Interconnection Feasibility Study Report
GIP-IR727-FEAS-R1

Generator Interconnection Request 727
100 MW Wind Generation Facility
Yarmouth County, NS

2024/06/14
Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer *(IC)* submitted an Interconnection Request, both Network Resource Interconnection Service *(NRIS)* and Energy Resource Interconnection Service *(ERIS)*, for a proposed 100 MW wind generation facility interconnected to the NSPI transmission system with a Commercial Operation Date of 2027/12/31. The Point of Interconnection *(POI)* requested by the customer is the 138kV line L6024, approximately 15.9 km from 9W-Tusket/IR677:Wedgeport Wind and 95 km from 50W-Milton.

There are twenty-two transmission and sixteen distribution higher-queued Interconnection Requests in the Advanced Stage Transmission and Distribution Queue included in this study. IR686 is a higher queued transmission-connected generation IR with its SIS in progress, however it was not included in this study as the IR686 SIS was not complete when IR727 was initiated.

In addition, there is a long-term firm Transmission Service Reservation *(TSR)* that must be accounted for: 550 MW from New Brunswick to Nova Scotia *(TSR411)*.

TSR411 is a long-term firm point-to-point Transmission Service Reservation and a Facilities Study is currently underway to determine the associated upgrades to the Nova Scotia transmission system. These upgrades are expected to materially alter the configuration of the transmission system in Nova Scotia. As a result, the following notice was posted to the OASIS site at https://www.nspower.ca/oasis/generation-interconnection-procedures:

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

This study assumes that the addition of generation from IR727 will displace coal-fired generation in eastern Nova Scotia for NRIS and ERIS.

IR727's NPCC BPS *(Bulk Power System)* categorization will be determined in the subsequent SIS. The higher queued IR677: Wedgeport Wind project's categorization may change if IR727 proceeds and is BPS categorized. IR677 was categorized as non-BPS at the time it was studied, however both IRs are in close electrical proximity and the larger combined injection will have more pronounced system impacts.

IR727 will be categorized NERC BES (*Bulk Electric System)* as its aggregate rated output is greater than 75 MVA. This new substation will be categorized Bulk Electric System under NERC criteria. The generators and elements in Interconnection Customer substation *(including collector bus and substation step-up transformer)*, are also categorized as BES.

Load flow analysis identified extensive thermal overloads and voltage violations in the Western Transmission System associated with IR727. The 99W-Bridgewater two transformers *(99W-T71 and 99W-T72)* and lines L6531 *(99W/50W)* and L5535 *(9W/15V)* were thermally overloaded even under system normal conditions.

Post-contingency conditions detected additional thermal overloads in nearly all 138kV and 69 kV network lines and transformers in and bordering the Western Transmission System *(L7009, L6531,* *L6025, L6024, L6021, L6020, L6006, L5541, L5535, L5532, and L5531)* along with the transformers at 9W-Tusket *(9W-T2 and 9W-T63)* and 99W-Bridgewater *(99W-T71 and 99W-T72)*.

It's noted that the IR727 IC station transformer's rating *(123MVA)* could be exceeded *(overload at 101%)* when the IR727 generation is operating at its maximum 100 MW output, while absorbing 50.2 MVar reactive power at its WECS.

The Vestas V150 6.2 MW WECS used for IR727 can meet the net power factor requirement of ±0.95 at the high voltage side of Interconnection Facility. The adequacy of reactive power supply will be further investigated in the System Impact Study as specific details of the collector circuits become available. It's indicated that Vestas V162 6.2MW WECS are also able to maintain the reactive power capability at low wind with no active power production.

IR727 was not found to adversely impact the short-circuit capabilities of existing circuit breakers. However, this study shows that the minimum short circuit level at the IR727 Interconnection Facility 34.5 kV bus is 309 MVA with all lines in service and IR727 off-line. This falls to 98 MVA with L6024 open at 50W-Milton, resulting in an extremely low short-circuit ratio *(SCR)* of 0.8.

More detailed EMT analysis is required if IR727 proceeds to the SIS stage, as the standard SCR screening methodology becomes less definitive due to IR677: Wedgeport Wind (80 MW) being approximately 15.9 km away. With IR677 under consideration, the effective SCR will be lower.

The IC should consult the generator vendor, Vestas, to determine if any modifications for low SCR conditions are required. Vestas documentation states the minimum SCR for V150 6.2 MW WECS is 5.0 and the calculated SCR in the area is significantly lower than that. The impact of the low SCR will be further examined when detailed data for the project is made available for the SIS.

Note that Section 7.4.15 of NSPI's TSIR states:

> *System short circuit level may decline over time with changes to transmission configuration and generation mix. The Generating Facility shall be able to accommodate these changes.*

It is required that the project design meets NSPI requirements for low-voltage ride-through and voltage control. IR727 must meet NS Power's required short term and long-term voltage flicker requirements. Harmonics must meet the Total Harmonics Distortion provisions of IEEE 519.

The preliminary value for the unit loss factor is calculated as +2.24% at the POI on L6024, net of any losses on the IC facilities up to the POI.

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.

The steady state contingency analysis evaluated in this study demonstrates that there is no further capacity in the vicinity under ERIS for IR727.

No cost estimate is provided for ERIS as there is no available transmission capacity. System normal overloads are present with IR727 injecting its requested 100 MW amount. Reducing its generation removes the system normal overloads, however additional thermal overloads re-appear post-contingency.

Extensive Network Upgrades are required in the Western Transmission System to operate at the requested 100 MW both under system normal and post-contingency conditions. The list of violations and remediation measures are summarized below:

1) 99W-T71 and 99W-T72 system normal overloads:
   a) Replace the existing 120/160/200 MVA transformers with 235/314/392 MVA transformers.
2) L6531 *(99W/50W)*, L6025 *(99W/50W)*, and L5535 *(9W/15V)* system normal thermal overloads:
   a) Upgrade thermal rating and associated breakers, switches, relaying, and metering.
3) L5535 *(9W/15V)* system normal overloads:
   a) Rebuild L5535 to higher thermal rating and modify IR677 L5535 AAS *(Automatic Action Scheme)*.
4) 9W-T2 and 9W-T63 overloads:
   a) Implement a new AAS to cross trip IR727.
5) L7009 *(120H/99W)* overloads:
   a) Complete rebuild from 50°C 795 Drake to 70°C 1113 Beaumont.
6) L6006 *(99W/50W)* overloads:
   a) Upgrade thermal rating.
7) L6020 *(50W/30W)*, L6021 *(30W/9W)*, L6024 *(9W/IR677/IR727/50W)* thermal overloads:
   a) Construct new 138 kV line *(103 km)* and associated nodes at 9W-Tusket and 50W-Milton.
8) L5532 *(3W/14V)*, L5531 *(13V/15V)*, L5541 *(3W/4W/50W)* overloads:
   a) Implement a new AAS to cross trip IR727.
9) Under voltage issues in the Western Transmission System:
   a) Upgrade the proposed IR677 POI synchronous condenser.

Note, the proposed AAS *(Automatic Action Schemes)* are only possible if IR727 is not BPS categorized.

The preliminary non-binding NRIS cost estimate for interconnecting 100 MW at the L6024 POI is $490,690,000 including a 25% contingency. In this estimate, $386,240,000 *(plus 25% contingency)* of the amount represents Network Upgrade costs which are funded by the Interconnection Customer, but which are eligible for refund under the terms of the GIP. It does not include TBD costs to address any stability issues identified at the SIS stage based on dynamic analysis and EMT analysis.

The estimated time to construct the Transmission Providers Interconnection Facilities and the Network Upgrades are estimated to be completed 60-72 months after receipt of funds and cleared right of way from the customer.

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1 Introduction

The IC *(Interconnection Customer)* submitted an Interconnection Request for both NRIS *(Network Resource Interconnection Service)* and ERIS *(Energy Resource Interconnection Service)* for the proposed "Tusket Wind" 100 MW wind generation facility interconnected to the NSPI Transmission System with a 2027/12/31 Commercial Operation Date. The Point of Interconnection *(POI)* requested by the customer is the 138kV line L6024, approximately 15.9 km from 9W-Tusket substation.

The IC signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI transmission system dated 2023/11/17, and this report is the result of that Study Agreement. This project is listed as Interconnection Request 727 in the NSPI Interconnection Request Queue and will be referred to as IR727 throughout this report.

Figure 1 shows the proposed geographic location of IR727 in relation to the NSPI transmission system.

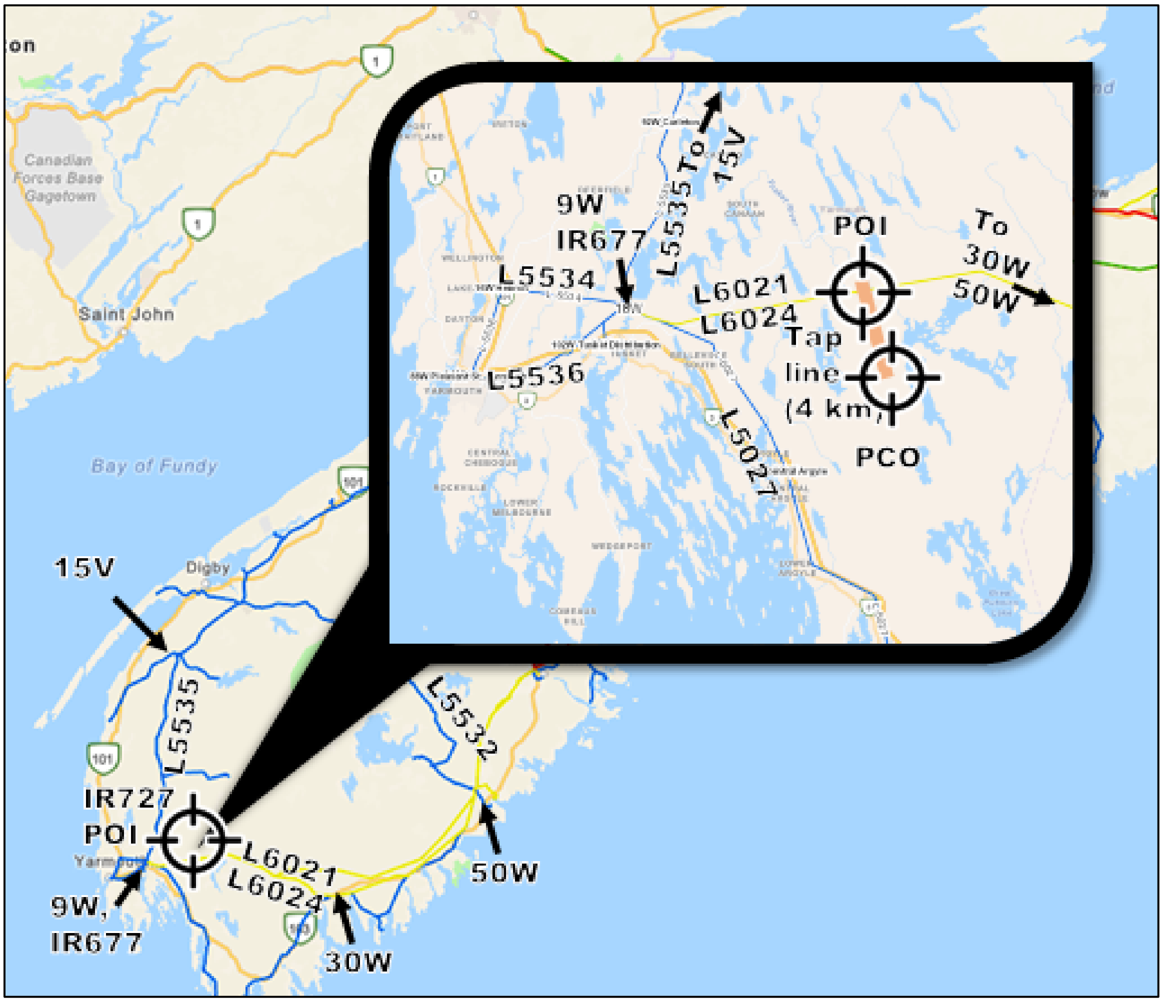

Figure 1 IR727 Site Location

Figure 2 is a simplified one-line diagram of the transmission system configuration in NS.

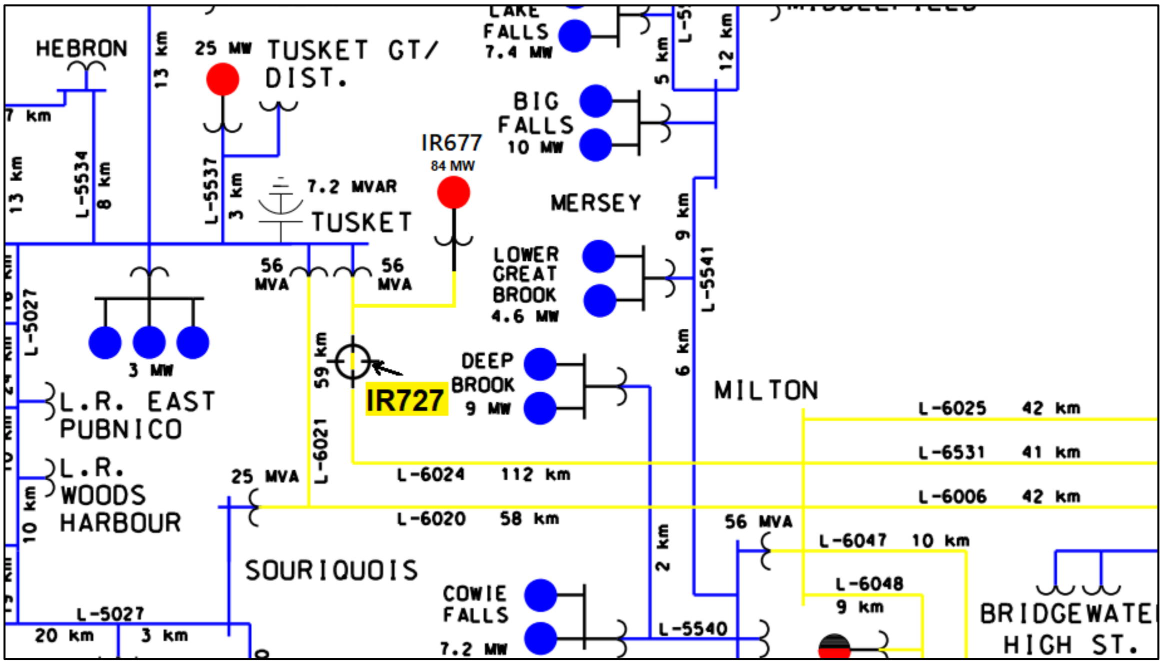

Figure 2 Point of Interconnection *(not to scale)*

2 Scope

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

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

- Preliminary identification of any circuit breaker short circuit capability limits exceeded because of the interconnection, and any network upgrades necessary to address the short circuit issues associated with the IR. Expected minimum short circuit capability will also be identified for the purposes of Short Circuit Ratio analysis.
- Preliminary identification of any thermal overload or voltage limit violations resulting from the interconnection and identification of the necessary network upgrades to allow full output of the proposed facility. Thermal limits are applied to the seasonal *(summer/winter)* emergency ratings of transmission elements. Voltage violations occur when the post-contingency transmission bus voltage is outside the range of +/-10% of nominal voltage.

- Preliminary analysis of the ability of the proposed Interconnection Facility to meet the reactive power, power quality and cold-weather capability requirements of the NSPI *Transmission System Interconnection Requirements*[1].
- Preliminary description and high-level non-binding estimated cost and time to construct the facilities required to interconnect the generating facility to the transmission system.
- For comparative purposes, the impact of IR727 on incremental system losses under standardized operating conditions is examined.

This FEAS is based on a power flow and short circuit analysis and does not include a complete determination of facility changes/additions required to increase the system transfer capabilities that may be required to meet the design and operating criteria established by NSPI, the Northeast Power Coordinating Council *(NPCC)*, and the North American Electric Reliability Corporation *(NERC)*. These requirements will be determined by a more detailed analysis in the subsequent interconnection System Impact Study *(SIS)*. An Interconnection Facilities Study *(FAC)* follows the SIS to ascertain the final cost estimate to the interconnect the generating facility.

3 Assumptions

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

1. NRIS and ERIS per section 3.2 of the Generator Interconnection procedures *(GIP)*.
2. Commercial Operation date 2027/12/31.
3. The Interconnection Customer Interconnection Facility *(ICIF)* consists of eighteen Vestas V150 6.2 MW wind turbines *(Type 4 full converter)* Wind Energy Converter System *(WECS)* units, with a total capacity of 111.6 MW, capped at 100 MW.
   3.1. The generator terminals are at 720V.
   3.2. Connected to three collector circuits operating at a voltage of 34.5kV. Two collector circuits connected to 4 WECS units each *(totalling 8 WECS)* and two collector circuits connected to 5 WECS units each *(totalling 10 WECS)*.
4. The ICIF will require the construction of a 4 km 138 kV transmission spur line from the POI to the IC 138kV/34.5kV transformers. The IC will be responsible for providing the Right-of-Way for the lines. Line data was provided and based on 1272 kcmil Bittern ACSR conductor with the nominal rating of 283 MVA.
5. IR727 will be connected onto L6024 via a single breaker line tap in accordance with Table 8 of the NSPI *Transmission System Interconnection Requirements.*

[1] transmission-system-interconnection-requirements *(nspower.ca)*

6. The generation technology used must meet NSPI requirements for reactive power capability of at least 0.95 capacitive to 0.95 inductive at the HV terminals of the IC substation step up transformer. It is also required to have high-speed Automatic Voltage Regulation to maintain constant voltage at the designated voltage control point during and following system disturbances as determined in the subsequent System Impact Study. The designated voltage control point will either be the low voltage terminals of the wind farm transformer, or if the high voltage terminals are used, equipped with droop compensation controls. It is assumed that the generating units are not de-rated in their MW capability when delivering the required reactive power to the system.
7. Preliminary data was provided by the IC for the IC substation interconnection facility:
   7.1. The transformer was rated at 74/98/123 MVA and modeled with a positive-sequence impedance of 9% on 100 MVA with an X/R ratio of 38.44.
   7.2. The IC indicated that these interconnection facility transformers have a wye-delta-wye winding configuration assumed with de-energized tap changers with ±5% taps and 5 equal steps.
   7.3. The impedance of each generator step-up 0.72/34.5kV transformer was modeled as 10.6% on 7.5 MVA with an X/R ratio of 11.74 and no tap changer.
8. Equivalent collector circuit data was provided by the IC and Z=0.0075 + j0.0109 p.u and B=0.0321 p.u were used. The net real and reactive power output of the plant will be impacted by losses through transformers and collector circuits.
9. Generation Interconnection Queue and OATT Transmission Service Queue that have completed a System Impact Study, or that have a System Impact Study in progress will proceed, as listed in Section 4 below.
10. It is required that the wind turbines are equipped with a "cold weather option" suitable for delivering full power under expected Nova Scotia winter environmental conditions.
11. Planning criteria meeting NERC Standard TPL-001-5.1 *Transmission System Planning Performance Requirements* and NPCC Directory 1 *Design and Operation of the Bulk Power System* as approved for use in Nova Scotia by the Utility and Review Board, are used in evaluation of the impact of any facility on the Bulk Electric System.
12. Transmission line ratings used in this study are listed in Appendix A: Transmission line ratings.

4 Projects with Higher Queue Positions

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

As of 2024/01/25, 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 IR727 was initiated.

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

- TSR411: SIS in progress
- TSR412: Withdrawn

TSR411 is a long-term firm point-to-point Transmission Service Reservation and a Facilities Study is currently underway to determine the associated upgrades to the Nova Scotia transmission system. As a result, the following notice has been posted to the OASIS site at https://www.nspower.ca/oasis/generation-interconnection-procedures:

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

5 Short-Circuit Duty / Short Circuit Ratio

The NS Power design criteria for maximum system fault capability *(3-phase, symmetrical)* is 10,000 MVA at the 230 kV voltage levels, 5,000 MVA at the 138 kV voltage levels and 3,500 MVA at the 69 kV voltage levels. The fault current characteristic for this Nordex Vestas V150 6.2 MW wind turbines is given as 1.05 times rated current, or X'd = 0.952 per unit on machine base MVA.

Short circuit analysis was performed using PSS/E for a classical fault study, 3LG and flat voltage profile at 1.0 p.u. The short-circuit levels in the area before and after this development are provided below in Table 1.

Table 1: Short-Circuit Levels[2]

Location	Without IR727	With IR727
All transmission facilities in service		
POI on L6024 *(138kV)*	588	686
Interconnection Facility *(138kV)*	556	655
9W-Tusket *(138kV of 9W-T63)*	592	668
50W-Milton *(138kV)*	1,571	1,615
9W-Tusket *(69kV)*	611	638
50W-Milton *(69kV)*	628	634
Minimum Conditions *(TC3, LG1, ML In-Service)*, **all lines in service**		
Interconnection Facility *(138kV)*	538	637
IR727 34.5 kV	309	424
Minimum Conditions *(TC3, LG1, ML In-Service)*, **L6024 open at IR677**		
Interconnection Facility *(138kV)*	530	629
IR727 34.5 kV	107	206
Minimum Conditions *(TC3, LG1, ML In-Service)*, **L6024 open at 50W**		
Interconnection Facility *(138kV)*	306	421
IR727 34.5 kV	94	208

The interrupting capability of the 138 kV circuit breakers is at least 5,000 MVA at 9W-Tusket and 50W-Milton. The interrupting capability of the 69 kV circuit breakers is at least 3,500 MVA at 9W-Tusket and 50W-Milton. As such, the breaker interrupting ratings at these substations will not be exceeded by this development on its own.

Inverter-based generation installations often have a minimum Short Circuit Ratio *(SCR)* for proper operation of converters and control circuits. Based on the calculated short circuit levels with the 111.6 MW[3] installation consisting of 18 Vestas V162 6.2MW units, the SCR would be 2.8 at the

[2] Classical fault study, flat voltage profile.
[3] While 100 MW is the requested amount, the wind farm's fault contribution will reflect its 111.6 MW nameplate capability.

34.5 kV Interconnection Facility of the IR727 substation with all lines in service and IR727 offline. This falls to 0.8 with L6024 open at 50W end and 1.0 if L6024 opens at 9W end.

More detailed EMT analysis is required if IR727 proceeds to the SIS stage, as the standard SCR screening methodology becomes less definitive due to IR677: Wedgeport Wind (80 MW) being approximately 15.9 km away. The SCR at IR727's 34.5 kV bus, under minimum conditions with L6024 open at 50W, with IR677 considered will be lower than 0.8.

As per the data received from the IC, the minimum SCR for Vestas V150 6.2MW wind turbines is 5.0. The calculated SCR under minimum conditions, with all facilities in service and with L6024 open at either 50W or 9W, is significantly lower than the minimum SCR recommended for Vestas V150 6.2 MW. SCR is further reduced at the high side of the generator step-up transformers due to the collector circuit impedance.

The IC should consult the generator vendor to determine what modifications are required to ensure IR727 meets reliability requirements under very low SCR conditions. The impact of the low SCR will be further examined when detailed data for the machine is made available for the SIS. Note that the minimum short circuit level on the 34.5kV bus will also be greatly impacted by the impedance of the Interconnection Facility transformer.

Note that Section 7.4.15 of NSPI's TSIR states:

> *System short circuit level may decline over time with changes to transmission configuration and generation mix. The Generating Facility shall be able to accommodate these changes.*

6 Voltage Flicker and Harmonics

Voltage flicker is not calculated in this study as the flicker coefficient data is currently not available. IR727 is required to meet NS Power's short term and long-term voltage flicker requirements based off the measured data.

As for harmonics, NSPI requires IR727 to meet Harmonics IEEE-519 standard limiting Total Harmonic Distortion *(all frequencies)* to a maximum of 2.5%, with no individual harmonic exceeding 1.5% for 138 kV. The total harmonic distortion *(THD)* for Vestas V150 6.2MW is currently not available. If for some reason, in the actual installation, IR727 causes issues with voltage flicker or harmonics, then IR727 will be responsible for mitigating the issues.

7 Load Flow Analysis

The load flow analysis was completed for generation dispatches under system summer peak, spring light load, shoulder season, and winter peak load conditions which stress the Western and Valley interfaces. Generation dispatch was also selected to represent import and export scenarios that consider expected flows from the existing transmission service reservation associated with the Maritime Link, and scenarios where Maritime Link imports displace NS thermal generation.

For these cases, transmission connected wind generation facilities were dispatched between 19% and 100% of their rated capability. There is high correlation between wind plants in the western part of the province, so it is reasonable to expect these wind plants would be near full output when IR727 is at capped 100 MW output. All interface limits were respected for base cases.

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

- Pre-IR727 cases ending with “-1”: IR727 off.
- Post-IR727 cases ending with “-2”: IR727 dispatched at 100 MW under both NRIS and ERIS designation.

The cases and dispatch scenarios considered are shown in Table 2.

Table 2: Base Cases for IR727

Case	NS Load	IR727	System Wind generation	NS/NB[4]	ML[4]	CBX	ONS	ONI	Valley import	Western import	Valley export	West Valley import
-	-	-	-	-	-	L8004, L7003, L7004, L7005, L6515	*L8002, L7001, L7002, L7018, L6001*	*L8003, L7003, L7019, L7005, L6503*	*L6054, L6011, L6051*	*L7008, L7009*	*L5532, L5535, L5025*	*L5022, L5532, L5535, L6013, L6015*
c_ll01-1	871	0	540	330	-475	349	26	371	76	-222	-5	25
c_ll01-2	871	100	640	330	-475	305	-16	329	69	-297	-9	29
c_ll02-1	871	0	696	395	-352	217	-281	161	-22	-282	42	-22
c_ll02-2	871	100	797	394	-349	175	-323	119	-30	-355	39	-19
c_sh01-1	1,202	0	808	331	-316	338	183	548	42	-155	-22	57
c_sh01-2	1,202	100	908	330	-316	252	99	463	34	-232	-25	60
c_sh02-1	1,202	0	699	331	-375	329	-107	308	-61	-301	36	-1
c_sh02-2	1,202	100	799	331	-337	247	-188	226	-68	-377	34	1
c_sp01-1	1,670	0	1,139	333	-475	407	309	647	117	-164	-10	45
c_sp01-2	1,670	100	1,239	333	-475	321	226	564	110	-240	-14	51
c_sp02-1	1,661	0	1,279	333	-475	317	367	662	135	-125	-25	55
c_sp02-2	1,661	100	1,379	333	-475	240	290	585	128	-203	-29	61
c_wp01-1	2,313	0	1,393	151	-330	497	643	835	94	-185	-25	101
c_wp01-2	2,313	100	1,493	151	-330	407	556	748	87	-264	-28	104
c_wp02-1	2,321	0	1,393	150	-330	583	741	932	160	-147	-24	100
c_wp02-2	2,321	100	1,493	150	-330	489	651	842	153	-228	-27	103
c_wp03-1	2,354	0	691	150	-330	795	770	1,106	173	-101	-26	101
c_wp03-2	2,354	100	791	150	-330	701	681	1,017	166	-182	-29	105

Note 1: All values are in MW.
Note 2: CBX *(Cape Breton Export)* and ONI *(Onslow Import)* are Interconnection Reliability defined interfaces.
Note 3: Wind refers to transmission connected wind only.
Note 4: Positive indicates export from NS to NB/NFLD while negative indicates import from NB/NFLD to NS.

For both NRIS and ERIS analysis, this FEAS added IR727 and displaced coal-fired generation in the system based on operating orders. Single contingencies were applied at the 230 kV, 138 kV, and 69 kV voltage levels for the above system conditions with IR727 interconnected to the POI on L6024. Automated analysis searched for violations of continuous thermal ratings and nominal voltage limits for system normal conditions, and emergency thermal ratings and emergency voltage limits for each contingency condition. Contingencies studied are listed in Table 3.

Table 3: Contingency List

Transmission Line	Transformer / Bus	Circuit Breaker Failure	Double Circuit Tower
L7008, L7009, L5545, L5546, L6531, L6006, L6025, L6002, Shunt *(138 kV)*	99W-T61, T62, T71, T72 B71, B72, B51	99W: 708, 709, 600, 501, 545, 546, 562	L7008+ L7009 L7009+ L8002
L6012, L6013, L6054, L6015, L6052, L5017, L5022, L5035, L5019, 50V-Load *(138kV)*,	43V-T61, T62, B51, C61	43V: 604, 613, 505, 562, 503, 506, 501, 502, 504, IR737: 601	L5016+ L6012
L6051, L6011, L5014, L5060, L5015, L5016	17V-T2, T63, T1, C51, B2	17V: 610, 612, 611, 563, 512, 519, 505	
L5025*, L6053, L6004	51V-T61*, B51*, B52, B61	101V:601, 602	
L5531, L5532*, L5026*	13V-B51, 11V-B51*		
L6002, L6009, L6008, L6004, L6003, L5003, L5004	90H-T1	90H: 611, 608, 605, 604, 602, 612, 609, 606, 603, 610, 607, 601, 503, 506, 501 101H: 600; IR671:601	
L6005, L6010, L6011	120H-T71, T72	120H: 710, 711, 712, 713, 714, 715, 716, 720, 621, 622, 623, 624, 626, 627, 628, 629	L6005+ L6016 L6011+ L6010 L6005+ L6016
L6042, L6007, L6014, L5049, L5012, L5041	91H-T62, T11,	91H: 621, 613, 603, 604, 605, 606, 607, 608, 609, 611, 516, 521, 523	
L6020, L6024, L6025, L6048, L5541, L5530, L5539, L5540	50W-T53, B3, B4, B2, IR597	50W: 615, 600, 514, 517	
L6021, L5535, L5027	9W-T2, T63, B52, B53	9W: 500 IR677:600 IR727:600	
	30W-T62, B51		

This study identified extensive thermal overloads and voltage violations in the Western Transmission System, including the Bridgewater, Milton and Tusket areas. Thermal overloads were observed in both system normal and post-contingency conditions. Table 4: Highest Overloads *(based off nominal rating)* contains a summary of the highest overloads and the contingencies/cases they occur in. Other contingency/case combinations also exhibited overloads, however, to a lesser extent.

Load flow solutions were not able to converge under the contingencies of L6024 between 50W and IR727, 9W-T63, 50W-600 and 50W-B4 in certain cases.

Contingencies 50W-615 and 50W-B3 would result in under-voltage in the Western Milton and Tusket areas. Low voltage would also occur on 230 kV bus at 99W-Bridgewater under the loss of the other 230 kV line or transformer at 99W.

There are pre-existing issues, mainly due to the low generation dispatch at Tuft's Cove, that IR727 is not required to address on L6003 *(91H/90H)*, L6004 *(90H/IR671 POI)*, and L6010 *(90H/120H)*.

Table 4: Highest Overloads *(based off nominal rating)*

Line/Transformer	Highest Overload *(%)*	Case	System Condition/Contingency	IR727 to address?
99W-T71	109	ll02, sh02	System normal	Yes
99W-T72	101	ll02, sh02	System normal	Yes
L6531 *(99W/50W)*	108	sp02, wp02, sh02, sp01	System normal	Yes
L5535 *(92W/15V)*	141	ll01, sh01, sp01, sp02	System normal	Yes
L5535 *(9W/92W)*	146	ll01, sh01, sp01, sp02	System normal	Yes
99W-T71	178	ll01, ll02, sh01, sh02, sp01, sp02, wp01, wp02	Various Contingencies	Yes
99W-T72	179	ll01, ll02, sh01, sh02, sp01, sp02, wp01, wp02, wp03	Various Contingencies	Yes
50W-T1	100	wp03	9W-500	No
9W-T63	200	sp02, wp02, wp03	L6024, 50W, 50W-501, 50W-615, 50W-B3, 50W-B4	Yes
9W-T2	217	ll01, ll02, sh01, sh02, sp01, sp02, wp02	11V-B51, 13V-B51, 15V-B51, 43V-613, 50W-514, 50W-517, 50W-B2, 50W-B4, 51V-500, 51V-521, 51V-562, 51V-B51, 51V-B52, 90H_L6004-1, 90H-604, 90H-605, DCT_L5016][L6012, IR597_IR675, IR727-602, L5025, L5026, L5531, L5535, L5541, L6024	Yes
L6003 *(91H/90H)*	111	sh02, sp01, wp01, wp02	101H-600, 108H-B3, 90H-610, 90H-611, 90H-L6009, 90H-L6009-2	No
L6010 *(120H/90H)*	110	wp01, wp02	120H-622, DCT_L6005][L6016	No
L6004 *(90H/IR671)*	107	sh02	43V-503	No
L7009 *(120H/99W)*	175	ll01, ll02, sh01, sh02, sp01, sp02	120H_L7008, 120H-715, 120H-716, 99W-501, 99W-708, 99W-B71, 99W-L7008, 99W-T61, 99W-T71	Yes
L6006 *(99W/50W)*	147	ll01, ll02, sh01, sh02, sp01, sp02	50W-501, 50W-615, 50W-B3, 99W-501, 99W-L6025, 99W-L6531, 99W-T61, IR739-601, L6025	Yes
L6531 *(99W/50W)*	187	ll01, ll02, sh01, sh02, sp01, sp02, ll01, ll02, sh01, sh02, sp01, sp02	Various Contingencies *(was already overloaded at system normal in some cases)*	Yes
L6025 *(99W/IR739)*	151	ll01, sh01, sh02, sp01, sp02, wp01	99W-562, 99W-T62	Yes
L6025 *(IR739/50W)*	114	ll01, sh02	99W-562, 99W-T62	Yes
L6024 *(50W/IR727)*	130	ll01, ll02, sh01, sh02, sp01, sp02, wp01, wp02, wp03	11V-B51, 30W-508, 30W-T62, 50W-501, 50W-615, 50W-B3, 51V-500, 51V-521, 51V-B51, 9W-500, 9W-B52, 9W-B53, 9W-T2, 9W-T63, L5025, L5026, L6020	Yes
L6021 *(30W/9W)*	153	ll01, ll02, sh02, sp02	L6024, 50W-B4	Yes
L6020 *(50W/30W)*	211	sp02	L6024	Yes
L5541 *(50W/4W)*	134	ll02, sh02	11V-B51, 51V-500, 51V-521, 51V-B51, L5025, L5026	Yes
L5541 *(3W/4W)*	127	ll02, sh02	11V-B51, 51V-500, 51V-521, 51V-B51, L5025, L5026	Yes
L5535 *(9W/92W)*	216	ll01, ll02, sh02, sp02	Various Contingencies *(was already overloaded at system normal in some cases)*	Yes

Line/Transformer	Highest Overload *(%)*	Case	System Condition/Contingency	IR727 to address?
L5535B *(92W/15V)*	213	sp02, wp02	Various Contingencies *(was already overloaded at system normal in some cases)*	Yes
L5532 *(3W/91W)*	120	ll02, sh02	11V-B51, 51V-500, 51V-521, 51V-B51, 99W-562, 99W-T62, 9W-500, 9W-B53, L5025, L5535	Yes
L5532 *(91W/57W)*	115	ll02, sh02	11V-B51, 51V-500, 51V-521, 51V-B51, 99W-562, 99W-T62, L5025, L5026	Yes
L5532 *(57W/7W)*	116	ll01, ll02, sh01, sp01, sp02	11V-B51, 51V-500, 51V-521, 51V-B51, 99W-562, 99W-T62, L5025, L5026	Yes
L5532 *(7W/76V)*	117	ll01, ll02, sh02, sp02	9911V-B51, 51V-500, 51V-521, 51V-B51, 99W-562, 99W-T62, L5025, L5026	Yes
L5532 *(76V/14V)*	119	ll01, ll02	11V-B51, 51V-500, 51V-521, 51V-B51, 99W-562, 99W-T62, L5025, L5026	Yes
L5532 *(14V/13V)*	111	ll01, ll02, sh01, sh02, sp01, sp02, wp01, wp02, wp03	11V-B51, 51V-500, 51V-521, 51V-B51, 99W-562, L5025	Yes
L5531 *(13V/15V)*	161	ll01, ll02, sh01, sh02, sp01, sp02, wp01, wp02, wp03	120H_L7008, 120H_L7009, 120H-712, 120H-713, 120H-715, 120H-716, 13V, 15V-L5538, 30W, 30W-508, 30W-T62, 3W-B53, 50W, 50W-501, 50W-514, 50W-517, 50W-615, 50W-B2, 50W-B3, 99W-501, 99W-562, 99W-708, 99W-709, 99W-B71, 99W-B72, 99W-L7008, 99W-L7009, 99W-T61, 99W-T62, 99W-T71, 99W-T72, 9W, 9W-B52, 9W-T2, DCT_L7009][L8002, L5533, L5541, L6024	Yes

The steady state contingency analysis evaluated in this study demonstrates that there is no available capacity in the vicinity under ERIS for IR727. System normal overloads are present with IR727 injecting its requested 100 MW amount. Reducing its generation removes the system normal overloads, however additional thermal overloads re-appear post-contingency.

For NRIS, extensive Network Upgrades are required in the Western Transmission System to operate at the requested 100 MW both under system normal and post-contingency conditions.

Proposed Network Upgrades are as follows:

1) 99W-T71 and 99W-T72 system normal overloads:
    a) Replace the existing 120/160/200 MVA transformers with 235/314/392 MVA transformers.
2) L6531 *(99W/50W)*, L6025 *(99W/50W)*, and L5535 *(9W/15V)* system normal thermal overloads:
    a) Upgrade thermal rating and associated breakers, switches, relaying, and metering.
3) L5535 *(9W/15V)* system normal overloads:
    a) Rebuild L5535 to higher thermal rating and modify IR677 L5535 AAS.

4) 9W-T2 and 9W-T63 overloads:
   a) Implement a new AAS to cross trip IR727.
5) L7009 *(120H/99W)* overloads:
   a) Complete rebuild from 50°C 795 Drake to 70°C 1113 Beaumont.
6) L6006 *(99W/50W)* overloads:
   a) Upgrade thermal rating.
7) L6020 *(50W/30W)*, L6021 *(30W/9W)*, L6024 *(9W/IR677/IR727/50W)* thermal overloads:
   a) Construct new 138 kV line *(103 km)* and associated nodes at 9W-Tusket and 50W-Milton.
8) L5532 *(3W/14V)*, L5531 *(13V/15V)*, L5541 *(3W/4W/50W)* overloads:
   a) Implement a new AAS to cross trip IR727.
9) Under voltage issues in the Western Transmission System:
   a) Upgrade the proposed IR677 POI synchronous condenser.

Additional issues to be aware of are:

- 50W-T1 is right at its 100% rating in the wp03 case for the 9W-500 breaker failure; this will be further examined at the System Impact Study stage.
- The IR727 IC station transformer's rating *(123MVA)* could be exceeded *(overload at 101%)* when the IR727 generation is operating at its maximum 100 MW output, while absorbing 50.2 MVar reactive power from its WECS.

8 Reactive Power and Voltage Control

In accordance with the *Transmission System Interconnection Requirements* Section 7.6.2, IR727 must be capable of delivering reactive power for a net power factor of at least +/- 0.95 of rated capacity to the high side of the plant interconnection transformer*(s)*. Reactive power can be provided by the asynchronous generator or by continually acting auxiliary devices such as STATCOM, or synchronous condenser, supplied by the Interconnection Customer.

This report assessed the IR727's reactive power performance based on the technical bulletin[4] that IC provided for a Vesta V162 6.2 MW unit. The information *(Figure 5)* provided indicates that, at the machine terminal voltage of 1.0 p.u., the Vestas V162 6.2MW WECS have a rated power factor of 0.85 lagging and 0.88 leading *(+3.4/-2.93 MVAr per WECS)* from 0% to 88% of rated real power; the reactive power capability reduced to a power factor of 0.9 lagging and 0.94 leading *(+2.735/-2.053 MVAr per WECS)* from 88% to 100% rated real power. It's calculated that the

[4] 0107-3707_V162-6.2 Performance Spec_V01.PDF

WECS have a reactive power capability of +3.924/- 2.789 MVAr when operating at 5.55 MW with the machine terminal voltage of 1.0 p.u. *(a total capped MW of 100 MW for IR727)*.

It's indicated that Vestas V162 6.2MW WECS is able to maintain the reactive power capability at low wind with no active power production.

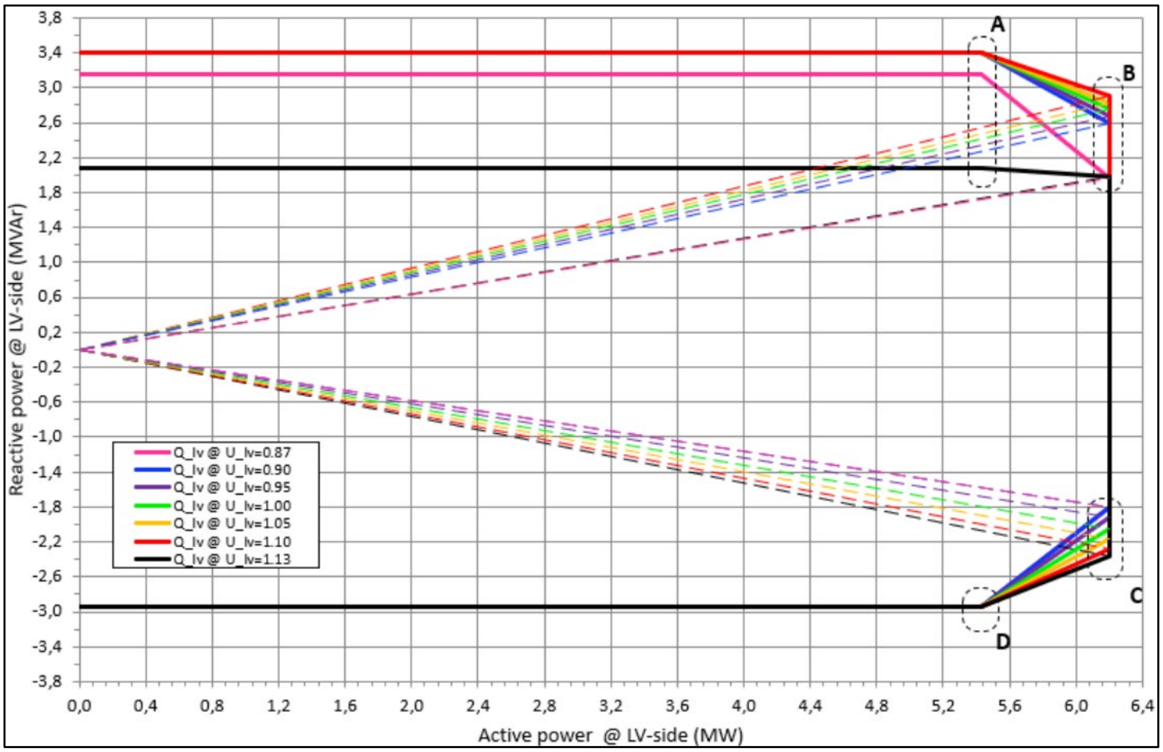

Figure 3 Model Vestas V162 6.2MW PQ Curve and Reactive Capability

	Coordinates								Power factor	
Point:	A		B		C		D		B (Capacitive)	C (Inductive)
Coordinate:	x (P)	y (Q)	x (P)	y (Q)	x (P)	y (Q)	x (P)	y (Q)		
Reactive power [kVAr] @ LV side @ U_lv = 0.87 p.u. voltage	5,430	3,160	6,200	1,963	6,200	-1,797	5,430	-2,933	0,953	0,960
Reactive power [kVAr] @ LV side @ U_lv = 0.90 p.u. voltage	5,430	3,400	6,200	2,586	6,200	-1,797	5,430	-2,933	0,923	0,960
Reactive power [kVAr] @ LV side @ U_lv = 0.95 p.u. voltage	5,430	3,400	6,200	2,670	6,200	-1,918	5,430	-2,933	0,918	0,955
Reactive power [kVAr] @ LV side @ U_lv = 1.00 p.u. voltage	5,430	3,400	6,200	2,753	6,200	-2,053	5,430	-2,933	0,914	0,949
Reactive power [kVAr] @ LV side @ U_lv = 1.05 p.u. voltage	5,430	3,400	6,200	2,827	6,200	-2,163	5,430	-2,933	0,910	0,944
Reactive power [kVAr] @ LV side @ U_lv = 1.10 p.u. voltage	5,430	3,400	6,200	2,900	6,200	-2,287	5,430	-2,933	0,906	0,938
Reactive power [kVAr] @ LV side @ U_lv = 1.13 p.u. voltage	5,430	2,080	6,200	1,983	6,200	-2,359	5,430	-2,933	0,952	0,935

Figure 4 ***Reactive power capability (for 7500kVA transformer variant)***

Analysis shown in Figure 5 indicates that IR727 can meet the full-load reactive power requirement of 0.95 at the high side of ICIF transformer. The test indicated that, with 18 WECS units operating at a total 100 MW and 59.5 MVar with machine terminal voltage of 1.05 p.u *(+3.306/- 2.807 Mvar per WECS, as shown in Figure 4)*, the delivered power to the high side of the ICIF transformers is 97.8 MW and 34.3 MVAr, or a power factor of 0.943 with WECS terminal voltage at 1.05 p.u.

This configuration would also be able to meet the leading power factor requirement of -0.95 at the high side of ICIF transformer. The model shows that with 18 units of WECS units operating at a total of 100 MW and -50.2 MVAr with machine terminal voltage of 1.0 p.u *(+3.294/- 2.789 Mvar per WECS, as shown in Figure 4)*, the delivered power to the high side of the ICIF transformers is 97.9 MW and -74.4 MVAr, or a power factor of -0.796 with WECS terminal voltage at 1.0 p.u.

It's noted that the IR727 IC station transformer's rating *(123MVA)* could be exceeded *(overload at 101%)* when the IR727 generation is operating at its maximum 100 MW output, while absorbing 50.2 MVar reactive power from its WECS.

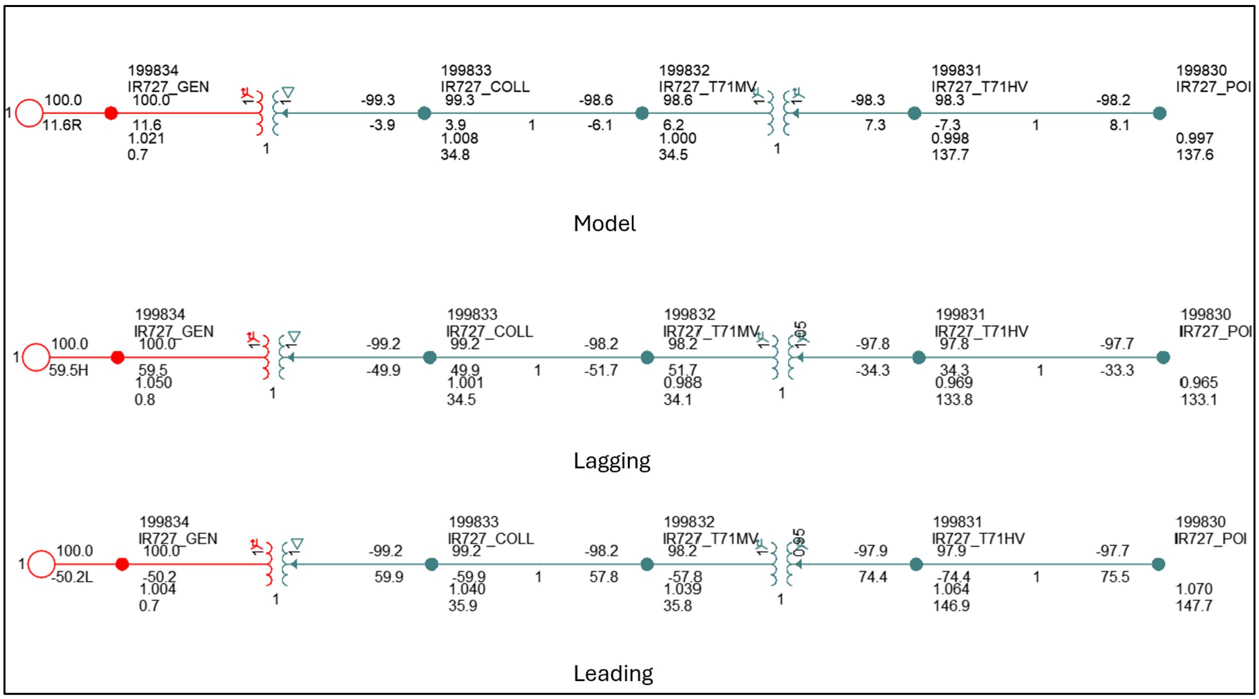

Figure 5 Power Factor Analysis

Because this analysis is based on preliminary transformer data and assumed collector circuit models, reactive capability will be confirmed in the SIS when detailed design is submitted.

A centralized controller will be required which continuously adjusts individual generator reactive power output within the plant capability limits and regulates the voltage at the 34.5 kV bus voltage. The voltage controls must be responsive to voltage deviations at the terminals of the Interconnection Facility substation; be equipped with a voltage set-point control; and can slowly adjust the set-point over several *(5-10)* minutes to maintain reactive power within the individual generator capabilities. The details of the specific control features, control strategy and settings will be reviewed and addressed in the SIS, as will the dynamic performance of the generator and its excitation. Line drop compensation, voltage droop, control of separate switched capacitor banks must be provided.

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

This facility must also have low voltage ride-through capability as per Appendix G of the Standard Generator Interconnection and Operating Agreement *(GIA)*. The SIS will state specific options, controls and additional facilities that are required to achieve this.

Settings for the ICIF on-load tap-changer must be coordinated with plant voltage controller for long-term reactive power and voltage management at the POI.

9 System Security / Bulk Power Analysis

IR727's NPCC BPS *(Bulk Power System)* categorization will be determined in the subsequent SIS. The higher queued IR677: Wedgeport Wind project's categorization may change if IR727 proceeds and is BPS categorized. IR677 was categorized as non-BPS at the time it was studied, however both IRs are in close electrical proximity and the larger combined injection will have more pronounced system impacts.

IR727 will be categorized NERC BES (Bulk *Electric System)* as its aggregate rated output is greater than 75 MVA. This new substation will be categorized Bulk Electric System under NERC criteria. The generators and elements in Interconnection Customer substation *(including collector bus and substation step-up transformer)*, are also categorized as BES.

10 Expected Facilities Required for Interconnection

The following facility changes will be required to connect IR727 to the NSPI transmission system at the L6024 POI. Note, there is no ERIS list provided as there is no available capacity in the Western Transmission System. System normal overloads are present with IR727 injecting its requested 100 MW amount. Reducing its generation removes the system normal overloads, however additional thermal overloads re-appear post-contingency.

Required NRIS Network Upgrades[5]:

1. Upgrade 99W-T71 from a 120/160/200 MVA transformer to a 235/314/392 MVA transformer.
2. Upgrade 99W-T72 from a 120/160/200 MVA transformer to a 235/314/392 MVA transformer.
3. Upgrade L6531 *(556 Dove, 41 km)* thermal rating from 50°C to 100°C.
4. Upgrade L6025 *(1113 Beaumont, 41 km)* thermal rating from 70°C to 100°C along with associated breakers, switches, relaying, and metering at 99W and 50W.
5. Upgrade L6006 *(795 Drake, 42 km)* thermal rating from 50°C to 100°C.
6. Complete rebuild of L7009 *(78 km)* from 50°C 795 Drake to 70°C 1113 Beaumont.

[5] The proposed AAS *(Automatic Action Schemes)* are only possible if IR727 is not NPCC BPS categorized.

7. Construct a new 138 kV line and associated nodes at 50W-Milton and 9W-Tusket *(103 km)* to address L6020, L6021, and L6024 overloads.
8. Rebuild L5535 *(64 km)* from 50°C Quail to 556.5 100°C Dove.
9. Modifications to IR677's proposed 99W AAS *(if already implemented)*.
10. Modifications to IR677's proposed L5535 AAS.
11. A new AAS to cross trip IR727 for 9W-T2/T63 overloads.
12. A new AAS to cross trip IR727 for L5532 overloads.
13. IR677 synchronous condenser upgrade *(cost TBD)*.

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

1. Install a single breaker tap off the L6024 POI with control and protection. A Remote Terminal Unit *(RTU)* to interface with NSPI's SCADA, with telemetry and controls as required by NSPI.
2. Construct a total of approximately 4 km 138 kV transmission spur line between the L6024 POI and the Interconnection Customer's Interconnection Facility.
3. Add control and communications between the IR727 wind farm plant and NSPI SCADA system *(to be specified)*.

Required Interconnection Customer's Interconnection Facilities *(ICIF)*

1. 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.
2. Meet all requirements detailed in the TSIR, including the following:
    - 2.1. Facilities to provide 0.95 leading and lagging power factor when delivering rated output at the HV terminals of the IC Substation Step Up Transformer when the voltage at that point is operating at 100 % of nominal.
    - 2.2. Centralized controls. These will provide centralized voltage set-point controls and are known as Farm Control Units *(FCU)*. The FCU will control the 34.5 kV bus voltage and the reactive output of the machines. Responsive *(fast-acting)* controls are required. The controls will also include a curtailment scheme which will limit or reduce total output from the facility, upon receipt of a telemetered signal from NSPI's SCADA system.
    - 2.3. NSPI will have control and monitoring of reactive output of this facility, via the centralized controller. This will permit the NSPI Operator to raise or lower the voltage set-point remotely.

2.4. Low voltage ride-through capability per Section 7.4.1 of the Nova Scotia Power Transmission System Interconnection Requirements *(TSIR)*.

2.5. Real-time monitoring *(including an RTU)* of the interconnection facilities. Local wind speed and direction, MW and MVar, as well as bus voltages are required.

2.6. Facilities for NSPI to execute high speed rejection of generation *(transfer trip)* if determined in SIS. The plant may be incorporated into RAS run-back schemes.

2.7. With reference to TSIR section 7.6.7: Inertia Response - WECS, IR727 shall provide an 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.

2.8. Automatic Generation Control to assist with tie-line regulation.

2.9. Operation at ambient temperature of -30°C.

2.10. Note that Section 7.4.15 of NSPI's TSIR states "System short circuit level may decline over time with changes to transmission configuration and generation mix. The Generating Facility shall be able to accommodate these changes".

11 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

Estimates for NSPI Interconnections Facilities and Network Upgrades for interconnecting 100 MW wind energy at the L6024 POI as NRIS are included in Table 5.

No ERIS list is provided as there is no available capacity in the Western Transmission System. System normal overloads are present with IR727 injecting its requested 100 MW amount. Reducing its generation removes the system normal overloads, however additional thermal overloads re-appear post-contingency.

Table 5: Cost Estimates for NRIS @ L6024 POI

Item	Network Upgrades	Estimate
i	Upgrade 99W-T71 from a 120/160/200 MVA transformers to a 235/314/392 MVA transformer.	$ 5,700,000
ii	Upgrade 99W-T72 from a 120/160/200 MVA transformers to a 235/314/392 MVA transformer.	$ 5,700,000
iii	Upgrade L6531 *(556 Dove, 41 km)* thermal rating from 50°C to 100°C.	$ 33,210,000
iv	Upgrade L6025 *(1113 Beaumont, 41 km)* thermal rating from 70°C to 100°C.	$ 24,907,500
v	Upgrade breakers, switches, relaying, and metering at 99W and 50W associated with L6025.	$ 3,100,000
vi	Upgrade L6006 *(795 Drake, 42 km)* thermal rating from 50°C to 100°C.	$ 25,515,000
vii	Complete rebuild of L7009 *(78 km)* from 50°C 795 Drake to 70°C 1113 Beaumont.	$ 117,000,000
viii	Construct a new 138 kV line and associated nodes at 50W-Milton and 9W-Tusket *(103 km)* to address L6020, L6021, and L6024 overloads.	$ 106,400,000
ix	Rebuild L5535 *(64 km)* from 50°C Quail to 556.5 100°C Dove.	$ 64,000,000
x	Modifications to IR677's proposed 99W AAS.	$ 100,000
xi	Modifications to IR677's proposed L5535 AAS.	$ 100,000
xii	A new AAS to cross trip IR727 for 9W-T2/T63 overloads.	$ 250,000
xiii	A new AAS to cross trip IR727 for L5532 overloads.	$ 250,000
xiii	Upgrade IR677 POI synchronous condenser	TBD
	Sub-total	**$ 386,240,000**

	TPIF	Estimate
i	L6024 line tap with single breaker, communications, and protection modifications at IR677's interconnection station and 50W-Milton.	$ 2,000,000
ii	4 km 138kV spur line from L6024 POI to IR727's substation, with IC responsible for providing Right-Of-Way	$ 4,000,000
iii	Protection and control equipment & modifications	$ 100,000
iv	Telecommunications (teleprotection & SCADA)	$ 150,000
v	NSPI SCADA RTU housed at IR727	$ 60,000

Sub-total	**$ 6,310,000**

Determined costs	
Subtotal	$ 392,550,000
Contingency (25%)	$ 98,140,000
Total of determined cost items	$ 490,690,000

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

The preliminary non-binding cost estimate for interconnecting 100 MW at the POI on L6024 under both NRIS is $490,690,000 including a 25% contingency. In this estimate, $386,240,000 *(plus 25% contingency)* of the amount represents Network Upgrade costs which are funded by the Interconnection Customer, but which are eligible for refund under the terms of the GIP. It does not include TBD costs to address the IR677 Synchronous Condenser upgrade or any stability issues identified at the SIS stage based on dynamic analysis and EMT analysis.

The estimated time to construct the Transmission Providers Interconnection Facilities and the Network Upgrades are estimated to be completed 60-72 months after receipt of funds and cleared right of way from the customer.

12 Loss Factor

Loss factor is calculated by running the winter peak load flow case with and without the new facility in service while keeping 91H-Tufts Cove as the Nova Scotia Area Interchange bus. This methodology reflects the load centre in and around Metro.

The loss factor for IR727 is calculated as 2.24% at IR727's POI *(L6024, 138kV bus)*, net of any losses on the IC facilities up to the POI. This means system losses on peak are marginally increased by 2.24% when IR727 is operating at 100 MW. The MW measured at POI is 98.2 MW, the displaced MW generation at Tufts Cove is 96 MW. Therefore, the loss factor is calculated as 2.2/98.2 = 2.24%.

Table 6: Loss factor analysis

Component	At IR727 POI
IR727 at 100 MW	98.2 MW
Tufts Cove with IR727 on	375.6 MW
Tufts Cove with IR727 off	471.6 MW
IR 727 loss factor	2.24%

13 Preliminary Scope of Subsequent SIS

The following provides a preliminary scope of work for the subsequent SIS for IR727.

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:

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

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 *Transmission System Interconnection Requirements*.
- 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 TPL001-5.1.
- NSPI System Design Criteria, report number NSPI-TPR-003-6.

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 and NERC criteria as well as NSPI guidelines and good utility practice. The SIS will also determine the contingencies for which this facility must be curtailed.

14 Conclusion

The conclusion is covered in the Executive Summary.

Nova Scotia Power
Transmission System Operations
2024/06/14

Appendix A: Transmission line ratings

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

LINE	STATION	CONDUCTOR Type	Maximum Operating Temp. (Celsius)	SUMMER RATING 25 DEG (MVA)	WINTER RATING 5 DEG (MVA)	BREAKER 100% Name-plate	SWITCH 100% Name-plate	CURRENT TRANSFORMER RELAYING Ratio	RELAYING R.F.	RELAYING MVA	FULL SCALE METERING Ratio	METERING R.F.	METERING MVA	TRIP MVA
L-6006	99W Bridgewater	ACSR 795 Drake	50	135	205	478	478	800	2	382	800	1	231	973
	50W Milton					287	287	800	2	382	800	1	231	973
L-6020	50W Milton	ACSR 336.4 Linnet	50	82	121	287	287	300	2	143	400	1	115	342
	30W Souriqouis							300	2	143	N/A			
L-6024	50W Milton	ACSR 795 Drake	70	203	251	478	287	600	1.3	186	800	1	231	250
	9W Tusket					96	72	400	2	191	600	1	173	97
L-6025	99W Bridgewater	ACSR 1113 Beaumont	70	242	301	287	287	800	1	200	800	1	231	972
	50W Milton					287	287	800	1	200	800	1	231	972
L-6047	50W Milton	ACSR 795 Drake	70	203	251	287	287	800	1.2	229	800	1	231	191
	101W Abitibi-Bowater					287	287	800	1.2	229	800	1	231	
L-6048	50W Milton	ACSR 795 Drake	70	203	251	287	287	800	1.2	230	800	1	231	191
	101W Abitibi-Bowater					287	287	800	1.2	230	800	1	231	
L-5532c	75V S. Milford	ACSR 2/0 Quail	50	23	34		48				NA			
	76V Maitland						72				NA			

NSPI Transmission Line Ratings

Last Updated: 2020-09-01

LINE	STATION	CONDUCTOR Type	CONDUCTOR Maximum Operating Temp. (Celsius)	CONDUCTOR SUMMER RATING 25 DEG (MVA)	CONDUCTOR WINTER RATING 5 DEG (MVA)	BREAKER 100% Name-plate	SWITCH 100% Name-plate	CURRENT TRANSFORMER RELAYING Ratio	RELAYING R.F.	RELAYING MVA	FULL SCALE METERING Ratio	FULL SCALE METERING R.F.	FULL SCALE METERING MVA	TRIP MVA
L-6531	99W Bridgewater	ACSR 556.5 Dove	50	110	165	299	202	800	1.5	287	800	1	231	973
	50W Milton					287	301	800	2	382	800	1	231	943
L-5530a	50W Milton	ACSR 4/0 Penquin	50	31	45	96	72	300	1	36	400	1	58	108
	46W Broad River						72				NA			
L-5530b	46W Broad River	ACSR 4/0 Penquin	50	31	45		72				NA			
	36W Green Harbour						48				NA			
L-5530c	36W Green Harbour	ACSR 4/0 Penquin	50	31	45		48				NA			
	30W Sourquois					96	72	300	2	72	300	2	42	102
L-5532a	13V Gulch Hydro	ACSR 2/0 Quail	50	23	34	143	38	150	2	36	300	1	42	22
	14V Ridge Hydro						72				NA			
L-5532b	14V Ridge Hydro	ACSR 2/0 Quail	50	23	34		72				NA			
	75V S. Milford						48				NA			
L-5532c	75V S. Milford	ACSR 2/0 Quail	50	23	34		48				NA			
	76V Maitland						72				NA			

NSPI Transmission Line Ratings

Last Updated: 2020-09-01

LINE	STATION	CONDUCTOR Type	Maximum Operating Temp. (Celsius)	SUMMER RATING 25 DEG (MVA)	WINTER RATING 5 DEG (MVA)	BREAKER 100% Name-plate	SWITCH 100% Name-plate	CURRENT TRANSFORMER RELAYING Ratio	RELAYING R.F.	RELAYING MVA	FULL SCALE METERING Ratio	FULL SCALE METERING R.F.	FULL SCALE METERING MVA	TRIP MVA
L-5532d	76V Maitland	ACSR 2/0 Quail	50	23	34		72				NA			
	58W Harmony Hills						72				NA			
L-5532e	58W Harmony hills	ACSR 2/0 Quail	50	23	34		72				NA			
	57W Caledonia						48				NA			
L-5532f	57W Caledonia	ACSR 2/0 Quail	50	23	34		48				NA			
	91W Middlefield Dist						48				NA			
L-5532g	91W Middlefield Dist.	ACSR 2/0 Quail	50	23	34		48				NA			
	3W Big Falls					96	72	200	2	48	200	1	28	66
L-5541a	50W Milton	ACSR 4/0 Penguin	50	31	45	96	72	300	1.2	43	400	1	58	43
	4W Lower Great Brook						72				NA			