IR686 - Windy Ridge SIS

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IESO Nova Scotia

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REVISION TABLE

Rev.	Description	Date	Comments
0	Draft	2026-02-03	Issued for internal review
1	Report issued	2026-02-19	Issued for release
2	Revision	2026-03-13	Minor clarifications

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES AND TABLES

TABLE OF ABBREVIATIONS

Term	Definition
BES	Bulk Electric System
BESS	Battery Energy Storage System
BPS	Bulk Power System
CB	Circuit Breaker
CBF	Circuit Breaker Fail
DCT	Double Circuit Tower
EMT	Electromagnetic Transient
FRT	Fault Ride Through
GIA	Generator Interconnection Agreement
GIP	Generator Interconnection Procedure
HVRT	High Voltage Ride Through
IBR	Inverter Based Resource
IC	Interconnection Customer
IESO-NS	Nova Scotia Independent Energy System Operator
IR###	Interconnection Request No. ###
LVRT	Low Voltage Ride Through
MQT	Model Quality Test
NERC	North American Electric Reliability Cooperation
NPCC	Northeast Power Coordinating Council
NSPI	Nova Scotia Power Inc.
OLTC	On Load Tap Changer
PCO	Point of Change of Ownership
POI	Point of Interconnection to Transmission Owner facilities
PPC	Power Plant Controller
SIS	System Impact Study
RAS	Remedial Action Scheme
SMIB	Single Machine Infinite Bus
SVC	Static Var Compensator
VSC	Voltage Source Converter
TSIR	Transmission System Interconnection Requirements
WECS	Wind Energy Conversion System
WF	Wind Farm

1 INTRODUCTION

The Interconnection Customer (IC) submitted an Interconnection Request (IR) for the connection of a Wind Energy Conversion System (WECS) facility to the Nova Scotia Power Inc. (NSPI) system as Network Resource Interconnection Service (NRIS). The proposed Commercial Operation Date is 2028-05-31. The facility is planned to deliver 336 MW to the 345 kV Point of Interconnection (POI). The installed capacity of the facility is planned to be 352 MW.

The IC signed a System Impact Study (SIS) Agreement, and this report is the result of that Agreement. This project is listed as Interconnection Request #686 in the NSPI/IESO-NS Interconnection Request Queue and will be referred to as IR686 throughout this report.

The SIS for IR686 has been conducted in both Root Mean Squared (RMS) and Electromagnetic Transient (EMT) domains. The RMS assessment has been conducted in PSS®E, while the EMT assessment has been conducted in PSCAD™. Both assessments are based on the Nova Scotia (NS) 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).

1.1 Scope

The requested POI for IR686 is the 345 kV line L-8001 (67N-Onslow to 410N-Memramcook). During the IR686 study, it was determined that a more feasible POI is via a new 345 kV six-breaker ring substation which taps two 345 kV lines: L-8001 and L-8006 (future 67N-Onslow to 410N-Memramcook line known as the "Reliability Tie"). The proposed generation site will be interconnected to the POI via two 345 kV transmission lines from the Point of Change of Ownership (PCO).

Figure 1 shows the approximate geographic location for IR686, Figure 2 the one-line diagram electrical configuration.

Figure 1: IR686 geographical location

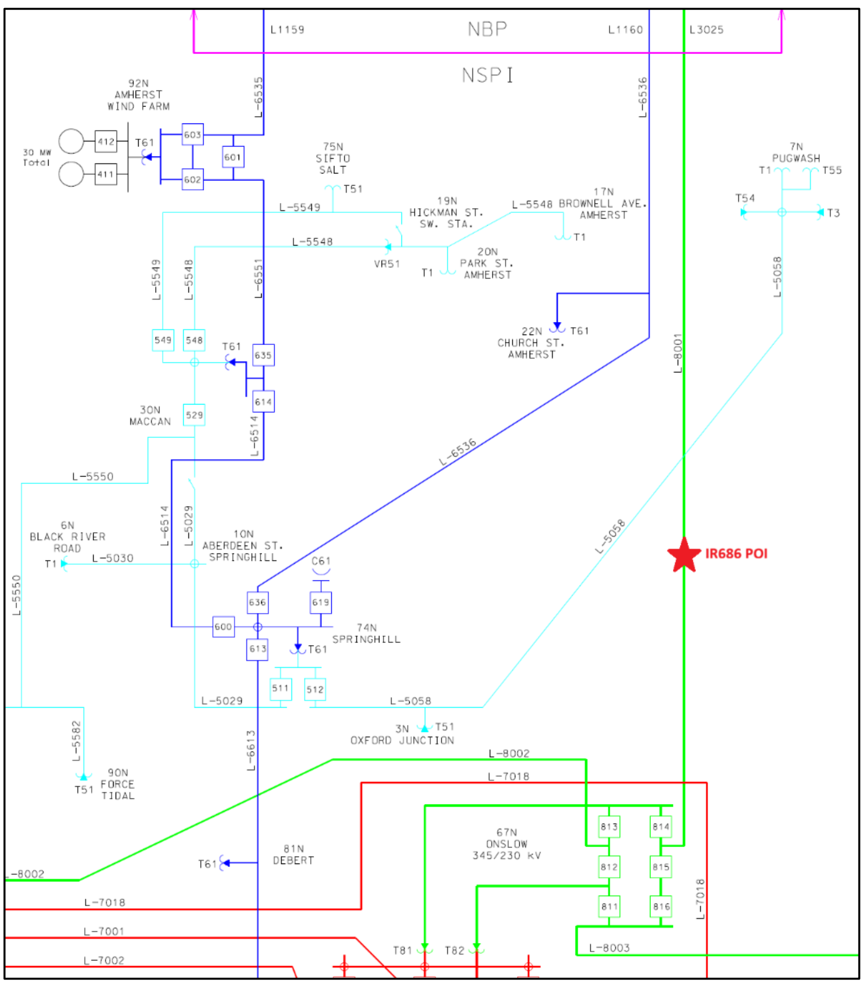

Figure 2: IR686 electrical location

The scope of this study to assess the impact of the proposed generation facility on the interconnected system includes but is not limited to:

- Steady state analysis:
  - Identification of any thermal overload of transmission elements
  - Identification of any steady state voltage criteria violation
- Stability analysis:
  - Assess NPCC BPS and NERC BES classification criteria for the substation in PSS®E
  - Identification of any requirements necessary for the interconnected power system to maintain stable and well damped performance for normal contingencies in PSS®E and PSCAD™
- EMT analysis, Wide Area Model simulation to assess:
  - Control interactions between the proposed facility and surrounding Invert Based Resource (IBR) facilities
  - Control interactions with neighbouring devices and/or with synchronous machines
- Active Power and Inertia Review of compliance with the TSIR requirements for Active Power Control and Inertia response
  - Assess the ability of the proposed facility to ride through frequency deviation
- Review compliance with the TSIR requirement for Reactive Power and Voltage Control
  - Assess the ability of the proposed facility to ride through voltage deviations
- Short circuit analysis and its impact on circuit breaker ratings
- Power factor requirement at the high side of the ICIF transformer(s)
- Assessment of voltage flicker and harmonics
- Impact on any existing Remedial Action Schemes (RAS)

This report describes methodology, plant and equipment models, and results of the study work carried out to evaluate the impact of connecting IR686 to the Nova Scotia transmission network.

1.2 Background

Nova Scotia is moving towards very high levels of IBR, while maintaining a stable and well damped grid. To achieve high levels of IBR, planning criteria have been developed to ensure that new IBR generation facilities are able to stay online and produce power during all expected operating scenarios and do not adversely the ability of other IBR plants to do the same. No limits are placed on the proximity of new IBR facilities to existing IBR facilities other than limiting the loss of generation for a single contingency to the maximum dictated by reserve carrying capacity.

As the grid transitions to more hours at high IBR, SCMVA levels will be maintained to meet today's required operating levels to ensure sufficient SCMVA for existing customer large motor starts, HVDC ride through etc. This is planned to be achieved with synchronous condenser capability on new fast acting generation, standalone synchronous condensers in select locations as required, and potentially the conversation of existing thermal unit equipment.

For IBR, the ride-through capability is less determined by the SCMVA at its POI than the SCR (SCMVA/rated plant MW). The rated MW for calculation of the facility SCR at the POI includes the sum of the rated MW of all electrically close IBR facilities. While minimum SCMVA will not drop over time, the SCR at a facility POI will vary depending on the proximity of other IBR facilities. To ensure the SCR is sufficiently high for an IBR to ride-through normal contingencies and not cause an adverse impact to other interconnection customers, there is an inertia requirement for all new generation facilities.

The SIS for all new interconnections includes all inertia sources that would be expected to be online for a particular study scenario. Facilities, such as the Maritime Link HVDC, that provide fast frequency response (not to be confused with inertia) are online and dispatched in study cases to provide performance comparable to that expected under the operating scenario under study. As the Maritime Link, existing IBR facilities and existing motor loads around the province require a minimum SCMVA for FRT or motor starts, online inertia resources will be maintained comparable to the existing levels when required to ensure no adverse impact to existing facilities as synchronous units are removed from service or dispatched with lesser frequency. Existing synchronous resources such as small generators and large motor loads in the province are dispatched to align with credible dispatches in the operating timeframe.

All new facilities (load, generation and BESS) will be required to stay online under a range of operating conditions with performance meeting all IESO-NS, NPCC and NERC criteria without causing adverse impact to existing facilities.

1.3 Project Queue Position

All in-service generation facilities are included in the SIS, except for Lingan Unit 2, which is assumed to be retired.

Due to ongoing development discussions and engineering studies, most Transmission System Network Upgrades identified as part of Transmission Service Request #411 will not be included in the SIS analysis for Generator Interconnection Procedures (GIP) Study Groups #32 to #35. Analysis will include the Reliability Tie, any material Network Upgrades identified in higher queued projects and the 2025 Transmission System configuration.

The following Transmission System Network Upgrades are included in this study:

- Reliability Tie (345 kV line from 67N-Onslow to 410N-Memramcook)
- 67N-Onslow substation re-configuration due to Reliability Tie

- Memramcook and Salisbury substation re-configurations due to Reliability Tie
- Additional 345-138 kV transformer at Memramcook
- +/-300 MVAR STATCOM facility connected to Salisbury substation

As of 2026/01/08, the following projects are higher queued in the Advanced Stage Interconnection Request Queue:

- IR #516: GIA executed, 2027/12/31 in-service date.
- IR #542: GIA executed, 2027/06/30 in-service date.
- IR #574: GIA executed, 2026/12/31 in-service date.
- IR #598: GIA executed, 2027/06/30 in-service date.
- IR #597: GIA executed, 2026/09/30 in-service date.
- IR #664: GIA executed, in-service.
- IR #662: GIA executed, in-service.
- IR #670: GIA in progress, 2027/08/31 in-service date.
- IR #671: GIA in progress, 2027/03/31 in-service date.
- IR #669: GIA executed, 2025/12/31 in-service date.
- IR #668: GIA executed, 2026/10/31 in-service date.
- IR #618: GIA executed, 2026/06/30 in-service date.
- IR #673: GIA executed, in-service.
- IR #675: GIA executed, 2028/05/31 in-service date.
- IR #677: GIA executed, 2026/11/15 in-service date.
- IR #697: SIS in progress, 2026/08/21 in-service date.

The higher-queued Interconnections will be modelled and included in IR686 study base cases. If any of these included projects are subsequently withdrawn from the Queue, it may be necessary to update this SIS or perform a re-study.

2 PLANT AND EQUIPMENT MODEL

The study is based on technical information provided by the IC. This study in completed based on the interconnection of the WECS facility without any accompanying load facility.

2.1 WECS Facility

IR686 will be equipped with 44 x Goldwind V15 (premium version) WTGs, each rated at 8.0 MW. The plant installed capacity is 352 MW but is limited to 336 MW at the POI.

Table 1 provides a summarized overview of the project.

Table 1: Project Overview

Attribute	Description
Project name	Windy Ridge
Project identifier	IR686
Project type	Wind Energy Conversion System (WECS) Type 4
Project rating	352 MW installed, 336 MW at POI
Connection point	104N-Windy Ridge substation (taps L-8001, L-8006)
Connection Voltage	345 kV
Operating Mode	Voltage droop control, Frequency response control
V/Q control strategy	Voltage droop control, Reactive power control, power factor control modes available
Filter / capacitor banks	None
OEM	Goldwind
OEM reference model	V15 WTG Premium Version 8.0 MW (Type 4)
Number of units	44

The POI and configuration are studied with the following:

- NRIS with an in-service date of 2028-05-31.
- The 44 WTGs were modeled as two equivalent lumped parameter generators. The equivalent models were provided by the IC.
- A 1.296 pu fault current is used for short circuit analysis, per manufacturer data provided by the IC.
- The POI is studied at a new 345 kV six-breaker ring substation (104N-Windy Ridge) which taps L-8001 (67N-Onslow to 410N-Memramcook) and L-8006 ("Reliability Tie"). IR686 facility will tie into the 104N substation via two 5.9 km transmission lines. Impedance of these lines has been provided by the IC. It is assumed that these lines follow a parallel ROW but are not on shared structures.
- Generic synchronous condensers were modelled with connection at the 104N substation to provide the minimum synchronous inertia (or equivalent) required by the TSIR for Nova Scotia.
- It is assumed that IR686 generation meets IEEE Standard 519 limiting total harmonic distortion (all frequencies) to a maximum of 1.5% with no individual harmonic exceeding 1.0% for 345 kV.
- Generation in a higher queue position are modeled in the base cases. The included projects are listed in Section 1.3.

2.2 Plant Control

The IR686 PSSE model has been provided with split configuration between the two equivalent generators (lumped equivalent models of 22 WTG units each). As such, each plant control element (active power/frequency plant controller, voltage/reactive power plant controller, etc.) has been duplicated with identical parameters.

For the purposes of this SIS, the plant is studied using the following control modes, per the latest model submission:

- Voltage droop control mode with setting of 4%
- Frequency response control enabled

2.3 PSS®E and PSCAD™ Models

To facilitate the load flow analysis, the proposed 44 WTGs are grouped as two equivalent generators with terminal voltage of 1.14 kV. The voltage is stepped up to 34.5 kV at the WTG transformers modelled with two equivalent step-up transformers. This equivalent model is then stepped up to 345 kV via two interconnection transformers.

The PSS®E model for load flow is shown in Figure 3 below. Based on information provided by the IC, each equivalent 1.14 kV/34.5 kV generator step-up transformer was modeled to have an impedance of 10.47% based on 198.0 MVA. Each interconnection transformer was modeled to have 9.40% impedance on 200 MVA rating with an X/R ratio of 39.5. The SIS results must be updated if the actual nameplate data for these transformers materially differs from these impedance values.

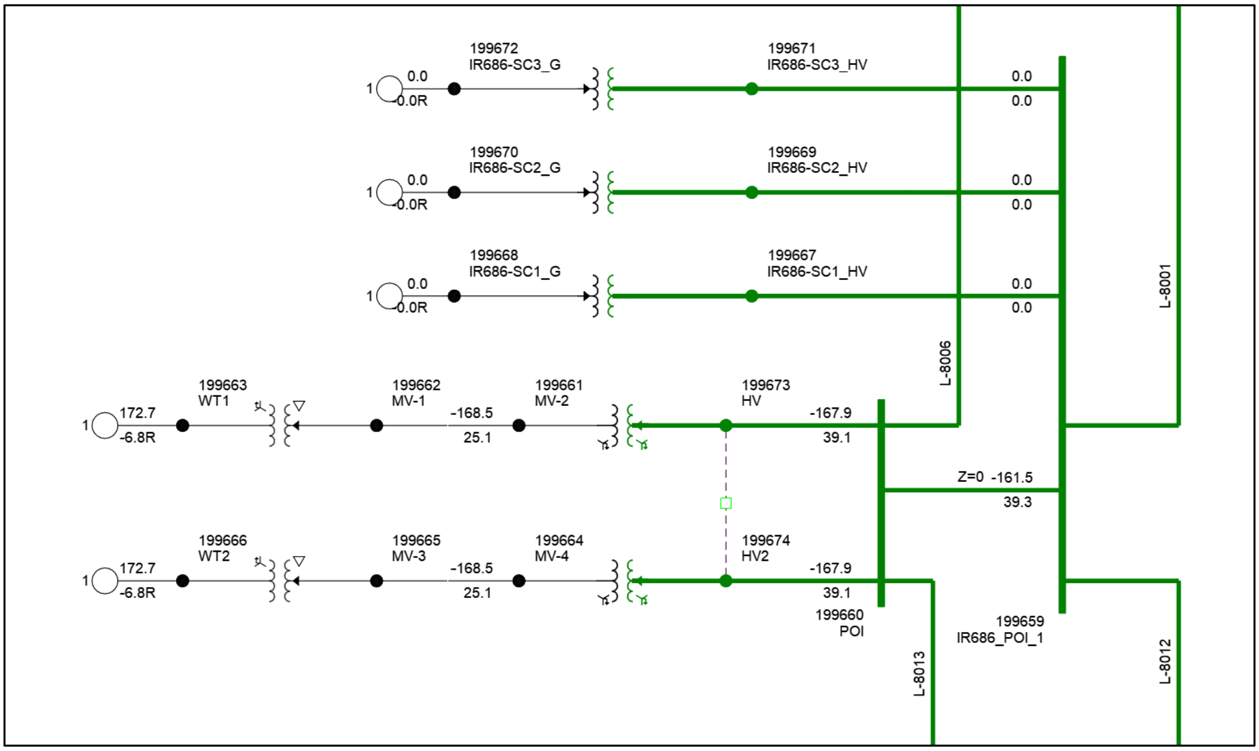

Figure 3: PSSE model for IR686

The same configuration was used to integrate the plant PSCAD™ model in the PSCAD™ wide area network model. To perform the complete EMT analysis of the plant in accordance with TSIR, the original PSCAD™ model (which was used for MQT) was divided into two separate models, one per a Wind Farm, as shown in Figure 4 and Figure 5, below.

Each of the models comprises one Wind Turbine connected to a single 1.14 kV/34.5 kV generator step-up transformer which has its output scaled by the number of turbines and a factor of 2 representing two step-up transformers per turbine as described by the customer. The π section represents the collector circuits connecting the turbines through a 34.5kV/345kV 200MVA interconnection transformer to the 5.9 km Transmission Line which leads to 104N – Windy Ridge 345kV substation.

The double circuit Transmission Line and the Synchronous Condensers are modeled on the 104N – Windy Ridge substation page as shown in Figure 6.

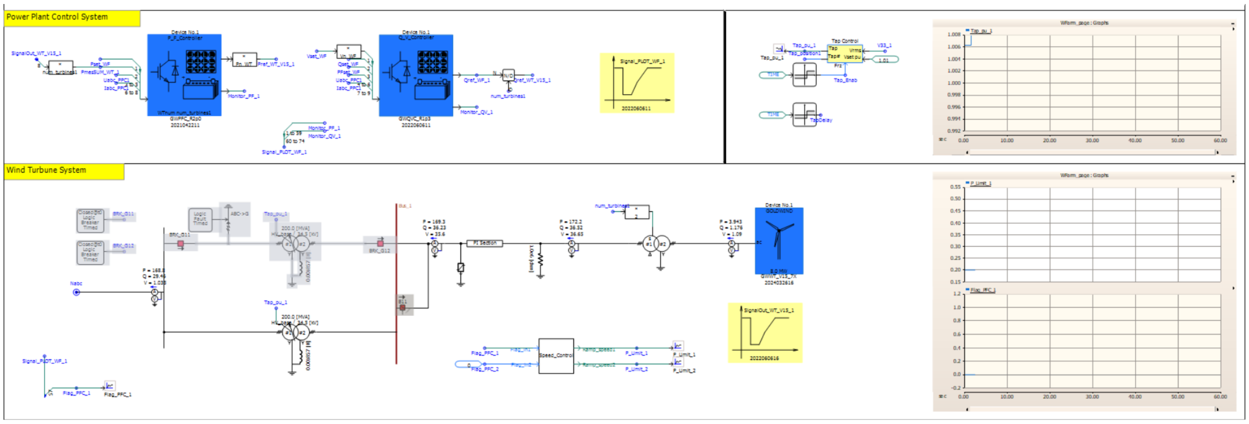

Figure 4: PSCAD™ Model for IR686 WF 1

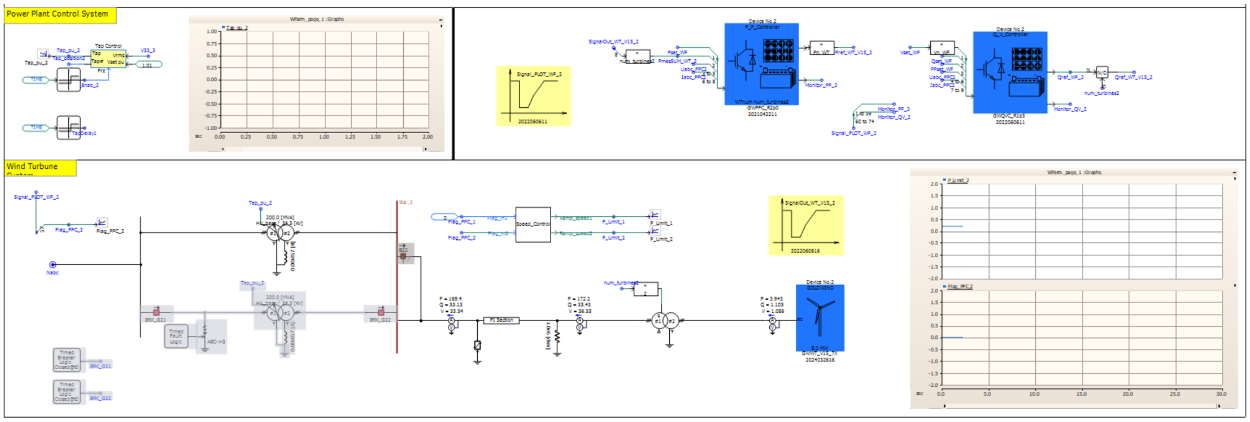

Figure 5: PSCAD™ Model for IR686 WF 2

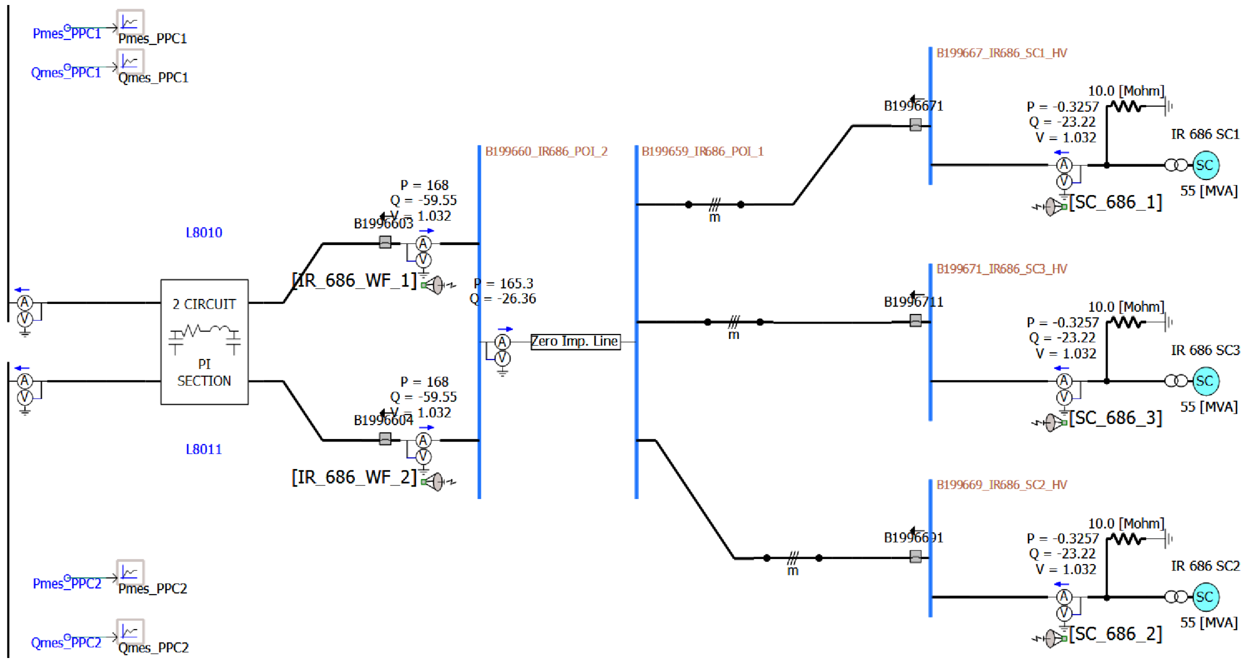

Figure 6: PSCAD™ Model for 104N – Windy Ridge substation

Table 2 and Table 3 identify the PSS®E and the PSCAD™ plant models used for this SIS.

Table 2: PSS®E Model Files for IR686

File Name	File type	Comments
WindyRidge_v6_mqt.sav	PSS®E savecase	IR686 steady-state SMIB plant model
WindyRidge_V06_UDM.dyr	PSS®E dynamics model	Includes the following IR686 dynamics models: • CV1520: WTG model (PSSE v34) • CVIMS2: WTG model (PSSE v35) • BUPPCB02: Reactive power control model • BFPPCB02: Active power control model • OLTC1T: Tap changer model
GW_CV1520_WTG_PSSE347_20240709.dll	PSS®E dynamics library	CV1520 model (for PSSE v34)
GW_IMS2_V356_20251114.dll	PSS®E dynamics library	CVIMS2 model (for PSSE v35)
GW_PPC_PSSE347_20241225.dll	PSS®E dynamics library	BUPPCB02 and BFPPCB02 model (for PSSE v34)
GW_PPC_V356_20250716.dll	PSS®E dynamics library	BUPPCB02 and BFPPCB02 model (for PSSE v35)
Goldwind WTG and PPC Model User Manual_V2.1.pdf	Documentation	Model descriptions
Goldwind_PPC_PSSE_Model_ Datasheet_20241118.xlsx	Documentation	Model data

Table 3: PSCAD™ Model Files for IR686

File Name	File Type	Comments
IR_686_V6.pscx	PSCAD™ Project file	Runs using Intel® Fortran Compiler Classic 2021.12.0
Goldwind_Gencon_DLL.dll	PSCAD™ Library file	
Goldwind_SYSPro_DLL.dll	PSCAD™ Library file	
GW_Gencon_Interface.obj	PSCAD™ Object file	
GW_Protect_Interface.obj	PSCAD™ Object file	
GWPPC_PFC_R21042211.lib	PSCAD™ Object file library	
GWPPC_QVC_R220606.lib	PSCAD™ Object file library	
GWSnapshot.dll	PSCAD™ Library file	
Goldwind_Gridcon_V15_7X_DLL.dll	PSCAD™ Library file	
GW_Gridcon_V15_7X_Interface.obj	PSCAD™ Object file	
GWWT_V15_7X_R24032616_if12.lib	PSCAD™ Object file library	
Speed_Control.f	Visual Studio Fortran File	

2.4 Model Quality Testing

To identify potential modelling issues for the plant Model Quality Test (MQT) reports were prepared for both the PSS®E and PSCAD™ models.

1002-2025-TSEP-Rev7 describes the performance of the IR686 PSS®E model. 102-2025-TSEP-5 MQT report describes the performance of the IR686 PSCAD™ model. The following is the conclusions outlined in the report:

Given the results, the model for IR686 can be accepted for use in system studies with the following considerations:

- Transformer Saturation Phenomenon:

  The design must consider the behavior related to transformer saturation, which can cause transients in voltage and reactive power variables. This issue should be mitigated during the IC design stage.

- Strategy for Iq Control:

  It is required to provide IESO-NS with documentation on the strategy used for Iq control.

- Frequency Response Characteristics:

  The delay observed in the over frequency and under frequency tests must be considered. This characteristic should be considered in the model's response to such events.

- Wind Speed Variation:

  This model does not have the capability to vary wind speed dynamically. As a result, Test 12 (related to wind speed variation) is not analyzed in this report.

3 SYSTEM TECHNICAL MODELS

To assess the performance of the plant models described in Section 2.3, wide-area system models in PSS®E and PSCAD™ are used. These models consist of transmission elements, generating facilities, load, and network support devices as outlined below.

3.1 System Data

The load forecast included in the "*2025 10-Year System Outlook*", dated July 14, 2025, produced by NSPI, and submitted to Nova Scotia Utility and Review Board *(NSUARB)* was used in this study. The winter peak load forecast for the near future is shown in Table 4, with 2029 used for this study due to the projected in-service date of IR686.

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

Table 4: Load Forecast for Study Period

Forecast Year	System Peak	Interruptible contribution to peak	Firm Contribution	Demand Response	Growth %
2025	2,403	132	2,267	4	15.1
2026	2,408	133	2,263	12	0.2
2027	2,423	131	2,268	24	0.6
2028	2,443	133	2,274	36	0.8
2029	2,458	134	2,285	39	0.6
2030	2,474	132	2,303	39	0.7
2031	2,503	132	2,332	39	1.2
2032	2,535	133	2,364	38	1.3
2033	2,573	133	2,402	38	1.5
2034	2,618	132	2,449	37	1.8
2035	2,672	132	2,503	37	2.0

The rating of transmission facilities in the vicinity of IR686 are shown in Table 5 and Table 6.

Table 5: Transmission Line Ratings					
Line	Conductor	Design Temp. (C)	Limiting Element	Summer Rating Normal/Emerg. (MVA)	Winter Rating Normal/Emerg. (MVA)
L-6613	ACSR 1113 Beaumont	100	Metering	333.0/333.0	333.0/333.0
L-6555	ACSR 1113 Beaumont	100	Metering	333.0/333.0	333.0/333.0
L-6535	ACSR 556.5 Dove	100	Conductor	229.0/251.9	247.0/271.7
L-6536	ACSR 556.5 Dove	100	Conductor	229.0/251.9	247.0/271.7
L-8001	ACSR 2x795 Drake / ACSR 2156 Bluebird	49 / 60	Conductor / Metering	650.0/715.0	831.0/831.0
L-8006*	ACSR 1192 Grackle / ACSR 2515 Joree	TBD	TBD	1644.0/1644.0	1856.0/1856.0
L-7003	ACSR 556.5 Dove	70**	Conductor	285.0/313.5	345.0/379.5
L-7019	ACSR 556.5 Dove	70	Conductor	285.0/313.5	345.0/379.5
L-7005	ACSR 1113 Beaumont	70	Metering	429.0/462.0	462.0/462.0
*Reliability Tie (L-8006) is expected to be in service with these parameters prior to in-service date of IR686. **The existing L-7003 is limited to 60C but is expected to be upgraded to 70C prior to in-service date of IR686.					

Table 6: Transformer Ratings		
Transformer	Normal Rating / 15-Minute Emergency Rating	
	Summer (MVA)	Winter (MVA)
67N-T81/T82	392/478	392/478
67N-T71	224/268.8	224/292

3.2 Steady State

Steady State analysis in PSS®E used version 34.9.6. 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 2029 were modelled to develop base cases to best test system reliability in accordance with IESO-NS and NPCC design criteria:

- Light load: Spring Minimum (SML);
- Off-Peak load: Summer Peak (SUM);
- High load: Winter Peak (WIN).

3.2.1 Steady State Base Cases

The bases cases used for power flow analysis are listed in Appendix A: Base Cases

One-line diagram comparisons of a subset of base cases are presented in Appendix C: One-line Diagrams Load Flow

For these cases:

- Transmission connected wind generation facilities were dispatched between 17% and 100% of their rated capability.
- Transmission connected wind is used to displace thermal generation in the province. No minimum thermal unit requirement is enforced.
- No restrictions were placed on BESS charging/discharging during peak load conditions.
- There is no associated load facility added in these cases. IR686 is studied as NRIS, serving native NS load.
- TSR 411 550MW import is not considered. Refer to Section 4.1.
- All existing interface limits were respected for base case scenarios.

The configuration studied in this SIS relies on the completion of the Reliability Tie project and the associated substation re-configuration work at 67N-Onslow and 410N-Memramcook. Single line diagrams for 67N-Onslow, 410N-Memramcook, and 104N-Windy Ridge are included for reference in Appendix G: Station One Line Diagrams

For each of the three load levels studied, the following variables were adjusted to create a wide range of base cases:

- Nova Scotia <> New Brunswick transfer
- Nova Scotia <> Newfoundland transfer
- Port Hawkesbury Paper load (max load / min load)
- BESS charge/discharge status
- Wind levels (high / low)

Transmission connected wind was curtailed as necessary to balance the system, with preference given to wind sites that are electrically close to IR686 (e.g. electrically remote wind was curtailed first). All cases were studied with IR686 online at maximum output – where violations were identified, the case was compared without IR686 online to determine if pre-existing.

3.2.2 Steady State Contingencies

The steady state power flow analysis was performed using the contingencies listed in Appendix B: Contingencies

3.3 Stability

Stability analysis was performed in PSS®E, version 34.9.6. The base cases for PSS®E stability analysis were derived from a subset of the steady-state cases listed in Appendix A. These cases were used for the NPCC BPS testing described in Section 4.3.1 of this report.

Additional stability analyses were performed in PSCAD™. Details on the contingencies studied are provided in Section 3.4.6. These scenarios represent a critical subset of the contingencies studied in PSS®E.

3.4 Electromagnetic Transient

To supplement the analysis performed in RMS, EMT simulations in PSCAD™ are performed to assess model performance and stability in the microsecond timescale.

3.4.1 Study Scenarios

The base cases used for the EMT simulations match the same subset of load flow cases used for System Stability analysis which was conducted in PSS®E and outlined in Section 4.3.1 of this report.

The correspondences between PSCAD™ and PSS®E base cases names are shown in Table 7 below.

Table 7: PSCAD™ and PSS®E Base Cases

PSS®E Base Case	PSCAD™ Base Case	Notes
2030SML_b1	2026_2_2025-5006_0_B1	
2030SML_b4	2026_2_2025-5006_0_B4	
2030SML_b7	2026_2_2025-5006_0_B7	
2030SUM_b1	2026_2_2025-5006_1_B1	
2030SUM_b4	2026_2_2025-5006_1_B4	
2030SUM_b6	2026_2_2025-5006_1_B6	
2030SUM_b9	2026_2_2025-5006_1_B9	
2030SUM_b9*	2026_2_2025-5006_1_B9_NSI	*N-1 case: Generation dispatch modified to reflect 350 MW import from NB.
2030SUM_b9**	2026_2_2025-5006_1_B9_NSI_2	** N-1 case: Generation dispatch modified to reflect 350 MW import from NB, IR686 dispatch reduced to 150 MW and 130 MW.
2030WIN_b1	2026_2_2025-5006_2_B1	
2030WIN_b4	2026_2_2025-5006_2_B4	

The dispatch scenarios described in Section 3.2.1 apply to PSCAD™ base cases.

Cases with minimum synchronous inertia and maximum IBR dispatch, having low inertia coupled with low damping (low load), are studied to analyze control interactions and/or ride through issues after the addition of the new WECS.

3.4.2 PSCAD™ Model Version

Table 8 identifies the PSCAD™ wide area network model version used in this SIS.

Table 8: PSCAD™ Wide Area Network Model Files for IR686

File Name	File Type	Comments
2026-2	Case Folder	Overall collection of files for the transmission system
NSPI_2026_01_16.py	Python Script	Script for configuring and running contingency simulations
PSCAD_Contingencies_new_IR669_IR686.xlsx	Excel Workbook	Contingency list as described in Section 3.4.6

3.4.3 Model Overview

The Maritimes Area is included in the PSCAD™ model. Nova Scotia was divided in six major regions: Valley, Western, Northen, Halifax, Canso, and Sydney. Each of these regions is contained in a PSCAD™ project 'network'. Neighbouring regions are also included in six project networks: Central, East, North, South and West for New Brunswick, and PEI for Prince Edward Island (connected through New Brunswick). Note that all synchronous machines within represented networks are included using PSCAD™'s synchronous machine model for NS and NB networks. Synchronous machines in the PEI network are represented using voltage source components in series with a pre-calculated source impedance.

The PSCAD™ model for IR686 includes all existing dynamic devices, including synchronous machines, wind farms, and static var compensators (SVC), as well as the voltage source converter (VSC) high-voltage direct current (HVDC) Maritime Link. All the investigations presented here are based on EMT simulations using PSCAD™ software version 5.0.2.

3.4.4 Model Boundaries

Network equivalent voltage sources are used at the wide area model boundaries to represent the remainder of the Eastern North America power system. The network equivalent voltages, angles and impedances are precalculated such that power flows and short circuit levels are preserved according to the solved PSS®E load flow used to setup the scenario initial conditions. Table 9 enumerates the locations where the network equivalents are located.

Table 9: PSCAD™ Wide Area Network Mode Boundaries

Region	Area	Bus Number
Central	NB	190230
North	NB	190493 and 190494 Eel River HVDC link
South	NB	190237
West	NB	190619, 190001, and 190028

3.4.5 Dynamic Plants

All synchronous machines in NS and all IBR facilities are represented using their latest available PSCAD™ models. It should be noted that different scenarios or dispatches may not have all synchronous machines and IBRs in service.

3.4.6 PSCAD™ Contingencies

This portion of SIS used a selected set of representative contingencies to study the impact of adding IR686 to the network. These contingencies are a subset of those tested in PSS®E and are listed in Appendix B: Contingencies

4 TECHNICAL ASSESSMENT

The models described in Sections 2 and 3 were used to simulate the system with the inclusion of IR686. The results of these studies are described below.

4.1 NRIS

NRIS dispatch was studied for all scenarios with IR686 serving NS load with the exception of the TSR 411 550MW firm import. To assess the upgrades required in NS and NB for the rare dispatch with wind in NS at maximum and an import of 550MW firm, a joint study would be required with New Brunswick Power. To allow for the project to proceed in a timely manner it is recommended the project proceed with the noted requirements in Section 6 to provide for NRIS level of service for NS load and execute the GIA for ERIS.

4.2 Steady State

The steady state power flow analysis in PSS®E was conducted with IR686 in service. The differential line flows are shown in Appendix D: Steady-State Results

The one-line diagrams display the difference in flow on each transmission line with and without IR686. The addition of IR686 generation has the capability to offset thermal generation in the Halifax region (increasing flows on the Onslow South corridor including transmission lines L-8002, L-7001, L-7002, L-7018) or thermal generation east of Halifax (decreasing the flows on the Onslow Import corridor including lines L-8003, L-7003, L-7019, L-7005).

Due to the electrical location of IR686, it appears to the NS system similarly to an import from New Brunswick. As such, the addition of IR686 has a material impact on the NS-NB interchange limits and two Limited Impact RAS: NS Import Power Monitor and NS Export Power Monitor. With the addition of IR686 and the Reliability Tie, these RAS will require a full restudy and expected changes to logic and parameters settings.

Results of the steady state analysis are presented in Appendix D: Steady-State Results

The power flow analysis did not identify any transmission system contingencies inside Nova Scotia that violate thermal loading or voltage criteria for system normal (N-0), attributed to IR686.

Various N-1 system configurations were studied as part of the steady state analysis. Results are presented in Appendix D: Steady-State Results

A summary of the results is also presented below in Table 10. The power flow analysis identified several N-1-1 contingencies resulting in violations of thermal loading or voltage criteria:

North NS Voltage collapse:

- With L-8013 out of service, contingencies which trip the parallel line L-8012 (67N-Onslow to 104N-Windy Ridge) result in voltage collapse in the Northern NS and South NB area. This electrically isolates IR686 from the NS grid. Power flow is routed through the remaining 138 kV tie with NB via 410N-Memramcook, causing severe overloading and voltage collapse.

  Mitigation of this contingency may require curtailment of IR686 output to levels as determined by the system operator. Ongoing work with New Brunswick on NS Import Power Monitor RAS may impact the operating scenarios for IR686 when L-8013 (or L-8012) are out of service.

- With L-8006 out of service, the breaker failure contingency 104N-801 (clears L-8001, L-8010 [IR686 - half of facility], and one synchronous condenser) results in all 345 kV connections to NB tripped. The additional trip of half of IR686 drives excess import from NB via the remaining 138 kV connection (primarily L-6555 and L-6613), causing severe overloading and voltage collapse.

  Mitigation of this contingency may require curtailment of IR686 output to levels as determined by the system operator. Ongoing work with New Brunswick on NS Import

Power Monitor RAS may impact the operating scenarios for IR686 when L-8006 (or L-8001) are out of service.

L-6555 overload:

- With L-8006 out of service, the loss of L-8001 (individually or via breaker failure) results in all 345 kV connections to NB tripped. In cases where NS is exporting to NB, the remaining 138 kV connection (primarily L-6555 and L-6613), becomes overloaded.

  Mitigation of this contingency may require curtailment of IR686 output to levels as determined by the system operator. Ongoing work with New Brunswick on NS Import Power Monitor RAS may impact the operating scenarios for IR686 when L-8006 (or L-8001) are out of service.

Table 10: Summary of Steady State Violations in N-1 Cases

Violation	Case(s)	Element Out of Service	Contingency(ies)
Non converged solution (voltage collapse)	2030SML_b1_L8013 2030SUM_b1_L8013 2030SUM_b2_L8013 2030SUM_b3_L8013 2030SUM_b4_L8013 2030SUM_b5_L8013 2030SUM_b7_L8013 2030SUM_b8_L8013 2030SUM_b9_L8013 2030WIN_b1_L8013 2030WIN_b2_L8013 2030WIN_b3_L8013 2030WIN_b4_L8013 2030WIN_b5_L8013 2030WIN_b6_L8013 2030WIN_b7_L8013	L8013	c_67N_814_G0 c_67N_L8012_G0
Non converged solution (voltage collapse)	2030WIN_b4_L8006	L8006	c_104N_801
Thermal overload L-6555 and voltage violations in NB/North NS	2030SUM_b4_L8006 2030SUM_b8_L8006 2030SUM_b9_L8006	L8006	c_104N_801
Thermal overload L-6555	2030SUM_b6_L8006	L8006	c_104N_L8001 c_104N_802 c_410N_ME3_2 c_410N_ME3_3

Table 10: Summary of Steady State Violations in N-1 Cases			
Violation	Case(s)	Element Out of Service	Contingency(ies)
Thermal overload L-6001	2030SUM_b1_67N-T81 2030SUM_b2_67N-T81 2030WIN_b1_67N-T81	67N-T81	c_67N_813

4.3 Stability Analysis

4.3.1 System Stability

System Stability analysis was conducted in PSS®E for a subset of load flow cases. Results of the analysis are presented in Appendix E: Stability Results

A summary of findings from the analysis is presented in Table 11.

Table 11: Summary of Stability Analysis		
Case	Contingency Violations	Notes
2030SML_b1	N/A	• 89N WTG trips for nearby fault • 24C hydro trips for nearby fault • 96H hydro trips for nearby fault • Various SynCons trip for nearby fault
2030SML_b4	N/A	• 89N WTG trips for nearby fault • 24C hydro trips for nearby fault • 96H hydro trips for nearby fault • Various SynCons trip for nearby fault
2030SML_b7	N/A	• 89N WTG trips for various nearby faults • 24C hydro trips for nearby fault • 96H hydro trips for nearby fault • Various SynCons trip for nearby fault
2030SUM_b1	N/A	• 89N WTG trips for various nearby faults • 24C hydro trips for nearby fault • 96H hydro trips for nearby fault • Various SynCons trip for nearby fault
2030SUM_b4	N/A	• 89N WTG trips for various nearby faults • 24C hydro trips for nearby fault • 96H hydro trips for nearby fault • Various SynCons trip for nearby fault
2030SUM_b6	N/A	• 24C hydro trips for nearby fault • 96H hydro trips for nearby fault • Various SynCons trip for nearby fault
2030SUM_b9	N/A	• 24C hydro trips for nearby fault • 96H hydro trips for nearby fault • Various SynCons trip for nearby fault

Table 11: Summary of Stability Analysis		
Case	Contingency Violations	Notes
2030WIN_b1	N/A	• 47C PHP load trips for various faults (101S, 2C, 3C, 67N, IR618) • IR670 WTG trips for various faults at 67N • 24C hydro trips for nearby fault • 96H hydro trips for nearby fault • Various SynCons trip for nearby fault
2030WIN_b4	N/A	• 47C PHP load trips for various faults (2C, 3C, 67N, IR618) • IR670 WTG trips for various faults at 67N • 24C hydro trips for nearby fault • 96H hydro trips for nearby fault • Various SynCons trip for nearby fault

4.3.2 NPCC-BPS / NERC-BES

Compliance with NERC reliability standards is mandatory to maintain reliability of the NS transmission system and its interconnection to the wider North American transmission system. Based on NERC BES brightline criteria, IR686 is BES classified due to its gross plant/facility aggregate nameplate rating being greater than 75 MVA in BES Inclusion I2a.

NSPI and IESO-NS are members of NPCC and adher 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". The methodology in the latest A-10 document, dated March 27, 2020, is used to determine if IR686 will be categorized as BPS.

Based on BPS testing in PSS®E, the IR686 345 kV HV bus and its 104N-Windy Ridge substation POI will be categorized as BPS.

The stability tests were performed by placing a 3-phase fault at the two buses under study, assuming all local protection out of service. The fault was maintained on the bus for 400 milliseconds to allow remote protection at 410N-Memramcook and 67N-Onslow to trip lines L-8001, L-8006, L-8012, and L-8013 with their assumed back-up protection times. The testing was completed in three load conditions (WIN, SUM, SML).

Appendix E: Stability Results

has the complete results (2030WIN_b1, 2030SUM_b1, 2030SML_b1) to demonstrate IR686 HV and POI buses are classified as BPS.

4.4 Electromagnetic Transient Assessment

To expand on the Steady State and Stability Assessments described above, additional contingency simulations were performed to evaluate the plant against applicable performance requirements and its impact on system stability. These contingency simulations were also used to validate the performance of the PSCAD™ model against applicable planning requirements.

4.4.1 Active Power Requirements and Frequency response

Frequency response for grid disturbance assesses performance during over and under frequency events including Nova Scotia islanding from the Eastern Interconnection with load shedding in the wide area model as well MQT assessment in a SMIB model.

4.4.1.1 Off-Nominal Frequency Operations

Underfrequency dynamic simulation was performed to demonstrate that NS Power's automatic Under Frequency Load Shedding (UFLS) program sheds load to assist stabilizing system frequency, without IR686's generators being tripped. This test is accomplished by triggering a sudden loss of generation by placing a fault on L-8001 under high import conditions using one of the N-1 cases. The 2030SUM_b9 case was modified to reflect a scenario of L-8006 out of service with high import of 350 MW from NB (2025-5006_1_B9_NSI).

With L-8006 out of service and NS Import Monitor RAS armed, the loss of L-8001 contingency (clears L-8001 and Transfer Trips L-6555 at 100N to avoid thermal overloads on the 138kV transmission lines) results in all 345 kV and 138 kV connections to NB tripped. This controlled separation will island Nova Scotia from the Eastern Interconnection causing major deficit in generation resulting in the Under Frequency event in the province. System frequency is expected to be stabilized through UFLS schemes which shed load across Nova Scotia as well as generation support from Newfoundland via the Maritime Link. All IBRs, including IR686, are required to remain online and perform according to TSIR’s requirements under this scenario. Two contingencies (1400 and 1403) were simulated on modified “2025-5006_1_B9” base case with WF_1 and WF_2 of IR686 dispatched differently as described in Table 7.

In all tested scenarios, the model performed as expected and meets this requirement. The full set of simulation plots for this contingency can be found in Appendix F: EMT Analysis Results

The following (Figure 7 and Figure 8) is the result of one of the scenarios tested, base case 2026_2_2025-5006_1_B9_NSI_2 with applied 1400 contingency (3 phase fault on L-8001 at 67N end with L-8006 is out and NSI armed, cleared in 4 cycles and TT L-6555 at 100N).

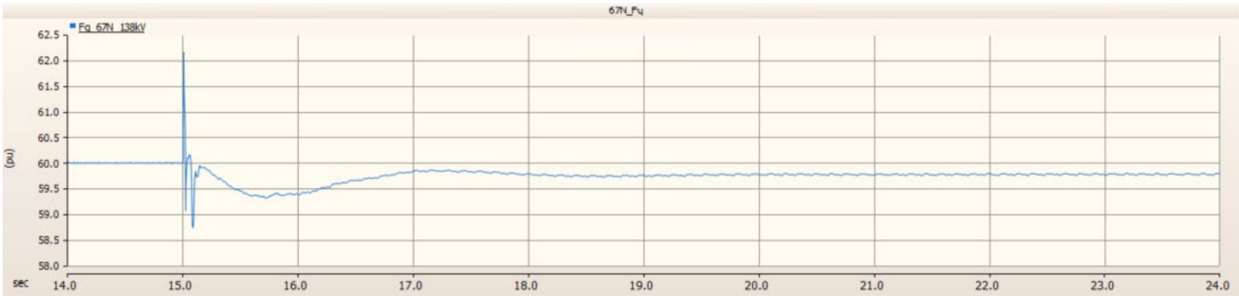

Figure 7: Frequency deviation at 67N - Onslow

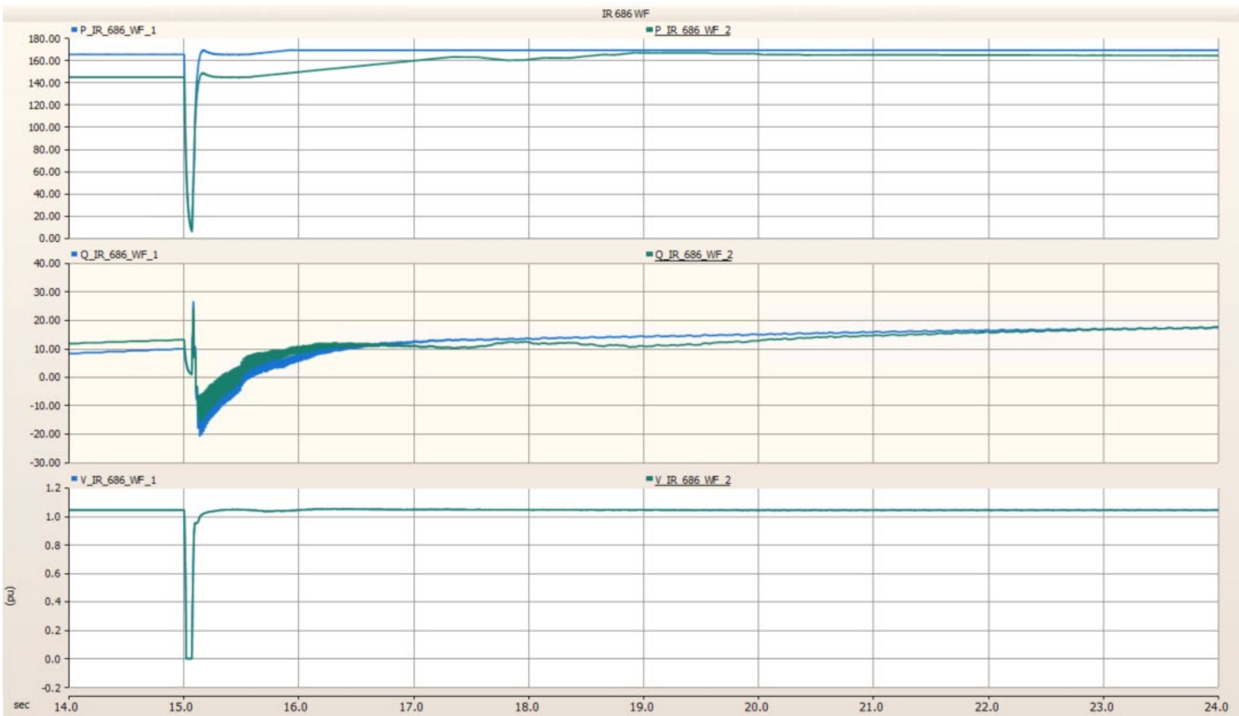

Figure 8: IR686 response to Frequency deviations

4.4.1.2 TSIR Section 7.6.5 Active Power Control - WECS and Solar

This TSIR requirement states:

- *Asynchronous Generators connected to the Transmission System must be capable of controlling active power in response to frequency deviations and control signals from the NSPI System Operator to the extent enabled by the technology utilized.*
- *While the Asynchronous Generating Facility is curtailed, it shall offer over-frequency and under- frequency control with a deadband of +/- 0.2 Hz and a droop characteristic of 4% or as otherwise directed by NS Power. The active power controls shall also react to continuous control signals from the NS Power Automatic Generation Control (AGC) system to control tie-line fluctuations when required.*

This requirement was validated in section 3.3 “Robustness of the Control System” and section 3.4 “Dynamic Response” of MQT report for the PSCAD™ model. While the tests demonstrate compliance with criteria, the model does have some limitation and functionality issues:

T10: Active Power Reference Change

> *The model takes 3 seconds for the plant to follow the setpoint, and a wait of 50 seconds before submitting a new command.*

T14: Frequency Response (Over frequency), T15: Frequency Response (Underfrequency) and T16: Frequency Response with Headroom (Underfrequency)

> *The plant meets the droop requirement, but the model process has a delay of about 11 seconds before the value is reached.*
>
> *The delay is observed in the over frequency and under frequency tests.*

4.4.1.3 TSIR Section 7.6.11 Inertia Equivalent Response - Grid following IBR

There is a minimum inertia equivalent response required for this facility. For facilities in weak areas of the grid, adjacent to existing IBR facilities that do not have inertial support or in a high-density IBR cluster, higher levels of inertial support will be required.

For this facility the SIR scaling factor is 0.48 for interconnection at POI voltage level of 345 kV. The facility will require a synchronous support (or equivalent) located at or near the POI with a rating of at least 165 MVA, specified for low inertia, high SCMVA. A combination of generic synchronous condensers was used to enable this facility to meet all applicable criteria in this study.

Generic synchronous condensers, were modelled in both PSS®E and PSCAD™ study cases to provide stable performance of the plant under expected operating scenarios. Protection action for a single contingency cannot clear more than 50% generation and not more than 50% of the synchronous condenser (or equivalent) support.

Additionally, TSIR Section 7.6.11 requires WECS turbines to support under frequency deviations with a power boost (virtual inertia response) for at least 10 seconds and, where headroom exists, shall offer over-frequency and under-frequency control with a deadband of +/- 0.2 Hz and a droop characteristic of 4% or other droop setting as directed by the system operator.

This requirement was validated in section 3.4 Dynamic Response of MQT report for PSCAD™ model, in the following tests: T15: Frequency Response (Underfrequency) and T16: Frequency Response with Headroom (Underfrequency).

4.4.2 Reactive Power Requirements and Voltage Control

4.4.2.1 *Power Factor Requirements*

TSIR requirement states that:

> 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 facility interconnection transformer over the range shown in Figure 9 below.

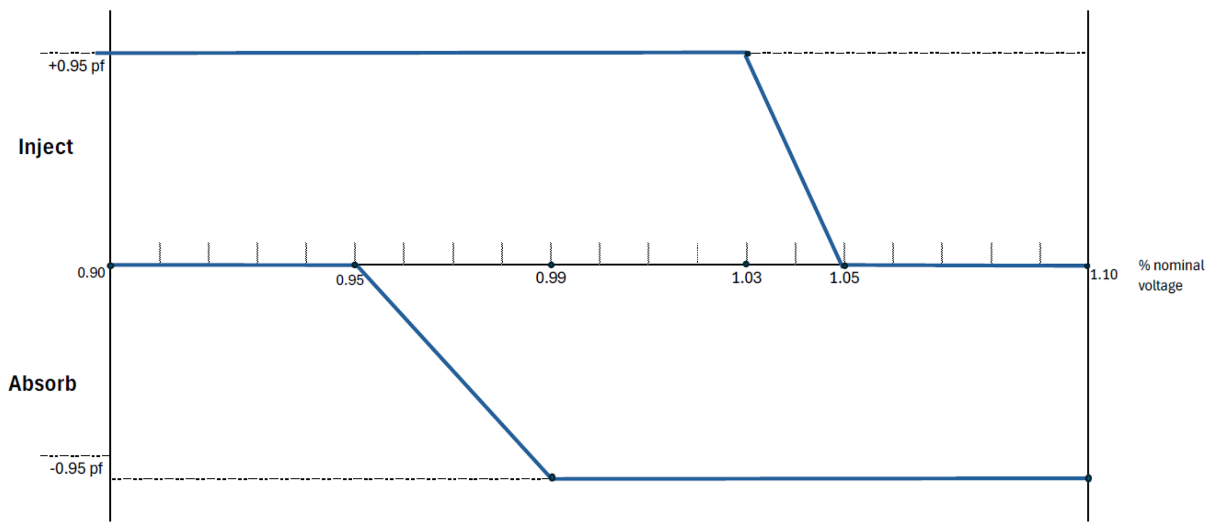

Figure 9: Reactive Power Requirement

This requirement was validated in section 3.3 "Robustness of the Control System" of MQT report for the PSCAD™ model in test T09: Power Factor Reference Change. The model has passed the test. The results are summarized in Table 12 and Figure 11 below.

4.4.2.2 *TSIR Section 7.6.3 Reactive Power and Voltage Control*

TSIR requirement states that:

- Rated reactive power shall be available through the full range of active power output of the *Generating Facility*, from zero to full power.
- Unless otherwise determined by the *System Impact Study SIS*, continuously acting voltage regulation shall have a voltage response time of no greater than 100 milliseconds.

These requirements were validated in section 3.3 "Robustness of the Control System" of MQT report for the PSCAD™ model in tests T08: Reactive Power Reference Change and T07: Voltage Reference Change. The model has passed the tests. The results are summarized in Table 12, Figure 10, and Figure 11 below.

Table 12: Robustness of the Control System					
Test #	Event	SCR	X/R	Active Power (pu)	Reactive Power (pu)
7.01	Voltage reference change per Figure 10	10	10	1	N/A
7.02	Voltage reference change per Figure 10	10	10	0	N/A
7.03	Voltage reference change per Figure 10	10	10	-1	N/A
7.04	Voltage reference change per Figure 10	3	3	1	N/A
7.05	Voltage reference change per Figure 10	3	3	0	N/A
7.06	Voltage reference change per Figure 10	3	3	-1	N/A
8.01	Reactive power reference change per Figure 11	10	10	1	Varies
8.02	Reactive power reference change per Figure 11	10	10	0	Varies
8.03	Reactive power reference change per Figure 11	10	10	-1	Varies
8.04	Reactive power reference change per Figure 11	3	3	1	Varies
8.05	Reactive power reference change per Figure 11	3	3	0	Varies
8.06	Reactive power reference change per Figure 11	3	3	-1	Varies
9.01	Power factor reference change per Figure 11	10	10	1	N/A
9.02	Power factor reference change per Figure 11	10	10	0	N/A
9.03	Power factor reference change per Figure 11	10	10	-1	N/A
9.04	Power factor reference change per Figure 11	3	3	1	N/A
9.05	Power factor reference change per Figure 11	3	3	0	N/A
9.06	Power factor reference change per Figure 11	3	3	-1	N/A

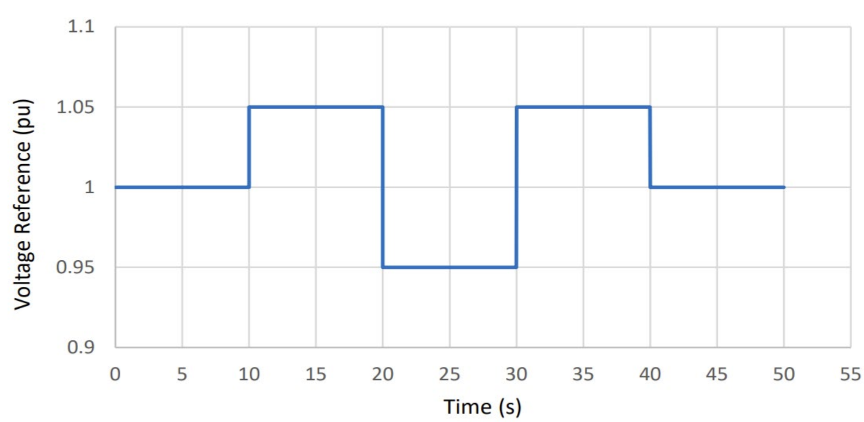

Figure 10: Voltage Reference Change

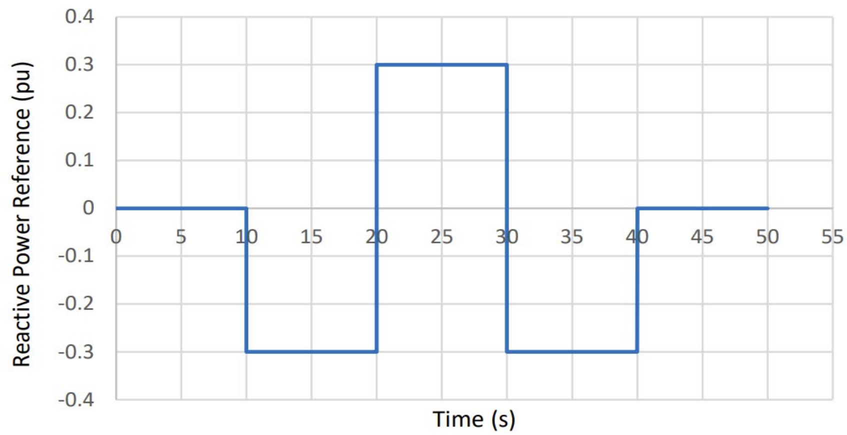

Figure 11: Reactive Power Reference Change

4.4.2.3 TSIR Section 7.6.4 Voltage Ride-through

IR686 is required to remain connected to the grid during and immediately following a system disturbance.

The MQT report for the PSCAD™ model confirmed that the IR686 plant (as a single plant) remains online and operational across the normal operating and stressed voltage conditions.

As described earlier in Section 2.3, to perform the complete EMT analysis of the plant in accordance with TSIR, the plant was modeled as two Wind Farms connected to the common POI with two separate transmission lines in the PSCAD™ Wide Area model.

Each one of the Wind Farms is required to ride through disturbances that may result in protection system disconnecting the second Wind Farm from the grid. Also, both Wind Farms are required to ride through disturbances of other elements connected to the POI which is 104N – Windy Ridge substation.

Multiple contingencies (most critical are 147 to 152 and 161 to 166) simulating these type of scenarios were applied to all PSCAD™ base cases (described in Table 7 except N-1 cases) as part of the EMT analysis to assess the IR686 model performance. Full set of contingency simulations results can be found in Appendix F: EMT Analysis Results

The results demonstrate that the plant meets the voltage ride-through requirements specified by PRC-024-2.

Few examples of the plant's ride-through ability (contingencies 147 and 148 applied on 2026_2_2025-5006_0_B1 base case and contingency 162 applied on 2026_2_2025-5006_1_B4 base case) for three-phase-to-ground faults on each one of the Wind Farms (Figure 12 and Figure 13) and a three-phase-to-ground fault on L-8001 at 104N - Windy Ridge substation including 104N-802 BBU operation (Figure 14) are shown on the following figures.

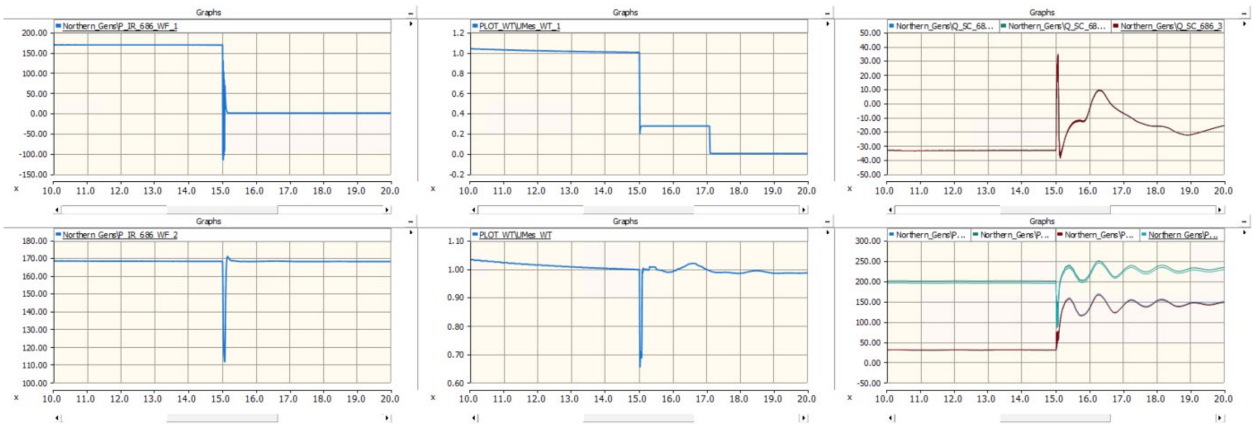

Figure 12: IR686 WF_2 Ride Trough the 3ph fault on IR686 WF_1

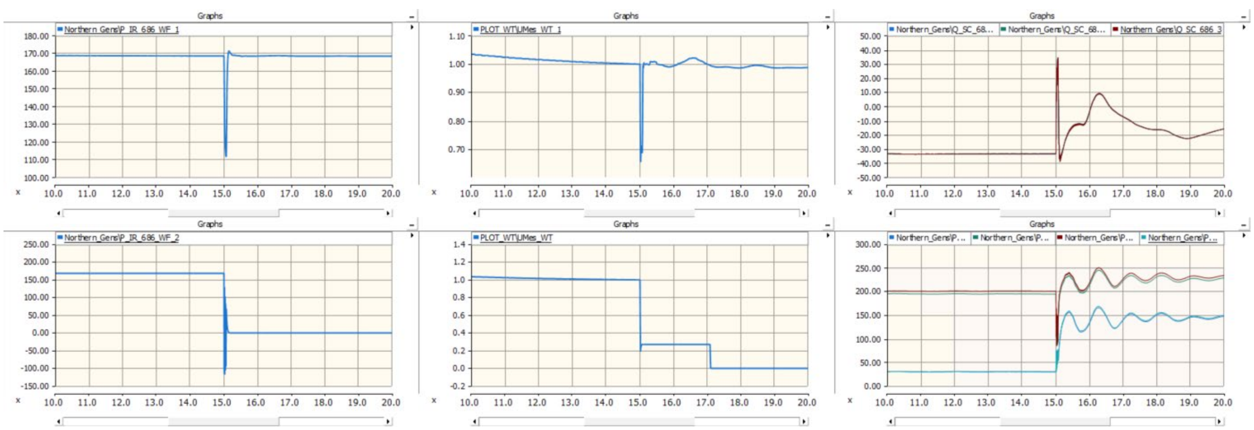

Figure 13: IR686 WF_1 Ride Trough the 3ph fault on IR686 WF_2

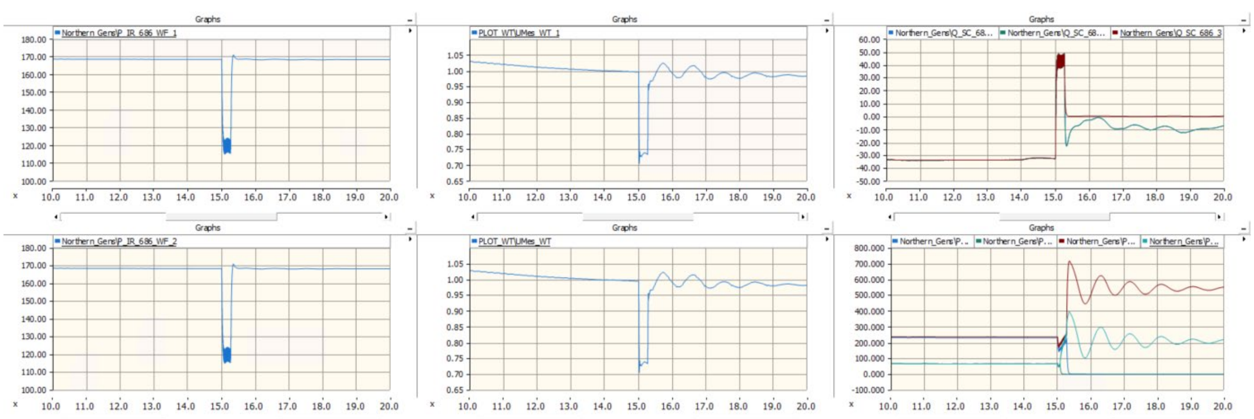

Figure 14: Ride Trough 3ph fault on L-8001, and L-8012, SC_3 trip for 104N-802 BBU

4.4.3 Control Interactions

EMT simulations were performed to evaluate control interactions between IR686 and nearby facilities. This has two primary forms, the first being interactions between the proposed facility and nearby IBR facilities while the second is concerned with the interactions between IR686 and synchronous machines.

For this purpose, full set of PSCAD contingencies was applied to all PSCAD™ base cases (described in Table 7 except N-1 cases). Full set of contingency simulations results can be found in Appendix F: EMT Analysis Results

These assessments did not reveal that the presence of IR686 resulted in unacceptable impacts on nearby IBR or synchronous machines.

Power swings and oscillatory behaviour can be observed in some IBR plants and synchronous machines for some scenarios. In these cases, IR686 model's responses did not result in the plant tripping. Additional simulations verified that the observed phenomena does persist with or without IR686 in service. As these phenomena are not IR686 related, IESO-NS system study will be undertaken to review the behaviour to determine the root cause and implement appropriate model and/or system mitigations as necessary for the NS system.

4.5 Remedial Action and Load Shedding Schemes

IR686 is connected in the northern part of the province, geographically and electrically close to the border with New Brunswick. The installation has direct impact on two existing Limited Impact RAS (NS Import Power Monitor and NS Export Power Monitor). As such, both RAS will be subject to the Reliability Coordinator and NPCC review and approval processes that accompany a functional modification per NPCC Directory #7 and NERC PRC-012 Remedial Action Schemes.

Wide-area studies will be performed to review current RAS settings and provide mitigation for the system design criteria violations introduced by the interconnection of IR686 as described in Section 4.1.

4.6 Short Circuit Maximum Short Circuit Assessment for Breaker Rating

PSS®E 34.9.6, classical fault study, flat voltage profile at 1 PU voltage, and 3LG fault was used to assess before and after short circuit conditions. The 2029 system configuration with IR686 in service and out of service was studied, with comparison between the two. Results are provided in Table 13.

The machine was modelled using the SMIB case provided by the IC with the short circuit specific data added based on additional short circuit data provided by the IC[1]. The transient reactance of 0.7716 was used in the short circuit calculation for IR686 generators.

IR686 will not impact the neighbouring breaker's interrupting capability based on this study's short circuit analysis. The interrupting capability at the 345 kV level is as follows:

- 345 kV breakers at 67N-Onslow are at least 25 kA.

The NS Power design criteria for maximum system fault capability (3-phase, symmetrical) is 15,000 MVA at the 345 kV voltage level.

Table 13: Short Circuit Levels, Three Phase, MVA

Location	IR686 Off (MVA)	IR686 On (MVA)	Post % Increase
Maximum generation, all transmission facilities in service			
IR686 POI (345kV)	6167.1	6506.9	5.5%
IR686 HV (345kV)	4565.7	4829.7	5.8%
IR686 MV (34.5kV)	1369.3	1565.6	14.3%
67N-Onslow (345kV)	6404.7	6687.0	4.4%
410N-Memramcook (345kV)	5390.2	5507.4	2.2%
Low Generation, all transmission facilities in service			
IR686 POI (345kV)	2168.9	2508.7	15.7%
IR686 HV (345kV)	1930.8	2235.9	15.8%
IR686 MV (34.5kV)	971.6	1192.0	22.7%
67N-Onslow (345kV)	2168.6	2481.0	14.4%
410N-Memramcook (345kV)	2293.5	2535.9	10.6%
Low Generation, L-8006 (104N-Windy Ridge to 410N-Memramcook) out of service			
IR686 POI (345kV)	1993.2	2333.0	17.1%
IR686 HV (345kV)	1790.3	2097.8	17.2%
IR686 MV (34.5kV)	934.7	1158.6	24.0%
67N-Onslow (345kV)	2008.8	2325.4	15.8%
410N-Memramcook (345kV)	2192.6	2375.7	8.4%
Low Generation, L-8013 (104N-Windy Ridge to 67N-Onslow) out of service			
IR686 POI (345kV)	2124.2	2464.0	16.0%
IR686 HV (345kV)	1895.3	2200.9	16.1%
IR686 MV (34.5kV)	962.5	1184.1	23.0%
67N-Onslow (345kV)	2123.4	2406.4	13.3%
410N-Memramcook (345kV)	2265.6	2511.2	10.8%

[1] Technical Memo: Goldwind V15 WTG Premium Version Short-circuit Current Contribution, Jun. 11, 2025

The minimum short circuit level for IR686 is expected when L-8006 (between 104N-Windy Ridge to 410N-Memramcook) is out of service and generation is at minimum. Under these conditions, the Short Circuit Ratio (SCR), a measure of system strength relative to the size of the facility, is calculated to be 5.7 at IR686 345 kV POI bus. Please note that Nova Scotia TSIR, section 7.4.14, states that "System short circuit level may decline over time due to changes to transmission configuration and generation mix. The Generating or BESS Facility shall be tunable to accommodate these changes to SCR as low as 1.4".

4.7 Voltage Flicker

A Power Quality Tests Result Report (as described in the IEC 61400-21 standard) for the Goldwind V15 Premium Version 8.0 MW WTG was not provided.

Flicker coefficient information for the Goldwind V15 Premium Version 8.0 MW WTG was not provided.

Per the TSIR Section 7.6.9: "the wind turbines shall not exceed the flicker emission limits established by the IEC 61000-3-7 standard."

4.8 Harmonics

IESO-NS requires IR686 to meet Harmonics IEEE-519 standard limiting Total Harmonic Distortion (all frequencies) to a maximum of 1.5%, with no individual harmonic exceeding 1.0% for 345 kV.

A separate report on Harmonics assessment will be issued for IR686.

5 OPERABILITY

It is required that plant output be stable and well damped in response to contingencies. An updated model meeting all MQT requirements and with any outstanding issues mitigated is required at least one year prior to the target COD to allow for operating studies and commissioning studies to be performed.

When final models are available, operating studies will be completed, determining operating constraints for grid elements maintenance outages or other restrictive operating scenarios

6 REQUIREMENTS AND COST ESTIMATE

The following facility changes will be required to connect IR686 to the NS transmission system at the POI:

- Transmission Network Upgrades (NU):

  - Install new 6-breaker ring substation at IR686 POI (104N-Windy Ridge). Complete with line terminations for L-8001, L-8006, L-8012, L-8013 and three transformers for three synchronous condensers. Include all P&C for the substations and line taps to the 345 kV lines.
  - Functional modification to the NS Import Power Monitor RAS and the NS Export Monitor RAS. Relocate to 104N-Windy Ridge substation and/or expand functionality to trigger on outages to L-8001, L-8006, L-8012, or L-8013.
  - Modification of protection systems at 67N-Onslow and 410N-Memramcook due to the addition of IR686.
- Transmission Provider's Interconnection Facilities (TPIF) Upgrades:
  - Two 345 kV line extensions and termination to IR686 substation (105N).
  - Transmission Provider equipment at IR686 substation (105N) including P&C relaying equipment, RTU, and telecommunications equipment.
  - Installation of revenue metering for WECS interconnection.
- IC Interconnection Facility (ICIF):
  - Facilities for NSPI to execute high speed rejection of generation (transfer trip). The plant may be integrated into the area RAS schemes.
  - 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 farm control unit. This will permit the Nova Scotia 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 voltages to a settable point and will control the reactive output of each inverter unit of IR686 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.
  - Frequency ride through capability to meet the requirements in Section 4.4.1.1.
  - The ability to control active power in response to control signals from the Nova Scotia System Operator and frequency deviations.
  - Voltage ride through capability to meet the requirements in Section 4.4.2.
  - 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).

- To minimize the need to curtail non-dispatchable wind generation at light load, all facilities must have the functionality to be incorporated into the NS Export Power Monitor RAS.
- At a minimum, the facility must meet the NS TSIR version 1.3.

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 is shown in Table 14. It includes 25% contingency but excludes applicable taxes. This cost estimate includes the additions/modifications to the NS Power system only. The cost of IC's substation, interconnection facilities and generating facility are not included. The Interconnection Facilities Study will provide a more detailed cost estimate.

Table 14: System Upgrade Cost Estimate

Determined Cost Items		Estimate
Network Upgrades (IC Cost Responsibility)		
1	• 6-breaker ring substation at IR686 POI (104N-Windy Ridge). • Complete with line terminations for L-8001, L-8006, L-8012, L-8013. • Include all P&C for the substations and line taps to the 345 kV lines.	$38,100,000
2	• Functional modifications to the NS Import Power Monitor RAS and the NS Export Power Monitor RAS. • Remote protections modifications. • Telecommunications system additions.	$1,200,000
	Contingency (25%)	$9,825,000
	Subtotal	$49,125,000
Transmission Providers Interconnection Facilities		
1	• Two 345 kV line extensions (~5.9 km each) and termination to IR686 substation (105N).	$28,400,000
2	• Transmission Provider equipment at IR686 substation (105N) including P&C relaying equipment, RTU, and telecommunications equipment. • Installation of revenue metering for WECS interconnection.	$1,400,000
	Contingency (25%)	$7,500,000
	Subtotal	$37,300,000

Determined Costs	
Network Upgrades	$49,125,000
Transmission Providers Interconnection Facilities	$37,300,000
Total of determined cost items	$86,425,000

7 CONCLUSIONS

It is concluded that the interconnection of the proposed IR686 facility into the NS transmission system at the specified location has no adverse impacts on the reliability of the Nova Scotia grid, provided the items below are addressed.

7.1 Summary of Technical Points to be Addressed

7.1.1 Study Assumptions

This SIS was completed based on the assumption that generation from the IR686 facility will be used to supply native loads.

It is understood that the originally planned configuration of the project was to have IR686 WECS facility dedicated to supply a large load facility. If the final configuration is to serve a specific load customer, additional study will be required, as the corridor flows can change dramatically when supplying a large load customer rather than Nova Scotia base load.

The planned IR686 facility has completed all prior agreements with the stated facility capacity of 336 MW. For the purpose of this study, the facility capacity was provided as 352 MW, with the intention of capping the output at the facility POI to 336 MW. This change must be reflected through the GIP process.

NRIS dispatch was studied for all scenarios with IR686 serving NS load with the exception of the TSR 411 550MW firm import. To assess the upgrades required in NS and NB for the rare dispatch with wind in NS at maximum and an import of 550MW firm, a joint study would be required with New Brunswick Power. To allow for the project to proceed in a timely manner it is recommended the project proceed with the requirements noted in Section 6 to provide for NRIS level of service for NS load and execute the GIA for ERIS.

The planned IR686 facility is connected via two 345 kV transmission lines (spur lines) between the POI and the ICIF substation. This study has assumed these lines to share a single ROW with separate transmission structures to meet NPCC and NERC criteria to avoid a double circuit contingency. This is a requirement for the facility to avoid the planning event contingency loss of both spur lines attached to a double circuit tower within this study.

7.1.2 Steady State Violations / RAS Modifications

While there were no violations noted for the system normal state, multiple steady state violations were identified with N-1 conditions. At present, there are two RAS (NS Import Power Monitor and NS Export Power Monitor) which exist for system normal and trigger on loss of L-8001. This SIS assumed that the Reliability Tie L-8006 was in-service. As a result, the scenarios which currently require these RAS become N-1 scenarios. The addition of IR686 increases the scenarios under which the RAS is required. The exact RAS design, functional modifications, and typing will be determined with further study. The results of the study will require presentation to and approval by the relevant NPCC groups as defined in NPCC Directory #7 and NERC PRC-012. If the RAS changes are not approved, IR686 may be subject to curtailment or other operating restrictions during some N-1 conditions.

7.1.3 BES/BPS Analysis

Based on the NERC-BES and NPCC-BPS analysis, the IR686 facility will be classified as both BES and BPS. IR686 will be required to register with NERC and NPCC and adhere with applicable standards.

7.1.4 System Stability / EMT

The two 345 kV line extensions (~5.9 km each) connecting IR686 substation (105N) with the 6-breaker ring substation at IR686 POI (104N-Windy Ridge), shall be built to avoid Double Circuit Tower contingency which would cause a loss of 336 MW in a single contingency.

EMT re-assessment will be required for RAS modifications outlined in section 7.1.2 above.

Additional future tuning of the Wind Farm controls may be required in case any EMT re-assessment for any reason reveals the need for it.

As noted in Section 2.4, MQT testing, it is required to provide documentation on the strategy used for Iq control.

IR686 will require synchronous condenser support, or equivalent, located at or near the POI with a total rating of at least 165 MVA specified for low inertia, high SCMVA.

7.1.5 Power Quality and Flicker

A Power Quality Tests Result Report (as described in the IEC 61400-21 standard) for the Goldwind V15 Premium Version 8.0 MW WTG was not provided.

Flicker coefficient information for the Goldwind V15 Premium Version 8.0 MW WTG was not provided.

A Power Quality report and Flicker coefficient data is to be provided 1 year prior to in service date to allow sufficient time for review and assessment and implementation of any mitigation required by IR686.

7.2 Summary of Expected Facilities

To accommodate IR686, the total high level non-binding estimated cost, detailed in Section 6, in 2026 Canadian dollars is $86,425,000 which includes a 25% contingency but does not include HST.

Of that, $49,125,000 is NU while the remaining $37,300,000 is TPIF. The costs of all associated facilities required at the IC's substation and Generating Facility are in addition to this estimate.

The IC will be responsible for acquiring the ROW (Right-Of-Way) for all the facilities.

The preliminary and non-binding estimate for the construction of the customer funded TPIF is 24 months. Timelines will be confirmed in the Facility Study.

7.3 Facility Specification

Control system parameters from the tuned model will be provided to the IC and must be reflected in the installed plant. If there are control parameter changes made to the installed plant, IESO-NS must be informed to ensure that simulation models are accurate representations of the facility.

7.4 Commissioning Tests and Tuning

Change in plant design, such as transformer specification, will require updated models to be submitted to the IESO-NS for review of impact on plant performance.

Any updates to the plant design and PSCAD™ model must be delivered to IESO-NS with sufficient time to assess and run in simulation prior to the expected review and approval of commissioning tests.

Once updated models have been accepted for use, PSCAD™ studies will be performed for use in benchmarking against commissioning results. Any discrepancy must be remedied prior to the facility receiving permission for commercial operation.

In the operational time frame, parameter changes may be required to accommodate rapidly evolving technology and regulatory requirements for the large-scale integration of inverter-based energy sources.