Interconnection Feasibility Study Report

GIP-222-FEAS-R3

System Interconnection Request #222

48 MW Steam Generating Facility

Pictou County (53N)

2010 07 30

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The interconnection Customer submitted a Network Resource Service Interconnection Request (NRIS) to NSPI for a proposed 48 MW steam generating facility in Pictou Couty, and this generating facility will be the replacement for the existing 25MW generator in the customer plant at 53N-Northern Pulp. The power flow injected into NSPI transmission system via L-5508 will be 24.5 MW net of the load at the plant. When plant load is off-line, the net output of the generator will be 17.5 MW due to the reduction in steam supply.

The Point of Interconnection for the new generation will be the line L-5508 side of the existing 69 kV switch 53N-508A.

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.

L-5508 between 53N-Northern Pulp and 54N-Abercrombie Pt. is constructed with 2/0 Quail ACSR conductor designed for maximum operating temperature of 60°C. The conductor has a thermal rating of 28 MVA summer. However, the thermal rating of L-5508 is less than 28 MVA when the ambient temperature is higher than 25°C. Therefore an SPS will be installed to run-back the generator automatically to ensure the line rating not be exceeded for any purposes; Otherwise L-5508 should be uprated or re-built as an alternative to the curtailment SPS.

The loss factor for IR #222 is approximately 5.6%.

The preliminary non-binding estimated cost of facilities required to interconnect IR#222 to the transmission line L-5508 as NRIS is $671,000 if an curtailment SPS is installed, and it would be brought up to $924,000 with L-5508 being re-built. Both estimated costs include a contingency of 10%. The non-binding estimates 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 Network Resource Interconnection Service (NRIS) to NSPI for a proposed 48 MW steam generating facility in Pictou County. The generating facility will be interconnected to the NSPI transmission system via the 53N-Northern Pulp substation and will be the replacement for the existing 25MW generator in customer's plant.

The Interconnection Customer signed a Feasibility Study Agreement to study the connection of their proposed generating facility to the NSPI transmission system, dated 2010-06-23, and this report is the result of that Study Agreement. This project is listed as Interconnection Request #222 in the NSPI Interconnection Request Queue, and will be referred to as IR#222 throughout this report.

2 Scope

The Interconnection Feasibility Study (FEAS) consists of a power flow and short circuit analyses. 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 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 NR Interconnection Service 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.

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. Network Resource Interconnection Service type.
2. 48 MW steam generation utilizing a synchronous generator.
3. The Point of Interconnection is located at the line L-5508 side of the existing 69kV switch 53N-508A.
4. The generation technology used must meet NSPI requirement for reactive power capability of 0.95 capacitive to 0.95 inductive at the Point of Interconnection (POI). The generator is specified as 48 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 disturbances.
5. Preliminary data was provided for the generator step-up transformer. Modeling was conducted using a 69kV-13.8kV 60/67 MVA transformer with an assumed positive sequence impedance of 8%. It was indicated that the step-up transformer has a grounded wye (HV) - delta (LV) winding configuration.
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 #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 #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 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 cost of interconnecting the 48 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 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 69kV systems. The short-circuit levels in the area before and after this development are provided below in Table 6-1.

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

Location	IR #222 in service	IR #222 not in service
All transmission facilities in service		
53N 69kV Bus (POI)	874	652
54N-Abercrombie Pt. 69kV	932	722
50N-Trenton 69kV	1292	1119
Minimum Conditions		
53N 69kV Bus (POI)	838	616

(1) Classical fault study, flat voltage profile. Machine X'_d=0.158

The maximum short-circuit level at the POI is presently 652 MVA. After installing IR #222 the short-circuit level will increase to 874 MVA at the POI. Under summer light load conditions with certain generation units offline, the short-circuit level will be approximately 838 MVA at the POI with IR#222 on line. This translates into a maximum equivalent system impedance at the POI of 0.119 per unit on 100 MVA base.

The interrupting capability of 69kV circuit breaker is 2000MVA at 50N-Trenton and 2500 MVA at 54N-Abercrombie Pt. and therefore they will not be exceeded by this development on its own.

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

NSPI does not have a record of the capability of the switchgear (53N-508) in the Interconnection Customer's plant, and therefore the impact of the above noted increase in fault level should be reviewed by the IC.

7 Voltage Flicker and Harmonics

The generator is a conventional synchronous machine 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

The total generation output of the existing generator in Northern Pulp plant is 25 MW which supplies the 23.5 MW load in that plant. The proposed 48 MW generating facility will replace the existing generator, and therefore the power flow injected into NSPI transmission system via L-5508 will be 24.5 MW net of the load at the plant, When plant load is off-line, the net output of the generator will be 17.5 MW due to the reduction in steam supply.

L-5508 between 53N-Northern Pulp and 54N-Abercrombie Pt. is constructed with 2/0 Quail ACSR conductor designed for maximum operating temperature of 60°C. The conductor has a summer thermal rating of 28 MVA (based on an average ambient temperature 25°C) and a winter rating of 37 MVA (based on an average ambient temperature 5°C). However, the thermal rating of L-5508 is less than 28 MVA when the ambient temperature is higher than 25°C. If there is a drop in plant load that results in the net generation increasing above the nominal amount of 24.5 MW, the rating of L-5508 could be exceeded. It is recommended that a Special Protection System (SPS)[2] be installed to run-back the generator automatically to ensure the line rating not be exceeded for any purposes, otherwise L-5508 should be re-built or uprated.

L-5502 is primarily used to supply the load in the Pictou Area from 50N-Trenton to 54N-Abercrombie Point. It is constructed with 336 ACSR Linnet conductor designed for a maximum operating temperature of 50°C and a summer thermal rating of 41 MVA and a winter rating of 61 MVA (based on ambient temperatures of 25°C and 5°C respectively). Under summer light load condition with IR#222 at full generation of 48MW, loss of the plant load could cause the flow on L-5502 to rise to 43.5 MW (48 MW minus local load in the Pictou area) before the generator is curtailed. The conductor temperature could exceed 50°C in a very short period of time (4 to 6 minutes). Therefore the generation must be re-dispatched quickly enough to avoid causing any permanent damage of the

[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.*

conductors; otherwise the NSPI System Operator will execute the high speed rejection of the generation via a transfer trip. The SPS discussed with respect to L-5508 will provide the required generation reduction functionality. It should be noted that any SPS must be reviewed and approved by NPCC.

The present setting for the SPS #120 associated with the loss of the double-circuit Strait of Canso crossing (loss of L-8004 and L-7005) requires tripping one Lingan unit when Cape Breton Export (CBX) exceeds 500 MW and two Lingan units when ONI exceeds 875 MW. The addition of flow due to IR#222 (up to 25 MW) would cause L-7019 to approach (but not exceed) its thermal limit under contingency when CBX is operating close to 500 MW with the loss of the double-circuit Strait of Canso crossing. The potential impact on the existing SPS arising from IR#222 will be further 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 high voltage terminals of the POI, at all production levels up to the full rated load of 48 MW. The generator must be equipped with a high-speed continuously-acting automatic voltage regulator set to control its 13.8 kV 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.

With the assumed generator step-up transformer impedance of 8% on 60 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 NSPI System Operator must have manual and remote control of the voltage set-point and the reactive power set-point of this facility to coordinate reactive power dispatch requirements. Manual control would likely be in the form of phone contact between the NSPI System Operator and the IC operator.

10 System Security / Stability Limits

In general, the SIS will determine if any facility changes are required to permit the proposed increase to 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 #222:

Additions/Changes to POI:

1. L-5508 line tap re-built.
2. Protection system modifications.
3. Control and communications between the generating facility and the NSPI SCADA system (to be specified).

Requirements for the Generating Facility (Preliminary)

1. The IC must ensure that the short circuit capability of the existing 69kV circuit breaker (53N-508) is not exceeded by the addition of the new generator.
2. Revenue metering upgrades and in-plant protection modifications.
3. Facilities to provide 0.95 leading and lagging power factor when delivering rated output (48 MW) at the 69 kV 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 13.8 kV bus voltage. Responsive (fast-acting) controls are required. The controls are to 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. If the generating facility is to have a full-time operator (24/7), the voltage control function can be communicated manually.
6. Low voltage ride-through capability equivalent to FERC Order 661a[3] .
7. Real-time monitoring (RTU) of the interconnection facilities for NSPI to execute high speed rejection of generation (transfer trip).

Note: To permit the load to be isolated with the generator during plant maintenance, two additional circuit breakers for the interconnection are required in the plant.

12 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

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

[3] 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 #222 must meet the same requirement to remain on-line during and following a fault

Table 12-1: Cost Estimates identified from FEAS Scope		
	Determined Cost Items	**Estimate**
NSPI Interconnection Facilities		
i	Re-built L-5508 Line Tap at 53N substation	$10,000
Network Upgrades		
ii	Protection, control, communication	$500,000
iii	Curtailment SPS Design and Installation	$100,000
Totals		
iv	Contingency (10%)	$61,000
	Total of Determined Cost Items	$671,000
	To be Determined Costs	
v	System additions to address potential stability limits	TBD (SIS)

Note: For item iii if L-5508 is uprated or re-built as an alternative to the curtailment SPS, the cost will be $330,000 instead; therefore the total preliminary non-binding estimated cost would be $924,000 including a contingency of 10%.

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 cases 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. Onslow Import
2. Onslow South
3. Metro reactive reserve requirements
4. NS – NB export/import

13.1 Steady-state post-contingency analysis

All elements within acceptable voltage and thermal limits under the following single contingencies, in accordance with NPCC[4] and NERC[5] criteria

i. L-8004
ii. Hopewell transformer 79N-T81
iii. L-8003

13.2 System stability for the following faults

Loss of any element without a fault

i. L-8004
ii. Hopewell transformer 79N-T81
iii. L-8003

Three-phase fault cleared in normal time:

i. L-8003 at Onslow end
ii. L-8003 at Hopewell end
iii. L-8001 at import and export limits
iv. 1N-B61 (for 138kV option at export limits)

Single-phase to ground fault cleared in backup time (Breaker Failure)

i. L-8003 at Onslow with failure of 67N-812 (lose L-8002)

Single-phase to ground fault on separated circuits of double-circuit tower:

i. L-8004 plus L-7005 at Canso Crossing
ii. L-7003 plus section of L-7004 at Trenton

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

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

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 #222 which is lost through the transmission system. Preliminary value is calculated to be 5.6% (system losses increase by 1.4 MW when IR #222 is operated at 48 MW).

Nova Scotia Power
2010 07 30