wp06-4	1,958	-50	559	150	-320	501	784	546
wp07-1	2,142	-	559	150	-320	395	670	416
wp07-2	2,142	50	559	150	-320	343	620	366
wp07-3	1,949	-	559	150	-320	386	612	373
wp07-4	1,949	-50	559	150	-320	439	663	425

Note 1: All values are in MW.
Note 2: CBX *(Cape Breton Export)* and ONI *(Onslow Import)* are Interconnection Reliability defined interfaces.
Note 3: Wind refers to transmission connected wind only.
Note 4: Negative MW in the IR662 column indicates charging.
Note 5: Negative MW in NS/NB and ML columns, represent imports to NS.

- wp01-x, wp02-x, wp03-x, wp04-x, wp05-x, wp06-x and wp07-x represents peak load, with high East-West transfers. Generation dispatched is assumed to be typical for peak load, with high load in the Valley area.
- sp07-x represents the NS/NB import limit, presently 27% of net in-province load, to a maximum 300 MW. This case tests the performance of the Underfrequency Load

Shedding (UFLS) system during contingencies that isolates NS from the interconnected power system (like the loss of L8001).

- ll01-x, ll02-x, ll03-x, sp01-x, sp02-x, sp03-x, sp05-x, sp06-x, and sp08-x represent high enough export levels from NS to NB to require arming of the Export Power Monitor SPS. ll01-x, ll03-x, sp01-x, sp02-x, sp03-x, sp05-x, sp06-x, and sp08-x require Group 5 arming, while ll02-x requires Group 6 arming. In either condition, the Maritime Link *(ML)* is targeted to reduce NS generation for conditions resulting from the loss of the 345kV tie line, L8001, and subsequent action to reduce flow on the 138kV line L6613, between 1N-Onslow and 74N-Springhill.

3.4.2 Steady state contingencies

The steady state power flow analysis includes the contingencies listed in *Table 5: Steady state contingencies*.

Table 5: Steady state contingencies

ID	Element	Type	Location	ID	Element	Type	Location
p001	2C-B61*	Bus fault	2C-Hastings	p159	67N-704	Breaker fail	67N-Onslow
p002	2C-B62*	Bus fault	2C-Hastings	p160	67N-705	Breaker fail	67N-Onslow
p003	3C-710*	Breaker fail	3C-Hastings	p161	67N-706	Breaker fail	67N-Onslow
p004	3C-711	Breaker fail	3C-Hastings	p162	67N-710	Breaker fail	67N-Onslow
p005	3C-712	Breaker fail	3C-Hastings	p163	67N-711*	Breaker fail	67N-Onslow
p006	3C-713	Breaker fail	3C-Hastings	p164	67N-712	Breaker fail	67N-Onslow
p007	3C-714	Breaker fail	3C-Hastings	p165	67N-713	Breaker fail	67N-Onslow
p008	3C-715	Breaker fail	3C-Hastings	p166	67N-811*	Breaker fail	67N-Onslow
p009	3C-716	Breaker fail	3C-Hastings	p167	67N-812	Breaker fail	67N-Onslow
p010	3C-720*	Breaker fail	3C-Hastings	p168	67N-813	Breaker fail	67N-Onslow
p011	3C-T71	Transformer fault	3C-Hastings	p169	67N-814*	Breaker fail	67N-Onslow
p012	3C-T72	Transformer fault	3C-Hastings	p170	67N-T71	Transformer fault	67N-Onslow
p013	L6515	Line fault	2C-Hastings	p171	67N-T81	Transformer fault	67N-Onslow
p014	L6516	Line fault	2C-Hastings	p172	67N-T82	Transformer fault	67N-Onslow
p015	L6517	Line fault	2C-Hastings	p173	74N-600	Breaker fail	74N-Springhill
p016	L6518	Line fault	2C-Hastings	p174	79N-B61*	Bus fault	79N-Hopewell
p017	L6523	Line fault	2C-Hastings	p175	79N-B81*	Bus fault	79N-Hopewell
p018	L6537*	Line fault	2C-Hastings	p176	L5029	Line fault	74N-Springhill
p019	L6543	Line fault	2C-Hastings	p177	L5058	Line fault	74N-Springhill
p020	L7003	Line fault	3C-Hastings	p178	L6001	Line fault	1N-Onslow
p021	L7004	Line fault	3C-Hastings	p179	L6057	Line fault	50N-Trenton
p022	L7005*	Line fault	3C-Hastings	p180	L6503	Line fault	50N-Trenton
p023	47C-B1	Bus fault	47C-Port Hawkesbury Paper	p181	L6507	Line fault	79N-Hopewell
p024	47C-B2	Bus fault	47C-Port Hawkesbury Paper	p182	L6508	Line fault	50N-Trenton
p025	47C-B3	Bus fault	47C-Port Hawkesbury Paper	p183	L6511	Line fault	50N-Trenton

ID	Element	Type	Location	ID	Element	Type	Location
p026	47C-B4	Bus fault	47C-Port Hawkesbury Paper	p184	L5502	Line fault	50N-Trenton
p027	47C-B5	Bus fault	47C-Port Hawkesbury Paper	p185	50N-GT6	Generator Trip	50N-Trenton
p028	47C-B6	Bus fault	47C-Port Hawkesbury Paper	p186	50N-GT5	Generator Trip	50N-Trenton
p029	47C-B7	Bus fault	47C-Port Hawkesbury Paper	p187	50N-T12	Transformer fault	50N-Trenton
p030	L-6552	Line fault	4C-Lochaber Rd	p188	50N-T8	Transformer fault	50N-Trenton
p031	4C-T63	Transformer fault	4C-Lochaber Rd	p189	50N-LOAD1	load trip	50N-Trenton
p032	4C-T2	Transformer fault	4C-Lochaber Rd	p190	50N-LOAD2	load trip	50N-Trenton
p033	4C-620	Breaker fail	4C-Lochaber Rd	p191	50N-614	Breaker fail	50N-Trenton
p034	4C-621	Breaker fail	4C-Lochaber Rd	p192	50N-621	Breaker fail	50N-Trenton
p035	4C-622	Breaker fail	4C-Lochaber Rd	p193	50N-606	Breaker fail	50N-Trenton
p036	4C-623	Breaker fail	4C-Lochaber Rd	p194	50N-666	Breaker fail	50N-Trenton
p037	103H-881	Breaker fail	103H-Lakeside	p195	50N-607	Breaker fail	50N-Trenton
p038	103H-600	Breaker fail	103H-Lakeside	p196	50N-622	Breaker fail	50N-Trenton
p039	103H-608	Breaker fail	103H-Lakeside	p197	50N-612	Breaker fail	50N-Trenton
p040	103H-681	Breaker fail	103H-Lakeside	p198	50N-601	Breaker fail	50N-Trenton
p041	103H-B61	Bus fault	103H-Lakeside	p199	50N-604	Breaker fail	50N-Trenton
p042	103H-B62	Bus fault	103H-Lakeside	p200	50N-513	Breaker fail	50N-Trenton
p043	103H-T63	Transformer fault	103H-Lakeside	p201	50N-512	Breaker fail	50N-Trenton
p044	103H-T61	Transformer fault	103H-Lakeside	p202	50N-521	Breaker fail	50N-Trenton
p045	103H-T81	Transformer fault	103H-Lakeside	p203	50N-508	Breaker fail	50N-Trenton
p046	104H-600	Breaker fail	104H-Kempt Rd	p204	50N-522	Breaker fail	50N-Trenton
p047	113H-601	Breaker fail	113H-Dartmouth East	p205	50N-511	Breaker fail	50N-Trenton
p048	101H-600	Breaker fail	101H-Cobequid Road	p206	50N-500	Breaker fail	50N-Trenton
p049	108H-600	Breaker fail	108H-Burnside	p207	2S-513	Breaker fail	2S-Victoria Junction
p050	108H-B1	Bus Fault	108H-Burnside	p208	L6514	Line fault	74N-Springhill
p051	108H-B3	Bus Fault	108H-Burnside	p209	L6527	Line fault	1N-Onslow
p052	120H-621	Breaker fail	120H-Brushy	p210	L6536	Line fault	74N-Springhill
p053	120H-622	Breaker fail	120H-Brushy	p211	L6613	Line fault	74N-Springhill
p054	120H-623	Breaker fail	120H-Brushy	p212	L7001	Line fault	67N-Onslow
p055	120H-624	Breaker fail	120H-Brushy	p213	L7002	Line fault	67N-Onslow
p056	120H-625	Breaker fail	120H-Brushy	p214	L7003	Line fault	67N-Onslow
p057	120H-626	Breaker fail	120H-Brushy	p215	L7005*	Line fault	67N-Onslow
p058	120H-627	Breaker fail	120H-Brushy	p216	L7019	Line fault	67N-Onslow
p059	120H-628	Breaker fail	120H-Brushy	p217	L8001*	Line fault	67N-Onslow
p060	120H-629	Breaker fail	120H-Brushy	p218	L8002	Line fault	67N-Onslow
p061	120H-710	Breaker fail	120H-Brushy	p219	L8003*	Line fault	67N-Onslow
p062	120H-711	Breaker fail	120H-Brushy	p220	L8003*	Line fault	79N-Hopewell
p063	120H-712	Breaker fail	120H-Brushy	p221	L8004*	Line fault	79N-Hopewell

ID	Element	Type	Location	ID	Element	Type	Location
p064	120H-713	Breaker fail	120H-Brushy	p222	101S-701	Breaker fail	101S-Woodbine
p065	120H-714	Breaker fail	120H-Brushy	p223	101S-702	Breaker fail	101S-Woodbine
p066	120H-715	Breaker fail	120H-Brushy	p224	101S-703	Breaker fail	101S-Woodbine
p067	120H-716	Breaker fail	120H-Brushy	p225	101S-704	Breaker fail	101S-Woodbine
p068	120H-720	Breaker fail	120H-Brushy	p226	101S-705	Breaker fail	101S-Woodbine
p069	120H-T71	Transformer fault	120H-Brushy	p227	101S-706	Breaker fail	101S-Woodbine
p070	120H-B61	bus fault	120H-Brushy	p228	101S-711	Breaker fail	101S-Woodbine
p071	120H-T72	Transformer fault	120H-Brushy	p229	101S-712	Breaker fail	101S-Woodbine
p072	120H-SVC	SVC trip	120H-Brushy	p230	101S-713	Breaker fail	101S-Woodbine
p073	132H-602	Breaker fail	132H-Spider Lake	p231	101S-811	Breaker fail	101S-Woodbine
p074	132H-603	Breaker fail	132H-Spider Lake	p232	101S-812*	Breaker fail	101S-Woodbine
p075	132H-605	Breaker fail	132H-Spider Lake	p233	101S-813*	Breaker fail	101S-Woodbine
p076	132H-606	Breaker fail	132H-Spider Lake	p234	101S-814	Breaker fail	101S-Woodbine
p077	1H-603	Breaker fail	1H-Water St	p235	101S-816	Breaker fail	101S-Woodbine
p078	T1	Transformer fault	90H-Sackville	p236	101S-ML-POLE1	Line fault	101S-Woodbine
p079	C51	Cap Bank trip	90H-Sackville	p237	101S-ML-POLE2	Line fault	101S-Woodbine
p080	C61	Cap Bank trip	90H-Sackville	p238	101S-ML-BIPOLE	Line fault	101S-Woodbine
p081	90H-601	Breaker fail	90H-Sackville	p239	101S-T81	Transformer fault	101S-Woodbine
p082	90H-602	Breaker fail	90H-Sackville	p240	101S-T82	Transformer fault	101S-Woodbine
p083	90H-603	Breaker fail	90H-Sackville	p241	101S-L-7011*	Line fault	101S-Woodbine
p084	90H-604	Breaker fail	90H-Sackville	p242	101S-L-7012*	Line fault	101S-Woodbine
p085	90H-605	Breaker fail	90H-Sackville	p243	101S-L-7015	Line fault	101S-Woodbine
p086	90H-606	Breaker fail	90H-Sackville	p244	88S-710	Breaker fail	88S-Lingan
p087	90H-607	Breaker fail	90H-Sackville	p245	88S-711	Breaker fail	88S-Lingan
p088	90H-608	Breaker fail	90H-Sackville	p246	88S-712	Breaker fail	88S-Lingan
p089	90H-609	Breaker fail	90H-Sackville	p247	88S-713	Breaker fail	88S-Lingan
p090	90H-610	Breaker fail	90H-Sackville	p248	88S-714	Breaker fail	88S-Lingan
p091	90H-611	Breaker fail	90H-Sackville	p249	88S-715	Breaker fail	88S-Lingan
p092	90H-503	Breaker fail	90H-Sackville	p250	88S-720	Breaker fail	88S-Lingan
p093	90H-506	Breaker fail	90H-Sackville	p251	88S-721	Breaker fail	88S-Lingan
p094	90H-501	Breaker fail	90H-Sackville	p252	88S-722	Breaker fail	88S-Lingan
p095	90H-612	Breaker fail	90H-Sackville	p253	88S-723*	Breaker fail	88S-Lingan
p096	90H-613	Breaker fail	91H-Tufts Cove	p254	88S-T71	Transformer fault	88S-Lingan
p097	90H-621	Breaker fail	91H-Tufts Cove	p255	88S-T72	Transformer fault	88S-Lingan
p098	91H-603	Breaker fail	91H-Tufts Cove	p256	88S-G2	Generator Trip	88S-Lingan
p099	91H-604	Breaker fail	91H-Tufts Cove	p257	88S-G3	Generator Trip	88S-Lingan
p100	91H-605	Breaker fail	91H-Tufts Cove	p258	88S-G4	Generator Trip	88S-Lingan
p101	91H-606	Breaker fail	91H-Tufts Cove	p259	L7011	Line fault	101S-Woodbine
p102	91H-607	Breaker fail	91H-Tufts Cove	p260	L7014	Line fault	88S-Lingan
p103	91H-608	Breaker fail	91H-Tufts Cove	p261	L7015	Line fault	101S-Woodbine

ID	Element	Type	Location	ID	Element	Type	Location
p104	91H-609	Breaker fail	91H-Tufts Cove	p262	L7021	Line fault	88S-Lingan
p105	91H-611	Breaker fail	91H-Tufts Cove	p263	L7022	Line fault	88S-Lingan
p106	91H-613	Breaker fail	91H-Tufts Cove	p264	L8004	Line fault	101S-Woodbine
p107	91H-621	Breaker fail	91H-Tufts Cove	p265	91N-701	Breaker fail	91N-Dalhousie
p108	91H-511	Breaker fail	91H-Tufts Cove	p266	91N-702	Breaker fail	91N-Dalhousie
p109	91H-516	Breaker fail	91H-Tufts Cove	p267	91N-703	Breaker fail	91N-Dalhousie
p110	91H-521	Breaker fail	91H-Tufts Cove	p268	91N-B71	Breaker fail	91N-Dalhousie
p111	91H-523	Breaker fail	91H-Tufts Cove	p269	L6011 + L6010	Double ckt tower	Sackville
p112	91H-T62	Transformer fault	91H-Tufts Cove	p270	L6507 + L6508	Double ckt tower	Trenton
p113	91H-T11	Transformer fault	91H-Tufts Cove	p271	L6534 + L7021	Double ckt tower	Lingan / VJ
p114	91H-G2	Generator Trip	91H-Tufts Cove	p272	L7003 + L7004*	Double ckt tower	Canso Causeway
p115	91H-G3	Generator Trip	91H-Tufts Cove	p273	L7008 + L7009	Double ckt tower	Bridgewater
p116	91H-G4	Generator Trip	91H-Tufts Cove	p274	L7009 + L8002	Double ckt tower	Sackville
p117	91H-G5	Generator Trip	91H-Tufts Cove	p275	L5039+ L6033	Double ckt tower	
p118	L5049	Line fault	91H-Tufts Cove	p276	L6010+ L6005	Double ckt tower	
p119	L5012	Line fault	91H-Tufts Cove	p277	L6005+ L6016	Double ckt tower	
p120	L5041	Line fault	91H-Tufts Cove	p278	L6033+ L6035	Double ckt tower	
p121	L5003	Line fault	90H-Sackville	p279	L6040	Line fault	132H-Spider Lake
p122	L5004	Line fault	90H-Sackville	p280	110W-T62	Transformer fault	110W-S. Canoe
p123	L6044	Line fault	132H-Spider Lake	p281	110W-661	Breaker fail	110W-S. Canoe
p124	L6002E	Line fault	90H-Sackville	p282	110W-B61	Bus fault	110W-S. Canoe
p125	L6003	Line fault	90H-Sackville	p283	L6053	Line fault	101V-MacDonald Pond
p126	L6004	Line fault	90H-Sackville	p284	101V-601	Breaker fail	101V-MacDonald Pond
p127	L6005	Line fault	120H-Brushy	p285	L5060	Line fault	102V
p128	L6007	Line fault	91H-Tufts Cove	p286	102V-T51	Transformer fault	102V
p129	L6008	Line fault	103H-Lakeside	p287	102V-GT1	Generator Trip	102V
p130	L6009	Line fault	90H-Sackville	p288	17V-B1	Bus fault	17V-St Croix
p131	L6010	Line fault	120H-Brushy	p289	17V-B2	Bus fault	17V-St Croix
p132	L6011	Line fault	120H-Brushy	p290	17V-T2	Transformer fault	17V-St Croix
p133	L6014	Line fault	91H-Tufts Cove	p291	17V-T63	Transformer fault	17V-St Croix
p134	L6016	Line fault	120H-Brushy	p292	82V-600	Breaker fail	82V-Elmsdale
p135	L6033	Line fault	103H-Lakeside	p293	L6001N	Line fault	82V-Elmsdale
p136	L6035	Line fault	1H-Water St	p294	L6001S	Line fault	82V-Elmsdale
p137	L6038	Line fault	103H-Lakeside	p295	99W-B62	Bus fault	99W-Bridgewater
p138	L6040	Line fault	91H-Tufts Cove	p296	99W-B71	Bus fault	99W-Bridgewater
p139	L6042	Line fault	91H-Tufts Cove	p297	99W-B72	Bus fault	99W-Bridgewater

ID	Element	Type	Location	ID	Element	Type	Location
p140	L6043	Line fault	113H-Dartmouth East	p298	99W-T61	Transformer fault	99W-Bridgewater
p141	L6044	Line fault	113H-Dartmouth East	p299	99W-T62	Transformer fault	99W-Bridgewater
p142	L6051	Line fault	120H-Brushy	p300	99W-T71	Transformer fault	99W-Bridgewater
p143	L6055	Line fault	132H-Spider Lake	p301	99W-T72	Transformer fault	99W-Bridgewater
p144	L7018	Line fault	120H-Brushy	p302	99W-708	Breaker fail	99W-Bridgewater
p145	T1	Transformer fault	90H-Sackville	p303	99W-709	Breaker fail	99W-Bridgewater
p146	T1	Transformer fault	1N-Onslow	p304	99W-601	Breaker fail	99W-Bridgewater
p147	T4	Transformer fault	1N-Onslow	p305	99W-602	Breaker fail	99W-Bridgewater
p148	T65	Transformer fault	1N-Onslow	p306	L7008	Line fault	99W-Bridgewater
p149	1N-C61	Cap Bank trip	1N-Onslow	p307	L7009	Line fault	99W-Bridgewater
p150	1N-B61	Bus fault	1N-Onslow	p308	89S-G1	Generator Trip	89S-Point Aconi
p151	1N-B62	Bus fault	1N-Onslow	p309	L3004	Line fault	SALISBURY
p152	1N-600	Breaker fail	1N-Onslow	p310	L3013	Line fault	SALISBURY
p153	1N-601	Breaker fail	1N-Onslow	p311	SA3-2	Line fault	SALISBURY
p154	1N-613	Breaker fail	1N-Onslow	p312	L3006	Line fault	SALISBURY
p155	50N-604	Breaker fail	50N-Trenton	p313	L1159	Line fault	MEMRAMCOOK
p156	67N-701	Breaker fail	67N-Onslow	p314	L1160	Line fault	MEMRAMCOOK
p157	67N-702	Breaker fail	67N-Onslow	p315	ME3-1*	Breaker fail	MEMRAMCOOK
p158	67N-703	Breaker fail	67N-Onslow	* Indicates RAS/AAS			

3.4.3 Steady state evaluation

The steady state contingencies evaluated in this study demonstrate IR662 does not require Network Upgrades beyond the POI to operate at requested MW.

IR662 has little impact on the transmission constraints in the Metro Halifax region. The differential line flows are shown in *Appendix C: Differential line flows*. The one-line diagrams display the difference in flow on each transmission line with and without IR662.

Results of the steady state analysis are presented in *Appendix D: Steady-state analysis results*. The power flow analysis identified no transmission system contingencies inside Nova Scotia that violate thermal loading criteria or voltage criteria.

However, contingency p102 *(91H-607 breaker fail)* can cause slightly more loading on transformer 91H-T11 in wp03-2 cases with IR662 discharging. Flow increase attributed to IR662 from 93.1MVA to 94.6MVA is observed. 91H-T11 is rated at 88.33MVA with 110% overload capability under emergency conditions. The observed loading does not exceed the 91H-T11 emergency capability.

3.5 Stability analysis

System design criteria requires the system to be stable and well damped in all modes of oscillations.

3.5.1 Stability base cases

All steady-state cases were studied for contingencies that provide the best measure of system reliability. The parameters of these base cases are repeated below in *Table 6: Stability base cases* for convenience.

Table 6: Stability base cases

Case Name	NS load	IR 662	Wind	NS/NB	ML	CBX	ONI	ONS
ll01-2	768	50	419	330	-475	334	363	32
ll01-4	792	-50	419	330	-475	385	413	82
ll02-2	768	50	559	500	-475	296	353	-132
ll02-4	788	-50	559	500	-475	346	403	-82
ll03-2	783	50	419	330	-330	247	278	-53
ll03-4	783	-50	419	330	-330	290	319	-11
sp03-2	1,420	50	389	330	-475	872	1,012	642
sp03-4	1,426	-50	389	330	-475	927	1,064	693
sp04-2	1,361	50	168	-108	-175	600	644	660
sp04-4	1,361	-50	168	-108	-175	654	695	711
sp05-2	1,392	50	559	330	-475	316	429	58
sp05-4	1,408	-50	559	330	-475	445	604	233
sp07-2	1,392	50	419	-300	-300	181	237	479
sp07-4	1,392	-50	419	-300	-300	190	256	498
wp02-2	2,145	50	559	0	-475	760	1,021	917
wp02-4	1,952	-50	559	0	-475	781	1,050	964
wp03-2	2,142	50	559	-170	-300	493	765	831
wp03-4	1,940	-50	559	-170	-300	366	652	735
wp04-2	2,160	50	559	186	-320	950	1,199	907
wp04-4	1,967	-50	559	186	-320	929	1,189	915
wp06-2	2,151	50	559	150	-320	468	741	487
wp06-4	1,958	-50	559	150	-320	501	784	546

3.5.2 Stability contingencies

The contingencies tested for this study are listed in *Table 7: Stability contingency list*.

Table 7: Stability contingency list

132H-602_LG	103H-681_LG	67N-705_ LG *	79N-601_LG *	2C L6515_3PH
132H-603_LG	103H L6008_3PH	67N-706_ LG	79N-803_LG *	2C L6516_3PH
132H-606_LG	103H L6016_3PH	67N-710_ LG	79N-810_LG *	2C L6517_3PH
132H-605_LG	103H L6033_3PH	67N-711_ LG	79N-T81_3PH *	2C L6518_3PH
132H L6044_3PH	103H-881_LG	67N-712_ LG	79N L6507_3PH	2C L6537_3PH
132H L6055_3PH	103H L8002_LG	67N-713_ LG	79N L8003_3PH*	3C_710_LG *
108H L6055_3PH	120H-622_LG	67N-811_ LG *	79N L8004_3PH*	3C_711_LG *

108H-651_LG	120H-628_LG	67N-811_T82_ LG *	410N L8001_3025_3PH*	3C_712_LG *
108H-B3_3PH	120H-710_LG	67N-813_ LG	101S-701_LG *	3C_713_LG *
91H L6007_3PH	120H-715_LG	67N-814_ LG*	101S-702_LG *	3C_714_LG *
91H L6014_3PH	120H L6005_3PH	67N L7001_3PH	101S-706_LG	3C_715_LG *
91H L6040_3PH	120H L6010_3PH	67N L7003_3PH*	101S-711_LG	3C_716_LG *
91H-605_LG	120H L6011_3PH	67N L7005_3PH*	101S-712_LG	3C_720_LG *
91H-606_LG	120H L6016_3PH	67N L7018_3PH	101S-811_LG	3C-T71_LG
91H-607_LG	120H L6051_3PH	67N L7019_3PH*	101S-812_LG *	3C-T72_LG
91H-608_LG	120H L7008_3PH	67N L8001_3PH*	101S-813_LG *	3C L7004_3PH *
139H-B61_3PH	120H L7018_3PH	67N L8002_3PH	101S L7011_3PH *	3C L7005_3PH *
113H L6044_3PH	1N-B61_3PH	67N L8003_3PH*	101S L7012_3PH *	3C L7012_3PH *
113H-601_LG	1N-B62_3PH	74N-600_ LG	101S L7014_3PH	DCT L6005_L6010_LLG
113H L6042_3PH	1N L6001_3PH	74N L6514_3PH	101S L7021_3PH	DCT L6010_L6011_ LLG
90H-605_LG	1N L6503_3PH	74N L6536_3PH	101S L7022_3PH	DCT L6005_L6016_ LLG
90H-606_LG	91N-701_LG *	74N L6613_3PH	101S L8004_3PH *	DCT L6033_L6035_ LLG
90H-608_LG	91N L7004_3PH *	50N-604_LG	101S-MLPOLE1_3PH	DCT L6534_L7021_ LLG
90H-609_LG	91N L7019_3PH *	50N-B61_3PH	101S-MLPOLE2_3PH	DCT L7003_L7004_ LLG *
90H L6008_3PH	67N-701_LG	50N-B62_3PH	101S-MLBIPOLE_LG	DCT L7009_L8002_ LLG
90H L6009_3PH	67N-702_ LG	50N L6503_3PH	101S-MLBIPOLE_3PH	DCT L7009_L8002_A_ LLG
103H-600_LG	67N-703_ LG	50N L6507_3PH	2C-B61_3PH *	* Indicates RAS/AAS
103H-608_ LG	67N-704_ LG	50N L6508_3PH	2C-B62_3PH	

3.5.3 Stability evaluation

PSS®E plotted output files for each contingency with IR662 in service are presented in *Appendix H: Stability analysis results*. All contingencies were found to be stable and well-damped.

3.6 NPCC-BPS/NERC-BES

NSPI is a member of NPCC and adheres to NPCC's requirements, including the requirements for BPS. The methodology for determining if a substation is BPS is defined in NPCC's criteria document A-10 titled "Classification of Bulk Power System Elements". NPCC BPS criteria is performance based, and currently the 138 kV bus at 132H-Spider Lake is not designated NPCC BPS.

Table 8 summarizes the BPS/BES status of neighbouring system elements.

Table 8: BPS & BES classification of neighbouring elements

Neighbouring element classification	NPCC BPS	NERC BES
132H 138 kV Bus	no	no
L6001	yes	yes

L6040	no	no
L6044	no	no
L6055	no	no

Both steady state and stability BPS testing was performed using the Light Load, Summer Peak, Winter Peak case. The steady state test was conducted by dispatching the new facility at request MW output, then disconnecting it. Post-contingency results reveal no voltage violations or thermal overloads outside the local area.

The stability test was performed by placing a 3-phase fault at the 132H 138 kV bus, assuming all local protection out of service. The fault is maintained on the bus for 0.35 seconds to allow remote protection at surrounding substations to trip the lines L-6001, L-6055, L-6040 and L-6044 with their corresponding back-up protection times. *Appendix E: NPCC-BPS determination results* demonstrates IR662 does not have adverse impact outside the local area, confirming the transmission facilities associated with IR662 are not classified as NPCC BPS.

Note NPCC's A-10 Classification of Bulk Power System Elements requires NS Power to perform a periodic comprehensive re-assessment at least once every five years[5]. It is possible for this site's BPS status to change, depending on future system configuration changes, requiring the IC to adapt to NPCC reliability requirements accordingly[6].

NERC BES criteria uses a bright line approach for expected facilities required for interconnection. Based on NERC BES criteria, IR662 is not considered part of the BES because:

- The ICIF transformer's secondary terminal is <100kV.
- The gross plant/facility aggregate nameplate rating is <75MVA.
- It is not a Blackstart resource identified in NS Power's restoration plan.
- It is a radial system that emanates from a single point of connection of ≥100kV and only includes generation resources <75MVA.

While IR662 is not a designated Blackstart resource, one of the Blackstart cranking paths, through the 138 kV Interconnection, passes by 132H-Spider Lake. However, IR662 is

[5] Regional Reliability Reference Criteria A-10, *Classification of Bulk Power System Elements*, 2020/03/27, https://www.npcc.org/content/docs/public/program-areas/standards-and-criteria/regional-criteria/criteria/a-10-20200508.pdf

[6] NPCC Reliability Reference Directory # 4, *Bulk Power System Protection Criteria*, 2020/01/30, https://www.npcc.org/content/docs/public/program-areas/standards-and-criteria/regional-criteria/directories/directory-4-tfsp-rev-20200130.pdf.

considered radial off 132H and is not considered part of the Blackstart plan despite its POI at 132H.

3.7 Underfrequency operation

IR662's low frequency ride-through performance was tested by simulating a fault on L-8001 under high import conditions. The case selected for dynamic simulation was based on 2026 Shoulder, with 300 MW import into Nova Scotia. sp07-2 represents IR662 discharging, and sp07-4 is for IR662 charging. IR662 remains stable and online as required for both discharging and charging scenarios.

When IR662 is discharging at 50MW *(sp07-2)*, simulation indicates that NS Power's Stage 2 UFLS activates to stabilize system frequency by shedding 224 MW load. The simulation results are shown in *Figure 8: Underfrequency performance with IR662 discharging at 50MW (frequency at 120H-Brushy Hill:138kV)*, *Figure 9: Underfrequency performance with IR662 discharging at 50MW (frequency at NS_410N, Mass, Cherrywood, Orrington, and 120H-Brushy Hill)* and *Figure 10: Underfrequency performance with IR662 discharging at 50MW*.

IR662 is required to cap the plant's steady state output to 50 MW as the requested injection amount is 50 MW and the plant's nameplate capability is 76 MW. However, as *Figure 10: Underfrequency performance with IR662 discharging at 50MW* indicates, the plant is capable and does inject more than the 50 MW in the post-contingency transient period timeframe.

Note values are plotted on 100 MVA system base, so IR662 at 0.5 PU power represents full output of the generator rather than 50.0% output.

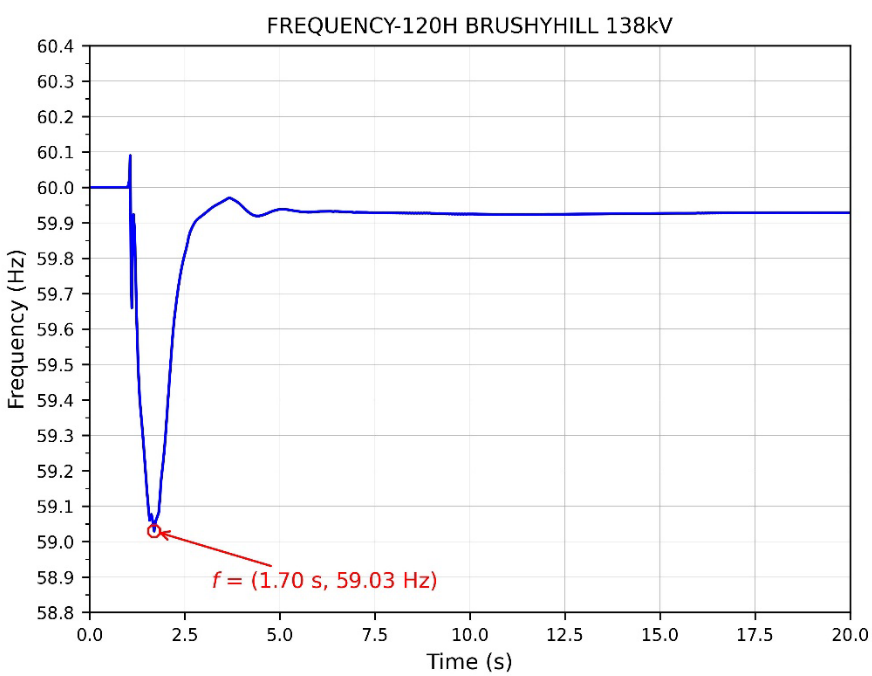


Figure 8: Underfrequency performance with IR662 discharging at 50MW *(frequency at 120H-Brushy Hill:138kV)*

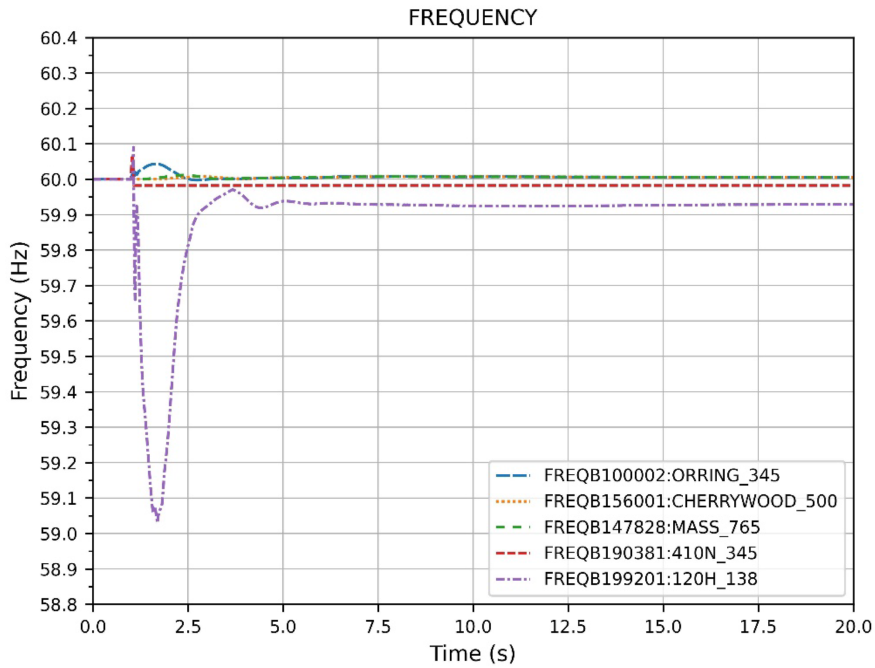


Figure 9: Underfrequency performance with IR662 discharging at 50MW *(frequency at NS_410N, Mass, Cherrywood, Orrington, and 120H-Brushy Hill)*

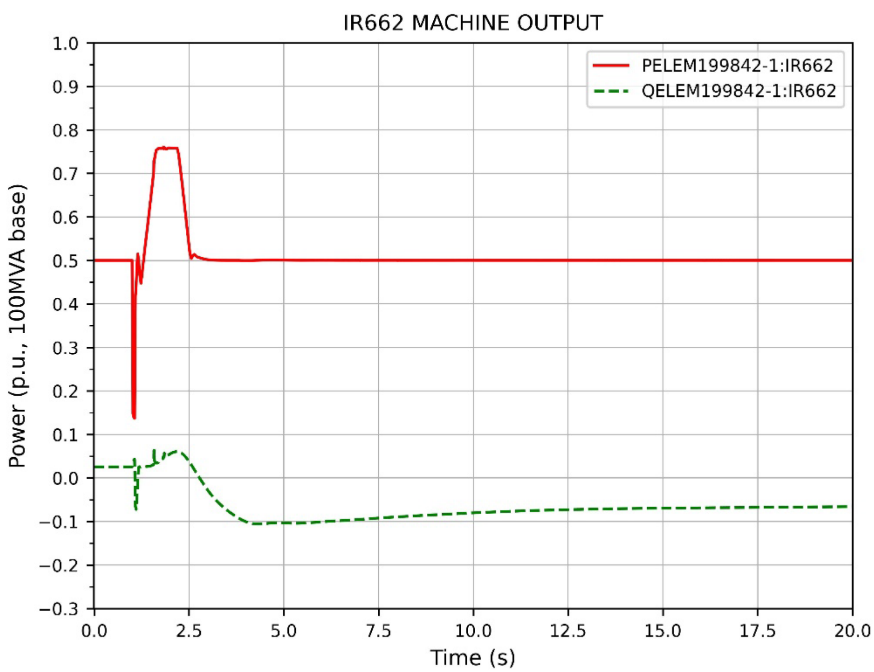


Figure 10: Underfrequency performance with IR662 discharging at 50MW

When IR662 is charging at 50MW *(sh03-4)*, simulation indicates that IR662 provided MW support for the frequency drop and rapidly changed the output from charging to discharging as needed to alleviate the UFLS. NS Power's Stage 1 UFLS activates to stabilize system frequency by shedding 141 MW load. IR662 helps to improve the system frequency performance. The simulation results are shown in *Figure 11: Underfrequency performance with IR662 charging at 50MW (frequency at 120H-Brushy Hill:138kV)*, *Figure 12: Underfrequency performance with IR662 charging at 50MW (frequency at NS_410N, Mass, Cherrywood, Orrington, and 120H-Brushy Hill)* and *Figure 13: Underfrequency performance with IR662 charging at 50MW*. Note values are plotted on 100 MVA system base. Specially, the battery is charging at a lower level after the primary frequency response. The control centre should consider guidelines on the charging behaviour after the primary frequency response is complete.

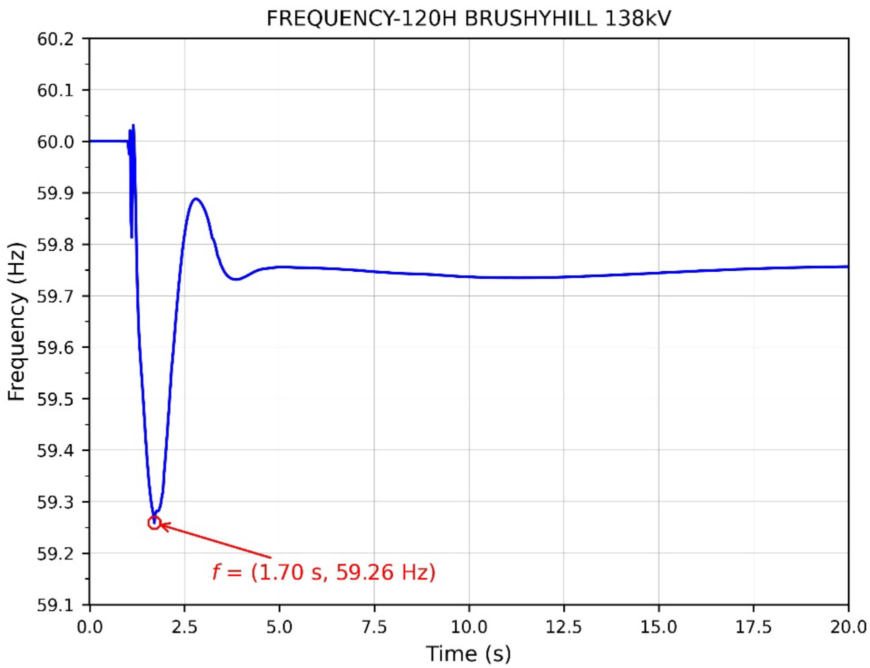


Figure 11: Underfrequency performance with IR662 charging at 50MW *(frequency at 120H-Brushy Hill:138kV)*

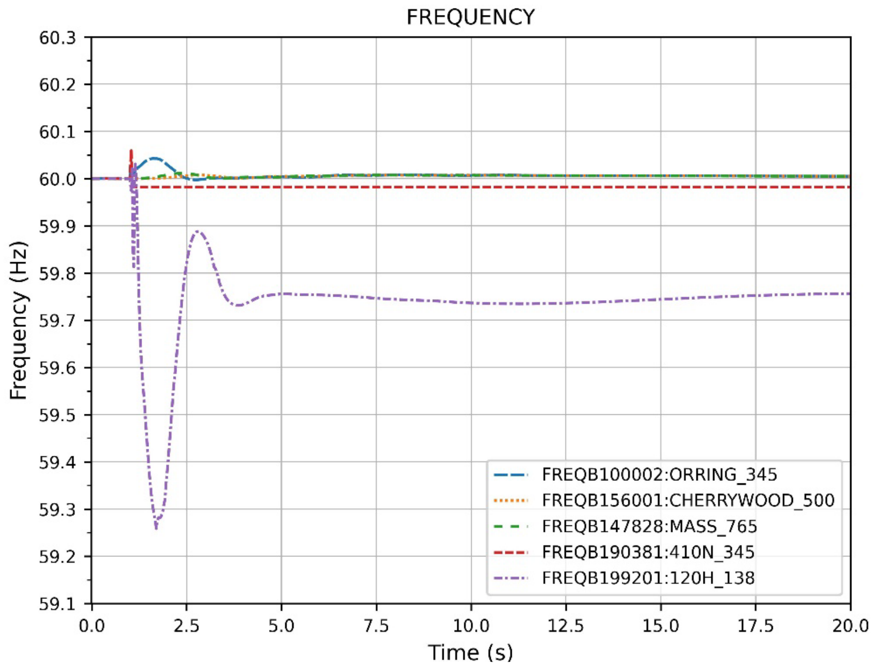


Figure 12: Underfrequency performance with IR662 charging at 50MW *(frequency at NS_410N, Mass, Cherrywood, Orrington, and 120H-Brushy Hill)*

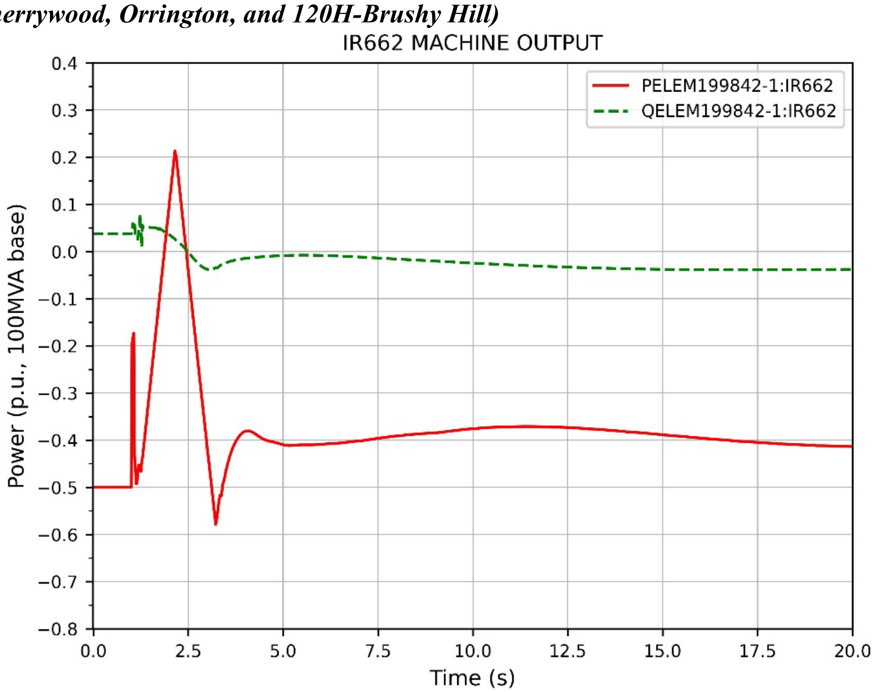


Figure 13: Underfrequency performance with IR662 charging at 50MW

3.8 Voltage ridethrough

IR662 low voltage ride through *(LVRT)* capability was tested under expected system operating conditions in winter peak, summer peak and light load. A 3-phase fault for 9 cycles was applied to IR662 138kV and 34.5kV buses under all stability base cases.

The stability plots in *Appendix G: Low voltage ride through* and *Figure 15: IR662 LVRT performance (MV fault, 9 cycles, discharging)* demonstrate IR662 rides through the fault and stays online under both faults with IR662 discharging at 50MW. The stability plot in *Figure 16: IR662 LVRT performance (HV fault, 9 cycles, charging)* and *Figure 17: IR662 LVRT performance (MV fault, 9 cycles, charging)* demonstrate IR662 rides through the fault and stays online with IR662 charging at 50MW, as required.

Note values are plotted on 100 MVA system base, so IR662 at ±0.5 PU power represents full discharging/charging of the battery system rather than 50.0% output.

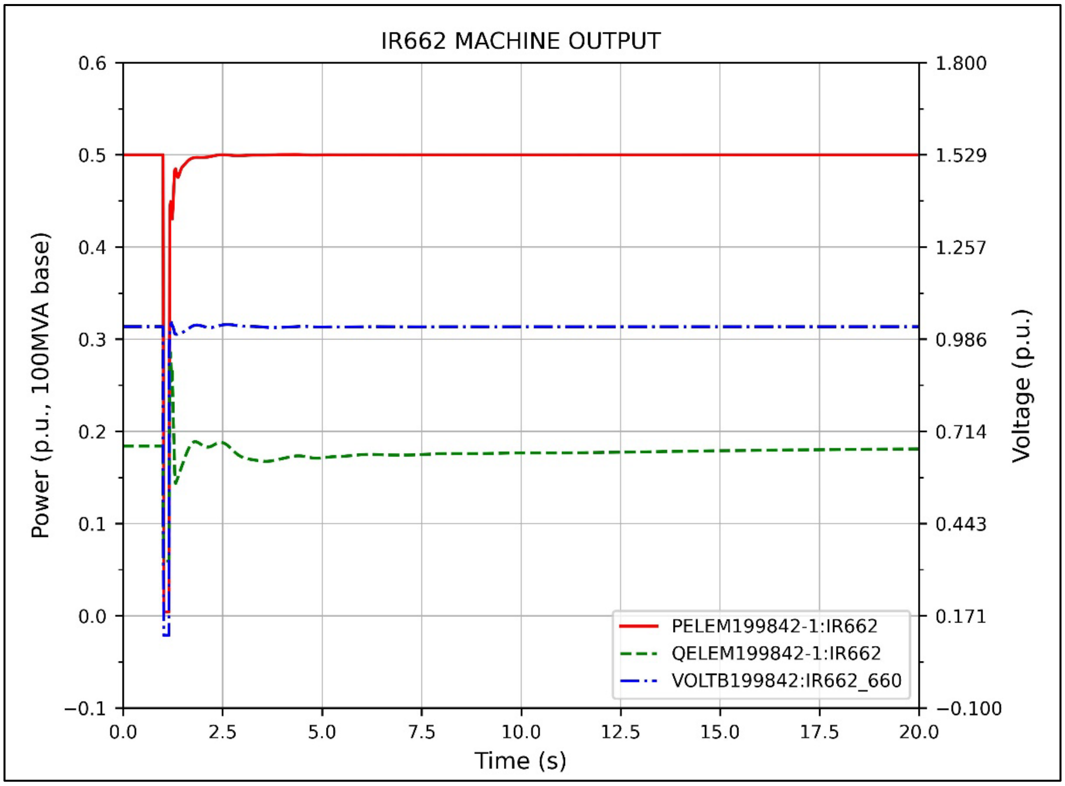


Figure 14: IR662 LVRT performance *(HV fault, 9 cycles, discharging)*

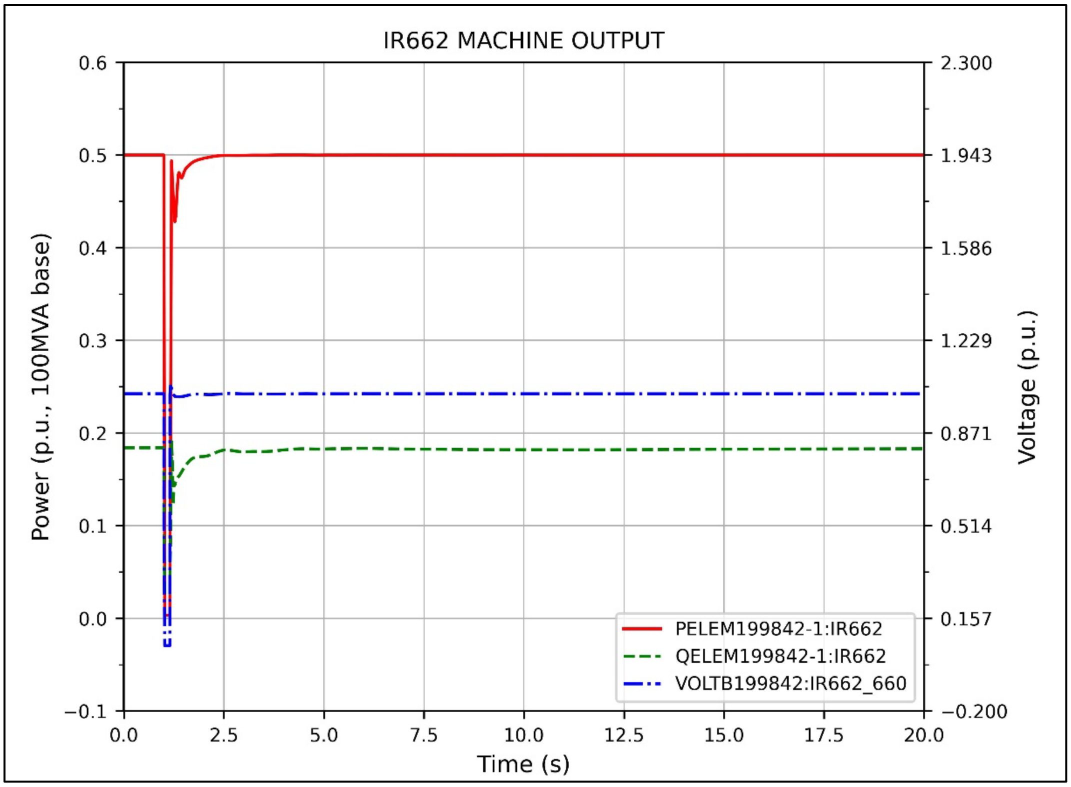


Figure 15: IR662 LVRT performance ***(MV fault, 9 cycles, discharging)***

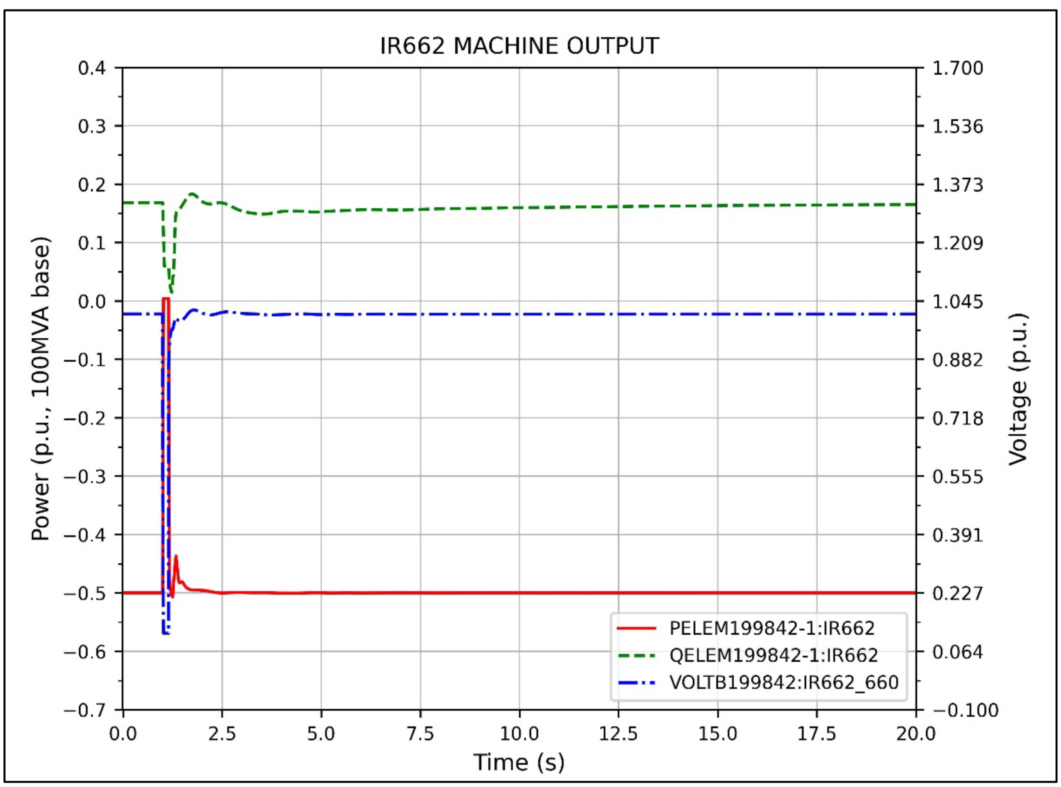


Figure 16: IR662 LVRT performance ***(HV fault, 9 cycles, charging)***

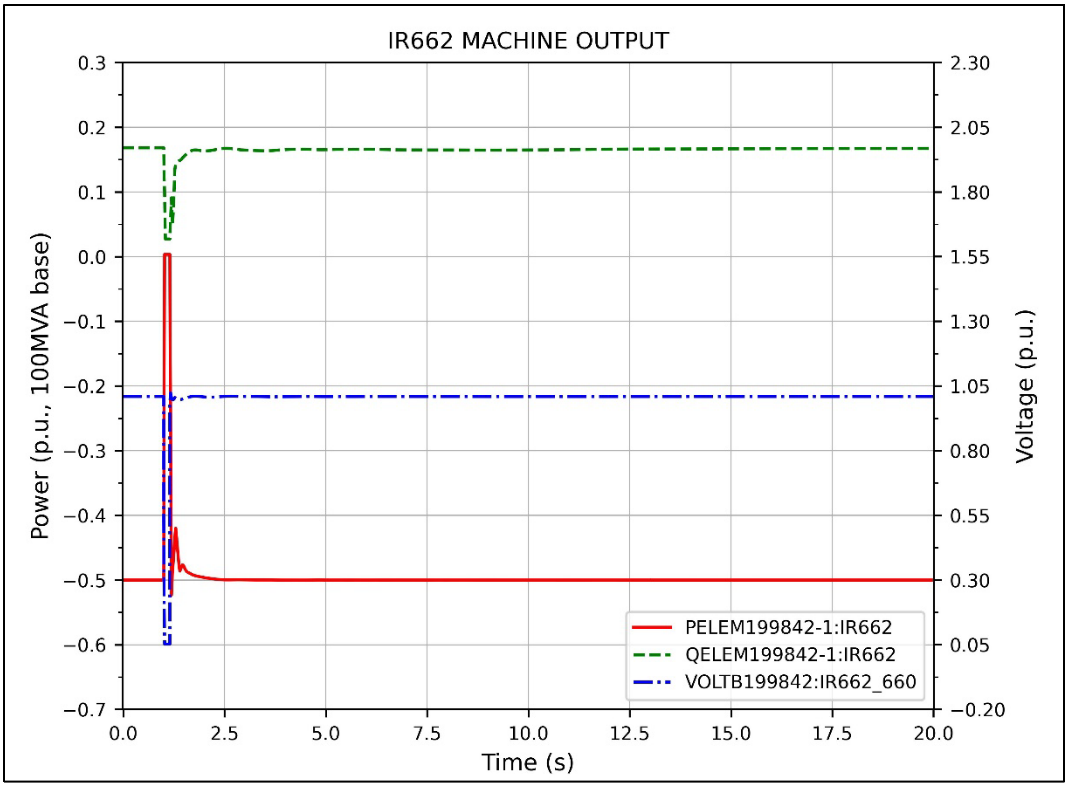


Figure 17: IR662 LVRT performance ***(MV fault, 9 cycles, charging)***

3.9 Loss factor

The loss factor for IR662 is calculated as 0.1% at IR662's generator terminal *(660V)* and -0.7% at its 138kV ICIF bus. This means system losses on peak are slightly reduced when IR662 is discharging at 50.0 MW.

This preliminary loss factor analysis is calculated on the hour of system peak as a means for comparing multiple projects but is not used for any other purpose.

Table 9: 2026 Loss factor

Loss Factor measured at IR662 Terminal *(660 V)*	
Description	**MW**
IR662 On	50.00
TC3 with IR662 On	82.04
TC3 with IR662 Off	132.00
Loss Factor Measured at IR662 Voltage Terminal	0.1%

Loss Factor Measured at POI *(132H-Spider Lake, 138kV)*	
Description	**MW**
IR662 On	50.00
Power measured at POI	49.62
TC3 with IR662 On	82.04
TC3 with IR662 Off	132.00
Loss Factor Measured at POI	-0.7%

4.0 Re-study Due To IR672 Withdrawal

Due to the higher-queued project IR672’s withdrawal, a re-study was performed on the steady state analysis, stability analysis and NPCC-BPS test with IR672 removed from the study and the results are reported in the following sections.

4.1 Steady state analysis

Power flow analysis was performed for cases representing system light load, summer peak load, and winter peak load conditions. IR672 was removed from the base cases in Section 3.4.1. The generation in the system was re-dispatched to represent import and export scenarios with New Brunswick for various flows associated with the existing Maritime Link transmission service reservation.

4.1.1 Base cases

The bases cases used for power flow analysis re-study are listed in *Table 10: Power flow base cases*.

Table 10: Power flow base cases

Case Name	NS Load	IR 662	Wind	NS/NB	ML	CBX	ONI	ONS
c_ll01_r-1	786	0	394	332	-475	410	437	107
c_ll01_r-2	777	50	394	332	-475	359	387	57
c_ll01_r-4	892	-50	394	332	-475	410	437	107
c_ll02_r-1	777	0	526	505	-475	379	435	-51
c_ll02_r-2	777	50	526	505	-475	344	401	-85
c_ll02_r-4	882	-50	526	504	-475	379	434	-50
c_ll03_r-1	792	0	394	332	-330	315	344	13
c_ll03_r-2	792	50	394	333	-330	265	295	-37
c_ll03_r-4	897	-50	394	332	-330	314	344	13
c_sp01_r-1	1426	0	394	332	-475	796	912	523
c_sp01_r-2	1426	50	394	333	-475	743	862	472
c_sp01_r-4	1535	-50	394	332	-475	796	912	523
c_sp02_r-1	1420	0	526	332	-475	803	946	576
c_sp02_r-2	1420	50	526	332	-475	749	895	525
c_sp02_r-4	1529	-50	526	333	-475	803	946	575
c_sp03_r-1	1429	0	379	332	-475	938	1074	704
c_sp03_r-2	1429	50	379	333	-475	883	1023	652
c_sp03_r-4	1538	-50	379	331	-475	938	1074	704
c_sp04_r-1	1361	0	158	-108	-175	654	705	722
c_sp04_r-2	1361	50	158	-108	-175	600	654	670
c_sp04_r-4	1466	-50	158	-107	-175	654	705	721
c_sp05_r-1	1401	0	526	332	-475	370	510	140
c_sp05_r-2	1401	50	526	333	-475	370	461	90
c_sp05_r-4	1517	-50	526	333	-475	507	663	292
c_sp06_r-1	1429	0	394	332	-475	925	1034	645
c_sp06_r-2	1429	50	394	333	-475	871	983	593
c_sp06_r-4	1538	-50	394	333	-475	925	1034	644
c_sp07_r-1	1392	0	394	-298	-300	215	281	523
c_sp07_r-2	1392	50	394	-298	-300	179	233	475
c_sp07_r-4	1501	-50	394	-298	-300	215	281	523
c_sp08_r-1	1401	0	526	332	-370	246	367	-3
c_sp08_r-2	1401	50	526	332	-370	246	328	-43
c_sp08_r-4	1510	-50	526	334	-370	354	520	148
c_wp01_r-1	2160	0	526	150	-320	887	1139	885
c_wp01_r-2	2160	50	526	151	-320	831	1087	832
c_wp01_r-3	2017	0	526	150	-320	844	1110	873
c_wp01_r-4	2072	-50	526	151	-320	844	1111	872
c_wp02_r-1	2145	0	526	1	-475	818	1075	971
c_wp02_r-2	2145	50	526	1	-475	762	1022	917
c_wp02_r-3	2002	0	526	0	-475	781	1051	963
c_wp02_r-4	2057	-50	526	1	-475	781	1051	963
c_wp03_r-1	2151	0	526	-169	-300	583	851	918
c_wp03_r-2	2151	50	526	-169	-300	528	799	865
c_wp03_r-3	1990	0	526	-169	-300	400	686	768

Case Name	NS Load	IR 662	Wind	NS/NB	ML	CBX	ONI	ONS
c_wp03_r-4	2045	-50	526	-169	-300	400	686	768
c_wp04_r-1	2160	0	526	187	-320	1008	1252	961
c_wp04_r-2	2160	50	526	188	-320	951	1200	908
c_wp04_r-3	2017	0	526	187	-320	965	1223	948
c_wp04_r-4	2067	-50	526	187	-320	965	1223	948
c_wp05_r-1	2169	0	357	322	-475	1028	1239	786
c_wp05_r-2	2169	50	357	323	-475	973	1188	735
c_wp05_r-3	2026	0	357	322	-475	973	1200	764
c_wp05_r-4	2076	-50	357	322	-475	973	1200	764
c_wp06_r-1	2151	0	526	150	-320	555	825	571
c_wp06_r-2	2151	50	526	151	-320	502	774	520
c_wp06_r-3	2008	0	526	150	-320	536	817	579
c_wp06_r-4	2058	-50	526	150	-320	536	817	579
c_wp07_r-1	2142	0	526	150	-320	429	703	449
c_wp07_r-2	2142	50	526	151	-320	377	653	398
c_wp07_r-3	1999	0	526	150	-320	420	644	406
c_wp07_r-4	2049	-50	526	151	-320	420	696	457

Note 1: All values are in MW.
Note 2: CBX *(Cape Breton Export)* and ONI *(Onslow Import)* are Interconnection Reliability defined interfaces.
Note 3: Wind refers to transmission connected wind only.
Note 4: Negative MW in the IR662 column indicates charging.
Note 5: Negative MW in NS/NB and ML columns, represent imports to NS.

4.1.2 Steady state contingencies

The steady state power flow analysis includes the contingencies listed in *Table 5: Steady state contingencies*.

4.1.3 Steady state evaluation

The steady state contingencies re-evaluation maintains the same conclusion that IR662 does not require Network Upgrades beyond the POI to operate at requested MW.

Results of the steady state analysis are presented in *Appendix I: Re-study Steady State analysis results*. The power flow analysis identified no contingencies inside Nova Scotia that violate thermal loading criteria or voltage criteria.

However, contingency p102 *(91H-607 breaker fail)* can cause more loading on transformer 91H-T11 in wp01-2 and wp03-2 cases with IR662 discharging. Up to 6% increase of flow from 90.1MVA to 96.1MVA is observed that is attributed to IR662. 91H-T11 is rated at 88.33MVA with 110% overload capability under emergency conditions. The observed loading does not exceed the 91H-T11 emergency capability.

4.2 Stability analysis

System design criteria requires the system to be stable and well damped in all modes of oscillations.

4.2.1 Stability base cases

Sp07 summer peak cases and wp04 winter peak cases were selected as the worst-case scenarios for the re-study with the same set of contingencies. The parameters for these base cases are represented below in *Table 11: Stability base cases*.

Table 11: Stability base cases

Case Name	NS Load	IR 662	Wind	NS/NB	ML	CBX	ONI	ONS
c_sp07_r-2	1392	50	394	-298	-300	179	233	475
c_sp07_r-4	1501	-50	394	-298	-300	215	281	523
c_wp04_r-2	2160	50	526	188	-320	951	1200	908
c_wp04_r-4	2067	-50	526	187	-320	965	1223	948

4.2.2 Stability contingencies

The contingencies tested for the re-study are listed in *Table 7: Stability contingency list*.

4.2.3 Stability evaluation

PSS®E plotted output files for each contingency with IR662 in service and IR672 out of service are presented in *Appendix J: Re-study Stability analysis results*.

4.3 NPCC-BPS

Both steady state and stability BPS testing was re-evaluated using the Light Load, Summer Peak and Winter Peak case shown in *Table 12: BPS base cases*.

Table 12: BPS base cases

Case Name	NS Load	IR 662	Wind	NS/NB	ML	CBX	ONI	ONS
c_ll01_r-2	777	50	394	332	-475	359	387	57
c_ll01_r-4	892	-50	394	332	-475	410	437	107
c_ll02_r-2	777	50	526	505	-475	344	401	-85
c_ll02_r-4	882	-50	526	504	-475	379	434	-50
c_ll03_r-2	792	50	394	333	-330	265	295	-37
c_ll03_r-4	897	-50	394	332	-330	314	344	13
c_sp03_r-2	1429	50	379	333	-475	883	1023	652
c_sp03_r-4	1538	-50	379	331	-475	938	1074	704
c_sp04_r-2	1361	50	158	-108	-175	600	654	670
c_sp04_r-4	1466	-50	158	-107	-175	654	705	721
c_sp05_r-2	1401	50	526	333	-475	370	461	90
c_sp05_r-4	1517	-50	526	333	-475	507	663	292
c_sp07_r-2	1392	50	394	-298	-300	179	233	475
c_sp07_r-4	1501	-50	394	-298	-300	215	281	523
c_wp02_r-2	2145	50	526	1	-475	762	1022	917
c_wp02_r-4	2057	-50	526	1	-475	781	1051	963
c_wp03_r-2	2151	50	526	-169	-300	528	799	865
c_wp03_r-4	2045	-50	526	-169	-300	400	686	768
c_wp04_r-2	2160	50	526	188	-320	951	1200	908
c_wp04_r-4	2067	-50	526	187	-320	965	1223	948
c_wp06_r-2	2151	50	526	151	-320	502	774	520

Case Name	NS Load	IR 662	Wind	NS/NB	ML	CBX	ONI	ONS
c_wp06_r-4	2058	-50	526	150	-320	536	817	579

The steady state test was conducted by dispatching the new facility at request MW output, then disconnecting it. Post-contingency results reveal no voltage violations or thermal overloads outside the local area.

The stability test was performed by placing a 3-phase fault at the 132H 138 kV bus, assuming all local protection out of service. The fault is maintained on the bus for 0.35 seconds to allow remote protection at surrounding substations to trip the lines L-6001, L-6055, L-6040 and L-6044 with their corresponding back-up protection times. *Appendix K: Re-study BPS results* demonstrates that the BPS test results remains the same for IR662 with IR672 removed, it does not have adverse impact outside the local area, confirming the transmission facilities associated with IR662 are not classified as NPCC BPS.

5.0 Requirements & cost estimate

The following facility changes will be required to connect IR662 as NRIS to NSPI transmission system at the POI of 132H-Spider Lake:

- Transmission Provider's Interconnection Facilities *(TPIF)*:
    - A 138 kV breaker, associated switches, and substation modifications at 132H-Spider Lake. This includes the 150m transmission line from the 132H POI to the IR662 PCO.
    - Protection modifications at 132H-Spider Lake.
    - Modifications to existing 132H-Spider Lake RTU.

- IC Interconnection Facility *(ICIF)*:
    - Facilities to meet ±0.95 power factor requirement when delivering rated output *(50 MW)* at the 138 kV bus. Rated reactive power shall be available through the full range of real power output, from zero to full power.
    - The ability to interface with the NS Power SCADA and communications systems to provide control, communication, metering, and other items to be specified in the forthcoming Interconnection Facilities Study.
    - NSPI to have supervisory and control of this facility, via the centralized controller such as a plant control unit. 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.
    - The centralized voltage controller to control the 34.5 kV bus voltage to a settable point and will control the reactive output of each inverter unit of IR662 to achieve this common objective. Responsive *(fast-acting)* controls are required. The setpoint for this controller will be delivered via the NS Power SCADA system. The voltage controller must be tuned for robust control across a broad range of SCR.

- Voltage flicker and harmonics characteristics as described in Section 3.3: Voltage flicker.
- Frequency ride through capability to meet the requirements in Section 2.3.8: Underfrequency operation.
- The ability to control active power in response to control signals from the NS Power System Operator and frequency deviations. This includes automatic curtailment to pre-set limits *(0%, 33%, 66% and no curtailment)*, over/under frequency control, and Automatic Generation Control *(AGC)* system to control tie-line fluctuations as required.
- 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%.
- Voltage ride through capability to meet the requirements in Section 2.3.9: Voltage ride-through.
- Real-time monitoring of the interconnection facilities including MW, MVAR, bus voltages, curtailment state, and state of charge.
- Operation at ambient temperatures as low as -30ºC.
- 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 ±15º)*.
- Facilities for NSPI to execute high speed rejection of generation and load *(transfer trip)*. The plant may be incorporated in SPS runback or load reject schemes.
- The facility must meet NSPI's TSIR as published on the NSPI OASIS site.

The cost estimate as shown in *Table 13: NRIS cost estimate* is high level non-binding in 2023 Canadian dollars. It includes 10% contingency but excludes applicable taxes. This cost estimate includes the additions/modifications to the NS Power system only, and the cost of the IC's substation, interconnection facilities and generating facility are not included. It does not include additional costs to be identified by the subsequent SIS Part 2 report and Facility Study. The Interconnection Facilities Study will provide a more detailed cost estimate.

Table 13: NRIS cost estimate

	NRIS	
	TPIF	**Estimate**
I	Terminal at 132H-Onslow *(breaker, switches, 150m transmission line from 132H POI to IR662 PCO...)*	$ 1,320,000
II	Protection modifications	$ 380,000
	Sub-total	**$ 1,700,000**

Determined costs	
Subtotal	$ 1,700,000
Contingency *(10%)*	$ 170,000
Total of determined cost items	$ 1,870,000

Item	**To Be Determined costs**	**Estimate**
I	Findings pending the release of Part 2 of the SIS *(EMT analysis)*.	TBD

6.0 Conclusion & recommendations

6.1 Summary of technical analysis

Technical analysis, including short circuit, power factor, voltage flicker, steady state, stability, and protection and control analysis was performed. Both NS Power and NPCC planning criteria were applied.

The short circuit analysis shows that the maximum short circuit levels are below 5,000 MVA for 138 kV with IR662 added into the power system at POI. IR662 short circuit contribution does not require any uprating of existing breakers in the transmission system. The minimum short circuit level at IR662 34.5 kV bus, with L-6055 out of service, is 431 MVA, which equates to an 8.6 SCR.

The IC has confirmed that the inverters battery system units can provide ±50.0 MVAr reactive power when delivering capped power at ±50.0 MW and have full ±50.0 MVAr reactive power capability at 0 MW real power. Therefore, IR662 meets the leading and lagging power factor requirement based on the preliminary information supplied. This should be re-evaluated once the detailed design information on transformer impedances and collector circuit *(if any)* design are finalized.

IR662 does not require any major Network Upgrades at 132H and beyond to operate at request MW capability under NRIS. No issues were identified in the steady state or stability analysis that are attributed to IR662.

The facilities associated with IR662 are not designated as NPCC BPS as IR662 does not affect the BPS status of existing facilities. IR662 also does not qualify as NERC BES based on project size and interconnection point.

IR662 Under Frequency Ride Through capability was tested under dynamic simulation. The facility remained connected when system frequency deviation caused Under Frequency Load Shedding *(UFLS)* relays to activate. While charging, IR662 also assisted in frequency recovery by momentarily switching to discharging while system frequency was below nominal.

IR662 low voltage ride through *(LVRT)* capability was tested to cover expected system operating conditions in winter peak, summer peak and light load. The simulations showed that IR662 remained on-line with temporarily reduced power and ramped back to rated power during contingency and remained stable post contingency.

The loss factor calculation is based on a winter peak case with and without IR662 in service. The calculated loss factor is 0.1% at IR662's generator terminal *(660V)* and -0.7% at its 138kV ICIF bus. This means system losses on peak are slightly reduced when IR662 is discharging at 50 MW.

Due to the higher-queued project IR672's withdrawal from the Queue, steady state analysis, stability analysis, and NPCC-BPS test was re-studied with IR672 removed from the study. No other issues were identified in the steady state or stability analysis that are attributed to IR662. IR662 does not affect the BPS status of existing facilities.

It is concluded that the incorporation of the proposed facility into the NS Power transmission at the specified location has no negative impacts on the reliability of the NS Power grid, provided the recommendations provided in this report are implemented.

6.2 Summary of expected facilities

To accommodate IR662's 132H-B61 POI, the total high level non-binding estimated cost in 2023 Canadian dollars for the new Transmission Provider's Interconnection Facilities *(TPIF)* is $1,870,000, which includes 10% contingency but excludes HST. The costs of all associated facilities required at the IC's substation and Generating Facility are in addition to this estimate. This cost excludes any additional costs or changes to be identified by the subsequent Facility Study as well as any cost associated with ICIF generating facility.

The IC will be responsible for acquiring the ROW *(Right-Of-Way)* for all the facilities. The right of way shall be registered in NSPI's name.

The non-binding construction tine estimate of NSPI Transmission Provider Interconnection Facilities is two years, but to be confirmed by the Facility Study.