Interconnection Feasibility Study Report

GIP-219-FEAS-R2

System Interconnection Request #219

64 MW Biomass (Steam) Generating Facility

Richmond County (47C)

2010 07 05

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The interconnection Customer submitted an Energy Resource Interconnection Service (ERIS) Interconnection Request to NSPI for a proposed 64 MW biomass-fired steam generation facility interconnected to the NSPI 138kV transmission system at the existing substation 47C. The nominal output of the generator will be rated 60 MW. One new 138kV circuit breaker at 47C and associate switches and protection are required, which must be designed to meet the NPCC Bulk Power System criteria.

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.

There is a potential to exceed the summer overload rating on L-6517 for loss of L-6518 or overload on L-6518 for loss of L6517, if the existing customer-owned generators connected to 47C run with the proposed generation facility simultaneously under the light load condition. Therefore, an operation restriction will be required at the plant or the Strait Area Overload SPS (NPCC designation #139 that automatically curtails non-firm load at 47C) will need to be modified to account for all three generators at 47C location.

In accordance with the application for Energy Resource Interconnection Service, the IR#219 generating facility is permitted to deliver its output using the existing transmission system capacity on an ‘as available’ basis. To enable the delivery of the full output of IR#219 generating facility, other generation must be dispatched in such a fashion that existing transmission constraints are honoured. If generation is off-line at 50N-Trenton, then the limit of the Cape Breton Export interface must be reduced to prevent thermal overloads of L-6511 and L-7019 for the loss of the double-circuit Strait of Canso crossing circuit.

The loss factor for IR #219 is approximately 11.5%.

The preliminary non-binding estimated cost of facilities required to interconnect the IR#219 generating facility to the transmission system is $1,518,000 including the modifications to the SPS and a contingency of 10%. This non-binding 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 for Energy Resource Interconnection Service (ERIS) to NSPI for a proposed 64 MW biomass generation facility interconnected to the NSPI 138kV transmission system at the existing 47C substation in Richmond County. The nominal output of the generator will be rated 60MW.

The Interconnection Customer signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI transmission system, dated 2010-06-03, and this report is the result of that Study Agreement. This project is listed as Interconnection Request #219 in the NSPI Interconnection Request Queue, and will be referred to as IR #219 throughout this report.

2 Scope

The Interconnection Feasibility Study (FEAS) report 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; and
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 3.2.1.2 of the Standard Generation Interconnection Procedures, as approved by the UARB on February 10, 2010 (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 interface limit will not be exceeded to avoid system upgrades in an ERIS study.

A more detailed analysis of the technical implications of this development is included in the System Impact Study (SIS) report. This SIS includes system stability analysis, 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. 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 facilities.

3 Assumptions

This 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 Services.
2. 64 MW biomass with a single synchronous generator and a biomass-fired steam turbine.
3. The generation technology used must meet NSPI requirement for reactive power capability of 0.95 capacitive to 0.95 inductive at the 47C 138kV bus. The generator is specified for 64 MW at a rated power factor of 0.85. It is also required to have high-speed Automatic Voltage Regulation to maintain constant voltage at the generator terminals during and following system disturbances.
4. The Interconnection Customer indicated interconnection at the 138kV bus of 47C substation. The biomass generating facility will be connected to the 47C substation by approximately 500m of 138kV cable, a generator step-up transformer, and a low voltage generator circuit breaker. Unit service will be fed from the low-voltage terminals of the generator step-up transformer.
5. Preliminary data was provided for the generator step-up transformer. Modeling was conducted using a 138kV-13.8kV 70.6 MVA transformer with a positive sequence impedance of 13%. It was indicated that the step-up transformer has a grounded wye - delta winding configuration.
6. The FEAS analysis is based on the inclusion of IRs higher in the Generation Interconnection Queue (Queue) that have completed a System Impact Study, or that have a System Impact Study in progress, in accordance with GIP Section 6.2. As such, IR #8, IR #45, IR #82, IR #114, IR #141 and IR#151 are included in this study

(IR #56 has not been included in this study base case because its network location has no potential impact on this study).

7. The bulk of the customer load at 47C is considered non-firm (interruptible), and therefore this study assumes that this load is at minimum (10 MW).

4 Projects with Higher Queue Positions

All in-service generation is included in the FEAS.

As of 2010-07-02 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 Unexecuted GIA filed
- 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 RGIP SIS progression milestones, or have Feasibility Study agreement complete.

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	IR #223	IR #225
IR #226					

If any of the higher-queued projects included in this FEAS are subsequently withdrawn from the Queue, the results of this FEAS may require 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 cost of interconnecting the 64MW 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 Energy Resource Interconnection Service assessment.

This assessment 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 the Northeast Power Coordinating Council (NPCC) and/or the North American Reliability Corporation (NERC) or required to maintain system stability. These requirements will be determined by the subsequent interconnection System Impact Study (SIS).

6 Short-Circuit Duty

The maximum (design) expected short-circuit level on 138kV systems is 5000 MVA. The short-circuit levels in the area before and after this development are provided in Table 6-1 below.

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

Location	IR #219 in service	IR #219 not in service
All transmission facilities in service		
47C 138kV (POI)	2088	1938
1C-Point Tupper 138kV	2110	1975
2C-Port Hastings 138kV	2522	2400
Minimum Conditions		
138kV Interconnection Point	1466	1235

(1) Classical fault study, flat voltage profile

The maximum short-circuit level at the POI is presently 1938 MVA. After installing IR #219 the increase will bring the short-circuit level to 2088 MVA at the POI. Under contingency operation, with IR#219, the existing generator at 1C-Point Tupper as well as

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

the generators and synchronous motors off-line at 47C and with L-6518 open at 2C-Port Hastings, the short-circuit level will be approximately 1235 MVA at the POI. This translates into a maximum equivalent system impedance at the POI of 0.081 per unit on 100 MVA base.

The interrupting capability of 138kV circuit breakers in the vicinity of 47C is at least 3500 MVA which will not be exceeded by the addition of IR #219.

7 Voltage Flicker and Harmonics

The generator is a conventional synchronous machine with a brushless excitation system and therefore voltage flicker is not expected to be not a concern for this project. 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

Lines L-6517 and L-6518 have a continuous summer rating of 215 MVA based on an ambient temperature of 25ºC. The total generation in the area is currently 202 MW, rising to 266 MW with the addition of IR #219. The summer overload rating of each of these lines is 236 MVA, so when the total load at 1C-Point Tupper, 46C and 47C is less than 30 MW, there is potential for overload of a circuit for contingency loss of the other circuit.

It should be noted that the load itself (no generation on-line) at 47C can exceed the thermal rating of these circuits for the same contingencies; however this is presently managed through the use of a Special Protection System (SPS) which automatically curtails non-firm load at 47C if the contingencies of concern result in line overload. If an overload occurs due to excess generation instead of excess load, and if the existing SPS operated and tripped load, it would make the situation worse, and therefore the SPS will need to be modified. The details of this modification will be developed in the SIS and FAC. However, during the scoping meeting for IR #219, the Interconnection Customer proposed the possibility that the existing generators at 47C (the 8 MW Westinghouse unit and the 18 MW Stahl unit) will not be used simultaneously with the proposed generation facility, which would mean that the total generation in this area will normally be less than 240MW. Assuming the minimum local load is 10MW, there would be no potential overload of a circuit for single transmission contingency.

If one generating unit at 50N-Trenton is off-line, then the addition of IR #219 at 47C could result in a higher percentage of the Cape Breton Export to flow on the 138kV transmission lines. The Strait of Canso double-circuit tower contingency could therefore result in line L-6511 West loading to 125% of its normal summer rating as well as L-7019 loaded to 115% of its normal summer rating (following the activation of the NPCC designation #120 SPS that trips two Lingan units). Therefore the Cape Breton Export

transfer limit must either be reduced, or IR #219 must be curtailed when generation is off-line at 50N-Trenton and the summer line ratings are in effect. Details of this curtailment will be addressed in the SIS study.

9 Voltage Limits

This generating facility must be capable of providing both lagging and leading power factor of 0.95, measured at the 138kV terminals of the 47C substation, at all production levels up to the full rated load of 64 MW. The generator must be equipped with a high-speed continuously-acting automatic voltage regulator set to control its 13.8kV terminals to a value established by the NSPI System Operator. 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 be capable of staying on-line during and following a three-phase fault on the 138kV bus at 47C, cleared in 100ms (6 cycles). The performance of the generator controls to meet this requirement will be studied in detail in the SIS.

With the proposed generator step-up transformer impedance of 13% on 70.6 MVA, and the rated generator power factor of 0.85 measured at the machine 13.8kV terminals, the net power factor requirements of 0.95 measured at the Point of Interconnection can be achieved.

The Onslow Import and Onslow South interfaces are both stability limited and voltage limited. IR #219 will increase flows across these interfaces, potentially exceeding present limits. Stability will be addressed in Section 10 below, and voltage violations are addressed in this section. The Onslow South interface limit is a function of the reactive power (Mvar) dispatch and associated reactive power reserve in the Metro area. Higher transfer levels are possible if reactive power is kept in reserve to respond to contingencies. However, as power transfer increases across the Onslow South Interface, the resulting increase in steady-state reactive power requirements reduces the available reserve. Therefore this facility would require curtailment or re-dispatch by NSPI system operators when the Onslow Import and Onslow South interfaces are stressed. This is consistent with ERIS.

10 System Security / Stability Limits

The NSPI transmission system has limited east to west transfer capability. Transmission corridors between Sydney and Halifax are often operated to security limits. This project

increases flow across the Cape Breton Export, the Onslow Import, and the Onslow South interfaces. Generation rejection Special Protection Systems[2] (SPS's) are utilized to increase system stability limits to maximize east to west power transfers. Depending on the impact of other generation additions ahead of this project in the Interconnection Request Queue, the additional generating capacity that this facility provides may not be integrated into the NSPI system under all dispatch conditions without system upgrades.

Under some dispatch conditions with certain contingencies, transmission corridors become overstressed, which may require Network Upgrades. The SIS will determine if this action solves the stability issues associated with the congested interfaces.

In general, the SIS will determine the facility changes that are required to permit higher transmission loadings while maintaining compliance with NERC/NPCC standards and in keeping with good utility practice.

11 Expected Facilities Required for Interconnection

The following facility changes are required to interconnect IR #219:

Additions/Changes at 47C substation

1. One new 138kV circuit breaker and associated switches at 47C-NewPage ring bus, between breakers 47C-605 and 47C-673[3],
2. Disconnect switch and grounding switch with an interlock at the connection node between the 138kV bus and the cable,
3. Protection systems designed to NPCC Bulk Power System criteria,
4. Modification of the Strait Area Overload Protection SPS (NPCC designation #139) to accommodate excess generation in addition to excess load or Utilization of operation restriction on the plant generations.

Requirements for the Generating Facility

1. Facilities to provide 0.95 leading and lagging power factor when delivering rated output (64 MW) all 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 to control the 13.8kV bus voltage. 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.

[2] Also known as Remedial Action Schemes, SPS's are defined by NPCC as "A protection system designed to detect abnormal system conditions, and take corrective action other than the isolation of faulted elements." *NPCC Document A7 - Glossary of Terms*.

[3] 138kV cable to generator step-up transformer is not included in this estimate.

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 equivalent to FERC Order 661a[4] .
5. Real-time monitoring (RTU's) of the interconnection facilities for NSPI to execute high speed rejection of generation (transfer trip).

12 NSPI Interconnection Facilities and Network Upgrade Cost Estimate

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

Table 12-1: Cost Estimates identified from FEAS scope		
	Determined Cost Items	**Estimate**
NSPI Interconnection Facilities		
i	Disconnect and grounding switches before the connection node	$ 30,000
Network Upgrades		
ii	138kV circuit breaker at 47C(1)	$1,200,000
iii	Protection, control, communication	$100,000
iv	SPS Modification(2)	$50,000
Totals		
v	Contingency (10%)	$138,000
	Total of Determined Cost Items	$1,518,000
	To be Determined Costs	
iii	System additions to address potential stability limits	TBD (SIS)

(1) 138kV cable to generator step-up transformer is not included in this estimate.
(2) Cost of SPS Modification could be avoided if there is the operation restriction on the plant generations.

[4] FERC Order 661A addresses the requirement for wind-powered generation to ride-through faults in a manner similar to traditional synchronous generator. This reference is meant to indicate that IR #219 must meet the same requirement to remain on-line during and following a fault.

13 Issues to be Addressed in SIS

The SIS must determine the facilities required to operate this facility at full capacity, withstand the 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 be conducted in accordance with the RGIP with all appropriate higher-queued projects included in the SIS study base case as well as identified Network Upgrades associated with those higher-queued projects.

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 assessment will consider but not be limited to the following. The facility additions/changes required to increase NSPI east to west transfers under system normal conditions (all transmission in) over the range of NSPI loads and with interruptible loads on or off. Some of the constrained interfaces that will be included in the assessment are as follows.

1. Cape Breton Export
2. Onslow Import
3. Onslow South
4. Metro reactive reserve requirements
5. NS – NB export/import

Steady-State Post-contingency Analysis

All elements within acceptable voltage and thermal limits under the following single contingencies, in accordance with NPCC[5] and NERC[6] criteria

1. L-6517
2. L-6518
3. 2C-Port Hastings 138kV bus outage
4. L-8004
5. Hopewell transformer 79N-T81
6. L-8003
7. Circuit breaker 67N-812 (L-8002 plus L-8003)

System stability for the following faults

Loss of any element without a fault

1. L-8004
2. Hopewell transformer 79N-T81
3. L-8003

[5] NPCC criteria are set forth in it's Reliability Reference Directory #1 *Design and Operation of the Bulk Power System*

[6] NERC transmission criteria are set forth in *NERC Reliability Standards TPL-001, TPL-002, TPL-003*

Three-phase fault cleared in normal time:
1. L-6518 at 47C-NewPage
2. L-8004 at Woodbine end
3. L-8004 at Hopewell end
4. L-8003 at Onslow end
5. L-8003 at Hopewell end
6. 79N-T81 transformer at 345kV (trip L-8004 + L-8003)
7. L-8001 at import (NS islanded with under-frequency) and export limits

Single-phase to ground fault cleared in backup time (Breaker Failure)
1. L-8003 at Onslow with failure of 79N-803 (lose L-8004)
2. L-8003 at Onslow with failure of 67N-811 (lose 67N-T82)

Single-phase to ground fault on separated circuits of double-circuit tower:
1. L-7003 plus L-7004 at Canso Causeway
2. L-7005 plus L-8004 at Strait of Canso crossing.

Aside from the required change to the Strait Area Overload Protection SPS, 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 and NPCC criteria as well as NSPI guidelines and good utility practice. The SIS will also determine the contingencies for which this facility must be curtailed.

The SIS will calculate the unit loss factor, which is a measure of the percentage of the net output of IR #219 which is lost through the transmission system. Preliminary value is calculated to be 11.5% (system losses increase by 7.4 MW when IR #219 is operated at 64 MW.

Nova Scotia Power
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