# Interconnection Feasibility Study Report
# GIP-085-FEAS-R2

**System Interconnection Request #85**

**50 MW Wind Generating Facility**

**Pictou County (L-6511)**

August 17, 2007

Control Centre Operations
Nova Scotia Power Inc.

# Executive Summary

The Interconnection Customer submitted an Interconnection Request to NSPI for a proposed 50 MW wind generation facility interconnected to the NSPI 138kV transmission line L-6511 between 50N-Trenton and 4C-Lochaber Road, approximately 34 km from 50N-Trenton near Barney's River Station, Pictou County.

No significant concerns regarding short-circuit level, or voltage control were found, provided that the project design meets NSPI requirements for low-voltage ride-through, reactive power range and voltage control system. Under minimum short circuit conditions, however, voltage flicker could become a concern at 4C-Lochaber Road. This will be further studied in the SIS, when the generation technology is identified.

Excessive thermal loading on L-6503 at the 50N-Trenton terminal was found under single contingency conditions, and therefore the circuit breaker and associated switches and current transformers at the Trenton end of this circuit must be updated from 1200A to 2000A.

It is assumed that the Interconnection Facility substation is located at the Point of Interconnection, and therefore the non-binding cost estimate excludes any 138kV spur line that might be required.

The direct cost of interconnection, assuming that this is the only project in the vicinity to proceed, is estimated to be $5,830,000**.**

Because this project can impact transmission congestion between Cape Breton and Onslow, there is the potential requirement for significant transmission reinforcement, depending on the amount of generation that is added in the vicinity. The requirement for such reinforcements 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 50 MW wind generation facility interconnected to the NSPI 138kV transmission line L-6511 between 50N-Trenton and 4C-Lochaber Road, approximately 34 km from 50N-Trenton near Barney's River Station. The Interconnection Request specified Network Resource Interconnection Service (NRIS). The Interconnection Customer signed a 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 Interconnection Request #85 in the NSPI Interconnection Request Queue, and will be referred to as IR #85 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 #85. 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 Council (NPCC) will be addressed in the SIS, including the Bulk Power System status of IR #85 in accordance with the NPCC A-10 Criteria[1]. The SIS may identify requirements and system upgrades that are not identified in the FEAS.

[1] NPCC Document A-10, *Classification of Bulk Power System Elements*, 2007 04 28.

# 3 Assumptions

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

i. A 50 MW wind farm with unspecified wind turbines. For the purposes of this study, it is assumed that the generators are asynchronous induction generators with external reactive support (Static Var Compensation). If other machines are used, the results of this analysis may require revision.

ii. The generation technology used must meet NSPI requirement for reactive power capability of 0.95 capacitive to 0.95 inductive at the high voltage terminals of the Interconnection Facilities. It is also required to provide high-speed Automatic Voltage Regulation to maintain constant voltage at the high voltage terminals of the Interconnection Facilities.

iii. The Interconnection Customer indicated a 138kV interconnection point. This point on L-6511 is approximately 32 km from 50N-Trenton substation.

iv. The wind generating facility is assumed to be located in close proximity to the POI on L-6511 and therefore the Interconnection Facility is also the wind farm substation. If the wind farm substation is located remote from the POI, then a separate 138kV transmission line connecting the Interconnection Facility substation to the POI switching station is required.

v. No information was provided regarding the transformer, therefore it is assumed that there will be one 138kV transformer with a base rating of 40 MVA and a top rating of 55 MVA. Transformer impedance assumed to be 7% (on 40 MVA ONAN base) and 5 fixed taps between -5% and +5%. Collector voltage will be at the discretion of the Interconnection Customer. It should be noted that NSPI standard distribution voltage is 25kV.

This feasibility study is based on the assumption that projects that are ahead of this project 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 #85, 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

This IR #85 and IR #8, IR #23, IR #42, IR #44, IR #72, IR #79 and IR #84 affect 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 or IR #84 proceed, the results of this feasibility study must be updated to reflect the impact of increased Onslow Import flow on IR #85, and any transmission upgrades that might be required for this or other projects ahead in the queue. In addition to the above transmission Interconnection Requests, there are 27.7 MW of distribution connected wind generation proposals ahead of this IR #85 which may have an impact on the results of this FEAS.

# 5 Objective

The objective of this feasibility study is to determine the primary physical requirements to interconnect 50 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 Network Resource Interconnection Service assessment.

This FEAS 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 138kV systems is 5000 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[2]**

| Location | This project in service | This project not in service |
|---|---|---|
| **All transmission facilities in service** | | |
| 50N-Trenton | 2820 | 2740 |
| 4C-Lochaber Road | 1192 | 1120 |
| 138kV Interconnection Point | 1363 | 1216 |
| **Minimum conditions[3]** | | |
| 138kV Interconnection Point | 581 | 434 |

The maximum short-circuit level at the POI is presently 1216 MVA. Although the actual increase in short-circuit levels will be dependent on the specific type of generator installed, the increase will bring the short-circuit level to not more than 1363 MVA at the POI. Under contingency operation, with the generator at Point

[2] Classical fault study, flat voltage profile.
[3] L-6511 open between 50N-Trenton and IR #85 POI, unit off-line at 1C-Point Tupper.

Tupper off-line and the Interconnection Facility only connected to 4C-Lochaber Road (L-6511 open at 50N-Trenton), the short-circuit level will be approximately 434 MVA at the POI.

The interrupting capability of the 138kV circuit breakers at 50N-Trenton and 4C-Lochaber Road is at least 3500 MVA which will not be exceeded by this development on its own.

# 7 Voltage Flicker

Because the minimum Short Circuit Ratio at the POI is 8.6 (based on proposed plant rating of 50 MW), the generator is assumed to be based on induction generator technology, and therefore voltage flicker may be a concern for this project when L-6511 is open between the POI and 50N-Trenton. The full System Impact Study will examine the requirements in detail using actual data for the generator selected.

# 8 Thermal Limits

Line L-6511 is constructed with 556 kcm Dove ACSR conductor designed for maximum operating temperature of 50°C. The conductor has a thermal rating of 110 MVA summer and 165 MVA winter. However, the switchgear at the 4C-Lochaber Road end of the circuit has a thermal rating of 143 MVA (summer or winter), so the transmission line is currently rated 143 MVA in winter.

Loss of L-8003 can result in line L-6503 between 50N-Trenton and 49N-Granton Tap exceeding the rating of the switchgear at the 50N-Trenton end with IR #85 in-service. This equipment (switches, circuit breakers, and current transformers) must be uprated to 2000 amp.

# 9 Voltage Control

This project, like all new generating facilities must be capable of providing both lagging and leading power factor of 0.95, measured at the 138kV terminals of the Interconnection Facility substation, at all production levels up to the full rated load of 50 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 138kV bus voltage. The voltage controls must be responsive to voltage deviations at the 138kV terminals of the Interconnection Facility substation, be equipped with a voltage set-point control, and also have facility that will slowly adjust the set-point over several minutes (5-10) 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[4]. 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.

# 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. This project increases flow across the Onslow Import interface. Generation rejection Special Protection Systems[5] (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 this project in the Interconnection Request Queue, the additional generating capacity that this facility provides may not be integrated into the NSPI system under all dispatch conditions without system upgrades.

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#85 in the Interconnection Request queue, do not proceed.

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

[5] Also known as Remedial Action Schemes, SPS's are defined by NPCC as "A protection system designed to detect abnormal system conditions, and take corrective action other than the isolation of faulted elements." *NPCC Document A7 - Glossary of Terms.*

**Additions/Changes to NSPI systems**

Develop a switching substation at the POI with L-6511 (near Barney's River Station) consisting of:

i. Three 138kV circuit breakers and associated switches in a ring-bus arrangement,

ii. Control building and protection systems,

iii. Control and communications between the POI switching station and NSPI SCADA system,

iv. Structures to turn L-6511 into new switching station.

v. Any conductors needed to connect the wind farm to the POI will use 556 Dove ACSR conductor rated 100°C conductor temperature.

vi. Control and Communications between the POI and NSPI SCADA system (to be specified)

**Requirements for the Interconnection Customer's Interconnection Facility**

i. Facilities to provide 0.95 leading and lagging power factor when delivering rated output (50 MW) all at the 138kV 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 138kV 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 SIS.

# 12 NSPI Interconnection Facilities Cost Estimate

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

| Table 12-1: Cost Estimates | | |
|---|---|---|
| | **Determined Cost Items** | **Estimate** |
| i | Uprate L-6503 switchgear at 50N-Trenton | $200,000 |
| ii | Develop 138kV substation (Barney's River Station) | $1,000,000 |
| iii | Develop 138kV ring bus with three circuit breakers | $3,600,000 |
| iv | Protection, control, communication | $500,000 |
| v | Contingency (10%) | $530,000 |
| | **Total of Determined Cost Item** | **$5,830,000** |
| | **To be Determined Costs** | |
| vi | System additions to increase east-west transfer capability | TBD (SIS) |

NSPI estimates the time required to construct the above facilities at 12-24 months provided that no more than 2 to 3 projects per year go forward, and assuming all easements and permits are provided and complete.

# 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. The SIS will be conducted with the assumption that all projects higher-queued will proceed and the facilities associated with those projects are installed.

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

## 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. L-8004
ii. Hopewell transformer 79N-T81
iii. L-8003
iv. L-8003 plus L-8002
v. L-8004 plus L-7005

## 13.2 System stability for the following faults

Loss of any element without a fault

i. L-8004
ii. Hopewell transformer 79N-T81
iii. L-8003

Three-phase fault cleared in normal time:

i. L-8003 at Onslow end
ii. L-8003 at Hopewell end
iii. L-8001 at import and export limits

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

i. L-8003 at Onslow with failure of 67N-812 (lose L-8002)

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

i. L-8004 plus L-7005 at Canso Crossing
ii. L-7003 plus section of L-6511 at Trenton

[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*

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 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.