Interconnection Feasibility Study Report
GIP-131-FEAS-R2

Interconnection Request #131
11.5 MW Expansion to Lingan Wind Generating Facility
Cape Breton County (L-5580)

August 17, 2007

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

This Interconnection Request is to install an incremental 11.5 MW of wind generation at the existing 109S-Lingan Wind Farm connected to the 69kV transmission line L-5573/L-5580. The new generation will bring the total capacity of that facility to 25.5 MW. The Interconnection Customer reports that no changes are proposed to the existing substation at 109S-Lingan Wind Farm because there is sufficient capacity in the existing transformer and substation equipment.

No adverse issues were determined for this project if no other generation in the Interconnection Request queue with a higher queue position proceeds.

No new facilities or upgrades to the NSPI transmission system are needed if this is the only new generation project in the vicinity.

The potential requirement for system upgrades between the Sydney and Halifax areas will depend on the projects in the Interconnection Request queue ahead of this project, and will be determined in a subsequent System Impact Study.

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1 Introduction

The Interconnection Customer submitted an Interconnection Request to NSPI for a proposed 11.5 MW expansion to the existing 109S-Lingan Wind Farm interconnected to the NSPI 69 kV transmission line L-5573/L-5580[1] approximately 15 km from 2S-Victoria Junction. The Interconnection Request is for Energy Resource Interconnection Service (ERIS). The Interconnection Customer signed an Interconnection Feasibility Study Agreement to study the connection of their proposed generation to the NSPI transmission system. This report is the result of that Study Agreement.

This project is listed as #131 in the NSPI Interconnection Request queue, and will be referred to as IR #131 throughout this report.

2 Scope

The Interconnection Feasibility Study (FEAS) report shall provide the following information:

i. Preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the interconnection;

ii. Preliminary identification of any thermal overload or voltage limit violations resulting from the interconnection;

iii. Preliminary description and non-bonding estimated cost of facilities required to interconnect the Generating Facility to the Transmission System, the time to construct such facilities, and to address the identified short circuit and power flow issues.

Subsequent to this FEAS, a System Impact Study (SIS) will examine the project in more detail in the context of Interconnection Requests ahead of this IR #131. This may include system stability issues, single contingencies and extreme contingencies, off-nominal frequency operation, low voltage ride-through, harmonic current and voltage distortion, system protection, Special Protection System interaction, Automatic Generation Control action, and islanded operation. The impacts on neighboring power systems and the requirements set by reliability authorities such as the North American Electric Reliability Council (NERC) and the Northeast Power Coordinating ouncil will be addressed in the SIS, including the Bulk Power System status of IR #131 in accordance with the NPCC A-10 Criteria[2]. The SIS may identify requirements and system upgrades that are not identified in the FEAS.

[1] L-5580 is a 2.4km line tap off of L-5573 between 2S-Victoria Junction and 80S-Lingan Mine.
[2] NPCC Document A-10, *Classification of Bulk Power System Elements*, 2007 04 28.

The final study will be a detailed engineering review and design, known as the Interconnection Facilities Study (FAC).

3 Assumptions

The Point of Interconnection (POI) and configuration studied is as follows:

i. 11.5 MW wind farm comprised of 5 – 2.3 MW Enercon E-70 wind turbines using IGBT (full-inverter) technology. If other machines are used, the results of this analysis may require revision.

ii. Generators have a rated power factor from 0.87 inductive to 0.87 capacitive. This meets NSPI requirements of 0.95 inductive to 0.95 capacitive at the high voltage terminal of the interconnection.

iii. The new wind turbines will be connected to the same low voltage grid as the existing 14 MW of wind generation at 109S-Lingan Wind Farm. The existing 12/16/20 MVA transformer will not be uprated for this expansion.

This feasibility study is based on the assumption that projects that are ahead of IR #131 in the Generation Interconnection Request queue will not proceed, however the potential impact of those projects will be reviewed qualitatively.

4 Projects with Higher Queue Positions

As of 2007 06 18 the following projects have a higher Queue Position than IR #131 and have the status indicated.

In Service and committed generation projects

Wind Generation – 30.5 MW – connected to L-5027 (in-service)

Wind Generation – 14.0 MW – connected to L-5573 (in-service)

Wind Generation – 20.0 MW – distribution connected (in-service)

Wind Generation – 40.0 MW – distribution connected (committed)

Generation projects with a higher Queue position, not yet committed

IR 008 Wind – Guysborough, L-5527B, 15 MW – FAC Complete

IR 017 Wind – Lunenburg, L-6004, 100MW – SIS in Progress

IR 023 Wind – Inverness, L-6549, 100MW – SIS in Progress

IR 042 Wind – Cape Breton, New 138kV line, 100MW – SIS in Progress

IR 044 Wind – Colchester, L-6503, 35MW – FEAS in Progress

IR 045 Wind – Cumberland, L-6535, 35MW – SIS Complete

IR 046 Wind – Colchester, L-6513, 32MW – FEAS in Progress

IR 056 Wind – Cumberland, L-5058, 60MW – FEAS in Progress

IR 067 Wind – Annapolis, L-5026, 40MW – FEAS in Progress
IR 068 Wind – Digby, L-5533, 35MW – FEAS in Progress
IR 072 Wind – Guysborough, L-6515, 100MW – FEAS in Progress
IR 079 Wind – Antigonish, L-6515, 50MW – FEAS in Progress
IR 080 Wind – Cumberland, L-5550, 30MW – FEAS in Progress
IR 081 Wind – Shelburne, L-5027, 50MW – FEAS in Progress
IR 082 Wind – Colchester, L-5040, 45MW – FEAS in Progress
IR 083 Wind – Shelburne, L-6021, 150MW – FEAS in Progress
IR 084 Wind – Pictou, L-7004, 50MW – FEAS in Progress
IR 085 Wind – Pictou, L-6511, 50MW – FEAS in Progress
IR 086 Wind – Pictou, L-7003, 50MW – FEAS in Progress
IR 100 Wind – Yarmouth, New 69kV line, 52MW – FEAS in Progress
IR 114 Wind – Pictou, L-6511, 60MW – FEAS in Progress
IR 115 Wind – Pictou, L-7003, 120MW – FEAS in Progress
IR 117 Wind – Shelburne, L-5027, 10MW – FEAS in Progress
IR 126 Wind – Cumberland, L-6513, 70MW – IR valid
IR 128 Wind – Cumberland, L-6536, 40.5MW – FEAS in Progress
IR 130 Wind/Water pumped – Cape Breton, L-6516, 200MW – FEAS in Progress

This IR #131 and IR #8, IR #23, IR #42, IR #44, IR #72, IR #79, IR #84, IR #85 IR #86, IR #114, IR #115 and IR#130 impact the interface known as Onslow Import. Onslow Import is presently a congested interface from time to time. If any of the projects IR #8, IR #23, IR #42, IR #44, IR #72, IR #79, IR #84, IR #85, IR #86, IR #114, IR 115 or IR #130 proceed, the results of this feasibility study must be updated to reflect the impact of increased Onslow Import flow on IR #131, and any transmission upgrades that might be required for this or other projects ahead in the queue.

This IR #131 and IR #23, IR #42, and IR #130 impact the interface known as Cape Breton Export, which is presently congested and managed by generation rejection Special Protection Systems. If any of the projects ahead of IR #131 proceed, the results of this FEAS must be revised.

5 Objective

The objective of this feasibility study is to determine the primary physical requirements to interconnect an incremental 11.5 MW of generation 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 uprated. Single contingency criteria are applied for the Energy Resource Interconnection Service assessment.

The feasibility study does not produce a binding estimate of all costs and changes that may be required to interconnect the facility. These costs are limited to facility additions/changes that are in the immediate vicinity of the proposed generating facility and any other system costs that are foreseen at the time this report is completed.

This assessment does not include any 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 the Northeast Power Coordinating Council (NPCC) and/or the North American Reliability Corporation (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 (future) expected short-circuit level on 69kV systems is 3500 MVA.

The short-circuit levels in the area before and after this development are provided in Table 6-1 below.

Table 6-1: Short-Circuit Levels. Three-phase MVA[3]		
Location	**This project in service**	**This project not in service**
All transmission facilities in service		
2S-Victoria Junction 69kV	1374	1347
109S-Lingan Wind Farm 69kV	524	497
Minimum conditions[4]		
109S-Lingan Wind Farm 69kV	417	390

The maximum short-circuit level at the POI is presently 497 MVA. Although the actual increase in short-circuit levels will be dependent on the specific type of generator installed, the increase will raise the short-circuit level to not more than 524 MVA at the POI. Under contingency operation, with generators at 83S-Victoria Junction GT off-line and 2S-T1 transformer open, the short-circuit level will be approximately 390 MVA at the POI.

The interrupting capability of 69 kV circuit breakers at 2S-Victoria Junction will not be exceeded by this development. The transformer fuse at 15S-New Waterford is rated at more than 2000 MVA and will not be affected by IR #131.

7 Voltage Flicker

The proposed generator is an Enercon fully-inverted machine. Based on the minimum Short Circuit Ratio at the POI of 15, voltage flicker is not a concern for IR #131 on its own.

[3] Classical fault study, flat voltage profile.
[4] 83S-Victoria Junction generation off-line and one transformer open at 2S-Victoria Junction.

8 Thermal Limits

Line L-5573 between 2S-Victoria Junction and the 109S-Lingan Wind Farm tap is constructed with 336 kcm Linnet ACSR conductor designed for maximum operating temperature of 50°C. The conductor has a thermal rating of 41 MVA summer and 60 MVA winter.

Line L-5573 is a loop out of 2S-Victoria Junction which is capable of feeding 109S-Lingan Wind Farm, 15S-New Waterford, and 82S-Whitney Pier. The loop is normally open between 15S-New Waterford and 82S-Whitney Pier, but all substations can be fed from either end of the loop under conditions of maintenance or contingency. However, in accordance with the findings of the SIS for the original wind farm at 109S-Lingan Wind Farm, the Generating Facility interconnection is not designed to operate if the section of L-5573 between the 109S-Lingan Wind Farm and 2S-Victoria Junction is open. The same restriction applies to this IR #131.

IR #131 does not result in thermal limit violations on its own.

9 Voltage Control

IR #131, like all new generating facilities must be capable of providing both lagging and leading power factor of 0.95, measured at the 69 kV terminals of the Interconnection Customer substation, at all production levels up to the full rated load of 11.5 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 69 kV terminals of the Interconnection Customer substation. The voltage controls must be responsive to voltage deviations at the connection point, be equipped with a voltage set-point control, and also have facility that will slowly adjust the set-point over several (5-10) minutes to maintain reactive power just within the individual generators capabilities. Details of the specific control features, control strategy and settings will be reviewed and addressed in the SIS.

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

This facility must have low-voltage ride-through capability in accordance with FERC Order 661a[5]. The SIS will examine the generator/plant capabilities and controls in detail specify any options, controls and additional facilities that are required to achieve low-voltage ride-through.

[5] Post-transition Period LVRT Standard; "Interconnection for Wind Energy", Federal Energy Regulatory Commission, Docket RM05-4-001; Order No. 661-A, December 12, 2005.

10 System Security

The NSPI transmission system has limited east to west transfer capability. Transmission corridors between Sydney and Halifax are often operated to security limits. IR #131 increases flow across the Cape Breton Export and Onslow Import interfaces. Generation rejection SPS's are utilized to increase system stability limits to maximize east to west power transfers. Depending on the impact of other generation additions ahead of IR #131 in the IR queue, significant transmission system upgrades may be required to integrate IR#131.

This generating facility will also increase loading on the Onslow South corridor (Truro to Halifax) by replacing generation 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 the facility changes that are required to permit higher transmission loadings while maintaining compliance with NERC/NPCC standards and in keeping with good utility practices.

11 Expected Facilities Required for Interconnection

We expect the following facilities will be required assuming that the projects ahead of IR #131, in the Interconnection Request queue, do not proceed.

Additions/Changes to NSPI systems

None.

Requirements for the Interconnection Customer's Interconnection Facility

i. Facilities to provide 0.95 leading and lagging power factor when delivering rated output (11.5 MW plus existing 14 MW) all at the 69 kV bus when the voltage at that point is operating between 95 and 105 % of nominal.

ii. Centralized controls. These will provide centralized voltage set-point controls and reactive power set-point controls acting to control the voltage on the 69 kV system 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.

iii. 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 and change the status of any reactive power controls, remotely. NSPI will also have remote manual control of the load curtailment scheme.

iv. Low voltage ride-through capability in accordance with FERC Order 661a.

v. Real-time monitoring (RTU's) of the interconnection substation and facilities for NSPI to execute high speed rejection of generation (transfer trip) if determined by the SIS.

12 High Level Cost Estimate for NSPI Additions/Changes

It is anticipated that the high level cost estimates (non-binding), excluding HST taxes, for the items identified above will be in the range:

Table 12-1: Cost Estimates

Determined Cost Items	Estimate
None	n/a
Total of Determined Cost Items	n/a
To be Determined Costs	
System additions to increase east-west transfer capability	TBD (SIS)

13 Issues to be addressed in SIS

The SIS must determine the facilities required to operate this facility at full capacity, withstand the contingencies as defined by NPCC/NERC and identify any restrictions that must be placed on the system following a first contingency loss (N-1 operation). The SIS will be conducted with the assumption that all projects higher-queued will proceed and the facilities associated with those projects are installed.

Because IR #131 increases east-west transmission flow, transmission losses will increase. The SIS will determine the incremental impact of IR #131 on system losses.

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.

i. Onslow Import
ii. Cape Breton Export
iii. Onslow South
iv. Metro reactive reserve requirements
v. NS – NB export

13.1 Steady-state post-contingency analysis

All elements within acceptable voltage and thermal limits under the following single contingencies, in accordance with NPCC[6] and NERC[7] criteria.

i. Hopewell transformer 79N-T81
ii. Trenton Bus 50N-B62
iii. L-8003
iv. L-8004
v. Loss of double-circuit tower line L-8004 +L-7005 at Hastings

13.2 System stability for the following faults

Loss of any element without a fault

i. L-8003
ii. L-8004
iii. 79N-T81
iv. L-6516

Three-phase fault cleared in normal time:

i. L-8003 at Hopewell end
ii. High voltage side of 79N-T81
iii. L-8004 at Woodbine end

[6] NPCC criteria are set forth in it's A-2 Document *Basic Criteria for Design and Operation of Interconnected Power Systems*
[7] NERC transmission criteria are set forth in *NERC Reliability Standards TPL-001, TPL-002, TPL-003*

Single-phase to ground fault cleared in backup time (Breaker Failure)

i. L-8003 at Onslow with failure of 67N-812 (lose L-8002)
ii. L-7012 at Lingan end with failure of 88S-712 (lose L-7014)

Single-phase to ground fault on separated circuits of double-circuit tower:

i. L-7003 + L-7004 at Trenton
ii. L-8004 + L-7005 at Hastings.

Any changes to SPS schemes required for operation of this generating facility, in addition to existing generation and facilities that can proceed before IR #131, will be determined by the SIS as well as any required additional transmission facilities. The determination will be based on NERC and NPCC criteria as well as NSPI guidelines and good utility practice. The SIS will also determine the contingencies for which this facility must be curtailed.