Interconnection Feasibility Study Report
GIP-067-FEAS-R2

Generator Interconnection Request #67

40MW Wind Generating Facility

Annapolis County, NS

August 17, 2007

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer submitted an Interconnection Request (IR 067) to Nova Scotia Power Inc. (NSPI) for a proposed 40 MW wind generation facility interconnected to the NSPI system via the 69kV substation 70V-Bridgetown Rural.

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 with a nonbinding estimated cost of $3,465,000 are:

- Construct approximately 5 km of 69kV transmission line from the Generation Facility to 70V-Bridgetown Rural
- 69kV circuit breaker, switchgear and protection at the Bridgetown tap of L-5026.
- Control and Communications between this generating facility, L-5026 tap substation and NSPI Supervisory Control and Data Acquisition (SCADA) system (to be specified)
- Upgrade L-5025 and L-5026 protection systems and switches

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 40 MW wind Generation Facility interconnected to the NSPI system via the 69kV substation 70V-Bridgetown Rural. 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 north of Bridgetown in Annapolis County, and connect to 70V-Bridgetown Rural Substation via a newly constructed 69kV line approximately 5 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 Energy Resources Integration Services (ERIS), if the FEAS determines that transmission upgrades are required as a result of thermal overload, voltage violation, or equipment rating, then the FEAS will determine the amount of generation that can be installed without necessitating major transmission upgrades. The FEAS will provide a preliminary high level estimate of the 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. 40 MW wind farm comprised of 27 – 1.545 MW General Electric 1.5sle wind turbines, and has requested ERIS service

ii. The wind Generating Facility is located approximately 5 km from the 70V-Bridgetown Rural Substation. 70V-Bridgetown Rural is connected the 69kV system via L-5047 which taps line L-5026 between 11V-Paradise Hydro and 81V-Annapolis Royal Hydro.

iii. Transformer impedance assumed at 7.25 % (on ONAN Base), rated 47.5/50 MVA.

iv. 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.

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

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, IR017 connected to L-6004 will change the flows on the transmission lines in the Valley. The SIS will determine any resulting upgrades/requirements. 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 level 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		
13V-Gulch	365	344
74V-Cornwallis	323	301
12V-Lequille	400	350
81V-Annapolis	361	319
70V-Bridgetown Rural	420	309
11V-Paradise	435	347
IR 067 HV	387	270
Local Generation Off and L-5025 out (11V-Paradise to 65V-Middleton Rural tap)		
13V-Gulch	214	154
74V-Cornwallis	192	132
12V-Lequille	201	121
81V-Annapolis	186	114
70V-Bridgetown Rural	204	98
11V-Paradise	184	96
IR 067 HV	205	94

(1) Classical fault study

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.

A 69kV circuit breaker, switchgear and protection will be required at the Bridgetown tap to provide adequate protection coordination between the Interconnection Customer and NSPI. Upgrades to protection and control facilities at 13V-Gulch and 11V-Paradise will also be required.

6 Thermal Limits

This facility would be interconnected to the NSPI 69kV transmission system by constructing approximately 5 km of 69kV transmission line from 70V-Bridgetown Rural Substation to the Interconnection Substation. Bridgetown Rural Substation is tapped (3.1 km 336 kcmil) off line L-5026 from 11V-Paradise to 13V-Gulch Hydro.

From Paradise, L-5025 transfers power to 51V-Tremont. From Gulch, L-5531 and L-5532 feed through to 15V-Sissiboo Hydro and 14V-Ridge Hydro respectively.

Under certain dispatch conditions, the addition of IR 067 would cause an overload on the relaying and metering equipment of L-5025 and L-5026. A protection coordination study will be required as part of the SIS to determine the changes required for this project to proceed.

For certain single contingencies or maintenance outages on L-5025 and L5026, at specific dispatch conditions, the switch at the 13V-Gulch end of L-5026 will be overloaded. The switch will be upgraded as part of a protection systems upgrade as required for protection coordination. The SIS will determine the nature and cost of any required upgrades.

7 Voltage Control

The ratio of short-circuit level to generating capacity under normal system conditions is 6.8 (270/40) and is 2.4 (94/40) with low hydro and L-5025 out. Such a low ratio is an indication of voltage control issues. 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 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 40 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. Approximately 5 km 69kV transmission 556 MCM ACSR (Generation Facility to 70V-Bridgetown Rural)

ii. 69kV circuit breaker, switchgear and protection the Bridgetown tap (of L-5026)

iii. Control and Communications between this Generating Facility, L-5026 tap substation and NSPI Supervisory Control and Data Acquisition (SCADA) system (to be specified)

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

i. 69kV Interconnection Substation. This will include a 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 (40 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 Interconnection Facilities are included in Table 10-1.

Table 10-1: Cost Estimates

	Determined Cost Items	Estimate
i	Build 5 km of 69kV transmission line	$1,000,000
ii	Control and Communications between NSPI and customer	$500,000
iv	Upgrade 13V-Gulch and 11V-Paradise Protection Systems and Switch	$150,000
v	Add a 69kV Breaker and Switchgear at the Bridgetown tap of line L-5026	$1,500,000
vi	Contingency (10%)	$315,000
	Total of Determined Cost Items	$3,465,000
	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)

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, 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 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 completed in order to assess the impacts. It is recognized that 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
- SLG fault on L-5025 with failure of 11V-504
- SLG fault on L-5531 with failure of 13V-511

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.