System Impact Study Part1 Report
Report GIP-IR673-SIS-Part1-R0

Generator Interconnection Request #673
33.6 MW Wind Generating Facility
Hants County, NS

Control Centre Operations
Nova Scotia Power Inc.
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Executive Summary

This report is for Part 1 of a two part system impact study (SIS) for a proposed 33.6 MW wind turbine generating facility to be connected to the Nova Scotia Power Inc (NSPI) transmission system on a 138 kV transmission line, L-6054, between 43V-Canaan Road substation and 101V-MacDonald Pond substation.

The Interconnection Customer (IC) of the proposed generating facility applied for Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS). The interconnection request has been designated as IR#673, which will be referred to in this report as IR673.

Part 1 study uses a Power System Simulator software to determine the impacts of IR673 on the NSPI power system with respect to steady state, stability, short circuit, power factor, voltage flicker, bulk power system status, under-frequency operation, low voltage ride through and loss factor. The assessment is based on NSPI's system design criteria, Generator Interconnection Procedure (GIP), Transmission System Interconnection Requirements (TSIR), applicable Northeast Power Coordinating Council (NPCC) planning criteria for Bulk Power System (BPS), and applicable North American Electric Reliability Corporation (NERC) planning criteria for Bulk Electricity System (BES).

Part 2 study will use Electro Magnetic Transient (EMT) software to determine the impact and control interactions of IR673 with the NSPI power system. Part 2 study will progress in parallel with the next phase of the GIP process (facilities study). The outcomes of the Part 2 study will be captured as an addendum to the SIS Part 1 report and may trigger restudy for facilities study work completed at that time.

It is important to note that this study is based on IR673 generation and higher queued IRs displacing Cape Breton coal fired generation, hence Cape Breton Export (CBX) and Onslow Import arming level and limit will be reduced accordingly by these IRs depending upon their locations. In addition, this study excludes Transmission Service Request TSR411 as per NSPI's current posting on its GIP site: Generation Interconnection Procedures| Nova Scotia Power (nspower.ca).

The point of interconnection (POI) for IR673 will be on L-6054 at 4.1 km from 101V-MacDonald Pond substation. The POI will be a direct tap to L-6054. The new transmission line extension from the POI to the IC substation will be approximately 300 meters in length. The IC substation will have a breaker on the 138 kV side of the 138kV to 34.5 kV power transformer.

Since practically only a limited number of power systems cases can be studied as compared to a live power system that continually changes at any moment from present to distant future, it is important to note that even though this study is for IR673 being NRIS, NSPI's Control Center Operations can curtail IR673 output at anytime as permitted in Section 9.7.2 of NSPI's Standard Generator Interconnection Agreement (GIA).

As per NSPI's GIP, all Interconnection Requests, which are in higher queued positions than IR673 and which are not considered electrically remote from IR673, were modelled, and included in the power system cases for this study.

Below are the findings of Part 1 study:

- The short circuit analysis shows that IR673 short circuit contribution does not require any upgrade of existing breakers in the transmission system.
- The minimum short circuit ratio (SCR) at IR673's 34.5 kV voltage bus is 6.3. However, as there are two existing wind farms on L6054/L6004 plus a higher queued IR671 wind farm plus the new IR673, the weighted SCR (WSCR) for all the four wind farms on L6054/L6004 can be 1.4 at system normal and minimum generation, hence IR673 should discuss with the wind turbine supplier for a SCR to closer to 1.4. Please note that NSPI's TSIR, section 7.4.15, states that "System short circuit level may decline over time with changes to transmission configuration and generation mix. The Generating Facility shall be able to accommodate these changes. If the Point of Interconnection does not provide sufficient SCR for acceptable operation of the Generating Facility, the Interconnection Customer must provide facilities such as synchronous condensers or control systems to permit low SCR operation".
- The power flow analysis shows that IR673 wind turbines with a combination of three wind turbines with FT capability and five wind turbines with FTQ capability can meet the first part of the power factor requirement of +/- 0.95 on the high voltage side of the main substation transformer. However, FT and FTQ capabilities do not meet the second power factor requirement of full rated MVAR at 0 MW output. One option to meet this requirement is to have all eight wind turbines equipped with FTQS capabilities. Please note that Part 2 EMT study may identify additional required resources such as synchronous condenser, Flexible AC Transmission System (FACTS), etc. for other reasons. If so, these resources may have their own reactive power capability which may complement or provide an alternative to FTQS option.
- The short circuit analysis shows that voltage flicker and harmonics are not expected to be an issue at the POI. If for any reason, in the actual installation, IR673 causes issues with voltage flickers or harmonics, then IR673 will be responsible for mitigating the issues.
- The steady state power flow analysis shows that IR673 addition to the system will have the following system impacts:
    - For NRIS:
        - 21.1km of L-6054 section from IR673 to 43V-Canaan Road substation of L-6054 will be overloaded under contingencies and will require upgrade.
        - 44.5 km of L-6004 section from IR671's POI to 90H-Sackville substation will be overloaded under contingencies and will require upgrade.
        - L-6054 protection at 43V-Canaan Road substation will require upgrade. Metering will require Current Transformer (CT) ratio to be raised to higher tap for full scale substation metering.
        - L-6054 protection at 101V-MacDonald Pond will require upgrading.
    - For ERIS:

    - ERIS output above 9 MW will be subjected to curtailment.
    - L-6054 protection at 43V-Canaan Road substation will require upgrade. Metering will require Current Transformer (CT) ratio to be raised to higher tap for full scale substation metering.
    - L-6054 protection at 101V-MacDonald Pond will require upgrading.
- The stability analysis shows that the power system and IR673 remain stable and well damped for all dynamic contingencies studied hence no stability issue.
- Bulk power system (BPS) analysis confirms that L-6054, POI, and IC's substation are non-BPS.
- The dynamic simulation of NS being suddenly islanded from NB shows that IR673 reduces its output immediately to zero MW then ramps up to rated output and remains stable and well damped post contingency. While this meets the LVRT requirement, it does not provide inertial frequency response as inherently provided by traditional synchronous generators. As more inverter based generators will be added to the NS power system to replace the traditional synchronous generators, the lack of inertial frequency response may increase, and it is expected that the inverter based generators will be required to provide the inertial frequency response or its equivalent in the form of fast frequency response or by synchronous condenser or other means. Please note that NSPI's TSIR, section 7.6.7 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". This issue will be studied in Part 2 EMT study.
- The LVRT dynamic simulation shows that IR673 meets low voltage ride through (LVRT) requirement.
- The power flow analysis shows that the loss factor is +0.6% if IR673 power is measured at its voltage terminal or -0.9% if power is measured at POI.

The following facility changes will be required to connect IR673 to NSPI transmission system at the POI on L-6054:

- NSPI Transmission Network Upgrades for NRIS:
    - 21.1 km of L-6054 section from IR673's POI to 43V-Canaan Road substation will require its conductor operating temperature upgraded from 75 deg C to 100 deg C.
    - 44.5 km of L-6004 section from IR671's POI to 90H-Sackville substation will require its conductor operating temperature upgraded from 75 deg C to 100 deg C.
    - L-6054 protection at 43V-Canaan Road substation will require upgrade. Metering will require Current Transformer (CT) ratio to be raised to higher tap for full scale substation metering.
    - L-6054 protection at 101V-MacDonald Pond will require upgrading.

- NSPI Transmission Network Upgrades for ERIS:
    - L-6054 protection at 43V-Canaan Road substation will require upgrade. Metering will require Current Transformer (CT) ratio to be raised to higher tap for full scale substation metering.

  - L-6054 protection at 101V-MacDonald Pond will require upgrading.
  - IR673 output above 9 MW will be subjected to curtailment.

- Transmission Provider's Interconnection Facilities (TPIF) Upgrades NRIS or ERIS
  - Installation of 300 meters of new 138 kV spur line extension from POI tap point to the IC substation with Dove conductors designed for 100 deg C using NSPI's standard 138 kV construction.
  - Installation of NSPI P&C Relaying Equipment.
  - Installation of NSPI supplied RTU.
  - Installation of Tele-protection and SCADA communication.
- New IC Interconnection Facilities (ICIF):
  - IR673 must be capable of providing 0.95 leading and lagging power factor at the HV terminals of the IC main substation step up transformer for the full range of IR673 real power output from zero to rated output. The generating facility must be capable of providing rated reactive power at zero MW output.
  - IR673 must provide centralized controls such as a farm control unit (FCU) that can control the 34.5 kV bus voltage to a settable point and will control the reactive output of each wind turbine of IR673 to achieve this common objective. 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. Please refer to NSPI's TSIR such as section 7.6.6 on "Active Power Control (Fast Frequency Response) and Curtailment" for additional requirements.
  - NSPI will have control and monitoring of reactive output of this facility, via the centralized controller. This will permit the NSPI Operator to raise or lower the voltage set point remotely.
  - Low voltage ride-through capability per Nova Scotia Power Transmission System Interconnection Requirements (TSIR) document.
  - Real-time monitoring (including an RTU) of the interconnection facilities via NSPI's SCADA (Supervisory Control and Data Acquisition) regarding wind speed, MW and MVAR, bus voltage and curtailment levels.
  - Facilities for NSPI to execute high speed rejection of generation (transfer trip). The plant may be incorporated into RAS run-back schemes.
  - Automatic Generation Control to assist with tie-line regulation.
  - Revenue metering.
  - The facility must meet NSPI's TSIR as published on the NSPI OASIS site.
  - Compliance with section 7.6.7 of TSIR, "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.". Please note that the assessment of section 7.6.7 of TSIR will be in Part 2 EMT study, which may identify additional resources such as synchronous condenser, Flexible AC Transmission System (FACTS) devices, etc.

The high level non-binding cost estimate in 2023 Canadian dollars for the Network Upgrades will be $15.08 million for NRIS and $0.18 million for ERIS. The Transmission Provider's

Interconnection Facilities (TPIF) is $1.74 million for NRIS or ERIS. Hence, the combined cost estimate for NRIS is $16.82 million and for ERIS is $1.91 million.

The line upgrade cost estimates, for L-6054 section from IR673's POI to 43V-Canaan Road substation and for L-6004 section from IR671's POI to 90H-Sackville substation, are based on historical averages. The actual number of spans that require upgrading cannot be confirmed until the lines are surveyed.

The above cost estimates include 10% contingency but exclude HST and any additional costs or upgrades to be identified by Part 2 EMT study and Facility Study. They also exclude any cost associated with ICIF generating facility. They are high-level and non-binding and will be revised by the Facility Study.

The IC will be responsible for acquiring the ROW (Right-Of-Way) for and access to all the facilities.

The non-binding estimate for the time to construct NSPI Transmission Network Upgrades is two years after the IC has obtained the necessary easements and ROW. The Facilities Study will confirm the estimated construction time.

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1.0 Introduction

The Interconnection Customer (IC) submitted an Interconnection Request (IR), dated 9th August 2022, for a Network Resource Interconnection Service (NRIS) to Nova Scotia Power Inc. (NSPI) for a proposed 33.6 MW wind generating facility interconnected to the NSPI transmission system.

However, the System Impact Study (SIS), signed by NSPI on 23rd August 2022 and by the IC on 10th of October 2022, indicates both NRIS and ERIS options. This IR has been designated by the NSPI System Operator as Interconnection Request #673 and will be referred to as IR673 throughout this report.

1.1 Scope

The SIS Agreement states that the Point of Interconnection (POI) of IR673 will be on the 138 kV line L-6054 between 43V-Canann Road substation and 101V-MacDonald Pond substation. Since then, the IC has confirmed that the POI will be at 4.1 km from 101V-MacDonal Pond substation on L-6054 as shown in Figure 1 locationally and on Figure 2 electrically.

The IC's supplied one shows a direct tap to L-6054 with a 300m line extension from the tap to the IC's substation, which has a main 138 kV to 34.5 kV transformer, a high voltage side breaker and associated switches.

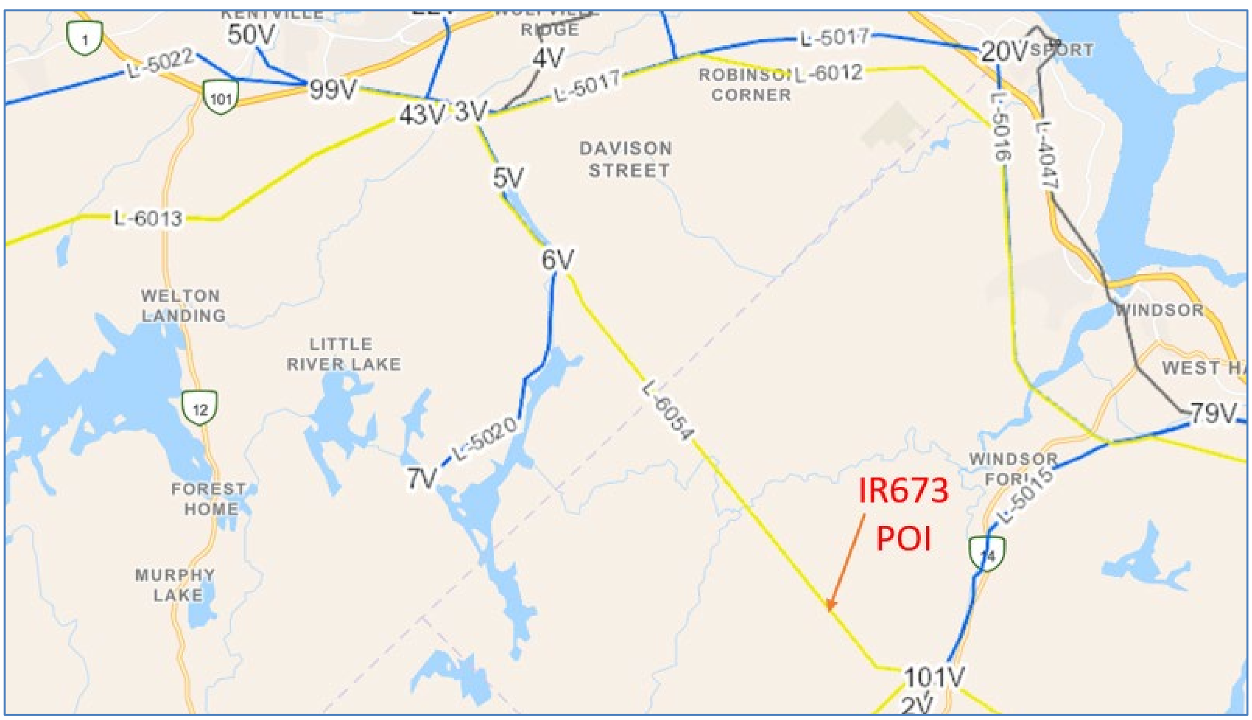

Figure 1: IR673 POI to L-6054 locationally

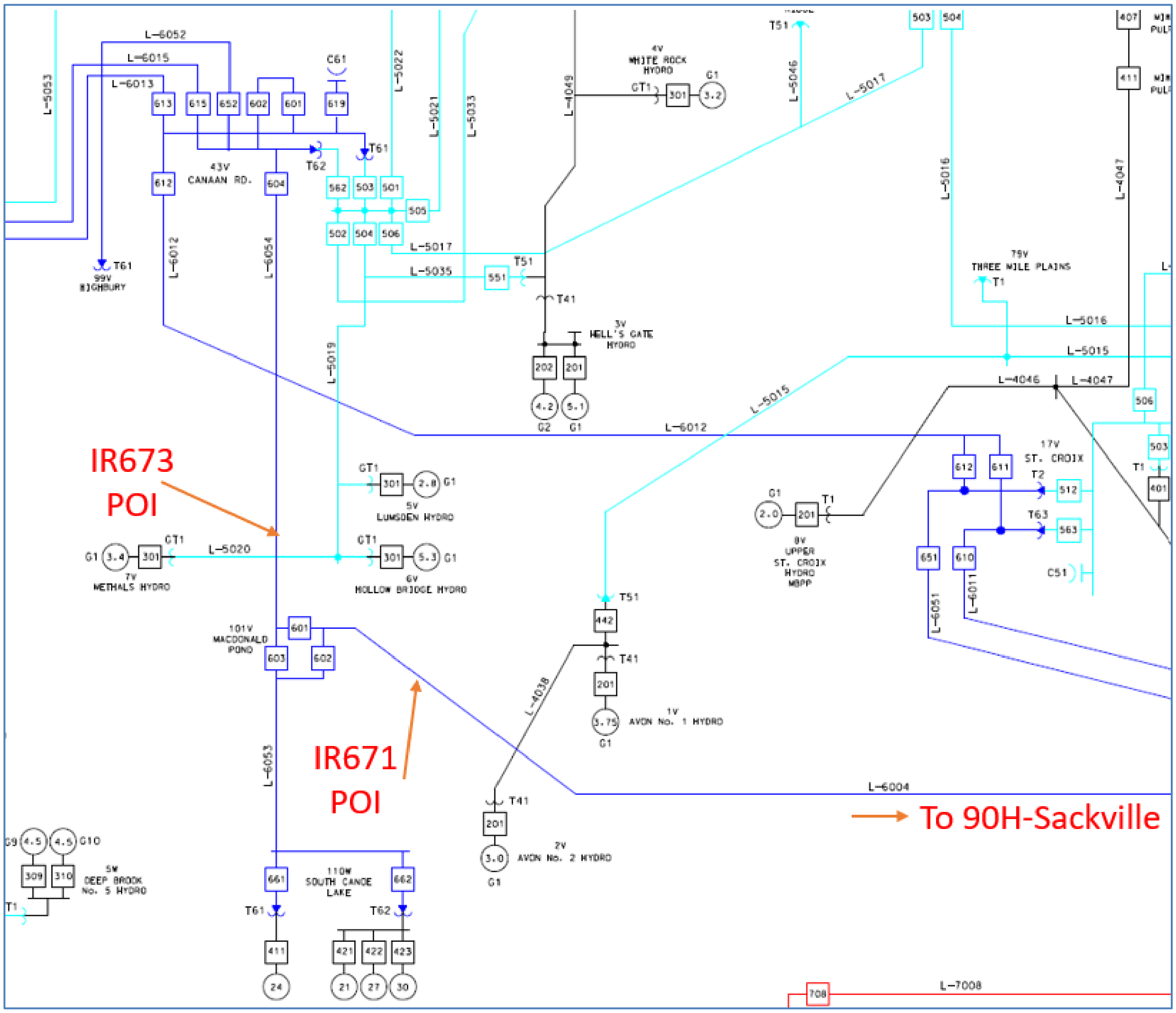

Figure 2: IR673 POI to L-6054 electrically

The SIS will be completed in two parts.

Part 1 will use a Power System Simulator software to determine the impacts of IR673 on the NSPI power system with respect to system normal and system under first contingencies in steady state and system stability, and other steady state analysis.

Part 2 study will use Electro Magnetic Transient (EMT) software to determine the impact and control interactions of IR673 with the NSPI power system. Part 2 study will progress later in parallel with the next phase of the GIP process (facilities study). The outcomes of the Part 2 study will be captured as an addendum to the SIS Part 1 report and may trigger restudy for facilities study work completed at that time.

The scope of Part 1 study will determine the impact of the IR673 generating facility on the NSPI transmission system for the following:

- Steady state analysis to determine any thermal overload of transmission elements or voltage criteria violation under system normal and contingencies.
- Stability analysis to demonstrate that the interconnected power system is stable and well damped during and post contingencies.
- Bulk Power System (BPS) determination for the substation.
- Short circuit analysis and its impact on circuit breaker ratings.
- Power factor requirement at the high side of the interconnection transformer.
- Voltage flicker and Harmonics.
- Low voltage ride through.
- Under frequency operation when NS is suddenly islanded from NB.
- Loss Factor.
- Impact on any existing Special Protection Systems (SPSs) as previously referred to or Remedial Action Scheme as presently known.

This report provides a high-level non-binding cost estimate for the connection of the generation facility to ensure there will be no adverse impact on the reliability of the NSPI transmission system.

1.2 Assumptions

The study is performed using the following assumptions:

1. NRIS and ERIS with an in-service date of December 31, 2024.
2. The proposed generating facility will be equipped with eight Enercon E-138 EP3 E2 wind turbine generators, each rated at 4.2 MW, three units with FT option and five units with FTQ option.
3. Individual wind turbine generator step-up transformer (690V/34.5 kV) is modeled to have an impedance of 6% on 4.6 MVA for FT option and on 5 MVA for FTQ option.
4. The interconnection facility transformer is modelled based on it having 138 kV grounded wye to 34.5 kV grounded wye and a delta winding, with a base rating of 34 MVA and a top rating of 57 MVA, Z = 7.5% on base rating and X/R = 28.65. The original SIS agreement has the transformer as having a rating of 96/128/160 MVA but since then, the IC has revised the ratings.
5. The POI will be on L-6054 at 4.1 km from 101V-MacDonal Pond substation as per updated information provided by the IC. The original one-line in the application shows the POI being 2.3 km from 101V-MacDonald Pond substation, but since then, the IC has revised the length.
6. The IC provided the collector circuit layout which was used to estimate the equivalent impedances.

7. The IC confirmed that the spur 138 kV line extension from the IC main 138 kV substation to the POI will be constructed with Dove conductors using NSPI's standard wood poles 138 kV H frame construction.
8. NSPI's transmission line ratings as last updated and issued on June 13, 2022.

1.3 Project Queue Position

All in-service generation facilities are included in the SIS except for Lingan Unit 2 which is assumed to be retired.

As of November 15, 2022, the "Combined T/D Advanced Stage Interconnection Request Queue", available on NSPI's OASIS site, is shown on Figure 3, 4, and 5.

Combined T/D Advanced Stage Interconnection Request Queue

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Publish Date: *Tuesday, November 15, 2022*

Queue Order*	IR #	Request Date DD-MMM-YY	County	MW Summer	MW Winter	Interconnection Point Requested	Type	Inservice date DD-MMM-YY	Revised Inservice date	Status	Service Type	IC Identity
1 -T	426	27-Jul-12	Richmond	45	45	47C	Biomass	01-Jan-17	9/1/2018	GIA Executed	NRIS	NSPI
2 -T	516	05-Dec-14	Cumberland	5	5	37N	Tidal	01-Jul-16	5/31/2020	GIA Executed	NRIS	N/A
3 -T	540	28-Jul-16	Hants	14.1	14.1	17V	Wind	01-Jan-18	10/31/2023	GIA Executed	NRIS	N/A
4 -T	542	26-Sep-16	Cumberland	3.78	3.78	37N	Tidal	01-Jan-19	6/30/2025	GIA Executed	NRIS	N/A
5 -D	557	19-Apr-17	Halifax	5.6	5.6	24H	CHP	01-Sep-18		SIS Complete	N/A	N/A
6 -D	569	26-Jul-19	Digby	0.6	0.6	509V-302	Tidal	01-Mar-21	2/24/2022	GIA Executed	N/A	N/A
7 -D	566	16-Jan-19	Digby	0.7	0.7	509V-301	Tidal	31-Jul-19	4/30/2022	GIA Executed	N/A	N/A
8 -T	574	27-Aug-20	Hants	58.8	58.8	L-6051	Wind	30-Jun-23		GIA Executed	NRIS	N/A
9 -T	598	13-May-21	Cumberland	2.52	2.52	37N	Tidal	01-Dec-22		GIA Executed	NRIS	N/A

Nova Scotia Power - Interconnection Request Queue: Page 1 of 3

ERIS - Energy Resource Interconnection Service
NRIS - Network Resource Interconnection Service
N/A - Not Applicable
T - Transmission Interconnection Request
D - Distribution Interconnection Request

*** Note: Queue reflects current list of IR's which have established an advanced queue position per GIP/DGIP Section 4.1**

Figure 3: Advanced Stage IR queue, page 1 of 3

Queue Order*	IR #	Request Date DD-MMM-YY	County	MW Summer	MW Winter	Interconnection Point Requested	Type	Inservice date DD-MMM-YY	Revised Inservice date	Status	Service Type	IC Identity
10 - D	604	07-Jun-21	Cape Breton	0.45	0.45	11S-303	Solar	15-Jan-22		GIA Executed	N/A	N/A
11 - D	603	31-May-21	Cumberland	0.4	0.4	22N-404	Solar/Battery	16-Feb-22		GIA Executed	N/A	N/A
12 - D	600	27-May-21	Halifax	0.6	0.6	99H-312	Solar/Battery	02-Mar-22		GIA Executed	N/A	N/A
13 - T	597	07-May-21	Queens	36	36	50W	Wind	31-Aug-23		SIS Complete	NRIS	N/A
14 - T	629	20-Sep-21	Cumberland	0.5	0.5	7N	Solar	28-Sep-21		GIA Executed	ERIS	N/A
15 - T	647	06-Oct-21	Cumberland	1.5	1.5	37N	Tidal	31-Dec-23		GIA in Progress	NRIS	N/A
16 - D	653	19-Jan-22	Halifax	0.09	0.09	24H-406	Solar	30-Oct-22		GIA in Progress	N/A	N/A
17 - D	654	16-Feb-22	Halifax	0.125	0.125	127H-413	Solar	20-Sep-22		GIA in Progress	N/A	N/A
18 - T	656	28-Mar-22	Cumberland	4	4	37N	Tidal	31-Dec-22		GIA in Progress	NRIS	N/A
19 - T	672	05-Aug-22	Hants	33.4	33.4	L-5060	Wind	02-Dec-24		SIS in Progress	NRIS	N/A
20 - T	664	26-Jul-22	Lunenburg	50	50	99W	Battery	15-Dec-23		SIS in Progress	NRIS	NSPI
21 - T	662	26-Jul-22	Halifax	50	50	132H	Battery	15-Dec-24		SIS in Progress	NRIS	NSPI

Nova Scotia Power - Interconnection Request Queue: Page 2 of 3

ERIS - Energy Resource Interconnection Service
NRIS - Network Resource Interconnection Service
N/A - Not Applicable
T - Transmission Interconnection Request
D - Distribution Interconnection Request

*** Note: Queue reflects current list of IR's which have established an advanced queue position per GIP/DGIP Section 4.1**

Figure 4: Advanced Stage IR queue, page 2 of 3

Queue Order*	IR #	Request Date DD-MMM-YY	County	MW Summer	MW Winter	Interconnection Point Requested	Type	Inservice date DD-MMM-YY	Revised Inservice date	Status	Service Type	IC Identity
22 - T	663	26-Jul-22	Colchester	50	50	1N	Battery	15-Jun-24		SIS in Progress	NRIS	NSPI
23 - T	661	26-Jul-22	Kings	50	50	92V	Battery	15-Mar-24		SIS in Progress	NRIS	NSPI
24 - T	670	05-Aug-22	Colchester	97.98	97.98	L-7005	Wind	28-Feb-26		SIS in Progress	NRIS	NSPI
25 - T	671	05-Aug-22	Halifax	88.96	88.96	L-6004	Wind	28-Feb-26		SIS in Progress	NRIS	NSPI
26 - T	669	04-Aug-22	Cumberland	99	99	L-6613	Wind	31-Dec-25		SIS in Progress	NRIS	N/A
27 - T	668	03-Aug-22	Antigonish	94.4	94.4	L-7003	Wind	01-Dec-25		SIS in Progress	NRIS	N/A
28 - T	618	21-Jul-21	Guysborough	130.2	130.2	L-6515	Wind	01-Jan-25		SIS in Progress	NRIS	N/A
29 - T	673	09-Aug-22	Hants	33.6	33.6	L-6054	Wind	31-Dec-24		SIS in Progress	NRIS	N/A
30 - T	675	10-Aug-22	Queens	112.5	112.5	50W	Wind	01-Dec-24		SIS in Progress	NRIS	N/A
		Totals:		1069.81	1069.8							

Nova Scotia Power - Interconnection Request Queue: Page 3 of 3

ERIS - Energy Resource Interconnection Service
NRIS - Network Resource Interconnection Service
N/A - Not Applicable
T - Transmission Interconnection Request
D - Distribution Interconnection Request

*** Note: Queue reflects current list of IR's which have established an advanced queue position per GIP/DGIP Section 4.1**

Figure 5: Advanced Stage IR queue, page 3 of 3

The following IRs have been excluded from IR673 Part 1 SIS:

- IR661, which was withdrawn.
- IR672, which was withdrawn during IR673 Part 1 SIS progress.

According to NSPI's posted Generator Interconnection Procedure (GIP), Transmission Service Requests which are in higher queued positions than IR673 will be modelled and included in IR673 study base cases.

As the GIP section 4.2 allows for "Transmission Provider may study an Interconnection Request separately to the extent warranted by Good Utility Practice based upon the electrical remoteness of the proposed Generating Facility", the following IRs are considered electrically remote and are not included in this study:

- IR540
- IR557
- IR569
- IR566
- IR604
- IR603
- IR600
- IR629
- IR653
- IR654

Of the remaining higher queued IRs to be included in this SIS, some are in SIS progress but not yet completed, so the information from the corresponding Feasibility Study will be used to do the modelling. In some cases, to reduce the time to model the details of the local system associated with these higher queued IRs, their generating sources will be modelled directly on the local buses.

As per the GIP, if any of the higher-queued projects included in this SIS are subsequently withdrawn from the Queue, "the Transmission Provider will notify the Interconnection Customer if a SIS re-study is required".

The Transmission Service Request queue is shown on Figure 6.

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OATT Transmission Service
Queued System Impact Studies
Active January 31, 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.

Figure 6: Transmission Service Request Queue

The transmission service request queue is accounted for in this study as follows:

- TSR400: included.
- TSR411: excluded as per NSPI's current posting on its GIP site: Generation Interconnection Procedures| Nova Scotia Power (nspower.ca) as shown below:

POWER | OUTAGE CENTRE | PAY YOUR BILL | START, STOP, MOVE SERVICE | CUSTOMER SERVICE | MYACCOUNT LOGIN

Notices

Please be advised of the following notices:

1) Due to the ongoing COVID-19 pandemic response there may be delays in processing physical copies of documentation. Please use the contact details above for the Interconnection Engineer to determine suitable submission arrangements.

2) Due to ongoing development discussions and engineering studies, the Transmission System Network Upgrades identified as part of Transmission Service Request #411 will not be included in the System Impact Study (SIS) Analysis for Generator Interconnection Procedures (GIP) Study Groups #32 and #33. GIP Study Group #32 and #33 analysis will be limited to the 2022 Transmission System configuration plus any material Network Upgrades identified in higher queued projects.

3) Due to the expected increase in inverter-based generation resources in Nova Scotia and the anticipated decrease in synchronous generation related to the requirement to phase-out of coal fired generation by 2030, GIP System Impact Study analyses are being expanded to include Electromagnetic Transient (EMT) Analysis in addition to Load Flow and Dynamic Analysis. To accommodate this change, Interconnection Customers are required to provide the System Operator with the appropriate PSCAD™ models for their generators in addition to the PSS®E generator models required in the Generator Interconnection Procedures. A separate report will be issued for the Electromagnetic Transient Analysis.

4) Grid Code Requirement 7.6.7: Inertia Response – WECS
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.

Background:
With the next round of wind coming online, NSPI has identified a need for grid support to arrest the rate of change of frequency following a system disturbance when the energy dispatch is predominantly wind.

NSPI will consider the following as an alternative to meet Grid Code Requirement 7.6.7:

For Round 32, WEC Generating Facilities may propose a mix of inertia and Fast Frequency Response (FFR) to an equivalent of 3.0 MW-s/MVA. The FFR response time will be at full response in less than 200ms and be sustained for at least 2 seconds. The FFR equivalent can be determined in the System Impact Study stage.

End of Notice

2.0 Technical Model

To facilitate the power flow analysis, three FT wind turbines are grouped as one equivalent generator and the other five FTQ wind turbines are grouped together as another equivalent generator. The 690V generator terminal voltage is stepped up to 34.5 kV at the collector substation with a single equivalent generator step-up transformer, then to 138 kV via the main substation transformer 34.5 kV to 138 kV. The high voltage side of this transformer will be connected to the POI via a spur 138 kV line extension with an approximate length of 300 meters.

Figure 7 shows the PSS®E equivalent model for IR673 generating facility connection to the transmission system.

The wind turbine technical bulletin shows that FT model provides +/-1.85 MVAR per wind turbine and FTQ model provides +/-2.65 MVAR per wind turbine. Hence, the first FT equivalent generator for the three FT wind turbines is modelled with rated power of 12.6 MW and a reactive power range of +/- 5.55 MVAR. The second FTQ equivalent generator for the other five wind turbines is modelled with rated power of 21.0 MW and a reactive power range of +/- 13.25 MVAR.

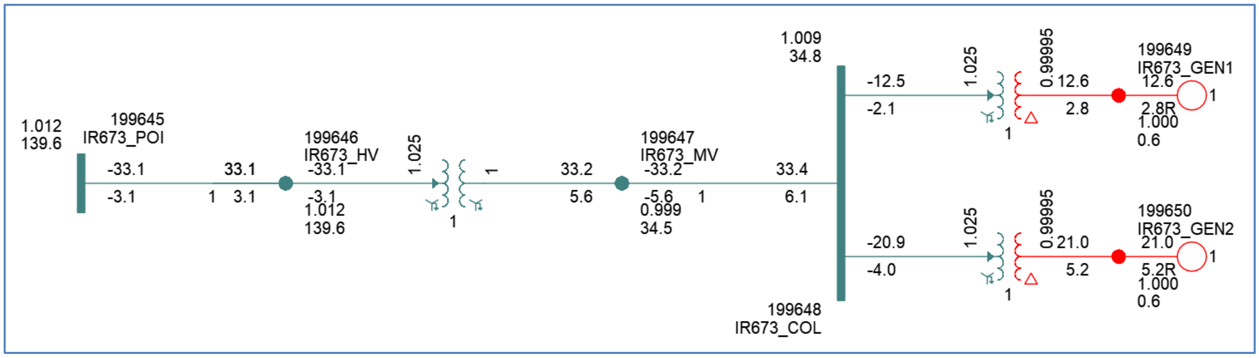

Figure 7: PSS®E model

2.1 System Data

The "*2022 Load Forecast Report*", dated April 29, 2022, produced by NSPI, and submitted to the Nova Scotia Utility and Review Board (NSUARB) was used to allocate the loads in NS. This study uses a Net System Peak Demand of 2,532 MW as shown in Table 1.

Please note that the load forecast includes the power system losses but excludes the station service loads at power generating stations.

Table 1: Study Year Load Forecast

Forecast Year	Season	Net System Peak Demand (MW)	Non-Firm Peak Demand (MW)	Firm Peak Demand (MW)	Demand Response (MW)
2026	Winter Peak	2291	154	2101	-36
2027	Winter Peak	2326	153	2133	-39
2028	Winter Peak	2361	153	2170	-39
2029	Winter Peak	2398	153	2207	-39
2030	Winter Peak	2434	152	2243	-38
2031	Winter Peak	2479	152	2289	-38
2032	Winter Peak	2532	152	2342	-37

As for the summer peak and the light load forecast, their typical values are based on 67% and 35% respectively of the winter peak values.

2.2 Generating Facility

IR673 will have eight Enercon E-138 EP3 E2 wind turbine generators with three units having FT option and five units having FTQ option as specified by the IC. The total generating facility will be 33.6 MW.

The proposed generating facility will be equipped with a SCADA-based central regulator which controls the individual generator reactive power output to maintain constant voltage at the Interconnection Facility substation.

3.0 Technical Analysis

3.1 Short Circuit

The short circuit capability is modelled based on the information is provided by the wind turbine technical bulletin for IR673.

Short circuit analysis was performed using PSSE Version 34. The solution is based on flat voltage profile at 1 per unit voltage. The relevant short-circuit levels before and after IR673 are provided in Table 2. Maximum generation includes existing and higher queued generation in NS in service. Minimum generation includes a selected number of generators in NS in service: Tuft Cove 3, Point Aconi, and Lingan 4. System normal means all system elements in service.

Table 2: Short-Circuit Levels, Three-phase MVA

Location	IR673 Off	IR673 On
Maximum Generation System Normal (Magnitude in MVA / Angle in Degree)		
43V-Canaan Rd 138 kV	1324 /-80.86	1344 / -80.94
101V-MacDonald Pond	1348 /-80.95	1379 / -81.13
IR673 POI 138 kV	1309 /-80.77	1343 /-80.99
IR673 34.5 kV	283 /-83.34	323 /-84.11
Minimum Generation System Normal		
43V-Canaan Rd 138 kV	779 /-82.16	804 /-82.32
101V-MacDonald Pond	773 /-81.99	805 /-82.26
IR673 POI 138 kV	764 /-81.94	799 /-82.26
IR673 34.5 kV	259 /-83.35	298 /-84.18
Minimum Generation System Normal Plus L6054b (101V-IR673) Out of Service		
43V-Canaan Rd 138 kV	586 /-81.16	620 /-81.60
101V-MacDonald Pond	568 /-80.58	572 /-80.54
IR673 POI 138 kV	456 /-80.16	490 /-80.81

Table 2: Short-Circuit Levels, Three-phase MVA		
IR673 34.5 kV	212 /-82.29	251 /-83.45
Minimum Generation System Normal Plus L6054a (43V-IR673) Out of Service		
43V-Canaan Rd 138 kV	586 /-81.16	590 /-81.13
101V-MacDonald Pond	568 /-80.58	602 /-81.07
IR673 POI 138 kV	539 /-80.37	573 /-80.91
IR673 34.5 kV	227 /-82.52	266 /-83.58

The lowest short circuit level, from the above table, at IR673's 34.5 kV bus is 212 MVA, which equates to a SCR of 6.3. However, L-6054 and L6004 effectively form a 138 kV line between 43V-Canaan Road substation and 90H-Sackville substation, which presently has two South Canoe wind farms at 101V-MacDonald Pond substation as well as two new wind farms IR673 and IR671, the calculated weighted SCR (WSCR) for all four wind farms is 1.4 under system normal and minimum generation, hence IR673 should discuss with the wind turbine supplier for a SCR to closer to 1.4. Please note that NSPI's TSIR, section 7.4.15, states that "System short circuit level may decline over time with changes to transmission configuration and generation mix. The Generating Facility shall be able to accommodate these changes. If the Point of Interconnection does not provide sufficient SCR for acceptable operation of the Generating Facility, the Interconnection Customer must provide facilities such as synchronous condensers or control systems to permit low SCR operation".

NSPI design criteria for ultimate system fault capacity (three phase, symmetrical) is 5,000 MVA or 21 kA on 138 kV system voltage and substation equipment are designed to meet this short circuit level. The short circuit table above shows that the maximum short circuit levels are far below 5,000 MVA. As all 138 kV breakers in the area are rated 5,000 MVA for short circuit current interrupting capabilities, IR673 short circuit contribution does not require any uprating of existing breakers in the transmission system.

3.2 Power Factor

NSPI's TSIR (Transmission System Interconnection Requirements, version 1.1, dated February 25, 2021), section 7.6.2 Reactive Power and Voltage Control requires "The Asynchronous Generating Facility shall be capable of delivering reactive power at a net power factor of at least +/- 0.95 of rated capacity to the high side of the plant interconnection transformer" and " Rated reactive power shall be available through the full range of real power output of the Generating Facility, from zero to full power".

The power factor assessment is evaluated based on three wind turbines with FT option and five wind turbines with FTQ option as per the IC's application. Wind turbine with FT option provides +/-1.85 MVAR per wind turbine and wind turbine with FTQ option provides +/-2.65 MVAR per wind turbine.

Hence, the first equivalent generator, which represents three FT wind turbines, is modelled with rated power of 12.6 MW and a reactive power range of +/- 5.55 MVAR. The second equivalent generator, which represents five FTQ wind turbines is modelled with rated power of 21.0 MW and a reactive power range of +/- 13.25 MVAR.

The result shows that IR673 meets the power factor requirement of +0.95 on the high voltage side of the 138 kV to 34.5 kV transformer as shown in Figure 8. The figure shows that, when IR673 produces the maximum 18.8 MVAR (5.55+13.25) at 33.6 MW (12.6+21), it delivers 12.5 MVAR and 33.0 MW at the high voltage side of the main substation transformer, equating to a power factor of 0.94, meeting the power factor requirement of 0.95 or less.

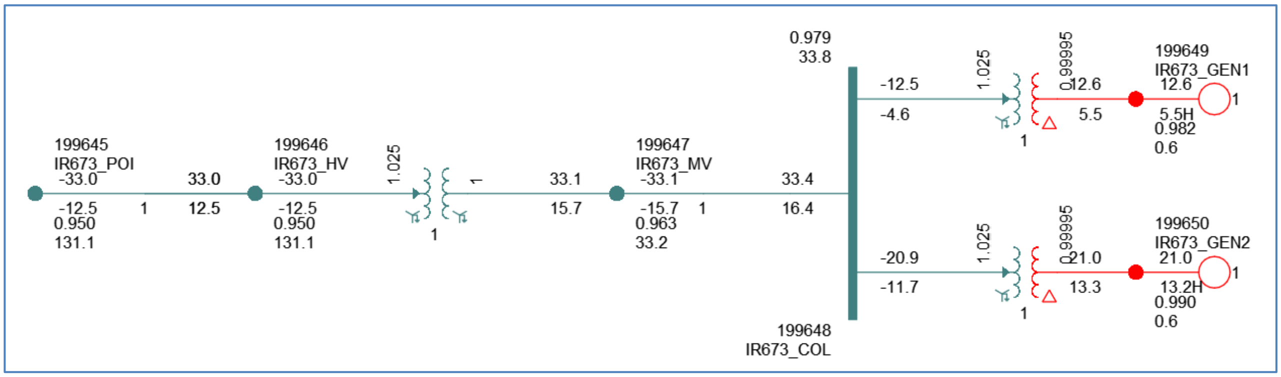

Figure 8: IR673 maximum reactive power output.

When the system voltage is high, IR673 is required to absorb reactive power to help bring down the system voltage. Figure 9 shows that IR673 can absorb 9.8 MVAR (3.5+6.3) while generating 33.6 MW (12.6+21). The 138 kV side of the main substation transformer delivers 33.1 MW and absorbs 15.2 MVAR, which equates to a power factor of 0.91, meeting the power factor requirement of 0.95 or less.

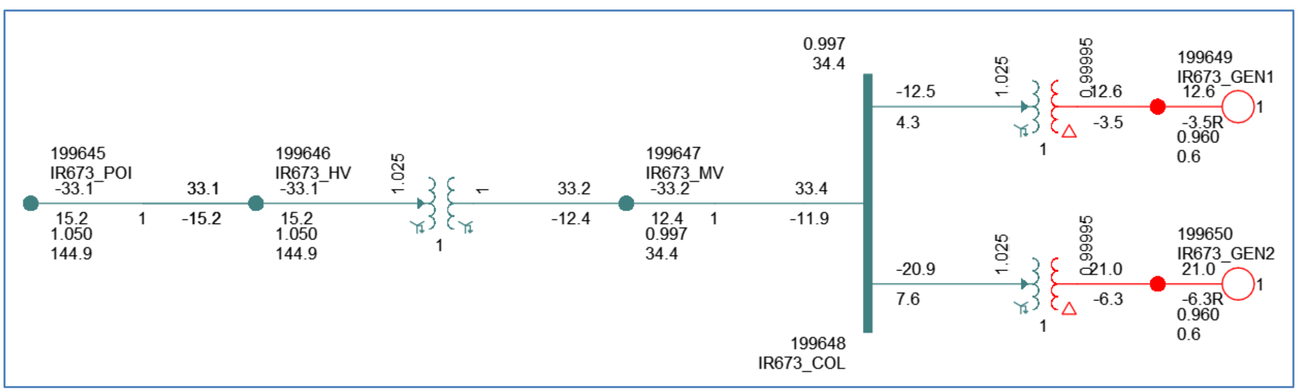

Figure 9: IR673 reactive power absorption.

While the combination of the FT and FTQ wind turbines meet the first power factor requirement of +/- 0.95 on the high voltage side of the main substation transformer, this combination does not meet the second part of the power factor requirement that requires IR673 facility to deliver rated MVAR at 0 MW.

One option to meet both power factor requirements is to have all eight wind turbines equipped with FTQS (FTQ plus Statcom) which can provide rated MVAR at 0 MW output according to the technical bulletin from the wind turbine supplier for IR673.

Please note that Part 2 EMT study may identify additional required resources such as synchronous condenser, Flexible AC Transmission System (FACTS), etc. for other reasons. If so, these resources may have their own reactive power capability which may complement or provide an alternative to FTQS option.

3.3 Voltage Flicker & Harmonics

Voltage Flicker contribution is calculated in accordance with the methodology described in CEATI Report No. T044700-5123 “Power Quality Impact Assessment of Distributed Wind Generation”.

The voltage flicker calculation is completed at the POI for the lowest short circuit case. This case has minimum generation and L-6054 section from IR673 to 101V-MacDonald Pond substation is out of service. If the calculated flicker level meets NSPI’s required levels under this scenario, then voltage flicker should not be an issue in system normal operations.

Under this scenario, based the values provided in the wind turbine technical bulletin, the calculated voltage flicker at the POI 138 kV bus is 0.014 for Pst and Plt for switching operations, which meet NSPI’s requirements of Pst less than 0.25 and Plt less than 0.35, hence voltage flicker is not expected to be an issue for IR673.

As for harmonics, NSPI requires IR673 to meet Harmonics IEEE-519 Standard, which requires individual harmonic to be less than 1.5% and total harmonic distortion (THD) to be less than 2.5% at 138 kV POI. IR673’s supplied bulletin shows individual harmonic being less than 1% and THD of 0.79% measured at 34.5 kV compared to IEEE-519 Standard of 3% for individual harmonic and 5% for THD for the same voltage class, hence harmonics are not expected to be an issue at the POI.

If, for some reason, in the actual installation, IR673 causes issues with voltage flickers or harmonics, then IR673 will be responsible for mitigating the issues.

3.4 Steady State Analysis

3.4.1 Base Cases

This study is based on IR673 generation and higher queued IRs displacing Cape Breton coal fired generation, hence Cape Breton Export (CBX) and Onslow Import (ONI) arming levels and limits will be reduced accordingly by these IRs depending upon their locations. In addition, this study excludes Transmission Service Request TSR411 as per NSPI’s current posting on its GIP site: Generation Interconnection Procedures| Nova Scotia Power (nspower.ca).

Table 3 shows the base cases used in this study for steady state analysis.

Cases ending with "a" are pre-IR673 cases (IR673 off). Cases with ending with "b" are post-IR673 cases (IR673 at rated output). This way, the system impact by IR673 can be determined differentially, and appropriate differential system upgrades can be attributed to IR673.

The light load cases LL1a, LL1b, LL2a, and LL2b have NS export to NB at limit and NB export to NE at limit. Cases LL2 and LL2b have the Valley Export in NS at limit. Cases LL3a and LL3b have NS modelled wind farms dispatched at 75 %.

The summer peak cases SP1a, SP1b, SP2a, and SP2b have NS export to NB at summer firm level and NL export to NS via the Maritime Link HVDC at limit. The SP3a and S3b have NS modelled wind farms dispatched at 100 %.

The winter peak cases WP1a, WP1b, WP2a, and WP2b have NS export to NB at winter firm level and NL export to NS via the Maritime Link HVDC at limit. The WP3a and W3b have NS modelled wind farms dispatched at 100 %.

Table 3: Steady State Base Cases

Case Name	IR 673	NB to NS	NB to PEI	NB to NE	NB to HQ	NL to NS	CBX	ONI	ONS	NS Load	Western Valley Import	Valley Export	West + Valley Export	NS Tr. Wind
IR673_LL1a	0	-500	61	1000	-441	330	88	397	-35	652	31.8	-16.2	11.4	799
IR673_LL1b	33.6	-500	61	1000	-441	330	88	397	-35	652	31.9	-16.2	-20.8	833
IR673_LL2a	0	-500	61	1000	-441	330	88	298	-177	652	-24.5	40.2	155.8	710
IR673_LL2b	33.6	-500	61	1000	-441	330	88	298	-177	652	-24.7	40.3	123.8	744
IR673_LL3a	0	-433	61	1000	-441	330	102	378	44	652	10.1	5.5	-9.5	776
IR673_LL3b	33.6	-465	61	1000	-441	330	102	378	11	652	10.1	5.5	-9.5	810
IR673_SP1a	0	-329	193	801	-797	475	441	830	531	1558	75.4	-27.9	-196.4	888
IR673_SP1b	33.6	-330	193	802	-797	475	407	798	498	1558	75.5	-28.0	-196.1	922
IR673_SP2a	0	-330	194	801	-797	475	372	661	332	1546	18.0	29.1	21.1	923
IR673_SP2b	33.6	-330	194	801	-797	475	338	628	299	1546	17.9	29.2	21.2	957
IR673_SP3a	0	-330	193	801	-797	475	400	842	566	1620	70.5	-23.1	-180.2	1036
IR673_SP3b	33.6	-330	193	801	-797	475	365	809	532	1620	70.6	-23.1	-179.9	1070
IR673_WP1a	0	-150	294	0	-912	475	648	930	755	2353	86.4	-7.2	-296.3	810
IR673_WP1b	33.6	-150	294	0	-912	475	612	895	720	2353	86.3	-7.2	-295.8	844
IR673_WP2a	0	-150	294	0	-912	475	684	984	810	2357	86.4	-7.3	-172.8	949
IR673_WP2b	33.6	-150	294	0	-912	475	647	950	775	2357	86.3	-7.2	-172.2	983
IR673_WP3a	0	-150	294	0	-912	475	677	1041	910	2357	99.0	-19.7	-301.4	1036
IR673_WP3b	33.6	-150	294	0	-912	475	641	1006	875	2357	99.0	-19.7	-300.8	1070

3.4.2 Steady-State Contingencies

Table 4 shows the steady state contingencies in NS and in NB conducted for each of the power flow cases discussed in the previous section.

Contingencies with "*" denote applicable Remedial Action Schemes (RAS) that run back the Maritime Link HVDC

Contingencies with "**" denote applicable Automatic Action Schemes (AAS) that reject local Valley or West loads or Gulliver's wind farm in NS.

Contingencies with "***" denote applicable RAS in NB.

Contingencies with "****" denote possible separation of the Valley local area in NS.

Contingencies with "*****" denote applicable RAS that rejects a Wreck Cove hydro generator.

Table 4: Steady State Contingencies					
101S_701	1C_G2	51V_B52	99W_501	L-5521	L6053
101S_702	1H_LOL	51V_T61**	99W_600****	L-5524	L6054
101S_703	1N_600	51V_T62	99W_B51	L-5530	L6054a
101S_704	1N_601	67N_701	99W_B61	L-5531	L6054b
101S_705	1N_613	67N_702	99W_B62	L-5532	L6055
101S_706	1N_B51	67N_703	99W_T61	L-5533L5581	L6503
101S_711	1N_B52	67N_704	99W_T71	L-5534	L6507
101S_712	1N_B61	67N_705	99W_T72	L-5535	L65076508
101S_713	1N_B62	67N_706	9W_500	L-5536	L6508
101S_811	1N_C61	67N_710	9W_B52	L-5537	L6510
101S_812*	1N_T1	67N_713	9W_B53	L-5538	L6511
101S_813*	1N_T4	67N_811*	IR574	L-5539	L6514
101S_814	1V_B51	67N_812	IR618	L-5540	L6515
101S_816	20V_B51	67N_813	IR618_POI	L-5541	L6516
101S_T81	2CB61*****	67N_814*	IR668	L-5545	L6517
101S_T82	2CB62*****	67N_T71	IR668_POI	L-5546	L6518
101V_601	2S_513	67N_T81	IR669	L-5547L5551	L6523
101V_602	2S_600	67N_T82	IR669_POI	L-5548	L6531
101V_603	2S_B64	67N711*	IR670	L-5549	L6535
103H_600	2S_B65	67N712*	IR670_POI	L-5550L5582	L6536
103H_608	2S_T1	7003a_4*	IR671	L-5559L5579	L6537*****
103H_681	2S_T2	7003c_4*	IR672	L-5560	L6538
103H_881	30N_B61	70087009****	IR673	L-5561L5565	L6539
103H_B61	30NT61	74N_B61	L1108	L-5563	L6551

Table 4: Steady State Contingencies					
103H_B62	30W_B51	79N-T81*	L1142	L-5564L5576	L6552
103H_T81	30W_B61	82V_B61	L1143	L-5571	L6613
104H600	3C_711	85S_B61	L1157	L-5573L5575	L7001
108H_600	3C_712*	85S_G1	L1190	L-5580	L7002
108H_B1	3C_713	88S_710	L1190-L1215	L6001	L7003a
108H_B3	3C_714	88S_711	L1244	L6002_90H	L7003b
110W	3C_715*	88S_712	L3004	L6002_99W	L7003c
113H_600	3C_716	88S_713	L3006	L6003	L7004
11481151***	3C_T71	88S_714	L3013	L60036007	L7005Has*
11V_B51**	3C_T72	88S_715	L3017_3019	L60036009	L7005Ons*
120H_621	3C710*	88S_720	L-5003	L6004	L7008
120H_622	3C720*	88S_721	L-5011	L6004a	L7009
120H_623	3S_T1	88S_722	L5012	L6004b	L7011
120H_624	3W_B53	88S_723*	L-5014	L6005	L7012
120H_625	43V_503	88S_G4	L-5015	L60056010	L7014
120H_626	43V_562	88S_T71	L-5016	L60056016	L7015
120H_627	43V_B51	88S_T72	L-5017	L6006	L7019
120H_628	43V_B61**	89S_G1	L5019_L5035	L6007	L7021
120H_629	43V_B62	90H_503	L-5020	L6008	L70216534
120H_710	43V_T61**	90H_602	L-5021	L6009	L7022
120H_711	43V_T62**	90H_603	L-5022	L6010	L8001*
120H_712	47C_602	90H_605	L-5024	L6011	L8002
120H_713	47C_603	90H_606	L-5025**	L6012	L80027009
120H_714	47C_674	90H_608	L-5026**	L6013	L8003*
120H_715	47C_T65	90H_609	L-5027	L6014	L8004*
120H_716	47C_T67	90H_611	L-5028	L6015	Lepreau
120H_720	49N_600	90H_612	L-5029L5030	L6016	ME1-10
120H_SVC	4C_T2	90H_T1	L-5032L5004	L6020	ME1-11
120H_T71	4C_T63	91H_511	L-5033	L6020_6021	ME1-12
120H_T72	50N_500	91H_513	L-5036	L6021	ME1-13
132H_602	50N_604	91H_516	L-5037L3031	L6024	ME1-14
132H_603	50N_B55	91H_521	L-5039	L6025	ME1-15
132H_605	50N_G6	91H_523	L-5040	L6033	ME1-16
132H_606	50N_T12	91H_603	L5041	L60335039	ME1-6
13V_B51	50N_T8	91H_604	L-5042	L60336035	ME1-7
15V_B51	50NB57L5500	91H_605	L5049	L6035	ME1-8
17V_512	50NB61G6	91H_606	L-5053	L6038	ME1-9
17V_563	50NB62G5	91H_607	L-5054	L6040	ME3-1*
17V_611	50W_501**	91H_608	L-5058	L60406042	ME3-2*
17V_B1	50W_600****	91H_609	L-5060	L6042	ME3-3*

Table 4: Steady State Contingencies					
17V_B2	50W_B2	91H_611	L-5500	L6043	Mem_T3
17V_B63	50W_B3**	91H_613	L-5501	L6044	ML_2Poles
17V_T1	50W_B4	91H_621	L-5502	L6047	ML_Pole1
17V_T2	51V_500**	91H_T11	L-5505	L6048	ML_Pole2
17V_T63	51V_601	91H_T62	L-5506	L6051	PHP
1C_689	51V_602	91H_TC3	L-5507L5508	L6051a	South Canoe
1C_B61	51V_603	91N_701	L-5511	L6051b	
1C_B62	51V_B51**	92V_B51	L-5512	L6052	

3.4.3 Steady-State Result

Thermal ratings of transmission equipment in NS and NB are checked against rate A under system normal (all equipment in service). Post contingency system conditions are checked against rate B in NS while in NB, if rate B is exceeded, then it is checked against rate C, and if it passes Rate C, then it is acceptable in NB.

For NS, the transmission line and equipment thermal ratings are based on NSPI's transmission line rating book issued and dated June 13, 2022.

The following changes were made to the base cases to match the thermal ratings of equipment in the rating book for the local area under study:

- L-5016 summer rate A = 41 MVA, summer rate B = 60 MVA, rate C = 55 MVA.
- L-6054 rate C = 166 MVA (metering at 43V-Canaan Road substation).
- L-6004 rate C = 221 MVA (metering at 90H-Sacville substation).
- L-6012 rate C = 231 MVA (metering at 17V-St Croix substation).
- L-5022 rate A = rate B = 61 MVA for all seasons (relay setting at 92V-Michelin substation).
- L-6002 rate C = 173 MVA (metering at 90H-Sackville substation).
- L-5017 rate C = 55 MVA (metering at both ends)
- L-5017 summer rate A = 41 MVA and summer rate B = 42.9 MVA (Five Point-Wolfville Tap line section).
- L-5017 summer rate A = 60 MVA and summer rate B = 66.0 MVA (Canaan Road-Wolfville Tap line section).

In NS and NB, system voltage criteria are 0.95 to 1.05 per unit in system normal and 0.9 to 1.1 per unit post contingencies.

In some cases, under system normal (with all system elements in service), there are some existing local equipment overload pre-IR673 that are for NSPI to address separately and are not attributed to IR673:

- Two 113H 138 kV/25 kV transformers
- 58H 69kV/26.4kV transformer
- 103H 138kV/26.4kV transformer
- 103H 138kV/69kV transformer
- 92H 138kV/13.2 kV transformer
- 75W 138kV/69kV transformer

In some cases, under system normal (with all system elements in service), the bus voltage at 22W substation can be marginally below 0.95 per unit voltage pre-IR673 that is for NSPI to address separately and is not attributed to IR673.

The local area has many existing automatic action schemes (AAS) that are essential to mitigating post contingency issues. Their applications are as per NSPI system operating guidelines.

In addition, loss of major 230 kV or 138 kV corridors to the local area can cause it to separate from the main power grid. There are three contingencies that can result in such a local separation:

- Double circuit tower L-7008/L-7009 contingency (loss of 230 kV corridor)
- 99W-600 bus tie breaker failure at Bridgewater substation (loss of 230 kV and 138 kV corridors)
- 50W-600 bus tie breaker failure at Milton substation (loss of 138 kV corridor)

Table 5 shows which cases and which contingencies have these AAS or local area separation applied. Contingencies with NAAS means AAS is not applied. Contingencies with NSEP means local area separation is not applied.

Table 5: Steady State Contingencies

WP1a, b	WP2a, b	WP3a, b	SP1a, b	SP2a, b	SP3a, b	LL1a, b	LL2a, b	LL3a, b
11V_B51NAAS	11V_B51NAAS	11V_B51NAAS	11V_B51NAAS	11V_B51AAS	11V_B51NAAS	11V_B51NAAS	11V_B51AAS	11V_B51NAAS
43V_B61AAS	43V_B61AAS	43V_B61AAS	43V_B61AAS	43V_B61NAAS	43V_B61NAAS	43V_B61NAAS	43V_B61NAAS	43V_B61NAAS
43V_T61AAS	43V_T61AAS	43V_T61AAS	43V_T61AAS	43V_T61NAAS	43V_T61NAAS	43V_T61NAAS	43V_T61NAAS	43V_T61NAAS
43V_T62AAS	43V_T62AAS	43V_T62AAS	43V_T62AAS	43V_T62NAAS	43V_T62NAAS	43V_T62NAAS	43V_T62NAAS	43V_T62NAAS
50W_501AAS	50W_501AAS	50W_501AAS	50W_501AAS	50W_501NAAS	50W_501AAS	50W_501AAS	50W_501AAS	50W_501NAAS
50W_600SEP	50W_600SEP	50W_600SEP	50W_600SEP	50W_600SEP	50W_600SEP	50W_600SEP	50W_600SEP	50W_600NSEP
50W_B3AAS	50W_B3AAS	50W_B3AAS	50W_B3AAS	50W_B3NAAS	50W_B3AAS	50W_B3AAS	50W_B3AAS	50W_B3NAAS
51V_500NAAS	51V_500NAAS	51V_500NAAS	51V_500NAAS	51V_500AAS	51V_500NAAS	51V_500NAAS	51V_500AAS	51V_500NAAS
51V_B51NAAS	51V_B51NAAS	51V_B51NAAS	51V_B51NAAS	51V_B51AAS	51V_B51NAAS	51V_B51NAAS	51V_B51AAS	51V_B51NAAS
51V_T61AAS	51V_T61AAS	51V_T61AAS	51V_T61AAS	51V_T61NAAS	51V_T61NAAS	51V_T61AAS	51V_T61AAS	51V_T61NAAS
70087009SEP	70087009SEP	70087009SEP	70087009SEP	70087009SEP	70087009SEP	70087009SEP	70087009SEP	70087009NSEP
99W_600SEP	99W_600SEP	99W_600SEP	99W_600SEP	99W_600SEP	99W_600SEP	99W_600SEP	99W_600SEP	99W_600NSEP
L-5025NAAS	L-5025NAAS	L-5025NAAS	L-5025NAAS	L-5025AAS	L-5025NAAS	L-5025NAAS	L-5025AAS	L-5025NAAS
L-5026NAAS	L-5026NAAS	L-5026NAAS	L-5026NAAS	L-5026AAS	L-5026NAAS	L-5026NAAS	L-5026AAS	L-5026NAAS

The steady state power flow analysis was conducted without IR673 in service and with IR673 in service and the results are compared to determine the system upgrades to be attributed to IR673. There are a number of existing overloads and voltage issues that exist pre-IR673 that are for NSPI to address and only the issues that are new or made more severe will be attributed to IR673. The summary of the steady state power flow analysis is shown in section 6 "Steady State Analysis Result Summary".

The results show that the following system upgrades will be attributed to IR673 for NRIS:

- 21.1km of L-6054 section from IR673 to 43V-Canaan Road substation will require upgrading its conductor operating temperature of 75 deg C (174 MVA summer) to 100 deg C. The steady state power flow analysis shows that this line section can be overloaded up to 217 MVA under contingencies.
- 44.5km of L-6004 section from IR671's POI to 90H-Sackville substation will require upgrading its conductor operating temperature of 75 deg C (174 MVA summer) to 100 deg C. The steady state power flow analysis shows that this line section can be overloaded up to 222 MVA under contingencies.
- L-6054 protection at 43V-Canaan Road substation will require upgrade. Metering will require Current Transformer (CT) ratio to be moved to higher tap for full scale substation metering.
- L-6054 protection at 101V-MacDonald Pond will require upgrading.

For ERIS, IR673 generating output above 9 MW will be subjected to curtailment and will require:

- L-6054 protection at 43V-Canaan Road substation will require upgrade. Metering will require Current Transformer (CT) ratio to be moved to higher tap for full scale substation metering.
- L-6054 protection at 101V-MacDonald Pond will require upgrading.

The following observations are noted during the study:

- L-6004 metering at 90H-Sackville substation was identified initially by the load flow analysis as it was modelled at 221 MVA rating as per the transmission line rating book, but it was subsequent determined by NSPI's protection and control engineering department that L-6004 metering at this location is in fact 231 MVA rating, hence it is not an issue for IR673 study.
- The present arming level for AAS, that rejects Gulliver's wind farm under specific contingencies is 40 MVA, will need revision to 29 MVA.

3.5 Stability Analysis

The stability analysis is based on NSPI design criteria and NPCC planning criteria that require the system to be stable and well damped following first contingencies (from system normal) as defined in these criteria.

3.5.1 Stability Base Cases

Table 6 shows the base cases with IR673 in service for the stability analysis. If any contingency simulation with IR673 being on-line causes system instability, then the simulation would be repeated with IR673 off-line to determine if the system instability already exists prior to the installation of IR673.

Table 6: Stability Base Cases

Case Name	IR 673	NB to NS	NB to PEI	NB to NE	NB to HQ	NL to NS	CBX	ONI	ONS	NS Load	Western Valley Import	Valley Export	West + Valley Export	NS Tr. Wind
IR673_LL1b	33.6	-500	61	1000	-441	330	88	397	-35	652	31.9	-16.2	-20.8	833
IR673_LL2b	33.6	-500	61	1000	-441	330	88	298	-177	652	-24.7	40.3	123.8	744
IR673_LL3b	33.6	-465	61	1000	-441	330	102	378	11	652	10.1	5.5	-9.5	810
IR673_SP1b	33.6	-330	193	802	-797	475	407	798	498	1558	75.5	-28	-196.1	922
IR673_SP2b	33.6	-330	194	801	-797	475	338	628	299	1546	17.9	29.2	21.2	957
IR673_SP3b	33.6	-330	193	801	-797	475	365	809	532	1620	70.6	-23.1	-179.9	1070
IR673_WP1b	33.6	-150	294	0	-912	475	612	895	720	2353	86.3	-7.2	-295.8	844
IR673_WP2b	33.6	-150	294	0	-912	475	647	950	775	2357	86.3	-7.2	-172.2	983
IR673_WP3b	33.6	-150	294	0	-912	475	641	1006	875	2357	99	-19.7	-300.8	1070

3.5.2 Stability Contingencies

Table 7 shows the contingencies in NS and in NB used for the stability analysis.

Contingencies with "*" denote applicable Remedial Action Schemes (RAS) that run back the Maritime Link HVDC

Contingencies with "**" denote applicable Automatic Action Schemes (AAS) that reject local Valley or West loads or Gulliver's wind farm in NS.

Contingencies with "***" denote applicable RAS in NB.

Contingencies with "****" denote possible separation of the Valley local area in NS.

Contingencies with "*****" denote applicable RAS that rejects of a Wreck Cove hydro generator.

Application of fault contingencies in stability simulation is as follows:

- Faults applied to transmission lines, transformers, and buses are three phase faults.
- Faults applied to breaker failures are line-to-ground faults.

- Faults applied to double circuit towers involve a line-to-ground fault on phase A of first circuit and a line-to-ground fault on phase B of the second circuit at the location of common towers.

Table 7: Stability Contingencies			
101S BBU 101S-701*	17V BBU 17V-612	50N B62	88S BBU 88S-723*
101S BBU 101S-702*	17V_512_T2_HV	50N L6503	88S L7014
101S BBU 101S-706	17V_563_T63_HV	50N L6507	88S L7021
101S BBU 101S-712	17V_611_L6012	50N_604 BBU	88S L7022
101S BBU 101S-811	17V_B1 _Bus	50W BUS 50W-B2	90H L6008
101S BBU 101S-812*	17V_B63 _Bus	50W BUS 50W-B3 **	90H_602_L6002
101S BBU 101S-813*	17V_T63 _HV	50W BUS 50W-B4	90H_605_L6004
101S L7011 *	1N BBU 1N-601	50W_501_T1_HV**	90H_608_L6005
101S L7012 *	1N BBU 1N-613	50W_600_B3****	90H_611_L6008
101S L7014	1N BKR 1N-600	51V BUS 51V-B51 **	90H_T1 _HV
101S L7021	1N BUS 1N-B61	51V L5025 **	91N BBU 91N-701
101S L7022	1N BUS 1N-B62	51V_500_B51**	91N L7004 *
101S L8004 *	1N L6001	51V_601_L6015	91N L7019 *
101S MLBIPOLE 1LG	1N L6503	51V_B52 _Bus	92V_B51 _Bus
101S MLBIPOLE 3P	1N L6613	51V_T61 _HV**	99W_501_T61_HV
101S MLPOLE1 3P	20V_B51 _Bus	67N BBU 67N-701	99W_600_B61****
101S MLPOLE2 3P	2C BUS 2C-B61 *****	67N BBU 67N-702	99W_B51 _Bus
101V_601_L6004	2C BUS 2C-B62 *****	67N BBU 67N-703	99W_B61 _Bus
101V_601_L6054	2C L6515	67N BBU 67N-704	99W_B62 _Bus
103H BBU 103H-608	2S-513 BBU	67N BBU 67N-705	99W_T61 _HV
103H BBU 103H-681	3C BBU 3C-710*	67N BBU 67N-706	99W_T71 _HV
103H BBU 103H-881	3C BBU 3C-711*	67N BBU 67N-710	9W BUS 9W-B53
103H BKR 103H-600	3C BBU 3C-712*	67N BBU 67N-711*	9W L5535
103H L6008	3C BBU 3C-713	67N BBU 67N-712*	9W L6021
103H L6016	3C BBU 3C-714	67N BBU 67N-713	9W L6024
103H L6033	3C BBU 3C-715*	67N BBU 67N-811*	9W_500_B52
103H L8002	3C BBU 3C-716	67N BBU 67N-811 T82*	9W_B52 _Bus
104H-600 BBU	3C L7003(3C-IR618) *	67N BBU 67N-813	DCT 6005][6010
108H L6055	3C L7004	67N BBU 67N-814*	DCT 6005][6016
110W_B61 _Bus	3C L7005 *	67N L7001	DCT 6010][6011
11V BUS 11V-B51 **	3C L7012 *	67N L7003(67N-IR668) *	DCT 6033][6035
11V L5025 **	3C T71	67N L7005 *	DCT 6507][6508 50N
11V L5026 **	3W_B53 _Bus	67N L7018	DCT 6507][6508 79N
120H BBU 120H-622	410N L3006	67N L7019	DCT 6534][7021
120H BBU 120H-710	410N L8001 *	67N L8001 *	DCT 7003(3C-IR618)][7004 3C*
120H BBU 120H-715	43V BBU 43V-612**	67N L8002	DCT 7003(67N-IR668)][7004 50N*
120H L6005	43V BUS 43V-B61 **	67N L8003 *	DCT 7008][7009****

Table 7: Stability Contingencies			
120H L6010	43V BUS 43V-B62	79N BBU 79N-601*	DCT 7009][8002
120H L6011	43V L6012	79N BBU 79N-803*	DCT 7009][8002
120H L6016	43V_503_T61_HV	79N BBU 79N-810*	L6004 _90H
120H L7008	43V_562_T62_HV	79N L6507	L6011 _120H
120H L7018	43V_B51 _Bus	79N L8003 *	L6015 _43V
13V BUS 13V-B51	43V_T61 _HV**	79N L8004 *	L6051 _120H
13V L5026 **	47C-602 BBU	79N T81 HV *	L6054 _43V
13V L5531	47C-603 BBU	88S BBU 88S-713	
13V L5532	47C-674 BBU	88S BBU 88S-720	
15V BUS 15V-B51	4C BBU 4C-621	88S BBU 88S-721	
15V L5535	50N B61	88S BBU 88S-722	

3.5.3 Stability Results

The 188 stability contingencies in Table 7 were simulated for each of the 9 power system cases in Table 6 for a total of 1,692 simulations. The results were plotted and reviewed for each simulation and found to be stable and well damped, hence there is no system upgrades that are attributed to stability issues for IR673.

The stability plots are too large to practically include in this report; hence they are contained in a companion document called “Appendices for Report GIP_IR673_SIS_Part1_R0”.

3.6 Bulk Power System (BPS) Analysis

NSPI is a member of NPCC and adheres to NPCC’s requirements, including the requirements for BPS. The methodology for determining if a substation is BPS is defined in NPCC’s criteria document A-10 titled “Classification of Bulk Power System Elements”, Version 3, dated May 6, 2020.

The existing L-6054 between 43V-Canaan Road substation and 101V-MacDonald Pond is non-BPS. As IR673’s POI will be on this line, it will be evaluated based on A-10 methodology to determine if IR673 and L-6054 will be BPS or not.

Dynamic simulation of A-10 for the stability cases shows that the power system remains stable and well damped and met the non-BPS status for IR673’s POI (a sample plot is shown on Figure 10) and the IC 138 kV substation bus (a sample plot is shown on Figure 11), therefore IR673 facilities and L-6054 will remain non-BPS.

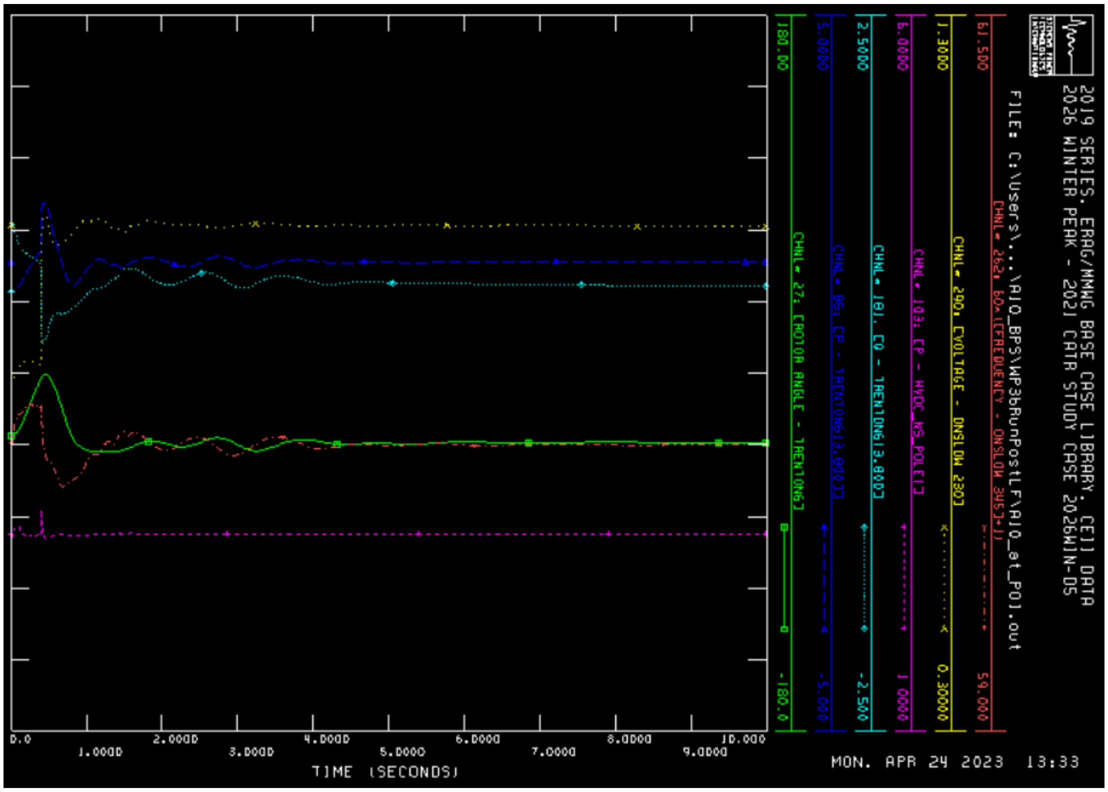

Figure 10: A-10 simulation at 138 kV POI.

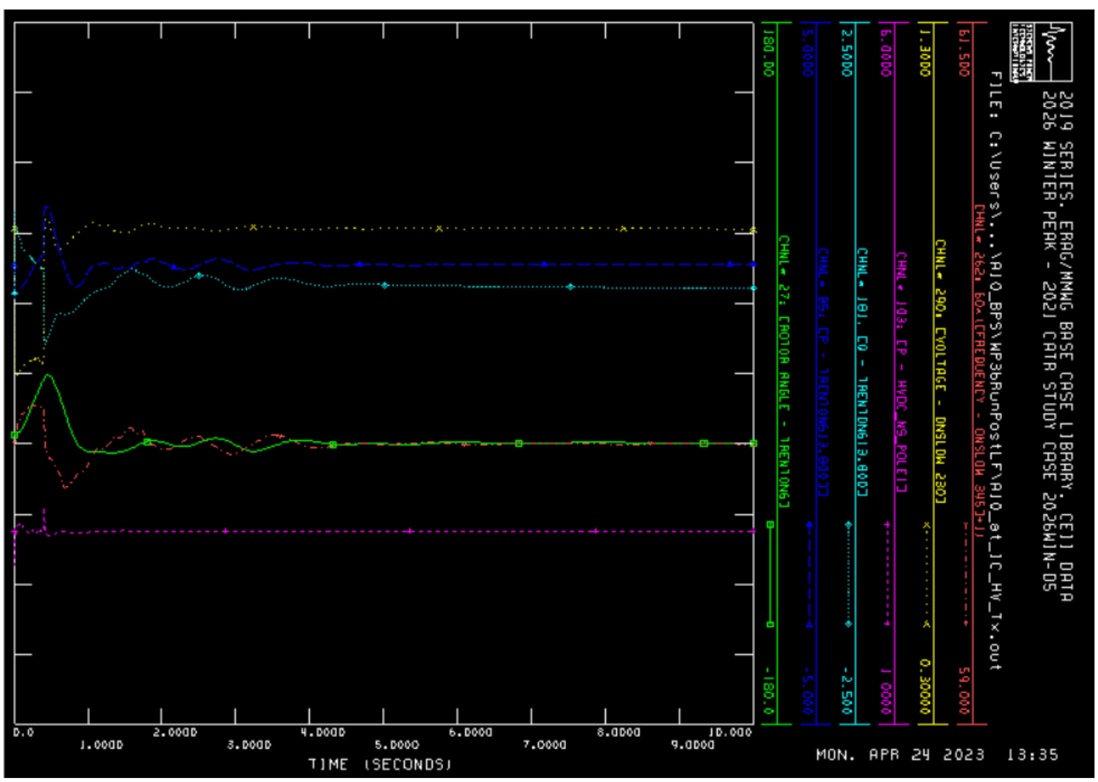

Figure 11: A-10 simulation at the IC 138 kV bus.

3.7 Under Frequency Operation

Nova Scotia is connected to the rest of the Eastern Interconnection power network by a 345 kV line L-8001 and two 138 kV lines L-6535 and L-6536 to New Brunswick. Under certain import conditions, if L-8001 trips or NB trips L-3025 or L-3006, an 'Import Power Monitor' RAS will cross-trip L-6613 at 67N-Onslow to avoid its thermal overload or uncontrolled separation. The Nova Scotia system is then islanded and relies on under frequency load shedding (UFLS) schemes to shed load across Nova Scotia to make up the generation deficiency and restore balance. During and post NS islanding, IR673 is required to remain online and not to trip.

The present NERC standard PRC-006-NPCC-2, "Automatic Underfrequency Load Shedding", requires the under frequency trip settings of IR673 wind turbine generators must be set below the black trace for Eastern Interconnection in Figure 2 of the standard, which shown on Figure 12.

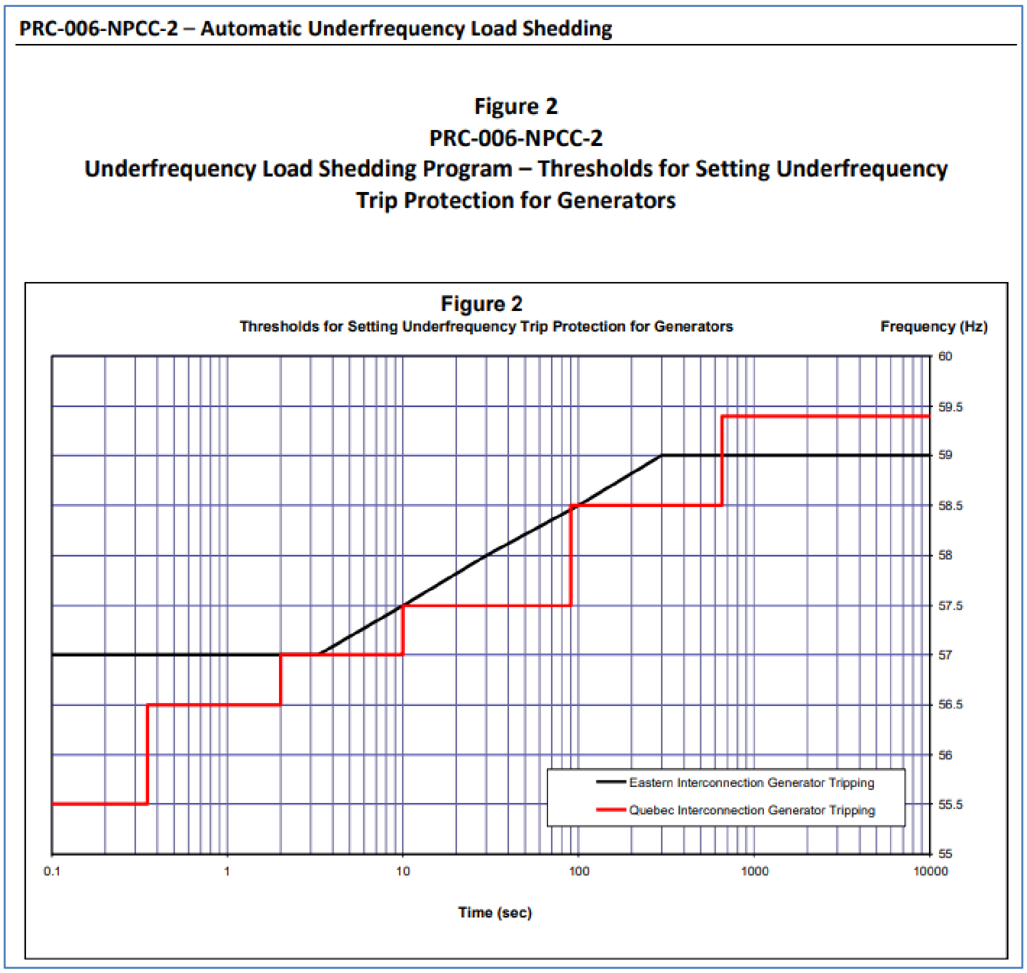

Figure 12: PRC-006-NPCC-2 UFLS Setting Requirement for IR673

The dynamic simulation for IR673 under frequency performance was based on a summer peak case, with Nova Scotia importing 300 MW from New Brunswick. This case is created to verify that IR673 can ride through an under frequency event in NS in the event that, under special circumstances, NS may have high non-firm import and reserve delivery from NB. A three phase fault is simulated on L-8001, which would cause L-8001 to send a transfer trip to L-6613 at 1N-Onslow terminal. This event causes both L-8001 and L-6513 to trip and island Nova Scotia.

The simulation shows that NSPI under-frequency load shedding (UFLS) scheme activates to stabilize NS system frequency. The simulation also shows that IR673 reduces its output immediately during the fault then ramps up to rated output and remains stable and well damped post contingency as shown on Figure 13. The power output trace shows that the wind turbines do not provide inertial frequency response, inherently provided by traditional synchronous generators. As more inverter based generators will be added to NS power system to replace the synchronous generators, the lack of inertial frequency response may increase, and it is expected that the inverter based generators will be required to provide the inertial frequency response in the form of fast frequency response or by other means such as synchronous condensers, FACTS, etc. This issue will be studied in Part 2 EMT study.

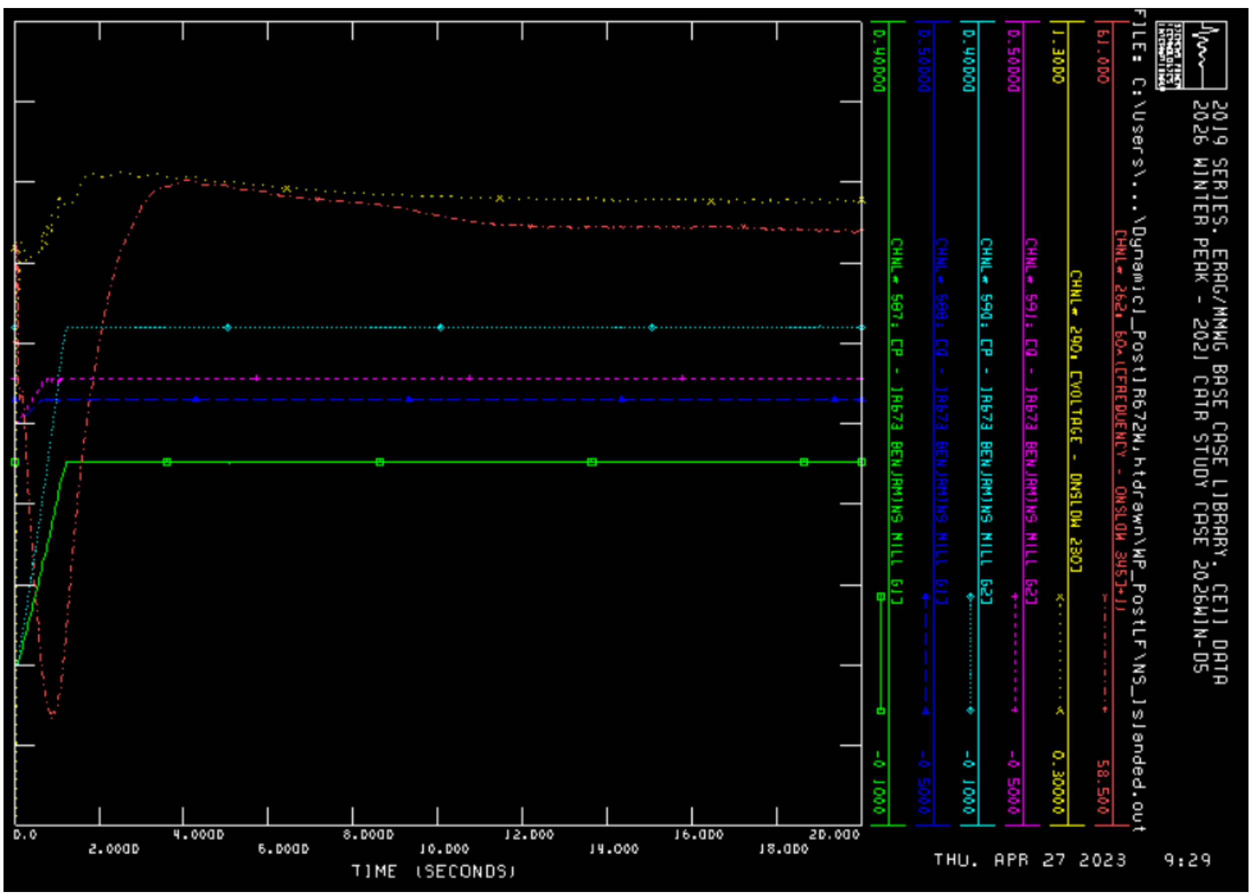

Figure 13: IR673 output power comes back post fault and remains stable post islanding.

3.8 Low Voltage Ride Through

It is a requirement that IR673 must be able to ride through faults in the power system without tripping itself off.

IR673 low voltage ride through (LVRT) capability was modelled and simulated with a three phase fault at the POI for 9 cycles and the dynamic plot, as shown on Figure 14, shows that IR673 can ride through the fault and remains on-line at rated output and stable post contingency, thus it meets the LVRT requirement.

While this meets the LVRT requirement, it does not provide inertial frequency response as discussed in the previous section.

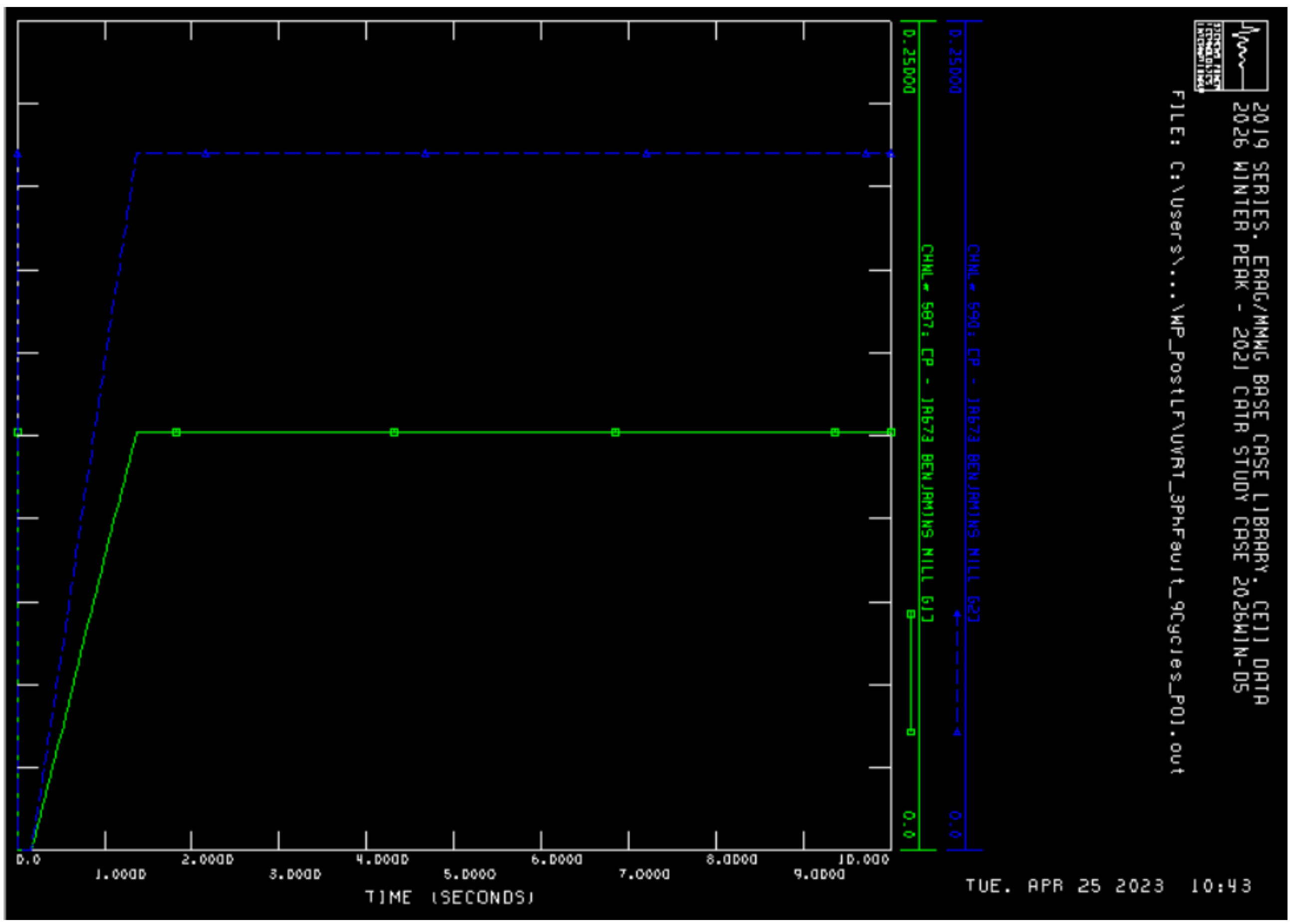

Figure 14: IR673 meets LVRT requirement.

3.9 Loss Factor

The loss factor calculation is based on a winter peak case without IR673 in service and with IR673 at rated output, while keeping 91H-Tufts Cove Generator TC3 as the NS area interchange generator and the power import from NB to NS is kept at zero. This methodology reflects the load centre in Metro Halifax.

The loss factor for IR673 is shown in Table 8 and 9. Table 8 shows the loss factor if the power is measured at IR673 voltage terminal (which includes IR673 generating facility losses), whereas for Table 9, the power is measured at the 138 kV POI (which excludes IR673 generating facility losses).

A positive value indicates that IR673 power output, at the location that it is measured, is higher than Tufts Cove power reduction, meaning that IR673 locational measured power output is more lossy than Tufts Cove generation. A negative value is the reverse.

Table 8: Loss Factor Measured at IR673 Terminal

Description	MW
IR673 On	33.6
TC3 with IR673 On	116.6
TC3 with IR673 Off	150.0
Loss Factor measured at IR673 voltage terminal	+0.6 %

Table 9: Loss Factor Measured at POI (138 kV)

Description	MW
IR673On	33.6
Power measured at POI	33.1
TC3 with IR673 On	116.6
TC3 with IR673 Off	150.0
Loss Factor measured at POI	-0.9 %

4.0 Expected Facilities Required

The following facility changes will be required to connect IR673 as NRIS to NSPI transmission system at the POI using a direct tap to L-6054 between 43V-Canaan Road substation and 101V-MacDonald Pond substation:

- NSPI Transmission Network Upgrades for NRIS:
  - 21.1km of L6054 section from IR673 to 43V-Canaan Road substation will be upgraded from its conductor operating temperature of 75 deg C to 100 deg C.
  - 44.5 km of L-6004 section from IR671's POI to 90H-Sackville substation will be upgraded from its conductor operating temperature of 75 deg C to 100 deg C.
  - L-6054 protection at 43V-Canaan Road substation will require upgrade. Metering will require Current Transformer (CT) ratio to be moved to higher tap for full scale substation metering.
  - L-6054 protection at 101V-MacDonald Pond will require upgrading.

- NSPI Transmission Network Upgrades for ERIS:
  - L-6054 protection at 43V-Canaan Road substation will require upgrade. Metering will require Current Transformer (CT) ratio to be moved to higher tap for full scale substation metering.
  - L-6054 protection at 101V-MacDonald Pond will require upgrading.
  - ERIS output above 9 MW will be subjected to curtailment.

- Transmission Provider's Interconnection Facilities (TPIF) Upgrades NRIS or ERIS
  - Installation of 300 meters of new 138 kV spur line extension from POI tap point to the IC substation with Dove conductors designed for 100 degree C using NSPI's standard 138 kV construction.
  - Installation of NSPI P&C Relaying Equipment.
  - Installation of NSPI supplied RTU.
  - Installation of Tele-protection and SCADA communication.

- IC Interconnection Facilities (ICIF)

  - IR673 must be capable of providing 0.95 leading and lagging power factor at the HV terminals of the IC main substation step up transformer for the full range of IR673 real power output from zero to rated output. The generating facility must be capable of providing rated reactive power at zero MW output.
  - IR673 must provide centralized controls such as a farm control unit (FCU) that can control the 34.5 kV bus voltage to a settable point and will control the reactive output of each wind turbine of IR673 to achieve this common objective. 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. Please refer to NSPI's TSIR such as section 7.6.6 on "Active Power Control (Fast Frequency Response) and Curtailment" for additional requirements.
  - NSPI will have control and monitoring of reactive output of this facility, via the centralized controller. This will permit the NSPI Operator to raise or lower the voltage set point remotely.
  - Low voltage ride-through capability per Nova Scotia Power Transmission System Interconnection Requirements (TSIR) document.
  - Real-time monitoring (including an RTU) of the interconnection facilities. Local wind speed and direction, MW and MVAR, as well as bus voltages are required.
  - Facilities for NSPI to execute high speed rejection of generation (transfer trip). The plant may be incorporated into RAS run-back schemes.
  - Automatic Generation Control to assist with tie-line regulation.
  - Revenue metering
  - The facility must meet NSPI's TSIR as published on the NSPI OASIS site.
  - Compliance with section 7.6.7 of TSIR, "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.”. This item will be assessed in Part 2 EMT study, which may identity additional resources such as synchronous condenser, Flexible AC Transmission System (FACTS) devices, etc.

5.0 Cost Estimate

The high level non-binding cost estimate, excluding applicable taxes, in 2023 Canadian dollars, to interconnect IR673 to NSPI transmission system for NRIS is shown in Table 10 and for ERIS is shown on Table 11.

The line upgrade cost estimates for item 1 and 2 in Table 10 are based on historical averages. The actual number of spans that require upgrading cannot be confirmed until the lines are surveyed.

These cost estimates include 10% contingency but exclude HST and any additional costs or upgrades to be identified by Part 2 ETM study and Facility Study. They also exclude any cost associated with ICIF generating facility. They are high-level and non-binding and will be revised by the Facility Study.

The IC will be responsible for acquiring the ROW (Right-Of-Way) for and access to all the facilities.

The non-binding estimate for the time to construct NSPI Transmission Network Upgrades is two years after the IC has obtained the necessary easements and ROW. The Facilities Study will confirm the estimated construction time.

Table 10: High Level Non-Binding Cost Estimate for NRIS		
Item	**Network Upgrades**	**Estimate ($M CAN)**
1	Upgrade 21.1 km of L-6054 section from 43V to IR673 from Dove conductor operating temperature of 75 deg C to 100 deg C	4.36
2	Upgrade 44.5km of L-6004 section from 90H to IR671 from Dove conductor operating temperature of 75 deg C to 100 deg C	9.19
3	Upgrade L-6054 protection at 43V- Canaan Road substation. Move CT ratio to higher tap for full scale substation metering to 217 MVA or higher	0.08
4	Upgrade L-6054 protection at 101V- MacDonald Pond substation	0.08
	Contingency (10%)	1.37
	Network Upgrade Sub-total	15.08
Item	**TPIF Upgrades**	
1	New line extension from IR673 direct tap to IC sub, 300 meters Dove, 100 deg C, H-frame, wood pole	0.51
2	P&C relaying equipment	0.35
3	NSPI supplied RTU	0.14
4	Tele-protection and SCADA communications	0.58
	Contingency (10%)	0.16
	TPIF Upgrade Sub-total	1.74
	Total Network Upgrades and new TPIF, excluding HST	**16.82**

Table 11: High Level Non-Binding Cost Estimate for ERIS		
Item	**Network Upgrades**	**Estimate ($M CAN)**
1	Upgrade L-6054 protection at 43V- Canaan Road substation. Move CT ratio to higher tap for full scale substation metering to 217 MVA or higher	0.08
2	Upgrade L-6054 protection at 101V- MacDonald Pond substation	0.08
	Contingency (10%)	0.02
	Network Upgrade Sub-total	0.18
Item	**TPIF Upgrades**	
1	New line extension from IR673 direct tap to IC sub, 300 meters Dove, 100 deg C, H-frame, wood pole	0.51
2	P&C relaying equipment	0.35
3	NSPI supplied RTU	0.14
4	Tele-protection and SCADA communications	0.58
	Contingency (10%)	0.16
	TPIF Upgrade Sub-total	1.74
	Total Network Upgrades and new TPIF, excluding HST	**1.91**

6.0 Steady State Result Summary

Case Pre IR673	Contingency	Rating	MW	MVAR	MVA	%	Line Number	Contingency	Bus Number	Bus Name	KV	V-Cont	Case Post IR673	Contingency	Rating	MW	MVAR	MVA	%	Line Number	Contingency	Bus Number	Bus Name	KV	V-Cont
LL3a Rate B	Empty												LL3b Rate B	Empty											
LL3a Rate C	Empty												LL3b Rate C	L60048	166	-171.7	15.8	172.4	103.8	L-6054a 43V-IR678					
														90H_605	166	-171.7	15.8	172.4	103.8	L-6054a 43V-IR678					
Case Pre IR673	Contingency	Rating	MW	MVAR	MVA	%	Line Number	Contingency	Bus Number	Bus Name	KV	V-Cont	Case Post IR673	Contingency	Rating	MW	MVAR	MVA	%	Line Number	Contingency	Bus Number	Bus Name	KV	V-Cont
LL2a Rate B	Empty												LL2b Rate B	48V_503	195.4	-215	46.5	220	112.6	L-6004b 90H-IR671					
														L6056A	195.4	-214.3	45.6	219	112.1	L-6004b 90H-IR671					
														48V_B62	195.4	-214.2	45.6	219	112.1	L-6004b 90H-IR671					
														L60048	195.4	-215.7	21.2	216.7	111.4	L-6054a 43V-IR678					
														90H_605	195.4	-215.7	21.2	216.7	111.4	L-6054a 43V-IR678					
														17V_512	195.4	-211.1	46.1	216.1	110.5	L-6004b 90H-IR671					
														17V_611	195.4	-205.5	43.9	210.2	107.6	L-6004b 90H-IR671					
														17V_B2	195.4	-203.1	43.6	206.6	105.7	L-6004b 90H-IR671					
														43V_B61NAAS	195.4	-200.7	42.8	205.1	104.9	L-6004b 90H-IR671					
														L6012	195.4	-198.5	41.4	203.8	104.3	L-6004b 90H-IR671					
														BASE CASE	174	-175.5	38.1	178.6	100.4	L-6004b 90H-IR671					
LL2a Rate C	L60048	166	-182.6	33.5	184.3	109.3	L-6054a 43V-IR678						LL2b Rate C	L60048	166	-215.7	21.2	216.7	128.5	L-6054a 43V-IR678					
	90H_605	166	-182.6	33.5	184.3	109.3	L-6054a 43V-IR678							90H_605	166	-215.7	21.2	216.7	128.5	L-6054a 43V-IR678					
														BASE CASE	174	-175.5	38.1	178.6	100.4	L-6004b 90H-IR671					
Case Pre IR673	Contingency	Rating	MW	MVAR	MVA	%	Line Number	Contingency	Bus Number	Bus Name	KV	V-Cont	Case Post IR673	Contingency	Rating	MW	MVAR	MVA	%	Line Number	Contingency	Bus Number	Bus Name	KV	V-Cont
LL1a Rate B	Empty												LL1b Rate B	L6056A	195.4	-214.3	41	218.1	112.2	L-6004b 90H-IR671					
														48V_B62	195.4	-214.3	40.9	218.1	112.2	L-6004b 90H-IR671					
														L60048	195.4	-215.7	18.5	216.5	111.5	L-6054a 43V-IR678					
														90H_605	195.4	-215.7	18.5	216.5	111.5	L-6054a 43V-IR678					
LL1a Rate C	L60048	166	-182.6	21.1	183.8	109.2	L-6054a 43V-IR678						LL1b Rate C	L60048	166	-215.7	18.5	216.5	128.6	L-6054a 43V-IR678					
	90H_605	166	-182.6	21.1	183.8	109.2	L-6054a 43V-IR678							90H_605	166	-215.7	18.5	216.5	128.6	L-6054a 43V-IR678					
Case Pre IR673	Contingency	Rating	MW	MVAR	MVA	%	Line Number	Contingency	Bus Number	Bus Name	KV	V-Cont	Case Post IR673	Contingency	Rating	MW	MVAR	MVA	%	Line Number	Contingency	Bus Number	Bus Name	KV	V-Cont
SP3a Rate B	50W_BAAAS	56	57	8.2	57	101.8	9W-T63	L6020_6021	199271	30W-SOURIQUO	69	0.92652	SP3b Rate B	L6056A	195.4	-214.3	58.1	220.7	112.1	L-6004b 90H-IR671	L6020_6021	199271	30W-SOURIQUO	69	0.92726
	L60086009	60.5	-61.2	-1.8	61.2	100.2	L-5009-2	L6020_6021	199272	25W-SHELBURN	69	0.9243		48V_B62	195.4	-214.3	58.1	220.7	112.1	L-6004b 90H-IR671	L6020_6021	199272	25W-SHELBURN	69	0.92504
								L6020_6021	199274	23W-CLYDE_RI	69	0.91926		L60048	195.4	-215.7	18.5	216.6	111.5	L-6054a 43V-IR678	L6020_6021	199274	23W-CLYDE_RI	69	0.92001
								30W_B61	199271	30W-SOURIQUO	69	0.92815		90H_605	195.4	-215.7	18.5	216.6	111.5	L-6054a 43V-IR678	30W_B61	199271	30W-SOURIQUO	69	0.92882
								30W_B61	199272	25W-SHELBURN	69	0.92593		L60086009	60.5	-62.6	-1.8	62.6	103.1	L-5009-2	30W_B61	199272	25W-SHELBURN	69	0.9266
								30W_B61	199274	23W-CLYDE_RI	69	0.9209		50W_BAAAS	56	56.2	4.5	56.3	100.5	9W-T63	30W_B61	199274	23W-CLYDE_RI	69	0.92158
SP3a Rate C	43V_B61NAAS	28	30.4	2.5	30.5	110.1	L-6017 20V-43V						SP3b Rate C	L60048	166	-215.7	18.5	216.6	128.5	L-6054a 43V-IR678					
	L60048	166	-182.6	20.4	183.7	109.2	L-6054a 43V-IR678							90H_605	166	-215.7	18.5	216.6	128.5	L-6054a 43V-IR678					
	90H_605	166	-182.6	20.4	183.7	109.2	L-6054a 43V-IR678							L6056A	178	-214.3	58.1	220.7	124	L-6004b 90H-IR671					
	L6056A	178	-183.9	41.6	187.5	105.5	L-6004b 90H-IR671							48V_B62	178	-214.3	58.1	220.7	124	L-6004b 90H-IR671					
	L6054B	178	-183.9	41.8	187.6	105.5	L-6004b 90H-IR671							L6054B	178	-183.8	48.3	187.9	105.5	L-6004b 90H-IR671					
	L6054	178	-183.9	41.8	187.6	105.5	L-6004b 90H-IR671							L6054	178	-183.8	48.3	187.9	105.5	L-6004b 90H-IR671					
	48V_B62	178	-183.9	41.6	187.5	105.5	L-6004b 90H-IR671							48V_562	178	-183.8	48.3	187.9	105.5	L-6004b 90H-IR671					
	48V_562	178	-183.8	41.8	187.5	105.5	L-6004b 90H-IR671							101V_602	178	-183.8	48.3	187.9	105.5	L-6004b 90H-IR671					
	101V_602	178	-183.9	41.8	187.6	105.5	L-6004b 90H-IR671							L6054B	178	-183.8	48.7	188	105.5	L-6004b 90H-IR671					
Case Pre IR673	Contingency	Rating	MW	MVAR	MVA	%	Line Number	Contingency	Bus Number	Bus Name	KV	V-Cont	Case Post IR673	Contingency	Rating	MW	MVAR	MVA	%	Line Number	Contingency	Bus Number	Bus Name	KV	V-Cont
SP2a Rate B	50W_501NAAS	24.2	-24.9	9.4	26.6	106.6	L-5532-1	50W_501NAAS	199249	4W-L_GR_BRK	69	1.11493	SP2b Rate B	L6056A	195.4	-214.3	58.3	222.2	112.2	L-6004b 90H-IR671	50W_501NAAS	199249	4W-L_GR_BRK	69	1.11586
	50W_B2	24.2	-24.9	9.4	26.6	106.6	L-5532-1	50W_501NAAS	199252	3W-BIG_FALL	69	1.11453		48V_B62	195.4	-214.2	58.2	222.2	112.2	L-6004b 90H-IR671	50W_501NAAS	199252	3W-BIG_FALL	69	1.11546
	L60086009	60.5	-62.8	2.6	62.9	103.5	L-5009-2	50W_501NAAS	199254	2W-LLFAL_TAP	69	1.116		L60048	195.4	-215.7	26.6	217.3	111.2	L-6054a 43V-IR678	50W_501NAAS	199254	2W-LLFAL_TAP	69	1.11693
								L-6541	199252	3W-BIG_FALL	69	1.1145		90H_605	195.4	-215.7	26.6	217.3	111.2	L-6054a 43V-IR678	L-6541	199252	3W-BIG_FALL	69	1.11546
								L-6541	199254	2W-LLFAL_TAP	69	1.11598		50W_501NAAS	24.2	-24.9	9.4	26.6	106.6	L-5530-1	L-6541	199254	2W-LLFAL_TAP	69	1.11694
								50W_B2	199249	4W-L_GR_BRK	69	1.11482		50W_B2	24.2	-24.9	9.4	26.6	106.6	L-5530-1	50W_B2	199249	4W-L_GR_BRK	69	1.11583
								50W_B2	199252	3W-BIG_FALL	69	1.11441		L60086009	60.5	-64.2	2.8	64.3	102.6	L-5009-2	50W_B2	199252	3W-BIG_FALL	69	1.11543
								50W_B2	199254	2W-LLFAL_TAP	69	1.11589									50W_B2	199254	2W-LLFAL_TAP	69	1.1169
SP2a Rate C	L60048	166	-182.6	27.7	184.7	109	L-6054a 43V-IR678						SP2b Rate C	L60048	166	-215.7	26.6	217.3	128.4	L-6054a 43V-IR678					
	90H_605	166	-182.6	27.7	184.7	109	L-6054a 43V-IR678							90H_605	166	-215.7	26.6	217.3	128.4	L-6054a 43V-IR678					
	L6056A	178	-182.8	48.6	189.1	105.6	L-6004b 90H-IR671							L6056A	178	-214.3	58.3	222.2	124.1	L-6004b 90H-IR671					
	L6054B	178	-182.8	48.8	189.2	105.6	L-6004b 90H-IR671							48V_B62	178	-214.3	58.2	222.2	124.1	L-6004b 90H-IR671					
	L6054	178	-182.8	48.8	189.2	105.6	L-6004b 90H-IR671							L60056010	178	-186.9	47.5	192.9	108	L-6004b 90H-IR671					
	48V_B62	178	-182.8	48.5	189.1	105.6	L-6004b 90H-IR671							90H_608	178	-186.9	47.5	192.9	108	L-6004b 90H-IR671					
	48V_562	178	-182.8	48.7	189.2	105.6	L-6004b 90H-IR671							L6054B	178	-183.8	49.2	189.3	105.6	L-6004b 90H-IR671					
	101V_602	178	-182.8	48.8	189.2	105.6	L-6004b 90H-IR671							L6054	178	-183.8	49.3	189.3	105.6	L-6004b 90H-IR671					
														48V_562	178	-183.8	49.2	189.3	105.6	L-6004b 90H-IR671					
														101V_602	178	-183.8	49.3	189.3	105.6	L-6004b 90H-IR671					
														48V_503	178	-178.3	55.1	187.6	104.8	L-6004b 90H-IR671					
Case Pre IR673	Contingency	Rating	MW	MVAR	MVA	%	Line Number	Contingency	Bus Number	Bus Name	KV	V-Cont	Case Post IR673	Contingency	Rating	MW	MVAR	MVA	%	Line Number	Contingency	Bus Number	Bus Name	KV	V-Cont
SP1a Rate B	50W_BAAAS	56	59.1	2.8	59.2	105.7	9W-T63	L6020_6021	199271	30W-SOURIQUO	69	0.92748	SP1b Rate B	L6056A	195.4	-214.3	56.5	221.5	112.1	L-6004b 90H-IR671	L6020_6021	199271	30W-SOURIQUO	69	0.92814

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