



**Interconnection Feasibility Study Report**  
**GIP-356-FEAS-R1**

**System Interconnection Request #356**  
**100.44 MW Wind Generating Facility**  
**Cumberland County (30N)**

2012-01-03  
Control Centre Operations  
Nova Scotia Power Inc.

### Executive Summary

The IC submitted an Interconnection Request (IR#356) for Network Resource Interconnection Service (NRIS) for a proposed 100.44 MW wind generation facility interconnected to the NSPI transmission system and also asked that Energy Resource Interconnection Service (ERIS) be studied concurrently. The Point of Interconnection (POI) requested by the customer is on the 138 kV bus at the 30N- Maccan substation via approximate 14 km of newly-constructed line from the wind farm located near Minudie. An alternative POI on line L-6535 was also identified by the customer, which is located approximately 11 km away from the 30N-Maccan end.

In addition to the proposed generating facility, there is a Transmission Service Request (TSR100) that will have an impact on the transfer capability between Nova Scotia and New Brunswick and on the special protection systems (SPS) that have been installed to facilitate those transfers. While TSR100 is higher queued, it has an in-service date of 2016, whereas IR#356 has an in-service date of 2015. Therefore the FEAS for this IR is performed twice – for 2015 without TSR100 in service and again for 2016 with TSR100 in-service.

Under the existing “Import Power Monitor” SPS arming level (without TSR100), the flow on L-6513 could be at its conductor thermal limit during summer when L-8001 trips for any reason. With the addition of IR#356, loss of L-8001 could cause L-6513 to be overloaded up to 220% of its thermal ratings during periods when summer line ratings are in effect, assuming other generation in this area is concurrently generating at full output. Thermal overloads on L-6513 could also occur under the same contingency during winter. The overloads would depend on the real-time local load demands and other local generation output. Similarly, thermal violations on L-6513 could also occur under the contingency of 88S-721 breaker failure (resulting in the loss of two generator units at 88S-Lingan) with high NS imports (up to 300 MW) during periods when summer line ratings are in effect. For high NS export levels (up to 350 MW) during periods when summer line ratings are in effect, the addition of IR#356 could cause L-6536 to be overloaded up to 120% of its conductor thermal ratings after the loss of L-6535 between IR#45 and Memramcook NB. Therefore this study recommends that L-6513 should be re-built and L-6536 should be upgraded to accommodate IR#356.

The “Import Power Monitor” SPS will be eliminated once the system upgrades associated with TSR100 are completed in 2016. IR#356 can operate without restrictions assuming that L-6513 would have been re-built in 2015.

As ERIS IR#356 would require the establishment of the operating restrictions on this wind facility while NS exports less than 20 MW and imports under the “Import Power Monitor” SPS arming level. The restriction could be significant which depends on NS Import/Export level, other local generation real-time output and load demands. There would also be operating restrictions required while NS imports above 580MW with TSR-100 in service after 2016.

The assessment of the alternative POI on L-6535 shows similar results as on the 138kV bus at 30N-Maccan.

No concern regarding short-circuit or voltage flicker was found for this project on its own, provided that the project design meets NSPI requirements for low-voltage ride-through, reactive

power range and voltage control system. Harmonics must meet the Total Harmonics Distortion provisions of IEEE 519.

The preliminary value for the unit loss factor is calculated to be 5.3% (system losses increased by net 5.3 MW when IR #356 is operated at 100.44 MW).

The preliminary non-binding estimated cost of facilities required to interconnect 100.44 MW to the 30N-Maccan substation is \$32.9 Million for NRIS and \$7.4 Million for ERIS including a contingency of 10%. This estimate will be further refined in the System Impact Study and the Facility Study.

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### 1 Introduction

The IC submitted an Interconnection Request (IR#356) for Network Resource Interconnection Service (NRIS) for a proposed 100.44 MW wind generation facility interconnected to the NSPI transmission system, and also asked that Energy Resource Interconnection Service (ERIS) be studied concurrently. The Point of Interconnection (POI) requested by the customer is on the 138 kV bus at the 30N- Maccan substation via approximate 14 km of newly-constructed line from the wind farm located near Minudie. An alternative POI on line L-6535 was also identified by the customer and it is located approximately 11 km from the 30N-Maccan end.

The Interconnection Customer (IC) signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI transmission system dated 2011-09-14, and this report is the result of that Study Agreement. This project is listed as Interconnection Request #356 in the NSPI Interconnection Request Queue, and will be referred to as IR#356 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 3.2.1.2 of Revised Generation Interconnection Procedures (RGIP), as approved by the UARB on February 10, 2010, the FEAS for ERIS 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 and would also identify the maximum allowed output, at the time the study is performed, of the interconnecting Generating Facility without requiring additional Network Upgrades. It is therefore assumed that transmission interfaces limits will not be exceeded to avoid system upgrades in an ERIS study.

In accordance with Section 3.2.2.2 of the Standard Generation Interconnection Procedures (RGIP), the Interconnection Study for NR Interconnection Service shall assure that the Interconnection Customer's Generating Facility meets the requirements for NR Interconnection Service and as a general matter, that 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.

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 and Energy Resource Interconnection Service types per section 3.2 of the RGIP.
2. 100.44 MW wind with 62 units of GE 1.6-XLE 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 assumed to be specified for 34.5 kV 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 IC indicated that the generation interconnection point is on the 138 kV bus at the 30N-Maccan substation. The line tap to the wind facility is approximately 14 km. An alternative POI on line L-6535 was also identified by the customer and it is located approximately 11 km away from 30N-Maccan.
5. Preliminary data was provided by the IC for the generator step-up and IC substation step-up transformers. Modeling was conducted with a 138kV-34.5kV 70/90/112 MVA Interconnection Facility transformer with a positive sequence impedance of 8% and an X/R ratio of 50. The IC indicated that this Interconnection Facility step-up transformer has a grounded wye-delta-wye winding configuration with +/-5% off-load tap changer. The generator step-up transformers are indicated with an impedance of 5.75% on 1.8 MVA.
6. 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 2012-01-03 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 GIA in Progress
- IR #225 GIA in Progress
- IR #234 SIS completed

### Interconnection Requests –Not Included in FEAS

- IR #131 SIS Milestones Met
- IR #360 SIS in Progress
- IR #362 SIS in Progress

### OATT Transmission Service Queue– Included in FEAS

- TSR 100 SIS in progress

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

- TSR 400 SIS Agreement Completed

In addition to IR#356, TSR100 will also have an impact on the transfer capability between Nova Scotia and New Brunswick and on the special protection systems (SPS) that has been installed to facilitate those transfers. While TSR100 is higher queued, it has an in-service date of 2016, whereas IR#356 has an in-service date of early 2015. Therefore the FEAS for this IR will be performed twice – for 2015 without TSR100 in service and again for 2016 with TSR100 in-service.

The additional Transmission Service Request TSR400, IR#131, IR#360 and IR#362 are higher queued than IR#370 and SISs are either in progress or about to be initiated. However, the results of these SISs are not sufficiently defined to be included in the FEAS for IR#356.

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#117	IR #126	IR #128	IR #149
IR #163	IR #213	IR #222	IR #235	IR #238	IR #241
IR #242	IR #273	IR #291	IR#314		

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.

## 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 100.44 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<sup>1</sup> are applied for both NRIS and ERIS 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

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



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).

## 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.

<b>Table 6-1: Short-Circuit Levels. Three-phase MVA <sup>(1)</sup></b>		
<b>Location</b>	<b>IR #356 in service</b>	<b>IR #356 not in service</b>
All transmission facilities in service		
30N-Maccan 138 kV (POI)	1494	1102
74N-Springhill 138 kV	1472	1229
1N-Onslow 138 kV	2557	2495
30N-Maccan 69 kV	400	368
74N-Springhill 69 kV	430	409
Minimum Conditions		
30N-Maccan 138 kV (POI)	1056	664

<sup>(1)</sup> 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 the 138 kV bus at the 30N-Maccan substation is presently 1102 MVA. After installing IR # 356 the increase will bring the short-circuit level to 1494 MVA at the POI. Similarly, under summer light load conditions with certain generation units offline and certain lines out-of-service, the minimum short-circuit level will be approximately 664 MVA at the POI. This translates into maximum equivalent system impedance at the POI of 0.151 per unit on 100 MVA base.

The interrupting capability of the 138kV circuit breakers at 1N-Onslow is at least 3500 MVA, and the interrupting capability of the 138kV circuit breakers at 30N-Maccan is at least 3000 MVA and all 69 kV circuit breakers at that substation are rated at least 1000 MVA, As such, the interrupting ratings will not be exceeded by this development on its own. At 74N-Springhill the breaker ratings are at least 5000 MVA (138kV breakers) and

3500 MVA (69kV breakers); therefore IR#356 will not impact the circuit breakers at these stations.

### 7 Voltage Flicker and Harmonics

Due to the lack of flicker coefficient information on the GE 1.6-XLE machine, this study assumes the same flicker data as for the GE 1.5SLE machine. The calculated voltage flicker at the POI using IEC Standard 61400-21 and the published values for GE 1.5 SLE machines is 0.018 under normal conditions and 0.025 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 generator 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 facility is requested to be interconnected at the 30N-Maccan substation by constructing approximately 14 km of 138kV transmission line with 556 ACSR Dove conductors and a maximum operating temperature of 100°C. The proposed new line terminal will be connected onto the 138 kV bus via a dedicated circuit breaker.

Any new generating facilities added to the system in northern Nova Scotia (between Truro and New Brunswick) could have an impact on the transfer capability between Nova Scotia and New Brunswick and on the associated SPSs. The NSPI transmission line ratings records show that L-6513 between 74N-Springhill and 1N-Onslow substation is built with 556 ACSR Dove conductors with a maximum operating temperature of 50°C and a Summer/Winter line rating of 110/165 MVA limited by conductor sag. Under the existing "Import Power Monitor" SPS arming level, the flow on L-6513 could be at its conductor thermal limit during summer when 345 kV line L-8001 trips for any reason. With the addition of IR#356 loss of L-8001 could cause L-6513 to be overloaded up to 220% of its conductor thermal ratings during periods when summer line ratings are in effect, assuming other generation in this area is concurrently generating at full output. Thermal overloads on L-6513 could also occur under the same contingency during winter. The overloads would also depend on the real-time local load demands and other local generation output. Similarly, thermal violations on L-6513 could also occur under the contingency of 88S-721 breaker failure (resulting in the loss of two generator units at 88S-Lingan) with high NS imports (up to 300 MW) during periods when summer line ratings are in effect. For high NS export levels (up to 350 MW) during periods when summer line ratings are in effect, the addition of IR#356 could cause L-6536 to be overloaded up to 120% of its conductor thermal ratings after the loss of L-6535 between 92N-Amherst and Memramcook NB. Therefore this study recommends that L-6513 should be re-built and L-6536 should be uprated to at least 60°C to accommodate IR#356.

TSR100 involves a request for a NS import from New Brunswick of 320 MW (firm) plus 400 MW (non-firm) with an in-service date of 2016. System network upgrades associated with TSR100 include:

- New 345 kV transmission line from Coleson Cove, NB to Salisbury, NB
- New 345 kV transmission line from Salisbury NB to Memramcook, NB
- New 345 kV transmission line from Memramcook, NB to Onslow NS
- Switched capacitor banks in NB at Memramcook, Salisbury and Norton
- Static Var Compensators (SVC) in NB at Salisbury and Memramcook

Once these upgrades are completed, the “Import Power Monitor” SPS will be eliminated. IR#356 can operate without restrictions assuming that L-6513 would have been re-built in 2015.

As ERIS without transmission reinforcement on L-6513, IR#356 would require the establishment of operating restrictions on this wind facility while NS exports less than 20 MW and imports under the “Import Power Monitor” SPS arming level. The restriction could be significant and depends on NS Import/Export level, real-time output of other local generation and load demands. There would also be operating restrictions required while NS imports above 580MW with TSR-100 in service after 2016.

The assessment of the alternative POI on L-6535 shows similar results as on the 138kV bus at 30N-Maccan.

The SIS will determine the detailed system requirements to accommodate IR#356. The requirement for restrictions or curtailments of this facility when operating with an element (transmission line, transformer etc) out of service (N-1 operation) will be further assessed in the SIS.

## 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 100.44 MW. 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 also have the ability to slowly adjust the set-point over several (5-10) minutes to maintain reactive power within the individual generators 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.

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.

### 10 System Security / Stability Limits (Transfer Capability)

There are a number of proposed generation additions in New Brunswick that may have an impact on projects in northern NS and vice versa. Their POI, size and relative position of the NS and NB interconnection Queues will determine the impact. This will be resolved through collaboration with NBSO at the SIS stage.

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 #356 to the 30N-Maccan substation:

#### Additions/Changes for POI on the 138 kV bus at 30N:

1. Addition of approximate 14 km of 138kV spur line to connect the wind farm to the POI with 556 Dove ACSR conductors rated 100°C conductor temperature,
2. A dedicated 138 kV circuit breakers and associated switches at 30N for the spur line to the wind farm,
3. Modification on NSPI protection systems,
4. Control and communications between the wind farm and NSPI SCADA system (to be specified),
5. Re-build L-6513 (65 km) as required for NRIS type,
6. Up-rate L-6536 (32 km) to the maximum operating temperature of 60°C as required for NRIS type.

#### Requirements for the Generating Facility

1. 138 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 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.
3. 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.
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 voltage 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.

## 12 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

Estimates for NSPI Interconnections Facilities and Network Upgrades for interconnecting 100.44 MW wind energy as NRIS onto the 138 kV systems are included in Table 12-1:

<b>Table 12-1: Cost Estimates identified from FEAS scope</b>		
	<b>Determined Cost Items</b>	<b>Estimate</b>
<b>NSPI Interconnection Facilities</b>		
i	Build 14 km 138kV single circuit line into the 30N substation	\$ 4,830,000
ii	138 kV circuit breakers& associated switches and the new line terminal into 30N-Maccan	\$ 1,180,000
iii	Protection, control, communication	\$ 700,000
<b>Network Upgrades</b>		
iv	Re-build L-6513 (65 km) & upgrades at 1N-Onslow end	\$19,200,000
v	Uprate L-6536 (32 km)	\$4,000,000
<b>Totals</b>		
vi	Contingency (10%)	\$2,991,000
vii	Total of Determined Cost Items	\$32,901,000

	<b>To be Determined Costs</b>	
viii	System additions to address potential stability limits	TBD (SIS)

The preliminary non-binding cost estimate for interconnecting 100.44 MW into the 30N-Maccan substation as NRIS would be \$32,901,000 including a contingency of 10%. The Interconnection Customer is also required to fund the Item iv) and v) costs, but would be eligible for repayment in accordance with the terms of the GIA.

The preliminary non-binding cost estimate for interconnecting IR#356 into the 30N-Maccan substation as ERIS would be \$7,381,000 including a contingency of 10%, and the cost estimates does not include the network upgrades on L-6513 and L-6536.

### **13 Issues to be addressed in SIS**

The following provides a preliminary scope of work for the subsequent SIS for IR#356. 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.

- 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. System loss impacts
- v. Under-frequency load shedding impacts

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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-6513
- L-6514
- L-6535/L-1159
- L-6536/L-1160
- L-8003
- L-8002 & L-8003 (common circuit breaker)
- L-8003 & L-8004 (common circuit breaker)
- L-8001 & 67N-T81 TX (common circuit breaker)
- L-8002 & 67N-T81 TX (common circuit breaker)
- L-3006 & L-3025 & Memramcook 345/138 kV Tx (common breaker)
- L-3006 & L3017 (common breaker)
- 1N-B61
- L-1108/1190 Common 138kV structure
- Loss of 180 MW of load under peak load conditions and 250 MW under light load conditions
- Loss of largest generation – Pt. Aconi 174MW net
- Loss of two generating units at Lingan – 312 Net
- Loss of the Trenton Bus (Two units with load)

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

- 3 phase fault L-8001/3025 at 67N-Onslow, NS Import SPS operation (islanding)
- 3 phase fault L-3006 at Memramcook, NB SPS/UVLS operation (islanding)
- 3 phase fault L-3006 at Salisbury, NB SPS/UVLS operation (islanding)
- 3 phase fault L-8003 at 67N-Onslow
- 3 phase fault L-8002 at 67N-Onslow
- Slg L-3017, drops L-3017&L-3006 (common CB), NB SPS/UVLS operation,
- Slg Memramcook T3, drops L-3006 (common CB), NB SPS/UVLS operation
- Slg L-8002 at Onslow, drops L-8003, Grp5 SPS Operation
- 3 phase fault at 79N-Hopewell, drops L-8003, 8004, bus, SPS operation
- 3 phase fault 1N-Onslow 138 kV bus B61
- 3 phase fault 74N-Springhill 138 kV bus

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



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determination will be based on NERC<sup>2</sup> and NPCC<sup>3</sup> criteria as well as NSPI guidelines and good utility practice. 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 #356 which is lost through the transmission system. Preliminary value is calculated to be 5.3% (system losses increased by net 5.3 MW when IR #356 is operated at 100.44 MW).

Nova Scotia Power  
2012-01-03

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<sup>2</sup> NPCC criteria are set forth in its Reliability Reference Directory #1 *Design and Operation of the Bulk Power System*

<sup>3</sup> NERC transmission criteria are set forth in *NERC Reliability Standards TPL-001, TPL-002, TPL-003*





# **Interconnection Feasibility Study Report Addendum**

**GIP-356-FEAS-R2**

**System Interconnection Request #356**

**80 MW Wind Generating Facility**

**Cumberland County (30N)**

2012-02-10  
Control Centre Operations  
Nova Scotia Power Inc.

# 1 Introduction

The Interconnection Customer (IC) originally submitted an Interconnection Request (IR) for Network Resource Interconnection Service (NRIS) to NSPI for a proposed 100.44 MW wind generation facility interconnected to the NSPI transmission system and also asked that Energy Resource Interconnection Service (ERIS) be studied concurrently. Report no. GIP-356-FEAS-R1 shows the study results of that Interconnection Request. The IC subsequently requested a reduction in the nameplate capacity of IR#356 from 100.44 MW to 80 MW. This report shows the study results of the 80 MW generating facility. This report only includes the assessment of the thermal issues and the associated high-level estimated costs and supersedes Section 8, 9, 11 and 12 of the original report GIP-356-FEAS-R1.

## 2 Thermal Limits (Supersedes GIP-356-FEAS-R1 Section 8)

This facility is requested to be interconnected onto the 138 kV bus at the 30N-Maccan substation by constructing approximately 14 km of 138kV transmission line with 556 ACSR Dove conductors and a maximum operating temperature of 100°C. The proposed new line terminal will be connected onto the 138 kV bus via a dedicated circuit breaker.

The addition of 80 MW added to the system in northern Nova Scotia between Truro and New Brunswick would have an impact on the transfer capability between Nova Scotia and New Brunswick and on the associated SPSs. The NSPI transmission line ratings records show that L-6513 between 74N-Springhill and 1N-Onslow substation is built with 556 ACSR Dove conductors with a maximum operating temperature of 50°C and a Summer/Winter line rating of 110/165 MVA limited by conductor sag with the restriction of 172 MVA due to metering scales at both line terminals and protection at 1N-Onslow end. Under the pre-existing “Import Power Monitor” SPS arming level, the flow on L-6513 could be at its conductor thermal limit during summer when 345 kV line L-8001 trips for any reason. With the addition of IR#356 loss of L-8001 could cause L-6513 to be overloaded up to 197% of its conductor thermal ratings during periods when summer line ratings are in effect, assuming other generation in this area is concurrently generating at full output. Thermal overloads on L-6513 could also occur under the same contingency during winter. The overloads would also depend on the real-time local load demands and other local generation output. Similarly, thermal violations on L-6513 could also occur under the contingency of 88S-721 breaker failure (resulting in the loss of two generator units at 88S-Lingan) with high NS import (up to 300 MW) during periods when summer line ratings are in effect. For high NS export levels (up to 350 MW) during periods when summer line ratings are in effect, the addition of IR#356 could cause L-6536 to be overloaded up to 115% of its conductor thermal ratings after the loss of L-6535 between 92N-Amherst and Memramcook NB.

To accommodate IR#356 as NRIS L-6513 would be required to be up-rated to a maximum operating temperature of 100°C or to be completely re-built. The cost of L-6513 reinforcement will depend on the number of structures and spans that need to be remedied, but an estimate of the cost ranges from \$8.2M for thermal uprating to \$19.2M

for complete rebuild. Further analysis will be required for the upgrade solutions of L-6513. L-6536 should be up-rated to a maximum operating temperature of at least 60°C.

TSR-100 involves a request for a NS import from New Brunswick of 320 MW (firm) plus 400 MW (non-firm) with an in-service date of 2016. System network upgrades associated with TSR-100 include:

- New 345 kV transmission line from Coleson Cove, NB to Salisbury, NB
  - New 345 kV transmission line from Salisbury NB to Memramcook, NB
  - New 345 kV transmission line from Memramcook, NB to Onslow NS
  - Switched capacitor banks in NB at Memramcook, Salisbury and Norton
  - Static Var Compensators (SVC) in NB at Salisbury and Memramcook
- Once these upgrades are completed, the “Import Power Monitor” SPS will no longer be needed under normal system conditions. IR#356 could then operate without restrictions assuming that L-6513 is re-built in 2015.

As ERIS without transmission reinforcement on L-6513 and L-6536, IR#356 would require the establishment of operating restrictions on this wind facility during the periods while NS imports below the “Import Power Monitor” SPS arming level and with high NS import (up to 300 MW). The restriction could be significant and depends on NS Import/Export level, real-time output of other local generation and load demands. These operating restrictions would no longer be needed after TSR-100 is in service in 2016 along with the associated system upgrades. However there would also be operating restrictions associated with TSR-100 when NS imports are above 585MW. When NS imports are above 585 MW, either the loss of one 345 kV transmission line from New Brunswick or the breaker failure of 88S-721 would cause L-6513 to exceed its conductor thermal limits. Therefore IR#356 would have to be curtailed or the NS Import would have to be reduced in order to avoid further transmission expansion requirements.

With a NS high export (up to 350 MW) there should also be operating restrictions established on IR#356 for loss of L-6535 between 92N-Amherst and Memramcook NB. The potential overloads on L-6536 under this contingency can also be managed by a new Special Protection System (SPS) to trip the wind farm. However, any new SPS scheme would have to be presented to NPCC and would require their approval. This will be further examined in the SIS study.

The addition of 80 MW added to the system in northern Nova Scotia between Truro and New Brunswick could also have an impact on the ‘Export Power Monitor’ SPS and the impact will be further examined in the SIS study.

The requirement for restrictions or curtailments of this facility when operating with an element (transmission line, transformer etc) out of service (N-1 operation) will be further assessed in the SIS.

### **3 Voltage Limits (Supersedes GIP-356-FEAS-R1 Section 9)**

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 80 MW. 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 also have the ability to slowly adjust the set-point over several (5-10) minutes to maintain reactive power within the individual generators 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.

Data provided by the IC indicates that IR#356 may not be able to meet this requirement without additional reactive support. Based on the provided rated power factor of the GE XLE 1.62 MW (0.90), and the provided impedances of the transformers, supplementary reactive support may be needed in the form of capacitor banks at the low voltage terminals of the Interconnection Transformer. This will be further investigated in the System Impact Study.

The SIS will confirm the options and ancillary equipment that the customer must install to control the voltage profile.

#### **4 Expected Facilities Required for Interconnection (Supersedes GIP-356-FEAS-R1 Section 11)**

The following facility changes are required to interconnect IR #356 to the 30N-Maccan substation:

##### **Additions/Changes Required for ER Interconnection Services (ERIS)**

1. Addition of approximate 14 km of 138kV spur line to connect the wind farm to the POI with 556 Dove ACSR conductors rated 100°C conductor temperature,
2. A dedicated 138 kV circuit breakers and associated switches at 30N for the spur line to the wind farm,
3. Modification on NSPI protection systems,
4. Control and communications between the wind farm and NSPI SCADA system (to be specified),

##### **Additions/Changes Required for Full Generating Facility Output (NRIS)**

5. Up-rate or Re-build L-6513 (65 km) and Upgrades the line terminals as required for NRIS type,
6. Up-rate L-6536 (32 km) to the maximum operating temperature of 60°C as required for NRIS type.

### **Requirements for the Generating Facility**

1. 138 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 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.
3. 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.
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 voltage 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.

## **5 NSPI Interconnection Facilities and Network Upgrades Cost Estimate (supersedes GIP-356-FEAS-R1 Section 12)**

Estimates for NSPI Interconnections Facilities and Network Upgrades for interconnecting 80 MW of wind energy onto the 138 kV systems are included in Table 5-1 for NRIS and Table 5-2 for ERIS.

<b>Table 5-1: Cost Estimates identified from FEAS scope for NRIS</b>		
	<b>Determined Cost Items</b>	<b>Estimate</b>
<b>NSPI Interconnection Facilities</b>		
i	Build 14 km 138kV single circuit line into the 30N substation	\$ 4,060,000
ii	138 kV circuit breakers& associated switches and the new line terminal into 30N-Maccan	\$ 1,180,000
iii	Protection, control, communication	\$ 700,000
<b>Network Upgrades</b>		
iv	Up-rate or Re-build L-6513 (65 km)	\$8,125,000~ \$18,800,000
v	Line L-6513 terminal upgrades at 1N-Onslow and 74N-Springhill	\$400,000
vi	Uprate L-6536 (32 km)	\$4,000,000
<b>Totals</b>		
vii	Contingency (10%)	\$1,846,500~ \$2,914,000
viii	Total of Determined Cost Items	\$20,311,500~ \$32,054,000
<b>To be Determined Costs</b>		
ix	System additions to address potential stability limits	TBD (SIS)

The preliminary non-binding cost estimate for interconnecting 80 MW into the 30N-Maccan substation as NRIS ranges from \$20,311,500 to \$32,054,000 (including a contingency of 10%) depending on the solution of L-6513 reinforcement. The Interconnection Customer is required to fund Items iv), v) and vi) costs, but would be eligible for repayment in accordance with the terms of the GIA.

<b>Table 5-2: Cost Estimates identified from FEAS scope for ERIS</b>		
	<b>Determined Cost Items</b>	<b>Estimate</b>
<b>NSPI Interconnection Facilities</b>		
i	Build 14 km 138kV single circuit line into the 30N substation	\$ 4,060,000
ii	138 kV circuit breakers& associated switches and the new line terminal into 30N-Maccan	\$ 1,180,000
iii	Protection, control, communication	\$ 700,000
<b>Totals</b>		
iv	Contingency (10%)	\$594,000
v	Total of Determined Cost Items	\$6,534,000
<b>To be Determined Costs</b>		
vi	System additions to address potential stability limits	TBD (SIS)

The preliminary non-binding cost estimate for interconnecting IR#356 into the 30N-Maccan substation as ERIS would be \$6,534,000 including a contingency of 10%, and the cost estimate does not include the network upgrades of L-6513 and L-6536.

Nova Scotia Power  
2012-02-10