Interconnection Feasibility Study Report

GIP-291-FEAS-R1

System Interconnection Request #291

48.0 MW Wind Generating Facility

Cape Breton County (L-5565)

2011-11-10

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer (IC) submitted an Interconnection Request (IR#291) for Network Resource Interconnection Service (NRIS) to NSPI for a proposed 48 MW wind generation facility interconnected to the NSPI transmission system. The Point of Interconnection (POI) requested by the customer is on L-5565, approximately 1.13 km from 1S-Seaboard switching station, via approximately 7 km of newly-constructed line from the wind farm located near Port Morien NS.

The proposed tap point on L-5565 is 1.13 km from the switching station 1S-Seaboard, and the rating of L-5565 is only 22 MVA in summer and 34 MVA in winter, so that section would have to be re-built to handle a 48 MW generation facility. The tap point would have to be developed to accommodate a circuit breaker. For this reason, the POI is proposed to be the 1S-Seaboard switching station, 8 km away from IR291.

Several contingencies result in overload of line L-5561A, which has a summer rating of 29 MVA and a winter rating of 42 MVA. It is recommended that this 15 km line between 1S-Seaboard and 2S-Victoria Junction be re-conductored or re-built.

Because the IC requested Network Resource Interconnection Service, the system was studied with the output of IR#291 superimposed on the transmission system while operating at present limits. Load flow analysis demonstrated that unacceptable overloads would occur for the contingency loss of the double-circuit tower lines L-8004 (345kV) and L-7005 (230kV). The overload would affect 321 km of 230 kV circuit (L-7004, L-7003, L-7019) and 86 km of 138kV (L-6511 and L-6515). It is recommended that the contingency be eliminate rather than uprate the transmission (which would meet thermal criteria but perhaps not stability criteria).

No concern regarding short-circuit level was found for this project on its own. Insufficient data was available on the flicker coefficient of the proposed generation equipment, but typical data for a Double-Fed Induction Generator suggests that it will not be a problem. The project must meet NSPI requirements for low-voltage ride-through, reactive power range and power factor control system. The data provided indicates that individual machines have a rated power factor of 0.9, and based on the supplied transformer and collector circuit data, supplementary reactive support may be needed in the form of capacitor banks at the low voltage terminals of the Interconnection Transformer. Harmonics must meet the Total Harmonics Distortion provisions of IEEE 519. NSPI recommends a grounded-wye/delta/grounded-wye transformer winding configuration rather than the proposed grounded-wye/delta configuration (to provide ground-faults protection on the collector circuits).

The preliminary unit loss factor is calculated to be 15.8% (system losses increased by net 7.6 MW when IR #291 is operated at 48 MW).

The preliminary non-binding estimated cost of facilities required to interconnect IR#291 to 1S-Seaboard under the terms of NRIS is $33,769,000 including a contingency of 10%. Of this, $29,837,500 is considered to be Network Upgrades and is reimbursable in accordance with the GIA. This estimate will be further refined in the System Impact Study and the Facility Study.

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1 Introduction

The Interconnection Customer submitted an Interconnection Request (IR) for Network Resource Interconnection Service (NRIS) to NSPI for a proposed 48 MW wind generation facility interconnected to the NSPI transmission system, with an in-service date of 2014-12-01. The Point of Interconnection (POI) requested by the customer is on line L-5565, approximately 1.13 km from 1S-Seaoard switching station. The line tap from the wind farm is assumed to be approximately 7 km.

The Interconnection Customer (IC) signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI transmission system dated 2011-09-15, and this report is the result of that Study Agreement. This project is listed as Interconnection Request #291 in the NSPI Interconnection Request Queue, and will be referred to as IR#291 throughout this report.

2 Scope

This Interconnection Feasibility Study (FEAS) consists of a power flow and short circuit analysis. Based on this scope, the FEAS report shall provide the following information:

1. Preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the interconnection;
2. Preliminary identification of any thermal overload or voltage limits violations resulting from the interconnection;
3. Preliminary description and high level non-bonding estimated cost of facilities required to interconnect the Generating Facility to the Transmission System, and to address the identified short circuit and power flow issues.

The Scope of this FEAS includes modeling the power system in normal state (with all transmission elements in service) under anticipated load and generation dispatch conditions.

In accordance with Section 3.2.2.2 of Revised Generation Interconnection Procedures (RGIP), the FEAS for NRIS consists of short circuit/fault duty, steady state (thermal and voltage) analyses. The short circuit/fault duty analysis would identify direct Interconnection Facilities required and the Network Upgrades necessary to address short circuit issues associated with the Interconnection Facilities. The steady state studies would identify necessary upgrades to allow full output of the proposed Generating Facility. A key feature of NRIS, to differentiate it from ERIS, is quoted from the RGIP:

> *... such Generating Facility's interconnection is also studied with the Transmission Provider's Transmission System at peak load, under a variety of severely stressed conditions, to determine whether, with the Generating Facility at full output, the aggregate of generation in the local area can be delivered to the aggregate of load on the Transmission Provider's Transmission System, consistent with the Transmission Provider's reliability criteria and procedures.*

Because the NSPI power system is winter-peaking the above conditions would not necessarily demonstrate thermal loading issues, since transmission elements generally have a higher thermal rating in the winter. Therefore, the studies are also conducted under summer peak load conditions, when transmission element ratings are reduced by higher ambient temperature.

A more detailed analysis of the technical implications of this development will be included in the System Impact Study (SIS) report. The SIS includes system stability analysis, power flow analysis such as single contingencies (including contingencies with more than one common element), off-nominal frequency operation, off-nominal voltage operation, low voltage ride through, harmonic current distortion, harmonic voltage distortion, system protection, special protection systems (SPS), automatic generation control (AGC) and islanded operation. The impacts on neighbouring power systems and

the requirements set by reliability authorities such as Northeast Power Coordinating Council (NPCC), North American Electric Reliability Corporation (NERC), and NSPI will be addressed at that time and will include an assessment of the status of the Interconnection Facility as a Bulk Power System element. The SIS may identify and provide a non-binding estimate of any additional interconnection facilities and/or network upgrades that were not identified in this FEAS.

An Interconnection Facilities Study follows the SIS in order to ascertain the final cost estimate to 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. Network Resource Interconnection Service type per Section 3.2.2 of the RGIP.
2. 48 MW wind with 16 units of Vestas V112-3.0 MW Wind Turbines.
3. The generation technology used must meet NSPI requirement for reactive power capability of 0.95 capacitive to 0.95 inductive at the HV terminals of the IC Substation Step Up transformer. The generator is specified for 34.5 MW at a rated power factor of 0.9 for both lagging and leading. It is also required to have high-speed Automatic Voltage Regulation to maintain constant voltage at the generator terminals during and following system disturbances as determined in the subsequent System Impact Study.
4. The Interconnection Customer indicated that the generation interconnection point is on line L-5565, approximately 1.13 km from the 1S-Maccan switching station. The proposed line tap to the wind facility is approximately 7 km.
5. Preliminary data was provided by the Interconnection Customer for the generator step-up and IC substation step-up transformers. Modeling was conducted with a 69kV-34.5kV 30/40/55 MVA Interconnection Facility transformer with a positive sequence impedance of 9% on a base rating of 30 MVA (an X/R ratio of 20 was assumed). The Interconnection Customer indicated that this Interconnection Facility step-up transformer has a grounded wye-delta winding configuration but no tap changer information was provided. It should be noted that NSPI prefers a grounded-wye grounded-wye transformer with a delta tertiary winding for all wind farm interconnections with overhead collector circuits.
6. The generator step-up transformers are indicated with a delta-grounded wye configuration, ratio of 34.5kV-0.65kV, and an impedance of 8% on 3.375 MVA.
7. The FEAS analysis is based on the assumption that IR's higher in the 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.

4 Projects with Higher Queue Positions

All in-service generation is included in the FEAS.

As of 2011-10-26 the following projects are higher queued in the Interconnection Request Queue and OATT Transmission Service Queue, and have the status indicated.

Interconnection Requests -Included in FEAS

- IR #8 GIA Executed
- IR #45 GIA Executed
- IR #56 GIA Executed
- IR #151 GIA Executed
- IR #219 GIA Executed
- IR #227 FAC Completed
- IR #225 FAC Completed
- IR #234 SIS completed

OATT Transmission Service Queue– Included in FEAS

- TSR 100 SIS in progress

Interconnection Requests not included in FEAS

The following IRs either have SIS Agreements complete (but have not yet met the RGIP SIS progression milestones), or have Feasibility Study agreements complete. As such, they are not included in this FEAS.

IR #67	IR #68	IR #86	IR #115	IR #117	IR #126
IR #128	IR #130	IR #131	IR #149	IR #163	IR #213
IR #222	IR #235	IR #238	IR #241	IR #242	IR #263

OATT Transmission Service Queue– **Not** Included in FEAS

- TSR 400 SIS Agreement Completed

If any of the higher-queued projects included in this FEAS are subsequently withdrawn from the Queue, the results of this SIS may require updating or a re-study may be necessary. The re-study cost incurred as a result of the withdrawal of the higher-queued project shall be the responsibility of the Interconnection Customer that withdraws the higher queued project.

While TSR-100 is higher queued, it has an in-service date of 2016, whereas IR#291 has an in-service date of late 2014. Therefore the FEAS for this IR will be performed twice – for 2014 without TSR-100 in service and again for 2016 onwards with TSR-100 in-service, along with any related system changes.

An additional Transmission Service Request, TSR-400 is higher queued than IR#291 and a SIS is in progress. However, the results of this SIS are not sufficiently defined to be included in the FEAS for IR#291.

5 Objective

The objective of this FEAS is to provide a preliminary evaluation of the system impact and the high-level non-binding cost estimate of interconnecting the 48 MW generating facility to the NSPI transmission system at the designated location. The assessment will identify potential impacts on the loading of transmission elements, which must remain within their thermal limits. Any potential violations of voltage criteria will be identified and addressed. If the proposed new generation increases the short-circuit duty of any circuit breakers beyond their rated capacity, the circuit breakers must be upgraded. Single contingency criteria[1] are applied for the NRIS assessments.

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 system transfer capabilities that may be required to the Bulk Power System to meet the design and operating criteria established by NPCC and NERC or required to maintain system stability. These requirements will be determined by the subsequent interconnection System Impact Study (SIS).

[1] The Single Contingency Criteria is defined by NPCC in its A-7 Document, and may involve more than one transmission element.

6 Short-Circuit Duty

The maximum (design) expected short-circuit level is 5000 MVA on 138kV systems and 3500 MVA on 69 kV systems. The short-circuit levels in the area before and after this development (including TSR#100) are provided below in Table 6-1.

Table 6-1: Short-Circuit Levels. Three-phase MVA [(1)]

Location	IR #291 in service	IR #291 not in service
All transmission facilities in service		
Interconnection Facility (POI)	650	574
2S-Victoria Junction 69kV	1405	1327
81S-Reserve St 69kV	708	646
1S-Seaboard 69kV	705	646
Minimum Conditions		
Interconnection Facility (POI)	573	497

(1) Classical fault study, flat voltage profile

In determining the maximum short-circuit levels with this generating facility in service the generators have been modeled as conventional machines with reactance comparable to induction machines regardless of the type of generators proposed, which provides a worst case scenario. The SIS will refine the fault level based on the actual machine characteristics.

The maximum short-circuit level at the POI on L-5565 is presently 574 MVA. After installing IR #291 the increase will bring the short-circuit level to 650 MVA at the POI. Similarly, under summer light load conditions with certain generation units offline the minimum short-circuit level will be approximately 497 MVA at the POI. This translates into maximum equivalent system impedance at the POI of 0.2 per unit on 100 MVA base.

The interrupting capability of the 69kV circuit breakers at 2S-Victoria Junction and 81S-Reserve St. is at least 2500 MVA, which will not be exceeded by this development on its own.

7 Voltage Flicker and Harmonics

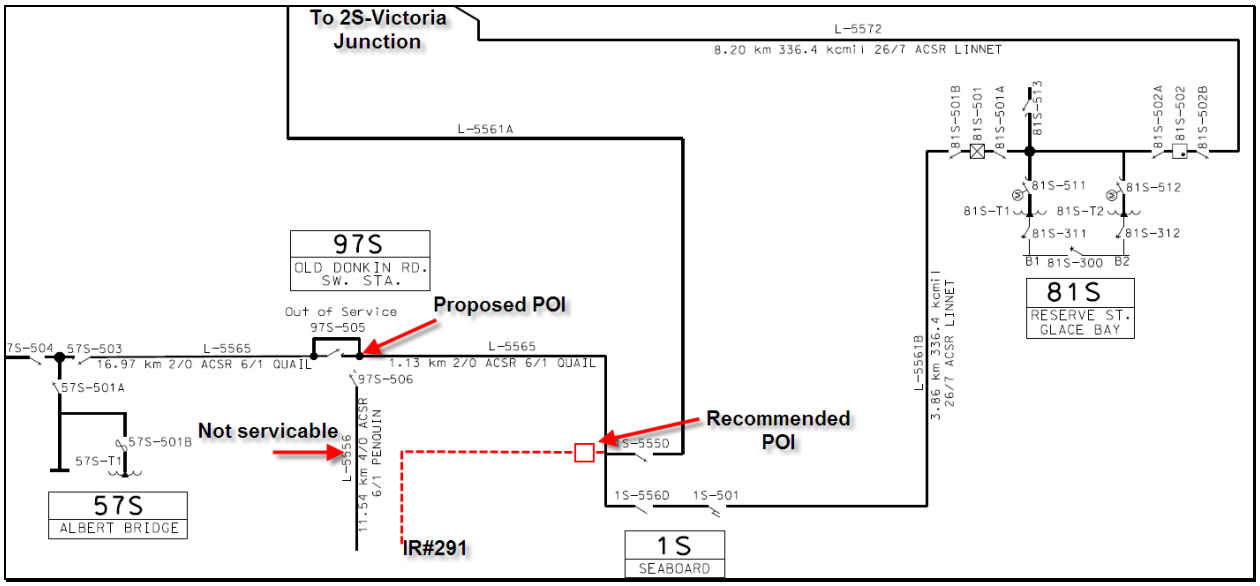
Due to the inefficient information on the flicker coefficient of the Vestas V112-3.0 MW Wind Turbines, this study assumes typical flicker data for a Double-fed Induction Generator machine. The calculated voltage flicker at the POI on line L-5565 using IEC Standard 61400-21 and the assumed values for typical DFIG machines is 0.052 under normal conditions and 0.055 under minimum generation conditions. These are both below NSPI's required limit of 0.35 for P_{st}. Therefore voltage flicker should not be a concern for this project.

The Interconnection Facility is expected to meet IEEE Standard 519 limiting Total Harmonic Distortion (all frequencies) to a maximum of 5%, with no individual harmonic exceeding 1%.

8 Thermal Limits

This Interconnection Facility is proposed to interconnect with L-5565 approximately 1.13 km from the 1S-Seaboard switching station. The line section between the POI and 1S-Seaboard is constructed with 2/0 Quail ACSR conductor with a maximum operating temperature of 50ºC with a thermal rating of 22 MVA summer and 34 MVA winter. Protection is currently set at 22 MVA (which would be changed if necessary). Therefore IR#291 cannot interconnect at the proposed POI. Considering that a 69kV circuit breaker and controls would be required at the POI, it is proposed that the POI be the 1S-Seaboard switching station, extending the newly-constructed radial circuit to the Interconnection Facility by 1.13 km. This would ensure that the interconnection has minimal impact on the customers at 57S-Albert Bridge fed from the radial line L-5565.

The 1S-Seaboard switching station is connected to 2S-Victoria Junction via L-5561A, which is constructed of 2/0 Copper conductor with a maximum operating temperature of 50ºC, and a summer/winter rating of 29/42 MVA respectively. 1S-Seaboard switching station is also connected to the load-serving substation 81S-Reserve St, via L-5561B, which is constructed of 336.4 Linnet ACSR conductor designed to 50ºC and has a summer/winter rating of 41/60 MVA. The 69kV loop is completed with line L-5572 from 81S-Reserve St. to 2S-Victoria Junction. This line is constructed of 336.4 Linnet ACSR conductor designed to 50ºC and has a summer/winter rating of 41/60 MVA. There are circuit breakers at 81S-Reserve St. but only switches at 1S-Seaboard.



Load flow analysis demonstrated that there was no significant impact on reliability for winter peak conditions, primarily due to the higher thermal rating of transmission elements in winter, and local load (at peak) kept transmission flows below limits.

In summer load conditions, opening circuit breaker 81S-501, loss of line L-5572 or bus 2S-B52 will overload line L-5561A. Depending on the load at 57S-Albert Bridge and 81S-Reserve St, the loading on L-5561A could be as high as 150% of its normal rating. If the ambient temperature is above 25ºC the line rating would be lower and subsequent overload higher.

Line section 5561B, between 1S-Seaboard and 81S-Reserve St. could be loaded to 106% of its normal summer loading if line L-5561A opens at 2S-Victoria Junction (bus fault or line-end open). This would be considered acceptable for short periods of time, but the NSPI Operator must have appropriate line monitoring and the ability to curtail IR#291 remotely.

It is therefore recommended that the 15 km line L-5561A should be re-conductored or rebuilt to allow a summer rating of at least 50 MVA. This can be accomplished using a 336.4 Linnet ACSR conductor designed for 100 ºC. The Facility Study will optimize this design given the characteristics of the existing structures. This is considered a Network Upgrade in accordance with RGIP. The switchgear at the 2S-Victoria Junction end of this circuit has a continuous thermal rating of 143 MVA and is sufficient for this upgrade, however the rating of switch 1S-555D must be verified.

As stated above in the Scope, the RGIP requires that studies for NRIS include winter peak load with aggregate generation in the area of IR#291 be studied to determine if reliability criteria (i.e. single contingency criteria) can be met while supplying aggregate system load. For this FEAS, all generation in Cape Breton was put on-line at full rated output, and the non-firm load was adjusted to maintain Cape Breton export below the present limit of 900 MW. Then IR#291 was added, increasing Cape Breton export to approximately 948 MW. There were no thermal loading violations or voltage violations for any single contingency under that flow condition (it should be noted again that the scope of this FEAS does not include stability analysis).

Section 3.2.2.2 of the RGIP states that NRIS studies can include off-peak conditions if warranted. Considering that IR#291 is a non-dispatchable wind generation project, summer peak and light load cases were also studied to determine if the addition of this facility at the east end of the NSPI power system will result in criteria violations. The approach taken was to dispatch the NSPI system to the present limits of the transmission Interconnection Reliability Operating Limits (IROL) without IR#291 on-line, and then add the generation and displace generation in the load center of Halifax Metro. This increased the IROL flows Cape Breton Export (CBX) from 900 MW to 945.6 MW, and Onslow Import (ONI) from 1025 MW to 1067 MW. These cases used summer ratings for transmission elements.

Load flow analysis found that unacceptable overloads occurred for a permanent fault on separate phases of each circuit on the double circuit tower that crosses the Strait of Canso near Port Hastings, resulting in the loss of the 345kV line L-8004 and the 230kV line L-7005. This contingency activates a Type 1 Special Protection System[2] which trips two thermal units at Lingan (total of 310 MW net). Without IR#291, post-contingency system conditions meet criteria. However, the addition of IR#291 results in overload of the following transmission elements:

Element	Voltage	Line Length	Post Contingency Load % of Summer Rating
L-7004	**230 kV**	**131 km**	**110%**
L-7019	**230 kV**	**29.6 km**	**109%**
L-7003	**230 kV**	**160.6 km**	**108%**
L-6515*	**138 kV**	**50.7 km**	**111% from 2C to 100C, 107% 100C to 4C**
L-6511	**138 kV**	**35.6 km**	**141%**

*see TSR100 note below.

The cost of uprating these lines will depend on the number of structures and spans that need to be remedied, but an estimate of the cost ranges from $88.9M for thermal uprating to $176.4M for complete rebuild. It is therefore recommended to eliminate the offending contingency by separating L-8004 and L-7005 from the common double circuit tower. An additional crossing of the Strait of Canso has been estimated at $26M. This is considered a Network Upgrade in accordance with the RGIP.

In 2016, the following system changes in NS have been recommended by TSR100:

- New 345 kV transmission line from the NB Border to Onslow NS
- Uprate L-6552 between Glen Dhu and Lochaber Rd.
- Uprate L-6515 between Lochaber Rd. and Port Hastings.
- Uprate switchgear and meter scales at Lochaber Rd. and Port Hastings substation.
- Uprate L-6538, between Glen Tosh and Gannon Rd, including the Bras D'Or Lakes crossing near the Seal Island Bridge

These system changes will not impact IR#291 or change the recommended system upgrades. The uprating of L-6515 would be the financial responsibility of TSR100, such that IR#291 would only be responsible for the advancement costs to bring it forward from 2016 to 2014, but it would not impact the recommendation to eliminate the Strait Crossing contingency rather than uprate the transmission.

[2] A Special Protection System is classified by NPCC as Type 1 if the consequences of failure to operate or unintended operation result in "significant adverse impact outside the local area"

9 Voltage Limits

This project, like all new generating facilities must be capable of providing both lagging and leading power factor of 0.95, measured at the HV terminals of the IC Substation Step Up Transformer, at all production levels up to the full rated load of 48 MW.

Data provided by the IC indicates that IR#291 may not be able to meet this requirement without additional reactive support. Based on the assumed rated power factor of the Vestas V112-3.0 MW (0.90), and the provided impedances of the collector circuits and transformers, capacitor banks in the range of 3-4 Mvar installed at the 34.5kV bus of the Interconnection Facility substation may be able to meet the requirements. This will be further investigated in the System Impact Study. More information on a potential tap-changer will be required for that analysis.

A centralized controller will be required which continuously adjusts individual generator reactive power output within the plant capability limits. Because IR#291 is at the end of a radial 69kV circuit supplying load customers at 57S-Albert Bridge and 81S-Reserve St, NSPI prefers the centralized controller to regulate the net power factor at the 69 kV bus. The power factor controls must be responsive to plant output variations at the terminals of the Interconnection Facility substation, and be equipped with a power factor set-point control. 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.

The NSPI System Operator must have manual and remote control of 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 to the Standard Generator Interconnection and Operating Agreement (GIA). The SIS will state specific options, controls and additional facilities that are required to achieve this.

10 System Security / Stability Limits (Transfer Capability)

There are a number of Special Protection Systems (SPS) and protective systems employed by NSPI to permit high transfer levels across the Nova Scotia Bulk Power System. The Type I SPS designated #119 trips either one or two thermal units at Lingan for faults on the 345kV system between 101S-Woodbine and 67N-Onslow (lines L-8004, L-8003, and bus faults or breaker failures at 79N-Hopewell and 67N-Onslow). Thermal analysis conducted in Section 8 above examined the impact of the addition of IR#291 on the steady-state post-contingency conditions assuming that this SPS has rejected the expected level of generation, however the SPS is primarily required for system stability, to prevent cascading tripping of parallel transmission on the corridor between Cape Breton and Onslow. The limits of the two interfaces designated as IROL (CBX and ONI) cannot be exceeded as required by NERC Standards TOP-004 and TOP-007, therefore the limits must be increased. Increasing the thermal capacity of lines may not increase the stability limit of interfaces, so a key objective of the System Impact Study will be the increase of ONI and CBX interfaces to permit the addition of flow from IR#291.

This generating facility will also increase loading on the Onslow South corridor (Truro to Halifax) by replacing generation located south and west of Truro. This may require increased reactive support requirements in the Halifax area or invoke facility additions that can reduce the reactive support requirements. This will be evaluated in the SIS.

The SIS will determine if any facility changes are required to permit the proposed higher transmission loadings while maintaining compliance with NERC/NPCC standards and in keeping with good utility practice.

11 Expected Facilities Required for Interconnection

The following facility changes are required to interconnect IR #291 to the 69 kV switching station at 1S-Seaboard:

Additions/Changes to POI at 1S-Seaboard:

1. New 69kV circuit breaker at 1S-Seaboard for the radial circuit to the Generating Facility.
2. Approximately 8 km newly-constructed 69 kV line from POI to Generating Facility.
3. Control and communications between the Generating Facility and NSPI SCADA system. It is expected that new 7 GHz radio links and tower upgrades will meet the requirements.
4. Protection upgrades at 2S-Victoria Junction 81S-Reserve St. substations.
5. The line to connect the Generating Facility to the POI will use 336.4 Linnet ACSR conductor rated 100°C conductor temperature.

Network Upgrades to Increase BPS Capacity:

1. New towers at Strait of Canso.
2. Re-routing of L-7005 to new Strait Crossing

Requirements for the Generating Facility

1. 69 kV Interconnection Substation. This will include a circuit breaker at high side of customer power transformer and protections as acceptable to NSPI. An RTU to interface with NSPI's SCADA, with telemetry and controls as required by NSPI.
2. Facilities to provide 0.95 leading and lagging power factor when delivering rated output (48 MW) at the HV terminals of the IC Substation Step Up Transformer when the voltage at that point is operating between 95 and 105 % of nominal. Preliminary analysis indicates that 3-4 Mvar of capacitors may be required at the low voltage terminals of the Interconnection Facility transformer to meet this requirement.
3. Centralized controls. These will provide centralized power factor set-point controls and are known as Farm Control Units (FCU). The FCU will control the net power factor delivered to the 69 kV bus at the Generating Facility 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. The controller will also limit the load ramp rate of the facility to within limits set by NSPI and/or telemetered from NSPI's SCADA system.
4. NSPI to 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 reactive power set-point remotely.

5. Low voltage ride-through capability as per Appendix G to the Standard Generator Interconnection and Operating Agreement (GIA).
6. Real-time monitoring (including a Remote Terminal Unit) of the interconnection facilities.
7. Facilities for NSPI to execute high speed rejection of generation (transfer trip) if determined in SIS.
8. The Interconnection Facility is expected to meet IEEE Standard 519 limiting Total Harmonic Distortion (all frequencies) to a maximum of 5%, with no individual harmonic exceeding 1%.

12 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

Estimates for NSPI Interconnections Facilities and Network Upgrades for interconnecting 48 MW wind generation facility onto the 69 kV system are included in Table 12-1.

Table 12-1: Cost Estimates identified from FEAS scope

	Determined Cost Items	Estimate
NSPI Interconnection Facilities		
i	Build 8 km 69 kV single circuit line from 1S-Seaboard with circuit breaker at 1S-Seaboard end	$2,750,000
ii	Communication	$615,000
iii	Protection, control	$200,000
Network Upgrades		
iv	Re-conductor L-5561A from 2S to 1S (336 Linnet ACSR)	$1,125,000
v	New Canso Strait Crossing separating L-8004 and L-7005	$26,000,000
Totals		
vi	Subtotal	$30,690,000
vii	Contingency (10%)	$3,069,000
viii	Total of Determined Cost Items	$33,769,000
	To be Determined Costs	
ix	System additions to address potential stability limits	TBD (SIS)

The preliminary non-binding cost estimate for interconnecting IR#291 at 1S-Seaboard would be $33,769,000. Customer is required to fund the Network Upgrade (Items iv and v) costs, and would be eligible for repayment in accordance with the terms of the GIA.

13 Issues to be addressed in SIS

The following provides a preliminary scope of work for the subsequent SIS for IR#291. 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 and ride through 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 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 will proceed and the facilities associated with those projects are installed.

The following outline provides the minimum scope that must be complete in order 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. The facility additions/changes required to increase NSPI east to west transfers under system normal conditions (all transmission in) over the range of NSPI loads and with interruptible loads on or off. Some of the interfaces that may be constrained and should be included in the assessment are as follows.

- Cape Breton Export
- Onslow Import
- Onslow South
- Metro reactive reserve requirements
- NS – NB export/import

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

i. Facilities that the customer must install to meet the requirements of the GIP.

ii. 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.

iii. Guidelines and restrictions applicable to first contingency operation (curtailments etc).

iv. Impact on System Losses.

v. Under-frequency load shedding impacts.

To complete this assessment the following first contingencies, as a minimum, will be assessed:

- L-8001/3025
- L-3006 – with and without NBPT SPS operation
- Memramcook 345/138 kV transformer
- L-8004
- L-8003
- L-6537
- L-8002 & L-8003 (common circuit breaker)
- L-8003 & L-8004 (common circuit breaker)
- L-8001 & 67N-T81 (common circuit breaker)
- L-8002 & 67N-T81 (common circuit breaker)
- L-8004 & L-7005 (common circuit tower)
- L-7003 & L-7004 (common circuit tower)

- 2C-B61 or 2C-B62 bus sections
- 1N-B61 bus
- 2S-B61 and 1S-B62 bus sectios

To complete this assessment the dynamics of the following first contingencies, as a minimum, will be assessed (all faults are considered permanent, i.e. automatic reclosing fails to restore the circuit):

- 3 phase fault L-8001/3025 at 67N-Onslow, NS Import SPS operation (islanding)
- 3 phase fault L-8003 at 67N-Onslow and 79N-Hopewell
- 3 phase fault L-8002 at 67N-Onslow
- 3 phase fault L-8004 at 101S-Woodbine
- Single Phase to Ground fault (slg) separate phases of L-8004 and L-7005 at the Strait of Canso.
- Slg L-8003 at 67N-Onslow, drops L-8003 and L-8002
- 3 phase fault at 79N-Hopewell, drops L-8003, L-8004, bus.
- 3 phase fault 2C-B62, drops L-6516, L-6515, L-6517
- 3 phase fault 2S-Victoria Junction 69 kV bus (repeated for each bus section)

Any changes to SPS schemes required for operation of this generating facility, in addition to existing generation and facilities that can proceed before this project, will be determined by the SIS as well as any required additional transmission facilities. The determination will be based on NERC[3] and NPCC[4] criteria as well as NSPI guidelines and good utility practice. Any new SPS, or any significant change to an existing SPS, must be approved by NPCC.
The SIS will also determine the contingencies for which this facility must be curtailed.

The SIS will calculate the unit loss factor, which is a measure of the percentage of the net output of IR #291 which is lost through the transmission system while displacing generation in the load centre. Preliminary value is calculated to be 15.8% (system losses increased by net 7.6 MW when IR #291 is operated at 48 MW).

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[3] NPCC criteria are set forth in it's Reliability Reference Directory #1 *Design and Operation of the Bulk Power System*
[4] NERC transmission criteria are set forth in *NERC Reliability Standards TPL-001, TPL-002, TPL-003*