Interconnection Feasibility Study Report
GIP-428-FEAS-R1

Generator Interconnection Request 428
1.0 MW Hydro Generating Facility
Queens County, NS

April 30, 2013

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer submitted a Network Resource Interconnection Request, IR#428, to Nova Scotia Power Inc. (NSPI) for a proposed 1 MW hydro generation facility interconnected to the NSPI system via the 69kV transmission line L-5532 at 7W-Harmony substation.

This project does not cause any concern regarding short-circuit level.

Existing NSPI transmission in the East Valley and West is not designed for maximum dispatch of all local generation under all possible system conditions. Under light load and high ambient (summer) temperature conditions, generation is dispatched to maintain system reliability. Currently, hydro generation is curtailed during certain stressed conditions to prevent overloading during system normal and single contingencies. Therefore, any new generation in the area should have the capability to be curtailed to maintain system reliability.

IR#428 must be equipped to provide 0.95 leading and lagging power factor when delivering rated output (1 MW) at Point of Change of Ownership when the voltage at that point is operating between 95% and 105% of nominal voltage.

The preliminary non-binding estimated cost of facilities required to interconnect the IR#428 to L-5535 under Network Resource Interconnection Service (NRIS) is $6.5 Million including a contingency of 10%. This estimate will be further refined in the System Impact Study and the Facility Study. This upgrade to L-5535 would not be required under Energy Resource Interconnection Service (ERIS).

The SIS will determine any costs or upgrades that may be required based on the assumption that all committed projects ahead of this project in the Queue will proceed.

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1 Introduction

The Interconnection Customer submitted an Interconnection Request (IR) for Network Resource Interconnection Service (NRIS) to Nova Scotia Power Inc. (NSPI) for a proposed increase of 0.5 MW at the hydro Generation Facility interconnected to the NSPI system via 69kV substation 7W-Harmony. The existing facility rating is 0.5 MW. The Interconnection Customer signed a Feasibility Study Agreement to study the connection of their proposed generation to the NSPI transmission system. This report is the result of that Agreement. The generation site would be located in Queens County, and would connect to 7W-Harmony, which is supplied via L-5532 by 1.6 km of 69 kV line from 58W-Harmony Hydro. This project has been designated IR#428 and is referred to as such throughout this report.

2 Scope

The Interconnection Feasibility Study (FEAS) report provides the following information:

i. Preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the interconnection

ii. Preliminary identification of any thermal overload or voltage limit violations resulting from the interconnection

iii. Preliminary description and non-binding estimated cost of facilities required to interconnect the Generating Facility to the NSPI Transmission System, the time to construct such facilities, and to address any identified short circuit and power flow issues

The Scope of this FEAS includes modeling the power system in normal state (with all transmission elements in service) under anticipated load and generation dispatch conditions. The FEAS will provide a preliminary high level estimate of the direct interconnection costs if upgrades are needed for NRIS.

A more detailed analysis of the technical implications of this development will be included in the System Impact Study (SIS) report. This may include system stability analysis, single contingencies, off-nominal frequency operation, off-nominal voltage operation, low voltage ride through, harmonic current distortion, harmonic voltage distortion, system protection, special protection systems (SPS), automatic 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 additional costs and upgrades that were not identified in this FEAS.

A separate Facilities Study will follow the SIS in order to ascertain the final cost estimate for the transmission upgrade requirements. The GIP permits combining the SIS and FAC studies in order to expedite small projects and NSPI will consider performing a combined study in this case upon request by the Interconnection Customer.

3 Assumptions

The Point of Interconnection and configuration studied is as follows:

i. Generator has been modeled as a synchronous machine with a transient reactance of 20% (1.25 MVA base) for short circuit calculations.

ii. Generator transformer impedance assumed at 6 % on ONAN Base (rated 1.5 MVA)

iii. The results of the analysis in this FEAS are based on the assumption that IRs higher in the Generation Interconnection Queue will not proceed, but the impacts of higher Queued IRs are reviewed qualitatively.

4 Projects with Higher Queue Positions

All in-service generation is included in the FEAS.

As of 2013-04-05 the following committed Transmission projects are higher queued in the Interconnection Request Queue and OATT Transmission Service Queue, and have the status indicated.

Committed Transmission Generation projects with a higher Queue position
IR 008 Wind – Guysborough, L-5527B, 15 MW – GIA Executed
IR 056 Wind – Cumberland, L-5058, 60 MW – GIA Executed
IR 219 Biomass – Richmond, 47C, 64 MW – Under Construction
IR 227 Biomass – Hants, L-4048, 10.2 MW – GIA Executed
IR 372 Wind – Lunenburg, L-6004, 24 MW – SIS completed
IR 379 Wind – Lunenburg, L-6004, 78 MW – SIS completed

In addition, there are 158MW of committed distribution connected projects ahead of IR 428 in the Queue that are distributed across the province of Nova Scotia.

All of the above projects can have a direct impact on this project for issues related to the management of the inter-provincial and inter-regional ties and on balancing the NSPI system.

This FEAS is based on the assumption that the above listed projects that are ahead of this project in the Queue are in-service. The FEAS determines any resulting upgrades/requirements. Should any of the committed transmission projects ahead of this

project in the Queue be withdrawn or changed, this FEAS or any SIS for this project may need to be updated according to the Standard Generator Interconnection Procedures (GIP), at the expense of the IC which is withdrawn or changed.

5 Short-Circuit Duties

The maximum (future) expected short-circuit levels on NSPI 138kV and 69kV systems are 5000MVA and 3500MVA respectively. The short-circuit levels in the vicinity of IR#428 before and after the development are provided in Table 5-1.

Table 5-1: Short-Circuit Levels. Three-phase MVA [(1)]

Location	Post IR#428	Pre IR#428
All transmission facilities and generation in service		
7W-Harmony 69kV (POI)	212	208
13V-Gulch 69 kV	331	329
3W-Big Falls	437	435
7W-Harmony 4 kV	22	10
Minimum Conditions (L-5532 Open at 3W-Big Falls)		
7W-Harmony 69kV (POI)	98	92

(1) Classical fault study

In determining the maximum short-circuit levels with this generating facility in service the generator has been modeled as a synchronous machine with the typical reactance (20% transient) of a hydro generator. The SIS will refine the fault level based on the actual machine characteristics.

The maximum short-circuit level on the 69 kV bus at 7W-Harmony is presently 208 MVA. After connecting IR#428, the short-circuit level will increase to 212 MVA at the POI. Similarly, with line L-5532 supplied radially from 13V-Gulch, the minimum short-circuit level will be approximately 98 MVA at the POI.

The interrupting capability of the 69kV circuit breakers at 3W-Big Falls and at 13V-Gulch is at least 2000 MVA. The increase fault level will be insignificant and not a cause for concern for circuit breakers. However, the existing fuses that protect the generator transformer may need to be replaced to co-ordinate with the line protection from 13V-Gulch and 3W-Big Falls. Existing fuses are capable of carrying the increased capacity but may not be fast enough for the increased fault level caused by the lower impedance transformer. Protection co-ordination will be studied in the SIS.

6 Thermal Limits

This facility will be interconnected to the NSPI 69kV transmission system at the existing 7W-Harmony substation, which is connected to line L-5532 at the 58W-Harmony Hydro switching station by 1.6 km of transmission line. L-5532 connects the Western Valley system to the Mersey system.

IR#428 did not cause any concern for winter peak base case during the contingencies studies in the western valley area. However, the more stressed case in this area occurs during spring when the hydro generation is high during light load and the ambient temperature is also high.

When all hydro, wind and tidal generation in the valley are generating at the maximum rated capacity, line L-5535 would be marginally overloaded above its summer rating (23 MVA) prior to the installation of IR#428. Under such circumstances, operator has to curtail hydro generation to keep the flow below the limits.

Following the contingency of loss of line L-5541 or bus 50W-B2, line L-5535 will overload to above 110% of its summer rating. This overload concern is possible even without 98V-Gullivers Cove Wind Farm production. In such cases, SPS action will not provide any relief to the overload. IR#428 will increase the flow on L-5535 by around 1% following this contingency. Existing generation in the valley will be manually curtailed by the operator once L-5535 overload is detected before the line trips itself. Therefore, any new generation in the West Valley and Mersey Hydro System should be equipped with the facility to enable it to be curtailed. Otherwise L-5535 must be upgraded.

7 Voltage Control

The facilities included with this installation must be such that the facility is capable of providing both lagging and leading power factor of 0.95, measured at the 69kV Point of Change of Ownership, when the facility is delivering 1 MW at the Point of Change of Ownership. A continuously acting AVR (Automatic Voltage Regulator) will be required which adjusts generator reactive power output and regulates the voltage on the machine terminals. The AVR must be responsive to voltage deviations and be equipped with a voltage set-point control. Details of the specific control features, control strategy and setting will be reviewed and addressed in the SIS.

This facility must be able to stay on-line for a transmission fault that does not isolate the machine. The SIS will state specific options, controls and additional facilities that are required to achieve this.

8 System Limitations (System Security)

The SIS will determine any facility changes required to maintain compliance with NERC/NPCC standards for good utility practice.

9 Expected Facilities Required for Interconnection

Based on the above discussion, this project is feasible at the requested capacity, subject to the results of the SIS. It is expected that the following facilities will be required for operation under system normal conditions, assuming that the committed transmission and distribution projects ahead of this project in the Queue proceed.

In order for IR#428 to proceed as NRIS and to operate at full capacity without any curtailment during certain stressed system conditions, L-5535 must be upgraded. Currently, the maximum operating temperature for L-5535 is 50° C providing a capacity of 23 MVA at 25° C. Upgrading L-5535 to 70° C will increase the summer rating to 31 MVA.

Generator transformer high side fuses may or may not need to be replaced to co-ordinate with the protection devices on the line terminal of L-5532. This will be confirmed in the SIS. There are no other additions/changes needed to the Transmission Provider's Interconnection Facilities.

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

i. Facilities to provide 0.95 leading and lagging power factor when delivering rated output (1 MW) at the Point of Change of Ownership when the voltage at that point is operating between 95% and 105% of nominal

ii. Low voltage ride-through capability for faults which do not isolate the generator

10 Magnitude of NSPI Interconnection Facilities Cost Estimate

Estimated cost for upgrading line L-5535 (65 km) to 70° C is $ 6,500,000. All costs of associated facilities required at the Interconnection Customer's substation and Generating Facility are in addition to the above estimate. This upgrade would not be required under ERIS.

11 Preliminary Scope of System Impact Study

The following provides a preliminary scope of work for the subsequent SIS. The SIS will include a more comprehensive assessment of the technical issues and requirements to interconnect generation as requested. In addition, this will include contingency analysis, system stability, ride through and operation following a contingency (N-1 operation). The SIS must determine the facilities required to operate this facility at full capacity, withstand any contingencies and identify any restrictions that must be placed on the system following a first contingency loss.

The SIS will confirm the options and ancillary equipment that the customer must install to control voltage and ensure that the facility has the required ride-through capability.

The following outline provides the minimum scope that must be completed in order to assess the impacts. It is recognized that the actual scope may deviate, to achieve the primary objectives.

The assessment will consider but not be limited to the following.

i. Facilities that the customer must install to meet the requirements of the GIP
ii. The minimum transmission additions/upgrades that are necessary to permit operation of this Generating Facility, under all dispatch conditions, catering to the first contingencies listed.
iii. Guidelines and restrictions applicable to first contingency operation
iv. System loss impacts
v. Underfrequency load shedding impacts
vi. Bulk Power System and Bulk Electric System Status

The SIS will be based on the cases listed in Table 11-1.

Table 11-1: Power Flow Base Case and Variations

Winter Peak	All Hydro, Wind and Tidal on
	Tidal off
Fall Peak	All Hydro, Wind and Tidal off
Spring Peak	All Hydro, Wind and Tidal on
Summer Peak	All Hydro, Wind and Tidal off
	Hydro off except Mersey system 50%, Tidal 100%
Summer Light Load	All Hydro, Wind and tidal off
	Hydro off except Mersey system 50%, Tidal 100%

To complete this assessment the following first contingencies, as a minimum, will be assessed:

- L-6004
- L-6012
- L-6013
- L-5025
- L-5026
- L-5531
- L-5532 (one terminal at a time)
- L-5535
- L-5541
- L-6024
- L-6021
- 51V-521 (taking out 51V-B51 and L-6013)
- 13V-516 (taking out 13V-B51 and L5026)
- 9W-500

To complete this assessment the dynamics of the following first contingencies, as a minimum, will be assessed:

- 3 phase fault on L-5025
- 3 phase fault on L-5531
- 3 phase fault on L-5532
- 3 phase fault on L-5541
- 3 phase fault on L-5535
- 3 phase fault at 3W-B53
- 3 phase fault at 13V-B51
- SLG fault on L-5531 with failure of 13V-511

After determining the changes/additions that are required to facilitate this interconnection "N-1" operation will be assessed. The objective is to determine the operating restriction or curtailments that must be enforced to ensure secure operation of the system. This

provides a thorough assessment to ensure that the facilities are adequate and the customer business risks are conveyed.

- Contingency analysis, as required
- Dynamic simulation, as required
- Determination of total generation to be constrained