Interconnection Feasibility Study Report

GIP-531-FEAS-R1

System Interconnection Request #531

20 MW Tidal Generating Facility

Cumberland County (37N-Parrsboro)

2015-01-29

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer submitted a Request to NSPI for a proposed generating facility of 20MW capacity connected to the 37N-Parrsboro substation (IR #531). The customer has requested Network Resource Interconnection Service with Energy Resource Interconnection Service studied concurrently, and with a planned in-service date of 2017-09-01.

Transmission line L-5550 serves to transmit power from the 30N-Maccan substation to the 37N-Parrsboro substation and is designed to 138kV specifications but operated at 69kV. Therefore, the new generating interconnection facilities should be built to 138kV standards to accommodate future system upgrades in this area.

During light system load and power import from New Brunswick of just under 100MW, loss of the 345kV line L-8001 between Onslow and Memramcook results in an overload of 138kV L-6513 from Springhill to Debert due to the additional 20MW generation from IR #531. As a result, there is presently no system capacity for IR #531 to operate as NRIS. However, Line L-6513 is scheduled for upgrade in 2018 as part of the Transmission Service Request (TSR) 400 project upgrades, which will eliminate the overload issue. Once the upgrades to L-6513 are complete, IR#531 would be able to operate as NRIS. Additional options for consideration are included in the report.

No other thermal loading violations were found under normal states and single contingency conditions. Additional requirements for potential system reinforcements will be determined in the System Impact Study.

No concern regarding short-circuit level or voltage control were 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. The harmonic level must be within the Total Harmonic Distortion provisions of IEEE 519.

Control and communication modifications will be required at NSPI and customer facilities, and include transfer trip signals from 30N-Maccan and 74N-Springhill substations and updated metering and protection on lines L-5550 (Maccan to Parrsboro) and L-5029 (Maccan to Aberdeen Street). As a result, protection schemes at these substations will also require upgrades.

Assuming that the committed higher queued projects shown on the Combined T/D Advanced Stage Interconnection Request Queue proceed as planned, the cost of interconnection for ERIS operation is estimated at $559,456.73. The cost of interconnection for NRIS operation after the planned line L-6513 upgrades are in place is also estimated at $559,456.73. The cost to advance the line L-6513 upgrades to allow NRIS operation by the proposed IR #531 in-service date will be determined in the System Impact Study if the Customer chooses to proceed with that option. Additional upgrades and costs may also be identified at the System Impact Study stage as a result of dynamic system analysis. These non-binding estimates will be further refined in the System Impact Study and the Facility Study (FAC).

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1 Introduction

The Interconnection Customer submitted a Network Resource Interconnection Service Interconnection Request to NSPI and also requested that Energy Resource Interconnection Service be studied concurrently. The request was for 20 MW of tidal generation to be connected via the 37N-Parrsboro substation with an in-service date of 2017-09-01. The generation substation will be located at 979 West Bay Road, Parrsboro, and is connected to the 37N-Parrsboro substation via an existing 3-phase 69kV line, approximately 10 km in length. The line is currently operated at 25 kV but is built to 138kV standards and is scheduled to be operated at 69 kV before the in-service date of this facility.

The Interconnection Customer signed a Feasibility Study Agreement to study the connection of their proposed generation facility to the NSPI transmission system, dated 2015-09-23, and this report is the result of that Study Agreement. This project is listed as Interconnection Request #531 in the NSPI Combined T/D Advanced Stage Interconnection Request Queue, and will be referred to as IR #531 throughout this report.

2 Scope

The Interconnection Feasibility Study (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 limit violations resulting from the interconnection;
3. Preliminary description and non-binding 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.

For Energy Resources Integration Service (ERIS), if the FEAS determines that transmission upgrades are required as a result of thermal overload, voltage violation, or equipment rating, then the FEAS will determine the amount of generation that can be installed without necessitating major transmission upgrades. The FEAS will provide a preliminary high level cost estimate of the direct interconnection costs.

For Network Resources Integration Service (NRIS), the FEAS will identify any transmission upgrades required as the result of thermal overload, voltage violation, or equipment rating. The FEAS will attempt to provide high level cost estimates for such upgrades and direct interconnection costs.

A more detailed analysis of the technical implications of this development will be included in the System Impact Study (SIS) report. This will include 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 additional costs and upgrades that were not identified in this FEAS. The SIS may require an appropriate computer model for study of the dynamic performance of the proposed facility.

A separate Facilities Study will follow the SIS in order to ascertain the final cost estimate for interconnection and any transmission upgrade requirements.

3 Assumptions

This FEAS analysis assumes that the committed higher queued projects shown on the Combined T/D Advanced Stage Interconnection Request Queue will proceed as planned; however, this project has a scheduled in service date that is earlier than others higher in the Queue. In particular, Transmission Service Request (TSR) - 400 which includes transmission and reliability upgrades for the Maritime Link project is scheduled to be in service in 2018, and this impacts the outcome of this FEAS. As such, the interconnection is studied both before and after TSR-400 is in service.

The Point of Interconnection (POI) and configuration studied is as follows:

- 20 MW tidal generation facilities with NRIS and ERIS service type.
- The generation technology used must meet the NSPI requirement for reactive power capability of 0.95 capacitive to 0.95 inductive at the high voltage terminals of the Interconnection Facilities. It is also required to provide high-speed Automatic Regulation to maintain constant voltage or constant power factor at either the high voltage or the low voltage (selectable) terminals of the Interconnection Facilities.
- The Generation Point of Interconnection is the 69 kV bus at 37N-Parrsboro substation.
- Transformer is assumed to be 69/34.5 kV with a base rating of 15 MVA and a top rating of 25 MVA, with a grounded wye (HV) – delta (LV) configuration. Transformer impedance is assumed to be 6% (on 15 MVA ONAN base). No tap changer information is yet available for this transformer.

4 Projects with Higher Queue Positions

All in-service generation is included in the FEAS.

As of 2016-01-29 the following committed projects are higher queued in the Combined T/D Advanced Stage Interconnection Request Queue, and have the status indicated.

Interconnection Requests ahead of IR #531 – Included in FEAS

- IR #497 Cumberland GIA Executed
- IR #516 Cumberland GIA Executed
- IR #517 Cumberland GIA Executed
- TSR-400 – L6513 Upgrades Scheduled for May 2018

Electrically Remote Interconnection Requests ahead of IR #531 – Not included in FEAS

- IR #227 Hants GIA Executed
- IR #461 Lunenburg GIA Executed
- IR #506 Yarmouth SIS complete
- IR #507 Digby FAC in Process

The FEAS will be based on the assumption that all the projects that are ahead of this project in the Queue, including certain Community Feed in Tariff (COMFIT) projects are in-service. Should any project that is ahead of this project be withdrawn, or changed, within the established GIP procedures, then the NSPSO may require that the SIS for this project be updated at the withdrawing Interconnection Customer's expense.

5 Objective

The objective of this feasibility study is to determine the primary physical requirements to interconnect 20 MW of generation 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. Potentially significant contingencies regarding SPS operation during import and export scenarios are studied based on the electrical location of the proposed 20 MW generation.

This FEAS does not produce a binding estimate of all costs and changes that may be required to interconnect the facility. The costs in this study are limited to facility additions/changes that are in the immediate vicinity of the proposed generating facility and any other system costs that are foreseen at the time this report is completed.

This assessment 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 Electric 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 (future) expected short-circuit level on 69kV systems is 3500 MVA. Inverter-based generation systems, such as the system proposed in this FEAS, do not contribute significant short circuit current greater than the steady-state full load current. Based on this information, there should be no specific issues regarding short circuit levels due to the addition of this generating facility.

Any short circuit level increase will not be significant enough, from an equipment rating perspective, to warrant equipment upgrades. However, the addition may cause protection coordination issues and that may require protection upgrades and communications additions to resolve. The protection additions and changes necessary to resolve coordination issues will be studied in the SIS and FAC.

7 Voltage Flicker and Harmonics

Due to insufficient information on the generator model, voltage flicker is not available within this report. However, because the short-circuit level at the POI under system normal condition is not adversely affected, there should be no specific issues regarding voltage control and power quality due to the addition of this facility alone.

The generator is expected to meet IEEE Standard 519 limiting Total Harmonic Distortion (THD) (all frequencies) to a maximum of 5%, with no individual harmonic exceeding 1%.

8 Thermal Limits

The 69kV line L-5550 serves to transmit power from 30N-Maccan to the substation at 37N-Parrsboro. L-5550 is currently rated 54/82 MVA (summer/winter) and the ratings are limited by conductor size although the present setting of the protective relaying limits this line to less than 29 MVA. The addition of this facility alone will not result in any thermal overloads on this line, although the protective relaying limits will require modification to increase the limit above 29 MVA.

Line L-5029 connects the 74N-Springhill substation with the 30N-Maccan substation. L-5029 is currently rated 31/45 MVA (summer/winter) and the ratings are limited by conductor size although the present setting of the protective relaying and metering limits this line to less than 29 MVA. The addition of this facility alone will not result in any

thermal overloads on this line, although the protective relaying and metering limits will require modification to increase the limit above 29 MVA.

The substations at 30N-Maccan and 74N-Springhill contain one 138/69 kV transformer each. These transformers have maximum thermal ratings of 56 MVA and both serve local distribution loads as well as the 69 kV system. To provide service reliability to customers in the areas of Pugwash, Oxford, Springhill and Amherst the 138/69 kV transformers at 74N-Springhill and 30N-Maccan provide alternate sources for the 69 kV system in the event that one transformer should fail or have to be removed from service for maintenance. The addition of this facility alone will not result in any thermal overloads while operating with either transformer out of service.

NSPI is connected to New Brunswick Power using three tie lines: L-8001 operated at 345 kV and L-6535 & L-6536 operated at 138 kV. Line L-6513 operated at 138 kV connects 74N-Springhill to 1N-Onslow. Hence, L-6513 is a crucial line during high transfers between the two utilities. It is noted in this FEAS that during light system load conditions (system load less than 1000 MW) where NSPI is importing close to 100 MW from NBP with the Import Power Monitor SPS not armed, the loss of L-8001 results in a thermal overload of L-6513 due to the addition of this generating facility. L-6513 is currently rated 110/165 MVA (summer/winter). In order to avoid this issue, the following options are presented:

- Postpone the planned in-service date for the project until 2018-06-01 or any date after L-6513 upgrade is completed as a part of TSR-400 project. TSR-400 includes line upgrades to L-6513 which are scheduled for May 2018. After the line upgrade is completed, IR #531 generation will not result in thermal overload.
- The customer may pay financing costs in order to complete L-6513 upgrades ahead of schedule to coincide with the in-service date of this generating facility. Extra costs will depend on the availability of resources to complete the work ahead of schedule and will be determined in the SIS if the Interconnection Customer chooses to pursue this option.
- Operate as a 20 MW ERIS facility, and submit a new application for NRIS after the TSR-400 upgrades have been completed.

The requirement for restrictions or curtailments of this facility when operating with an element (transmission line, transformer, bus 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 69kV bus of the transmission providers interconnection facilities, at all production levels up to the full rated load of 20 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

69kV bus voltage. The voltage controls must be responsive to voltage deviations at the connection point, be equipped with a voltage set-point control, and also have facilities that will slowly adjust the set-point over several minutes (5-10) to maintain reactive power within the individual generators capabilities. Details of the specific control features, control strategy and settings will be reviewed and addressed in the SIS.

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 have low-voltage ride-through capability in accordance with FERC Order 661-A. The SIS will examine the generator/plant capabilities and controls in detail and will specify any options, controls and additional facilities that are required to achieve low-voltage ride-through.

10 System Security / Stability Limits

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

11 Expected Facilities Required for Interconnection

There are no additions/changes required to NSPI facilities for IR#531 to operate as ERIS provided network upgrades associated with higher queued projects IR#516 and IR#517 are completed. Should these two projects not proceed, then any related upgrade costs would become the responsibility of IR #531 which is $1,759,882. The costs estimate includes Transmission Provider Interconnection Facilities (TPIF) cots and the Network Upgrade Costs (NU) broken down as follows:

TPIF: $1,484,882.
NU: $275,000.
For IR#531 to proceed as NRIS service with the proposed in-service date, upgrades to Line L-6513 must be completed.

Requirements for the Generating Facility

1. 138 kV Interconnection Substation (operating as 69kV). This will include a circuit switcher at high side of customer power transformer and protections as acceptable to NSPI. An RTU to interface with NSPI's SCADA, with telemetry and controls as required by NSPI.
2. Facilities to provide 0.95 leading and lagging power factor at the high side of the Interconnection Customer's interconnection transformer when delivering rated output (20 MW) at the 69kV bus when the voltage at that point is operating between 95% and 105% of nominal.

3. Centralized controls. These will provide centralized voltage set-point controls and reactive power set-point controls acting to control the voltage on the 69kV system 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.
4. 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 and change the status of any reactive power controls, remotely. NSPI will also have remote manual control of the load curtailment scheme.
5. Low voltage ride-through capability in accordance with FERC Order 661-A.
6. Real-time monitoring (RTU's) of the interconnection substation and facilities for NSPI to execute high speed rejection of generation (transfer trip).

12 NSPI Interconnection Facilities Cost Estimate

Estimates for NSPI Interconnections Facilities associated with IR#531 are included in Table 12-1 for ERIS service, and for NRIS service after 2018. These costs assume that work associated with higher queued projects IR#516 and IR#517 has been completed.

Table 12-1: Cost Estimates

ERIS / NRIS (Post L-6513 Upgrades) Service	
Protection and Telecommunication Upgrades	$15,000
TPIF costs reimburse to IR516/517	$544,456.73
To be Determined Costs	**Estimate**
System additions to address potential stability limits	TBD (SIS)
Financing of L-6513 upgrade resulting from scheduling change from 2018 to 2017 (required for NRIS service in 2017)	TBD (SIS)

13 Issues to be addressed in SIS

The following provides a preliminary scope of work for the subsequent SIS. It will be finalized following collaboration with NB Power. The SIS will include a more comprehensive assessment of the technical issues and requirements to interconnect IR#531. The SIS will also include contingency analysis, system stability and ride through capability and operation following a contingency (N-1 operation). The SIS must determine the facilities required to operate this facility at full capacity, withstand any first 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 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 study will identify any additional required changes to SPSs and any additional facilities required to maintain the import/export capabilities. It will include the impacts of generation that precedes this project in the NS and NB Queues. The SIS will also identify any generation that must be rejected by SPSs (including the Import Power Monitor and Export Power Monitor SPSs) to ensure acceptable post contingency voltages, equipment loadings and system stability. The SIS will also identify any generation whose operation will be curtailed with any single element out of service.

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 where necessary to achieve the primary objectives.

The SIS will determine the following

- Facilities that the customer must install to meet the requirements of the GIP
- The minimum transmission additions/upgrades that are necessary to permit operation of this generating facility, under all dispatch conditions, catering to the 1st contingencies listed.
- Impact on the operation of existing NS import/export and Lingan over-frequency SPS in terms of arming levels, arming means and operating limits.
- Impact on NB SPSs in southeast corridor
- Conceptual specification of any additional (proposed) SPSs
- Impact of generation addition on UFLS adequacy (forced islanding schemes)
- Impact of generation variability on SPS operation and forced islanding scheme
- Impact of generation variability on islanded operation
- Guidelines and restrictions applicable to N-1 operation (curtailments etc)
- In addition to the SPSs the UVLS systems in NB must be included in these assessments

The SIS will be studied for the following base cases:

Power Flow Base Cases	**Variations**	
Winter Peak*	Import 200 MW	Export 200 MW
Fall Peak	Import 100, 200, 300 MW	Export 100, 200, 350 MW
Summer Peak**	Import 100, 200, 300 MW	Export 100, 200, 350 MW
Summer Light Load	Import 100, 200 MW	Export 100, 250, 350 MW

**Winter Peak import case will have high NE-NB flows*
***Summer Peak export cases will have high NB-NE flows*

In each case accommodations for the addition of wind generation will be made to the dispatch by changing the unit commitment for that day, ensuring that sufficient capacity is available to meet the daily peak load. The assumptions regulating regulation, load following, and unit commitment at the minimum daily load (two shifting etc) will be noted.

To complete this assessment, the following 1st contingencies, as a minimum, will be assessed, in accordance with NPCC[3] and NERC[4] criteria:

- L-8001/L3025,
- L-3006 – with and without NBPT SPS operation,
- Memramcook 345/138 kV transformer,
- L-6513,
- L-6514,
- L-6535/L-1159,
- L-6536/L-1160,
- L-8003,
- L-8003 & L-8004 (common breaker),
- L-8001 & 67N-T81 Transformer (common breaker),
- L-3006 & L-3025 & Memramcook 345/138 kV Transformer (common breaker),
- L-3006 & L3017 (common breaker),
- 1N-B61,
- L-1108/1190 common 138kV structure,
- Loss of 180 MW of NS load,
- Loss of largest generation – Pt. Aconi (174MW net),
- Loss of two generating units at Lingan (312 MW net),
- Loss of the Trenton Bus (Two units with load).

To complete this assessment, the dynamics of the following 1st contingencies, as a minimum, will be assessed:

- 3 phase fault L-8001/3025 at 67N-Onslow, NS Import SPS operation (islanding),
- 3 phase fault L-3006 at Memramcook, NB SPS/UVLS operation (islanding),
- 3 phase fault L-3006 at Salisbury, NB SPS/UVLS operation (islanding),
- 3 phase fault L-8003 at 67N-Onslow,
- 3 phase fault L-8002 at 67N-Onslow,
- SLG L-3017, drops L-3017&L-3006 (common CB), NB SPS/UVLS operation,
- SLG Memramcook T3, drops L-3006 (common CB), NB SPS/UVLS operation,
- SLG L-8002 at Onslow, drops L-8003, Grp5 SPS Operation,
- 3 phase fault at 79N-Hopewell, drops L-8003, 8004, bus, SPS operation,
- 3 phase fault 1N-Onslow 138 kV bus B61,
- 3 phase fault 74N-Springhill 138 kV bus.

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 restrictions or curtailments that must be enforced to ensure secure operation of the system. This provides a final test to ensure that the facilities are adequate and the customers' business risks are conveyed. The "N-1" assessment will include, but will not be limited to, the following:

- Contingency analysis, as required,
- Dynamics simulation, as required,
- Determination of total generation constraint.

The "N-1" assessment will determine the operational constraints that must be applied for "N-1" operation after the facility upgrades/additions that are recommended for the interconnection are constructed.

Any changes to SPS schemes and/or additional transmission facilities 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. The SIS will also determine the contingencies for which this facility must be curtailed. The determination will be based on NERC and NPCC criteria as well as NSPI guidelines and good utility practice.

Nova Scotia Power Inc.
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