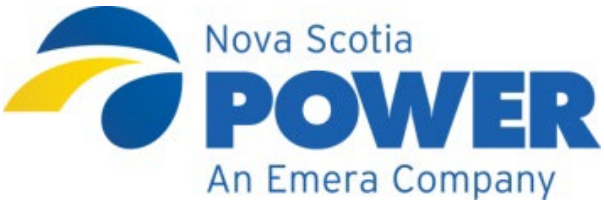

Interconnection Feasibility Study Report
GIP-IR703-FEAS-R0

Generator Interconnection Request #703
300 MW Offshore Wind Facility
Goldboro, NS

2024-04-05

Control Centre Operations
Nova Scotia Power Inc.

Executive summary

This Feasibility Study report (FEAS) is based on the Feasibility Study Agreement, signed by the Interconnection Customer (IC) on July 6, 2023 and Nova Scotia Power Inc. (NSPI) on July 7, 2023 for connection of a 300 MW offshore wind power generating facility at Goldboro in Nova Scotia (NS).

The agreement states twenty Siemens Gamesa SG 14-236 DD wind turbines with each turbine rated 15 MW.

The proposed Commercial Operation Date for IR703 is 2028/01/01.

The facility will interconnect to the NSPI system as Network Resource Interconnection Service (NRIS). The Point of Interconnection (POI) will be on L-7005, an existing 230 kV line between 3C-Port Hastings and 67N-Onslow substation. This line presently has another higher queued IR670 (ahead of IR703) to be connected prior to IR703.

In addition, there are a total of 22 transmission and distribution projects across NS identified in the Combined T/D Advanced Stage Interconnection Request Queue with higher queue positions than IR 703.

The power system base cases for the feasibility study include all transmission connected IRs in the GIP queue up to and including IR742 with the exception of IR686, as the IR686 SIS was not completed when IR703 was initiated.

In this feasibility study, IR703 is assessed with the premise that it will displace thermal generation in Nova Scotia, with the order of units in Cape Breton to Central to Halifax, for the clean power initiative. In doing so, NSPI continues to maintain a minimum number of thermal units (synchronous generators) to maintain system strength and system stability, hence, when this level of thermal generation is reached and Nova Scotia power system is operating at minimum generation, wind generation in NS, including IR703, will be curtailed accordingly. In addition, even though IR703 is studied as NRIS, NSPI system operators can curtail IR703 at any time to maintain system reliability as per the GIP.

The Transmission Service Reservation TSR-411for 550 MW from New Brunswick to Nova Scotia is not included as per the attached notice on NSPI's OASIS site.

Since L-7005 is a Bulk Power System element, connection to this line will require a three ring bus breaker substation at the POI on the line as per NSPI's requirements.

The assessment shows that addition of IR703 does not necessitate any change out of transmission circuit breakers due to increased short circuit levels contributed by IR703. This was based on the preliminary data provided by the IC regarding short circuit contributions from the wind turbines.

The minimum short circuit ratio (SCR) required for the wind turbines to operate was not available at the time of this assessment, however, based on the preliminary assessment, the short circuit levels at the 3.3 kV low voltage side of the wind turbine generating transformer is very low (372 MVA at system minimum generation and L-7005 section between IR703 and Port Hastings is out of service). This equates to a very weak SCR of 1.24, significantly far less than 3 or 4 or even 5 as required by some wind turbines, hence it is paramount that the IC will discuss with the wind turbine suppliers to ensure that the wind turbines can function effectively at these low short circuit levels.

In addition, the IC will need to discuss with the wind turbine suppliers to ensure that the wind turbines can meet all requirements of NSPI's Transmission System Interconnection Requirements (TSIR).

With reference to Inertia Response, section 7.6.7 of TSIR requires "WECS Generating Facilities shall support short-duration frequency deviations by providing inertia response equivalent to a Synchronous Generator with an inertia factor (H) of at least 3.0 MWs/MVA for a period of at least 10 seconds.".

The assessment of voltage flicker and harmonics was not completed due to the parameters and data sheets for these quantities not being available at the time of this study.

The assessment of thermal limit and voltage violations does not result in any issue that are attributed to IR703.

Since L-7005 is part of two Remedial Action Schemes (RAS) that govern the level of power transmission from Cape Breton to Mainland NS, these RAS will require changes to accommodate IR703.

One RAS is a Limited Impact RAS that has a Northeast Power Coordinating Council (NPCC) designation as "Type III SPS#113, 230 PHLO". In NSPI, it is referred to as Group 3 for L-7005, a subset of SPS#113.

The other RAS is a Type I RAS that has NPCC designation as "Type I SPS#119 NS 345 kV".

SPS stands for Special Protection Scheme which is just another term for RAS. Depending upon the extent of the changes, they may need NPCC's review and approval.

The detailed data sheet and capability curves for the power factor are not available at the time of this study but based on preliminary fixed values provided by the IC, IR703 will require power factor correction to meet NSPI's power factor requirements of +/- 0.95 at the high voltage side of the two main substation transformers (on the 230 kV side) and to be able to deliver rated reactive power down to 0 MW.

IR703 generation will be greater than the present largest generator (Point Aconi) in NS and that will have a major impact on the operating reserve (synchronous, 10-minute, and 30-minute) for NSPI, hence it is recommended that IC703 begins discussion with NSPI for the options to address operating reserve prior to the SIS stage.

As IR703's POI will be on L-7005, dissecting the line into two line sections, the protection system at the remote ends of L-7005 will require modification. As the proposed new IR607's POI will also be on L-7005, if it is built prior to IR703, then the protection system at IR670's POI substation and 3C-Port Hastings substation will require modifications. If IR670 does not proceed prior to the installation of IR703 then the protection systems at 67N-Onslow substation and 3C-Port Hastings substation will require modifications.

In summary the high level non-binding cost estimate for the Network Upgrades (NU), which include the three breaker ring bus at the POI substation, the RAS changes, and L-7005 protection modification, plus 25% contingency is $13.0 million Canadian.

The high level non-binding cost estimate for the Transmission Provider's Interconnection Facilities (TPIF) upgrades plus 25% contingency is $77.34 million Canadian. That includes the cost of installing 44 km of 230 kV transmission line from POI substation to IC substation, protection & control relaying equipment on the 230 kV side, NSPI supplied Remoter Terminal Unit, Tele-protection & SCADA communication. The biggest of the cost is the installation of the 230 kV line, which is estimated at $60.72 million.

Thus, the high level non-binding cost estimate for both NU and TPIF is $90.34 million Canadian in 2024 dollars, excluding taxes. This estimate is subject to changes to be determined in the SIS and Facility (FAC) studies.

The cost of the Interconnection Customer's Interconnection Facilities (ICIF) is separate at the IC's own cost and is not included in this study. Its design must meet NSPI's Transmission System Interconnection Requirements (TSIR) and NERC's BES and possibly NPCC's BPS requirements which will be determined by the SIS.

The IC will obtain Right Of Way (ROW) for the 44 km 230 kV transmission line from the IC's substation to the POI and fund its construction costs and maintenance costs in perpetuity, but NSPI will own and operate it. The IC will also obtain the ROW for the POI substation.

The estimated time to construct the NU and TPIF is 24-30 months after the receipt of funds. The time frame will be further determined by the FAC study.

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1.0 Introduction

This Feasibility Study report *(FEAS)* is based on the Feasibility Study Agreement, signed by the Interconnection Customer (IC) on July 6, 2023 and Nova Scotia Power Inc. (NSPI) on July 7, 2023 for connection of a 300 MW offshore wind power generating facility at Goldboro in Nova Scotia (NS).

The agreement states twenty Siemens Gamesa SG 14-236 DD wind turbines with each turbine rated 15 MW.

The facility will interconnect to the NSPI system as Network Resource Interconnection Service (NRIS). The Point of Interconnection (POI) will be on L-7005, an existing 230 kV line between 3C-Port Hastings and 67N-Onslow substation. This line presently has another higher queued IR670 (ahead of IR703) to be connected prior to IR703.

In addition, there are a total of 22 transmission and distribution projects across NS identified in the Combined T/D Advanced Stage Interconnection Request Queue with higher queue positions than IR 703.

The power system base cases for the feasibility study include all transmission connected IRs in the GIP queue up to and including IR742 with the exception of IR686, as the IR686 SIS was not completed when IR703 was initiated.

This project is listed as Interconnection Request #703 in the NSPI Interconnection Request Queue and will be referred to as IR703 throughout this report.

The proposed Commercial Operation Date is 2028/01/01 as stated in the Interconnection Request form signed by the IC on May 5, 2023 and NSPI on May 11, 2023.

In a letter from the IC to NSPI dated April 21, 2023, the IC indicated that the IC's preferred location for the POI will be at the IC substation in Goldboro and the secondary option for the POI will be at the village of Lower Springfield.

In the context of this Feasibility Study, the IC's preferred option of having the POI at the village of Lower Springfield, more than 41 km from L-7005, will expose L-7005 to faults on this additional line length and as L-7005 is a BPS line which is crucial to the power transmission corridor between Cape Breton and Mainland NS, this is not permissible as per the requirement of NSPI's Transmission System Interconnection Requirements (TSIR), which requires the POI at L-7005.

Based on the POI at Lat: 45.499746, Long: -61.862428, Figure 1 shows the approximate location of IR703 on L-7005. It also shows higher queued IR670 on the same line.

Figure 2, provided by IC, shows the four options of the transmission line extension routes (not yet decided by the IC) from the POI to the IC's substation.

Figure 1: IR703 POI approximate geographic location.

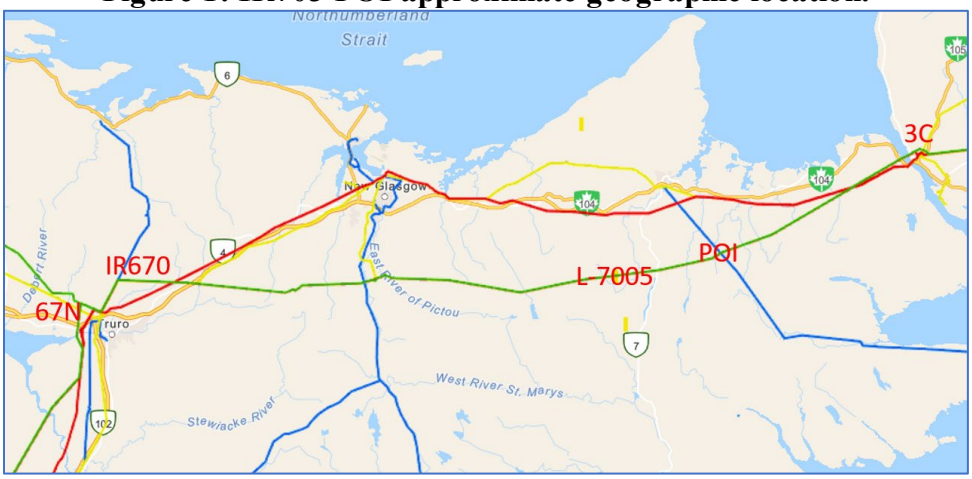


Figure 2: Transmission line extension from POI to IC's substation.

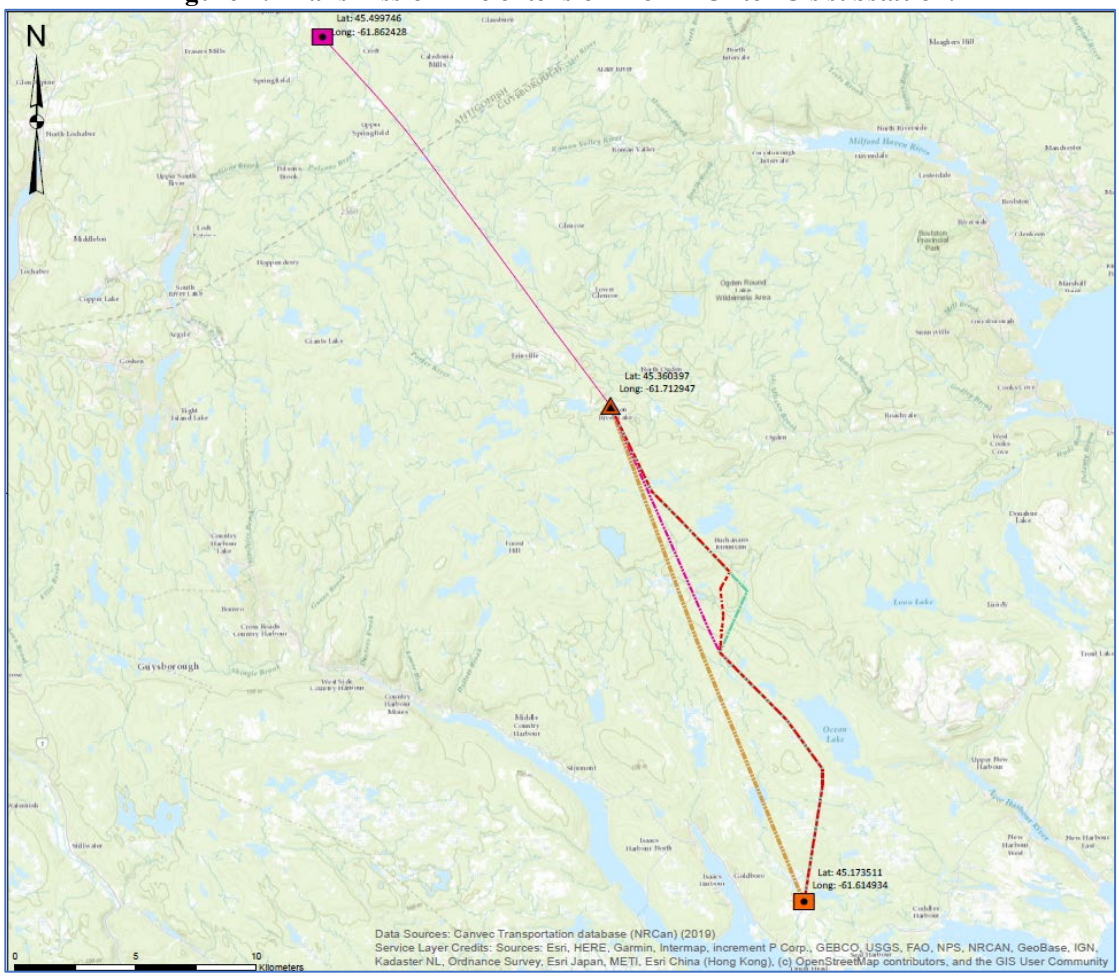
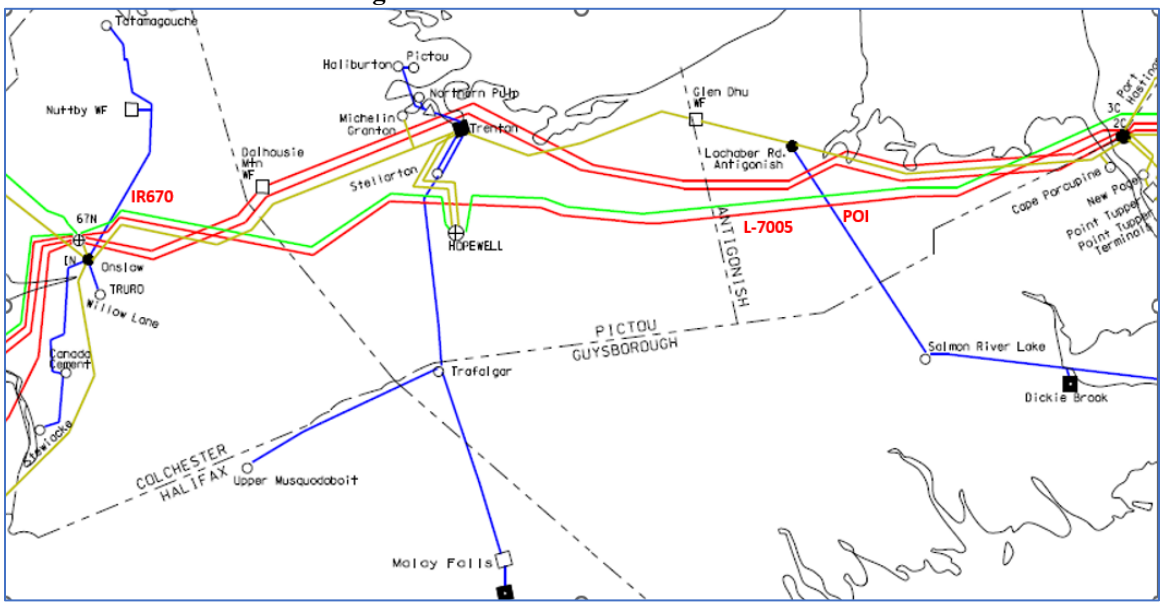


Figure 3 shows the POI location on NSPI's electrical transmission one-line.

Figure 3: IR703 POI on NSPI network.



2.0 Scope

This Interconnection Feasibility Study's *(FEAS)* objective is to provide a preliminary evaluation of system impact and a high-level non-binding cost estimate of interconnecting the new generation facility to the NSPI Transmission System at the designated location based on single contingency criteria.

This assessment will identify potential impacts on transmission element loading above their thermal limits and potential voltage criteria violations.

Circuit breakers must be upgraded if the proposed facility increases the short-circuit duty of any circuit breakers beyond their rated capacity.

The scope of the FEAS includes modelling the power system in normal state, with all transmission elements in service, under anticipated load and generation dispatch. A power flow and short circuit analysis will be performed to provide the following preliminary information:

- Identification of any circuit breaker short circuit capability limits exceeded because of the interconnection and any network upgrades necessary to address the short circuit issues associated with the IR.
- Identification of any thermal overload or voltage limit violations resulting from the interconnection and identify the necessary network upgrades.

- Description and high-level non-binding estimated cost of and time to construct the facilities required to interconnect the generating facility to the transmission system.

This FEAS does not include a complete determination of facility changes/additions required to increase the system transfer capabilities that may be required to the transmission system to meet the design and operating criteria established by NSPI, the Northeast Power Coordinating Council (NPCC), and the North American Electric Reliability Corporation (NERC). These requirements will be determined by a more detailed analysis in the subsequent interconnection System Impact Study *(SIS)*. An Interconnection Facilities Study (FAC) follows the SIS to ascertain the final cost estimate to the interconnect the generating facility.

3.0 Assumptions

This FEAS is based on the information provided by the IC as follows:

1. In a letter from the IC to NSPI dated April 21, 2023, the IC stated four options for the transmission line route from the IC's substation to the POI on L-7005. Rough tracing of the four routes on the map indicates that the short route would be about 41.7 km in length and the longest route would be about 44 km in length. This feasibility study will model the longest route to be conservative. As the IC does not indicate the conductor type, this feasibility study will assume 795 ACSR Drake conductors with NPSI's standard 230 kV wood pole construction. This will provide 436 MVA in summer at 30 degree ambient and 100 degree conductor temperature.
2. The proposed Commercial Operation Date is 2028/01/01 as stated in the signed Interconnection Request form.
3. As per the signed Feasibility Study Agreement:

   3.1. Network Resource Interconnection Service (NRIS).

   3.2. POI on L-7005.

   3.3. The maximum facility output is 300 MW, comprising of 20 Siemens Gamesa SG 14-236 DD wind turbines with each wind turbine rated for 15 MW. The power output of the wind turbines will be collected via four collector circuits.

   3.4. The individual wind turbine generating transformers will be 33kV (LV) stepping up to 66kV (HV) with a rating of 16 MVA each. Even though the Feasibility Study Agreement show each transformer having an impedance of 6%, the IC indicated that this value is approximate in the electrical one-line that the IC sent to NSPI. In addition, the IC also supplied a load flow report by its consultant who uses an impedance of 8% with an X/R ratio of 18.6. For consistency, this feasibility study will use 8% with X/R of 18.6.
4. The POI on L-7005 will be a three ring bus breaker substation as required by NSPI's TSIR.
5. The IC supplied an electrical one-line which shows that there are two 230 kV to 66 kV transformers in parallel at the IC's main substation. The one-line shows each

transformer is rated 105/140/175 MVA and has 8% impedance on 105 MVA but does not indicate X/R ratio. However, the IC's consultant doing the load flow study for the IC used an X/R ratio of 17.35 which this feasibility study will also use for consistency. The IC may want to ascertain the correct value for this X/R ratio in the SIS stage and in the final design of the generating facility.

6. The single equivalent collector circuit impedance is calculated based on the four collector circuits and the single line layout of the individual wind turbines as provided by the IC.
7. The single equivalent generator for twenty wind turbines is modelled as a 300 MW generator with a power factor of +/- 0.9375 as stated in the Interconnection Request signed by the IC.
8. The transmission line ratings are already in the power system cases using NSPI's latest "Transmission Line Ratings Summary", dated December 29, 2023.
9. The order of generation in NS to be displaced by IR703 is defined in NSPI's latest "Dispatch guidelines for GCP FEAS IRs", dated December 7, 2023 as follows:

    - Trenton 5
    - Lingan 1
    - Lingan 4
    - Lingan 3
    - Pt Aconi
    - Pt Tupper
    - Trenton 6
    - Tufts Cove 1
    - Tufts Cove 2
    - Tufts Cove 3
    - Tufts Cove 4, 5, 6

    while maintaining a minimum of three thermal units on-line to provide short circuit level for NSPI's system operation and system stability: Trenton 6, Tufts Cove 3, and Point Tupper 2. These three generating units can be dispatched at minimum power output, following which IR 703 and other renewable resources would be curtailed on a non-discriminatory basis to serve the remaining system load.

    In this feasibility study, it assumes that Lingan 2 is retired as per NSPI's generation plan.

4.0 Project queue position

All in-service generation is included in this FEAS; except Lingan Unit 2, which is assumed to be retired.

The combined Transmission and Distribution Advanced Stage Interconnection Request Queue dated November 24, 2023, at the start of the feasibility studies for the Green Choice Program (GCP), is attached in this report for reference.

The power system base cases for the feasibility study include all transmission connected IRs in the GIP queue up to and including IR742 with the exception of IR686, as the IR686 SIS was not completed when IR703 was initiated.

As for the Transmission Service Request (TSR) Queue, it is shown on Table 1.

Table 1: TSR queue

OATT Transmission Service
Queued System Impact Studies
Active December 11, 2023

Item	Project	Date & Time of Service Request	Project Type	Project Location	Requested In-Service Date	Project Size (MW)	Status
1	TSR 400	July 22, 2011	Point-to-point	NS-NB*	May 2019	330	System Upgrades in Progress
2	TSR 411	January 19, 2021	Point-to-point	NS-NB*	January 1, 2028	550	Facilities Study in Process

* Indicates project as being located near provincial border.

TSR411 is a long-term firm point-to-point transmission service reservation for 550 MW from New Brunswick to Nova Scotia. The system impact study was completed and the Facility Study is under way, but the system upgrades identified for the project are not included in this study as per the attached notice posted on NSPI's OASIS site.

5.0 Short circuit

The short circuit analysis was performed using PSS/e 34.12 with classical fault option, flat voltage profile at 1.0 per unit voltage, and three phase to ground faults.

The IC was not able to obtain the data sheet for short circuit current contribution for the wind turbines being considered in this feasibility study. However, email correspondence from the IC on January 4, 2024, the IC indicates a value of 1.2 per unit to be used for the time being. The equivalent impedances of the collector circuits and transformers were calculated based on the information provided by the IC.

IR703 short circuit model was incorporated into NSPI short circuit system case and was simulated with IR703 off-line and with IR703 on-line and the results for relevant buses are shown in Table 2.

Table 2: Short Circuit Levels

Location	IR703 Off	IR703 On
Maximum Generation System Normal (Magnitude in MVA / Angle in Degree)		
67N-Onslow 230 kV	4829/ -85.78	4917 / -85.75
3C-Port Hastings 230 kV	4007 / -84.91	4186 / -84.96
IR703 POI 230 kV	2194 / -84.63	2468 / -84.92
IR703 WEC Tx 66kV	734 / -81.58	1089/ -84.24
IR703 WEC Tx 3.3kV	611 / -82.39	993/ -85.33
Minimum Generation (TC3, TR6, PT2 on) System Normal		
67N-Onslow 230 kV	1898 / -87.32	2083 / -87.14
3C-Port Hastings 230 kV	1537 / -86.46	1747/ -86.43
IR703 POI 230 kV	1225 / -86.11	1499 / -86.31
IR703 WEC Tx 66kV	594 / -85.08	950 / -85.57
IR703 WEC Tx 3.3kV	512 / -82.56	894 / -86.32
Minimum Generation + L-7005(IR703-3C) Out		
67N-Onslow 230 kV	1872 / -87.23	2083 / -87.15
3C-Port Hastings 230 kV	1445 / -86.12	1511 / -85.86
IR703 POI 230 kV	657 / -85.16	931 / -85.77
IR703 WEC Tx 66kV	416 / -83.42	773 / -86.32
IR703 WEC Tx 3.3kV	**372** / -83.74	755 / -86.92
Minimum Generation _ L-7005(IR703-IR670) Out		
67N-Onslow 230 kV	1873 / -87.23	2012 / -86.98
3C-Port Hastings 230 kV	1442 / -86.11	1690 / -86.23
IR703 POI 230 kV	967 / -85.41	1241 / -85.81
IR703 WEC Tx 66kV	524 / -83.03	880 / -85.74
IR703 WEC Tx 3.3kV	458 / -83.47	841 / -86.44

All the 230 kV breakers in the vicinity of IR703 exceed the short circuit interrupting capability of 10, 000 MVA and the three phase short circuit levels shown in Table 2 do not exceed 10, 000 MVA, hence IR703 does not incur any change out of the 230 kV breakers.

The minimum short circuit ratio (SCR) required for the wind turbines to operate was not available at the time of this assessment, however, based on the preliminary assessment, the short circuit levels at the 3.3 kV low voltage side of the wind turbine generating transformer is very low (372 MVA at system minimum generation and L-7005 section between IR703 and Port Hastings is out of service). This equates to a very weak SCR of 1.24, significantly far less than 3 or 4 or even 5 as required by some wind turbines, hence

it is paramount that the IC will discuss with the wind turbine suppliers to ensure that the wind turbines can function effectively at these low short circuit levels.

In addition, the IC will need to discuss with the wind turbine suppliers to ensure that the wind turbines can meet all requirements of NSPI's Transmission System Interconnection Requirements (TSIR).

With reference to Inertia Response, section 7.6.7 of TSIR requires "WECS Generating Facilities shall support short-duration frequency deviations by providing inertia response equivalent to a Synchronous Generator with an inertia factor (H) of at least 3.0 MW.s/MVA for a period of at least 10 seconds.".

6.0 Voltage flicker & harmonics

The IC confirmed that the voltage flicker data and harmonic data for IR703 are not yet available at this time, hence, these two items will be assessed in the pursuing SIS when the time comes.

7.0 Thermal limit and voltage limit assessment

For the steady state thermal and voltage assessment, a total of 30 power flow cases and 330 transmission contingencies were developed and simulated for each case.

Half of the cases have IR703 off-line and the other half have IR703 on-line for determining any new system issues that can be attributed to IR703.

The cases reflect a number of system dispatches:

- Maritime Link HVDC at maximum and minimum.
- NS wind at capacity value of 17% and at 100% when the power system can allow.
- High levels of CBX and ONI.
- NB delivers 10 minute operating reserve to NS for loss of 1 pole of Maritime Link HVDC.
- NS delivers 10 minute operating reserve to NB for loss of Point Lepreau nuclear power plant.
- Seasons: winter peak (WIN), summer peak (SUM), summer light load (SML), summer shoulder (SSH).

In light load cases, with the Maritime Link HVDC at zero and depending upon NS to be able to export to NB, the light load cases may not be dispatched at 100% NS wind, hence it is expected that IR703 will be curtailed along with other wind facilities in NS.

The contingencies in NS and some in NB include:

- Loss of a single transmission system element.
- Breaker failure to operate (BBU).
- Loss of double circuit towers (DCT).
- Loss of load (LOL).
- Loss of source (LOS).

The criteria for assessment are as follows:

- Under system normal, all elements in service, system voltages are no less than 0.95 per unit and element loading must be within nominal rating (Rate A).
- Post contingency steady state, system voltages are no less than 0.9 per unit and element loading is within short time rating (Rate B). For NS, the element loading must also be within rate D (short time rating for the element auxiliary equipment).

There are some existing system conditions observed in the power system cases used in this feasibility study that are not attributed to IR703:

- VJ gas turbines are on-line in winter peak to avoid local overload (NSPI Operations to operate VJ gas turbine as needed)
- 22W remote 69 kV bus slightly below 0.95 per unit in system normal (NSPI to mitigate).
- Transformer at 58H has loading above rating in system normal (NSPI to mitigate).
- Transformer at 75W has loading above rating in system normal (NSPI to mitigate).

Table 5 and Table 6 of Section 14 show the detailed dispatch of the power flow cases and Table 7, Table 8, and Table 9 of Section 15 show the contingencies in NS and NB that were simulated in steady state power flow.

The power flow analysis shows that, under certain post contingencies, L-7005 current transformer relaying at 3C-Port Hastings and at 67N-Onslow can exceed the presently restricted value of 398 MVA. NSPI confirmed that it will remedy the issue and will not attribute it to IR703.

Since L-7005 is part of two Remedial Action Schemes (RAS) that govern the level of power transmission from Cape Breton to Mainland NS, these RAS will require changes to accommodate IR7003's POI on this line.

One RAS is a Limited Impact RAS that has a Northeast Power Coordinating Council (NPCC) designation as "Type III SPS#113, 230 PHLO". In NSPI, it is referred to as Group 3 for L-7005, a subset of SPS#113.

The other RAS is a Type I RAS that has NPCC designation as "Type I SPS#119 NS 345 kV".

Other than above mentioned items, the power flow analysis does not show any additional system issues that are attributed to IR703.

8.0 Reactive power & voltage control

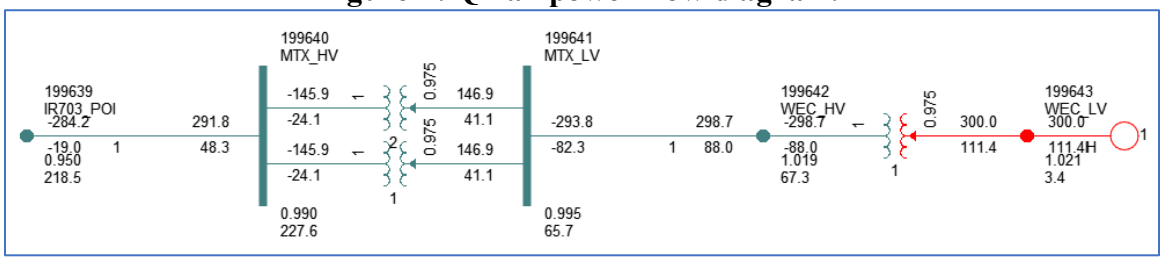
The IC was not able to provide the power factor table and curves for IR703 at this time to allow this feasibility study to examine the power factor requirements in detail.

The preliminary analysis of power factor requirements in this feasibility study is based on the power factor value of +/- 0.9375 that was stated in the Interconnection Request Application for IR703.

IR703, having a rated power of 300 MW and a power factor of +/- 0.9375, can deliver a maximum reactive power (Qmax) of +111.36 MVAR and can absorb down to a minimum reactive power (Qmin) of -111.36 MVAR.

For Qmax analysis, below is a one-line slider diagram showing the power flow when IR703 delivers its maximum MVAR at its full 300 MW output.

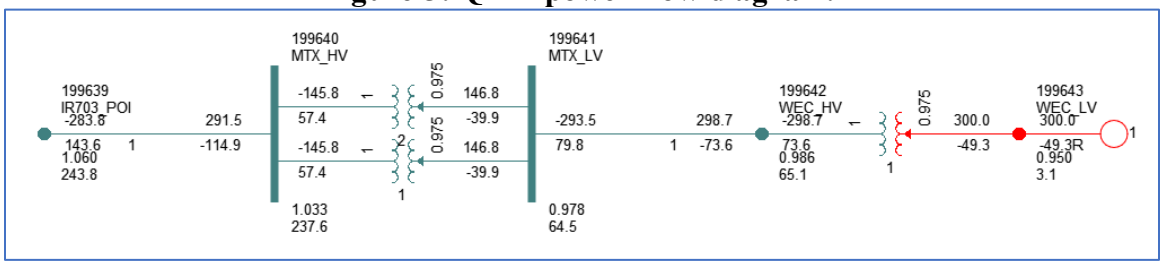
Figure 4: Qmax power flow diagram.



The slider shows that the high side of the two main substation transformers delivers 291.8 MW and 48.3 MVAR, equating to a power factor of 0.99 which is higher than NSPI's requirement of 0.95 or less, hence IR703 will require to install power factor correction equipment to allow it to deliver the required MVAR at the high voltage side the two main transformers.

For Qmin analysis, below is a one-line slider diagram showing the power flow when IR703 absorbs MVAR at its full 300 MW output.

Figure 5: Qmin power flow diagram.



The slider shows that the high side of the two main substation transformers delivers 291.8 MW and absorbs 114.9 MVAR, equating to a power factor of 0.93 which meets NSPI's requirement of 0.95 or less, hence IR703 will not require to install power factor correction equipment to absorb more reactive power.

Since the IC was not able to provide the table and curve for the power factor, it is not possible to for this feasibility study to verify the power factor requirement at the full range of IR703 output from 0 MW to rated 300 MW. The IC will be required to supply this information for the SIS to evaluate and address.

A centralized controller will be required, which continuously adjusts the individual generator reactive power output within the plant capability limits and regulates the voltage at the low voltage terminal of the two main transformers. The voltage controls must be responsive to voltage deviations, be equipped with a voltage setpoint control, and have facilities that will slowly adjust the setpoint over several (5-10) minutes to maintain reactive power within the generator's 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 setpoint and the reactive setpoint of this facility to coordinate reactive power dispatch requirements.

This facility must have voltage ride-through capability as detailed in the NS Power Transmission System Interconnection Requirements (TSIR)[1]. The SIS will examine the plant capabilities and controls in detail to specify options, controls, and additional facilities that are required to achieve low voltage ride through.

9.0 NPCC and NERC requirements

In NS, certain transmission system elements are required to meet NPCC[2] BPS (Bulk Power System) or NERC[3] BES (Bulk Electric System) requirements or both.

Since the POI for IR703 will be on the 230 kV line L-7005 which is classified for both NPCC BPS and NERC BES, therefore the POI substation, the 230 kV line extension to the IC substation will be BPS.

The SIS will determine the correct classification of the IC substation and the IC generating facility for NPCC BPS and/or NERC BES.

[1] NS Power Transmission System Interconnection Requirements; https://www.nspower.ca/oasis/generation-interconnection-procedures
[2] Northeastern Power Coordination Council.
[3] North American Electric Reliability Corporation.

10.0 Operating Reserve Requirement

NSPI must carry sufficient operating reserve to cover first contingency loss of its largest generating unit. The amount of operating reserve also depends on the sharing of operating reserve requirements with NB Power.

IR703 generation will be greater than NSPI's present (or planned) largest generator (Point Aconi 168 MW net) in NS and that will have a major impact on the operating reserve (synchronous, 10-minute, and 30-minute) for NSPI, hence it is recommended that IC703 begin discussion with NSPI for the options to address the operating reserve prior to the SIS stage.

11.0 Expected facilities required for interconnection.

The following facilities are required to interconnect IR703 to the NSPI system via the POI on L-7005 as NRIS:

1) **Network Upgrades (NU):**
   a) Three breaker ring bus at 230 kV POI substation complete with P&C and connection to L-7005. This substation must be designed to meet NPCC's BPS requirements and NERC's BES requirements.
   b) Protection and control modifications at 67N-Onslow substation (if IR670 does not proceed) or at IR670 substation (if IR670 is built ahead of IR703) and 3C-Port Hastings substation of L-7005.
   c) Changes to a Limited Impact RAS (NPCC Type III SPS#113, 230 PHLO). Group 3 for L-7005.
   d) Changes to a Type I RAS (NPCC Type I SPS#119, NS 345 kV).
2) **Transmission Provider's Interconnection Facilities (TPIF):**
   a) 44 km of Drake 795 ACSR, 100 deg C, 230 kV line from POI substation to IC substation. This new 230 kV line must be designed to meet NPCC BPS requirements and NERC's BES requirements. The IC is responsible for obtaining ROW and funding its construction and for maintenance costs in perpetuity, but NSPI will own and operate it.
   b) Protection and control for relaying equipment.
   c) NSPI supplied Remote Terminal Unit (RTU).
   d) Tele-protection and SCAD communications.
3) **Interconnection Customer's Interconnection Facilities (ICIF*):***
   a) Facilities to limit plant output to 300 MW.

b) Facilities to provide ±0.95 power factor when delivering rated output (300 MW) at the 230 kV bus when voltage is operating between ±5% of nominal. Rated reactive power shall be available through the full range of real power output, from zero to full power.

c) Centralized controls for voltage setpoint control for the low side of the ICIF transformers. Fast acting control is required and will include a curtailment scheme, which will limit/reduce total output from the facility, upon receipt of a telemetered signal from NSPI's SCADA system.

d) NSPI to have supervisory and control of this facility, via the centralized controller. This will permit the NSPI System Operator to raise/lower the voltage setpoint, change the status of reactive power controls, change the real/reactive power remotely. NSPI will also have remote manual control of the load curtailment scheme.

e) When curtailed, the facility shall offer over-frequency and under-frequency control with ±0.2 Hz dead band and 4% droop characteristic. The active power controls shall also react to continuous control signals from the NSPI SCADA system's Automatic Generation Control (AGC) system to control tie-line fluctuations as required.

f) Real-time telemetry will include MW, MVAR, bus voltages, and curtailment state.

g) Meet all the requirements detailed in the NS Power Transmission System Interconnection Requirements (TSIR)4. Among them is voltage ride-through capability per section 7.4.1, frequency ride-through per section 7.4.2, and section 7.6.7 regarding inertia “WECS Generating Facilities shall support short-duration frequency deviations by providing inertia response equivalent to a Synchronous Generator with an inertia factor (H) of at least 3.0 MW.s/MVA for a period of at least 10 seconds.”.

h) Facilities for NSPI to execute high speed rejection of generation and load (transfer trip), if determined in the SIS. The plant may be incorporated in SPS runback or load reject schemes.

i) The facility must use equipment capable of closing a circuit breaker with minimal transient impact on system voltage and frequency (matching voltage within ±0.05 PU and a phase angle within ±15°).

j) Operation at ambient temperatures as low as -30ºC.

[4] NS Power Transmission System Interconnection Requirements; https://www.nspower.ca/oasis/generation-interconnection-procedures

12.0 NU and TPIF Cost Estimates.

The high level, non-binding, cost estimate, excluding HST, for IR703's Network Resource Interconnection Service is shown in Table 3.

Table 3: Cost Estimate

Item	**Network Upgrades** (NU)	Estimate ($M CAN)
1	Three breaker ring bus at 230 kV POI substation complete with P&C and connection to L-7005. This substation must be designed to meet NPCC's BPS requirements and NERC's BES requirements	9.00
2	P&C modifications at 67N-Onslow substation (if IR670 does not proceed) or at IR670 substation (if IR670 is built ahead of IR703) and 3C-Port Hastings substation of L-7005	1.00
3	Changes to a Limited Impact RAS (NPCC Type III SPS#113, 230 PHLO). Group 3 for L-7005	0.20
4	Changes to a Type I RAS (NPCC Type I SPS#119, NS 345 kV)	0.20
	Contingency (25%)	2.60
	Network Upgrade Sub-total	13.00
Item	**Transmission Provider's Interconnection Facilities** (TPIF)	**Estimate ($M CAN)**
1	44 km of wood pole, H-frame Drake 795 ACSR, 100 deg C, 230 kV line from POI substation to IC substation. This new 230 kV line must be designed to meet NPCC BPS requirements and NERC's BES requirements.	60.72
2	P&C relaying equipment	0.30
3	NSPI supplied RTU	0.10
4	Tele-protection and SCADA communications	0.75
	Contingency (25%)	15.47
	TPIF Upgrade Sub-total	77.34
	Total NU and TPIF Upgrades (excluding HST)	**90.34**

This cost estimate is subject to change as will be determined by the SIS and FAC study.

The estimated time to construct the Network Upgrades and Transmission Provider's Interconnection Facilities is 24-30 months after receipt of funds. This time frame will be determined and confirmed in the Facility Study.

13.0 Loss factor

Loss factor is calculated by running the winter peak load flow case with and without the new facility in service, while keeping 91H-Tufts Cove as the NS Area Interchange bus. This methodology reflects the load centre in and around 91H-Tufts Cove and how effectively the new facility can displace generation at Tufts Cove. Generally, a negative loss factor reflects a reduction in system losses.

Table 4: IR703 Loss Factor

Component	at IR703 Terminal	at POI
IR703 on at 300 MW	300	291.5
TC plant total MW with IR703 on	217.58	217.58
TC plant total MW with IR703 off	477.21	477.21
IR703 Loss Factor	13.5%	10.9%

The loss factor at POI is lower because it does not include the losses from POI to IR703 facility.

14.0 Cases

Table 5: Steady State Power Flow Cases Part 1

Case	IR703	NB to NS	NB to PEI	NB to NE	NB to HQ	NL to NS	CBX	ONI	ONS	NS Trans Wind
C02a_WIN	0	0	289	0	-960	475	1098	1120	935	236
C02b_WIN	300	0	289	0	-960	475	816	1121	936	536
C03a_WIN	0	0	288	0	-960	86	210	593	552	1389
C03b_WIN	300	0	289	0	-960	19	-16	613	572	1689
C04a_WIN	0	142	258	0	-960	237	865	903	860	236
C04b_WIN	300	142	258	1	-960	237	584	903	860	536
C05a_WIN	0	-370	288	0	-960	475	1115	1223	696	500
C05b_WIN	300	-370	289	0	-960	475	833	1223	696	800
C22a_SUM	0	-149	228	799	-845	330	558	659	411	236
C22b_SUM	300	-149	228	799	-845	330	326	660	411	536
C23a_SUM	0	-150	228	801	-845	0	-131	280	176	1389
C23b_SUM	300	-327	229	800	-845	0	-227	462	178	1689
C24a_SUM	0	142	228	800	-845	237	467	571	615	236
C24b_SUM	300	142	228	800	-845	237	234	571	616	536
C25a_SUM	0	-500	228	800	-845	340	911	995	389	236
C25b_SUM	298	-500	227	800	-845	340	629	995	389	534
C42a_SML	0	-150	55	450	-460	170	39	210	47	236
C42b_SML	300	-150	55	450	-460	66	-90	284	121	536

Case	IR703	NB to NS	NB to PEI	NB to NE	NB to HQ	NL to NS	CBX	ONI	ONS	NS Trans Wind
C43a_SML	0	-330	55	448	-460	0	-143	134	-141	776
C43b_SML	189	-500	55	611	-460	0	-143	314	-135	965
C44a_SML	0	142	55	444	-460	85	-104	-9	121	236
C44b_SML	300	-137	55	723	-460	85	-104	271	121	536
C45a_SML	0	-500	55	440	-460	0	-83	194	-255	776
C45b_SML	7	-500	55	440	-460	0	-83	200	-249	783
C46a_SML	0	-66	55	465	-460	0	-199	219	141	574
C46b_SML	300	-340	55	734	-460	0	-200	497	141	874
C62a_SSH	0	-151	162	801	-813	330	291	369	163	236
C62b_SSH	300	-151	162	801	-813	330	181	515	309	536
C63a_SSH	0	-406	162	800	-813	0	-181	258	-61	1389
C63b_SSH	151	-500	162	889	-813	0	-183	401	-14	1540

Table 6: Steady State Power Flow Cases Part 2

Case	NS Load	Mot Load	TC	TR	PT2	LG	PA	BS	VJ	TUS	WC	Pt Lepre.
C02a_WIN	2340	0	390	165	155	343	184	0	66	30	190	715
C02b_WIN	2322	0	390	165	155	63	155	0	66	30	190	715
C03a_WIN	2297	0	213	110	100	0	0	0	66	30	190	715
C03b_WIN	2297	0	194	78	73	0	0	0	66	30	50	715
C04a_WIN	2340	0	390	165	156	343	184	72	66	30	190	715
C04b_WIN	2322	0	390	165	156	63	158	72	66	30	190	715
C05a_WIN	2340	0	390	165	155	353	184	100	66	30	190	0
C05b_WIN	2322	0	390	165	155	63	165	100	66	30	190	0
C22a_SUM	1545	135	386	160	150	110	184	0	0	0	80	715
C22b_SUM	1536	135	386	111	73	0	126	0	0	0	80	715
C23a_SUM	1587	197	70	80	96	80	0	0	0	0	0	715
C23b_SUM	1578	197	68	78	73	0	0	0	0	0	0	715
C24a_SUM	1541	135	182	160	150	110	184	0	0	0	80	715
C24b_SUM	1532	135	182	112	73	0	126	0	0	0	80	715
C25a_SUM	1563	135	329	160	150	480	184	80	0	0	80	0
C25b_SUM	1554	135	329	160	150	179	184	80	0	0	80	0
C42a_SML	738	165	141	154	100	0	0	0	0	0	0	600
C42b_SML	738	165	68	78	73	0	0	0	0	0	0	600
C43a_SML	738	165	74	79	73	0	0	0	0	0	0	419
C43b_SML	738	165	68	78	73	0	0	0	0	0	0	419
C44a_SML	770	197	68	78	73	0	0	0	0	0	0	715
C44b_SML	770	197	68	78	73	0	0	0	0	0	0	715
C45a_SML	738	165	74	79	73	0	0	100	60	16	0	0
C45b_SML	738	165	68	78	73	0	0	100	60	16	0	0

Case	NS Load	Mot Load	TC	TR	PT2	LG	PA	BS	VJ	TUS	WC	Pt Lepre.
C46a_SML	770	197	68	78	73	0	0	0	0	0	0	600
C46b_SML	770	197	68	78	73	0	0	0	0	0	0	600
C62a_SSH	1161	135	366	100	75	0	126	0	0	0	0	715
C62b_SSH	1141	135	217	78	73	0	0	0	0	0	0	715
C63a_SSH	1207	197	118	78	75	0	0	0	0	0	0	600
C63b_SSH	1203	197	68	78	73	0	0	0	0	0	0	600

15.0 Contingencies

Table 7: Steady State Contingencies Part 1					
101S_701	120H_624	1N_T4	50N_T12	88S_712	91H_621
101S_702	120H_626	2CB61*	50N_T8	88S_713	91H_T11
101S_703	120H_627	2CB62*	50NB61G6	88S_714	91H_T62
101S_704	120H_628	2S_600	50NB62G5	88S_715	91H_TC3
101S_705	120H_629	2S_B64	67N_701	88S_720	91N_701
101S_706	120H_710	2S_B65	67N_702	88S_721	91N_Dal_WF
101S_711	120H_711	2S_T1	67N_703	88S_722	CT-L1104-L1116
101S_712	120H_712	2S_T2	67N_704	88S_723*	CT-L1147-L1165
101S_713	120H_713	30N_B61	67N_705	88S_G4	CT-L1148-L1151*
101S_811	120H_714	30NT61	67N_706	88S_T71	CT-L1149-L1212
101S_812*	120H_715	3C_711	67N_710	88S_T72	CT-L1190-L1215
101S_813*	120H_716	3C_712*	67N_713	89S_G1	CT-L2145-L1199
101S_814	120H_720	3C_713	67N_811*	90H_602	IR618
101S_816	120H_SVC	3C_714	67N_812	90H_603	IR618_BBU
101S_T81	120H_T71	3C_715*	67N_813	90H_605	IR668
101S_T82	120H_T72	3C_716	67N_814*	90H_606	IR668_BBU
103H_600	132H_602	3C_T71	67N_T71	90H_608	IR670
103H_608	132H_603	3C_T72	67N_T81	90H_609	IR670_BBU
103H_681	132H_605	3C710*	67N_T82	90H_611	IR703
103H_881	132H_606	3C720*	67N711*	90H_612	IR703_BBU
103H_B61	1C_689	3S_T1	67N712*	90H_T1	L1147
103H_B62	1C_B61	47C_T63	7003a_4*	91H_603	L1149
103H_T81	1C_B62	47C_T64	7003c_4*	91H_604	L1157
108H_600	1C_G2	47C_T65	70087009sep	91H_605	L1159
108H_B1	1N_600	47C_T67	74N_B61	91H_606	L1160
108H_B3	1N_601	49N_600	74NT61	91H_607	L1165
113H_600	1N_613	4C_T2	79N-T81*	91H_608	L1193-UV
120H_621	1N_B61	4C_T63	85S_B61	91H_609	L1199

Table 7: Steady State Contingencies Part 1					
120H_622	1N_B62	50N_604	88S_710	91H_611	L2101*
120H_623	1N_T1	50N_G6	88S_711	91H_613	L2102*

Table 8: Steady State Contingencies Part 2	
L2103	L3009
L2130	L3009-BF-CO3-5
L2130-BF-K2-9	L3010
L2131-2111	L3010*
L2131-2111-BF-B2103-2131	L3010-BF-AN3-2-*
L2145	L3010-BF-AN3-3*
L2145-BF-K2-6	L3010-BF-E2104-TC3*
L2145-BF-K2-7	L3010-BF-E3-1*
L3001	L3011*
L3001*	L3011-BF-AN3-1*
L3001-BF-K3-7*	L3011-BF-AN3-6*
L3001-BF-K3-8*	L3011-BF-K3-5*
L3002	L3011-BF-K3-6*
L3002-BF-CO3-6	L3012-3114
L3002-BF-K3-1	L3013
L3002-BF-K3-2	L3013-BF-NO3-2
L3003	L3013-BF-NO3-2*
L3003-BF-K3-4	L3013-BF-SA3-4
L3003-BF-P3-4	L3016
L3004	L3016*
L3004-BF-CO3-11-UV	L3016-BF-P3-10*
L3004-BF-CO3-7*	L3016-BF-SA3-6
L3004-BF-NO3-01	L3017-3019
L3006	L3017-3019*
L3006-BF-ME3-1*	L3017-3019-BF-BA3-2*
L3006-BF-ME3-2*	L3017-3019-BF-SA3-1*
L3006-BF-SA3-3	L3017-3019-BF-SA3-2-UV
L3008	L3018
L3008-BF-BE3-1*	L3018*
L3008-BF-BE3-2*	L3018-BF-BA3-1*

Table 9: Steady State Contingencies Part 3		
L3018-BF-BA3-3*	L6507	L7012
L3018-BF-BE3-3*	L65076508	L7014
L3022	L6508	L7015

Table 9: Steady State Contingencies Part 3		
L3025-BF-ME3-3*	L6514	L7019
L6001	L6515	L7021
L60036007	L6516	L70216534
L60036009	L6517	L7022
L6005	L6518	L8001*
L60056010	L6523	L8002
L60056016	L6531	L80027009
L6006	L6535	L8003*
L6007	L6536	L8004*
L6008	L6537*	ML_2Poles
L6009	L6538	ML_Pole1
L6010	L6539	ML_Pole2
L60106011	L6551	NB_LOS_Lepreau
L6014	L6552	NS_LOL_104H600
L6015	L6613	NS_LOL_1H
L6016	L7001	NS_LOL_2S_513
L6033	L7002	NS_LOL_47C_602
L60335039	L7003a	NS_LOL_47C_603
L60336035	L7003b	NS_LOL_47C_674
L6035	L7003c	NS_LOL_PHP
L6038	L7004	T-BA-T7
L6040	L7005_IR670_IR703*	T-CC-T1-UV
L60406042	L7005Has*	T-CC-T2
L6042	L7005Ons*	T-ME-T3
L6043	L7008	T-NO-T1
L6044	L7009	T-SA-T2
L6055	L7011	T-SA-T3

Note: Contingencies with * means it is equipped with Remedial Action Scheme (RAS) or Special Protection Scheme (SPS).

16.0 Preliminary Scope of Subsequent SIS

The following provides a preliminary scope of work for the subsequent SIS for IR#718.

The SIS will include a more comprehensive assessment of the technical issues and requirements to interconnect generation as requested. It will include contingency analysis, system stability, transient stability, 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 contingencies (as defined by the criteria appropriate to the location) and identify any restrictions that must be placed on the system following a first contingency loss.

The SIS will confirm the options and ancillary equipment that the customer must install to control flicker, voltage response, frequency response, control interactions with other IBR facilities, active power and ensure that the facility has the required ride-through capability. The SIS will be conducted in accordance with the GIP with the assumption that all appropriate higher-queued projects proceed, and the facilities associated with those projects are installed.

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

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

- Facilities that the customer must install to meet the requirements of the GIP and the TSIR.
- 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.
- Guidelines and restrictions applicable to first contingency operation (curtailments etc.).
- Under-frequency load shedding impacts.

The SIS will assess system contingencies such that the system performance will meet the following criteria:

- Table 1 “Planning Design Criteria” of NPCC Directory 1.
- Table 1 “Steady State & Stability Performance Planning Events” of NERC TPL001-4.
- NSPI System Design Criteria, report number NSPI-TPR-003-4.

Any changes to RAS 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 NPCC[5] and NERC[6] criteria as well as NSPI guidelines and good utility practice. The SIS will also determine the contingencies for which this facility must be curtailed.

[5] NPCC criteria are set forth in its Reliability Reference Directory #1 *Design and Operation of the Bulk Power System*

[6] NERC transmission criteria are set forth in *NERC Reliability Standard TPL-001-4*

17.0 Conclusion

The conclusion is covered in the Executive Summary.

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