Interconnection Feasibility Study Report

GIP-223-FEAS-R3

System Interconnection Request #223

16 MW Biomass-Gasification Generating Facility

Cape Breton County (2S)

2010 07 29

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer submitted a Network Resource Interconnection Service (NRIS) Interconnection Request to NSPI for a proposed 16 MW biomass gasification-fired steam generating facility in Cape Breton County, and subsequently requested that it also be concurrently studied as an Energy Resource Interconnection Service (ERIS) Interconnection Request. The generation facility is proposed to be interconnected to the NSPI 138kV transmission system at the existing substation 8S-Sysco South. However the existing load at 8S substation will be removed soon and the associated facilities will subsequently become the Transmission Provider's Interconnection Facilities, which will be solely used by the Interconnection Customer; therefore the Point of Interconnection will be on the 138kV bus at 2S-Victoria Junction substation.

No concern regarding short-circuit or voltage flicker was found for this project on its own, provided that the project design meets NSPI requirements for low-voltage ride-through, reactive power range and voltage control system. Harmonics must meet the Total Harmonics Distortion provisions of IEEE 519.

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

The loss factor for IR #223 is approximately 10.6%.

The preliminary non-binding estimated cost of facilities required to interconnect the IR#223 generating facility to the NSPI transmission system is $572,000 including a contingency of 10%. This non-binding estimate is valid for both NR and ER Interconnection Service and will be further refined in the System Impact Study and the Facility Study.

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1 Introduction

The Interconnection Customer (IC) submitted an Interconnection Request for Network Resource Interconnection Service (NRIS) to NSPI for a proposed 16 MW biomass gasification-fired generating facility in Cape Breton County, and subsequently requested that it also be concurrently studied as an Energy Resource Interconnection Service (ERIS) Interconnection Request. The generation facility is proposed to be interconnected to the NSPI 138kV transmission line L-6540 at the existing 8S- Sysco South substation, and will utilize the existing transformer 8S-T20 at 8S-Sysco South substation. Both NRIS and ERIS were studied for this generating facility.

The Interconnection Customer signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI transmission system, dated 2010-05-21, and this report is the result of that Study Agreement. This project is listed as Interconnection Request #223 in the NSPI Interconnection Request Queue, and will be referred to as IR#223 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 3.2.2.2 of the Standard Generation Interconnection Procedures, as approved by the UARB on February 10, 2010 (RGIP), the Interconnection Study for NR Interconnection Service shall assure that the Interconnection Customer's Generating Facility meets the requirements for NRIS and as a general matter, that such Generating Facility's interconnection is also studied with the Transmission Provider’s Transmission System at peak load, under a variety of severely stressed conditions, to determine whether, with the Generating Facility at full output, the aggregate of generation in the local area can be delivered to the aggregate of load on the Transmission Provider’s Transmission System, consistent with the Transmission Provider’s reliability criteria and procedures.

In accordance with Section 3.2.1.2 of the RGIP, the FEAS for ERIS consists of short circuit/fault duty, steady state (thermal and voltage) analyses. The short circuit/fault duty analysis would identify direct Interconnection Facilities required and the Network Upgrades necessary to address short circuit issues associated with the Interconnection Facilities. The steady state studies would identify necessary upgrades to allow full output of the proposed Generating Facility and would also identify the maximum allowed output, at the time the study is performed, of the interconnecting Generating Facility without requiring additional Network Upgrades. It is therefore assumed that transmission interfaces limits will not be exceeded to avoid system upgrades in an ERIS study.

A more detailed analysis of the technical implications of this development will be included in the System Impact Study (SIS) report. The SIS 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 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. Network Resource Interconnection Services type plus concurrently study as Energy Resource Interconnection Service type per Section 3.2 of the RGIP.
2. 16 MW biomass-gasification with two 8 MW synchronous generators.
3. The IC proposed that the POI is on L-6540 terminal at 8S- Sysco South substation. However the existing load fed from 8S substation will be removed soon and therefore L-6540 will be solely used by the IC generating facility as a Transmission Provider's Interconnection Facilities. As such the POI will be on the 138kV bus at 2S-Victoria Junction.
4. The generation technology used must meet NSPI requirement for reactive power capability of 0.95 capacitive to 0.95 inductive at the 2S-Victoria Junction 138kV bus. The generators are specified for 8 MW each at a rated power factor of 0.80. It is also

required to have high-speed Automatic Voltage Regulation to maintain constant voltage at the generator terminals during and following system disturbances.

5. The biomass-gasfication generating facility will be connected to the 8S-Sysco South substation by approximately 500m of 23kV cable and a low voltage generator circuit breaker.
6. The IC proposes to use the existing transformer 8S-T20 at Sysco South substation (customer owned) as the step-up transformer, and so the modeling was conducted using a 138kV-23kV 30/40/50 MVA transformer with a positive sequence impedance of 9.2%. It was indicated that the step-up transformer has a grounded wye (HV) – grounded wye (LV)-delta (TV) winding configuration.
7. The FEAS analysis is based on the assumption that IR's higher in the Generation Interconnection Queue (Queue) that have completed a System Impact Study, or that have a System Impact Study in progress will proceed; As such, IR#8, IR #45, IR#56, IR #82, IR #114, IR #141 and IR#151 are included in this study.

4 Projects with Higher Queue Positions

All in-service generation is included in the FEAS.

As of 2010-07-29 the following projects are higher queued in the Interconnection Request Queue, and have the status indicated.

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

- IR #8 GIA in progress
- IR #45 Unexecuted GIA filed
- IR #56 FAC in progress
- IR #82 GIA executed
- IR #114 GIA executed
- IR #141 GIA executed
- IR #151 SIS 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 #219	IR #222	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 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 cost of interconnecting the 16MW 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 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 NPCC and/or NERC or required to maintain system stability. These requirements will be determined by the subsequent interconnection System Impact Study (SIS).

6 Short-Circuit Duty

The maximum (design) expected short-circuit level 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 #223 in service	IR #223 not in service
All transmission facilities in service		
2S-Victoria Junction 138kV (POI)	2231	2170
8S-Sysco South 138kV	1641	1579
Minimum Conditions		
2S-Victoria Junction 138kV (POI)	1687	1626

(1) Classical fault study, flat voltage profile. Machine X'_d=0.226

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

The maximum short-circuit level at the POI is presently 2170 MVA. After installing IR #223 the increase will bring the short-circuit level to 2231 MVA at the POI. Under contingency operation with IR#223 in service, with two of the four existing generators at 88S-Lingan and the generator at 89S-Point Aconi off-line and with L-7011 open at 88S-Lingan, the short-circuit level will be approximately 1687 MVA at the POI. This translates into a maximum equivalent system impedance at the POI of 0.059 per unit on 100 MVA base.

The interrupting capability of 138kV circuit breakers in the vicinity of 2S-Victoria Junction is at least 3500 MVA which will not be exceeded by the addition of IR #223.

7 Voltage Flicker and Harmonics

The generators are conventional synchronous machines therefore voltage flicker is not expected to be 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

L-6540 is a radial transmission line feeding 8S-Sysco South from 2S-Victoria Junction. It is constructed with 556 kcm Dove ACSR conductor designed for maximum operating temperature of 100°C. The conductor has a thermal rating of 215 MVA summer and 242 MVA winter. Since the proposed biomass-gasification facility is rated at 16MW, there would be no thermal issue on L-6540.

Under existing system conditions, loss of L-6538 with both Wreck Cove hydro units at full load results in exceeding the summer rating of L-6537 by up to 37%, and loss of L-6537 results in L-6538 and L-6539 overloaded with both Wreck Cove units at full load. A similar overload condition exists for loss of either of the Glen Tosh to Wreck Cove 138kV circuits L-6545 or L-6549. This overload occurs in spite of the activation of the Special Protection Systems (SPS)[2] SPS #193 which is used to run-back the Wreck Cove units if any of the contingencies occur. The potential impact on the existing SPS arising by IR#223 will be further addressed in the SIS study.

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.

[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.*

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 2S-Victoria Junction substation, at all production levels up to the full rated load of 16 MW. The generator must be equipped with a high-speed continuously-acting automatic voltage regulator set to control its 23 kV terminals to a value established by the NSPI System Operator, while the On-Load Tap Changer (OLTC) mechanism of 8S-T20 should be disabled. 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.

With the proposed generator step-up transformer impedance of 9.2% on 30 MVA, and the rated generator power factor of 0.80 measured at the machine 4.16kV 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 #223 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 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 able to 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 #223:

Additions/Changes at 2S and 8S substation

1. Line L-6540 terminal reconfiguration and 138kV switchgear removals at 8S substation.
2. Protection system additions for L-6540.
3. Control and communications between the POI switching station and NSPI SCADA system (to be specified).

Requirements for the Interconnection Customer's Generating Facility

1. One new 138kV circuit breaker at 8S-Sysco South 138kV bus[3],
2. 138kV Disconnect Switch between L-6540 line termination and Interconnection Customer's 138 kV circuit breaker,
3. Facilities to provide 0.95 leading and lagging power factor when delivering rated output (16 MW) all at the 138kV bus when the voltage at that point is operating between 95 and 105 % of nominal.
4. Centralized controls. These will provide centralized voltage set-point controls to control the 23 kV 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. 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.
5. 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.
6. Low voltage ride-through capability equivalent to FERC Order 661a[4] .
7. Real-time monitoring (RTU) of the interconnection facilities for NSPI to execute high speed rejection of generation (transfer trip).

[3] 23kV cable and generator step-up transformer 8S-T20 are not included in this estimate.

[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 #223 must meet the same requirement to remain on-line during and following a fault.

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	Protection, control, communication	$500,000
ii	L-6540 terminal reconfiguration and 138kV switchgear removals	$20,000
Network Upgrades		
	None	
Totals		
iii	Contingency (10%)	$52,000
	Total of Determined Cost Items	$572,000
	To be Determined Costs	
iv	System additions to address potential stability limits	TBD (SIS)

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

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 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 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-6537
2. L-6538
3. L-6539
4. L-6516
5. L-7012&7014
6. 2S-Victoria Junction 138kV bus outage
7. L-8004
8. Strait Canso L-8004&7005
8. Hopewell transformer 79N-T81
9. L-8003
10. 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

Three-phase fault cleared in normal time:
1. L-6537 at 5S-Glen Tosh
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

[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*

2. L-7005 plus L-8004 at Strait of Canso crossing.

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 #223 which is lost through the transmission system. Preliminary value is calculated to be 10.6% (system losses increase by 1.7 MW when IR #223 is operated at 16 MW.

Nova Scotia Power
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