Interconnection Feasibility Study Report

GIP-213-FEAS-R2

System Interconnection Request #213

15 MW Tidal Generating Facility

Cumberland County (37N-Parrsboro)

2009 12 22

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer submitted a Request to NSPI for a proposed 15MW tidal generation facility interconnected to the NSPI 69kV transmission system via the 37N-Parrsboro substation, which requires approximately 11km of newly-constructed 69kV line from the customer generation in Cumberland County, Nova Scotia. The customer has requested ERIS service.

L-5550 serves to transmit power from the 30N-Maccan to the 37N-Parrsboro substation and is designed to 138kV specifications but it is presently operated at 69kV. Therefore, the newly-constructed generating facilities should be built to 138kV standard to accommodate future system upgrades in this area. One new 69kV circuit breaker will be required at 37N-Parrsboro substation complete with associated switches and protection. These facilities must be designed to be capable of future 138kV operation as well.

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 system. Harmonic level must be within the Total Harmonic Distortion provisions of IEEE 519.

No thermal loading violations were found under normal states and single contingency conditions. The requirement of potential system reinforcements will be determined in a subsequent System Impact Study.

Control and communication modifications will be required at NSPI system and customer facilities, which include transfer trip signals from 30N-Maccan and 74N-Springhill substations. As a result, protection at these two substations will require upgrades.

Assuming that other projects with a higher queue position do not precede, the cost of interconnection, also assuming that this is the only project in the vicinity to proceed, is estimated to be $6,083,000. 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 Energy Resource Integration Service Interconnection Request to NSPI for a proposed 15 MW tidal generation facility interconnected to the NSPI 69kV transmission system via 37N-Parrsboro substation. The generation site would be located in Cumberland County, and would be connected to the 37N-Parrsboro substation via a newly constructed 69kV line, approximately 11 km in length (connecting to the Interconnection Customer's substation). The requested interconnection point is the 37N-Parrsboro substation bus with the one circuit breaker configuration.

The Interconnection Customer signed a Feasibility Study Agreement to study the connection of their proposed generation to the NSPI transmission system, dated 2009 10 20, and this report is the result of that Study Agreement. This project is listed as Interconnection Request #213 in the NSPI Interconnection Request Queue, and will be referred to as IR #213 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.

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

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

1. 15 MW tidal generation facilities with ERIS service type.

2. 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 Voltage Regulation to maintain constant voltage at either the high voltage or the low voltage (selectable) terminals of the Interconnection Facilities.

3. The Generation Interconnection Point is at 37N-Parrsboro substation. The tidal generating facility is located approximately 14 km from the substation including 3 to 4 km marine cable.

4. Transformer is assumed to be 69/13.8 kV with a base rating of 12 MVA and a top rating of 20 MVA. Transformer impedance is assumed to be 7.15% (on 12 MVA ONAN base) and it is assumed the transformer has fixed 32 tap positions between -10% and +10%. Collector voltage will be at the discretion of the Interconnection Customer.

5. This FEAS analysis is based on the assumption that IRs higher in the Generation Interconnection Queue (Queue) will not proceed; however, in accordance with UARB Order P890, projects IR# 45, IR #82, IR #84, IR #114, IR #137/150 and IR #141 have been included in this study.

4 Projects with Higher Queue Positions

As of 2009 12 10 the following projects can proceed ahead of this project, due to their position in the Generation Interconnection Request Queue, and have the status indicated.

In-service and committed generation projects

- Wind Generation - 30.5 MW - connected to L-5027 (in-service)
- Wind Generation – 15 MW – connected to L-5573 (in-service)
- Wind Generation – 25MW - distribution connected (in-service)
- IR #45 Wind – Cumberland, L-6535 30 MW – Unexecuted GIA Filed
- IR #82 Wind – Colchester, L-5040 45 MW – GIA Executed
- IR #84 Wind – Pictou, L-7004 50 MW – GIA Executed
- IR #114 Wind – Pictou, L-6511, 60MW – GIA Tendered
- IR #137/150 Wind – Richmond, 1C, 22MW – GIA Tendered
- IR #141 Wind – Digby, 77V, 30MW – GIA in Progress

Generation projects with a higher Queue position, not yet committed:

- IR #8 Wind – Guysborough, L-5527B 15 MW – GIA Tendered
- IR #56 Wind – Cumberland, L-5058 34 MW – FAC in Progress
- IR #67 Wind – Annapolis, L-5026 40 MW – SIS in Progress
- IR #68 Wind – Digby, L-5533 35 MW – SIS in Progress
- IR #86 Wind – Pictou, L-7003 50MW – SIS in Progress
- IR #115 Wind – Pictou, L-7003, 120MW – SIS in Progress
- IR #117 Wind – Shelburne, L-5027, 10MW – SIS Agreement Complete
- IR #126 Wind – Cumberland, L-6513, 70MW – SIS Agreement Complete
- IR #128 Wind – Cumberland, L-6536, 40.5MW – SIS Agreement Complete
- IR #130 Wind /hydro pumped storage – Cape Breton, L-6516, 200MW – SIS Agreement Complete
- IR #131 Wind – Cape Breton, L-5580, 11.5MW – SIS Agreement Complete
- IR #140 Wind – Antigonish, L-7004, 30MW– SIS Agreement Complete
- IR #149 Wind – Cumberland, L-6536, 70MW – SIS Agreement Complete
- IR #151 Steam Turbine – Halifax, 91H, 50 MW – SIS Agreement Complete
- IR #156 Wind – Antigonish, L-6511, 49.5MW – SIS Agreement Complete
- IR #157 Wind – Guysborough, L-6515, 49.5MW – SIS Agreement Complete
- IR #160 Wind – Colchester, L-5040, 45 MW – FEA in Progress
- IR # 163 Steam – Richmond, 47C, 60MW – SIS Agreement Completed

This project and projects IR#45, IR#56, IR#126, IR#128 and IR#149 add generation to transmission facilities that are part of the Nova Scotia to New Brunswick interconnection. These projects will compete for transmission capacity. The remaining projects may have an impact on this project in that all projects will require use of transmission facilities to deliver power to the load centres.

The SIS[1] will be based on the assumption that all the projects that are ahead of this project in the Queue are in-service. Should any project that is ahead of this project be withdrawn, or changed, within the established procedures then the SIS for this project must be updated accordingly, at the Interconnection Customer's expense.

5 Objective

The objective of this feasibility study is to determine the primary physical requirements to interconnect 15 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. Single contingency criteria are applied for the Energy Resource Interconnection Service assessment.

This FEAS does not produce a binding estimate of all costs and changes that may be required to interconnect the facility. These costs 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 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. The short-circuit levels in the area before and after this development are provided in Table 6-1 below.

[1] This process could change depending on the decision of the UARB with regard to "NSPI Application to Amend the Generation Interconnection Procedures (GIP) - P890"

Table 6-1: Short-Circuit Levels. Three-phase MVA (1)		
Location	**IR #213 in service**	**IR #213 not in service**
All transmission facilities in service		
Tidal Generating Facility 69kV	185	141
37N-Parrsboro 69kV (POI)	209	167
30N-Maccan 69kV	413	376
Minimum Conditions (2)		
37N-Parrsboro 69kV (POI)	194	152

(1) Classical fault study, flat voltage profile
(2) L-6535 open between 30N-Macacn and IR #45 POI with generation at Trenton offline

In determining the maximum short-circuit levels with this generating facility in service the generators have been modeled as conventional machines with reactance comparable to induction machines regardless of the type of generators proposed, which provides a worst case scenario.

The maximum short-circuit level at the POI is presently 167 MVA. After installing generating units the increase will bring the short-circuit level to not more than 209 MVA at the POI. Under contingency operation, with the generators at Trenton off-line and L-6535 open between 30N-Maccan and IR#45, the short-circuit level will be approximately 194 MVA at the POI. While the absolute short-circuit levels will be dependent on the specific type of generator, the 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 FIS.

The interrupting capability of 69kV circuit breakers at 37N-Parrsboro is at least 3500 MVA which will not be exceeded by this development on its own.

7 Voltage Flicker and Harmonics

Due to insufficient information on the generator model, voltage flicker is not available within this report. However, the ratio of short-circuit level to generating capacity at POI under system normal condition is 13.9 (based on proposed plant rating of 15MW). 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 (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 substations 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 and metering limits this line to less than 29 MVA. The addition of this facility alone will not result in any thermal overloads.

Line L-5029 connects the 74N-Springhill substation with the 30N-Maccan substation. 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. In order to permit removal or loss of one of these transformers, without curtailing generation, either the total generation connected to the 69 kV systems (30N-Maccan and 74N-Springhill) must be limited to 50 MW or the system reinforced.

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.

It was noted in this assessment that if all queued projects proceed then there is potential for overloading facilities in northern Nova Scotia for contingencies in that area. This condition would be further examined in the SIS when the impact of other projects ahead of IR#213 is considered.

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 15 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 just 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 661a[2]. 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

We expect the following facilities will be required assuming that the projects ahead of this project in the Interconnection Request queue (except IR# 45, IR #82, IR #84, IR #114, IR #137/150 and IR #141) do not proceed.

Additions/Changes to NSPI systems

Develop one circuit breaker configuration at the POI consisting of:

1. One 138kV circuit breaker and associated switches (operating as 69kV) at 37N-Parrsboro substation.
2. 11km newly-constructed 138kV line from POI to customer substation (operating as 69kV).
3. Control building and protection systems at 37N-Parrsboro substation.
4. Control and communications between the Generating Facility and NSPI SCADA system including transfer trip signals to the Generating Facility from 30N-Maccan and 74N-Springhill.
5. Protection upgrades at 30N-Maccan and 74N-Springhill substation.
6. Any conductors needed to connect the Generating Facility to the POI will use 556 Dove ACSR conductor rated 100°C conductor temperature.

[2] Post-transition Period LVRT Standard; "Interconnection for Wind Energy", Federal Energy Regulatory Commission, Docket RM05-4-001; Order No. 661-A December 12, 2005.

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 (15 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 138kV 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 661a.
6. Real-time monitoring (RTU's) of the interconnection substation and facilities for NSPI to execute high speed rejection of generation (transfer trip) if determined by SIS.

12 NSPI Interconnection Facilities Cost Estimate

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

Table 12-1: Cost Estimates

	Determined Cost Items	Estimate
I	Construct new 138kV single circuit line (11km, operating at 69kV)	$4,140,000
ii	Install 138kV circuit breaker and associated switches at 37N-Parrsboro substation (operating at 69kV)	$1,050,000
iii	Protection, control, communication	$340,000
iv	Contingency (10%)	$553,000
v	Total of Determined Cost Items	$6,083,000
	To be Determined Costs	
	System additions to address potential stability limits	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 NBSO. 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 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 (new or existing) 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, 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 based on the following bases cases

Power flow base cases	Variations
Winter Peak	import 200MW, export 200MW
Fall Peak	import 100,200,350, export 100,200,350
Summer Peak	import 100,200,300, export 100,200,350
Summer Light Load	import 100,200 export 100,250,350

*Summer Peak export will have high NB-NE flows
*Winter peak import case will have high NE-NB 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-8002 & L-8003 (common circuit breaker)
- L-8003 & L-8004 (common circuit breaker
- L-8001 & 67N-T81 Transformer (common circuit 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 load under peak load conditions and 250 MW under light load conditions
- Loss of largest generation – Pt. Aconi 174MW net
- Loss of two generating units at Lingan – 312 Net
- Loss of the Trenton Bus (Two units with load)

[3] NPCC criteria are set forth in it's A-2 Document *Basic Criteria for Design and Operation of Interconnected Power Systems*
[4]NERC transmission criteria are set forth in *NERC Reliability Standards TPL-001, TPL-002, TPL-003*

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 (9N-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 conveyed.

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

The "N-1" assessment will include, but not be limited to, the following. 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 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.

Nova Scotia Power
2009 12 22