Interconnection Feasibility Study Report
GIP-IR652-FEAS-R2

Generator Interconnection Request 652
200 MW Combined Solar & BESS Facility
Cumberland County, NS

2022-08-12

Control Centre Operations
Nova Scotia Power Inc.

Executive summary

This Feasibility Study report *(FEAS)* presents the results of a Feasibility Study Agreement for the connection of a combined solar PV generation and BESS facility interconnected to the NSPI system as Network Resource Interconnection Service *(NRIS)*. The max output of the facility is 200 MW however the facility is composed of 200 MW solar PV generation and a 104 MW BESS.

This project is designated as Interconnection Request #652 in the NSPI Interconnection Request Queue and will be referred to as IR652 throughout this report. IR652's proposed Commercial Operation Date is 2024/10/01.

The Point Of Interconnection *(POI)* studied in this FEAS is a new 230 kV node at 67N-Onslow, with a 1.9 km spur line to the Interconnection Customer's *(IC)* substation. This assumes TSR411, a higher-queued project explained below, does not require this node.

Transmission Service Reservation *(TSR)* 411 is a long-term firm reservation for 550 MW from New Brunswick to Nova Scotia. TSR411 is expected to be in service in 2025 and a system study is presently underway to determine the associated upgrades to the Nova Scotia transmission system. These upgrades are expected to materially alter the configuration of the transmission system in Nova Scotia. As a result, the following notice was posted to the OASIS site at https://www.nspower.ca/oasis/generation-interconnection-procedures:

> *Effective January 19th, 2021, please be advised that the completion of advanced-stage Interconnection Studies under the Standard Generator Interconnection Procedures (GIP) may be delayed pending the outcome of the Transmission Service Request (TSR) 411 System Impact Study, which is expected to identify significant changes to the NSPI transmission system. The revised expected completion date for the study is February 28, 2022. Feasibility Studies initiated prior to the completion of the TSR System Impact Study will be performed based on the current system configuration.*

There are no concerns regarding increased short circuit levels or voltage flicker for IR652. The increase in short circuit level is within the capability of neighbouring breakers. The minimum short circuit level at the Interconnection Facilities' *(IF)* high side bus is 2,029 MVA with all elements in service. It decreases to 1,385 MVA with 67N-T81 out of service. In this scenario, the SCR *(Short Circuit Ratio)* is 6.93. The IC is recommended to confirm with Power Electronics that its inverters will be able to operate in this range as transformer and collector circuit losses will reduce the SCR at the inverters' terminals.

Voltage flicker will be examined when data is made available for the System Impact Study *(SIS)*, however inverters, like the Power Electronics FS4200M and FP4200M2 used in this IR, are not expected to introduce significant voltage flicker under minimum generation conditions.

The project design must meet NSPI requirements for voltage ride-through, frequency ride-through, reactive power range, and voltage control. Harmonics must meet the Total Harmonic Distortion requirements in IEEE 519.

IR652 is required to meet NSPI's ±0.95 net power requirements at the Interconnection Facility's 230 kV bus. Analysis using preliminary data demonstrates IR652 does not require power factor correction, provided the BESS is supplementing the solar PV system VAR output while generating at high levels. Power factor correction is not required when the BESS is discharging at full capacity.

Portions of IR652 are categorized as NERC Bulk Electric System *(BES)* under NERC BES inclusion criteria I4. This includes its solar and BESS generating resources and the portions of Interconnection Facilities where its generating resource power flow aggregates to ≥75 MVA.

Presently the POI at the 67N-Onslow 230 kV bus is categorized as NPCC BPS and NERC BES. Complete transient and steady-state testing in the System Impact Study *(SIS)* stage will determine if the IR652 will be categorized as BPS. Portions of IR652 are categorized as BES *(individual generating resources and portions where they aggregate to ≥75 MVA)* per BES inclusion criteria I4.

The preliminary loss factor is calculated as 5.43 and 7.35% respectively for IR652’s max BESS and max solar PV output modelled in the winter peak case.

IR652 does not require Network Upgrades beyond the POI to operate at its full 200 MW capacity under NRIS based on the power flow analysis studied in this report. The necessary Network Upgrades at the POI are related to the creation of the new 230 kV node.

The preliminary non-binding cost estimate for interconnecting IR652 to 67N-Onslow’s 230 kV bus as Network Resource is $7,172,000. $4,972,000 of this amount is the TPIF costs, with the remainder as the Network Upgrade costs. These amounts include a 10% contingency. The IC will obtain Right Of Way *(ROW)* for the 1.9 km spur line and fund its construction, but NSPI will own and operate it. This estimate will be further refined in the SIS and Facility *(FAC)* studies.

The estimated time to construct the Network Upgrades and TPIF for NRIS operation is 24-30 months after the receipt of funds.

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1.0 Introduction

This Feasibility Study report *(FEAS)* presents the results of a Feasibility Study Agreement for connection of a combined facility consisting of 200 MW solar PV generation and a 104 MW Battery Energy Storage System *(BESS)*, with a max 200 MW output. The facility will interconnect to the NSPI system as Network Resource Interconnection Service (NRIS).

This project is listed as Interconnection Request #652 in the NSPI Interconnection Request Queue and will be referred to as IR652 throughout this report. The proposed Commercial Operation Date is 2024/10/01.

The Interconnection Customer *(IC)* identified the 230 kV bus at 67N-Onslow as the Point Of Interconnection (POI). This generation facility will be interconnected to the POI via a 1.9 km 230 kV transmission line from the Point of Change of Ownership (PCO). Figure 1 shows the approximate geographic location of the proposed POI and Figure 2 shows the approximate electrical location.

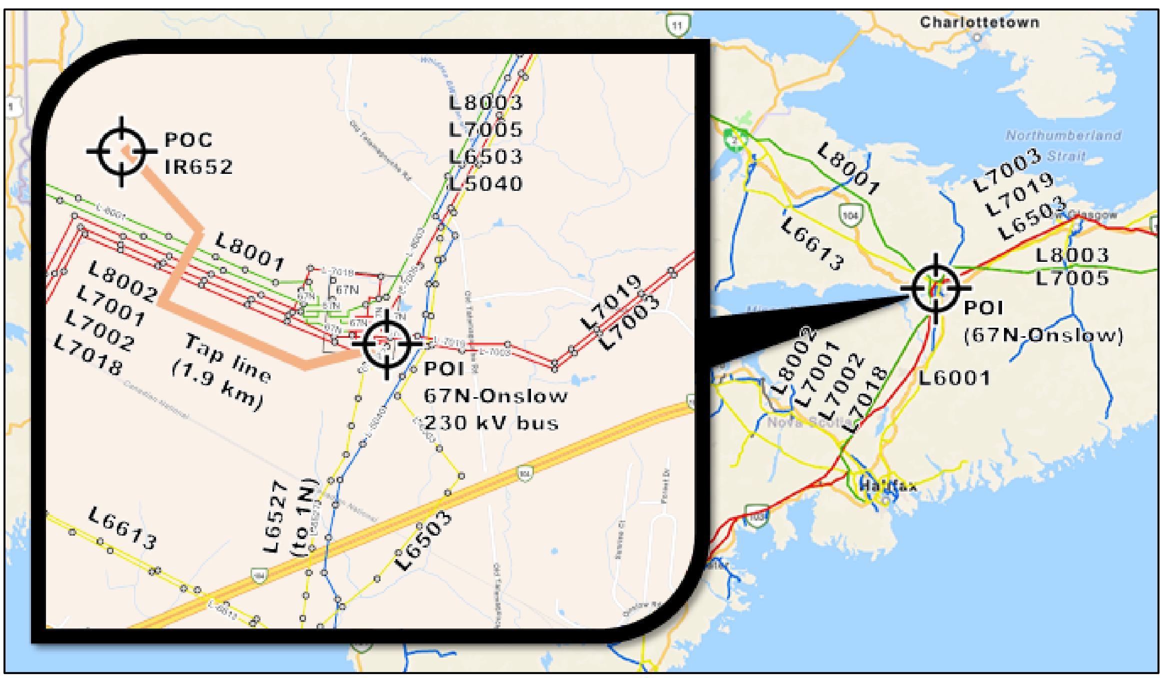


Figure 1: IR652 approximate geographic location

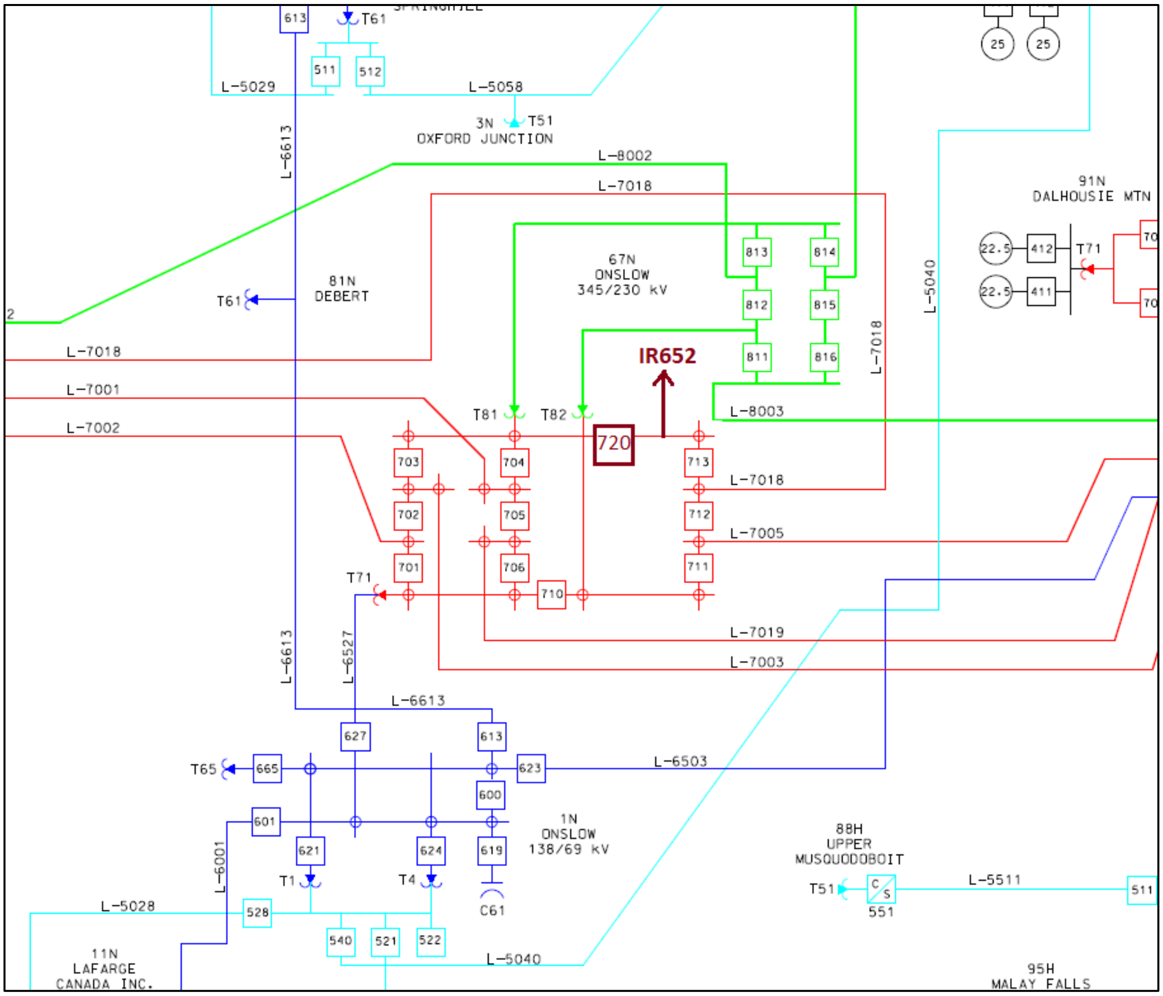


Figure 2: IR652 POI oneline

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 combined 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, which must remain with their thermal limits. Any potential voltage criteria violations will be identified and addressed. 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 to allow full output of the proposed facility.
- 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 technical information provided by the IC. The Point Of Interconnection *(POI)* and configuration is studied as follows:

1. Network Resource Interconnection Service *(NRIS)* per section 3.2 of the Generation Interconnection Procedures *(GIP)*.
2. Commercial Operation date: 2024/10/01.
3. The POI is a new 230 kV node at 67N-Onslow; through the installation of a new breaker, tentatively designated 67N-720 as illustrated in Figure 2. This assumes the node is not required for TSR411.
4. A 1.9 km 230 kV line, constructed with 60°C ACSR 795 Drake, will connect the Interconnection Customer Interconnection Facility *(ICIF)* to the 67N-Onslow POI.
5. The max facility output is 200 MW. The facility is comprised of 50 Power Electronics FS4200M inverters *(for solar PV)*, capped at 200 MW, and 30 Power Electronics FP4200M2 inverters *(for BESS)*, capped at 104 MW.
6. The FS4200M and FP4200M2 characteristics are assumed to be the same as the FP4200M inverters.
7. The following preliminary data for the substation step-up transformers and padmount transformers was provided by the IC, along with some assumptions:
   7.1. The two substation step-up transformers are modelled as 230 kV - 34.5 kV transformers, rated at 60/80/100 MVA, with a 9% positive sequence impedance, 56 X/R ratio, grounded wye/delta/grounded wye winding configuration, and ±16% taps.

7.2. The solar PV padmount transformers are modelled as two equivalent transformers, each based off 25x 34.5 kV – 0.69 kV transformers rated at 4.6 MVA, with a 6% positive sequence impedance, 10 X/R ratio, delta/wye winding configuration, and ±7.5% fixed taps.

7.3. The BESS padmount transformers are modelled as two equivalent transformers, each based off 15x 34.5 kV – 0.69 kV transformers rated at 4.0 MVA, with a 5.75% positive sequence impedance, 10 X/R ratio, delta/wye winding configuration, and ±7.5% fixed taps.

8. The preliminary solar PV collector circuit layout provided by the IC was used to model two equivalent circuits.
9. Collector circuit data was not provided for the BESS; however, impedance is considered negligible for this BESS facility, with the understanding that net real and reactive power output from this facility will be impacted by losses through the transformers.
10. Solar PV is assumed to be offline in light load conditions, which occur overnight.
11. BESS charge/discharge rate is 104 MW with a 4-hour capacity.
12. BESS discharging occurs in light load, summer peak, and winter peak conditions.
13. BESS charging occurs during light load and summer peak conditions. During the winter season, charging is studied under off-peak load conditions, several hours after winter peak, which coincides with loading levels ≤ 91% peak load.
14. Line ratings used are listed below in Table 1.

Table 1: Local transmission elements

Line	Conductor	Design temp (°C)	Limiting element	Summer rating (normal/emergency)	Winter rating (normal/emergency)
L8001	2x795 Drake	49	Metering	670/737	956/1051
L8002	2x795 Drake	49	Metering	670/737	956/1051
L8003	2x1113 Beaumont	120	Metering	1075/1182	1075/1182
L7001	795 Drake	60	Conductor	298/227	383/421
L7002	795 Drake	100	Metering	447/492	462/508
L7018	2x795 Drake/AACSR 2156	60	Metering	506/556	637/700
L7003	556.5 Dove	60	Conductor	275/303	348/383
L7005	1113 Beaumont	70	Relaying	398/437	398/437
L7019	2x795 Drake/AACSR 2156	60	Conductor	273/300	345/380
L6001	556.5 Dove	60	Conductor	140/154	184/202
67N-T81	-	-	-	392/478	
67N-T82	-	-	-	392/478	
67N-T71	-	-	-	93/102	
L6613	1113 Beaumont	100	Metering	287/315	287/315
L6503a	1113 Beaumont	100	Relaying/breaker/switch	287/315	287/315

15. This FEAS analysis assumes higher in the Generation Interconnection Queue and OATT Transmission Service Queue that have a completed System Impact Study

(SIS), or have an SIS in progress will proceed, as listed in Section 4.0 below. TSR411 is not included in this study for IR652.

16. The generation technology used must meet NSPI requirements for reactive power capability of at least 0.95 capacitive to 0.95 inductive at the HV terminals of the IC substation step up transformer. It is also required to have high-speed Automatic Voltage Regulation to maintain constant voltage at the designated voltage control point during and following system disturbances as determined in the subsequent System Impact Study. The designated voltage control point will either be the low voltage terminals of the IF's transformers, or if the high voltage terminals are used, equipped with droop compensation controls. It is assumed that the generating units are de-rated in their MW capability when delivering the required reactive power to the system.
17. Planning criteria meeting NERC Standard TPL-001-4 *Transmission System Planning Performance Requirements* and NPCC Directory 1 *Design and Operation of the Bulk Power System* as approved for use in Nova Scotia by the Utility and Review Board, are used in evaluation of the impact of any facility on the Bulk Electric System.

4.0 Project queue position

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

Higher queued projects in the Advanced Stage Interconnection Request *(IR)* Queue and Transmission Service Request *(TSR)* Queue are included in this study's base cases as of 2022/05/05. The IR and TSR projects are respectively listed in Table 2 and Table 3 below.

Table 2: IR queue

Combined T/D Advanced Stage Interconnection Request Queue

Nova Scotia POWER An Emera Company

Publish Date: *Friday, April 29, 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	7/30/2021	GIA Executed	N/A	N/A
7 -D	566	16-Jan-19	Digby	0.7	0.7	509V-301	Tidal	31-Jul-19	1/29/2021	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
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	Lunenburg	33.6	33.6	50W	Wind	31-Aug-23		SIS in Progress	NRIS	N/A
14 -T	629	20-Sep-21	Cumberland	0.5	0.5	7N	Solar	28-Sep-21		SIS in Progress	ERIS	N/A
15 -T	647	06-Oct-21	Cumberland	1.5	1.5	37N	Tidal	31-Dec-23		SIS in Progress	NRIS	N/A
16 -T	649	28-Oct-21	Colchester	100	100	L-6503	Wind	31-Mar-24		SIS in Progress	NRIS	NSPI
17 -T	650	28-Oct-21	Pictou	100	100	91N	Wind	31-Mar-24		SIS in Progress	NRIS	NSPI
18 -T	651	28-Oct-21	Lunenburg	144.5	144.5	L-7008	Wind	31-Mar-24		SIS in Progress	NRIS	NSPI
19 -D	653	19-Jan-22	Halifax	0.09	0.09	24H-406	Solar	30-Oct-22		SIS in Progress	N/A	N/A
		Totals:		517.74	517.74							

Nova Scotia Power - Interconnection Request Queue

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**

Table 3: TSR queue

OATT Transmission Service
Queued System Impact Studies
Active April 29, 2022

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, 2025	550	SIS in Progress
3	TSR 412	January 19, 2021	Point-to-point	Woodbine - NS	January 1, 2025	500	Withdrawn
4	TSR 413	April 14, 2021	Network	Antigonish - NS	January 1, 2022	8.792	Withdrawn

*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. It is expected to be in service in 2025 and a system study is currently underway to determine the required upgrades to the Nova Scotia transmission system. As a result, the following notice has been posted to the OASIS site[1]:

> *Effective January 19th, 2021, please be advised that the completion of advanced-stage Interconnection Studies under the Standard Generator Interconnection Procedures (GIP) may be delayed pending the outcome of the Transmission Service Request (TSR) 411 System Impact Study, which is expected to identify significant changes to the NSPI transmission system. The revised expected completion date for the study is February 28, 2022. Feasibility Studies initiated prior to the completion of the TSR System Impact Study will be performed based on the current system configuration.*

5.0 Short circuit

IR652 will not impact neighbouring breaker's interrupting capability based on this study's short circuit analysis. Analysis was performed using PSS/e 34.8, classical fault study, flat voltage profile at 1.0 PU voltage, and 3LG faults.

The maximum design interrupting capability of neighbouring 230 kV circuit breakers is at least 10,000 MVA. The manufacturer's short circuit statement letter, provided by the

[1] OASIS Generation Interconnection Procedures; https://www.nspower.ca/oasis/generation-interconnection-procedures

IC, specified the inverters contribute a maximum of 1.0 PU at 2 to 3 cycles post-fault. The short circuit levels in the area before and after this development are provided in Table 4: *Short circuit levels, 3-ph, in MVA*.

Minimum fault levels occur when either 67N-T81 or 67N-T82 is out of service. In this scenario, a 6.92 SCR *(Short Circuit Ratio)* is calculated at the high voltage bus of IR652's Interconnection Facility. The SCR will be lower at the inverter terminals due to losses associated with the substation step-up transformer, collector circuit, and generator step-up transformers.

The SCR may change when a more detailed collector circuit design is submitted. This study used the preliminary solar PV collector circuit layout and assumed the BESS collector circuit losses were negligible.

Table 4: Short circuit levels, 3-ph, in MVA

Location	IR652 not in service	IR652 in service	Post % increase
2023, max generation, all facilities in service			
67N-Onslow:230 kV bus	4,300	4,580	7%
IR652-hv:230 kV bus	4,299	4,580	7%
2023, min generation, all facilities in service			
67N-Onslow:230 kV bus	2,029	2,310	14%
IR652-hv:230 kV bus	2,029	2,310	14%
2023, min generation, L8001 out of service			
67N-Onslow:230 kV bus	1,908	2,189	15%
IR652-hv:230 kV bus	1,908	2,189	15%
2023, min generation, 67N-T81 out of service			
67N-Onslow:230 kV bus	1,385	1,666	20%
IR652-hv:230 kV bus	1,385	1,666	20%

6.0 Voltage flicker & harmonics

Voltage flicker will be examined when data is made available for the SIS. However, Type 4 generators, like the inverters used in IR652, are not expected to introduce significant voltage flicker under minimum generation conditions.

NS Power's voltage flicker requirements are:

- $P_{st} \leq 0.25$
- $P_{lt} \leq 0.35$

The generator must meet IEEE Standard 519-2014 limiting voltage Total Harmonic Distortion *(all frequencies)* to no higher than 1.0% with no individual harmonic exceeding 1.5% at 230 kV.

7.0 Thermal limits

IR652 does not require Network Upgrades beyond the POI to operate at its full 200 MW capacity under NRIS based on the contingencies and cases studied in this report.

Base cases used in this study are listed in Table 5: *Base case dispatch*. They were selected to examine stressed conditions in the surrounding area under varying levels of transmission-connected wind generation. The Onslow substation is a hub for major Nova Scotia transmission corridors. Generation dispatch also reflected import and export scenarios expected from flows associated with the Maritime Link TSR400.

Table 5: Base case dispatch

Case name	NS load	IR652	Wind	NS/NB	ML	CBX	ONI	ONS
ll01-1	867	-	196	-	-165	85	163	136
ll01-2	867	104	196	-	-165	4	64	136
ll01-3	980	-104	196	-	-165	186	264	136
ll02-1	866	-	377	330	-330	262	390	58
ll02-2	866	104	377	330	-330	187	290	58
ll02-3	977	-104	377	330	-330	364	490	58
sp01-1	1,579	-	294	320	-475	801	975	578
sp01-2	1,579	104	294	320	-475	696	875	578
sp01-3	1,690	-104	294	320	-475	907	1,076	578
sp01-4	1,570	200	294	320	-475	594	777	577
sp02-1	1,588	-	171	320	-475	911	1,108	691
sp02-2	1,579	104	171	320	-475	782	987	669
sp02-3a	1,688	-104	171	320	-475	1,007	1,198	681
sp02-3b	1,690	-104	171	320	-475	948	1,143	626
sp02-4	1,579	200	171	320	-475	702	910	691
sp03-1	1,579	-	133	150	-475	895	952	707
sp03-2	1,570	104	133	150	-475	789	851	707
sp03-3	1,681	-104	133	150	-475	941	995	650
sp03-4	1,570	200	133	150	-475	687	754	406
sp04-1	1,561	-	133	-150	-475	659	673	729
sp04-2	1,552	104	133	-150	-475	555	573	729
sp04-3	1,672	-104	133	-150	-475	764	773	729
sp04-4	1,552	200	133	-150	-475	455	475	728
wp01-1	2,193	-	490	150	-330	998	1,216	951
wp01-2	2,193	104	490	150	-330	890	1,115	950
wp01-3	2,076	-104	490	150	-330	899	1,140	794
wp01-4	2,193	200	490	150	-330	760	992	925
wp02-1	2,182	-	490	-	-330	1,012	1,050	936
wp02-2	2,182	104	490	-	-330	905	950	935
wp02-3	2,063	-104	490	-	-330	914	975	780
wp02-4	2,173	200	490	-	-330	801	852	935
wp03-1	2,202	-	490	300	-330	998	1,216	799
wp03-2	2,202	104	490	300	-330	892	1,116	799
wp03-3	2,085	-104	490	300	-330	902	1,143	645
wp03-4	2,193	200	490	300	-330	788	1,018	799
wp04-1	2,202	-	147	-150	-330	846	994	976
wp04-2	2,202	104	147	-150	-330	741	894	976
wp04-3	2,082	-104	147	-150	-330	811	977	878
wp04-4	2,193	200	147	-150	-330	639	797	975

Note 1: All values are in MW.
Note 2: CBX *(Cape Breton Export)* and ONI *(Onslow Import)* are Interconnection Reliability Operating Limit *(IROL)* defined interfaces.
Note 3: Wind refers to transmission connected wind only.
Note 4: "NS load" column also includes BESS charging load in the XX##-3 cases.

8.0 Reactive power & voltage control

Analysis using preliminary data demonstrates IR652 does not require power factor correction to meet NS Power's ±0.95 net power factor requirement at the HV terminals of the ICIF substation while the BESS is discharging at full. When the solar PV system is generating at full, the BESS is required for supplemental VAR support to meet the net power factor requirement.

The net power factor will be re-evaluated when detailed information on the transformers and collector circuit is provided in the SIS stage.

Using the Power Electronics inverter reactive power capability curve supplied by the IC, shown in Figure 3, this study performed power factor analysis on IR652's equivalent model.

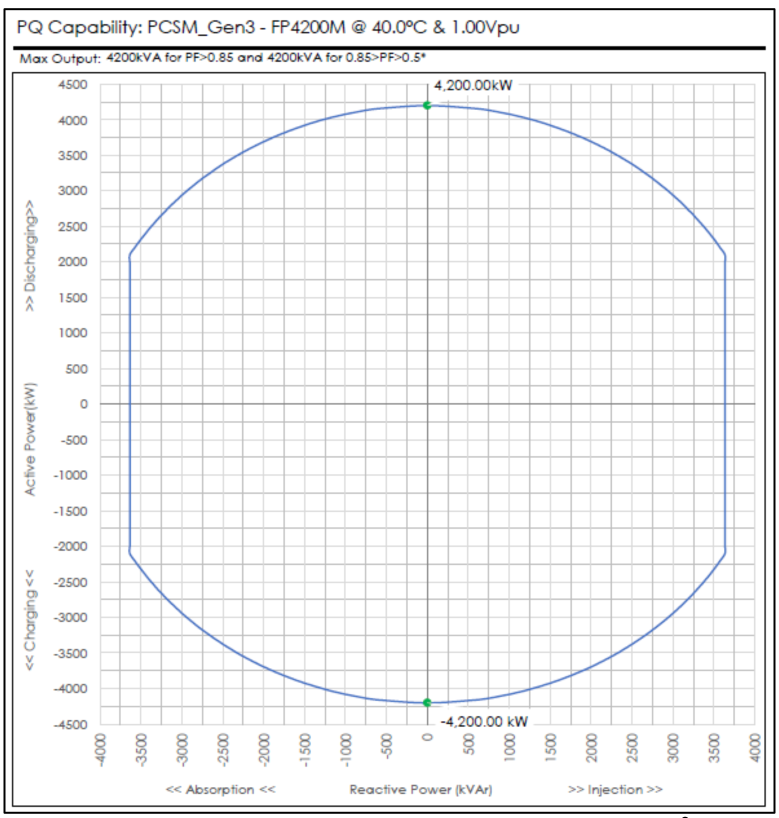


Figure 3: Power Electronics FP4200M PQ capability[2]

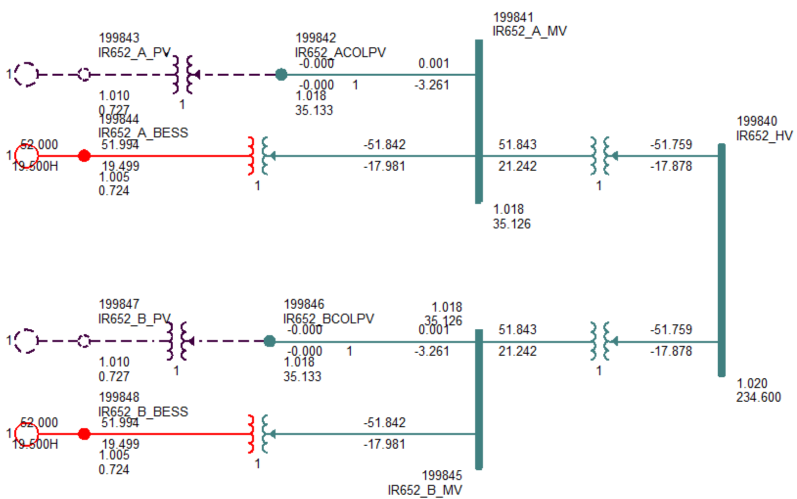
[2] Power Electronics Inverter Information, supplied by the IC.

Table 6 lists the calculated power factors at the high side of the IC's interconnection transformers. Note IR652 does not meet NS Power's ±0.95 net power factor requirement when producing VARs while operating at its max solar PV real power output unless the BESS is used to supplement the VAR output. IR652's results in its modes are illustrated in Figure 4.

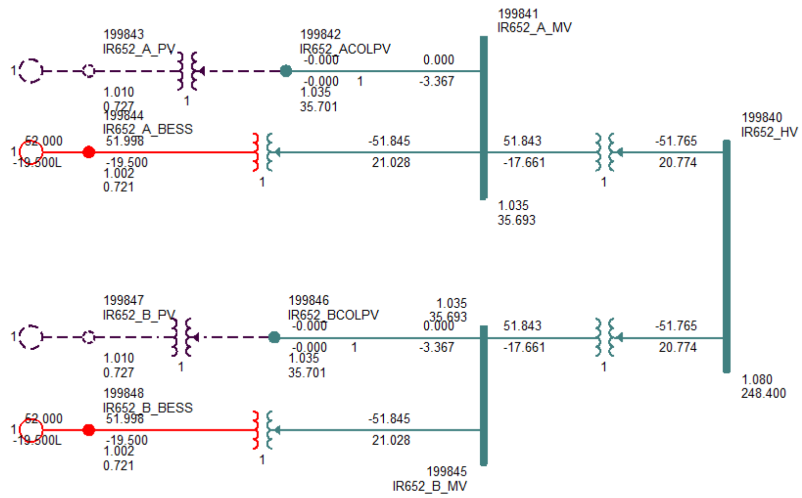
Table 6: Power factor analysis results

Source	Mode	MW @ source	MVAR @ source	MVA @ source	pf @ source	MW @ high side	MVAR @ high side	MVA @ high side	pf @ high side	pf requirements met?
BESS	Lagging	104	39	111	0.94	103.52	35.76	109.52	0.9452	yes
	Leading	104	-39	111	0.94	103.53	-41.55	111.56	0.9281	yes
PV	Lagging	200	65	210	0.95	196.93	34.08	199.85	0.9854	no
	Leading	200	-65	210	0.95	196.06	-106.77	223.24	0.8782	yes
PV + BESS	Lagging	200	104	225	0.89	196.86	70.42	209.07	0.9416	yes

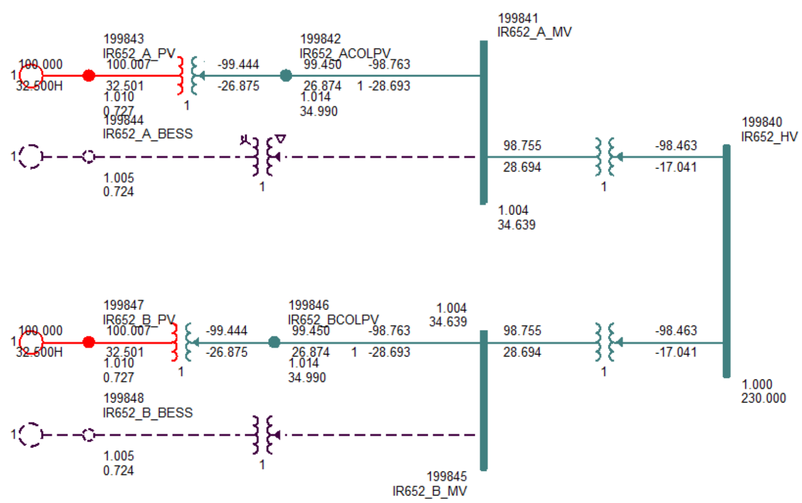
BESS discharging only: lagging



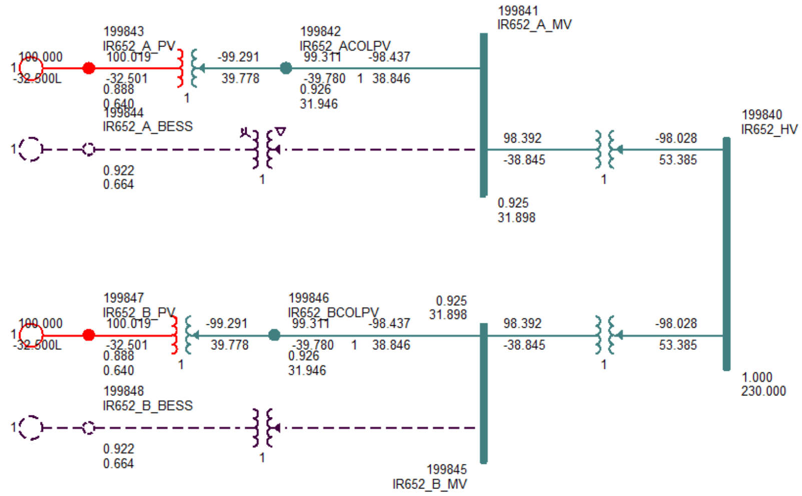
BESS discharging only: leading



PV generation only: lagging



PV generation only: leading



PV generation, with BESS VAR support: lagging

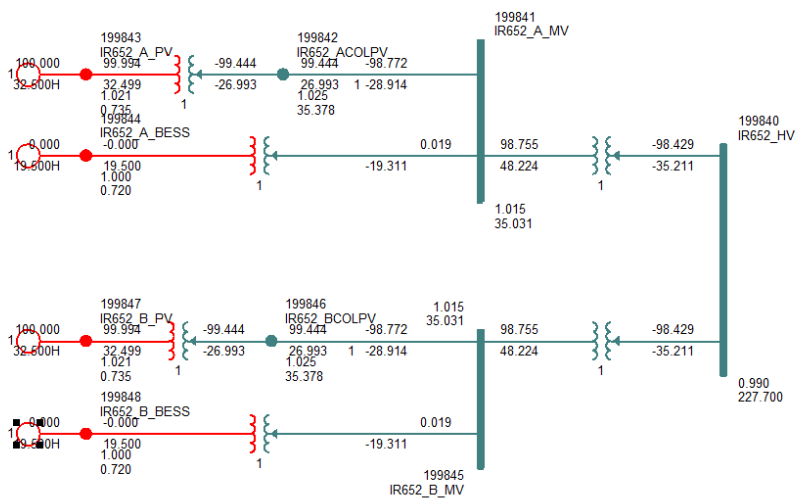


Figure 4: Power factor analysis

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 ICIF 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 individual batteries' 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)*[3]. 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 System security

Transmission System Elements may be required to meet NPCC[4] BPS *(Bulk Power System)* or NERC[5] BES *(Bulk Electric System)* requirements. NPCC BPS categorization is performance based while NERC BES criteria is bright line based.

At the time of this study, the POI at the 67N-Onslow 230 kV bus, is categorized both NPCC BPS and NERC BES. The complete NPCC BPS determination for IR652's facilities will be performed in the SIS, during the complete transient and steady-state testing[6]. Regardless of BPS categorization, IR652's protection systems must comply with NPCC Directory 4: System Protection Criteria.

NERC BES criteria categorizes portions of IR652 as NERC BES, due to BES inclusion criteria I4 shown in Figure 5. The IR652 facilities categorized BES are:

- The individual generating resources *(ex: batteries, solar panels, inverters, padmount transformers, ...)*.
- Portions where the generating resources aggregate to ≥75 MVA *(ex: 34.5 kV buses, substation step-up transformers, ...)*.

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[3] NS Power Transmission System Interconnection Requirements; https://www.nspower.ca/oasis/generation-interconnection-procedures
[4] Northeastern Power Coordination Council.
[5] North American Electric Reliability Corporation.
[6] Regional Reliability Reference Criteria A-10: *Classification of Bulk Power System Elements*; NPCC.

Unless modified by the lists shown below, all Transmission Elements operated at 100 kV or higher and Real Power and Reactive Power resources connected at 100 kV or higher
...
• I4 - Dispersed power producing resources that aggregate to a total capacity greater than 75 MVA (gross nameplate rating), and that are connected through a system designed primarily for delivering such capacity to a common point of connection at a voltage of 100 kV or above. Thus, the facilities designated as BES are:

a) The individual resources, and
b) The system designed primarily for delivering capacity from the point where those resources aggregate to greater than 75 MVA to a common point of connection at a voltage of 100 kV or above.
...

Figure 5: Appliable NERC BES inclusion criteria I4

NS must carry sufficient reserve to cover first contingency loss of its largest generation units[7]. IR652 introduces new max online generation contingencies, which requires an increase in system reserve *(synchronous, 10-minute, and 30-minute)* while IR652 is the largest online unit on the NS system. The reserve arrangement and financial impact will be reviewed in the FAC stage.

10.0 Expected facilities required for interconnection

The following facilities are required to interconnect IR652 to the NSPI system via the 230 kV bus at 67N-Onslow as NRIS:

1) **Network upgrades:**
   a) Create new node on 230 kV bus at 67N-Onslow by adding 67N-720.
2) **Transmission Provider's Interconnection Facilities *(TPIF)*:**
   a) 230 kV connection from ICIF to POI: 1.9 km spur line with 60°C ACSR 795 Drake conductor. The IC is responsible for obtaining ROW and funding its construction, but NSPI will own and operate it.
   b) Control and communications between the ICIF and the NSPI SCADA and protection systems.
3) **Interconnection Customer's Interconnection Facilities *(ICIF)*:**
   a) Facilities to limit plant output to 200 MW.

[7] NPCC Directory #5: *Reserve*

b) Facilities to provide ±0.95 power factor when delivering rated output *(200 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 deadband 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, curtailment state, and BESS charge state.

g) Meet the requirements detailed in the NS Power Transmission System Interconnection Requirements *(TSIR)*[8]. Among them is voltage ride-through capability per section 7.4.1 and frequency ride-through per section 7.4.2.

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.

11.0 NSPI Interconnection Facilities & Network Upgrades cost estimate

The high level, non-binding, cost estimate, excluding HST, for IR652's Network Resource Interconnection Service is shown in Table 7: *NRIS cost estimate*.

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

This estimate assumes the following:

1. The new 230 kV node at 67N-Onslow, created via the addition of 67N-720, is available for use and is not required by TSR411.
2. This does not include any TBD costs to address any stability issues identified at the SIS stage, based on dynamic analysis.

Table 7: NRIS cost estimate

Item	Network Upgrades	Estimate
I	Create new node on 230 kV bus at 67N-Onslow.	$ 2,000,000
	Sub-total	**$ 2,000,000**

	TPIF	Estimate
I	230 kV connection from ICIF to POI: 1.9 km spur line with 60°C ACSR 795 Drake conductor. The IC is responsible for obtaining ROW and funding its construction, but NSPI will own and operate it.	$ 4,020,000
II	Teleprotection and SCADA communications	$ 500,000
	Sub-total	**$ 4,520,000**

Total upgrades (Network Upgrades + TPIF)	
Subtotal	$ 6,520,000
Contingency (10%)	$ 652,000
Total of determined cost items	$ 7,172,000

The estimated time to construct the Network Upgrades and Transmission Provider's Interconnection Facilities is 24-30 months after receipt of funds.

12.0 Loss factor

With IR652 in service, the loss factor is calculated as 5.43% when the BESS is at full output and 7.35% when the solar PV is at full output. The data and calculation is detailed in Table 8 and Equation 1, respectively.

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. A negative loss factor reflects a reduction in system losses.

Table 8: IR652 loss factor data

	IR652 BESS	IR652 PV
IR652 MW output	104.00	200.00
TC w/ IR652	87.99	60.64
TC w/o IR652	186.34	245.93
Delta	5.65	14.71
2023 loss factor	5.43%	7.35%

Equation 1: IR652 loss factor calculation

$$loss\ factor = \frac{(IR652_{nameplate} + TC_{w/\ IR652}) - TC_{w/o\ IR652}}{IR652_{nameplate}}$$

13.0 Preliminary scope of subsequent SIS

The following provides a preliminary scope of work for the subsequent SIS for IR652.

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, ride through, and operation following a contingency (N-1 operation). The SIS must determine the facilities required to operate this facility at full capacity, withstand any contingencies (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, frequency response, 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 *Transmission System Interconnection Requirements*.
- The minimum transmission additions/upgrades that are necessary to permit operation of this Generating Facility, under all dispatch conditions, catering to NERC, NPCC, and NSPI design and operation criteria.
- 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 TPL-001-4.
- NSPI System Design Criteria, report number NSPI-TPR-003-4.

Additionally, electromagnetic transient study may be required to account for IR652's control system to coordinate with other facilities in the transmission system and to ensure fault ride through.

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 NERC[9] and NPCC[10] criteria as well as NSPI guidelines and good utility practice.

Nova Scotia Power
Control Centre Operations
2022/08/12

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

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