Interconnection Feasibility Study Report
GIP-141-FEAS-R2

Generator Interconnection Request #141

30MW Wind Generating Facility

Digby County, NS

August 17, 2007

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer submitted an Interconnection Request (IR 141) to Nova Scotia Power Inc. (NSPI) for a proposed 30 MW wind generation facility interconnected to the NSPI system via the 69kV substation 77V-Conway.

At the proposed interconnection location, the NSPI system will need upgrades to accommodate the addition of this Generating Facility.

Assuming that the projects ahead of this project in the Generation Interconnection Queue (Queue) do not proceed, required additions/changes to NSPI systems for this project with an estimated cost (non binding) of $11,320,000 are:

- Construct approximately 10 km of 69kV transmission line, 556 MCM ACSR (generation facility to 77V-Conway)
- 69kV switchgear for line termination at 77V-Conway
- Protection upgrade at 13V-Gulch
- Control and Communications between the Generating Facility, 77V-Conway and NSPI Supervisory Control and Data Acquisition (SCADA) system (to be specified)
- Upgrade L-5533 from 77V-Conway to 13V-Gulch Hydro
- Upgrade L-5531 from 15V-Sissiboo to 13V-Gulch Hydro

The generation facility requirements are listed in Section 9.

The SIS will determine any costs or upgrades that may be required if projects ahead of this project in the Queue proceed.

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1 Introduction

The Interconnection Customer submitted an Interconnection Request (IR) to Nova Scotia Power Inc. (NSPI) for a proposed 30 MW wind generation facility interconnected to the NSPI system at 77V-Conway Substation via a new (to be constructed) 69kV line. 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 in Digby County, and connect to 77V-Conway via the newly constructed 69kV line, approximately 10 km in length (connecting to the Interconnection Customer's substation).

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.

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 or double contingencies, 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 Point of Interconnection and configuration studied is as follows:

i. 30 MW wind farm comprised of 13 – 2.3 MW Siemens SWT -2.3-93 wind turbine, and has requested NRIS service type

ii. The wind generating facility is located approximately 10 km from 77V- Conway Substation.

iii. The FEAS analysis is 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.

4 Projects with Higher Queue Positions

As of July 2007, the following IRs can proceed ahead of this project due to their position in the 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 – 20.0 MW – distribution connected (in-service)
Wind Generation – 40.0 MW – distribution connected (committed)

<u>Generation projects with a higher Queue position, not yet committed</u>
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
IR 131 Wind – Cape Breton, L-5580, 11.5MW – FEAS in Progress
IR 137 Wind – Richmond, 1C, 10MW – FEAS in Progress
IR 139 Wind – Yarmouth, L-5027, 5.4MW – FEAS in Progress
IR 140 Wind – Antigonish, L-7004, 50.6MW – 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 017, IR 067, IR 068, IR 081, IR 083, IR 100, IR 117 and IR 139 will change the flows on the transmission lines in the Valley. The SIS will determine upgrades/requirements resulting from IR 141 in combination with other projects.

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 Short-Circuit Duties

The maximum (future) expected short-circuit levels are 5000MVA and 3500MVA on 138 and 69kV systems respectively.

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

Table 5-1: Short-Circuit Levels. Three-phase MVA [1]		
Location	**This Generating Facility in service**	**This Generating Facility not in service**
All transmission facilities in service		
77V-Conway	300	220
13V-Gulch	416	344
74V-Cornwallis	340	301
12V-Lequille	380	350
81V-Annapolis	341	319
70V-Bridgetown Rural	321	309
11V-Paradise	359	347
IR 141 HV	269	183
Local Generation Off and L-5026 (13V-Gulch to 11V-Paradise) Out		
77V-Conway	191	116
13V-Gulch	207	141
74V-Cornwallis	Out	Out
12V-Lequille	132	132
81V-Annapolis	128	128
70V-Bridgetown Rural	166	166
11V-Paradise	189	189
IR 141 HV	188	105

[1] Classical fault study, flat voltage profile

Although the actual increase in short-circuit levels will be dependent on the specific type of generator installed, the increase will be insignificant and not a cause for concern

Upgrades to protection and control facilities will be required at 77V-Conway and possibly 13V-Gulch, depending on the results of the SIS.

6 Thermal Limits

This facility would be interconnected to NSPI by constructing approximately 10 km of 69kV transmission line to 13V-Conway Substation. Conway Substation is connected to the grid via a 13.2km (2\0 ACSR) 69kV line, L-5533, to 13V-Gulch Hydro. From Gulch Hydro, lines L-5026, L-5531 and L-5532 transfer power out of the area. The ratings of the aforementioned 69kV lines are limited by ground clearance and conductor size.

Under system normal conditions during the summer months, this development will cause an overload on L-5533 from 77V-Conway to 13V-Gulch. The 13.2 km line will need to be upgraded.

Load Flow modeling for this Generating Facility indicate overload on L-5531 from 13V-Gulch to 15V-Sissiboo for a limited number of first contingencies and maintenance conditions. L-5531 (25 km) would have to be upgraded to maintain maximum output of 30 MW.

In addition to this Generating Facility, there are projects further ahead in the Queue (IR 017, IR 067, IR 068, IR 081, IR 083, IR 100, IR 117 and IR 139) that have the potential to cause thermal overload on the transmission lines throughout the Western and Valley portion of the province. At a minimum, to have multiple projects operational in this area (IR 067, IR 68 and IR 141) would require L-5025(30km), L-5026(47km) and L-5535(33km) line ratings be upgraded for system normal operation. For certain first contingencies and maintenance procedures L-5532(96km), L-5531(25km) and L-5541(15km) would require upgrades. The portion of any upgrades and changes due to IR 141 cannot be determined until preceding projects are confirmed or removed from the Queue.

The SIS will determine the details of operational restrictions and the cost of any upgrades required.

7 Voltage Control

The ratio of short-circuit level to generating capacity under normal system conditions is 6.1 (183/30) and is 3.5 (105/30) with low hydro dispatch and L-5026 out of service. Such a low ratio is an indication of voltage control issues. FEAS load flow analysis indicates that, without system upgrades, the voltage levels at 77V-Conway will vary by more 2.5 % when going from minimum to maximum generation. To reduce the voltage variation to below 2.5% will require the L-5533 from 77V-Conway to 13V-Gulch to be upgraded to 556 MCM ACSR. Care should be taken with regard to the selection of generator and controls to ensure good voltage control and acceptable levels of voltage flicker. The SIS will more closely define the type of voltage control for this location.

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 69kV Point of Change of Ownership, when the facility is delivering 30 MW at the Point of Change of Ownership. A centralized controller will be required which adjusts individual generator real and reactive power output, in real time, and regulates the voltage at the 69kV Point of Change of Ownership. The voltage controls must be responsive to voltage deviations, 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 setting will be reviewed and addressed 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 as per FERC order 661A. The SIS will state specific options, controls and additional facilities that are required to achieve this.

8 System Limitations (System Security)

The SIS will determine any facility changes required to maintain compliance with NERC/NPCC standards for good utility practice.

9 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.

Additions/Changes to the Transmission Provider's Interconnection Facilities

i. Construct approximately 10 km of 69kV transmission line, 556 MCM ACSR (Generation Facility to 77V-Conway)
ii. 69kV switchgear for line termination at 77V-Conway
iii. Protection upgrade at 13V-Gulch
iv. Control and Communications between the Generation Facility, 77V-Conway and NSPI Supervisory Control and Data Acquisition (SCADA) system (to be specified)
v. Upgrade L-5533 from 77V-Conway to 13V-Gulch Hydro
vi. Upgrade L-5531 from 15V-Paradise to 13V-Gulch Hydro

Additions/Changes to be included at the Interconnection Customer's Interconnection Facility

i. 69kV Interconnection Substation. This will include 69kV circuit breaker and protections as acceptable to NSPI, a Remote Terminal Unit (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 (30 MW) all at Point of Change of Ownership when the voltage at that point is operating between 95% and 105% of nominal.

iii. Low voltage ride through capability.

iv. Real-time monitoring RTUs of the Interconnection.

v. Facilities for NSPI to execute high speed rejection of generation (transfer trip).

10 Magnitude of NSPI Interconnection Facilities Cost Estimate

Estimates for NSPI Interconnections Facilities are included in Table 10-1.

Table 10-1: Cost Estimates

	Determined Cost Items	Estimate
i	Build 10 km of 69kV transmission line	$2,000,000
ii	69kV switchgear at 77V-Conway	$50,000
iii	Control and Communications between NSPI and customer	$500,000
iv	Protection Upgrade at 13V-Gulch	$100,000
v	Upgrade L-5533	$2,640,000
vi	Upgrade L-5531	$5,000,000
vii	Contingency (10%)	$1,029,000
	Total of Determined Cost Items	$11,319,000
	To be Determined Costs	
vii	Protection coordination for L-5025, 5026, 5531 and L-5532 as required	TBD (SIS)
viii	System Upgrades due to higher Queued IRs	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 Interconnection Customer's substation and 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 Rights Of Way (ROW) acceptable to NSPI for design and construction of any required new transmission line or Transmission Provider's substation are provided.
- that no more than 2 to 3 projects per year go forward, and assuming all easements and permits are provided and complete.

11 Preliminary Scope of System Impact Study

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 NPCC/NERC) 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 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 GIP
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

The SIS will be based on the cases listed in Table 11-1.

Table 11-1: Power Flow Base Case and Variations

Winter Peak	All Hydro and Tidal on
	Tidal off
Fall Peak	All Hydro and Tidal off
	All Hydro and Tidal on
Summer Peak	All Hydro and Tidal off
	Hydro off except Mersey system 50%, Tidal 100%

Summer Light Load	All hydro and tidal off
	Hydro off except Mersey system 50%, Tidal 100%

In each case, accommodations for the addition of wind generation will be made to the dispatch by changing the unit commitment for that day, ensuring that sufficient capacity is available to meet the daily peak load. The assumptions regulating regulation, load following and unit commitment at the minimum daily load (two shifting etc.) will be noted.

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

- L-6004
- L-6012
- L-6013
- L-5025
- L-5026
- L-5531
- L-5532
- L-5535
- L-5541
- L-6024
- L-6021
- 43V-613 (taking out 43V-B61, L-6013, L-6012, 43V-C61 and 43V-T61)
- 51V-521 (taking out 51V-B51 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

After determining the changes/additions that are required to facilitate this interconnection "N-1" operation will be assessed. The objective is to determine the operating restriction or curtailments that must be enforced to ensure secure operation of the system. This provides a thorough assessment to ensure that the facilities are adequate and the customer business risks are conveyed.

- Contingency analysis, as required
- Dynamic simulation, as required
- Determination of total generation to be constrained

The "N-1" assessment will include, but not be limited to, the following: The "N-1" assessment will determine the operation constraints that must be applied for "N-1" operation after the facility upgrades/additions that are recommended, for the interconnection, are constructed.