Interconnection Feasibility Study Report
GIP-IR722-FEAS-R0 (NRIS)

Generator Interconnection Request #722
500 MW Wind Generation Facility
Pictou, NS

2024-11-04
Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

This Feasibility Study report (FEAS) is based on the Feasibility Study Agreement, signed by the Interconnection Customer (IC) on October 4, 2023 and Nova Scotia Power Inc. (NSPI) on November 27, 2023 for connection of a 500 MW wind power generating facility to L-8004 (an existing 345 kV transmission line between 79N-Hopewell substation and 101S-Woodbine substation) at Blue Mountain/Websters Corner in NS.

The Feasibility Study Agreement shows the Interconnection Service will be NRIS/ERIS (Network Resources/Energy Resources), however, the Interconnection Request, Appendix 1 to GIP, has ERIS crossed out in red ink and NRIS is retained. As a result, this FEAS is based on NRIS.

The Interconnection Request, Appendix 1 to GIP states that the proposed Commercial Operation date for IR722 will be September 1, 2028.

This FEAS involves the study of IR722, which is the largest generator interconnection (500 MW) in NSPI's generation queue.

The power system base cases include other higher queued projects that are in the planning stages; 900 MW Bear Head hydrogen plant (largest proposed load in NS); 400 MW behind the meter (Btm) generation at Bear Head facility, as well as the load and resources for Everwind Fuels (represented in this study with a plant load of 325 MW and 207 MW Btm generation plus IR686 wind generation of 340 MW).

In addition, IR686 and IR742 (35 MW) SISs are not yet completed to identify system upgrades required for their interconnections so analysis was conducted to identify and assume system upgrades pre-IR722 prior to studying IR722.

Revision to this report will be required if any of the following assumption changes:

1. The facility will comprise of 97 wind turbines with each wind turbine (Enercon E-160 EP5 v.E3) having a rating of 5.56 MW. The wind turbines will generate at 750 volts and their voltages will be stepped up to 66 kV for collector circuits. The 66 kV will be stepped up to 345 kV voltages via two power transformers 150/200/250 MVA with an impedance of 14.5%, complete with OLTC (On Load Tap Changer).
2. The Point-Of-Interconnection (POI) to L-8004 will be approximately 24 km from 79N-Hopewell substation.
3. The power system base cases for the feasibility study include all transmission connected IRs in the GIP queue up to and including IR742. In this queue, the System Impact Studies (SISs) for IR686 and for IR742 have not yet been completed and they are anticipated to have major impact on the power system prior to IR722. This FEAS assumes that some pre-IR722 system upgrades will take place by these IRs. This includes the connection of IR686 at 67N-Onslow substation via a new rung with two 345 kV breakers and L-7024 conductor upgrade from existing 70 degree C summer operating temperature to 85 degree C. When the SISs for IR686

and IR742 are completed and identify system upgrades pre-IR722, then the information can be used to perform the SIS for IR722.

4. This FEAS is carried out with the assumption that IR722 will supply power to the Bear Head 900 MW hydrogen plant load which includes 400 MW behind-the-meter (Btm) generation for a net plant load of 500 MW. Variation of the net plant load is not in the scope of this Feasibility Study.
5. The conceptual representation of Bear Head load (BHL) facility was included in order to enable IR722 study, however, with regard to the Bead Head load facility, the Load Impact Study (LIS) for Bear Head will take precedence. Likewise, the SIS for Bear Head Btm, not yet studied, will take precedence.
6. The study does not examine cases where the BHE facility serves NS system load or NS system exports. If the IC would like to pursue those modes of operation, a second study is required and additional Network Upgrades may be identified.
7. IR722 generating facility is modeled with a combination of capacitor banks and STATCOMs to provide 200 MVAR for power factor requirements and voltage support.
8. This FEAS assumes that BHL POI, which is also on L-8004, and its load facility will be designed and installed such that no single contingency (single event as defined in Table 1 of NPCC Directory #1) can cause a loss of load more than 325 MW, which is the load loss limit in NS. NPCC stands for Northeast Power Coordinating Council, of which NSPI is a member.
9. The preliminary load flow models for Bear Head hydrogen plant load, Everwind Fuels plant load, and IR686 generation are included in the study base cases, but separate LISs are required for Bear Head hydrogen plant load and for Everwind Fuels plant load, and a separate SIS will be conducted for IR686 wind power generation. These studies are not in the scope of this FEAS.
10. The 345 transmission line L-8004 (211.7 km) between 101S-Woodbine and 79N-Hopewell that crosses the navigable water at Canso Strait will be divided into 3 sections. For the purpose of this study, the sections are labelled as: L-8004a between 79N-Hopewell and IR722, L-8004b between IR722 and BHL, L-8004c between BHL and 101S-Woodbine. The line sections are presently rated 550/880 MVA (summer/winter). These ratings are based on the special conductors that cross the Canso Strait and the permissible sag over the navigable water. NSPI is working with Transport Canada to get approval for higher ratings. Early indication is that the ratings could be 985/1137 MVA or higher which is assumed in this feasibility study.
11. The Reliability Tie (new 345 kV line between NS and NB) is not included in this Feasibility Study, consistent with all Interconnection Request studies to date.

System losses associated with IR722 and BHL will be discussed and resolved by the IC and NSPI. It is outside the scope of this FEAS.

IR722 generation will be greater than NSPI's present (or planned) largest generator (Point Aconi 168 MW net) in NS and that will have a major impact on the operating reserve requirement (synchronous, 10-minute, and 30-minute) for NSPI. IR722 will need to discuss with NSPI for the options to address the operating reserve prior to the SIS stage.

The Transmission Service Reservation TSR-411 for 550 MW from New Brunswick to Nova Scotia is not included as per the attached notice on NSPI's OASIS site. This FEAS is based on NSPI's present power system interconnection with New Brunswick Power via the 345 kV line (L-8001) and two 138 kV lines (L-6535 and L-6536).

The scope of this FEAS is as defined in the Feasibility Agreement:

1. Preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the interconnection.
2. Preliminary identification of any thermal overload or voltage limit violations resulting from the interconnection.
3. Preliminary description and non-bonding estimated cost of facilities required to interconnect the Generating Facility to the Transmission System and to address the identified short circuit and power flow issues.

The preliminary short circuit analysis results in the following:

1. All the 345 kV breakers in the vicinity of IR722 exceed the short circuit interrupting capability of 15, 000 MVA and the three phase short circuit levels shown in Table 2 are well below 15, 000 MVA, hence IR722 does not incur any replacement of 345 kV breakers in NS.
2. The lowest short circuit level in Table 2 at the collector circuit level is 395 MVA for 48 wind turbines with each wind turbine rated at 5.56 MW. This equates to a Short Circuit Ratio (SCR) of 1.48 which is much less than the required value of 3 as per the technical bulletin for IR722 wind turbines, hence the IC will need to discuss with Enercon regarding this topic prior to the SIS stage. Please note that section 7.4.15 of the TSIR states "Any Generating Facility which requires a minimum Short Circuit Ratio (SCR) for unrestricted operation must provide this information for the System Impact Study. 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 preliminary load flow simulations show many system issues: system voltage collapse (for high wind summer and light load cases), large numbers of voltage violations, and thermal overloads.

The load flow shows system voltage collapse for contingencies that involve loss of the 345 kV line section between IR722 POI and BHL POI: loss of L-8004b or breaker failure at IR722 POI or at BHL POI.

To resolve the issue associated with loss of L-8004b, the load flow analysis identified four options:

Option 1: Installation of a new 345 kV transmission line, approximately 90 km, between IR722 POI and BHL POI.

Option 2: Installation of a new 200 MVAR STATCOM at Woodbine substation.

Option 3: Installation of a new 170 MVAR STATCOM at BHL POI substation (in addition to reactive power devices already included in the study base cases).

Option 4: Installation of a Remedial Action Scheme (RAS) for L-8004b section. The SIS will determine the type of RAS.

Option 2 and 3 will be subject to BHL LIS currently in progress.

For each of the above options, additional NUs are required to address thermal overloads and voltage limit violations, and connection to IR722 generating facility.

Option 1 *additional* NUs (in addition to the installation of a new 345 kV transmission line between IR722 POI and BHL POI, Option 1 will also require):

1. Install a four breaker ring bus at IR722 POI substation. The design will be such that both L-8004b1 and L-8004b2 cannot be lost for breaker failure contingencies.
2. Install a 345 kV to 230 kV transformer (67N-T83) at 67N-Onslow substation. This includes installation of breakers on the 345 kV bus as well as on 230 kV bus and swap L-7018 with the new 230 kV node to avoid a breaker failure to take out T81 and T83.
3. Upgrade L-6552, approximately 20 km, between 4C-Lochaber Road substation and 93N-Glen Dhu substation.
4. Upgrade L-8001 metering at 67N-Onslow substation.
5. Upgrade L-8004a metering at 79N-Hopewell substation.
6. Install 2.5km of 345 kV line extension from each side of L-8004 to IR722 POI substation.
7. Install two 50 MVAR capacitor banks with each bank having 2 stages of 25 MVAR each stage and two 50 MVAR STATCOMs at IR722 IC substation for power factor correction and voltage support. The STATCOMs and the capacitor banks could be eliminated by the synchronous condenser required for Inertia Response which will be determined in the SIS.

Option 2 *additional* NUs (in addition to the installation of a new 200 MVAR STATCOM at Woodbine substation, Option 2 will also require):

1. **All of additional NUs in Option 1** except IR722 POI substation will have three breakers instead of four breakers.
2. Upgrade L-6511, 138 kV line, 36.5 km, between 50N-Trenton and 93N-Glendhu.
3. Upgrade L-6515, 138 kV line, 50.7 km, between 2C-Port Hastings, 100C-Cape Porcupine, and 4C-Lochaber Road.

4. Upgrade L-7004, 230 kV, 131 km, between 3C-Port Hastings and 91N-Dalhousie Mountain.
5. Upgrade L-7012, 230 kV, 40 km, between 3C-Port Hastings and Everwind Load POI.
6. Upgrade L-7024 (presently L-7003), 230 kV, 11.8 km, between 3C-Port Hastings and IR618+IR742 POI.
7. Upgrade L-7026 (presently L-7003), 230 kV, 50.2 km, between IR668 POI and IR618+IR742 POI.

Option 3 *additional* NUs (in addition to the Installation of a new 170 MVAR STATCOM at BHL POI substation, Option 3 will also require):

1. **All of additional NUs in Option 1** except IR722 POI substation will have three breakers instead of four breakers.
2. Upgrade L-6511, 138 kV line, 36.5 km, between 50N-Trenton and 93N-Glendhu .
3. Upgrade L-6515, 138 kV line, 50.7 km, between 2C-Port Hastings, 100C-Cape Porcupine, and 4C-Lochaber Road.
4. Upgrade L-7004, 230 kV, 131 km, between 3C-Port Hastings and 91N-Dalhousie Mountain.
5. Upgrade L-7012, 230 kV, 40 km, between 3C-Port Hastings and Everwind Load POI.
6. Upgrade L-7024 (presently L-7003), 230 kV, 11.8 km, between 3C-Port Hastings and IR618+IR742 POI.
7. Upgrade L-7026 (presently L-7003), 230 kV, 50.2 km, between IR668 POI and IR618+IR742 POI.

Option 4 *additional* NUs (in addition to the installation of a RAS for L-8004b section, Option 4 will also require):

1. **All of additional NUs in Option 1** except the POI substation will have three breakers instead of four breakers.
2. Upgrade L-6515, 138 kV, 50.7 km, between 2C-Port Hastings, 100C-Cape Porcupine, and 4C-Lochaber Road.
3. Upgrade L-7012, 230 kV, 40 km, between 3C-Port Hastings and Everwind Load POI.
4. Upgrade L-7024 (presently L-7003), 230 kV, 11.8 km, between 3C-Port Hastings and IR618+IR742 POI.

The high level non-binding cost estimates for the Network Upgrades for the four options, in Canadian dollars in 2024, including 25% contingency but excluding 15% Harmonized Sale Tax (HST) are:

1. $ 419 million
2. $ 639 million
3. $ 635 million

4. $ 259 million

For each of the four options above, the following installations will be required at the Transmission Provider's Interconnection Facilities (TPIF):

- 45 meters of 345 kV transmission line from POI substation to IC substation.
- Protection & control relaying equipment on the 345 kV side.
- NSPI supplied Remote Terminal Unit.
- Tele-protection & SCADA communication to NSPI's Control Centre.

The high level non-binding cost estimates, in Canadian dollars in 2024, including 25% contingency and excluding 15% Harmonized Sale Tax (HST) for TPIF is $1.6 million.

The combined cost estimates for NUs plus TPIF for the four Options are shown below:

1. $ 421 million
2. $ 641 million
3. $ 637 million
4. $ 261 million

To study the viability of the RAS option (Option 4), NSPI would need detailed dynamic models for IR722 generating facility, BHL facility, Bear Head Btm generating facility, IR686 generating facility, Everwind load facility and Btm generating facility. System dynamic stability base cases will need to be built for PSSE dynamic simulations and transient stability base cases will need to be built for PSCAD transient simulations. The stability and transient analysis must meet all the requirements of the RAS as defined by NPCC (Northeast Power Coordinating Council) and NERC (North American Electric Reliability Corporation) and will be submitted, presented, and subjected to NPCC approval and the Maritime Area Reliability Coordinator for approval. The RAS study is outside the scope of this Feasibility Study.

Cost wise, Option 4 is the least cost but it requires NPCC approval and RC approval for the RAS . These approvals are not guaranteed. The IC may take into consideration how its 400 MW Btm generation will be connected to the power system as Option 4 does not include a second 345 kV line between IR722 POI and BHL POI.

This estimate is subject to changes to be determined in the SIS and Facility (FAC) studies. The cost of the Interconnection Customer's Interconnection Facilities (ICIF) is separate, is at the IC's own cost and is not included in this study. Its design must meet NSPI's Transmission System Interconnection Requirements (TSIR) and NERC's BES and NPCC's BPS requirements.

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

The IC will also obtain the ROW for the POI substation.

The estimated time to construct the NU and TPIF is four years after the receipt of funds. The time will be further determined by the FAC study.

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1.0 Introduction

This Feasibility Study report (FEAS) is for Interconnection Request #722 (referred to as IR722), a 500 MW generating facility at Blue Mountain/Websters Corner in Nova Scotia (NS).

The Feasibility Study Agreement shows the Interconnection Service will be NRIS/ERIS (Network Resources/Energy Resources), however, the Interconnection Request, Appendix 1 to GIP, has ERIS crossed out in red ink and NRIS is retained, hence this FEAS is based on NRIS.

The Point of Interconnection (POI) will be on L-8004, an existing 345 kV line between 79N-Hopewell substation and 101S-Woodbine substation, at about 24 km from 79N-Hopewell substation.

The Feasibility Study will be based on the generating facility having ninety seven wind turbines (Enercon E-160 EP5 v.E3) generators, each rated 5.56 MW as per Feasibility Agreement.

The proposed Commercial Operation Date for IR722 is September 1, 2028.

There are a total of 22 transmission and distribution projects across NS identified in the Combined T/D Advanced Stage Interconnection Request Queue with higher queue positions than IR722.

The power system base cases for the feasibility study include all transmission connected IRs in the GIP queue up to and including IR742.

Since the SIS for IR686 was not completed at the time of this study was initiated and its connection is not yet finalized, this Feasibility Study assumes that IR686 will be connected radially to 67N-Onslow 345 kV substation. This assumption is based on the LIS for Bear Head hydrogen plant load.

Figure 1 shows the approximate physical locations for IR722 POI and for Bear Head hydrogen plant POI, both to be connected to L-8004.

Figure 2 shows the approximate electrical locations for both POIs on NSPI's electrical transmission one-lines.

Figure 1: IR722 POI on L-8004 (Approximate Physical Location).

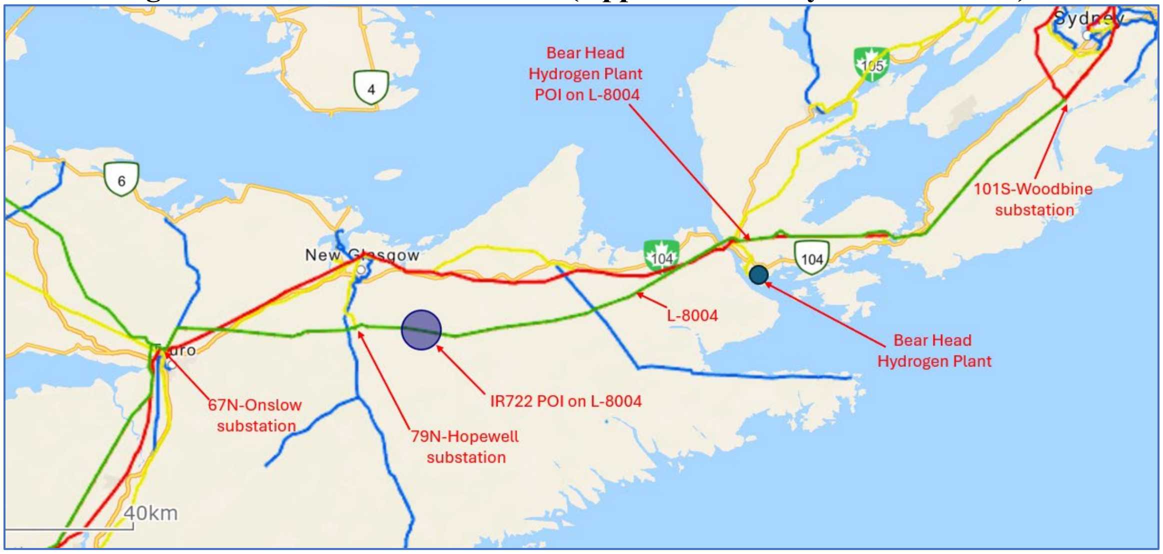
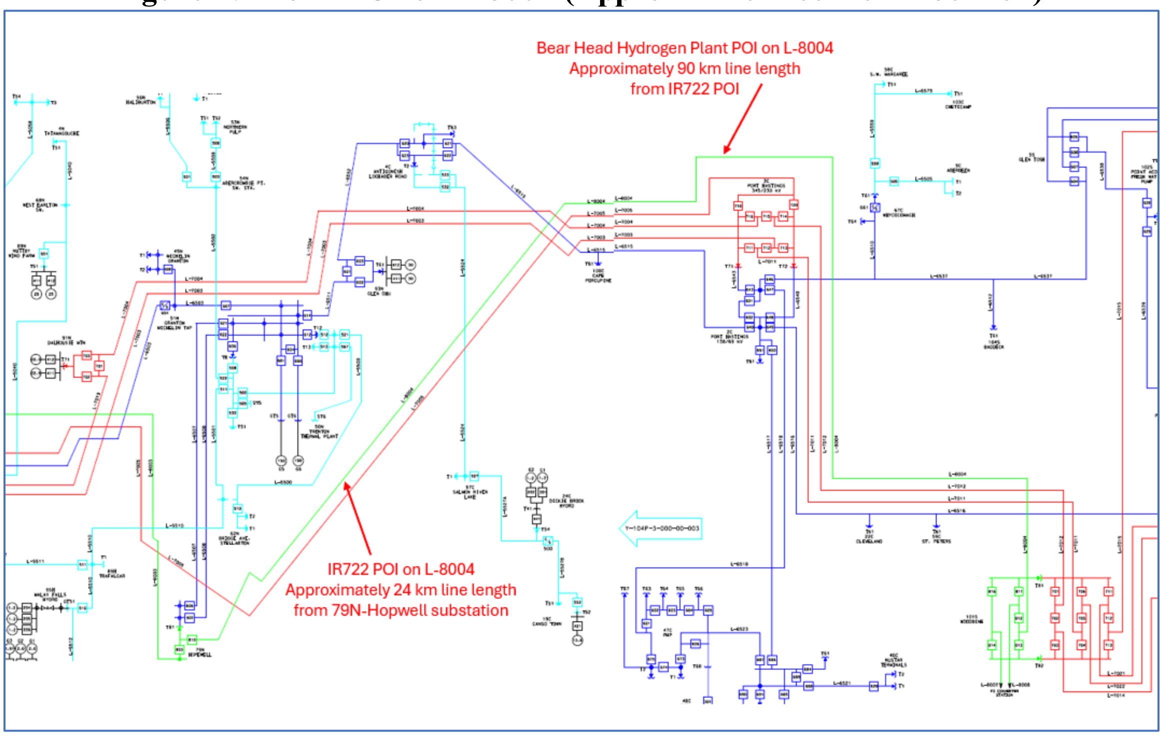


Figure 2: IR722 POI on L-8004 (Approximate Electrical Location)



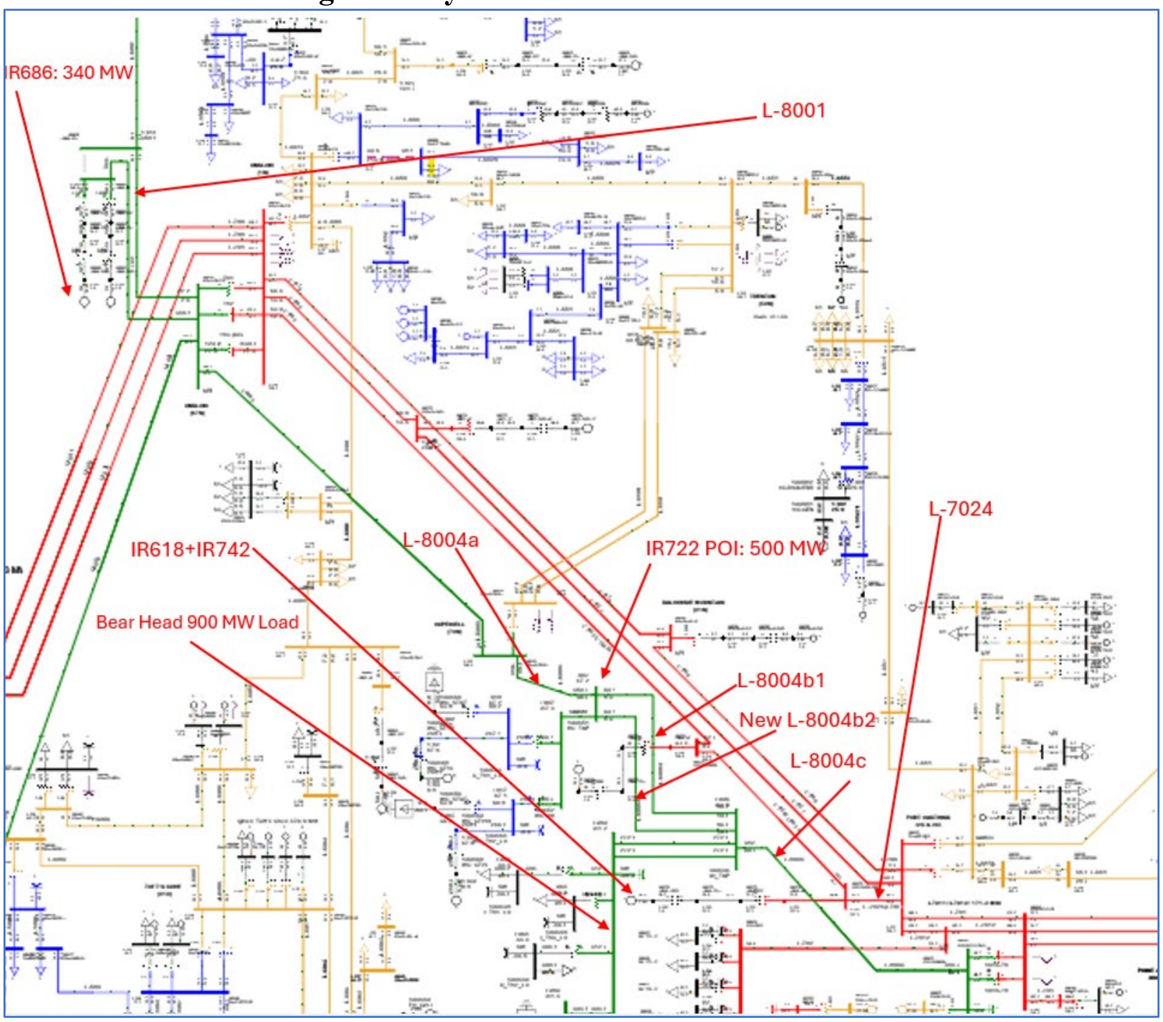
The power system model developed for this FEAS is shown in Figure 3. It shows IR722 POI and BHL POI on L-8004 which divides L-8004 into 4 sections L-8004a, L-8004b1, and L-8004c. New section L-8004b2 is added as the result of the load flow analysis.

Even though the SISs for IR686 (340 MW) and IR742 (35 MW) have not been completed, they are in higher queued positions than IR722 and they are included in the system model for IR722 FEAS. IR686 POI was to connect to L-8001 but a previous study (LIS for Bear Head hydrogen plant) identified an issue of the cases not solving for loss of

L-8001 and IR686. The assumption has been made to connect it radially from 67N-Onslow substation with its own node on a new rung for the purpose of including it in this study.

The model for system base cases also includes 900 MW Bear Head hydrogen plant load, 400 MW Bear Head Btm generation, 325 MW Everwind plant load and 207 MW Everwind Btm generation as per the LIS for Bear Head hydrogen plant. IR742 (35 MW) generation and IR618 (130 MW) generation for a total of 165 MW share a common POI and model as one generating facility (label as IR618+IR742).

Figure 3: System Model for IR722 FEAS.



2.0 Scope

The scope of this FEAS is as defined in the Feasibility Agreement:

- Preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the interconnection.
- Preliminary identification of any thermal overload or voltage limit violations resulting from the interconnection.
- Preliminary description and non-bonding estimated cost of facilities required to interconnect the Generating Facility to the Transmission System and to address the identified short circuit and power flow issues.

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.

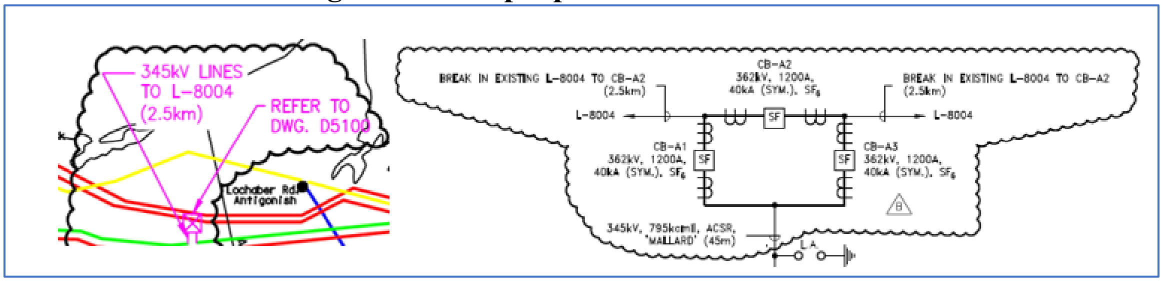
Separate Load Impact Studies (LISs) will be carried out for Bear Head hydrogen plant load and for Everwind Fuels plant load, as well, a separate SIS will be carried out for IR686 wind power generation. The preliminary models for these projects are included in the base cases, but the studies for them are not in the scope of this FEAS.

3.0 Assumptions

This FEAS is based on the following information:

1. As per the Feasibility Study Agreement, signed by IC on October 4, 2023 and by NSPI on November 27, 2023:
    1.1. Network and Energy Resource Interconnection Service (NRIS/ERIS). However, the Interconnection Request, Appendix 1 to GIP, has ERIS crossed out in red ink and NRIS is retained, hence this FEAS is based on NRIS.
    1.2. POI on L-8004.
    1.3. The maximum facility output is 500 MW, comprising of 97 wind turbines with each wind turbine (Enercon E-160 EP5 v.E3) having a rating of 5.56 MW.
2. The IC provided an electrical one-line that shows:
    2.1. Three breaker rings bus at POI on L-8004 with a line extension of 2.5 km on either side of L-8004, plus a spur line of 45m from the POI to the IC 345 kV substation as shown in Figure 4:

Figure 4: IC's proposed POI connection



2.2. The 345 kV voltage is stepped down to 66 kV, collector voltage, via two transformers. Each transformer is rated 150/200/250 MVA, grounded wye HV, grounded wye LV, and a buried tertiary. The positive sequence impedance is 14.5% on ONAN rating.

3. The transmission line ratings, which are already in the power system cases, are based on NSPI's "Transmission Line Ratings Summary", dated December 29, 2023, with exception of L-7003 from 67N-Onslow substation to 3C-Port Hastings substation. This line was upgraded from 60 degree C conductor operating temperature to 70 degree C, except for a very small potion that NSPI is making arrangement to complete it. For this reason, even though the "Transmission Line Ratings Summary" shows L-7003 rating at 60 degree C, the study system base cases use 70 degree C rating. The ratings of the transmission lines that are relevant to IR722 Feasibility Study are included in Appendix 1 as a pdf attachment to this report. The appendix shows the line ratings modeled in the base cases versus the line ratings in the "Transmission Line Ratings Summary".

4. IR722 will supply power to BHL of 900 MW which includes 400 MW Btm generation for a net load of 500 MW. System losses associated with IR722 and BHL will be discussed and resolved by the IC and NSPI, and it is outside the scope of this FEAS.

5. Bear Head Load (BHL) POI on L-8004 and its load facility will be designed and installed such that no single contingency (single event as defined in Table 1 of NPCC Directory #1) can cause a loss of load more than 325 MW, which is the load loss limit in NS for planning purposes. NPCC stands for Northeast Power Coordinating Council, of which NSPI is a member.

6. Three thermal units on-line to provide short circuit level for NSPI's present system operation and system stability: Trenton 6, Tufts Cove 3, and Point Tupper 2.

4.0 Project with Higher Queue Position

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

As of 2024/02/15, the following projects are higher queued in the Advanced Stage Interconnection Request Queue and are committed to the study base cases:

- IR426: GIA Executed
- IR516: GIA Executed
- IR540: GIA Executed

- IR542: GIA Executed
- IR517: GIA in Progress
- IR574: GIA Executed
- IR598: GIA Executed
- IR597: GIA Executed
- IR647: GIA in Progress
- IR664: FAC Complete
- IR662: FAC Complete
- IR670: FAC Complete
- IR671: FAC in Progress
- IR669: FAC Complete
- IR668: FAC Complete
- IR618: FAC Complete
- IR673: FAC Complete
- IR675: FAC Complete
- IR677: SIS in Progress
- IR697: SIS in Progress
- IR686: SIS in Progress
- IR739: SIS in Progress
- IR742: SIS in Progress

The power system base cases for the feasibility study includes all transmission connected IRs in the GIP queue up to and including IR742.

In addition, TSR-411 is included in the queue, which reflects the study of long-term firm Transmission Service Reservation (TSR) from New Brunswick to Nova Scotia. If approved by the NSUARB, the TSR is expected to be in service in 2028 and a system study is currently underway to determine the required updates to the Nova Scotia transmission system. This has not been included in the feasibility study and the following notice is posted to the OASIS site (at https://www.nspower.ca/oasis/generation-interconnection-procedures):

> *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 to 35. GIP Study Group #32 to #35 analysis will be limited to the 2024 Transmission System configuration plus any material Network Upgrades identified in higher queued projects.*

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

Table 1: TSR queue

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

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

* Indicates project as being located near provincial border.

5.0 Short Circuit Assessment

The short circuit analysis was performed using PSS/e 34.8.2 with classical fault option, flat voltage profile at 1.0 per unit voltage, and three phase to ground faults.

IR722 short circuit model was incorporated into NSPI short circuit system case and was simulated with IR722 off-line and with IR722 on-line and the results for relevant buses are shown in Table 2. Please note that this analysis is for NSPI to determine the impact of IR722 on NSPI's existing breaker fault interrupting ratings and not for IR722 generating facility design or operation. IR722 is required to do its own detailed design to ensure its operational viability.

Table 2: Short-Circuit Levels, Three-phase MVA		
Location	**IR722 Off**	**IR722 On**
Maximum Generation System Normal (Magnitude in MVA / Angle in Degree)		
79N-Hopewell 345 kV	3914 / -84.16	4294 / -84.54
101S-Woodbine 345 KV	4105 / -86.35	4221 / -86.45
IR722 POI 345 kV	3580 / -84.46	4063 / -84.98
IR722 GT1HV 66kV (48 WECS)	663 / -84.88	1001 / -86.50
IR722 GT2HV 66kV (49 WECS)	645 / -84.69	990 / -86.42
Minimum Generation (Just TC3,TR6,PT2 on) System Normal		
79N-Hopewell 345 kV	1717 / -87.23	2222 / -87.52
101S-Woodbine 345 KV	1353 / -86.49	1567 / -86.55
IR722 POI 345 kV	1639 / -87.10	2124 / -87.49
IR722 GT1HV 66kV (48 WECS)	619 / -87.21	973 / -88.02
IR722 GT2HV 66kV (49 WECS)	605 / -87.07	966 / -87.94
Minimum Generation + L-8004a (IR722 - 79N) Out		

Table 2: Short-Circuit Levels, Three-phase MVA		
Location	**IR722 Off**	**IR722 On**
79N-Hopewell 345 kV	1678 / -87.13	1792 / -86.93
101S-Woodbine 345 KV	891 / -84.97	1292 / -85.99
IR722 POI 345 kV	651 / -85.21	1135 / -86.74
IR722 GT1HV 66kV (48 WECS)	395 / -86.04	794 / -87.83
IR722 GT2HV 66kV (49 WECS)	389 / -85.96	793 / -87.80
Minimum Generation + L-8004c (101SWoodbine - BH Load POI) Out		
79N-Hopewell 345 kV	1674 / -87.12	2142 / -87.47
101S-Woodbine 345 KV	895 / -84.98	933 / -84.77
IR722 POI 345 kV	1499 / -86.99	1984 / -87.43
IR722 GT1HV 66kV (48 WECS)	598 / -87.17	956 / -88.01
IR722 GT2HV 66kV (49 WECS)	586 / -87.03	950 / -87.94

All the 345 kV breakers in the vicinity of IR722 exceed the design short circuit interrupting capability of 15, 000 MVA and the three phase short circuit levels shown in Table 2 are well below 15, 000 MVA, hence IR722 does not incur any replacement of 345 kV breakers in NS.

The lowest short circuit level in Table 2 at the collector circuit level is 389 MVA for 49 wind turbines with each wind turbine rated at 5.56 MW. This equates to a Short Circuit Ratio (SCR) of 1.43 which is much less than the required value of 3 as per the technical bulletin for IR722 wind turbines. Given this, the IC will need to work with Enercon to ensure that IR722 generating facility will be able to operate at low SCR. In addition, near by wind farm or wind turbines as in this case can lower the SCR significantly.

Please note that section 7.4.15 of the TSIR states “Any Generating Facility which requires a minimum Short Circuit Ratio (SCR) for unrestricted operation must provide this information for the System Impact Study. 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 TSIR’s section 7.6.7 titled “Inertia Response-WECS” as posted on June 24, 2024 on NSPI’s OASIS site would requires an installation of 240 MVA synchronous condenser. The location and details will be identified by the SIS, outside of the scope of the feasibility study.

6.0 Thermal and Voltage Limit Assessment

For the steady state thermal and voltage assessment, a total of 36 power flow cases and 483 transmission contingencies were simulated for each case. The cases and contingencies were run in 40 trials to determine the system upgrades pre-IR722 and post-IR722.

Cases with suffix "a" have IR722 off-line (pre-IR722).

Cases with suffix "b" have IR722 on-line (post-IR722).

Cases with suffix "c" are "b" cases plus a new 345 kV line (L-8004b2) between IR722 POI and Bear Head hydrogen plant POI.

Cases with suffix "d" are "c" cases plus a new 345 kV to 230 kV transformer (67N-T83) and other system upgrades identified for IR722.

Cases with suffix "e" are "d" cases, but without L-8004b2 and instead, a new STATCOM at 101S-Woodbine plus other system upgrades for evaluation of an alternative to installing the new L-8004b2.

The cases reflect a number of system dispatches:

- Maritime Link HVDC at maximum and minimum.
- NS wind tested at capacity value of 17% and 100%.
- NB delivers 10 minute operating reserve to NS for loss of 1 pole of Maritime Link HVDC.
- NS delivers 10 minute operating reserve to NB for loss of Point Lepreau nuclear power plant.
- Seasons: winter peak (WIN), summer peak (SUM), summer minimum load (SML).

The contingencies in NS and some in NB include:

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

The criteria for assessment are as follows:

- Under system normal, all elements in service, system voltages are no less than 0.95 per unit and element loading must be within nominal rating (Rate A).

- Post contingency steady state, system voltages are no less than 0.9 per unit and element loading is within short time rating (Rate B). For NS, the element loading must also be within Rate D (short time rating for the element auxiliary equipment).

There are some existing system conditions observed in the power system cases used in this feasibility study that are not attributed to IR722:

- VJ gas turbines are on-line in winter peak to avoid local overload (NSPI Operations to operate VJ gas turbine as needed)
- 22W remote 69 kV bus slightly below 0.95 per unit in system normal (NSPI to mitigate).
- Transformers at 58H, 137H, 75W have loading above rating in system normal (NSPI to mitigate).

The system dispatch of the power flow cases and the list of power flow system contingencies in NS and NB that were simulated are shown in Appendix 2 and 3 respectively as two pdf attachments to this report.

The contingencies studied are based on the tentative layout of breakers for IR722, BHL, Everwind Load, and connection of IR686 at Onslow substation. The layouts are shown in Appendix 14 and 15 as two pdf attachments to this report. Appendix 14 is for Option 1 and Appendix 15 is for Option 2, 3, and 4.

As discussed, since the SISs for IR686 and IR742 are not completed, analysis was done to estimate the Network Upgrade pre-IR722. The load flow analysis shows that L-7024 between IR618+IR742 POI and 3C-Port Hastings to be upgraded from 70 deg C conductor operating temperature to 85 deg C. This is preliminary and it will be up to IR742 SIS to determine.

The “a” cases (pre-IR722) were simulated and adjusted to achieve outcomes that are sufficiently free of thermal overload or voltage violations under contingencies prior to turning on IR722 at 500 MW generation.

In the “b” cases, IR722 was turned on at full 500 MW generation as per NRIS. The preliminary load flow results show many system issues: load flow solution halts due to sudden extreme divergence (an indication of system collapse or system instability), large numbers of voltage violations, and thermal overloads.

The load flow solution shows system voltage collapse for three contingencies that involve loss of the 345 kV line section between IR722 POI and BHL POI: loss of L-8004b or breaker failure at IR722 POI or at BHL POI for cases C42_SLL, C41b_SLL, C23b_SUM, C22b_SUM, high wind cases.

To resolve the issue associated, the load flow analysis identified four options:

Option 1: Installation of a new 345 kV transmission line, approximately 90 km, between IR722 POI and BHL POI.

Option 2: Installation of a new 200 MVAR STATCOM at Woodbine substation.

Option 3: Installation of a new 170 MVAR STATCOM at BHL POI substation (in addition to reactive power devices already included in the study base cases).

Option 4: Installation of a Remedial Action Scheme (RAS) for L-8004b section.

Option 2 and 3 will be subject to BHL LIS currently in progress.

To resolve the voltage violations and thermal overloads (shown in Appendix 4 to 13 as pdf attachments in this report), additional NUs are required for each option.

Option 1 *additional* NUs:

1. Install a four breaker ring bus at IR722 POI substation. The design will be such that both L-8004b1 and L-8004b2 cannot be lost for any breaker failure contingency.
2. Install a 345 kV to 230 kV transformer (67N-T83) matching to the existing two transformers (T81 and T82) at 67N-Onslow substation.
3. Install two 345 kV breakers on a new rung for the connection of 67N-T83 transformer at 67N-Onslow substation. (if IR686 ends up connecting to 67N-Onslow ahead of IR722, then IR722 can be connected with one breaker instead of two).
4. Upgrade L-6552, approximately 20 km, between 4C-Lochaber Road substation and 93N-Glen Dhu substation.
5. Upgrade L-8001 metering at 67N-Onslow substation.
6. Upgrade L-8004a metering at 79N-Hopewell substation.
7. Install 2.5km of 345 kV line extension from each side of L-8004 to IR722 POI substation.
8. Install two 50 MVAR capacitor banks (with each bank having 2 stages of 25 MVAR each stage) and two 50 MVAR STATCOMs at IR722 IC substation for power factor correction and voltage support.

Option 2 *additional* NUs:

1. All of additional NUs in Option 1 except IR722 POI substation will have three breakers instead of four breakers.
2. Upgrade L-6511, 138 kV line, 36.5 km, between 50N-Trenton and 93N-Glendhu .
3. Upgrade L-6515, 138 kV line, 50.7 km, between 2C-Port Hastings, 100C-Cape Porcupine, and 4C-Lochaber Road.
4. Upgrade L-7004, 230 kV, 131 km, between 3C-Port Hastings and 91N-Dalhousie Mountain.
5. Upgrade L-7012, 230 kV, 40 km, between 3C-Port Hastings and Everwind Load POI.

6. Upgrade L-7024 (presently L-7003), 230 kV, 11.8 km, between 3C-Port Hastings and IR618+IR742 POI.
7. Upgrade L-7026 (presently L-7003), 230 kV, 50.2 km, between IR668 POI and IR618+IR742 POI.
8. Upgrade Canso Strait Water Crossing of L-8004 at no cost to IC as NSPI is working with Transport Canada to obtain the approval for higher conductor ratings.

Option 3 *additional* NUs:

1. All of additional NUs in Option 1 except IR722 POI substation will have three breakers instead of four breakers.
2. Upgrade L-6511, 138 kV line, 36.5 km, between 50N-Trenton and 93N-Glendhu .
3. Upgrade L-6515, 138 kV line, 50.7 km, between 2C-Port Hastings, 100C-Cape Porcupine, and 4C-Lochaber Road.
4. Upgrade L-7004, 230 kV, 131 km, between 3C-Port Hastings and 91N-Dalhousie Mountain.
5. Upgrade L-7012, 230 kV, 40 km, between 3C-Port Hastings and Everwind Load POI.
6. Upgrade L-7024 (presently L-7003), 230 kV, 11.8 km, between 3C-Port Hastings and IR618+IR742 POI.
7. Upgrade L-7026 (presently L-7003), 230 kV, 50.2 km, between IR668 POI and IR618+IR742 POI.
8. Upgrade Canso Strait Water Crossing of L-8004 at no cost to IC as NSPI is working with Transport Canada to obtain the approval for higher conductor ratings.

Option 4 *additional* NUs:

1. All of additional NUs in Option 1 except the POI substation will have three breakers instead of four breakers.
2. Upgrade L-6515, 138 kV, 50.7 km, between 2C-Port Hastings, 100C-Cape Porcupine, and 4C-Lochaber Road.
3. Upgrade L-7012, 230 kV, 40 km, between 3C-Port Hastings and Everwind Load POI.
4. Upgrade L-7024 (presently L-7003), 230 kV, 11.8 km, between 3C-Port Hastings and IR618+IR742 POI.
5. Install 37 MVAR capacitor bank at Memramcook 138 kV substation in NB to avoid voltage violations under contingencies.
6. Upgrade Canso Strait Water Crossing of L-8004 at no cost to IC as NSPI is working with Transport Canada to obtain the approval for higher conductor ratings.

The high level non-binding cost estimates for the Network Upgrades for the four options, in Canadian dollars in 2024, including 25% contingency but excluding 15% Harmonized Sale Tax (HST) are:

1. $ 414 million

2. $ 634 million
3. $ 630 million
4. $ 254 million

For each of the four options above, the following installations will be required at the Transmission Provider's Interconnection Facilities (TPIF):

- 45 meters of 345 kV transmission line from POI substation to IC substation.
- Protection & control relaying equipment on the 345 kV side.
- NSPI supplied Remote Terminal Unit.
- Tele-protection & SCADA communication to NSPI's Control Centre.

The high level non-binding cost estimates, in Canadian dollars in 2024, including 25% contingency and excluding 15% Harmonized Sale Tax (HST) for TPIF is $1.6 million.

The combined cost estimates for NUs plus TPIF for the four Options are shown below:

1. $ 416 million
2. $ 636 million
3. $ 632 million
4. $ 256 million

To study the viability of the RAS option (Option 4), NSPI would need detailed dynamic models for IR722 generating facility, BHL facility, Bear Head Btm generating facility, IR686 generating facility, Everwind load facility and Btm generating facility. System dynamic stability base cases will need to be built for PSSE dynamic simulations and transient stability base cases will need to be built for PSCAD transient simulations. The stability and transient analysis must meet all the requirements of the RAS as defined by NPCC (Northeast Power Coordinating Council) and NERC (North American Electric Reliability Corporation) and will be submitted, presented, and subjected to NPCC approval and the Maritime Area Reliability Coordinator for approval. The RAS study is outside the scope of this Feasibility Study.

Cost wise, Option 4 is the least cost but it requires NPCC approval and RC approval for the RAS. These approvals are not guaranteed.

7.0 Reactive Power & Voltage Control

It is estimated that for IR722 to meet the power factor requirements of +/- 0.95 at the high voltage side of the interconnection transformers and through the full range of real power output from zero to full power, two STATCOMs and two capacitor banks will be required. Each unit will be rated 50 MVAR and will be on the low voltage side of the interconnection transformers. This is in addition to IR722 using FTQS Enercon E-160 EP5 E3 R1wind turbines.

A centralized controller will be required, which continuously adjusts the individual generator reactive power output within the plant capability limits. Voltage regulation and transformer tap changer option will be determined by the SIS. The voltage controls must be responsive to voltage deviations, be equipped with a voltage setpoint control, and have facilities that will slowly adjust the setpoint over several (5-10) minutes to maintain reactive power within the generator's capabilities. Details of the specific control features, control strategy, and settings will be reviewed and addressed in the SIS.

The NSPI System Operator must have manual and remote control of the voltage setpoint and the reactive setpoint of this facility to coordinate reactive power dispatch requirements. This facility must have voltage ride-through capability as detailed in the NS Power Transmission System Interconnection Requirements (TSIR)[1]. The SIS will examine the plant capabilities and controls in detail to specify options, controls, and additional facilities that are required to achieve low voltage ride through.

8.0 Operating Reserve

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

IR722 generation will be greater than NSPI's present (or planned) largest generator (Point Aconi 168 MW net) in NS and that will have a major impact on the operating reserve requirement (synchronous, 10-minute, and 30-minute) for NSPI. IR722 will need to discuss with NSPI for the options to address the operating reserve prior to the SIS stage. The IC may opt to design IR722 POI and its facility to meet the operating reserve requirements by keeping the single largest generation contingency below 150 MW as Point Aconi will be retired and the planned largest unit will be 150 MW net.

9.0 NPCC and NERC Requirements

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

Since IR722 POI will be on the 345 kV line (L-8004) which is classified as both NPCC BPS and NERC BES, therefore the 345 kV POI substation, the 345 kV line extension to the IC substation will be BPS. As IR722 generation will be higher than 75 MVA, IR722 generating facilities will be BES.

The SIS will determine the correct classification of the IC substation, the collector circuits, and the IC generating facility with regard to them being BPS or not.

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

10.0 Expected Facilities Required for Interconnection

The following facilities are required to interconnect IR722 to the NSPI system via the POI on L-8004 as NRIS:

1) Network Upgrades (NU):

This Feasibility Study identified four Options for the IC to select:

Option 1:

1. Install a new 345 kV transmission line (L-8004b2), approximately 90 km, between IR722 POI and BHL POI.
2. Install IR722 POI substation connecting to L-8004a (between IR722 and 67N-Onslow substation), L-8004b1 (existing between IR722 and BHL POI), L-8004b2 (new line between IR722 and BHL POI), and a new 345 kV spur line from IR722 POI to the IC 345 kV substation. The design will be such that both L-8004b1 and L-8004b2 cannot be lost for breaker failure contingencies.
3. Install a 345 kV to 230 kV transformer (67N-T83) at 67N-Onslow substation. This includes installation of breakers on the 345 kV bus as well as on 230 kV bus and swap L-7018 with the new 230 kV node to avoid a breaker failure to take out T81 and T83.
4. Upgrade L-6552, approximately 20 km, between 4C-Lochaber Road substation and 93N-Glen Dhu substation.
5. Upgrade L-8001 metering at 67N-Onslow substation.
6. Upgrade L-8004a metering at 79N-Hopewell substation.
7. Install 2.5km of 345 kV line extension from each side of L-8004 to IR722 POI substation.
8. Install two 50 MVAR capacitor banks with each bank having 2 stages of 25 MVAR each stage and two 50 MVAR STATCOMs at IR722 IC substation for power factor correction and voltage support.

Option 2:

1. Install a new 200 MVAR STATCOM at Woodbine 345 kV substation.
2. Install a three breaker ring bus at IR722 POI.
3. Install a 345 kV to 230 kV transformer (67N-T83) at 67N-Onslow substation. This includes installation of breakers on the 345 kV bus as well as on 230 kV bus and swap L-7018 with the new 230 kV node to avoid a breaker failure to take out T81 and T83.
4. Upgrade L-6552, approximately 20 km, between 4C-Lochaber Road substation and 93N-Glen Dhu substation.
5. Upgrade L-8001 metering at 67N-Onslow substation.

6. Upgrade L-8004a metering at 79N-Hopewell substation.
7. Install 2.5km of 345 kV line extension from each side of L-8004 to IR722 POI substation.
8. Install two 50 MVAR capacitor banks with each bank having 2 stages of 25 MVAR each stage and two 50 MVAR STATCOMs at IR722 IC substation for power factor correction and voltage support.
9. Upgrade L-6511, 138 kV line, 36.5 km, between 50N-Trenton and 93N-Glendhu.
10. Upgrade L-6515, 138 kV line, 50.7 km, between 2C-Port Hastings, 100C-Cape Porcupine, and 4C-Lochaber Road.
11. Upgrade L-7004, 230 kV, 131 km, between 3C-Port Hastings and 91N-Dalhousie Mountain.
12. Upgrade L-7012, 230 kV, 40 km, between 3C-Port Hastings and Everwind Load POI.
13. Upgrade L-7024 (presently L-7003), 230 kV, 11.8 km, between 3C-Port Hastings and IR618+IR742 POI.
14. Upgrade L-7026 (presently L-7003), 230 kV, 50.2 km, between IR668 POI and IR618+IR742 POI.
15. Upgrade Canso Strait Water Crossing of L-8004 at no cost to IC as NSPI is working with Transport Canada to obtain the approval for higher conductor ratings at NSPI's cost.

Option 3:

1. Install a new 170 MVAR STATCOM at BHL 345 kV substation.
2. Install a three breaker ring bus at IR722 POI.
3. Install a 345 kV to 230 kV transformer (67N-T83) at 67N-Onslow substation. This includes installation of breakers on the 345 kV bus as well as on 230 kV bus and swap L-7018 with the new 230 kV node to avoid a breaker failure to take out T81 and T83.
4. Upgrade L-6552, approximately 20 km, between 4C-Lochaber Road substation and 93N-Glen Dhu substation.
5. Upgrade L-8001 metering at 67N-Onslow substation.
6. Upgrade L-8004a metering at 79N-Hopewell substation.
7. Install 2.5km of 345 kV line extension from each side of L-8004 to IR722 POI substation.
8. Install two 50 MVAR capacitor banks with each bank having 2 stages of 25 MVAR each stage and two 50 MVAR STATCOMs at IR722 IC substation for power factor correction and voltage support.
9. Upgrade L-6511, 138 kV line, 36.5 km, between 50N-Trenton and 93N-Glendhu.
10. Upgrade L-6515, 138 kV line, 50.7 km, between 2C-Port Hastings, 100C-Cape Porcupine, and 4C-Lochaber Road.
11. Upgrade L-7004, 230 kV, 131 km, between 3C-Port Hastings and 91N-Dalhousie Mountain.
12. Upgrade L-7012, 230 kV, 40 km, between 3C-Port Hastings and Everwind Load POI.

13. Upgrade L-7024 (presently L-7003), 230 kV, 11.8 km, between 3C-Port Hastings and IR618+IR742 POI.
14. Upgrade L-7026 (presently L-7003), 230 kV, 50.2 km, between IR668 POI and IR618+IR742 POI.
15. Upgrade Canso Strait Water Crossing of L-8004 at no cost to IC as NSPI is working with Transport Canada to obtain the approval for higher conductor ratings.

Option 4:

1. Install of a Remedial Action Scheme (RAS) for L-8004b section.
2. Install of three breaker ring bus at IR722 POI.
3. Install a 345 kV to 230 kV transformer (67N-T83) at 67N-Onslow substation. This includes installation of breakers on the 345 kV bus as well as on 230 kV bus and swap L-7018 with the new 230 kV node to avoid a breaker failure to take out T81 and T83.
4. Upgrade L-6552, approximately 20 km, between 4C-Lochaber Road substation and 93N-Glen Dhu substation.
5. Upgrade L-8001 metering at 67N-Onslow substation.
6. Upgrade L-8004a metering at 79N-Hopewell substation.
7. Install 2.5km of 345 kV line extension from each side of L-8004 to IR722 POI substation.
8. Install two 50 MVAR capacitor banks with each bank having 2 stages of 25 MVAR each stage and two 50 MVAR STATCOMs at IR722 IC substation for power factor correction and voltage support.
9. Upgrade L-6515, 138 kV, 50.7 km, between 2C-Port Hastings, 100C-Cape Porcupine, and 4C-Lochaber Road.
10. Upgrade L-7012, 230 kV, 40 km, between 3C-Port Hastings and Everwind Load POI.
11. Upgrade L-7024 (presently L-7003), 230 kV, 11.8 km, between 3C-Port Hastings and IR618+IR742 POI.
12. Install 37 MVAR capacitor bank at Memramcook 138 kV substation in NB to avoid voltage violations under contingencies.
13. Upgrade Canso Strait Water Crossing of L-8004 at no cost to IC as NSPI is working with Transport Canada to obtain the approval for higher conductor ratings.

2) Transmission Provider's Interconnection Facilities (TPIF):

1. Extension of 45 meters of 345 kV line from IR722 POI to IR722 substation.
2. Protection and control for relaying equipment.
3. NSPI supplied Remote Terminal Unit (RTU).
4. Tele-protection and SCADA communications.

3) Interconnection Customer's Interconnection Facilities (ICIF):

a) Facilities to provide ±0.95 power factor when delivering rated output (500 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.

b) 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.

c) 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.

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

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

f) Meet all the requirements detailed in the NS Power Transmission System Interconnection Requirements (TSIR)[4]. Among them is voltage ride-through capability per section 7.4.1 and frequency ride-through per section 7.4.2.

g) Regarding TSIR's section 7.6.7 titled "Inertia Response-WECS", please refer to the notice posted on June 24, 2024 on NSPI's OASIS site. A copy of the notice is shown below:

> *Notice Date: June 24, 2024*
>
> 7.6.7. Inertia Response - WECS
>
> WECS Generating Facilities shall provide inertia response equivalent to a *Synchronous Generator* with a synchronous condenser, with rated MVA as a percentage of the rated MW of the associated WECS. The scaling factor is dependent on POI voltage. Support can be from a device other than a synchronous condenser if equivalent SCMVA support can be demonstrated.

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

Facilities adjacent to existing IBR facilities that do not have additional inertia support or in extremely weak areas of the grid may require greater inertial support and/or have turbines with a very low SCR requirement for ride through. The SIS will determine the total inertial response required to meet performance requirements.

WECS turbines shall support over frequency deviations with a power boost (virtual inertia response) for at least 10 seconds and, where headroom exists, shall offer over-frequency and under-frequency control with a deadband of +/- 0.2 Hz and a droop characteristic of 4%.

The following table is in effect starting from SIS Round 27:

Inertia Response - WECS Scaling factor	
POI voltage	SIR scaling factor
69 kV	0.60
138 kV	0.60
230 kV	0.52
345 kV	0.48

Example: 100MW WECS with 138kV POI will require, at a minimum, a synchronous condenser with an MVA rating of at least 60 MVA

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) Ambient temperature for outdoor equipment shall be -35deg C to +40deg C and for indoor equipment shall be -5deg C to +40 deg C.

NS Power notes that NERC standard PRC-029-1 is currently in development. As proposed, this standard will impose performance requirements for voltage and frequency ride through behaviour on inverter-based generating resources. It is anticipated that this standard will be applicable to the project currently under study. The Interconnection Customer is advised to consider the requirements of PRC-029-1 in their project design to ensure that their project can conform to these requirements. Conformance will be validated at the System Impact Study stage.

11.0 NU and TPIF Cost Estimates

The high level, non-binding, cost estimate, excluding HST, for IR722's NRIS for the four options are shown in Tables 3 to 6.

Table 3: Cost Estimate For Option 1

Item	Network Upgrades (NU)	Estimate ($M CAN)
1	Install a 345 kV transmission, ~ 90 km, between IR722 POI and BHL POI, wood pole with OHGW and ROW	201.00
2	Install four breaker ring bus at POI substation complete with P&C and connection. This substation must be designed to meet NPCC's BPS requirements and NERC's BES requirements. This cost estimate includes P&C modifications at remote line terminals.	16.50
3	Install a 345 kV to 230 kV transformer (T83) at 67N-Onslow matching existing 67N-T81 or T82	6.50
4	Install two 345 kV breakers on a new rung at 67N-Onslow for the new T83. (if IR686 connects to 67N-Onslow first to a new rung, then IR722 can connect via just one breaker)	7.00
5	Install a new breaker 67N-720 at 67N-Onslow 230 kV substation for 67N-T83 node	3.00
6	Swap L-7018 node with 67N-T83 node to avoid loss of T83 and T81 for 67N-720 breaker failure	1.00
7	Upgrade conductor rating of L-6552, 138 kV, 19.3 km, 4C-Lochaber Rd to 93N-Glen Dhu, from Dove 50 deg C 110 MVA summer to 56 deg 130 MVA summer	7.82
8	Upgrade L-8001 full scale meter rating at 67N-Onslow substation (assume CT ratio change)	0.01
9	Upgrade L-8004a full scale meter rating at 79N-Hopewell substation (assume CT ratio change)	0.01
10	Install 2.5 km 345 kV line extension on each side of L-8004 for IR722 POI	10.00
11	Install two 50 MVAR capacitor banks (2 stages with 25 MVAR each stage) at IR722	22.00
12	Install two 50 MVAR STATCOMs at IR722	60.00
	Contingency (25%)	83.71
	Network Upgrade Sub-total	418.55

Item	Transmission Provider's Interconnection Facilities (TPIF)	Estimate ($M CAN)
1	Extension of 45 meters of 345 kV line from IR722 POI to IR722 substation	0.09
2	P&C relaying equipment	0.30
3	NSPI supplied RTU	0.10
4	Tele-protection and SCADA communications	0.75
	Contingency (25%)	0.31
	TPIF Upgrade Sub-total	1.55
	Total Network Upgrades and TPIF, excluding HST	**420.10**

Table 4: Cost Estimate for Option 2

Item	Network Upgrades (NU)	Estimate ($M CAN)
1	Install 200 MVAR STATCOM at 101S-Woodbine 345 kV substation	120.00
2	Install a three breaker ring bus at POI substation complete with P&C and connection to L-8004. This substation must be designed to meet NPCC's BPS requirements and NERC's BES requirements. This cost estimate includes P&C modifications at the line remote terminals	13.00
3	Install a 345 kV to 230 kV transformer (T83) at 67N-Onslow matching existing 67N-T81 or T82	6.50
4	Install two 345 kV breakers on a new rung at 67N-Onslow for the new T83. (if IR686 connects to 67N-Onslow first to a new rung, then IR722 can connect via just one breaker)	7.00
5	Install a new breaker 67N-720 at 67N-Onslow 230 kV substation for 67N-T83 node	3.00
6	Swap L-7018 node with 67N-T83 node to avoid loss of T83 and T81 for 67N-720 breaker failure	1.00
7	Upgrade conductor rating of L-6552, 138 kV, 19.3 km, 4C-Lochaber Rd to 93N-Glen Dhu, from Dove 50 deg C 110 MVA summer to 86 deg 194 MVA summer plus replace switches and metering at 4C-Lochaber Rd for L-6552	15.98
8	Upgrade conductor rating of L-6511, 138 kV, 36.5 km, 50N-Trenton to 93N-Glendhu, from Dove 60 deg C 140 MVA summer to 80 deg C summer 184 MVA	14.78
9	Upgrade conductor rating of L-6515, 138 kV, 50.7 km, 2C-Port Hastings to 100C-Cape Porcupine, and to 4C-Lochaber Road) from Dove 50 deg C summer 110 MVA to 73 deg summer 170 MVA	41.07
10	Upgrade conductor rating of L-7004, 230 kV, 131 km, 3C-Port Hastings to 91N-Dalhousie Mountain from Dove 60 deg 233 MVA summer to 71deg 277 MVA	90.39
11	Upgrade conductor rating of L-7012, 230 kV, ~ 40 km, section from 3C Port Hastings to Everwind Load POI from Beaumont 70 deg 404 MVA summer to Bluebird 70 deg 595 MVA	55.20
12	Upgrade conductor rating of L-7024, 230 kV, ~ 11.8km, from 3C-Port Hastings to IR618+IR724 POI) from Dove 290 MVA to Beaumont 80 deg C summer 461 MVA plus relay & metering at 3C	16.28

13	Upgrade conductor rating of L-7026, 230 kV, ~50.2 km, from IR668 POI to IR618+IR742 POI from 70 deg C Dove 275 MVA summer to 83 deg C summer 315 MVA	34.64
14	Upgrade Canso Strait Water Crossing of L-8004 at no cost to IC as NSPI is working with Transport Canada to obtain the approval for higher conductor ratings.	0.00
15	Upgrade L-8001 full scale meter rating at 67N-Onslow substation (assume CT ratio change)	0.01
16	Upgrade L-8004a full scale meter rating at 79N-Hopewell substation (assume CT ratio change)	0.01
17	Install 2.5 km 345 kV line extension on each side of L-8004 for IR722 POI	10.00
18	Install two 50 MVAR capacitor banks (2 stages with 25 MVAR each stage) at IR722	22.00
19	Install two 50 MVAR STATCOMs at IR722	60.00
	Contingency (25%)	127.72
	Network Upgrade Sub-total	638.58
Item	**Transmission Provider's Interconnection Facilities (TPIF)**	**Estimate ($M CAN)**
1	Extension of 45 meters of 345 kV line from IR722 POI to IR722 substation	0.09
2	P&C relaying equipment	0.30
3	NSPI supplied RTU	0.10
4	Tele-protection and SCADA communications	0.75
	Contingency (25%)	0.31
	TPIF Upgrade Sub-total	1.55
	Total Network Upgrades and new TPIF, excluding HST	**640.13**

Table 5: Cost Estimate for Option 3

Item	Network Upgrades (NU)	Estimate ($M CAN)
1	Install additional 170 MVAR STATCOM at BHL 345 kV substation	102.00
2	Install a three breaker ring bus at POI substation complete with P&C and connection to L-8004. This substation must be designed to meet NPCC's BPS requirements and NERC's BES requirements. This cost estimate includes P&C modifications at the line remote terminals	13.00
3	Install a new 345 kV to 230 kV at 67N-Onslow (67N-T83) matching existing 67N-T81 or T82	6.50
4	Install two 345 kV breakers on a new rung at 67N-Onslow for the new T83. (if IR686 connects to 67N-Onslow first to a new rung, then IR722 can connect via just one breaker)	7.00
5	Install a new breaker 67N-720 at 67N-Onslow 230 kV substation for 67N-T83 node	3.00
6	Swap L-7018 node with 67N-T83 node to avoid loss of T83 and T81 for 67N-720 breaker failure	1.00

7	Upgrade conductor rating of L-6552, 138 kV, 19.3 km, 4C-Lochaber Rd to 93N-Glen Dhu, from Dove 50 deg C 110 MVA summer to 86 deg 194 MVA summer plus replace switches and metering at 4C-Lochaber Rd for L-6552	15.98
8	Upgrade conductor rating of L-6511, 138 kV, 36.5 km, 50N-Trenton to 93N-Glendhu, from Dove 60 deg C 140 MVA summer to 84 deg C summer 191 MVA	29.57
9	Upgrade conductor rating of L-6515, 138 kV, 50.7 km, 2C-Port Hastings to 100C-Cape Porcupine, and to 4C-Lochaber Road) from Dove 50 deg C summer 110 MVA to 73 deg summer 170 MVA	41.07
10	Upgrade conductor rating of L-7004, 230 kV, 131 km, 3C-Port Hastings to 91N-Dalhousie Mountain from Dove 60 deg 233 MVA summer to 71deg 277 MVA	90.39
11	Upgrade conductor rating of L-7012, 230 kV, ~ 40 km, section from 3C Port Hastings to Everwind Load POI from Beaumont 70 deg 404 MVA summer to Bluebird 70 deg 595 MVA.	55.20
12	Upgrade conductor rating of L-7024, 230 kV, ~ 11.8km, from 3C-Port Hastings to IR618+IR724 POI) from Dove 290 MVA to Beaumont 80 deg C summer 461 MVA plus relay & metering at 3C.	16.28
13	Upgrade conductor rating of L-7026, 230 kV, ~50.2 km, from IR668 POI to IR618+IR742 POI from 70 deg C Dove 275 MVA summer to 83 deg C summer 315 MVA	34.64
14	Upgrade Canso Strait Water Crossing of L-8004 at no cost to IC as NSPI is working with Transport Canada to obtain the approval for higher conductor ratings.	0.00
15	Upgrade L-8001 full scale meter rating at 67N-Onslow substation (assume CT ratio change)	0.01
16	Upgrade L-8004a full scale meter rating at 79N-Hopewell substation (assume CT ratio change)	0.01
17	Install 2.5 km 345 kV line extension on each side of L-8004 for IR722 POI	10.00
18	Install two 50 MVAR capacitor banks (2 stages with 25 MVAR each stage) at IR722	22.00
19	Install two 50 MVAR STATCOMs at IR722	60.00
	Contingency (25%)	126.91
	Network Upgrade Sub-total	634.56
Item	**Transmission Provider's Interconnection Facilities (TPIF)**	**Estimate ($M CAN)**
1	Extension of 45 meters of 345 kV line from IR722 POI to IR722 substation	0.09
2	P&C relaying equipment	0.30
3	NSPI supplied RTU	0.10
4	Tele-protection and SCADA communications	0.75
	Contingency (25%)	0.31
	TPIF Upgrade Sub-total	1.55
	Total Network Upgrades and new TPIF, excluding HST	**636.11**

Table 6: Cost Estimate for Option 4

Item	Network Upgrades (NU)	Estimate ($M CAN)
1	Install a RAS for L-8004 section (L-8004b) between IR722 POI and BHL POI to reject 300 MW load at BHL substation for loss of the line. This RAS will be subject to NPCC and RC approvals	2.00
2	Install a three breaker ring bus at POI substation complete with P&C and connection to L-8004. This substation must be designed to meet NPCC's BPS requirements and NERC's BES requirements. This cost estimate includes P&C modifications at the line remote terminals	13.00
3	Install a 345 kV to 230 kV transformer (T83) at 67N-Onslow matching existing 67N-T81 or T82	6.50
4	Install two 345 kV breakers on a new rung at 67N-Onslow for the new T83. (if IR686 connects to 67N-Onslow first to a new rung, then IR722 can connect via just one breaker)	7.00
5	Install a new breaker 67N-720 at 67N-Onslow 230 kV substation for 67N-T83 node	3.00
6	Swap L-7018 node with 67N-T83 node to avoid loss of T83 and T81 for 67N-720 breaker failure	1.00
7	Upgrade conductor rating of L-6515, 138 kV, 50.7 km, 2C-Port Hastings to 100C-Cape Porcupine, and to 4C-Lochaber Road) from Dove 50 deg C summer 110 MVA to 55 deg summer 127 MVA.	20.53
8	Upgrade conductor rating of L-6552, 138 kV, 19.3 km, 4C-Lochaber Rd to 93N-Glen Dhu, from Dove 50 deg C 110 MVA summer to 63 deg 148 MVA summer plus replacement of switches at 4C-Lochaber Rd and full scale metering.	8.17
9	Upgrade conductor rating of L-7012, 230 kV, ~ 40 km, section from 3C Port Hastings to Everwind Load POI from Beaumont 70 deg 404 MVA summer to 78 deg summer 453 MVA.	27.60
10	Upgrade conductor rating of L-7024, 230 kV, ~ 11.8km, from 3C-Port Hastings to IR618+IR724 POI) from Dove 290 MVA to Beaumont 63 deg C summer 370 MVA.	16.28
11	Upgrade Canso Strait Water Crossing of L-8004 at no cost to IC as NSPI is working with Transport Canada to obtain the approval for higher conductor ratings.	0.00
12	Install 37 MVAR capacitor bank at Memramcook 138 kV substation in NB	10.00
13	Upgrade L-8001 full scale meter rating at 67N-Onslow substation (assume CT ratio change)	0.01
14	Upgrade L-8004a full scale meter rating at 79N-Hopewell substation (assume CT ratio change)	0.01
15	Install 2.5 km 345 kV line extension on each side of L-8004 for IR722 POI	10.00
16	Install two 50 MVAR capacitor banks (2 stages with 25 MVAR each stage) at IR722	22.00
17	Install two 50 MVAR STATCOMs at IR722	60.00
	Contingency (25%)	51.78
	Network Upgrade Sub-total	258.88

Item	Transmission Provider's Interconnection Facilities (TPIF)	Estimate ($M CAN)
1	Extension of 45 meters of 345 kV line from IR722 POI to IR722 substation	0.09
2	P&C relaying equipment	0.30
3	NSPI supplied RTU	0.10
4	Tele-protection and SCADA communications	0.75
	Contingency (25%)	0.31
	TPIF Upgrade Sub-total	1.55
	Total Network Upgrades and TPIF, excluding HST	**260.43**

These cost estimates assume that L-7024 will already be upgraded from 70 deg C summer Dove to 85 deg C summer Dove pre-IR722 due to other higher queued IRs than IR722. The assumption is subject to change pending SISs being completed for IR686 and IR742. Any changes will be studied in the SIS for IR722 at a later date.

This cost estimate is subject to change as will be determined by the SIS and FAC study. The estimated time to construct the Network Upgrades and Transmission Provider's Interconnection Facilities is four years after receipt of funds. This time frame will be determined and confirmed in the Facility Study.

12.0 Preliminary Scope of Subsequent SIS

The following provides a preliminary scope of work for the subsequent SIS for IR#722. The SIS will include a more comprehensive assessment of the technical issues and requirements to interconnect generation as requested. It will include contingency analysis, system stability, transient stability, ride through capability, and operation following a contingency (N-1 operation). The SIS must determine the facilities required to operate this facility at full capacity, withstand any contingencies (as defined by the criteria appropriate to the location) and identify any restrictions that must be placed on the system following a first contingency loss.

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

The following notice on OASIS provides additional clarification on the SIS model requirements:

- *Notice Date: May 08, 2024*
    - To be eligible for inclusion in the Interconnection System Impact Study stage, and thereby advance the Interconnection Request’s initial Queue

Position, the Interconnection Customer must meet the progression milestone requirements of Section 7.2 of the GIP at least ten (10) Business Days prior to the Interconnection System Impact Study commencement date. For clarity, item 7.2 (i) – provision of a detailed stability model for the generator(s) shall mean:

- Provision of PSSE and PSCAD models in compliance with documents *NSPI-TPR-015-2: PSSE and PSCAD Model Requirements*, and
- Provision of test data demonstrating model testing in compliance with NERC, NPCC and NSPI criteria. *NSPI-TPR-014-1: Model Quality Testing* lists the minimum requirements that will be performed by NSPI. Additional testing may be performed to assess compliance with all applicable criteria. Any test not meeting the minimum NSPI requirements will be documented in the MQT report to the IC.
- *NSPI-TPR-015-2: PSSE* and *PSCAD Model Requirements* and *NSPI-TPR-014-1: Model Quality Testing* will undergo revision as the grid evolves and performance criteria changes. The most up to date version will be provided as they become available.

The following outline provides the minimum scope that must be complete to assess the impacts. It is recognized the actual scope may deviate, to achieve the primary objectives. The assessment will consider but not be limited to the following:

- Facilities that the customer must install to meet the requirements of the GIP and the TSIR.
- The minimum transmission additions/upgrades that are necessary to permit operation of this Generating Facility, under all dispatch conditions, catering to the first contingencies listed.
- Guidelines and restrictions applicable to first contingency operation (curtailments etc.).
- Under-frequency load shedding impacts.

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

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

Any changes to RAS schemes required for operation of this generating facility, in addition to existing generation and facilities that can proceed before this project, will be determined by the SIS as well as any required additional transmission facilities. The determination will be based on NPCC[5] and NERC[6] criteria as well as NSPI guidelines and good utility practice. The SIS will also determine the contingencies for which this facility must be curtailed.

13.0 Appendices (as pdf attachments)

The following appendices are included in this report as pdf attachments:

13.1 Appendix 1 Local Transmission Ratings.pdf

13.2 Appendix 2 Base Cases.pdf

13.3 Appendix 3 Contingencies.pdf

13.4 Appendix 4 LF Trial27 b Cases Load Flow Halts.pdf

13.5 Appendix 5 LF Trial27 b Cases Voltage Violation.pdf

13.6 Appendix 6 LF Trial27 b Cases Rate B Overload.pdf

13.7 Appendix 7 LF Trial27 b cases Rate D Overload.pdf

13.8 Appendix8 LF Trial38 STATCOM e Cases Voltage Violation.pdf

13.9 Appendix 9 LF Trial38 STATCOM e Cases Rate B Overload.pdf

13.10 Appendix 10 LF rial38 STATCOM e Cases Rate D Overload.pdf

13.11 Appendix 11 LF Trial40 RAS b Cases Voltage Violation.pdf

13.12 Appendix 12 LF Trial40 RAS b Cases Rate B Overload.pdf

13.13 Appendix 13 LF Trial40 RAS b Cases Rate D Overload.pdf

13.14 Appendix 14 Tentative Breaker Layout Option 1.pdf

13.15 Appendix 15 Tentative Breaker Layout Option 2, 3, and 4.pdf

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

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