



**Interconnection Feasibility Study Report
GIP-023-FEAS-R1**

**Generator Interconnection Request # 23
100 MW Wind Generating Facility
Inverness (L6549), NS**

February 16, 2006

Control Centre Operations
Nova Scotia Power Inc.

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1) Introduction:

The Interconnection Customer submitted an Interconnection Request to NSPI for a proposed 100.5 MW wind generation facility interconnected to the NSPI system via 138 kV line L6549 that runs between the (85S) Wreck Cove and (5S) Glen Tosh substation. 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. The generation site would be located in the Cape Breton Highlands, Inverness County and connected to L6549 substation via newly constructed 138 kV line approximately 20 km in length.

2) Scope:

The Interconnection Feasibility Study 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; and
- 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.

3) Assumptions:

The Point of Interconnection and configuration studied is as follows:

- i) 100 MW wind farm comprised of 67 – 1.5 MW GE 1.5s wind turbines
- ii) This wind generating facility is located approximately 20 km from L6549 (line tap location). The line L6549 tap location is approximately 17 km from (5S) Glen Tosh.
- iii) Transformer impedance assumed at 8% (on ONAN Base), rated 63/84//105 MVA
- iv) This feasibility study is based on the assumption that projects that are ahead of this project in the Generation Interconnection Queue (Queue) will proceed.

4) Projects With Higher Queue Positions

As of 5 February 2007 the following projects can proceed ahead of this project, due to their position in the Queue, and have the status indicated.

In-service and committed generation projects

- Wind - 30.5 MW - connected to L-5027 (in-service)
- Wind – 14 MW – connected to L5573 (in-service)
- Wind – 20 MW - distribution connected (in-service)
- Wind – 40 MW – distribution connected (committed)

Generation projects with a higher Queue position, not yet committed

- #8 Wind – Guysborough L5527B 15 MW – Facilities Study complete
- #17 Wind – Lunenburg L6004 100 MW - Feasibility Study complete
- #21 Wind – Inverness L5579 - Feasibility Study complete

This project and project 21 will interconnect with the Cape Breton 138 kV system may both invoke upgrades to 138 kV facilities between (2C) Port Hastings, (85S) Wreck Cove and (2S) Victoria Junction.

This project and projects 8 and 21 will increase east to west transmission loading and will also increase power transfers on Onslow South and therefore may require expansion of the east to west transmission system and increase reactive support requirements. Project 17, although ahead of this project in the Queue, does not share the same 138 kV transmission facilities. All of the above projects can have a direct impact on this project for issues related to management of the inter-provincial and inter-regional ties and on balancing the NSPI system.

The System Impact Study (SIS) will be based on the assumption that all projects that are ahead of this project in the Queue are in-service. Should any project that is ahead of this project be withdrawn, or changed, within the established procedures then this feasibility report and the SIS for this project must be updated accordingly, at the Interconnection Customer's expense.

5) Objective:

The objectives of the Feasibility Study are to identify the primary physical interconnection requirements. Specifically the short-circuit impacts on circuit breakers and any equipment overloads or voltage limits that may be exceeded under system normal (all transmission facilities in service). 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 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 Duties

The maximum (future) expected short-circuit level on 138 kV systems is 5000MVA.

The short-circuit levels in the area before and after this development are provided in Table 5-1 below.

Table 5-1: Short-Circuit Levels. Three-phase MVA (1)			
Location	This project in service	This project not in service	
	Wreck Cove On	Wreck Cove On	Wreck Cove Off
All transmission facilities in service			
(85S) Wreck Cove 138 kV	1480	1340	520
(5S) Glen Tosh	1470	1290	740
L6549 Line Tap		1110	610
138 kV Connection Pt		990	480
L6538 (Glen Tosh to Gannon Rd) Out			
(85S) Wreck Cove 138 kV			300
(5S) Glen Tosh			360
L6549 Line Tap			330
138 kV Connection Pt			290

(1) Classical fault study, flat voltage profile

(2) Connection Pt is 20 km from (L6549) tap

Although the actual increase in short-circuit levels will be dependent on the specific type of generator installed, the increase will not be more than 15% at Glen Tosh and less at Wreck Cove. Short-circuit levels following this development are expected to be less than 1600 MVA at both these locations. The interrupting capability of circuit breakers at (5S) Glen Tosh and (85S) Wreck Cove should not be exceeded by this development. The continuous current carrying capability of these circuit breakers is 1200A which should not be exceeded.

7) Thermal Limits

Under system normal conditions (all transmission in) this development will cause lines L6537, L6538 to be overloaded in both winter and summer conditions. These lines are sag limited. There is a Special Protection System (SPS) associated with L6538 which rejects generation to relieve the overloads on L6538. This SPS was installed to cover the contingent loss of L6537.

Lines L6537 and L6538 will require uprating if this project proceeds. This may be accomplished by increasing the ground clearance on limiting spans or may require substantial rebuilding and reinforcing. The cost to uprate can only be estimated after complete line surveys and condition assessments are completed which must follow completion of the SIS. These assessments can be undertaken during the Facilities Interconnection Study which follows the SIS.

Contingency loss of L6537, L6538 or L6539 will cause severe overloading of the remaining 138 kV circuits. Loss of L6538, for example, will cause the loading of L6537 to approach 300MW. This circuit runs 91.4 km to (2C) Port Hastings. High speed generation rejection schemes will be required, as a minimum, for any circuit-breaker operations on L6537, L6538, and L6539. This may be an acceptable solution if the SPS's can operate fast enough and can be made secure enough. This will be determined by the Interconnection System Impact Study (SIS) and Facilities Interconnection Studies. Should the SPS's fail to operate then a generation loss of 300MW may result.

This generating facility will require a curtailment scheme and high speed rejection scheme for integration with NSPI Supervisory Control and Data Acquisition (SCADA) controls and special protection schemes (SPSs) to maximize the capability of NSPI's transmission system, system security, and production of all generating facilities.

8) Voltage Control

The short-circuit level at the 138 kV tap, with Wreck Cove generation off and L6549 out, is 330 MVA which is only 3.3 times generation capacity. In this operating condition voltage flicker and voltage deviation may exceed NSPI requirements and acceptable utility practice. The facilities required to provide acceptable voltage control and flicker, occurring at the tap point, will have to be addressed in the SIS.

The facilities included with this installation must be such that the facility is capable of providing both lagging and leading power factor of 0.95, measured at the 138 kV tap point, when the facility is delivering 100 MW at the Point of Interconnection. A centralized controller will be required which adjusts individual generator real and reactive power output, in real time, and regulate the voltage at the Interconnection Customer's substation. The voltage controls must be responsive to voltage deviations at the Interconnection Customer's 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. The latter control may be referred to as a slow-Q control. Details of the specific control features, control strategy and settings will be determined in the SIS.

NSPI must have manual and remote control of the voltage set-point, the slow-Q controls and reactive power output from this facility.

This facility must also have low-voltage ride-through capability. The SIS will verify this and state any 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. Under system normal conditions, generation rejection SPS's are utilized to increase system stability limits to maximize east to west power transfers. Therefore, the additional generating capacity, that this facility provides, cannot be integrated into the NSPI system, under all dispatch conditions, without system upgrades. System upgrades will be required to increase transmission capacity from the east end of NSPI's system to the load centers.

The extent of the facility additions/changes required to increase the east-west transmission capability will be determined by the SIS.

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.

10) Expected Facilities Required for Interconnection

We expect the following facilities will be required assuming that the projects ahead of this project, in the Queue, do not proceed.

Additions/Changes to NSPI systems:

- i) Construct 20 km of 138 kV transmission in the Highlands
- ii) Tap L6549, installing one circuit switcher at the tap with communications
- iii) Protection changes L6549 at (5S) Glen Tosh and (85S) Wreck Cove. We expect this will entail replacing protection to a three-terminal protection scheme.
- iv) Add communications for protection, controls, telemetry and SPS's between Wreck Cove, Glen Tosh, the interconnection substation and NSPI.
- v) Conduct line surveys on L6537, 6538, 6539 and upgrade to ratings determined by SIS for system normal operation and for contingency operation in conjunction with SPS additions and changes (also determined by SIS)
- vi) Install new SPS's to cover 138 kV system contingencies that are not yet covered by SPS schemes. Modify existing SPS on L6538. These SPS's will now require redundancy (NPCC Type I status).
- vii) Inclusion of this generating facility in NSPI's generation rejection SPSs

- viii) Changes to NSPI system/SPS's to permit higher east to west transfers under normal system conditions (all facilities in) without any addition generation constraints.

Additions/Changes to be included at the generating facility:

- i) 138 kV interconnection substation. This will include a 138 kV circuit breaker and protection as acceptable to NSPI, an RTU to interface with NSPI's SCADA with telemetry and controls as required by NSPI.
- ii) Facilities to provide 0.95 leading and lagging power factor when delivering rated output (100 MW) all at the 138 kV Point of Interconnection when the voltage at that point is operating between 95 and 105 % of nominal.
- iii) Centralized controls. These will provide centralized voltage set-point controls and slow-Q controls which act to control the voltage on the 138 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.
- iv) 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 slow-Q controls, remotely. NSPI will also have remote manual control of the load curtailment scheme.
- v) Low voltage ride-through capability
- vi) NSPI will require real-time monitoring via remote terminal units (RTUs) of the interconnection substation
- vii) Facilities for NSPI to execute high speed rejection of generation (transfer trip)

11) Magnitude of NSPI Interconnection Facilities Cost Estimate

Determined Cost Items	Estimate
i) Build 20 km 138 kV transmission in challenging terrain	\$9,600,000
ii) Construct L6549 tap with circuit switcher & communications	\$250,000
iii) Protection changes Glen Tosh and Wreck Cove	\$100,000
iv) Communications between Wreck Cove, Glen Tosh and Interconnection Substation	\$500,000
v) Additions/changes to 138 kV SPSs	\$200,000
vi) Include this generating facility in existing SPS schemes	\$100,000
vii) Line surveys L6537,6538,6539 (Lidar)	\$150,000
viii) Contingency (10%)	<u>\$1,000,000</u>
Total of Determined Cost Items	\$11,700,000
To Be Determined Cost Items	
i) Upgrades to L6537,6538,6539	TBD (SIS,FIS)
ii) System additions to increase east-west transfer capability	<u>TBD (SIS)</u>
Total:	TBD

In this case the “To Be Determined Costs” may exceed the determined costs. The TBD costs will be determined when the SIS and subsequent FIS are completed.

We estimate the time required to construct above items i) through viii) (Determined Cost Items) to be 26 months. In this area, due to the terrain, much of the construction must occur between June and November. The time required to construct the TBD items will be estimated following completion of the SIS. **All costs associated with the interconnection substation are not included in the above estimates.**

12) Issues to be addressed in subsequent SIS

The SIS must identify the facilities required to operate this facility at full capacity, withstand any first 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 consider but not be limited to the following.

- i) 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.
 - (1) All Contingencies associated with Cape Breton 138 kV system
 - (2) Onslow Import (Group 5 & 6 SPS)
 - (3) Cape Breton Export (Group 5 & 6 SPS)

- (4) Lingan Total Gross generation
 - (5) Lingan overfrequency SPS
 - (6) Strait Area SPSs
 - (7) L6538 Overload SPS
 - (8) Onslow South and reactive support requirements
- ii) First contingencies involving loss of, and operation following the loss of, the following.
- (1) L7011
 - (2) L7012
 - (3) L7014
 - (4) L8004
 - (5) L8003
 - (6) L6503
 - (7) L6516
 - (8) L6537
 - (9) L6538
 - (10) L6539
 - (11) L6545
 - (12) L6549A, L6549B
 - (13) 88S-T71
 - (14) 88S-T72
 - (15) Operation with circuit breaker 2S-600 Open
 - (16) L8001 out (Import and Export Limits)
 - (17) 3C-T71
 - (18) 3C-T72
 - (19) 2C-B61
 - (20) 2C-B62
 - (21) Circuit breaker 2C-600 open
 - (22) Circuit breaker 1C-689 open
 - (23) Circuit Breaker 2S-600 open

The changes to SPS schemes to permit 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.

Control Centre Operations
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