Interconnection Feasibility Study Report
GIP-IR736-FEAS-R0

Generator Interconnection Request #736
84 MW Offshore Wind Facility
Pictou, NS

2024-05-31

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

This Feasibility Study report (FEAS) is based on the Feasibility Study Agreement, signed by the Interconnection Customer (IC) on November 30, 2023 and Nova Scotia Power Inc. (NSPI) on December 7, 2023 for connection of an 84 MW wind power generating facility at Pictou County in Nova Scotia (NS).

The agreement states twelve Nordex N-163 wind turbines with each turbine rated 7 MW.

The proposed Commercial Operation Date for IR736 is 2026/12/31.

The facility will interconnect to the NSPI system as Network Resource Interconnection Service (NRIS). The Point of Interconnection (POI) will be on L-7004, an existing 230 kV line between 3C-Port Hastings and 91N-Dalhousie Wind Farm substation.

There are a total of 22 transmission and distribution projects across NS identified in the Combined T/D Advanced Stage Interconnection Request Queue with higher queue positions than IR736.

The power system base cases for the feasibility study include all transmission connected IRs in the GIP queue up to and including IR742 with the exception of IR686, as the IR686 SIS was not completed when IR736 was initiated.

In this feasibility study, IR736 is assessed with the premise that it will displace thermal generation in Nova Scotia, with the order of units in Cape Breton to Central to Halifax, for the clean power initiative. In doing so, NSPI continues to maintain a minimum number of thermal units (synchronous generators) to maintain system strength and system stability. Hence, when this level of thermal generation is reached and Nova Scotia power system is operating at minimum generation, wind generation in NS, including IR736, will be curtailed accordingly. In addition, even though IR736 is studied as NRIS, NSPI system operators can curtail IR736 at any time to maintain system reliability as per the GIP.

The Transmission Service Reservation TSR-411 for 550 MW from New Brunswick to Nova Scotia is not included as per the attached notice on NSPI's OASIS site.

NS Power notes that NERC standard PRC-029-1 is currently in development. As proposed, this standard will impose performance requirements for voltage and frequency ride through behaviour on inverter-based generating resources. It is anticipated that this standard will be applicable to the project currently under study. The Interconnection Customer is advised to consider the requirements of PRC-029-1 in their project design to ensure that their project can conform to these requirements. Conformance will be validated at the System Impact Study stage.

Since L-7004 is a Bulk Power System element, connection to this line will require a three ring bus breaker substation at the POI on the line as per NSPI's requirements.

The assessment shows that addition of IR736 does not require any replacement of transmission circuit breakers due to increased short circuit levels contributed by IR736.

The minimum short circuit ratio (SCR) is estimated at 3.1, however there are a number of other wind farms in the vicinity which will reduce the effective SCR further. This value is just an estimate at this time and will very much depend on the design of the collector circuits and the impedances of the wind turbine generating transformers as well as the main substation transformer, hence the IC should carry out detailed short circuit modelling and discuss with the wind turbine supplier to ensure efficient operation of the wind turbines.

In addition, the IC will need to discuss with the wind turbine suppliers to ensure that the wind turbines can meet all requirements of NSPI's Transmission System Interconnection Requirements (TSIR).

With reference to Inertia Response, section 7.6.7 of TSIR requires "WECS Generating Facilities shall support short-duration frequency deviations by providing inertia response equivalent to a Synchronous Generator with an inertia factor (H) of at least 3.0 MWs/MVA for a period of at least 10 seconds."

The information provided for voltage flicker and harmonics does not indicate that IR736 will cause issues with voltage flicker or harmonics. However, if IR736 does, then IR736 will be required to resolve the issue.

The assessment of thermal limit and voltage violations does not result in any system issues that are attributed to IR736.

Since L-7004 is part of two Remedial Action Schemes (RAS) that govern the level of power transmission from Cape Breton to Mainland NS, these RAS will require changes to accommodate IR736. In addition, L-7004 shares common towers with L-7003 at Canso causeway and at Trenton, which are also part of the RAS.

- One RAS is a Limited Impact RAS that has a Northeast Power Coordinating Council (NPCC) designation as "Type III SPS#113, 230 PHLO".
- The other RAS is a Type I RAS that has NPCC designation as "Type I SPS#119 NS 345 kV".
- SPS stands for Special Protection Scheme which is just another term for RAS. Changes to RAS are subject to NPCC's review and approval.

The reactive power assessment indicates that IR736 will require power factor correction equipment installed to meet NSPI's power factor requirements of +/- 0.95 at the high voltage side of the main substation transformer (on the 230 kV side) when IR736 delivers reactive power to the system at full MW output and to deliver rated reactive power at 0 MW output. In addition, The IC will need to explore the options for IR736 to provide rated reactive power at 0 MW output and supply the information for the SIS to make the assessment.

The high level non-binding cost estimate for the Network Upgrades (NU), which include the three breaker ring bus at the POI substation which includes protection and control changes at the remote terminals of L-7004 and the RAS changes plus 25% contingency is $11.75 million CAD.

The high level non-binding cost estimate for the Transmission Provider's Interconnection Facilities (TPIF) upgrades plus 25% contingency is $1.58 million CAD. That includes the cost of installing 75 meters of 230 kV transmission line from POI substation to IC substation, protection & control relaying equipment on the 230 kV side, NSPI supplied Remote Terminal Unit, Tele-protection & SCADA communication.

Thus, the high level non-binding cost estimate for both NU and TPIF is $13.33 million CAD in 2024 dollars, excluding taxes. This estimate is subject to changes to be determined in the SIS and Facility (FAC) studies.

The cost of the Interconnection Customer's Interconnection Facilities (ICIF) is separate, is at the IC's own cost and is not included in this study. Its design must meet NSPI's Transmission System Interconnection Requirements (TSIR) and NERC's BES and possibly NPCC's BPS requirements which will be determined by the SIS.

The IC will obtain Right Of Way (ROW) for 75 meters of 230 kV transmission line from the IC's substation to the POI and fund its construction costs and maintenance costs in perpetuity, but NSPI will own and operate it. The IC will also obtain the ROW for the POI substation.

The estimated time to construct the NU and TPIF is 24-36 months after the receipt of funds. The time frame will be further determined by the FAC study.

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1.0 Introduction

This Feasibility Study report (FEAS) is for Interconnection Request #736 (referred to as IR736), an 84 MW wind power generating facility at Pictou County in Nova Scotia (NS), to be connected to NSPI power system as a Network Resource Interconnection Service (NRIS).

The Point of Interconnection (POI) will be on L-7004, an existing 230 kV line between 3C-Port Hastings and 91N-Dalhousie Wind Farm substation.

The POI will be at a line length of 54 km from 3C-Port Hastings substation. The generating facility will comprise of twelve Nordex N-163 wind turbines with each turbine rated 7 MW.

The proposed Commercial Operation Date for IR736 is 2026/12/31.

There are a total of 22 transmission and distribution projects across NS identified in the Combined T/D Advanced Stage Interconnection Request Queue with higher queue positions than IR736.

The power system base cases for the feasibility study include all transmission connected IRs in the GIP queue up to and including IR742 with the exception of IR686, as IR686 SIS was not completed when IR736 was initiated.

Figure 1 shows IR736 POI connection to L-7004.

Figure 1: IR736 POI to L-7004.

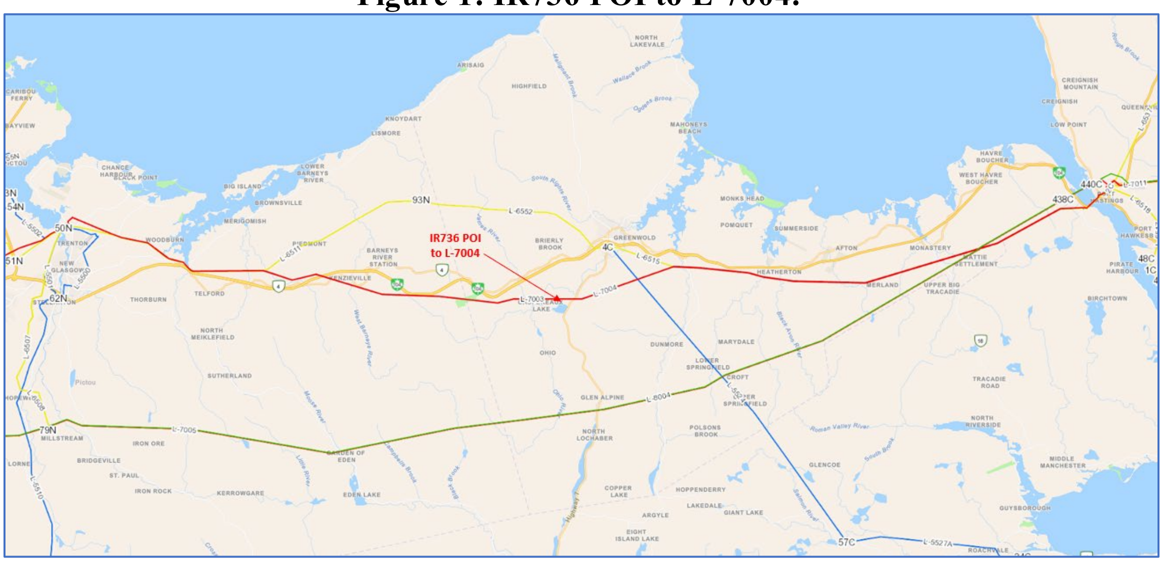
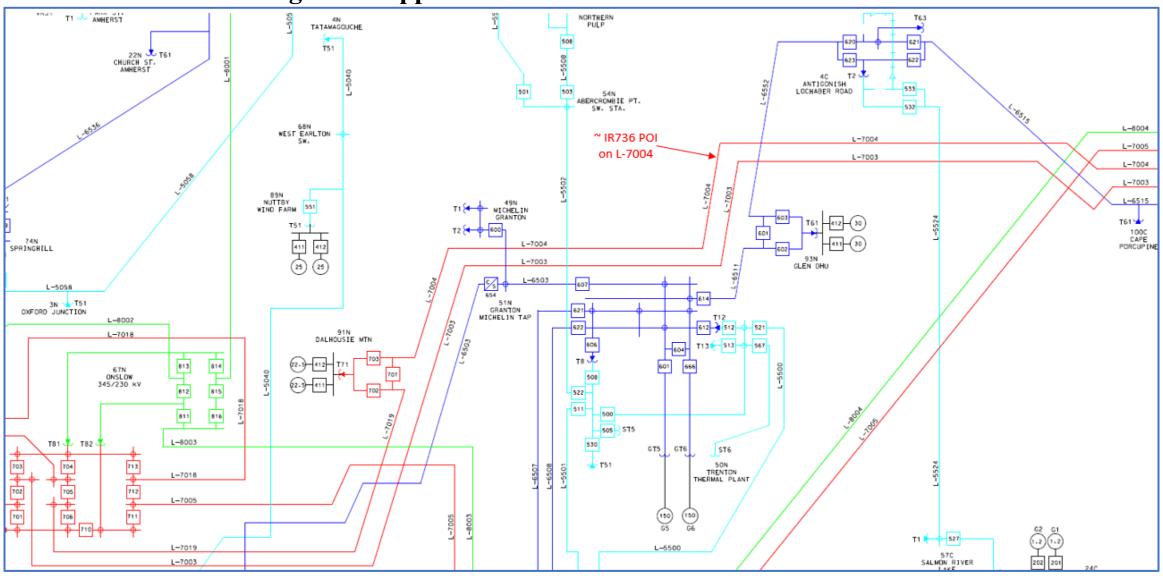


Figure 2 shows the approximate POI location on NSPI's electrical transmission one-line.

Figure 2: Approximate IR736 POI on NSPI network.



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 generation 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 above their thermal limits and potential voltage criteria violations.

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 because 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.
- 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 to ascertain the final cost estimate to the interconnect the generating facility.

3.0 Assumptions

This FEAS is based on the following information:

1. As per the Feasibility Study Agreement, signed by IC on November 30, 2023 and NPSI on December 7, 2023:
    1.1. Network Resource Interconnection Service (NRIS).
    1.2. POI on L-7004.
    1.3. The maximum facility output is 84 MW, comprising of twelve Nordex N-163 wind turbines with each wind turbine rated at 7 MW. The power output of the wind turbines will be collected via three collector circuits.
2. The IC provided an electrical one-line that shows:
    2.1. Three 230 kV breaker ring bus at the POI on L-7004
    2.2. The main IC substation transformer is rated 54/72/90 MVA, 230kV to 34.5 kV, Grounded Y HV/Grounded Y LV/ Delta Tertiary. Z+=8.5% (on 54 MVA).
        2.2.1. The X/R ratio was not available, so a value of 30 was assumed for this study.
3. The IC provided the layout of the collector circuits, which indicates the individual wind turbine step up transformer having an impedance of 9% on 7.8 MVA.
    3.1. The X/R ratio was not available, so a value of 14 was assumed for this study.
4. The transmission line ratings are already in the power system cases using NSPI's latest "Transmission Line Ratings Summary", dated December 29, 2023.
5. The order of generation in NS as defined by NSPI as follows:
    - Trenton 5
    - Lingan 1
    - Lingan 4
    - Lingan 3
    - Pt Aconi
    - Pt Tupper
    - Trenton 6
    - Tufts Cove 1
    - Tufts Cove 2

- Tufts Cove 3
- Tufts Cove 4, 5, 6

While maintaining a minimum of three thermal units on-line to provide short circuit level for NSPI's system operation and system stability: Trenton 6, Tufts Cove 3, and Point Tupper 2. These three generating units can be dispatched at minimum power output, following which IR 736 and other renewable resources would be curtailed on a non-discriminatory basis to serve the remaining system load.

In this feasibility study, it assumes that Lingan 2 is retired as per NSPI's generation plan.

4.0 Project Queue Position

All in-service generation is included in this FEAS; except Lingan Unit 2, which is assumed to be retired.

As of 2024/02/15, the following projects are higher queued in the Advanced Stage Interconnection Request Queue and are committed to the study base cases:

- IR426: GIA Executed
- IR516: GIA Executed
- IR540: GIA Executed
- IR542: GIA Executed
- IR517: GIA in Progress
- IR574: GIA Executed
- IR598: GIA Executed
- IR597: GIA Executed
- IR647: GIA in Progress
- IR664: FAC Complete
- IR662: FAC Complete
- IR670: FAC Complete
- IR671: FAC in Progress
- IR669: FAC Complete
- IR668: FAC Complete
- IR618: FAC Complete
- IR673: FAC Complete
- IR675: FAC Complete
- IR677: SIS in Progress
- IR697: SIS in Progress
- IR739: SIS in Progress
- IR742: SIS in Progress

The power system base cases for the feasibility study includes all transmission connected IRs in the GIP queue up to and including IR742 with the exception of IR686, as the IR686 SIS was not completed when IR736 was initiated.

In addition, TSR-411 is included in the queue, which reflects the study of long-term firm Transmission Service Reservation (TSR) from New Brunswick to Nova Scotia. If approved by the NSUARB, the TSR is expected to be in service in 2028 and a system study is currently underway to determine the required updates to the Nova Scotia transmission system. This has not been included in the feasibility study and the following notice is posted to the OASIS site (at https://www.nspower.ca/oasis/generation-interconnection-procedures):

> ***Due to ongoing development discussions and engineering studies, the Transmission System Network Upgrades identified as part of Transmission Service Request #411 will not be included in the System Impact Study (SIS) Analysis for Generator Interconnection Procedures (GIP) Study Groups #32 to 35. GIP Study Group #32 to #35 analysis will be limited to the 2022 Transmission System configuration plus any material Network Upgrades identified in higher queued projects.***

As for the Transmission Service Request (TSR) Queue, it is shown on Table 1.

Table 1: TSR queue

OATT Transmission Service
Queued System Impact Studies
Active December 11, 2023

Item	Project	Date & Time of Service Request	Project Type	Project Location	Requested In-Service Date	Project Size (MW)	Status
1	TSR 400	July 22, 2011	Point-to-point	NS-NB*	May 2019	330	System Upgrades in Progress
2	TSR 411	January 19, 2021	Point-to-point	NS-NB*	January 1, 2028	550	Facilities Study in Process

* Indicates project as being located near provincial border.

5.0 Short Circuit

The short circuit analysis was performed using PSS/e 34.8.2 with classical fault option, flat voltage profile at 1.0 per unit voltage, and three phase to ground faults.

The short circuit model for IR736 is based on Nordex technical bulletin "E0003661765, Rev 04, 24.02.2023" provided by the IC for N-163 wind turbines.

IR736 short circuit model was incorporated into NSPI short circuit system case and was simulated with IR736 off-line and with IR736 on-line and the results for relevant buses are shown in Table 2. Please note that this analysis is for NSPI to determine the impact of IR736 on NSPI's existing breaker fault interrupting ratings and not for IR736 generating facility design or operation. IR736 is required to do its own detailed design to ensure its operational viability.

Table 2: Short Circuit Levels

Location	IR736 Off	IR736 On
Maximum Generation System Normal (Magnitude in MVA / Angle in Degree)		
91N-Dalhousie WF 230 kV	2775/ -83.43	2839 / -83.47
3C-Port Hastings 230 kV	4085 / -84.91	4192 / -84.96
IR736 POI 230 kV	2041 / -82.23	2225 / -82.74
IR736 WEC Tx 34.5 kV	473 / -86.28	744/ -87.23
IR736 WEC Tx 950 V	327 / -86.18	707/ -88.23
Minimum Generation (TC3, TR6, PT2 on) System Normal		
91N-Dalhousie WF 230 kV	1405 / -85.42	1517 / -85.43
3C-Port Hastings 230 kV	1535 / -86.45	1673/ -86.50
IR736 POI 230 kV	1175 / -84.69	1359 / -85.20
IR736 WEC Tx 34.5 kV	420 / -86.56	691 / -87.48
IR736 WEC Tx 950 V	306 / -86.42	686 / -88.40
Minimum Generation + L-7004 (IR736-3C) Out		
91N-Dalhousie WF 230 kV	1273 / -85.04	1437/ -85.32
3C-Port Hastings 230 kV	1445 / -86.40	1501 / -86.27
IR736 POI 230 kV	692 / -82.86	876 / -84.04
IR736 WEC Tx 34.5 kV	338 / -85.34	609 / -86.93
IR736 WEC Tx 950 V	**262** / -85.53	641 / -88.18
Minimum Generation + L-7004 (IR736-91N_DalWF) Out		
91N-Dalhousie WF 230 kV	1273 / -85.04	1318 / -84.88
3C-Port Hastings 230 kV	1445 / -86.40	1615 / -86.55
IR736 POI 230 kV	864 / -83.91	1049 / -84.71
IR736 WEC Tx 34.5 kV	372 / -86.01	644 / -87.23
IR736 WEC Tx 950 V	281 / -86.02	660 / -88.31

All the 230 kV breakers in the vicinity of IR736 exceed the short circuit interrupting capability of 10, 000 MVA and the three phase short circuit levels shown in Table 2 do not exceed 10, 000 MVA, hence IR736 does not incur any change out of the 230 kV breakers.

Regarding the minimum short circuit ratio (SCR), Nordex's technical bulletin "9014839, Rev 01, Approved 22-09-2023" refers to a SCR of 3.

Table 2 shows the short circuit level at the wind turbine terminal can be 262 MVA which equates to a SCR of 262/84 = 3.1, however there are a number of other wind farms in the vicinity which will reduce the effective SCR further. This value is just an estimate at this time and will very much depend on the design of the collector circuits and the impedances of the wind turbine generating transformers as well as the main substation transformer, hence the IC should carry out detailed short circuit modelling and discuss with the wind turbine supplier to ensure efficient operation of the wind turbines.

In addition, the IC will need to discuss with the wind turbine suppliers to ensure that the wind turbines can meet all requirements of NSPI's Transmission System Interconnection Requirements (TSIR).

With reference to Inertia Response, section 7.6.7 of TSIR requires "WECS Generating Facilities shall support short-duration frequency deviations by providing inertia response equivalent to a Synchronous Generator with an inertia factor (H) of at least 3.0 MW.s/MVA for a period of at least 10 seconds.".

6.0 Voltage Flicker & Harmonics

Nordex's technical bulletin "2001290EN, Rev 04, approved 02-06-2023", provided by the IC, states that the testing of electrical characteristics are carried out at the wind turbine terminals at the lower voltage side of the wind turbine transformer.

Based on the information provided, it is estimated that the voltage flicker levels P_{st} and P_{lt} at the 230 kV POI would be 0.0693 and 0.0655 respectively, which are below NSPI's required levels of 0.25 for P_{st} and 0.35 for P_{lt}. Hence, it is not expected that IR736 will cause voltage flicker issues, but if IR736 does, then IR736 will be required to resolve the issue.

As for harmonics, NSPI requires all IRs to meet Harmonics IEEE-519 standard. Since the wind turbine technical bulletin on harmonics for IR736 states that the harmonics levels are measured at the 950 V of the wind turbine voltage terminal and the values provided are below those required in IEEE-519 standard for that voltage level, hence it is not expected that IR736 will cause harmonics issues or will exceed the harmonics limit at 230 kV POI, but if IR736 does, then IR736 will be required to resolve the issue.

7.0 Thermal Limit and Voltage Limit Assessment

For the steady state thermal and voltage assessment, a total of 32 power flow cases and 489 transmission contingencies were simulated for each case.

Half of the cases (with suffix a) have IR736 off-line and the other half (with suffix b) have IR736 on-line for determining any new system issues and upgrades that can be attributed to IR736.

The cases reflect a number of system dispatches:

- Maritime Link HVDC at maximum and minimum.
- NS wind at capacity value of 17% and at 100% when the power system can allow.
- High levels of Cape Breton Export (CBX) and Onslow Import (ONI).
- NB delivers 10 minute operating reserve to NS for loss of 1 pole of Maritime Link HVDC.
- NS delivers 10 minute operating reserve to NB for loss of Point Lepreau nuclear power plant.
- Seasons: winter peak (WIN), summer peak (SUM), summer minimum load (SML), summer shoulder (SSH).

In non system peak cases, with the Maritime Link HVDC at zero and depending upon NS to be able to export to NB, the non system peak cases may not be dispatched at 100% NS wind, hence it is expected that IR736 will be curtailed along with other wind facilities in NS. Nonpeak cases, C23a, C23b, C63a, C63b have IR739 off-line to avoid local system issues that are not yet resolved by IR739 as its SIS is not yet completed. IR739 is electrically remote from IR736 and can be omitted in these cases for the study of IR736.

The contingencies in NS and some in NB include:

- Loss of a single transmission system element.
- Breaker failure to operate (BBU).
- Loss of double circuit towers (DCT).
- Loss of load (LOL).
- Loss of source (LOS).

The criteria for assessment are as follows:

- Under system normal, all elements in service, system voltages are no less than 0.95 per unit and element loading must be within nominal rating (Rate A).
- Post contingency steady state, system voltages are no less than 0.9 per unit and element loading is within short time rating (Rate B). For NS, the element loading must also be within rate D (short time rating for the element auxiliary equipment).

There are some existing system conditions observed in the power system cases used in this feasibility study that are not attributed to IR736:

- VJ gas turbines are on-line in winter peak to avoid local overload (NSPI Operations to operate VJ gas turbine as needed)
- 22W remote 69 kV bus slightly below 0.95 per unit in system normal (NSPI to mitigate).
- Transformers at 58H, 137H, 75W have loading above rating in system normal (NSPI to mitigate).

Table 5 and Table 6 of Section 13 show the detailed dispatch of the power flow cases and Table 7 and Table 8 of Section 14 show the contingencies in NS and NB that were simulated in steady state power flow.

Since L-7004 is part of two Remedial Action Schemes (RAS) that govern the level of power transmission from Cape Breton to Mainland NS, these RAS will require changes to accommodate IR736's POI on this line.

One RAS is a Limited Impact RAS that has a Northeast Power Coordinating Council (NPCC) designation as "Type III SPS#113, 230 PHLO".

The other RAS is a Type I RAS that has NPCC designation as "Type I SPS#119 NS 345 kV".

SPS stands for Special Protection Scheme which is just another term for RAS, which is subject to NPCC's review and approval.

The power flow analysis does not identify any additional network upgrades other than the changes to the RASs.

8.0 Reactive Power & Voltage Control

The analysis of power factor requirements in this feasibility study is based on the power factor information in the technical bulletin (2015169EN, Rev.1/2022-02-02) provided by the IC. Table 1 in this bulletin shows that each 7 MW wind turbine can provide +3.25 MVAR capacitive and -3.39 MVAR inductive.

The aggregate of 12 wind turbines will be modeled with Qmax of +39 MVAR and Qmin of -40.68 MVAR.

For Qmax analysis, Figure 4 shows the power flow when IR736 delivers its maximum MVAR at its full 84 MW output.

Figure 3: Qmax power flow diagram.

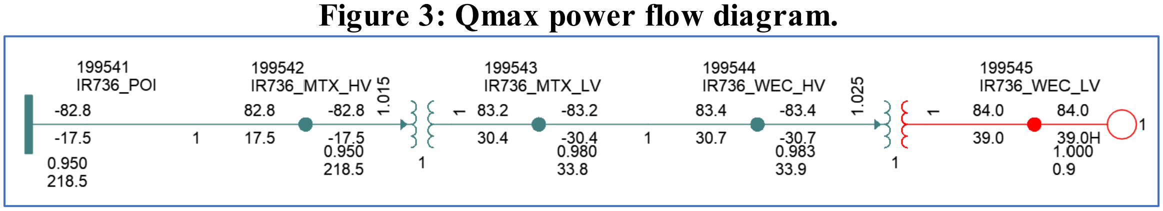


Figure 4 shows that the high side of the main substation transformer delivers 82.8 MW and 17.5 MVAR, equating to a power factor of 0.98 which is higher than NSPI's requirement of 0.95 or less, hence IR736 will require to install power factor correction equipment to meet NSPI's power factor requirements when it delivers MVAR to the power system.

For Qmin analysis, Figure 5 shows the power flow when IR736 absorbs MVAR at its full 84 MW output.

Figure 4: Qmin power flow diagram.

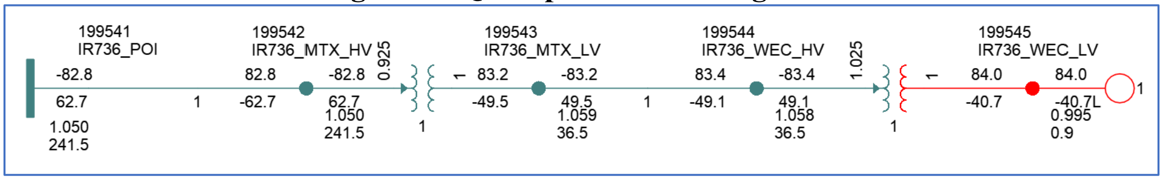


Figure 5 shows that the high side of the main substation transformer delivers 82.8 MW and absorbs 62.7 MVAR, equating to a power factor of 0.8 which meets NSPI's requirement of 0.95 or less, hence IR736 will meet NSPI's power factor requirement when it absorbs MVAR from the power system.

NSPI's power factor requirement also requires IR736 to provide rated MVAR at zero MW output. The IC will need to explore the options and supply the information for the SIS to make the assessment.

A centralized controller will be required, which continuously adjusts the individual generator reactive power output within the plant capability limits and regulates the voltage at the low voltage terminal of the two main transformers. 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 generator's 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 the NS Power Transmission System Interconnection Requirements (TSIR)[1]. The SIS will examine the plant capabilities and controls in detail to specify options, controls, and additional facilities that are required to achieve low voltage ride through.

9.0 NPCC and NERC Requirements

In NS, certain transmission system elements are required to meet NPCC[2] BPS (Bulk Power System) or NERC[3] BES (Bulk Electric System) requirements or both.

Since the POI for IR736 will be on the 230 kV line L-7004 which is classified for both NPCC BPS and NERC BES, therefore the POI substation, the 230 kV line extension to the IC substation will be BPS.

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[1] NS Power Transmission System Interconnection Requirements; https://www.nspower.ca/oasis/generation-interconnection-procedures
[2] Northeastern Power Coordination Council.
[3] North American Electric Reliability Corporation.

The SIS will determine the correct classification of the IC substation and the IC generating facility for NPCC BPS and/or NERC BES.

10.0 Expected Facilities Required for Interconnection

The following facilities are required to interconnect IR736 to the NSPI system via the POI on L-7004 as NRIS:

1) **Network Upgrades (NU):**
   a) Three breaker ring bus at 230 kV POI substation complete with P&C and connection to L-7004. This substation must be designed to meet NPCC's BPS requirements and NERC's BES requirements, which include protection and control modifications at 91N-Dalhousie Mountain substation and 3C-Port Hastings substation of L-7004.
   b) Changes to a Limited Impact RAS (NPCC Type III SPS#113, 230 PHLO).
   c) Changes to a Type I RAS (NPCC Type I SPS#119, NS 345 kV).
2) **Transmission Provider's Interconnection Facilities (TPIF):**
   a) 44 km of Drake 795 ACSR, 100 deg C, 230 kV line from POI substation to IC substation. This new 230 kV line must be designed to meet NPCC BPS requirements and NERC's BES requirements. The IC is responsible for obtaining ROW and funding its construction and for maintenance costs in perpetuity, but NSPI will own and operate it.
   b) Protection and control for relaying equipment.
   c) NSPI supplied Remote Terminal Unit (RTU).
   d) Tele-protection and SCAD communications.
3) **Interconnection Customer's Interconnection Facilities (ICIF*)*:**
   a) Facilities to provide ±0.95 power factor when delivering rated output (84 MW) at the 230 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 transformers. Fast acting control is required and will include a curtailment scheme, which will limit/reduce total 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 curtailed, the facility shall offer over-frequency and under-frequency control with ±0.2 Hz dead band and 4% droop characteristic. The active power controls shall also 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, and curtailment state.

f) Meet all the requirements detailed in the NS Power Transmission System Interconnection Requirements (TSIR)[4]. Among them is voltage ride-through capability per section 7.4.1, frequency ride-through per section 7.4.2, and section 7.6.7 regarding inertia "WECS Generating Facilities shall support short-duration frequency deviations by providing inertia response equivalent to a Synchronous Generator with an inertia factor (H) of at least 3.0 MW.s/MVA for a period of at least 10 seconds.".

g) 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.

h) 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°).

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

NS Power notes that NERC standard PRC-029-1 is currently in development. As proposed, this standard will impose performance requirements for voltage and frequency ride through behaviour on inverter-based generating resources. It is anticipated that this standard will be applicable to the project currently under study. The Interconnection Customer is advised to consider the requirements of PRC-029-1 in their project design to ensure that their project can conform to these requirements. Conformance will be validated at the System Impact Study stage.

11.0 NU and TPIF Cost Estimates

The high level, non-binding, cost estimate, excluding HST, for IR736's Network Resource Interconnection Service is shown in Table 3.

[4] NS Power Transmission System Interconnection Requirements; https://www.nspower.ca/oasis/generation-interconnection-procedures

Table 3: Cost Estimate

Item	Network Upgrades (NU)	Estimate ($M CAN)
1	Three breaker ring bus at POI substation complete with P&C and connection to L-7004. This substation must be designed to meet NPCC's BPS requirements and NERC's BES requirements. This cost estimate includes P&C modifications at 91N-Dalhousie Mountain substation and 3C-Port Hastings substation of L-7004	9.00
2	Changes to a Limited Impact RAS (NPCC Type III SPS#113, 230 PHLO)	0.20
3	Changes to a Type I RAS (NPCC Type I SPS#119, NS 345 kV)	0.20
	Contingency (25%)	2.35
	Network Upgrade Sub-total	11.75
Item	**Transmission Provider's Interconnection Facilities (TPIF)**	**Estimate ($M CAN)**
1	Install 75 m (0.075 km) of wood pole H-frame, Dove 556 ACSR, 100 deg C, 230 kV line from POI substation to IC substation. This new 230 kV line must be designed to meet NPCC BPS requirements and NERC’s BES requirements.	0.11
2	P&C relaying equipment	0.30
3	NSPI supplied RTU	0.10
4	Tele-protection and SCADA communications	0.75
	Contingency (25%)	0.32
	TPIF Upgrade Sub-total	1.58
	Total Network Upgrades and new TPIF, excluding HST	**13.33**

This cost estimate is subject to change as will be determined by the SIS and FAC study.

The estimated time to construct the Network Upgrades and Transmission Provider's Interconnection Facilities is 24-36 months after receipt of funds. This time frame will be determined and confirmed in the Facility Study.

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 and how effectively the new facility can displace generation at Tufts Cove.

Table 4: IR736 Loss Factor

Component	at IR736 Terminal	at POI
IR736 on at 84 MW	84.00	82.80
TC plant total MW with IR736 on	73.00	73.00
TC plant total MW with IR736 off	148.30	148.30
IR736 Loss Factor	+10.4%	+9.1%

The loss factor at POI is lower because it does not include the losses from POI to IR736 facility.

13.0 Cases

Table 5: Steady State Power Flow Cases Part 1

Case	IR736	NB to NS	NB to PEI	NB to NE	NB to HQ	NL to NS	CBX	ONI	ONS	NS Trans Wind
C02a_WIN	0	0	289	0	-960	475	1008	1037	851	261
C02b_WIN	84	0	289	0	-960	475	924	1037	851	345
C03a_WIN	0	0	288	0	-960	86	210	593	552	1389
C03b_WIN	84	1	288	0	-960	86	183	615	576	1473
C04a_WIN	0	142	259	0	-960	237	791	819	776	261
C04b_WIN	84	142	259	0	-960	237	708	819	776	345
C05a_WIN	0	-381	289	10	-960	475	1010	1145	607	528
C05b_WIN	84	-382	289	10	-960	475	927	1146	607	612
C22a_SUM	0	-150	228	800	-845	330	549	650	401	236
C22b_SUM	84	-150	228	800	-845	330	465	650	401	320
C23a_SUM	0	-163	228	813	-845	0	-144	347	230	1299
C23b_SUM	84	-163	228	814	-845	0	-226	347	230	1383
C24a_SUM	0	142	228	800	-845	237	467	571	615	236
C24b_SUM	84	142	228	800	-845	237	384	571	615	320
C25a_SUM	0	-500	228	800	-845	340	911	995	389	236
C25b_SUM	83	-500	229	799	-845	340	827	995	389	319
C42a_SML	0	-150	55	450	-460	170	39	210	47	236
C42b_SML	84	-150	55	450	-460	170	12	211	47	320
C43a_SML	0	-330	55	448	-460	0	-143	134	-141	776
C43b_SML	84	-404	55	520	-460	0	-143	216	-135	860
C44a_SML	0	142	55	444	-460	85	-104	-9	121	236
C44b_SML	84	59	55	528	-460	85	-104	73	121	320
C45a_SML	0	-500	55	440	-460	0	-83	194	-255	776
C45b_SML	6	-500	55	440	-460	0	-83	200	-249	782
C46a_SML	0	-66	55	466	-460	0	-199	219	141	574

Case	IR736	NB to NS	NB to PEI	NB to NE	NB to HQ	NL to NS	CBX	ONI	ONS	NS Trans Wind
C46b_SML	84	-147	55	547	-460	0	-199	301	141	658
C62a_SSH	0	-151	162	801	-813	330	291	369	163	236
C62b_SSH	84	-152	161	801	-813	330	289	427	221	320
C63a_SSH	0	-418	162	812	-813	0	-181	259	-73	1299
C63b_SSH	84	-419	162	812	-813	0	-183	339	5	1383
C72a_SUM	0	-150	228	800	-845	330	549	650	401	236
C72b_SUM	84	-150	228	800	-845	330	465	650	401	320

Table 6: Steady State Power Flow Cases Part 2

Case	NS Load	Mot Load	TC	TR	PT2	LG	PA	BS	VJ	TUS	WC	Pt Lepre.
C02a_WIN	2340	0	389	165	155	250	184	0	66	30	190	715
C02b_WIN	2340	0	389	165	155	189	158	0	66	30	190	715
C03a_WIN	2297	0	213	110	100	0	0	0	66	30	190	715
C03b_WIN	2297	0	190	78	73	0	0	0	66	30	190	715
C04a_WIN	2331	0	389	151	156	258	184	72	66	30	190	715
C04b_WIN	2331	0	389	151	156	172	184	72	66	30	190	715
C05a_WIN	2340	0	390	165	155	245	184	100	66	30	190	0
C05b_WIN	2340	0	390	165	155	189	153	100	66	30	190	0
C22a_SUM	1545	135	386	160	150	110	174	0	0	0	80	715
C22b_SUM	1545	135	386	160	150	63	135	0	0	0	80	715
C23a_SUM	1587	197	73	160	83	80	0	0	0	10	0	715
C23b_SUM	1578	197	73	158	73	0	0	0	0	10	0	715
C24a_SUM	1541	135	168	160	150	110	184	0	0	0	80	715
C24b_SUM	1541	135	168	160	150	63	145	0	0	0	80	715
C25a_SUM	1563	135	314	160	150	480	184	80	0	0	80	0
C25b_SUM	1563	135	314	160	150	392	184	80	0	0	80	0
C42a_SML	743	165	141	154	100	0	0	0	0	0	0	600
C42b_SML	743	165	141	97	73	0	0	0	0	0	0	600
C43a_SML	743	165	74	79	73	0	0	0	0	0	0	419
C43b_SML	743	165	68	78	73	0	0	0	0	0	0	419
C44a_SML	775	197	68	78	73	0	0	0	0	0	0	715
C44b_SML	775	197	68	78	73	0	0	0	0	0	0	715
C45a_SML	743	165	74	79	73	0	0	100	60	16	0	0
C45b_SML	743	165	68	78	73	0	0	100	60	16	0	0
C46a_SML	775	197	68	78	73	0	0	0	0	0	0	600
C46b_SML	775	197	68	78	73	0	0	0	0	0	0	600
C62a_SSH	1172	135	366	100	75	0	126	0	0	0	0	715
C62b_SSH	1172	135	308	78	73	0	126	0	0	0	0	715
C63a_SSH	1218	197	200	78	75	0	0	0	0	10	0	600

Case	NS Load	Mot Load	TC	TR	PT2	LG	PA	BS	VJ	TUS	WC	Pt Lepre.
C63b_SSH	1214	197	117	78	73	0	0	0	0	10	0	600
C72a_SUM	1545	135	311	160	150	110	174	0	0	25	80	715
C72b_SUM	1545	135	311	160	150	63	135	0	0	25	80	715

14.0 Contingencies

Table 7: Steady State Contingencies Part 1

101S_701	17V_B63	50N_G6	90H_606	L1193-UV
101S_702	17V_T1	50N_T12	90H_608	L1199
101S_703	17V_T2	50N_T8	90H_609	L2101*
101S_704	17V_T63	50NB61G6	90H_611	L2102*
101S_705	1C_689	50NB62G5	90H_612	L2103
101S_706	1C_B61	50W_501*	90H_T1	L2130
101S_711	1C_B62	50W_600SEP	91H_511	L2130-BF-K2-9
101S_712	1C_G2	50W_B2	91H_513	L2131-2111
101S_713	1N_600	50W_B3*	91H_516	L2131-2111-BF-B2103-2131
101S_811	1N_601	50W_B4	91H_521	L2145
101S_812*	1N_613	51V_500*	91H_523	L2145-BF-K2-6
101S_813*	1N_B51	51V_601	91H_603	L2145-BF-K2-7
101S_814	1N_B52	51V_602	91H_604	L3001*
101S_816	1N_B61	51V_603	91H_605	L3001-BF-K3-7*
101S_T81	1N_B62	51V_B51*	91H_606	L3001-BF-K3-8*
101S_T82	1N_C61	51V_B52	91H_607	L3002
101V_601	1N_T1	51V_T61*	91H_608	L3002-BF-CO3-6
101V_602	1N_T4	51V_T62	91H_609	L3002-BF-K3-1
101V_603	1V_B51	67N_701	91H_611	L3002-BF-K3-2
103H_600	20V_B51	67N_702	91H_613	L3003
103H_608	2CB61*	67N_703	91H_621	L3003-BF-K3-4
103H_681	2CB62*	67N_704	91H_T11	L3003-BF-P3-4
103H_881	2S_600	67N_705	91H_T62	L3004
103H_B61	2S_B64	67N_706	91H_TC3	L3004-BF-CO3-11-UV
103H_B62	2S_B65	67N_710	91N_701	L3004-BF-CO3-7*
103H_T81	2S_T1	67N_713	91N_Dal_WF	L3004-BF-NO3-01
108H_600	2S_T2	67N_811*	92V_B51	L3006
108H_B1	30N_B61	67N_812	99W_501	L3006-BF-ME3-1*
108H_B3	30NT61	67N_813	99W_600SEP	L3006-BF-ME3-2*
110W	30W_B51	67N_814*	99W_B51	L3006-BF-SA3-3
113H_600	30W_B61	67N_T71	99W_B61	L3008

Table 7: Steady State Contingencies Part 1				
11V_B51N*	3C_711	67N_T81	99W_B62	L3008-BF-BE3-1*
120H_621	3C_712*	67N_T82	99W_T61	L3008-BF-BE3-2*
120H_622	3C_713	67N711*	99W_T71	L3009
120H_623	3C_714	67N712*	99W_T72	L3009-BF-CO3-5
120H_624	3C_715*	7003a_4*	9W_500	L3010*
120H_626	3C_716	7003c_4*	9W_B52	L3010-BF-AN3-2*
120H_627	3C_T71	70087009SEP	9W_B53	L3010-BF-AN3-3*
120H_628	3C_T72	74N_B61	CT-L1104-L1116	L3010-BF-E2104-TC3*
120H_629	3C710*	74NT61	CT-L1147-L1165	L3010-BF-E3-1*
120H_710	3C720*	79N-T81 *	CT-L1148-L1151*	L3011*
120H_711	3S_T1	82V_B61	CT-L1149-L1212	L3011-BF-AN3-1*
120H_712	3W_B53	85S_B61	CT-L1190-L1215	L3011-BF-AN3-6*
120H_713	43V_503	85S_G1	CT-L2145-L1199	L3011-BF-K3-5*
120H_714	43V_562	88S_710	IR618	L3011-BF-K3-6*
120H_715	43V_B51	88S_711	IR618_BBU	L3012-3114
120H_716	43V_B61*	88S_712	IR668	L3013
120H_720	43V_B62	88S_713	IR668_BBU	L3013-BF-NO3-2*
120H_SVC	43V_T61*	88S_714	IR670	L3013-BF-SA3-4
120H_T71	43V_T62*	88S_715	IR670_BBU	L3016*
120H_T72	47C_T63	88S_720	IR725	L3016-BF-P3-10*
132H_602	47C_T64	88S_721	IR725_BBU	L3016-BF-SA3-6
132H_603	47C_T65	88S_722	IR736	L3017-3019*
132H_605	47C_T67	88S_723*	IR736_BBU	L3017-3019-BF-BA3-2*
132H_606	49N_600	88S_G4	IR739	L3017-3019-BF-SA3-1*
13V_B51	4C_620BBU	88S_T71	IR739_BBU	L3017-3019-BF-SA3-2-UV
15V_B51	4C_621BBU	88S_T72	L1147	L3018*
17V_512	4C_622BBU	89S_G1	L1149	L3018-BF-BA3-1*
17V_563	4C_623BBU	90H_503	L1157	L3018-BF-BE3-3*
17V_611	4C_T2	90H_602	L1159	L3022
17V_B1	4C_T63	90H_603	L1160	L3025-BF-ME3-3-Shunt
17V_B2	50N_604	90H_605	L1165	L-5003

Table 8: Steady State Contingencies Part 2		
L-5011	L-5571	L6516
L5012	L-5573L5575	L6517
L-5014	L-5580	L6518
L-5015	L6001	L6523
L-5016	L6002_90H	L6531
L-5017	L6002_99W	L6535
L5019_L5035	L6003	L6536

Table 8: Steady State Contingencies Part 2		
L-5020	L60036007	L6537*
L-5021	L60036009	L6538
L-5022	L6004	L6539
L-5024	L6004a	L6551
L-5025**	L6004b	L6552
L-5026**	L6005	L6613
L-5027	L60056010	L7001
L-5028	L60056016	L7002
L-5029L5030	L6006	L7003a
L-5032L5004	L6007	L7003b
L-5033	L6008	L7003c
L-5036	L6009	L7004a_IR736_91N
L-5037L3031	L6010	L7004b_IR736_3C
L-5039	L60106011	L7005Has*
L-5040	L6011	L7005Ons*
L5041	L6012	L7008
L-5042	L6013	L7009
L5049	L6014	L7011
L-5053	L6015	L7012
L-5054	L6016	L7014
L-5058	L6020	L7015
L-5060	L6021	L7019
L-5500	L6024	L7021
L-5501	L6025_50W-IR739	L70216534
L-5502	L6025_IR725-99W	L7022
L-5505	L6025_IR739-IR725	L8001*
L-5506	L6033	L8002
L-5507L5508	L60335039	L80027009
L-5511	L60336035	L8003 *
L-5512	L6035	L8004 *
L-5521	L6038	ML_2Poles
L-5524	L6040	ML_Pole1
L-5530	L60406042	ML_Pole2
L-5531	L6042	Lepreau
L-5532	L6043	104H600
L-5533L5581	L6044	1H
L-5534	L6047	2S_513
L-5535	L6048	47C_602
L-5536	L6051	47C_603
L-5537	L6051a	47C_674
L-5538	L6051b	PHP
L-5539	L6052	T-BA-T7

Table 8: Steady State Contingencies Part 2		
L-5540	L6053	T-CC-T1-UV
L-5541	L6054	T-CC-T2
L-5545	L6054a	T-ME-T3
L-5546	L6054b	T-NO-T1
L-5547L5551	L6055	T-SA-T2
L-5548	L6503	T-SA-T3
L-5549	L6507	
L-5550L5582	L65076508	
L-5559L5579	L6508	
L-5560	L6510	
L-5561L5565	L6511	
L-5563	L6514	
L-5564L5576	L6515	

Note: Contingencies with * are equipped with Remedial Action Scheme (RAS) or Special Protection Scheme (SPS) or Automatic Action Scheme (AAS).

15.0 Preliminary Scope of Subsequent SIS

The following provides a preliminary scope of work for the subsequent SIS for IR#736.

The SIS will include a more comprehensive assessment of the technical issues and requirements to interconnect generation as requested. It will include contingency analysis, system stability, transient stability, ride through capability, and operation following a contingency (N-1 operation). The SIS must determine the facilities required to operate this facility at full capacity, withstand any contingencies (as defined by the criteria appropriate to the location) and identify any restrictions that must be placed on the system following a first contingency loss.

The SIS will confirm the options and ancillary equipment that the customer must install to control flicker, voltage response, frequency response, control interactions with other IBR facilities, active power and ensure that the facility has the required ride-through capability. The SIS will be conducted in accordance with the GIP with the assumption that all appropriate higher-queued projects proceed, and the facilities associated with those projects are installed.

The following notice on OASIS provides additional clarification on the SIS model requirements:

NSPI-TPR-015-2: PSSE and PSCAD Model Requirements and NSPI-TPR-014-1: Model Quality Testing will undergo revision as the grid evolves and performance criteria changes. The most up to date version will be provided as they become available.
To be eligible for inclusion in the Interconnection System Impact Study stage, and thereby advance the Interconnection Request's initial Queue Position, the

Interconnection Customer must meet the progression milestone requirements of Section 7.2 of the GIP at least ten (10) Business Days prior to the Interconnection System Impact Study commencement date. For clarity, item 7.2 (i) – provision of a detailed stability model for the generator(s) shall mean:

- ***Provision of PSSE and PSCAD models in compliance with documents NSPI-TPR-015-2: PSSE and PSCAD Model Requirements, and***
- ***Provision of test data demonstrating model testing in compliance with NERC, NPCC and NSPI criteria. NSPI-TPR-014-1: Model Quality Testing lists the minimum requirements that will be performed by NSPI. Additional testing may be performed to assess compliance with all applicable criteria. Any test not meeting the minimum NSPI requirements will be documented in the MQT report to the IC.***

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

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

- Facilities that the customer must install to meet the requirements of the GIP and the TSIR.
- The minimum transmission additions/upgrades that are necessary to permit operation of this Generating Facility, under all dispatch conditions, catering to the first contingencies listed.
- Guidelines and restrictions applicable to first contingency operation (curtailments etc.).
- Under-frequency load shedding impacts.

The SIS will assess system contingencies such that the system performance will meet the following criteria:

- Table 1 "Planning Design Criteria" of NPCC Directory 1.
- Table 1 "Steady State & Stability Performance Planning Events" of NERC TPL001-4.
- NSPI System Design Criteria, report number NSPI-TPR-003-4.

Any changes to RAS schemes required for operation of this generating facility, in addition to existing generation and facilities that can proceed before this project, will be determined by the SIS as well as any required additional transmission facilities. The determination will be based on NPCC[5] and NERC[6] criteria as well as NSPI guidelines and good utility practice. The SIS will also determine the contingencies for which this facility must be curtailed.

____________________________________//____________________________________

[5] NPCC criteria are set forth in its Reliability Reference Directory #1 *Design and Operation of the Bulk Power System*

[6] NERC transmission criteria are set forth in *NERC Reliability Standard TPL-001-4*