Interconnection Feasibility Study Report

GIP-231-FEAS-R2

System Interconnection Request #231

40 MW Wind Generating Facility

Annapolis County (51V)

2011-01-27
Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer submitted an Interconnection Request for Energy Resource Interconnection Service (ERIS) to NSPI for a proposed 40 MW wind generation facility at Annapolis County. The Point of Interconnection (POI) requested by the customer is on 69kV L-5026 via an 8 km newly-constructed line tap from the wind farm which is located at Hampton Hill. An alternative POI on L-6013 was also identified by the customer. However this report studied a POI on the 69kV bus at 70V-Bridgetown Rural for the 69 kV option and the 138kV bus at 51V-Tremont substation for the 138 kV option. The 138kV option requires approximately 45 km of newly-constructed line between the wind farm and the 51V-Tremont substation.

The study results on this area show no remaining capacity to accommodate any additional generation injection on the local 69 kV systems. Under certain contingencies during light load and local peak generation, this facility will cause the power flow to exceed the summer ratings of some local 69 kV lines. To eliminate the potential thermal violations, over 200 km of 69 kV lines in the Valley and Western areas would have to be upgraded or re-built. Otherwise this generating facility would have to be tripped whenever any of these contingencies occurs. Therefore the option for interconnection to the NSPI 69 kV systems is not recommended in this study and cost estimates have not been included in this report.

For a POI on the 138 kV system, 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 or voltage 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 #231 is approximately 2.25% (system losses increased by net 0.9 MW when IR #231 is operated at 40 MW).

The preliminary non-binding estimated cost of facilities required to interconnect the IR#231 to the 51V- Tremont 138 kV bus is $21.7 Million including a contingency of 10%. This estimate 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 (IR) for Energy Resource Interconnection Service (ERIS) to NSPI for a proposed 40 MW wind generation facility interconnected to the NSPI transmission system. The Point of Interconnection (POI) requested by the customer is on 69kV L-5026 via an 8 km newly-constructed line tap from the wind farm which is located at Hampton Hill. However this report studied the POI on the 69kV bus at 70V-Bridgetown Rural since the substation is closer to the wind farm. An alternative POI on L-6013 was also identified by the customer. However a more effective POI is on the 138kV bus at 51V-Tremont substation since the 51V substation control and communication can also be utilized for the line termination. This 138kV option requires approximately 45 km of newly-constructed line from the wind farm to the 51V-Tremont substation. The spur line is about 40 km if it is tapped onto L-6013, but a new switching station associated with the new control and communication systems is required for this option. Therefore 138 kV POI into the 51V-Tremont substation is a more economic option.

The Interconnection Customer signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI transmission system dated 2010-11-29, and this report is the result of that Study Agreement. This project is listed as Interconnection Request #231 in the NSPI Interconnection Request Queue, and will be referred to as IR#231 throughout this report.

2 Scope

The Interconnection Feasibility Study (FEAS) consists of a power flow and short circuit analysis. Based on this scope, the 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 high level 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 3.2.1.2 of Revised Generation Interconnection Procedures (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 includes 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.

An Interconnection Facilities Study follows the SIS in order to ascertain the final cost estimate to interconnect the generating facility.

3 Assumptions

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

1. Energy Resource Interconnection Service type per section 3.2 of the RGIP.
2. 40 MW wind with 27 x 1.5 MW GE SLE Wind Turbines.
3. The generation technology used must meet NSPI requirement for reactive power capability of 0.95 capacitive to 0.95 inductive at the HV terminals of the IC Substation Step Up transformer. The generator is assumed to be specified for 40 MW at a rated power factor of 0.9 for both lagging and leading. It is also required to have high-speed Automatic Voltage Regulation to maintain constant voltage at the generator terminals during and following system disturbances as determined in the subsequent System Impact Study.
4. The Interconnection Customer indicated that the generation interconnection point is on the 69 kV line L-5026 with an alternative POI on 138kV line L-6013. This study considered the POI to be on the 69 kV bus at 70V-Bridgertown Rural substation and an alternative POI on the existing 138 kV bus at 51V-Tremont substation. The wind facility is located approximately 8 km from the 70V-Bridgetown Rural and 45 km from 51V-Tremont substation.

5. Only preliminary data was provided by the Interconnection Customer for the generator step-up and IC substation step-up transformers. Modeling was conducted assuming a 69kV-34.5kV 27/36/45 MVA Interconnection Facility transformer with a positive sequence impedance of 7.2% for POI at 70V-Bridgetown Rural substation. A 138kV-34.5kV 27/36/45 MVA transformer with a positive sequence impedance of 7.2% was assumed for POI on the 138 kV bus at 51V-Tremont substation. The Interconnection Customer indicated that the step-up transformer has a grounded wye-delta-wye winding configuration with +/-5% off-load tap changer. The generator step-up transformer was assumed to have an impedance of 5.8% on 1.75 MVA with an X/R ratio of 7.5.
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#151, IR#219, IR#227 and IR#225 are included in this study.

4 Projects with Higher Queue Positions

All in-service generation is included in the FEAS.

As of 2011-01-27 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 #45 Unexecuted GIA filed
- IR #8 GIA Executed
- IR #56 GIA Tendered
- IR #151 FAC in progress
- IR #219 SIS complete
- IR #227 SIS complete
- IR #225 SIS complete

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 RGIP 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 #222		

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 high-level non-binding cost estimate of interconnecting the 40 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 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 3500 MVA on 69 kV systems and 5000 MVA on 138kV systems. The short-circuit levels in the area before and after this development are provided below in Table 6-1 and Table 6-2 for POI at 70V-Bridgetown Rural and 51V-Tremont substation respectively.

Table 6-1: POI at 70V sub. 69kV. Short-Circuit Levels. Three-phase MVA (1)

Location	IR #231 in service	IR #231 not in service
All transmission facilities in service		
Interconnection Facility	494	311
11V- Paradise 69 kV	494	354
13V-Gulch 69kV	362	322
51V-Tremont 69 kV	653	603
Minimum Conditions		
Interconnection Facility	416	233

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

(1) Classical fault study, flat voltage profile

Table 6-2: POI at 51V sub 138kV. Short-Circuit Levels. Three-phase MVA		
Location	**IR #231 in service**	**IR #231 not in service**
All transmission facilities in service		
Interconnection Facility	971	798
43V- Cannon Rd 138 kV	1297	1153
51V-Tremont 69 kV	670	603
70V-Bridetown Rural 69kV	317	311
Minimum Conditions		
Interconnection Facility	870	696

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 69kV bus at 70V is presently 311 MVA. After installing IR # 231 the increase will bring the short-circuit level to 494 MVA at the POI. Similarly, under summer light load conditions with certain generation units offline, the short-circuit level will be approximately 233 MVA at the POI. This translates into maximum equivalent system impedance at the POI of 0.429 per unit on 100 MVA base.

The interrupting capability of the 69 kV circuit breakers at 11V-Paradise and 13V-Gulch is at least 1600 MVA which will not be exceeded by this development on its own.

For the 138 kV option, the maximum short-circuit level on 138kV bus at 51V is presently 798 MVA. After installing IR # 231 the increase will bring the short-circuit level to 971 MVA at the POI. Similarly, under summer light load conditions with certain generation units offline, the short-circuit level will be approximately 696 MVA at the POI. This translates into maximum equivalent system impedance at the POI of 0.144 per unit on 100 MVA base.

The interrupting capability of the 138kV circuit breakers at 51V-Tremont 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 on the 69kV bus at 70V-Bridgetown Rural substation using IEC Standard 61400-21 and the published values for GE SLE machines is 0.022 under normal conditions and 0.0259 under minimum generation conditions. These are both

below NSPI's required limit of 0.25 for P_{st} and 0.35 for P_{lt}. Therefore voltage flicker should not be a concern for this project with POI on 69kV.

Alternatively the voltage flicker at the POI at 51V-Tremont substation is 0.01 under normal conditions and 0.012 under minimum generation conditions. Therefore voltage flicker should not be a concern for this project with POI on 138 kV either. The full SIS 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

For a 69 kV POI this facility would be interconnected to 70V-Bridgetown substation by constructing an approximately 8 km of 69kV transmission line with 556 ACSR Dove conductors and maximum operating temperature of 70ºC. The Valley area is 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, the local 69kV system in the western Valley area could become overloaded. Therefore operating restrictions on the total generation output within this area have been established. The results of this study and previous study on this area show no remaining capacity to accommodate any additional injection on the local 69 kV systems. Under certain contingencies during light load and local peak generation, this facility will cause the power flow to exceed the summer ratings of some local 69 kV lines. To eliminate the potential thermal violations over 200 km of 69 kV lines in the Valley and Western areas would have to be upgraded or re-built, otherwise this generating facility would have to be tripped whenever any of the contingencies occurs. Therefore the option of interconnection to 69 kV systems is not recommended in this study and cost estimate have not been included in this report.

For the proposed 138 kV POI this facility would be interconnected to the 138kV bus at the 51V-Tremont substation. Approximately 45 km of 138kV transmission line would be constructed in the Valley area using 556 ACSR Dove conductors with maximum operating temperature of 100ºC. NSPI is currently building a second 138kV transmission line between 51V-Tremont and 43V-Canaan Rd. which is expected to be in service by end of 2011, and the NSPI 51V-Tremont termination of that new line will be developed with the addition of a 138/69 kV transformer and a 138 kV bus. Therefore the line from IR#231 to 51V-Tremont substation can be connected on the 138 kV bus at 51V-Tremont with one additional circuit breaker. Under this option no thermal loading issues were found under normal state and single contingency conditions for this project on its own.

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 HV terminals of the IC Substation Step Up Transformer, at all production levels up to the full rated load of 40 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 Appendix G to the Standard Generator Interconnection and Operating Agreement (GIA). 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 #231 to the 138 kV bus at 51V substation:

Additions/Changes to POI

1. Addition of one 138kV line terminal, one 138 kV circuit breakers and associated switches at 51V-Tremont bus,
2. Modification on NSPI protection systems,
3. Addition of approximate 45 km of 138kV spur line to connect the wind farm to the POI with 556 Dove ACSR conductor rated 100°C conductor temperature,
4. Control and communications between the wind farm 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 (40 MW) at the HV terminals of the IC Substation Step Up Transformer 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 Appendix G to the Standard Generator Interconnection and Operating Agreement (GIA).
5. Real-time monitoring (including a Remote Terminal Unit) of the interconnection facilities.
6. Facilities for NSPI to execute high speed rejection of generation (transfer trip) if determined in SIS.

12 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

Estimates for NSPI Interconnections Facilities and Network Upgrades for interconnecting 40 MW wind energy onto 138 kV systems are included in Table 12-1.

Table 12-1: Cost Estimates identified from FEAS scope

	Determined Cost Items	Estimate
NSPI Interconnection Facilities		
i	Build 45 km 138kV single circuit line and line termination into the 51V substation	$ 18,000,000
ii	Protection, control, communication	$500,000(1)
Network Upgrades		
iii	One 138kV circuit breaker and associated switches on 51V bus	$1,200,000
Totals		
v	Contingency (10%)	$ 1,970,000
	Total of Determined Cost Items	$21,670,000
	To be Determined Costs	
iii	System additions to address potential stability limits	TBD (SIS)

(1) The preliminary cost estimates on item ii) Protection, control and communication will be further assessed in the subsequent System Impact Study.

The preliminary non-binding cost estimate for interconnecting IR#231 with 51V-Tremont would be $21,670,000. Interconnection Customer is also required to fund the Item iii) costs, and would be eligible for repayment in accordance with the terms of the GIA.

13 Issues to be addressed in SIS

The following provides a preliminary scope of work for the subsequent SIS on 138 kV option. 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. Under-frequency 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[2] and NPCC[3] 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 #231 which is lost through the transmission system. Preliminary value is calculated to be 2.25% (system losses increase by net 0.9 MW when IR #231 is operated at 40 MW). The radial spur line from the Interconnection Facility to the POI while IR#231 is operating at full load incurs losses of 1.2 MW.

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

Interconnection Feasibility Report Addendum

GIP-231-FEAS-R3

System Interconnection Request #231

25 MW Wind Generating Facility

Annapolis County (70V)

2011-02-11
Control Centre Operations
Nova Scotia Power Inc.

1 Introduction

The Interconnection Customer (IC) originally submitted an Interconnection Request (IR) for Energy Resource Interconnection Service (ERIS) to NSPI for a proposed 40 MW wind generation facility interconnected to the NSPI transmission system. Report no. GIP-231-FEAS-R2 shows the study results of that Interconnection Request. However the IC re-submitted a request to reduce the nameplate capacity of IR#231 from 40MW to 25 MW which would be interconnected to the NSPI 69kV transmission system. This report shows the study results of the 25 MW generating facility based on the Point of Interconnection (POI) on the 69kV bus at 70V-Bridgetown Rural substation and an 8 km newly-constructed line to the wind farm. This report only includes the assessment of the thermal and voltage issues for the 69 kV POI option and the associated high-level estimated costs which updated Section 8, 9, 11 and 12 in the original report GIP-231-FEAS-R2.

2 Thermal Limits

For the 69 kV POI this facility would be interconnected to 70V-Bridgetown Rural substation by constructing approximately 8 km of 69kV transmission line with 556 ACSR Dove conductors and maximum operating temperature of 70ºC. The spur line would be interconnected into the substation through a line terminal, one 69kV circuit breaker and associated switches. 70V-Bridgetown Rural substation is on L-5026, and there are two generating facilities already on this transmission line. In order to avoid the multi-terminal protection scheme, two additional circuit breakers and associated switches are required to split L-5026 into two sections. The details on the protection schemes will be further addressed in the SIS study.

Under certain generation dispatch and contingency scenarios during peak and light load conditions during spring and summer, certain transmission lines on the local 69 kV systems in the Western and Valley area could become overloaded. Therefore operating restrictions on the total generation output within this area have been established. The addition of 25 MW proposed by IR#231 would cause the local 69 kV lines L-5531, L-5532, L-5535 and L-5541 to exceed their summer ratings during peak and light load with peak generation.

The most overloaded lines are L-5535 (64.1 km) and L-5531 (24.8 km) with the conductor temperature presently limited to 50ºC due to sag (ground clearance) limitation. The conductor is 2/0 ACSR with summer (sag limited) rating of 23MVA and winter rating of 34 MVA. Depending on load level and dispatch of other generation, these overload violations could occur under steady-state conditions even with operating restrictions (summer and winter). Based on historical generation and load patterns, IR#231 could be restricted from operating at any level due to the overloads on L-5535 and L-5531. It is estimated that this wind facility would not be able to operate for approximately 790 hours to 1150 hours per year, which represents 9% to 13% of the time

(including some hours in the winter months). In addition, there is also an undetermined amount of time for which the facility could operate in a restricted (less than full load) level.

L-5535 and L-5531 would need to be re-built in order to accommodate the full output of the proposed IR#231. Besides these network upgrades, a new SPS would have to be created specially for this wind facility which, once armed, would be activated by protection operation or breaker status for at least the following contingencies:

- loss of 69kV line L-5025,
- loss of 69kV bus B51 at 11V-Paradise substation and
- loss of 69 kV bus B51 at 51V-Tremont substation,
- loss of 69kV line L-5026,
- loss of 69kV line L-5535.

This SPS would be utilized to trip the wind facility through SCADA system. The new SPS scheme would have to be presented to NPCC and would require their approval. The contingencies that should be included in the SPS will be further assessed in the SIS study as well as the arming levels.

Statistics on the historical line outage and interruption frequency in the Western and Valley areas have been reviewed for the past ten years (2000-2010). These outages and interruptions could potentially have impacts on the dispatch of this wind facility. The average number of line interruption in this area is 29 times per year and the average outage duration for each year is 76.4 hours. Historical transmission performance is not necessarily an indicator of the future performance.

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.

3 Voltage Limits

With the addition of the full 25 MW in the Valley area, undervoltage and overvoltage violations at a number of 69 kV substations near 9W-Tusket were found under certain contingencies. Therefore a voltage control device will be required for this wind facility.

The SIS will confirm the options and ancillary equipment that the customer must install to control the voltage profile.

4 Expected Facilities Required for Interconnection

The following facility changes are required to interconnect IR #231 to the 69 kV bus at 70V substation:

Additions/Changes Required for ER Interconnection Services (ERIS)

1. Addition of one 69 kV line terminal, one 69 kV circuit breaker and associated switches on 70V-Bridgetown Rural bus,
2. Addition of approximate 8 km of 69 kV spur line to connect the wind farm to the POI with 556 Dove ACSR conductors rated 70°C conductor temperature,
3. A new switching station for L-5026 to accommodate two additional circuit breakers and associated switches.
4. Development of a Special Protection System (SPS) and the operating restrictions
5. Control and communications between the wind farm and NSPI SCADA system (to be specified).

Additions/Changes Required for Full Generating Facility Output

6. Re-build L-5531 (24.8 km) and L-5535 (64.1 km).

Requirements for the Generating Facility

1. Facilities to provide 0.95 leading and lagging power factor when delivering rated output (25 MW) at the HV terminals of the IC Substation Step Up Transformer 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 Appendix G to the Standard Generator Interconnection and Operating Agreement (GIA).
5. Real-time monitoring (including a Remote Terminal Unit) of the interconnection facilities.
6. Facilities for NSPI to execute high speed rejection of generation (transfer trip) if determined in SIS.

5 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

Estimates for Transmission provider's Interconnections Facilities and Network Upgrades for interconnecting 25 MW wind energy onto 69 kV systems with operating restrictions are included in Table 5-1.

Table 5-1: Cost Estimates identified from FEAS scope

	Determined Cost Items	Estimate
NSPI Interconnection Facilities required for ERIS		
i	Build 8 km 69kV single circuit line and line termination into the 70V substation	$ 2,000,000
ii	One 69kV circuit breaker and associated switches on 70V bus (including the replacement of the existing switches)	$ 750,000
iii	Control and communication	$400,000
iv	Develop a Special Protection System and operating restrictions	$ 400,000
Network Upgrades		
v	New switching station development with two 69 kV breakers and associated switches	$2,300,000
Totals		
vi	Contingency (10%)	$ 585,000
vii	Total of Determined Cost Items	$6,435,000
	To be Determined Costs	
viii	Voltage Control Device	TBD (SIS)
ix	System additions to address potential stability limits	TBD (SIS)

The preliminary non-binding cost estimate for interconnecting IR#231 at the 70V-Bridgetown Rural substation as ERIS with operating restrictions would be $6,435,000. The Interconnection Customer is also required to fund the Item v) cost, but would be eligible to receive refunds on this item once IR#231 has attained Commercial Operation in accordance with the terms of the GIA.

Estimates for Transmission provider's Interconnections Facilities and Network Upgrades for interconnecting the full output of 25 MW wind energy onto 69 kV systems are included in Table 5-2.

Table 5-2: Cost Estimates identified from FEAS scope		
	Determined Cost Items	**Estimate**
NSPI Interconnection Facilities required for Full Output		
i	Build 8 km 69kV single circuit line and line termination into the 70V substation	$ 2,000,000
ii	One 69kV circuit breaker and associated switches on 70V bus (including the replacement of the existing switches)	$ 750,000
iii	Control and communication	$400,000
iv	Develop a Special Protection System	$ 300,000
Network Upgrades required for Full Output		
v	New switching station development with two 69 kV breakers and associated switches	$2,300,000
vi	Re-build L-5535 (64.1 km) and L-5531 (24.8 km)	$ 19,562,400
Totals		
vii	Contingency (10%)	$ 2,535,240
viii	Total of Determined Cost Items	$27,887,640
	To be Determined Costs	
ix	Voltage Control Device	TBD (SIS)
x	System additions to address potential stability limits	TBD (SIS)

The preliminary non-binding cost estimate for interconnecting IR#231 at the 70V-Bridgetown Rural substation as ERIS without operating restrictions would be $27,887,640. The Interconnection Customer is also required to fund the Items v) and vi) costs, but would be eligible to receive refunds on these items once IR#231 has attained Commercial Operation in accordance with the terms of the GIA.

Nova Scotia Power
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