Interconnection Feasibility Study Report

GIP-226-FEAS-R3

System Interconnection Request #226

70 MW Wind Generating Facility

Kings County (L-6013)

2010 07 21

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The interconnection Customer submitted a Network Resource Interconnection Service (NRIS) Interconnection Request to NSPI for a proposed 70 MW wind generation facility in Kings County, and subsequently requested that it also be studied as an Energy Resource Interconnection Service (ERIS) Interconnection Request. The generation facility will be interconnected to the NSPI's 138kV transmission line L-6013 between 51V-Tremont and 43V-Canaan Rd via a new 138kV ring bus with three breakers and associate switches and 5.5km of newly-constructed 138kV line.

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.

No thermal loading violations or voltage violation issues were found under normal states and single contingency conditions for this project on its own. The requirement for potential system reinforcements will be further explored in a subsequent System Impact Study.

The loss factor for IR #226 is approximately -1.4% (system losses decreased by 1 MW when IR #226 is operated at 70 MW).

The preliminary non-binding estimated cost of facilities required to interconnect the IR#226 to the transmission line on L-6013 is $7,338,403 including a contingency of 10%. This estimate is valid for both NR and ER Interconnection Service and will be further refined in the System Impact Study and the Facility Study.

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1 Introduction

The Interconnection Customer submitted an Interconnection Request for Network Resource Interconnection Service (NRIS) to NSPI for a proposed 70 MW wind generation facility in Kings County. The generating facility will be interconnected to the NSPI 138kV transmission line L-6013 between 43V-Canaan Rd and 51V-Tremont, (approximately 19.75 km from 43V- Canaan Rd) via 5.5 km newly-constructed 138kV line. Both NRIS and Energy Resource Interconnection Service (ERIS) were studied for this generating facility.

The Interconnection Customer signed a Feasibility Study Agreement to study the connection of their proposed generation to the NSPI transmission system, dated 2010-05-20, and this report is the result of that Study Agreement. This project is listed as Interconnection Request #226 in the NSPI Interconnection Request Queue, and will be referred to as IR#226 throughout this report.

2 Scope

The Interconnection Feasibility Study (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 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.

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 3.2.2.2 of the Standard Generation Interconnection Procedures, as approved by the UARB on February 10, 2010 (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.

In accordance with Section 3.2.1.2 of the RGIP, 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.

A more detailed analysis of the technical implications of this development will be included in the System Impact Study (SIS) report. The SIS will include 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.

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

3 Assumptions

The FEAS is based on the technical information provided by the Interconnection Customer. The Point of Interconnection (POI) and configuration studied is as follows:

1. Network Resource Interconnection Service type plus concurrent study as Energy Resource Interconnection Service type per Section 3.2 of the RGIP.
2. 70 MW wind generation utilizing 35 x 2MW Enercon E82 Wind Turbines.
3. The generation technology used must meet the NSPI requirement for reactive power capability of 0.95 capacitive to 0.95 inductive at the Point of Interconnection (POI). The generator is specified for 70 MW at a rated power factor of 0.89. It is also required to have high-speed Automatic Voltage Regulation to maintain constant voltage at the generator terminals during and following disturbances.
4. The Interconnection Customer indicated that the generation interconnection point is on either the 138kV line L-6013 or L-6015, approximately 19.75km from 43V-

Canaan Rd. and 23 km from 51V-Tremont. The wind facility is located approximately 5.5km from the line tap.

5. Preliminary data was provided for the generator step-up transformer. Modeling was conducted using a 138kV-34.5kV 48/64/80 MVA transformer with a positive sequence impedance of 9% on the 48 MVA base. It was indicated that the step-up transformer has a grounded wye (HV) – grounded wye (LV) – delta (TV) winding configuration with +/-10% tap changer.
6. The FEAS analysis is based on the assumption that IR's higher in the Generation Interconnection Queue (Queue) that have completed a System Impact Study, or that have a System Impact Study in progress will proceed; As such, IR#8, IR#45, IR#56, IR #82, IR #114, IR #141 and IR#151 are included in this study.

4 Projects with Higher Queue Positions

All in-service generation is included in the FEAS.

As of 2010-07-13 the following projects are higher queued in the Interconnection Request Queue, and have the status indicated.

Per GIP Section 6.2 - Interconnection Requests -included in FEAS (Committed to study Base Case)

- IR #8 GIA in progress
- IR #45 Unexecuted GIA filed
- IR #56 FAC in progress
- IR #82 GIA executed
- IR #114 GIA executed
- IR #141 GIA executed
- IR #151 SIS in progress

Per GIP Section 6.2 – Interconnection Requests not included in FEAS

The following IRs either have SIS Agreements complete (but have not yet met the SIS progression milestones) or have Feasibility Study agreements complete. As such, they are not included in this FEAS.

IR #67	IR #68	IR #86	IR #115	IR #117	IR #126
IR #128	IR #130	IR #131	IR #140	IR #149	IR #156
IR #157	IR #163	IR #213	IR #219	IR #222	IR #223
IR #225					

If any of the higher-queued projects included in this FEAS are subsequently withdrawn from the Queue, the results of this FEAS may need to be updated. 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 has withdrawn the higher queued project.

5 Objective

The objective of this FEAS is to provide a preliminary evaluation of the system impact and the cost of interconnecting the 70 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[1] are applied for the 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 capabilities that may be required to the Bulk Power System to meet the design and operating criteria established by NPCC and/or 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. The short-circuit levels in the area before and after this development are provided below in Table 6-1.

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

Location	IR #226 in service	IR #226 not in service
All transmission facilities in service		
138kV Interconnection Point	981	839
51V- Tremont	889	798
43V- Canaan Rd	1283	1154
Minimum Conditions		
138kV Interconnection Point	872	730

(1) Classical fault study, flat voltage profile

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

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 on L-6013 is presently 839 MVA. After installing IR # 226 the increase will bring the short-circuit level to 981 MVA at the POI. Similarly, under summer light load conditions with certain generation units offline, the short-circuit level will be approximately 730 MVA at the POI. This translates into maximum equivalent system impedance at the POI of 0.137 per unit on 100 MVA base.

The interrupting capability of the 138kV circuit breakers at both 51V-Tremont and 43V-Canaan Rd. is at least 3500 MVA which will not be exceeded by this development on its own.

7 Voltage Flicker and Harmonics

The voltage flicker at the POI using IEC Standard 61400-21 and the published values for Enercon E82 machines is 0.0119 under normal conditions and 0.0134 under minimum generation conditions. These are both below NSPI's limit of 0.25 for P_{st} and 0.35 for P_{lt} at the 138kV side of the 34.5/138kV. Therefore voltage flicker should not be a concern for this project. The full System Impact Study will examine the requirements in detail.

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

L-6013 is constructed with 556 Dove ACSR conductor designed for maximum operating temperature of 100°C between 51V-Tremont and 43V-Canaan Rd. The conductor on L-6013 has a thermal rating of 215 MVA summer and 242 MVA winter. The present setting of line protection at 51V-Tremont terminal limits the power flow on this line to 143MVA in the direction from 51V-Tremont to 43V-Canaan Rd for both summer and winter. However NSPI is building a second 138kV transmission line between 51V-Tremont and 43V-Canaan Rd. which is expected to be in service by 2011. The second line has the same structure and conductor size as L-6013 and they share the right of way. The protection settings and metering at 51V for both 138kV lines will be upgraded by 2011 and therefore the constraints due to present setting of line protection will be eliminated.

This facility would be interconnected to L-6013 by constructing approximately 5.5 km of 138kV transmission line to tap L-6013 in the Valley area (the Valley area can be viewed as bounded by L-5025 at 51V-Tremont, L-5535 at 15V-Sissiboo, and L-5532 at 13V-Gulch). Under certain generation dispatch and contingency scenarios during summer

peak and light load condition, local 69kV system at western Valley area could become overloaded. Therefore operating restrictions on the total generation output within this area should be established. A Type III Special Protection System (SPS) will also be installed in this area as a result of IR#141, and this SPS will reject IR#141 generation for contingencies that would result in the overload of these local 69kV lines.

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 138kV terminals of the POI, at all production levels up to the full rated load of 70 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 FERC Order 661A. The SIS will state specific options, controls and additional facilities that are required to achieve this.

10 System Security / Stability Limits

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 #226 on L-6013:

Additions/Changes to POI

1. Three 138kV circuit breakers and associated switches in a ring-bus arrangement and structures to turn L-6013 into a new switching station,
2. Control building and protection systems,
3. 5.5 km 138kV spur line to connect the wind farm to the POI will use 556 Dove ACSR conductor rated 100°C conductor temperature,
4. Control and communications between the POI switching station and NSPI SCADA system (to be specified).

Requirements for the Generating Facility

1. Facilities to provide 0.95 leading and lagging power factor when delivering rated output (70 MW) at the 138kV bus when the voltage at that point is operating between 95 and 105 % of nominal.
2. Centralized controls. These will provide centralized voltage set-point controls known as a Farm Control Unit (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. 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.
3. 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.
4. Low voltage ride-through capability as per FERC Order 661a[2] .
5. Real-time monitoring (RTU) of the interconnection facilities for NSPI to execute high speed rejection of generation (transfer trip).

12 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

Estimates for NSPI Interconnections Facilities and Network Upgrades are included in Table 12-1.

[2] FERC Order 661A addresses the requirement for wind-powered generation to ride-through faults in a manner similar to traditional synchronous generator.

Table 12-1: Cost Estimates identified from FEAS scope		
	Determined Cost Items	**Estimate**
NSPI Interconnection Facilities		
i	Build 5.5 km 138kV single circuit line	$ 1,897,500
Network Upgrades		
ii	Three 138kV circuit breakers in a ring-bus arrangement at the POI	$4,273,775
iii	Protection, control, communication	$500,000
Totals		
v	Contingency (10%)	$667,128
	Total of Determined Cost Items	$7,338,403
	To be Determined Costs	
iii	System additions to address potential stability limits	TBD (SIS)

The preliminary non-binding cost estimate for interconnecting line L-6013 between 51V-Tremont and 43V-Canaan Rd. would be $7,338,403. The preliminary non-binding cost estimate for interconnecting to line L-6015 would be $7,338,403 plus the cost of a structure to enable the line tap to bypass L-6013.

The cost estimate in Table 12-1 is valid for both NR and ER Interconnection Service.

13 Issues to be Addressed in SIS

The following provides a preliminary scope of work for the subsequent SIS. The SIS will include a more comprehensive assessment of the technical issues and requirements to interconnect generation as requested. In addition, this 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 RGIP 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 RGIP

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. Underfrequency load shedding impacts

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

- L-6004
- L-6012
- L-6013
- L-6015
- L-5022
- L-5025
- L-5026
- L-5531
- L-5532
- L-5535
- L-5541
- L-6024
- L-6021
- 43V-613 (taking out 43V- T61 and L-6013)
- 51V-521 (taking out L-5024 and L-6013)
- 13V-516 (taking out 13V-B51 and L5026)
- 9W-500

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

- 3 phase fault on L-5025
- 3 phase fault on L-5531
- 3 phase fault on L-5532
- 3 phase fault on L-5533
- 3 phase fault on L-5535
- 3 phase fault at 11V-B51
- 3 phase fault at 13V-B31

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[3] and NPCC[4] 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 #226 which is lost through the transmission system. Preliminary value is calculated to be -1.4% (system losses decreased by 1 MW when IR #226 is operated at 70 MW.

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[3] NPCC criteria are set forth in it's Reliability Reference Directory #1 *Design and Operation of the Bulk Power System*
[4] NERC transmission criteria are set forth in *NERC Reliability Standards TPL-001, TPL-002, TPL-003*