Interconnection Feasibility Study Report
GIP-150-FEAS-R2

Generator Interconnection Request #150
Incremental 10 MW Wind Generating Facility
Richmond County, NS

March 10, 2008

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer submitted an Interconnection Request to Nova Scotia Power Inc. (NSPI) for a proposed 10 MW wind Generation Facility interconnected to the NSPI system via distribution feeders to 1C-Point Tupper.

This Interconnection Request is for 10 MW incremental to the previous Interconnection Request 137 and Distribution Interconnection Request 102. This study combines the effects of the total wind turbine generation of these Interconnection Requests for a total of 22 MW.

No adverse issues on the transmission system were determined for this project if no other generation higher in the Queue proceeds.

Assuming that the projects ahead of this project in the Generation Interconnection Queue do not proceed, required additions/changes to NSPI systems with a nonbinding estimated cost of $935,000 (combination of estimates for Interconnection Request 137 and 150) are:

- Reconductor 4.5 km of feeder 1C-411 (from 1C-Point Tupper to Interconnection Facility tap) to 336 AAC
- Install new feeder and termination (4.5 km)
- Control and communications between this Generating Facility and NSPI Supervisory Control and Data Acquisition (SCADA) system (to be specified)

The Generation Facility requirements are listed in Section 10.

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.

Table of Contents

Page

1 Introduction

The Interconnection Customer submitted an Interconnection Request (IR) to Nova Scotia Power Inc. (NSPI) for a proposed 10 MW wind Generation Facility interconnected to the NSPI system via the 25kV substation 1C-Point Tupper. This IR considers the total amount of generation associated with the Distribution Interconnection Request 102 plus the Interconnection request 137. The project under study under this IR 150 is therefore effectively a 22 MW wind generation facility. 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 Agreement. The generation site would be located approximately 4.5 km from 1C-Point Tupper and would connect to 1C-Point Tupper 25kV distribution system. Because this IR exceeds the minimum load on the 1C-Point Tupper distribution system, this study includes the impact on the transmission system as well as the distribution system.

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-binding estimated cost of facilities required to interconnect the Generating Facility to the NSPI Transmission System, the time to construct such facilities, and to address any 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. The direct analysis performed for this FEAS considers transmission elements. A Distribution SIS will also be required to perform analysis on distribution elements.

For Network Resources Integration Service (NRIS), the FEAS will identify any transmission upgrades required as the result of thermal overload, voltage violation, or equipment rating. The FEAS will attempt to provide high level cost estimates for such upgrades and direct interconnection costs.

A more detailed analysis of the technical implications of this development will be included in the System Impact Study (SIS) report. This may include system stability analysis, single contingencies (single or multiple elements as defined by the Northeast

Power Coordinating Council), 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 general 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. The SIS may identify additional costs and upgrades that were not identified in this FEAS.

A separate Facilities Study will follow the SIS in order to ascertain the final cost estimate for the transmission upgrade requirements.

3 Assumptions

The configuration studied is as follows:

i. 22 MW wind farm comprised of 11 Enercon E82 2.0 MW wind turbine generators,

ii. NRIS

iii. The wind Generating Facility will be located approximately 4.5 km from the 1C-Point Tupper substation. 1C-Point Tupper is connected to the NSPI transmission system via the L-6517 to 2C-Port Hastings and L-6523 to 47C-Stora.

iv. Point of Interconnection will be on the 1C-Point Tupper distribution system, approximately 4.5 km from the 1C-Point Tupper substation.

v. The results of the analysis in this FEAS are based on the assumption that IRs higher in the Generation Interconnection Queue (Queue) will not proceed, but the impacts of higher Queued IRs are reviewed qualitatively. This assumption does not apply to IR 137, which is combined with IR 150 for this analysis.

vi. The existing/committed wind generation on the feeder 1C-411 is 1.4 MW.

4 Projects with Higher Queue Positions

As of February 2008, the following IRs can proceed ahead of this project due to their position in the transmission Queue and have the status indicated.

<u>In Service and committed generation projects</u>
Wind Generation – 30.5 MW – connected to L-5027 (in-service)
Wind Generation – 14.0 MW – connected to L-5573 (in-service)
Wind Generation – 15.0 MW – distribution connected (in-service)

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 – FEAS Completed
IR 023 Wind – Inverness, L-6549, 100MW – FEAS Completed
IR 042 Wind – Cape Breton, New 138kV line, 100MW – FEAS Completed
IR 045 Wind – Cumberland, L-6535, 35MW – SIS Complete
IR 046 Wind – Colchester, L-6513, 32MW – FEAS Completed
IR 056 Wind – Cumberland, L-5058, 34MW – FEAS Completed
IR 067 Wind – Annapolis, L-5026, 40MW – FEAS Completed
IR 068 Wind – Digby, L-5533, 35MW – FEAS Completed
IR 082 Wind – Colchester, L-5040, 45MW – FEAS Completed
IR 084 Wind – Pictou, L-7004, 50MW – FEAS Completed
IR 086 Wind – Pictou, L-7003, 50MW – FEAS Completed
IR 114 Wind – Pictou, L-6511, 60MW – FEAS Completed
IR 115 Wind – Pictou, L-7003, 120MW – FEAS Completed
IR 117 Wind – Shelburne, L-5027, 10MW – FEAS Completed
IR 126 Wind – Cumberland, L-6513, 70MW – FEAS Completed
IR 128 Wind – Cumberland, L-6536, 40.5MW – FEAS Completed
IR 130 Wind/Water pumped – Cape Breton, L-6516, 200MW – FEAS Completed
IR 131 Wind – Cape Breton, L-5580, 11.5MW – FEAS Completed
IR 140 Wind – Antigonish, L-7004, 30MW – FEAS Completed
IR 141 Wind – Digby, 77V, 30MW – FEAS Completed
IR 149 Wind – Cumberland, L-6536, 70MW – FEAS in progress

All of the above projects can have a direct impact on this project for issues related to the management of the inter-provincial and inter-regional ties and on balancing the NSPI system.

The SIS will be based on the assumption that all projects that are ahead of this project in the Queue are in-service. In particular, IR 008, IR 023, IR 042, IR 084, IR 086, IR 114, IR 115, IR 130, IR 131, and IR 140 affect the interface known as Onslow Import. Similarly, IR 23, IR 42 and IR 130 and this IR 150 affect the interface know as Cape Breton Export. Onslow Import and Cape Breton Export are presently congested interfaces from time to time. Until each project is confirmed or removed from the Queue, any portion of costs to upgrade the Onslow Import and /or the Cape Breton Export interfaces that are due to the addition of IR 150 cannot be estimated.

Should any project ahead of this project in the Queue be withdrawn or changed, the System Impact Study for this project must be updated according to the Standard Generator Interconnection Procedures (GIP), at the Interconnection Customer's expense.

5 Flicker Levels

The Interconnection Customer is to ensure that the operation of the Generating Facility does not cause voltage variations on the Distribution System that result in objectionable lamp flicker to other connected customers. Considering the strong short-circuit ratio at the Point of interconnection (greater than 8), flicker is not a concern for this project.

6 Short-Circuit Duties

The maximum (future) expected short-circuit levels on 25kV and 138kV systems are 350 MVA and 5,000 MVA respectively.

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

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

Location	This Generating Facility in service	This Generating Facility not in service
All transmission facilities in service		
1C-Point Tupper B61	2259	2183
1C-Point Tupper B41	284	192
Minimum Conditions (1C-GT2 Off)		
1C-Point Tupper B61	1827	1673
1C-Point Tupper B41	280	188

(1) Classical fault study, induction type generator assumed[1]

Although the actual increase in short-circuit levels will be dependent on the specific type of generator installed, the increase will not impact the switching equipment at 1C-Point Tupper.

7 Thermal Limits

With all transmission lines in service and for first contingency operation, there are no thermal limitations on the transmission system due to this project if projects higher in the Queue do not proceed (with the exception of IR 137). However, this generation project increases flow across the Cape Breton Export and Onslow Import interface. If any of the projects ahead of this project in the Queue proceed there may be upgrades required to add IR 137 plus IR 150 to the NSPI system. The SIS will determine the costs of the upgrades

[1] Although the Interconnection Customer has specified an inverter-type machine, this test is typically conducted with the assumption of an induction generator to ensure that the fault duty will not be an issue if the generator type is changed during the project.

due to IR 137 plus IR 150 to the NSPI system in addition to all projects ahead of IR150 in the Queue at the time the SIS is performed.

The total project size of 22 MW exceeds the capacity of a single 25kV distribution circuit, so dual circuits are required. The existing distribution circuit 1C-411 is built with 2/0 AASC conductor. It is recommended that the 1C-411 conductor be uprated to 336 AAL conductor and a new feeder constructed with 336 AAL conductor. It may be cheaper to build the new circuit as a double-circuit distribution structure across the road from 1C-411, moving existing services to one of the circuits on the double circuit structures. A new 25kV bay would be needed at 1C-Point Tupper.

The rating of the distribution transformer is 15/20//25 MVA. The minimum load on this transformer is presently 4 MVA, therefore there will be reverse flow through this transformer of about 19 MVA, or 78% of its top rating. This transformer will need be closely monitored for impacts of this mode of operation. If adverse impacts are experienced, mitigation measures such as a transformer upgrade or curtailment of the output of this Interconnection Facility may be required.

8 Voltage Control

This project can be connected via re-conductoring 1C-411 plus a new 25kV feeder provided the power factor is controlled on individual turbines to provide acceptable voltage levels for nearby customers. An alternative would be voltage control coordinated with the tap changer on the 1C-Point Tupper distribution transformer.

The ratio of short-circuit level to generating capacity under normal system conditions is 8.7 (192/22) and is 8.5 (188/22) with local generation off. Such a ratio is an indication of ease of integration. There should be no specific issues regarding voltage control and power quality due the addition of this facility alone. The calculated flicker coefficient (Pst) is estimated to be 0.09, which is less than the required value of 0.35.

This facility must also have low voltage ride-through capability, reactive power control, and voltage control as per FERC Order 661A. The SIS will state specific options, controls and additional facilities that are required to achieve this.

9 System Limitations (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 Cape Breton Export and Onslow Import interfaces. Generation rejection SPSs are utilized to increase system stability limits to maximum east to west power transfers. Depending on the impact of other generation additions ahead of this project in the Queue, transmission system upgrades may be required to integrate IR 137 plus IR150.

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 for Good Utility Practice.

10 Expected Facilities Required for Interconnection

Based on the above discussion, this project is feasible at the requested capacity, subject to the SIS. It is expected that the following facilities will be required for operation under system normal conditions, assuming that the projects ahead of this project in the Queue do not proceed. This includes the assumption that the 2.4MW project proposed at the distribution level as per Report # 249-0307-IS25 (IR102) is in service.

The following additions/changes to the Transmission Provider's Interconnection Facilities are required:

i. Reconductor 4.5 km of feeder 1C-411 (from 1C-Point Tupper to Interconnection Facility) to 336 AAC

ii. Build new 4.5 km distribution feeder from 1C-Point Tupper to the Interconnection Facility, 336 AAC conductor. The Interconnection Customer may want to evaluate the risk vs. cost of installing both circuits on a common pole line versus separate lines, to provide continued supply to part of the Interconnection Facility in the event of a single contingency.

iii. Termination of new 25kV feeder at 1C-Point Tupper

iv. Control and communications between this Generating Facility and NSPI Supervisory Control and Data Acquisition (SCADA) system (to be specified)

The Interconnection Customer's Interconnection Facility is to include:

i. Wind turbine generators to provide 0.95 leading and lagging power factor when delivering rated output (22 MW) measured at the Interconnection Point.

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

iii. Real-time monitoring and control RTUs of the Interconnection Facility, with the capability of the NSPI System Operator to curtail part or all of the Interconnection Facility output.

iv. Facilities for NSPI to execute high speed rejection of generation (transfer trip) for disturbances on the distribution system.

11 Magnitude of NSPI Interconnection Facilities Cost Estimate

Estimates for NSPI Interconnection Facilities are included in Table 11-1.

Table 11-1: Cost Estimates

	Determined Cost Items	Estimate
i	Reconductor 5 km line to 336AAC	$300,000
ii	Construct 5 km new 3-phase feeder circuit	$400,000
iii	Terminate new feeder (recloser, switch) at 1C	$50,000
iv	Control and communications between NSPI and customer	$100,000
v	Contingency (10%)	$85,000
	Total of Determined Cost Items	$935,000
	To be Determined Costs	
vi	System upgrades to improve east to west flows	TBD (SIS)

In this case, the TBD costs may exceed the total of the determined cost items.

The above estimate includes the additions/changes to NSPI systems only. All costs of associated facilities required at the Generating Facility are in addition to the above estimate. Items identified as TBD will be assessed in the SIS. The estimated time to construct the "Determined Cost Items" will be 12 to 24 months, provided accessible and tree-cleared lands or ROW acceptable to NSPI for design and construction of any required new distribution line or Transmission Provider's substation are provided.

12 Preliminary Scope of System Impact Study

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 in service.

The assessment will consider but not be limited to the following: The facility additions/changes required increasing 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

Steady-state and post contingency analysis will have all elements within acceptable voltage and thermal limits under the following single contingencies, in accordance with NPCC/NERC criteria:

i. L-8004
ii. Hopewell transformer 79N-T81
iii. L-8003
iv. Loss of double Circuit tower line L-8004 and L-7005 at Hastings

System stability will be assessed for the following faults:

i. Loss of any element without a fault
    a. L-8004
    b. Hopewell transformer 79N-T81
    c. L-8003

ii. Three-phase fault cleared in normal time
    a. L-8003 at Onslow end
    b. L-8003 at Hopewell end
    c. L-8004 at Woodbine end
    d. High Voltage side of 79N-T81

iii. Single-phase to ground fault cleared in backup time (Breaker failure)

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

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

a. L-8004 plus L-7005 at Canso Crossing
b. L-7003 plus section of L-7004 at Trenton

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 may be curtailed.

In addition, a Distribution analysis will need to be performed to verify various issues related to the use of distribution feeders to transport power to the 1C-Point Tupper Substation. Such issues shall include, but not be limited to voltage levels, protection coordination, and compatibility with operational methods.