Preliminary Transmission Expansion Needs Analysis to Integrate Offshore Wind in Atlantic Canada

July 2026 Report

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Atlantic Canada Offshore Wind Grid Integration and Transmission Study

ACKNOWLEDGEMENTS

The Atlantic Canada Offshore Wind Grid Integration and Transmission Study is a research project developed and led by Net Zero Atlantic. This research is conducted by Stantec in partnership with Energy and Environmental Economics (E3) and is supported by funding from Natural Resources Canada's Office of Energy Research and Development through its Energy Innovation Program.

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Letter from Net Zero Atlantic

Net Zero Atlantic is pleased to share the findings of the Atlantic Canada Offshore Wind Grid Integration and Transmission Study.

This report provides a preliminary assessment of what transmission expansion needs exist to support reliably integrating large-scale offshore wind in Atlantic Canada by 2035 and 2050. The report considers possible transmission implications related to the development of energy-intensive industries, as well as power exports outside of Atlantic Canada.

Support for this work was provided by Natural Resources Canada's Office of Energy Research and Development through the Energy Innovation Program.

We thank consultants Stantec and Energy and Environmental Economics (E3) for their contributions throughout the study. Net Zero Atlantic is also greatly appreciative of the guidance and input provided by provincial governments and electrical utility representatives who participated on the project management and technical committees. We would also like to thank Dr. Lukas Swan of Charged Engineering for his valuable input and review of reports throughout the study.

The study has produced several key deliverables, including the Market Opportunities for Offshore Wind in the Atlantic Provinces report, the Actual Deployment Potential of Atlantic Canada Offshore Wind report, the Visual Interface Tool and associated database, the Evaluating the Electric Grid Impacts of Offshore Wind in the Atlantic Provinces report, the Roadmap and Action Plan for Integrating Offshore Wind into Atlantic Canada's Grid, and several other supporting reports. These resources can be accessed and downloaded through Net Zero Atlantic's website.

Thank you for your interest and engagement throughout this study. We greatly appreciate your support and look forward to continuing the conversation around the opportunities, challenges, and findings identified through this work.

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Revision Record

Revision	Description	Authors	Date	Quality Check	Date	Independent Review	Date
00	Initial draft issued for review	Rony Islam, Ashraf Haque, Ranbir Briar	January 16, 2026	Phaedra Taiarol	January 20, 2026	Praveen Rosario, Ericka Wicks	January 22, 27, 2026
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Executive Summary

Prepared as part of the *Atlantic Canada Offshore Wind Grid Integration and Transmission Study* led by Net Zero Atlantic, this *Preliminary Transmission Expansion Needs Analysis to Integrate Offshore Wind in Atlantic Canada* report provides a high-level, preliminary assessment of transmission expansion needs to support the reliable integration of large-scale offshore wind in Atlantic Canada by 2035 and 2050. The assessment also considers, at a high level, the transmission implications related to the potential development of energy-intensive industries, such as hydrogen and its derivatives, as well as the potential for power exports beyond Atlantic Canada.

Based on current grid conditions and the assumptions applied in this preliminary analysis, the study indicates that Atlantic Canada could accommodate approximately 5–7.5 GW of offshore wind capacity by 2035 and 10–16.5 GW by 2050, subject to market conditions, policy choices, and the timing and scale of associated transmission grid investments. Higher offshore wind deployment levels—up to 7.5 GW by 2035 and 16.5 GW by 2050—were examined to evaluate transmission system performance under high development scenarios. Key findings and preliminary observations for each planning horizon are summarized below.

Significant Offshore Wind Potential Enabled by Strategic Grid Investment: By 2035, Atlantic Canada could integrate several large offshore wind projects, with total capacity on the order of 5-7.5 GW, provided that targeted transmission reinforcements are implemented. These investments are required to maintain system reliability and compliance with applicable North American Electric Reliability Corporation (NERC) and Northeast Power Coordinating Council (NPCC) criteria and to alleviate projected transmission bottlenecks that would otherwise constrain offshore wind integration. The assessment identifies priority transmission investments that increase the thermal capacity of the system and enable near-term offshore wind integration. Dynamic analyses indicate that additional stability-focused investments may be required to fully satisfy reliability criteria and would be identified through subsequent detailed studies.

Looking ahead to 2050, offshore wind deployment at higher levels (10-16.5 GW), combined with the emergence of large-scale hydrogen production and export markets, would require substantial expansion of regional transmission infrastructure. All Atlantic provinces would need additional transmission capacity and enhanced system flexibility to support reliable operation under these conditions. Strategic, coordinated grid investments are therefore a prerequisite for enabling higher offshore wind integration by 2050.

2035 Outlook — Near-Term Offshore Wind Integration: The 2035 preliminary assessment identifies priority transmission upgrades that would enable the reliable integration of 5-6 GW of offshore wind capacity while preserving system stability. These upgrades are focused on strengthening interprovincial ties and reinforcing key provincial transmission networks to improve power sharing and export capability across the region.

New Brunswick is identified as a critical interprovincial hub. Its grid—if appropriately reinforced—could transmit Nova Scotia's surplus offshore wind power westward and support Prince Edward Island's needs. Nova Scotia could integrate several gigawatts of offshore wind within its system by 2035, with additional

capacity enabled through enhanced export capability and regional coordination. For Newfoundland and Labrador, a few large offshore projects (hundreds of MW) could connect locally by 2035, especially to supply on-island industry (e.g. green hydrogen in the Avalon Peninsula), but any significant exports off-island would require new transmission corridors (for example, a second HVDC link between the island of Newfoundland and Nova Scotia).

Infrastructure investments complemented by operational measures and emerging technologies to maintain reliability as inverter-based generation increases in the systems across all provinces are required. With these combined actions, this preliminary study finds that Atlantic Canada could support its near-term offshore wind vision while maintaining compliance with reliability standards.

2050 Outlook – A Clean Energy Hub Requires Transformational Expansion: By mid-century, the offshore wind integration scenarios envision Atlantic Canada as a major clean energy hub, integrating 10–16+ GW of offshore wind and supplying domestic loads, robust export markets, and large-scale production of hydrogen and its derivatives. This would represent a threefold increase in offshore wind over 2035 and the emergence of a new multi-GW hydrogen industry or other large-scale industry. Achieving this outcome would require strategic and coordinated transmission expansion across the region to address system capacity and stability needs.

The 2050 analysis demonstrates that substantial offshore wind buildout could be enabled through strategic grid expansion. Targeted transmission investments are necessary to address thermal and stability constraints and support reliable integration across the region. To achieve this 2050 vision, every province's transmission network must be strengthened ahead of the offshore wind deployments. While the infrastructure requirements for 2050 are significantly greater than those identified for 2035, they also represent an opportunity: early, strategic planning and investment could enable a fundamental transformation of the Atlantic Canadian power grid and unlock substantial offshore wind development.

Strategic Implications: With these actions, Atlantic Canada could become a leader in clean energy by harnessing its world-class offshore wind resource to decarbonize its own electricity supply and drive new industries and exports. The study recommendations align with utility roadmaps and net-zero policies[1], but they also extend beyond business-as-usual. Achieving this vision would require unprecedented regional collaboration, including coordinated transmission planning, shared investment in interprovincial infrastructure, and alignment of operational practices across jurisdictions. This preliminary needs assessment also underscores the need for policy support to enable the timely construction of critical infrastructure and the integration of innovative technologies.

Recommended Next Steps: Once offshore wind locations, capacities, offtake markets, and development timelines are more clearly defined, detailed transmission planning studies[2] would be required by each utility

[1] Generation dispatches, including offshore wind capacities, are based on Phase 2 PLEXOS analysis and may not be indicative of how generation may meet load demand in the future.

[2] The scenarios described in this report are preliminary in nature and were developed based on Phase 1 and Phase 2 results from this study. The scenarios and transmission system upgrades/reinforcements in this report do not represent commitments by provinces, utilities, or other stakeholders to pursue specific offshore wind development levels, transmission upgrades, or load scenarios.

and system operator to further evaluate provincial-level system impacts. The studies should assess injection levels, expansions and upgrade alternatives, loss of generation, and a more extensive set of contingencies. In parallel, stakeholder discussions with neighbouring system operators and planners regarding export integration should be initiated or continued, detailed engineering studies for proposed upgrades should be undertaken, and pilot projects (e.g. developing grid-forming inverter wind farms or large battery systems by 2030) should be considered to enhance overall system resilience.

This needs assessment provides a framework for preparing Atlantic Canada's grid for initial offshore wind development and identifies pathways for the region to scale toward becoming a clean energy hub by 2050—delivering reliable, emissions-free power for domestic use, hydrogen production, and export markets. Advancing this vision would require coordinated action across the following key areas:

- **Stakeholder Collaboration:** Engage with neighboring jurisdictions, including ISO-NE and Hydro Québec, to explore coordinated export pathways and associated technical requirements. If Nova Scotia or New Brunswick anticipates exporting surplus offshore wind generation, initiating agreements and technical studies in the next few years will be important to support potential infrastructure development by 2035. Continued engagement with the Canadian Federal Government is also recommended to assess funding opportunities that align with broader economic development goals and decarbonization objectives.
- **Policy and Regulatory Support:** Collaborate with regulatory authorities to develop cost-recovery and cost-sharing frameworks that reflect the regional value of transmission investments delivering multi-provincial benefits. Interprovincial intertie infrastructure plays a key role in enhancing regional reliability, enabling clean energy integration, and supporting economic development. As such, coordinated regulatory approaches will be important to ensure alignment with broader regional planning objectives.

Abbreviations and Terminology

AC	Alternating Current
BESS	Battery Energy Storage System
CBC	Come By Chance (NL substation/region referenced in report)
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CT	Combustion Turbine
EMT	Electromagnetic Transients
FACTS	Flexible AC Transmission Systems
GW	Gigawatts
HFO	Heavy Fuel Oil
HVDC	High Voltage Direct Current
ICE	Internal Combustion Engine
IRP	Integrated Resource Plan
ISO-NE	Independent System Operator of New England
kV	Kilovolt
Market Scenarios	Scenarios considered as part of the economic analysis in Phases 1 and 2 of the project
MMWG	Multiregional Modeling Working Group
MVA	Megavolt-Ampere
MW	Megawatt
NB	New Brunswick
NERC	North American Electric Reliability Corporation
NL	Newfoundland and Labrador
NPCC	Northeast Power Coordinating Council
NS	Nova Scotia
NZA	Net Zero Atlantic
PEI	Prince Edward Island
POI	Point of Interconnection
PPA	Power Purchase Agreement
Project Management Committee	Provincial government representatives from the Atlantic provinces that provide strategic oversight for the study
pu	Per Unit
RAS	Remedial Action Scheme
SCCT	Simple Cycle Combustion Turbine
SMR	Small Modular Reactor
ST	Steam
STATCOM	Static Synchronous Compensator
SVC	Static Var Compensator
Technical Committee	Utility representatives from each province and a system operator with expertise relevant to the project and transmission planning
Transmission Planning Scenarios	Scenarios considered in the transmission planning studies in Phase 3 of the project

1 Introduction and Context Setting

As part of Phase 3 of the *Atlantic Canada Offshore Wind Grid Integration and Transmission Study* project, preliminary transmission planning studies were carried out to assess the system impacts and identify transmission system upgrades required to integrate offshore wind. Transmission planning scenarios for the integration of offshore wind were developed based on the wind potential and economic analysis carried out in Phase 2, which identified offshore wind locations and generation capacities for various market scenarios (see Figure 1.A).

This Preliminary Transmission Expansion Needs Analysis to Integrate Offshore Wind in Atlantic Canada aims to assess a region-wide approach for the integration of offshore wind into Atlantic Canada's onshore transmission grid. The transmission planning scenarios were developed with feedback from the project's Technical and Project Management Committees, which include representatives from the four Atlantic Canadian provincial governments and some of the electrical utilities. The transmission planning scenarios represent a subset of many possible scenarios to aid in future planning. They explore the requirements needed to reinforce the onshore transmission grid to allow for the injection of substantial amounts of offshore wind. These studies are considered preliminary analyses of the onshore transmission requirements for the integration of offshore wind development, based on the work carried out in previous phases of this project. The scenarios described in this report are preliminary in nature and were developed for the purposes of this study. The scenarios and transmission system upgrades/reinforcements in this report do not represent commitments by provinces, utilities, or other stakeholders to pursue specific offshore wind development levels, transmission upgrades, or load scenarios. Each of the provincial utilities will need to perform additional transmission planning analysis to further assess the points of interconnection, generation dispatch, and system impacts resulting from planned offshore wind development.

Phase 1 of this study, conducted by Stantec and Energy and Environmental Economics (E3), explored market opportunities under a range of future demand conditions, as summarized in Figure 1.A below. These scenarios consider increasingly expansive offshore wind offtake opportunities ranging from the Domestic-Only Case, where offshore wind additions are scaled to help meet the electricity needs of the Atlantic Provinces, to an expansive "All Markets with High Hydrogen" scenario that includes domestic load growth, expanded export capacity to New England, and several gigawatts of electrolyzer demand to support hydrogen production and potential hydrogen and derivative exports. In these scenarios, by 2050, cumulative offshore wind buildouts varied from 2.5 GW in the domestic-only case to upwards of 16.5 GW under the All Markets, high-hydrogen case. Additional details on scenario design, including inputs and assumptions and detailed portfolio results for each of these scenarios can be found in the Phase 2 Actual Deployment Potential Report [3].

[3] This report is accessible at https://netzeroatlantic.ca/research/atlantic-canada-offshore-wind-grid-integration-and-transmission-study

Figure 1.A Offshore Market Scenarios Deployment for Future Demand Conditions in Atlantic Canada

As discussed in the Market Opportunities report, Phase1 of this study focused on capacity expansion analysis, which helped identify the economically optimal portfolio of resources that could meet demand and fulfill policy objectives in each of these scenarios. Phase 2 analysis built on this work by refining the potential estimates and resource characteristics of offshore wind, utilizing the data profiled in the Phase 2 Actual Deployment Potential report[4], and refreshing scenario results. As part of Phase 2, E3 led an additional assessment of hourly operations of these portfolios, an exercise that helped confirm operational reliability of these cases across full hourly weather conditions and delved into system dynamics in a wind heavy grid. Results from this operational assessment[5] were presented to the project's Project Management and Technical Committees and are available from the final public database.

Importantly, each of these studies evaluated system needs on a zonal basis for the Atlantic Canada provinces, while the transmission planning studies discussed throughout this report provide a more granular assessment, including models for each of the high voltage transmission lines, transformers, and other transmission equipment. This level of detail is necessary to conduct an in-depth assessment of power flows and stability of Atlantic Canada's transmission system, however it does complicate the way data is shared between these study phases, and how results can be understood and visualized within the broader project context[6]. Nonetheless, the project team worked to harmonize these critical analytical efforts, and leverage data and findings from each analytical stage in downstream modeling exercises. Specifically, the transmission planning scenarios were informed by the hourly dispatch results produced in the Phase 2 zonal operational analysis.

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[4] This report is also accessible at https://netzeroatlantic.ca/research/atlantic-canada-offshore-wind-grid-integration-and-transmission-study

[5] This operational analysis was also refreshed in Phase 3 of this study, and a detailed discussion of how this model works and the results observed can be found within the Technical Appendix to the Roadmap and Action Plan, accessible at https://netzeroatlantic.ca/research/atlantic-canada-offshore-wind-grid-integration-and-transmission-study

[6] Integrated results visualizations are included in the visual graphic interface

Figure 1.B describes the integrated project modeling framework used for Phases 1, 2, and 3 of the *Atlantic Canada Offshore Wind Grid Integration and Transmission Study.* As discussed above, this project is both integrated and iterative in nature. Market scenarios identified during Phase 1 were utilized to help determine the amount of offshore wind that could be developed. Data from the Phase 2 wind resource assessment (including technical, locational, and economic potential) were then used as input into the Phase 2 PLEXOS capacity expansion and production cost models to inform updated portfolios and hourly dispatch results. These hourly dispatches were then assessed to develop the transmission planning scenarios used in the PSS®E power flow and transient stability analysis.

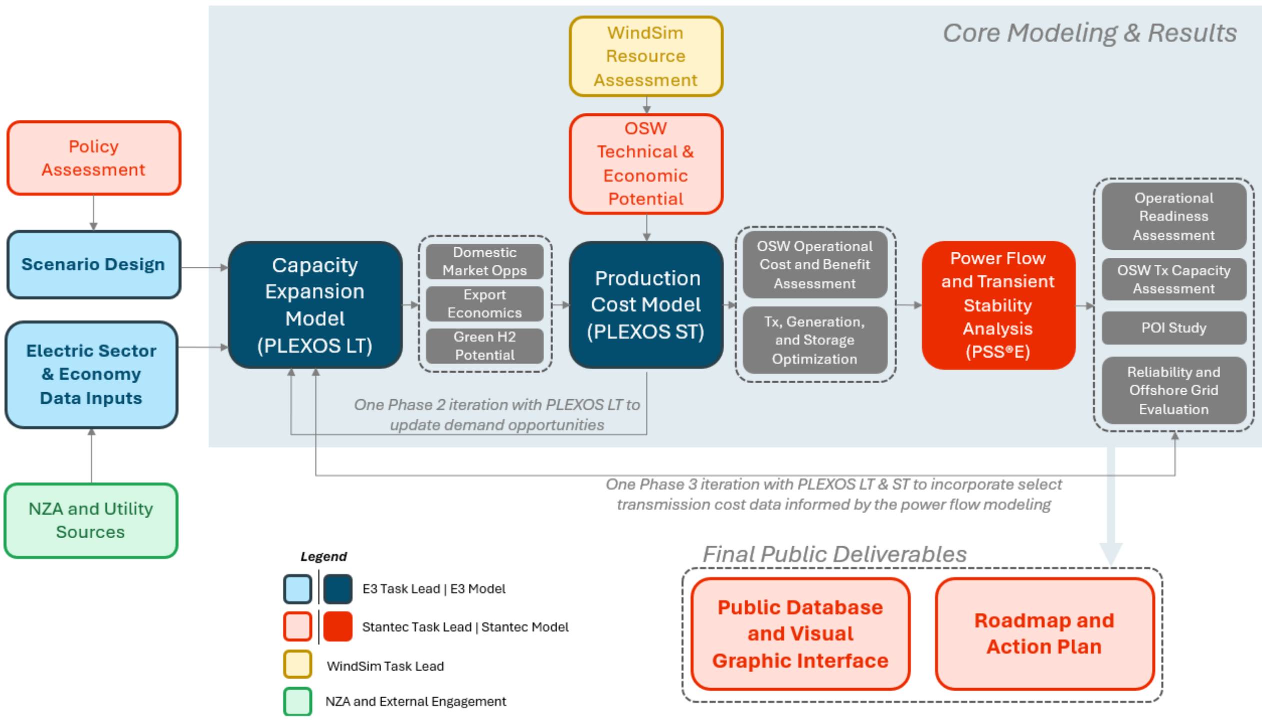

Figure 1.B Integrated Project Modeling Framework

With the intent of the Phase 3 preliminary transmission planning analysis being to assess the onshore infrastructure in the Atlantic Canada provinces and identify potential upgrades required to support the integration of high amounts of offshore wind, scenarios with lower amounts of offshore wind (i.e., with higher injections from other generation sources) weren't considered in the analysis. Additionally, transmission directly to export markets (e.g., dedicated submarine cables to transmit power directly to markets outside of the four Atlantic provinces) was not considered for the preliminary transmission planning scenarios (with the exception of C2 and C4 scenarios in 2050). This approach reflects the fact that onshore system impacts are greatest when offshore wind generation is predominantly integrated into the existing onshore grid. The focus of the analysis was on the Atlantic Canada provinces; impacts to systems outside of these 4 provinces were not assessed in the studies.

High level cost estimates of the potential transmission system upgrades identified based on the results of the power flow and transient stability analysis for the various transmission planning scenarios are included Section 6.3.8 for 2035 and Section 11.3 for 2050.

The following were not considered in this analysis:

- **Physical Constraints at Existing Substations and Transmission Corridors:**

  Site-specific limitations—such as space availability, equipment footprints, and constructability challenges at existing substations and transmission corridors—were not assessed. These factors may affect the feasibility, cost, and implementation of proposed transmission system upgrades.

- **Permitting and Environmental Constraints:**

  Regulatory approvals, environmental assessments, and stakeholder engagement requirements were not evaluated, though they may influence project timelines, routing, and development risk.

- **Export Transmission Infrastructure from Offshore Wind Areas to Onshore Points of Interconnection:**

  The study did not assess system limits related to the sudden loss of offshore wind. Current thresholds (~168–200 MW in Nova Scotia; ~660–720 MW across the Maritimes) may constrain integration. Staying within these limits would require additional transmission infrastructure and complex configurations; raising the limits would necessitate a regional system study and potential coordination with neighboring jurisdictions.

- **Operational Practices:**

  Potential changes to system operations—such as reserve margins, curtailment, protection schemes, or coordination protocols—were not considered, though they could influence infrastructure needs.

- **Export of Power to Other Regions:**

  The export of power to and system impact on other provinces and/or regions outside of the four Atlantic Canada provinces was not considered as part of this study, as the objective of the study was to assess onshore infrastructure needs for the injection of offshore wind into these four provinces.

2 Preliminary Transmission Expansion Needs Analysis – Scope, Approach, and Methodology

The preliminary transmission planning studies carried out as part of Phase 3 of the *Atlantic Canada Offshore Wind Grid Integration and Transmission Study* cover two planning horizons—2035 and 2050—to assess the infrastructure requirements for the grid under progressively larger offshore wind integration.

2.1 Transmission Expansion Needs Analysis - 2035

This part of the report presents the Phase 3 preliminary transmission expansion needs analysis for integrating large-scale offshore wind into the Atlantic Canada grid by 2035. It builds upon earlier phases of the Net Zero Atlantic (NZA) studies (Phase 1 “Path to Market” and Phase 2 “Resource Potential”) and aims to assess the transmission expansion needs for the grid to reliably accommodate high offshore wind generation while supporting domestic needs, interprovincial sharing, and energy exports. All studies were carried out according to NPCC[7] and NERC[8] transmission planning reliability criteria at the transmission level.

2.1.1 Scope of Phase 3 - 2035

Stantec’s Phase 3 work evaluated how the four Atlantic provinces—New Brunswick (NB), Nova Scotia (NS), Prince Edward Island (PEI), and Newfoundland and Labrador (NL)—could integrate significant offshore wind development by 2035. Key tasks are described in the following sections.

2.1.1.1 2035 Base Case Development

The 2035 base case development consisted of creating a detailed 2035 power system model incorporating utility Integrated Resource Plans (IRP), planned projects, generation retirements, and forecast loads for all four provinces. The 2035 Multiregional Modeling Working Group (MMWG) PSS®E (power system transmission simulation software) model was used for the analysis of the systems in NB, NS, and PEI, with updates confirmed by the Net Zero Atlantic Project Management and Technical Committee, and accounted for new interprovincial ties (e.g. a 345 kV NB–NS line by 2028) as well as known generation additions (e.g. wind, small modular reactors (SMR)) and retirements. The model maintained the required import and export capabilities at provincial interfaces. The PSS®E model provided by Newfoundland and Labrador Hydro was used for the analysis of the Newfoundland and Labrador system.

2.1.1.2 Offshore Wind Transmission Capacity Assessment

Hosting capacity studies were performed to determine the maximum offshore wind generation that each candidate point of interconnection (POI) could accommodate, considering potential network upgrades where applicable. This involved injecting incremental generation at 19 proposed POIs (in NB, NS, PEI, and NL) under system normal N-0 (all transmission equipment in service) and N-1 (single contingency) conditions, considering all facilities within 5 busses of the selected POI. For each POI, the limiting element (line or transformer) was identified along with its thermal rating and the contingency causing overload, if any. Where feasible, an upgrade (reconductor or new transformer installation) was applied to see if the hosting capacity could be increased, iterating until a major system reinforcement would be needed.

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[7] https://www.npcc.org/standards/regional-standards
[8] https://www.nerc.com/standards/reliability-standards

2.1.1.3 2035 Grid Integration Scenarios

The grid integration scenarios consisted of several future scenarios with large offshore wind deployments. The following four core scenarios identified in Phases 1 and 2 of the project were analyzed in the transmission expansion plan studies (with variants):

- **C1 – Domestic Only:** Approximately 1 GW of offshore wind serving provincial load, with no exports or hydrogen production.
- **C2 – Domestic + Export Markets:** Offshore wind generation supporting both local demand and interprovincial or cross-border exports.
- **C3 – Domestic + Base Hydrogen:** Offshore wind generation serving provincial load and baseline hydrogen production demand.
- **C4 – All Markets:** A comprehensive scenario with 6.5–7.5 GW of offshore wind supplying domestic load, export markets, and hydrogen production facilities.

Each scenario specified the geographic distribution of offshore wind build-out, new hydrogen electrolyzer loads, and expected interprovincial or export flows. These scenarios are aligned with Phase 1 market analysis (e.g. up to ~7.5 GW offshore wind in a high-hydrogen case by 2035) and were refined with the project's Project Management and Technical Committees.

2.1.1.4 2035 Power Flow Studies

For each grid integration scenario, steady state power flow simulations were conducted under high offshore wind output conditions to identify any thermal overloads or voltage violations on transmission lines and transformers under both normal N-0 and single contingency N-1 conditions. The results were analyzed to determine which overloads and voltage violations could be managed by operational measures and which required infrastructure upgrades. The analysis pinpointed critical corridors, substations, and voltage levels that became stressed as offshore wind and new loads increased in the system.

2.1.1.5 2035 Transient Stability Studies

The transient stability studies simulated selected worst-case N-1 disturbances (e.g. 345 kV line trips on the NB–NS interface or NS backbone) to verify dynamic voltage stability with high offshore wind penetration. The simulation results were assessed to determine if voltages recovered within acceptable criteria and to identify any instability or need for additional reactive support or inertia.

This comprehensive approach allows for the transmission expansion plan to address both steady state adequacy (thermal capacity) and dynamic security (transient stability) for the future grid.

2.2 Transmission Expansion Needs Analysis - 2050

The 2050 analysis extended the methodologies used for the 2035 analysis to mid-century scenarios with much higher renewable penetration. All studies were conducted in accordance with NPCC and NERC reliability planning standards, ensuring that the system meets applicable reliability criteria for steady state and transient conditions. Siemens PSS®E power system simulation software was used for all 2050 simulations (steady state and transients), providing an advanced platform to evaluate system performance under the expanded 2050 scenarios.

2.2.1 Scope of Phase 3 – 2050

The objective of the 2050 scenarios was to identify the infrastructure and operational measures required to maintain system reliability, stability, and transfer capability under a range of future scenarios. This section outlines the technical approach used to develop and analyze the 2050 scenarios, including power flow and transient stability assessments.

2.2.1.1 2050 Grid Integration Scenarios

To assess the 2050 horizon, a set of future grid integration scenarios mirroring the 2035 scenario framework (C1 through C4) were developed but scaled up for 2050's expected generation and load. The core scenarios are:

- **C1 – Domestic Only:** Offshore wind serving provincial loads (no exports, no new hydrogen demand), representing a baseline case with approximately 2.5 GW of offshore wind across NS and PEI by 2050.
- **C2 – Domestic + Export Markets:** Offshore wind deployment increases to approximately 8.5 GW across Nova Scotia, Prince Edward Island, and Newfoundland and Labrador, with surplus generation exported to out-of-region markets such as New England. This scenario places emphasis on the performance of interprovincial and export transmission corridors under high-export conditions.
- **C3 – Domestic + Base Hydrogen:** Offshore wind growth (~6.5 GW) combined with new hydrogen electrolyzer loads (several GW) in NS, NB, and NL. This scenario tests the grid under added steady industrial demand, using offshore wind for both traditional demand and baseline hydrogen production.
- **C4 – All Markets:** A maximal integration case with offshore wind supplying domestic, export, and substantial hydrogen production. By 2050, the "All Markets" scenario was studied in two variants:
    - **C4-1 (Base Hydrogen):** ~12.5 GW of offshore wind installed across all four provinces, coupled with moderate (baseline) hydrogen load.
    - **C4-2 (High Hydrogen):** A high-development scenario featuring up to ~16.5 GW of offshore wind and high hydrogen demand (~8 GW) by 2050. This case represents the upper bound of anticipated development to test the grid's limits.

Each 2050 scenario was built upon the 2035 scenario model (including all upgrades identified in the 2035 analysis) with additional generation and network expansions to reflect expected 2050 conditions. Rather than developing a new base case, the 2035 model was extrapolated to 2050 by adding the scenario-specific offshore wind generation at the designated POIs and incorporating any prerequisite network reinforcements (e.g. new transmission lines or transformers) identified through an iterative study process.

Notably, no separate hosting capacity analysis was performed for 2050; it was assumed that the offshore wind capacities specified in each scenario (as informed by Phases 1 and 2 market analysis and 2035 outcomes) would be injected, and the grid's performance with those injections was then evaluated. This approach focuses the 2050 study on integrated scenario stress-testing rather than incremental capacity testing at individual POIs.

2.2.1.2 2050 Power Flow Studies

For each 2050 scenario, steady state power flow analyses were conducted under high load and high offshore wind output to identify any thermal or voltage limit violations. Two dispatch conditions were examined per scenario for C1 and C2 – for example, a "high thermal, low renewables" case vs. a "low thermal, high renewables" case – to capture different plausible operating conditions (e.g. a cold winter morning with low onshore wind versus a high wind scenario with maximum renewables). In the power flow simulations, N-0 (all elements in service) and N-1 (single contingency) conditions were tested across the expanded network. The analysis pinpointed transmission elements (lines, transformers) that experienced thermal overloads or voltage deviations when subjected to the 2050 flows. Similar to the 2035 study, the 2050 study distinguished issues that could be managed through operational measures from those requiring physical infrastructure upgrades.

2.2.1.3 2050 Transient Stability Studies

In addition to steady state analysis, dynamic simulations were performed to verify that the 2050 grid could maintain stable operation following severe disturbances, given the high penetration of inverter-based, low-inertia generation. For each 2050 scenario (C1-1, C1-2, C2-1, C2-2, C3-1, C4-1, C4-2), a set of worst-case N-1 faults on the bulk system were simulated—for example, three-phase faults with loss of a critical 345 kV line using PSS®E's time-domain simulation module. The stability criteria focused on voltage recovery and machine angular stability. Following a normally cleared fault (typically 4–6 cycles clearing time), the criteria for system stability was for all provincial substation voltages to recover to at least ~0.8 per unit (pu) within ~1–2 seconds, and no generators or wind farms to lose synchronism or trip unexpectedly, in accordance with NPCC dynamic response guidelines.

This technical approach for the 2050 horizon—comprising scenario development, power flow assessments, and transient stability analyses—provides a good understanding of onshore transmission grid requirements for integrating on the order of 10–16 GW of offshore wind by 2050.

Power system analyses for this study, including steady state power flow and transient stability, were performed using Siemens PSS®E software, versions 34 and 35. These advanced modeling tools enabled a comprehensive evaluation of transmission network performance and system reliability under various offshore wind integration scenarios.

2.3 Offshore Wind Transmission Hosting Capacity Analysis (2035)

This section presents the hosting capacity analysis results for selected POIs in New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador, which was carried out to determine how much new wind generation could be accommodated in each location under system normal conditions (all facilities in service, denoted N-0) and single contingency conditions (one element out of service, denoted N-1).

The hosting capacity analysis was performed using the PSS®E base case developed for the year 2035. Stantec's power system studies team met with the project's Project Management and Technical Committees to reconfirm the base case requirements for the four provinces and modeled the base case using the MMWG transmission system PSS®E models for NB, NS, and PEI, and the PSS®E model provided by Newfoundland and Labrador Hydro for NL. The models incorporated updated load and generation forecasts as well as import and export to the neighbouring systems, including dynamic data based on IRP and long term-outlooks.

The results of the hosting capacity analysis identified the generation injection amounts in MW at each studied POI, along with the limiting transmission elements. Stantec identified potential solutions for upgrading the first limiting transmission elements obtained from the hosting capacity study. The identified upgrades were incorporated into the system model, and the hosting capacity study was rerun to determine the adjusted generation injections that could be accommodated and if any further upgrades were identified.

2.3.1 Hosting Capacity Assessment Methodology

The hosting capacity assessment adopted the following steps:

- Utilized the 2034/35 MMWG Series PSS®E base case for the NB, NS, and PEI transmission systems. Utilized the 2035 Winter (2025 Series) NL case received from Newfoundland and Labrador Hydro.
- The study area consisted of all 138 kV and higher voltage levels up to 5 busses away from the POI and associated generation dispatched.
- The generation and load forecast in the study area for the MMWG case was updated based on publicly available information. Generation was dispatched based on assumed capacity factors.
- A power flow analysis was conducted in PSS®E under the system normal N-0 condition and single contingency N-1 conditions, up to 5 busses away from the POI.

2.3.2 Offshore Wind Transmission Capacity Assessment Study Assumptions

Stantec considered the following assumptions to perform the study:

- Stantec used the MMWG base case and NL case from Newfoundland and Labrador Hydro to perform the studies.

- The capacity assessment study was limited to contingencies up to 5 busses away from the POI.
- The hosting capacity was determined at each POI, considering no new generation was added to other POIs in the network.
- Stantec used "generic" information for the wind turbine models for this stage of the project.

It is noted that the representation of the transmission system elements and generators in the power system study cases for the year 2035 forms the basis for the study results. The results are applicable to the models used in these studies. Changes to the transmission system as part of future planning and development of the grid will affect these study results.

2.3.3 2035 Base Case Development

Stantec developed the 2035 PSS®E base case model for the four provinces, incorporating updated generation, load, and transmission system data based on transmission owner IRPs, Long-Term Outlooks, and input from the Net Zero Atlantic Project Management and Technical Committees. The base cases described in this section were used to carry out the hosting capacity assessment for planning year 2035, as an initial step to assess the capacity available in the transmission system.

The hosting capacity assessment was carried out prior to the Phase 2 PLEXOS capacity expansion and production cost models. The results from the hosting capacity and Phase 2 PLEXOS were assessed in the development of the grid integration scenarios, as described in Sections 4 and 9.

2.3.3.1 2035 Base Case Development Assumptions

2.3.3.1.1 New Brunswick

The following documents were reviewed to prepare the assumptions for the New Brunswick Power transmission system model:

- 2023 Integrated Resource Plan: Pathways to a Net-Zero Electricity System[9]
- Powering our Economy and the World with Clean Energy: Our Path Forward to 2035[10]
- 10-Year Planned Transmission Infrastructure Upgrades (January 2025)[11]

This list of documents and the assumptions to be considered for the base case development were discussed and confirmed with the Net Zero Atlantic Project Management and Technical Committees before updating the system model in the MMWG PSS®E cases for the planning year 2035 for the New Brunswick

[9] 2023 Integrated Resource Plan: Pathways to a Net-Zero Electricity System: 2023 Integrated Resource Plan: Pathways to a Net-Zero Electricity System

[10] Powering our Economy and the World with Clean Energy: Our Path Forward to 2035: https://www2.gnb.ca/content/dam/gnb/Corporate/Promo/energy-energie/GNB-CleanEnergy.pdf

[11] 10-Year Planned Transmission Infrastructure Upgrades (January 2025): https://tso.nbpower.com/Public/en/docs-EN/10-Year%20Planned%20Transmission%20Infrastructure%20Upgrades%20(January%202025).pdf

transmission system. The 2035 MMWG case was refined to align the planned generation plants, long-term transmission upgrades, generation retirement schedules, internal and external tie information, and load growth information and assumptions based on the preceding documents and discussions with the Project Management and Technical Committees.

The following list of key assumptions and data points were validated:

- Small Modular Reactor rollout schedule and capacity
- Generation retirement schedules
- Transmission upgrade plans and intertie assumptions
- Clarification on Coleson Cove's limited operational profile

Generation Fuel Mix – Installed and Planned Capacity

Table 2-1 shows the installed and planned capacity of New Brunswick's generation fuel mix that was considered in the modified 2035 case.

Table 2-1 New Brunswick Generation Fuel Mix – Installed and Planned Capacity

Generating Type	Current Installed Capacity (MW)	Additional Capacity Planned (MW)	Total Planned Capacity in 2035 (MW)
Thermal & Combustion Turbine	2,250	400	2,183
Hydro	890	0	890
Biomass	120	380	500
Nuclear	660	600	1,260
Onshore Wind – Power Purchase Agreement (PPA)	400	800	1,200
Offshore Wind	0	0	0
Solar	0	0	0
Battery Energy Storage System (BESS)	0	150	150
Total	**4,300**	**2,350**	**6,200**

Planned Transmission Projects and In-Service Timeline

Table 2-2 presents the planned transmission projects including the in-service date for the New Brunswick transmission system.

Table 2-2 New Brunswick Planned Transmission Projects

Project Name	Description	Planned In-Service Date
Saint John Corridor Reinforcement	Construction of a new double-circuit 138 kV line from Coleson Cove to Fairvale, load transfers from L1149 to L1212, and relocation of a phase shifter.	2029-2030
Memramcook Tie Transformer	Procurement of a second 138/345 kV tie transformer at Memramcook to enhance regional redundancy and reliability.	2028-2033

Project Name	Description	Planned In-Service Date
NB-NS Interprovincial Transmission Line - Stage 1	New 345 kV line from Salisbury, NB to Onslow, NS.	2027-2028
NB-NS Interprovincial Transmission Line - Stage 2	Extension from Salisbury, NB to Point Lepreau.	2028-2029
NB-PEI Interprovincial Transmission Line - Stage 3 (Proposed)	Proposed new line from Memramcook, NB, to Borden, PEI.	2029-2030

Generation Retirement Schedules

The generation retirement schedule is shown in Table 2-3.

Table 2-3 New Brunswick Generation Retirement Schedules

Resource	Fuel Type	Capacity (MW)	End of Life	Comment
Grandview PPA	Natural Gas	95	2024/25	May be extended to 2040; assume inclusion through 2050.
Grand Manan	Diesel	26	2025/26	Remain in service in 2035.
Millbank	Diesel	397	2030/31	Retain through 2035 as peaking units.
Ste. - Rose	Diesel	99	2030/31	keep in until 2035, these are the peaking units.

2.3.3.1.2 Nova Scotia

The following documents were reviewed to prepare the assumptions for Nova Scotia Power's transmission system model:

- 2025 System Outlook: 10-Year Plan[12]
- Integrated Resource Plan: Action Plan Update 2025[13]
- Evergreen Integrated Resource Plan: Final Modeling Results[14]
- Nova Scotia's 2030 Clean Power Plan[15]

---

[12] 2025 System Outlook: 10-Year Plan: https://www.nspower.ca/docs/default-source/monthly-reports/10-year-system-outlook-report.pdf?sfvrsn=d39bca29_66

[13] Integrated Resource Plan: Action Plan Update 2025: https://www.nspower.ca/docs/default-source/irp/irp-action-plan-update-2025.pdf?sfvrsn=1a7257e8_1

[14] Evergreen Integrated Resource Plan: Final Modeling Results: https://www.nspower.ca/docs/default-source/irp/evergreen-irp-final-modeling-results-2023.pdf?sfvrsn=7dd208d8_1

[15] Evergreen Integrated Resource Plan: Final Modeling Results: https://www.nspower.ca/docs/default-source/irp/evergreen-irp-final-modeling-results-2023.pdf?sfvrsn=7dd208d8_1

- Reliability Plan: Five-Year Forecast 2025-2029[16]

The following list of key assumptions and data points were validated with the Project Management and Technical Committees:

- The Net Zero 2035 and Current Policy and Trends together define the baseline scenario for 2035.
- Timelines for coal retirement and gas and heavy fuel oil (HFO) addition remain unchanged, with no adjustments in capacity resulting from coal retirements.
- Transmission upgrade plans and intertie assumptions.
- Incorporation of large load (e.g., hydrogen production facilities) and generation interconnection requests into base case development.

Generation Fuel Mix – Installed and Planned Capacity

Table 2-4 shows the installed and planned capacity of Nova Scotia's generation fuel mix.

Table 2-4 Nova Scotia Generation Fuel Mix – Installed and Planned Capacity

Generating Type	Current Installed Capacity (MW)	Additional Capacity Planned (MW)	Total Planned Capacity in 2035 (MW)
Hydro	500	0	500
Steam & Combustion Type	1800	600	2,400
Combined Cycle	150	0	150
Others – Independent power producers (IPP)	100	0	100
Onshore Wind	700	1,400	2100
Offshore Wind	0	0	0
Solar	0	100	100
BESS	0	400	400
Total	**3,250**	**2,500**	**5,750**

Planned Transmission Projects and In-Service Timeline

Table 2-5 presents the planned transmission projects, including in-service dates for the Nova Scotia transmission system.

Table 2-5 Nova Scotia Planned Transmission Projects

Project Name	Description	Planned In-Service Date
Western Valley Transmission System	L-5531 (13V-Gulch to 15V-Sissiboo)	Over a 15-year transmission planning horizon
	L-5532 (13V-Gulch to 3W-Big Falls)	
	L-5535 (15V-Sissiboo to 9W-Tusket)	

[16] Reliability Plan: Five-Year Forecast 2025-2029: https://www.nspower.ca/docs/default-source/pdf-to-upload/20241220-nspi-to-nsuarb-five-year-reliability-plan.pdf

Project Name	Description	Planned In-Service Date
	L-5541 (3W-Big Falls to 50W-Milton)	
NB-NS Interprovincial Transmission Line - Stage 1	New 345 kV line from Salisbury, NB to Onslow, NS.	2027-2028

Generation Retirement Schedules

Full retirement of coal by 2030 was incorporated across all scenarios.

2.3.3.1.3 Prince Edward Island

The following documents were reviewed to prepare the assumptions of the PEI transmission system model:

- Ten-Year PEI Transmission Outlook – 2025[17]
- Maritime Electric Press Release December 18, 2024[18]
- Supplemental Capital Budget Request Application – On-Island Capacity for Security of Supply Project filed December 18, 2024[19]

The following list of key assumptions and data points were validated with the Project Management and Technical Committees:

- Considerations for reactive power support in Eastern and Western PEI.
- Assumptions regarding import limit from NB Power via the NB–PEI Interprovincial Transmission Line.
- Solar and wind generation capacity.

Generation Fuel Mix – Installed and Planned Capacity

Table 2-6 shows the installed and planned capacity of the PEI generation fuel mix.

Table 2-6 Prince Edward Island Generation Fuel Mix – Installed and Planned Capacity

Generating Type	Current Installed Capacity (MW)	Additional Capacity Planned (MW)	Total Planned Capacity in 2035 (MW)
Thermal & Combustion Turbine	105	140	245
Hydro	0	0	0
Wind	200	130	330

[17] Ten-Year PEI Transmission Outlook – 2025: https://secure.maritimeelectric.com/mesa/Documents

[18] Maritime Electric Press Release December 18, 2024: https://www.maritimeelectric.com/about-us/media-releases/maritime-electric-applies-for-increased-on-island-generation/

[19] Supplemental Capital Budget Request Application – On-Island Capacity for Security of Supply Project filed December 18, 2024: scbr-request-for-the-on-island-capacity-for-security-of-supply-project-filed-december-18-2024.pdf

Generating Type	Current Installed Capacity (MW)	Additional Capacity Planned (MW)	Total Planned Capacity in 2035 (MW)
Offshore Wind	0	0	0
Solar	70	160	230
BESS	0	25	25
Total	**375**	**455**	**830**

Planned Transmission Projects and In-Service Timeline

Table 2-7 presents the planned transmission projects, including in-service date for the PEI transmission system.

Table 2-7 Prince Edward Island Planned Transmission Projects

Project Name	Description	Planned In-Service Date
NB–PEI Interprovincial Transmission Line	Proposed new line from Memramcook, NB, to Borden, PEI.	2029–2030
Y-119	Y-119 line build	2025-2027
Y-101 and Y-103	Lines Y-101 and Y-103 rebuilds	2026-2028
Rebuild Projects 1	T-1	2029-2030
Rebuild Projects 2	T-15	2029-2030
Rebuild Projects 3	Y-107	2030

Generation Retirement Schedules

Borden Generating Station Combustion Turbine T1 and T2 have anticipated retirement dates of 2031 and 2033, respectively and are expected to be replaced by 60 MW of thermal generation by 2035.

2.3.3.1.4 Newfoundland and Labrador

Stantec used the Newfoundland and Labrador PSS®E 2035 winter system model (2025 series) supplied by Newfoundland and Labrador Hydro as the base case for the hosting capacity studies, without any modifications to the generation dispatch or planned transmission projects.

3 2035 Hosting Capacity Results

Hosting capacity refers to the maximum generation that can be injected at a POI without significant upgrades under specified conditions. Stantec utilized an in-house software tool alongside PSS®E to evaluate each POI's capacity. The analysis included system normal (N-0) and single contingencies (N-1) up to five busses away from the POI.

The results offer a high level assessment of available capacity at each location and indicate which upgrades (if any) could raise that capacity. The following sections present the 2035 hosting capacity results by province, including detailed tables for each evaluated POI, their limiting constraints, and any applied upgrades.

3.1 New Brunswick

Table 3-1 shows the hosting capacity results for the NB system. NB's 345 kV network shows a high hosting capacity at certain sites – up to 925 MW injection at the Eel River 345 kV substation – whereas the studied 138 kV POI is more constrained (285 MW). Limitations are primarily on 138 kV transmission lines near the POI. Notably, an upgrade of the Bathurst–Eel River 230 kV line (thermal capacity increase to 814 MVA) enables Bathurst to host 810 MW.

Table 3-1 2035 Hosting Capacity Results – New Brunswick

Location	Point of Interconnection	Point of Interconnection Bus Voltage (kV)	Maximum Injection Capacity (MW)
Saint-André/ Grand Falls	Grand Falls Substation	138	285
Eel River	Eel River Substation	345	925
Bathurst*	Bathurst Substation	345	810
Saint John*	Coleson Cove Substation	345	585
Salisbury*	Salisbury Substation	345	485
Keswick	Keswick Substation	345	545

* POIs identified in Phase I

3.2 Nova Scotia

Table 3-2 shows the hosting capacity results for the NS system. NS's hosting capacity is moderate at most sites, particularly at proposed 230 kV POIs in Cape Breton and northern NS, where limits range from 115 MW to 135 MW. A much higher capacity is found near Halifax at Lakeside substation: up to 505 MW. The limiting elements for many NS locations are the main transmission corridors (e.g. the Onslow–Hopewell 345 kV line or related 230 kV lines), which serve as the backbone for moving power from these POIs[20]. This indicates that beyond a few hundred MW, major transmission upgrades, such as reinforcing the 345 kV backbone or adding new high-capacity paths, would be needed to integrate more wind in NS.

[20] NS has several Remedial Action Schemes that were not modeled in the study cases.

Table 3-2 2035 Hosting Capacity Results – Nova Scotia

Location	Point of Interconnection	Point of Interconnection Bus Voltage (kV)	Maximum Injection Capacity (MW)
Lingan (Sydney)*	Lingan 88S Substation	230	135
Port Hastings	Port Hastings 3C Substation	230	115
Trenton (New Glasgow)	Trenton 50N Substation	138	175
Lakeside (Halifax)*	Lakeside 103H Substation	138	505
Tusket	Tusket 9W Substation	138	210
Guysborough*	Guysborough Bus	230	115

* POIs identified in Phase I

3.3 Prince Edward Island

Table 3-3 shows the hosting capacity results for the PEI system. Prince Edward Island can accommodate significant additional generation injection in the central region: 350 MW at West Royalty substation, limited by 138 kV lines to Borden and Bedeque. In contrast, eastern PEI's Church Road substation was initially limited to ~40 MW due to a 69 kV step-down transformer constraint. After upgrading that transformer and several 69 kV lines (Church Road–Dingwells Mills and Georgetown–Lorne Valley) to higher capacity, the Church Road POI can support ~95 MW. The Sherbrooke substation in western PEI can host about 200 MW, limited by the 138 kV network to Bedeque and Sherbrooke itself.

Table 3-3 2035 Hosting Capacity Results – Prince Edward Island

Location	Point of Interconnection	Point of Interconnection Bus Voltage (kV)	Maximum Injection Capacity (MW)	Limiting Transmission Element	Contingency (N-1 System Condition)	Additional Upgrades
Sherbrooke*	Sherbrooke Substation	138	200	Bedeque - Sherbrooke (138 kV)	Borden - Sherbrooke (138 kV)	
West Royalty	West Royalty Substation	138	350	Borden - Bedeque (138 kV)	Bedeque - West Royalty (138 kV)	
Church Road*	Church Road Substation	138	40	Church Road 138/69 kV Transformer	Church Road - West Royalty Tap (138 kV)	
			95	Church Road - Dingwell Mills (69 kV)	SC (Sherwood) Tap - West Royalty Tap (138 kV)	1. Church Road – Dingwells Mills (69 kV): thermal rating upgraded from 80 MVA to 122 MVA

Location	Point of Interconnection	Point of Interconnection Bus Voltage (kV)	Maximum Injection Capacity (MW)	Limiting Transmission Element	Contingency (N-1 System Condition)	Additional Upgrades
						2. Georgetown Tap – Lorne Valley (69 kV): thermal rating upgraded from 80 MVA to 122 MVA
						3. Church Road 138/69 kV Transformer: rating upgraded from 75 MVA to 150 MVA

* POIs identified in Phase I

3.4 Newfoundland and Labrador

Table 3-4 shows the hosting capacity results for the NL system. As the transmission system is isolated in some areas and stronger in other areas, the results are varied. On the eastern end of the province, the Come By Chance substation can reach approximately 720 MW with upgrades (230 kV lines and transformers uprated to ~814 MVA). Oxen Pond (near St. John's) similarly reached 720 MW when system support was exhausted. In western Newfoundland, the Massey Drive substation is constrained by long 138 kV lines – even after upgrading the critical lines (Bottom Brook–Massey Drive 230 kV and Indian River–Springdale 138 kV), the maximum injection is about 280 MW. These results suggest that large offshore wind injections in NL would require substantial system reinforcements and operational adjustments.

Table 3-4 2035 Hosting Capacity Results – Newfoundland and Labrador

Location	Point of Interconnection	Point of Interconnection Bus Voltage (kV)	Maximum Injection Capacity (MW)
Come by Chance*	Come by Chance Substation	230	720
St. John's*	Oxen Pond Substation	230	720
Corner Brook*	Massey Drive Substation	230	280

* POIs identified in Phase 1

4 2035 Grid Integration Scenarios

This section outlines the grid integration scenarios—C1 (Domestic-only), C2 (Domestic + Export), C3 (Domestic + Hydrogen), and C4-1/C4-2 (All Markets)—for deploying offshore wind across the Atlantic provinces, providing context and assumptions for each.

With the baseline hosting capacities determined for individual POIs, the offshore wind grid integration scenarios were developed to examine the aggregate deployment of offshore wind across the Atlantic provinces and the potential transmission system upgrades that would be required to support the integration. The onshore POIs were selected based on the proximity to the offshore wind areas and the available capacities observed in the hosting capacity study. In some cases, additional large loads (such as hydrogen production facilities) were included to increase the demand for generation to create various future scenarios. The preliminary transmission planning scenarios were defined in collaboration with Net Zero Atlantic and the Project Management and Technical Committees and aligned with the broader market analysis outcomes from Phases 1 and 2 of the Project.

Scenario modeling from earlier phases indicated that Atlantic Canada could feasibly integrate up to ~1 GW of offshore wind for domestic needs by 2035, and as much as ~7.5 GW when including exports and high hydrogen load forecasts.

Building on those findings, the 2035 offshore wind grid integration scenarios assume incremental offshore wind injections from 1,000 MW up to 7,500 MW and consider the necessary transmission upgrades and new loads (e.g. large hydrogen electrolyzers) for each case. The hosting capacity results provide a preliminary indication of where this wind generation could interconnect and what system reinforcements may be required.

Figure 4.A to Figure 4.D illustrate the geographical distribution of offshore wind capacity for each scenario based on the Phase 2 results across NB, NS, PEI, and NL.

See next page for figure

Figure 4.A Scenario C1 – Offshore Wind Capacities based on Phase 2 Results

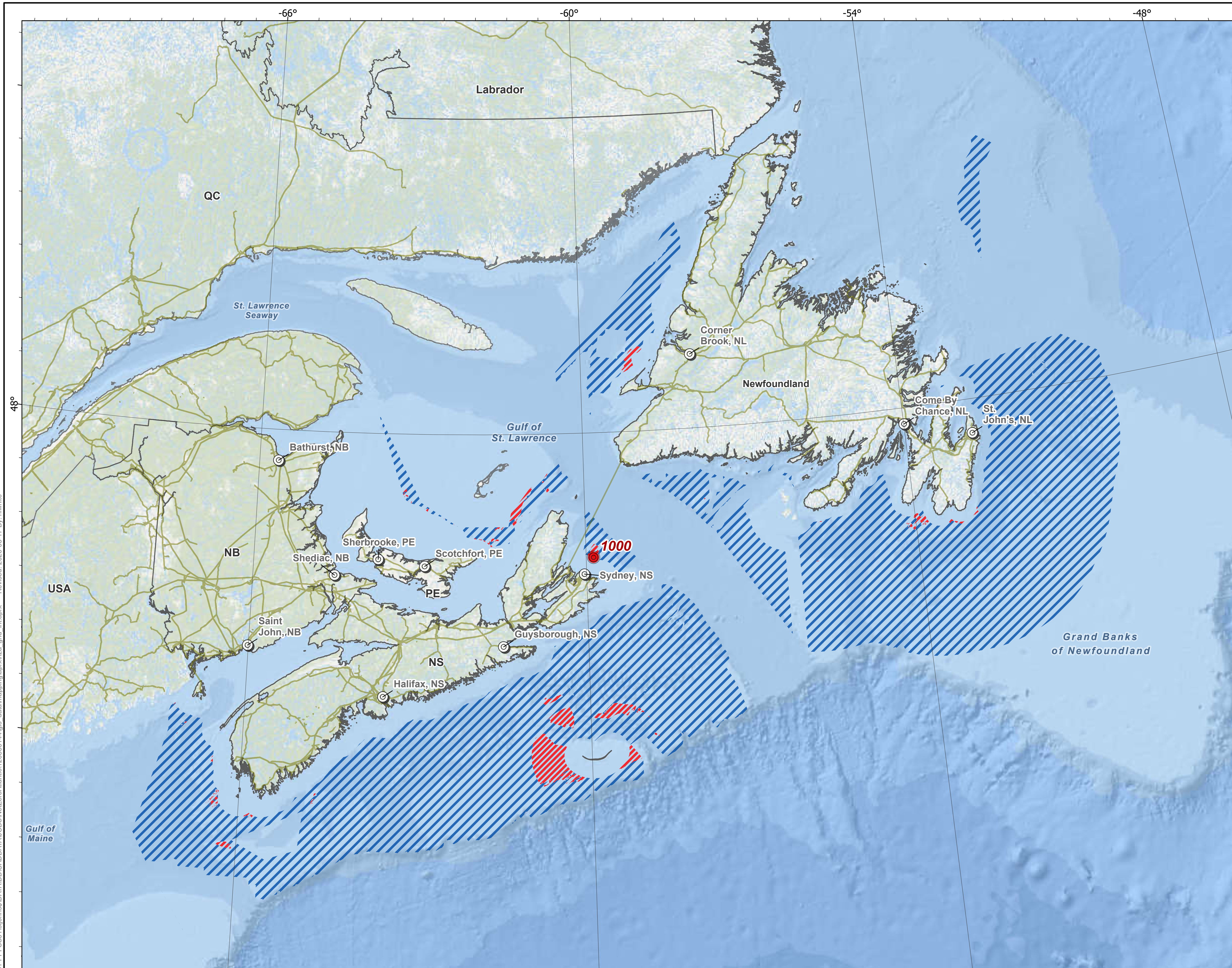


Figure No.
4.A

Title
Grid Integration 2035 Scenario C1

Client/Project
126560144_307

Net Zero Atlantic
Offshore Wind Resource Potential Study

Project Location
Prepared by NW on 2025-09-04

Atlantic Canada

N

0 100 200 Kilometers
(At original document size of 11x17)
1:5,500,000

Legend

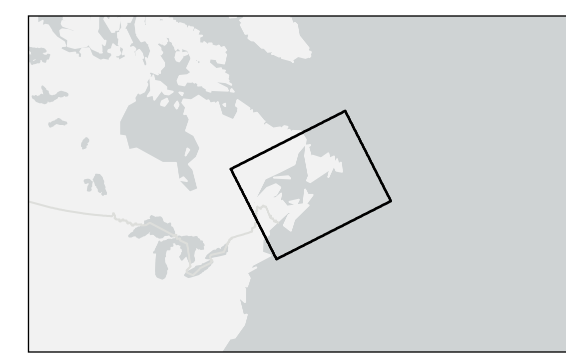
- Point of Interconnection
- Transmission Line

Turbine Approximate Deployment Locations[3]

- Fixed Platform
- Floating Platform
- Buildable Area - Fixed Platform
- Buildable Area - Floating Platform

Installed Capacity (MW)

- 0 - 100
- 101 - 500
- 501 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 2500
- 2501 - 3000
- 3001 - 3500



Notes
1. Coordinate System: WGS84 Azimuthal Equidistant Projection, Central Meridian -62
2. Data Sources: Stantec; Windsim / NASA MERRA reanalysis dataset
3. Turbine locations do not indicate specific deployment sites
4. Background: NRCan CanVec; OpenStreetMap; Statistics Canada; Basemap Service Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, CHS, Esri, GEBCO, Garmin, NaturalVue

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Figure 4.B Scenario C2 – Offshore Wind Capacities based on Phase 2 Results

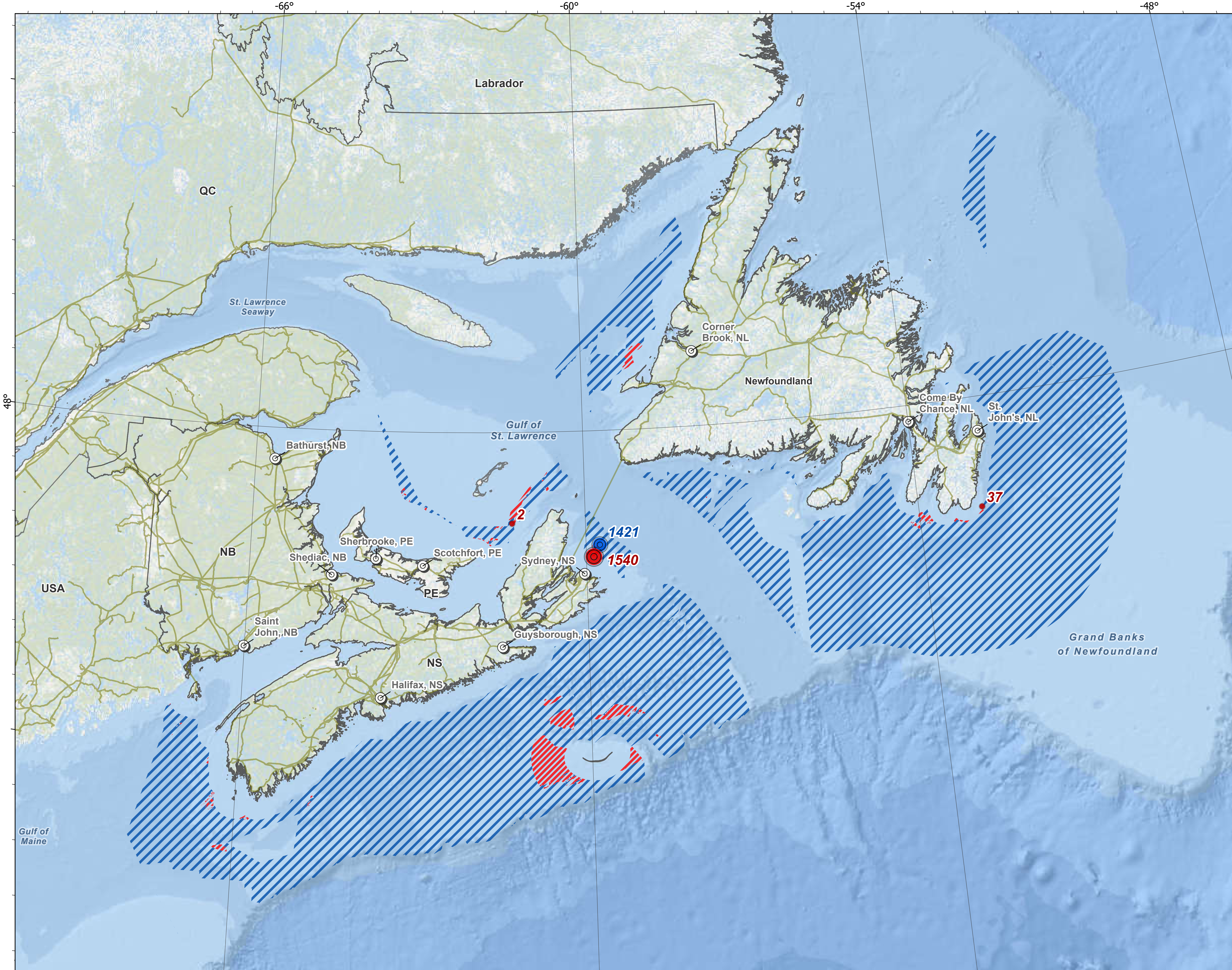

Figure No.
4.B

Title
Grid Integration 2035 Scenario C2

Client/Project | 126560144_307

Net Zero Atlantic
Offshore Wind Resource Potential Study

Project Location | Prepared by NW on 2025-09-04

Atlantic Canada

N

0 | 100 | 200 Kilometers
(At original document size of 11x17)
1:5,500,000

Legend

- Point of Interconnection
- Transmission Line

Turbine Approximate Deployment Locations[3]

- Fixed Platform
- Floating Platform
- Buildable Area - Fixed Platform
- Buildable Area - Floating Platform

Installed Capacity (MW)

- 0 - 100
- 101 - 500
- 501 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 2500
- 2501 - 3000
- 3001 - 3500

Notes
1. Coordinate System: WGS84 Azimuthal Equidistant Projection, Central Meridian -62
2. Data Sources: Stantec; Windsim / NASA MERRA reanalysis dataset
3. Turbine locations do not indicate specific deployment sites
4. Background: NRCan CanVec; OpenStreetMap; Statistics Canada; Basemap Service Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, CHS, Esri, GEBCO, Garmin, NaturalVue

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Figure 4.C Scenario C3 – Offshore Wind Capacities based on Phase 2 Results

Figure No.

4.C

Title

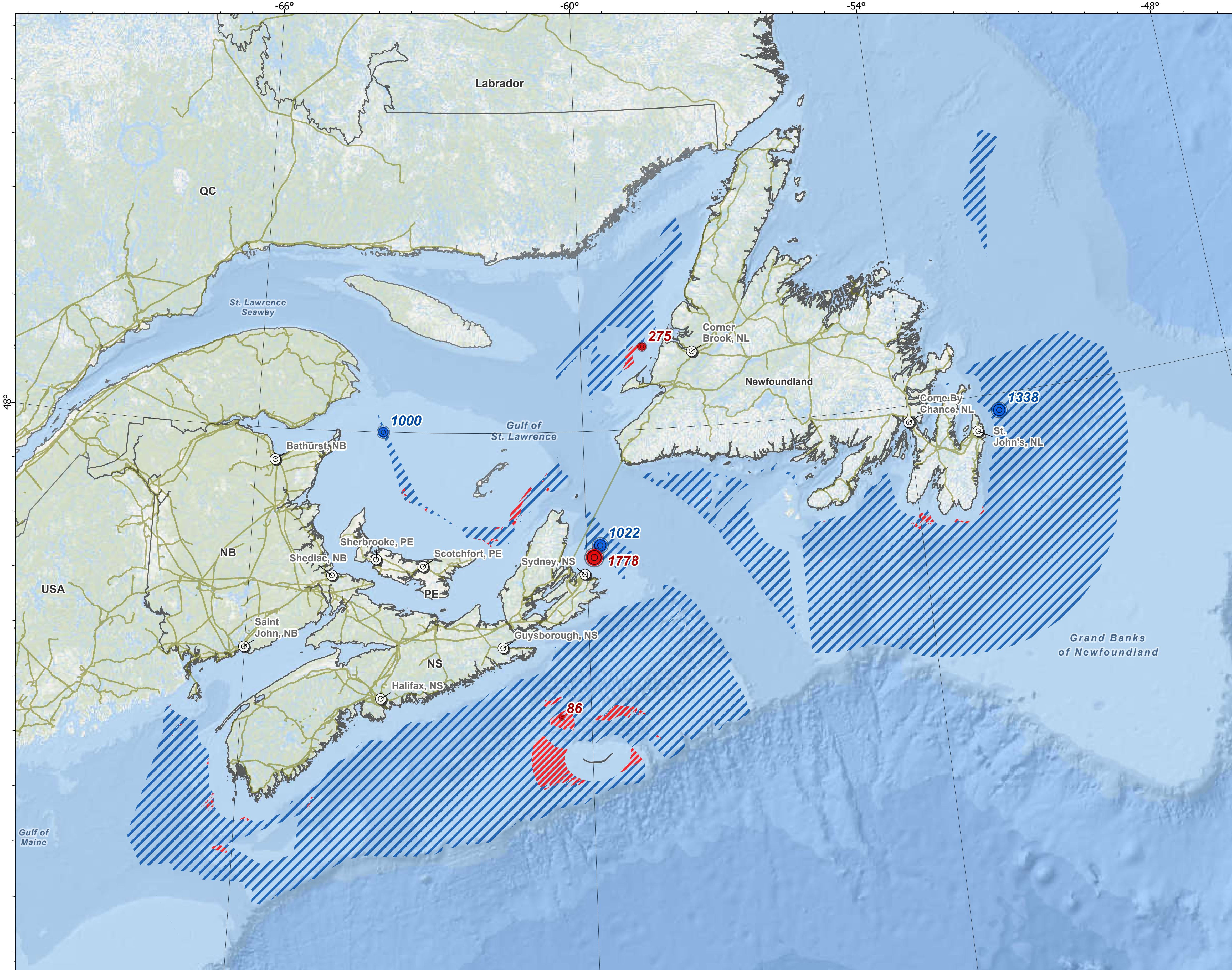
Grid Integration 2035
Scenario C3

Client/Project 126560144_307

Net Zero Atlantic
Offshore Wind Resource Potential Study

Project Location Prepared by NW on 2025-09-04

Atlantic Canada



0 100 200 Kilometers
(At original document size of 11x17)
1:5,500,000

Legend

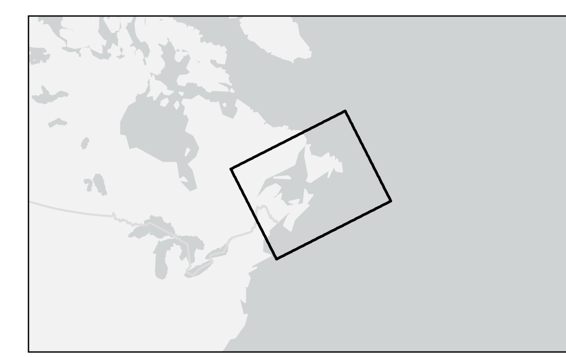
- Point of Interconnection
- Transmission Line

Turbine Approximate Deployment Locations[3]

- Fixed Platform
- Floating Platform
- Buildable Area - Fixed Platform
- Buildable Area - Floating Platform

Installed Capacity (MW)

- 0 - 100
- 101 - 500
- 501 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 2500
- 2501 - 3000
- 3001 - 3500



Notes

1. Coordinate System: WGS84 Azimuthal Equidistant Projection, Central Meridian -62
2. Data Sources: Stantec; Windsim / NASA MERRA reanalysis dataset
3. Turbine locations do not indicate specific deployment sites
4. Background: NRCan CanVec; OpenStreetMap; Statistics Canada; Basemap Service Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, CHS, Esri, GEBCO, Garmin, NaturalVue

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Figure 4.D Scenario C4 – Offshore Wind Capacities based on Phase 2 Results

Figure No.
4.D

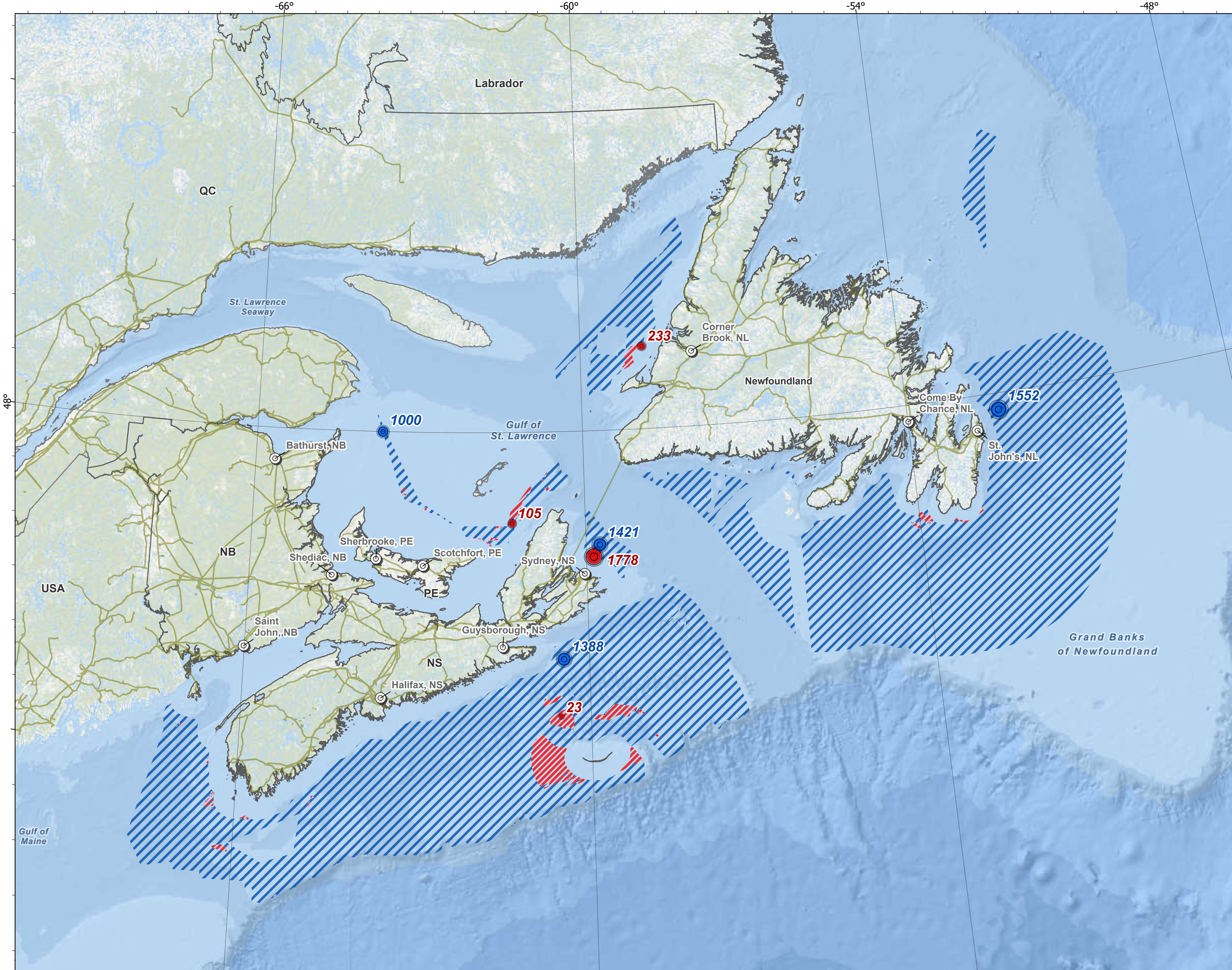
Title
Grid Integration 2035 Scenario C4

Client/Project 126560144_307

Net Zero Atlantic
Offshore Wind Resource Potential Study

Project Location Prepared by NW on 2025-09-04

Atlantic Canada



N

0 100 200 Kilometers
(At original document size of 11x17)
1:5,500,000

Legend

- Point of Interconnection
- Transmission Line

Turbine Approximate Deployment Locations[3]

- Fixed Platform
- Floating Platform
- Buildable Area - Fixed Platform
- Buildable Area - Floating Platform

Installed Capacity (MW)

- 0 - 100
- 101 - 500
- 501 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 2500
- 2501 - 3000
- 3001 - 3500

Notes
1. Coordinate System: WGS84 Azimuthal Equidistant Projection, Central Meridian -62
2. Data Sources: Stantec; Windsim / NASA MERRA reanalysis dataset
3. Turbine locations do not indicate specific deployment sites
4. Background: NRCan CanVec; OpenStreetMap; Statistics Canada; Basemap Service Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, CHS, Esri, GEBCO, Garmin, NaturalVue

Stantec

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The offshore wind grid integration study scenarios developed based on the Phase 2 results are summarized in Table 4-1. Each row corresponds to a scenario case, including the total offshore wind capacity, the assumed offshore wind project locations (by province and area), the primary POIs for those projects, and the load assumptions. The “New Hydrogen Load” column indicates additional hydrogen production loads that are modeled on top of the baseline provincial demand in each scenario. If the entry is “None,” it means no extra hydrogen load was added beyond the normal projected growth for 2035.

Market Scenario Definitions[21]**:**

C1: Domestic-Only – Atlantic provinces build offshore wind mainly to supply their own demand, with minimal new export or external load. ~1,000 MW of offshore wind in NS (Sydney Bight) is added. No new hydrogen load is considered in this scenario. This represents a future where offshore wind development is limited to what the local grids can absorb to meet growing electrification loads and replace generation from retiring assets (e.g. replacing coal in NS). In the reference case, which modeled the same load growth trajectory and resource retirement schedule but without including planned offshore wind additions, this incremental energy need is met predominantly with onshore wind builds.

C2: Domestic + Export – A larger offshore wind buildout (~3,000 MW) concentrated in NS, exceeding local needs and thus targeting exports (e.g. via NB to New England). Phase 1 identified ~3 GW by 2035 as a level that would require opening export markets. Two offshore wind projects were identified in the Phase 2 analysis: Sydney Bight fixed foundation and Sydney Bight floating foundation in NS. However, additional discussions with Net Zero Atlantic and the Project Management and Technical Committees resulted in the replacement of the Sydney Bight floating area with the Middle Bank fixed-bottom wind area for this assessment.

Additional hydrogen load was not considered in this scenario. The focus for this scenario is on transmission reinforcement for export (e.g. strengthening NB–NS ties, Nova Scotia’s backbone) and operational strategies to handle surplus generation.

C3: Domestic + Hydrogen (Base Hydrogen) – Approximately 4,500 MW of offshore wind across multiple provinces, with the introduction of new hydrogen production loads (electrolyzers) regionally was identified in this scenario in the Phase 2 results. In this Base Hydrogen case, about 2.1 GW of electrolyzer load was added: ~823 MW in NS, 456 MW in NB, 821 MW in NL (PEI’s hydrogen load is negligible). Offshore wind sites include two in NS (Sydney Bight and Middle Bank), one in PEI (north shore, “C22”), and one in NL (near Corner Brook). This scenario stresses both generation and demand sides, assessing if offshore wind could meet a new industry’s needs without overloading the system.

C4: All Markets (Base Hydrogen + Export) – A high-development scenario featuring approximately 6,500 MW of offshore wind supplying domestic use, exports, and base-level hydrogen simultaneously. Offshore wind is distributed across NS offshore wind areas (including Sydney Bight, Middle Bank, Canso Bank, French Bank), PEI (north shore), and NL (St. John’s). Hydrogen load remains at the base 2.1 GW

[21] Full portfolio details for each scenario are included in the Market Opportunities report, accessible at https://netzeroatlantic.ca/research/atlantic-canada-offshore-wind-grid-integration-and-transmission-study

level as in C3. This scenario envisions Atlantic Canada as a major clean energy hub by 2035, requiring maximal use of interties and robust grid upgrades to accommodate power flows.

C4: All Markets (High Hydrogen + Export) – A variant of C4 with 7,500 MW of offshore wind and a much larger hydrogen demand (~5.36 GW). This adds another offshore wind site in NB (a floating wind farm in Bathurst) to the C4 mix. Hydrogen loads nearly double: ~1,884 MW in NS, 1,246 MW in NB, 2,232 MW in NL. C4-High serves as a "stretch" case, used to identify the need for long-term reinforcements, such as potential HVDC links or 345 kV system upgrades, beyond the maximal use of interties and robust grid upgrades required to accommodate these elevated power flow levels.

Table 4-1 Summary of 2035 Offshore Wind Scenarios

PSSE Scenario Name	Market Opportunity Report Scenario Name	Offshore Wind Capacity (MW)	Offshore Wind Locations[22]	POIs	Provincial Loads Modeled	New Hydrogen Load (MW)	Generation Mix (Dispatch Hour)
2035 Scenario C1-1	C1 Domestic-only Market	1,000	NS: Sydney Bight Fixed	Woodbine Substation	Market Opportunity Report Scenario Forecasts[23]	None	High offshore wind, high thermal, low onshore wind
2035 Scenario C1-2	C1 Domestic-only Market	1,000	NS: Sydney Bight Fixed	Woodbine Substation	Market Opportunity Report Scenario Forecasts[23]	None	High offshore wind, low thermal, high onshore wind
2035 Scenario C1-3	C1 Domestic-only Market	1,000	NS: Sydney Bight Fixed	Woodbine Substation	Baseline (from Hosting Capacity case)	None	Hosting Capacity generation dispatch
2035 Scenario C2-1	C2 Domestic + Export Markets	3,000	NS: Sydney Bight Fixed NS: Middle Bank Fixed	Woodbine & Lakeside Substations	Market Opportunity Report Scenario Forecasts[23]	None	High offshore wind, high thermal, low onshore wind
2035 Scenario C2-2	C2 Domestic + Export Markets	3,000	NS: Sydney Bight Fixed NS: Middle Bank Fixed	Woodbine and Lakeside Substations	Market Opportunity Report Scenario Forecasts[23]	None	High offshore wind, low thermal, high onshore wind
2035 Scenario C3-1	C3 Domestic + Base Hydrogen	4,500	NS: Sydney Bight Fixed NS: Middle Bank Fixed PEI: C22 Fixed (North of PE) NL: C25 Fixed (Corner Brook) NL: C4 Floating (St. John's)	NS: Woodbine & Lakeside PEI: West Royalty 138 kV Tap NL: Oxen Pond Substation	Market Opportunity Report Scenario Forecasts[23 24]	NS: 823 NL: 821 NB: 456 Total: 2,099	High offshore wind, with added hydrogen load

[22] In this assessment, offshore wind projects with less than 100 MW of installed capacity are screened out, as it was assumed that developers would not pursue projects of this small scale. Installed capacity, rather than generation—which can fluctuate and is modeled by PLEXOS at a specific hour was used as the screening criterion.
[23] Load scenarios were designed in Phase 1 and have been consistent throughout the full study. Additional details on these load scenarios can be found in the Market Opportunities report, accessible at https://netzeroatlantic.ca/research/atlantic-canada-offshore-wind-grid-integration-and-transmission-study
[24] For scenarios C3-1, C4-1, and C4-2, the Market Opportunity Scenario forecast was modeled as provincial load, as the forecasted demand profile was moderate as compared to the earlier market scenario.

PSSE Scenario Name	Market Opportunity Report Scenario Name	Offshore Wind Capacity (MW)	Offshore Wind Locations[22]	POIs	Provincial Loads Modeled	New Hydrogen Load (MW)	Generation Mix (Dispatch Hour)
2035 Scenario C4-1	C4 All Markets (Domestic, Base Hydrogen and Exports)	6,500	NS: Sydney Bight Fixed NS: Middle Bank Fixed NS: Canso Bank Floating NS: French Bank Floating PEI: C22 Fixed (North of PEI) NL: C4 Floating (St. John's)	NS: Woodbine & Lakeside PEI: West Royalty 138 kV Tap NL: Oxen Pond Substation	Market Opportunity Report Scenario Forecasts[23 24]	NS: 823 NL: 821 NB: 456 Total: 2,099	High offshore wind, with base hydrogen and export
2035 Scenario C4-2	C4 All Markets (Domestic, High Hydrogen and Exports)	7,500	NS: Sydney Bight Fixed NS: Middle Bank Fixed NS: Canso Bank Floating PEI: C22 Fixed (North of PE) NL: C4 Floating (St. John's) NL: C25 Fixed (Corner Brook) NB: C24 Floating (Bathurst)	NS: Woodbine & Lakeside PEI: West Royalty 138 kV Tap NL: Oxen Pond & Massey Drive Substations	Market Opportunity Report Scenario Forecasts[23 24]	NS: 1,884 NL: 2,232 NB: 1,246 Total: 5,362	High offshore wind, with elevated hydrogen and export

Alignment with Phase 1: The scenario design and offshore wind integration levels across each of the scenarios evaluated in the power flow model are consistent with the Phase 1 modeling as profiled in the Market Opportunities report.

Offshore Wind Dispatch and Resource Mix: In each scenario, a representative dispatch hour from the Phase 2 production cost and resource adequacy analysis was analyzed (typically a high wind dispatch period in winter, when loads are high – a critical stress condition due to electrified heating). The results from the PLEXOS production cost modelling from Phase 2 provided generation dispatch snapshots for the selected hours, which were applied to the power flow cases. This allowed for consistency between the PLEXOS market simulations in Phases 1 and 2 and the transmission system analysis carried out in PSS®E as part of Phase 3. Summaries of generation by type in each scenario show the evolving resource mix. For instance, in C1 (domestic) scenarios, offshore wind primarily replaces coal and oil, while certain thermal generation units remain online to support system reliability and stability. In C4, offshore wind and onshore wind provide the bulk of energy with minimal fossil generation, requiring careful stability management.

By 2035, the transmission plan anticipates the potential integration of up to 7.5 GW of offshore wind generation. In conjunction, up to 5.36 GW of new electrolyzer load may be introduced to utilize this energy. These planning assumptions highlight both the scale of clean energy development under consideration and the corresponding need to address evolving transmission system requirements.

5 Development of Grid Integration Study Cases (Phase 3 – 2035)

In the Phase 3 transmission planning studies, eight detailed 2035 grid integration cases (C1-1, C1-2, C1-3, C2-1, C2-2, C3-1, C4-1, and C4-2) were modeled to examine how increasing levels of offshore wind combined with exports and new hydrogen production loads could be integrated into Atlantic Canada's grid.

The hosting capacity analysis results provided in this report served as a starting point – the results highlighted the immediate bottlenecks and the scale of transmission improvements needed. Building on this, power flow and transient stability studies were conducted for each of the grid integration scenarios to identify proposed transmission system upgrades, reinforcements, and operational strategies necessary for reliable offshore wind integration.

5.1 2035 Scenario C1-1: Domestic – Only (High Thermal, Low Onshore Wind)

Scenario C1-1 is a sub-case of the Domestic-Only scenario (Phase 1's "C1" market) where the Atlantic provinces build offshore wind primarily to serve new electrification-driven demand, aiming for net-zero by 2035. This scenario reflects a winter evening period with elevated electricity demand, during which offshore wind output is high, onshore wind contribution is limited, and thermal generation—including oil peakers and biomass—is dispatched at relatively high levels. The conditions illustrate a system state where dispatchable resources continue to play a role in maintaining reliability, even with substantial renewable generation online.

- **Offshore Wind Deployment:** 1,000 MW offshore wind in Nova Scotia's Sydney Bight area, interconnecting at the Sydney (Woodbine 345 kV) substation. No offshore wind in other provinces is included in this case. [25]
- **Dispatch Hour:** Phase 2 Market Opportunities results for January 1, 2035, 17:00 was chosen for maximum offshore wind output[26] (~87% utilization) coincident with high daily load (load that day peaks in the evening) and below average onshore wind generation, particularly in Nova Scotia. Offshore wind is dispatching 872 MW out of 1,000 MW.
- **Generation Mix:** In the Market Opportunities results for the selected dispatch hour, NS's offshore wind and hydro supply a large share of the load, but thermal units are still contributing ~15–20% for reliability. In New Brunswick, 396 MW of oil-fired simple-cycle combustion turbines are dispatched to meet local demand and to support firm exports to Prince Edward Island. All coal-fired units in Nova Scotia are assumed to be retired in alignment with 2035 decarbonization targets, and most

[25] Note that by 2035 in the C1: Domestic Markets only scenario, only one offshore wind project site has been selected by the model, and that site (at Sydney Bight) interconnects in Nova Scotia – offshore wind is modeled as integrating later in the study horizon in the other Atlantic Provinces in this scenario.

[26] This Scenario C1-1 dispatch hour, along with all subsequent scenario hours, was selected to represent conditions of maximum offshore wind output.

natural gas units are not operating. Onshore wind contributes a moderate 1,321 MW across the region, and the Point Lepreau nuclear facility (597 MW) remains a key source of supply for New Brunswick and plays a role in supporting interprovincial interconnections.

- **System Integration:** The simulation shows that even with significant offshore wind build-out, some thermal generation remains necessary for reliability during critical periods. The system benefits from a diverse resource mix, with offshore wind, hydro, and dispatchable thermal resources working together to meet demand and maintain reliability.
- **Transmission Coordination:** Efficient integration of offshore wind requires coordinated transmission investments to minimize curtailment and maximize utilization. Phase 1 highlights the importance of regional coordination and transmission upgrades, especially between Nova Scotia and New Brunswick, to fully realize offshore wind's benefits.

The total offshore wind build-out assumed for the C1-1 scenario is described in Table 5-1.

Table 5-1 C1-1 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2035 Scenario C1-1	C1 Domestic-only Market	NS: Sydney Bight Fixed	Sydney (Woodbine 345 kV Substation)	NS: High thermal generation and low onshore wind based on Market Opportunities results for January 1, 2035, 17:00	872	1,000

Notes:
1. Offshore wind values less than 100 MW in the Phase 2 results were not included in the PSS®E transmission planning studies.
2. PLEXOS figures are post-curtailment.[27]

Generation dispatch and loads for the selected hour are based on Market Opportunities results and presented in Table 5-2.

[27] Power flow models utilized delivered generation amounts to inform grid infrastructure needs and so leveraged post-curtailment data from the operational analysis carried out in previous phases of the project.

Table 5-2 C1-1 Generation Dispatch and Provincial Load from Market Opportunities Results

Generation/Load	Newfoundland and Labrador (MW)	New Brunswick (MW)	Nova Scotia (MW)	Prince Edward Island (MW)	Total (MW)
Gas - CCS	-	-	-	-	-
Gas - CCGT	46	79	546	-	671
Gas - CT	-	-	-	-	-
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-
Oil - SCCT	-	397	-	-	397
Oil - ST	-	-	113	-	113
Coal	-	-	-	-	-
Biomass	-	124	93	-	217
Nuclear	-	597	-	-	597
Hydro	1832	294	392	-	2518
Solar	-	-	-	-	-
Onshore Wind	30	708	346	237	1321
Offshore Wind	-	-	872	-	872
Storage	-	-	-	-	-
Provincial Load	1857	2802	2413	466	7538

These generation dispatches were modeled in PSS®E to closely match the selected PLEXOS dispatch hour, as illustrated in Figure 5.A. This stacked bar chart visualizes how different fuel types contribute to electricity generation across four Atlantic provinces—NL, NB, NS, and PEI for the selected hour in the 2035 Scenario C1-1 (Domestic-only Market). Each bar represents a fuel type, and the segments within each bar show how much each province contributes to that fuel's total dispatch.

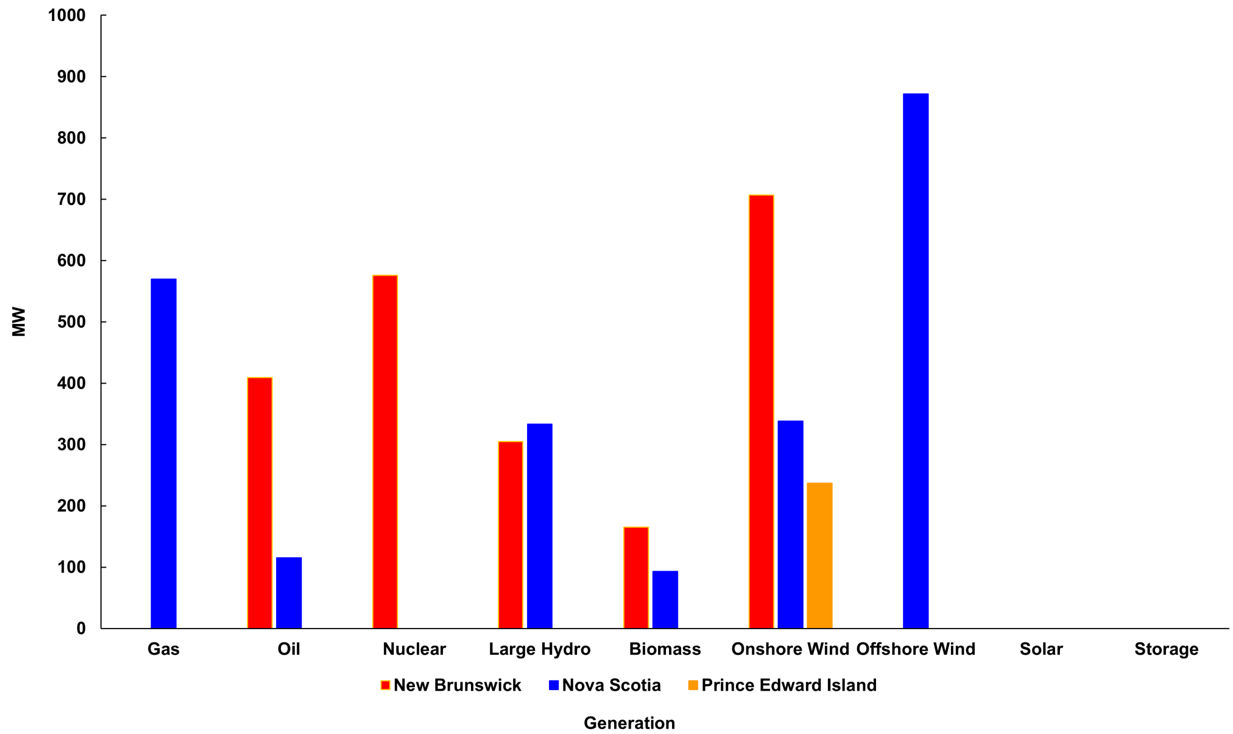

Figure 5.A   C1-1 Scenario – Generation Dispatch in PSS®E Case

Note:
The Newfoundland and Labrador system model was provided to Stantec as a separate PSS®E case, so all analyses have been performed independently for Newfoundland and Labrador-specific study scenarios.

Figure 5.B illustrates the electricity demand across the four provinces during the selected dispatch hour. It provides context for how generation resources are allocated to meet regional loads.

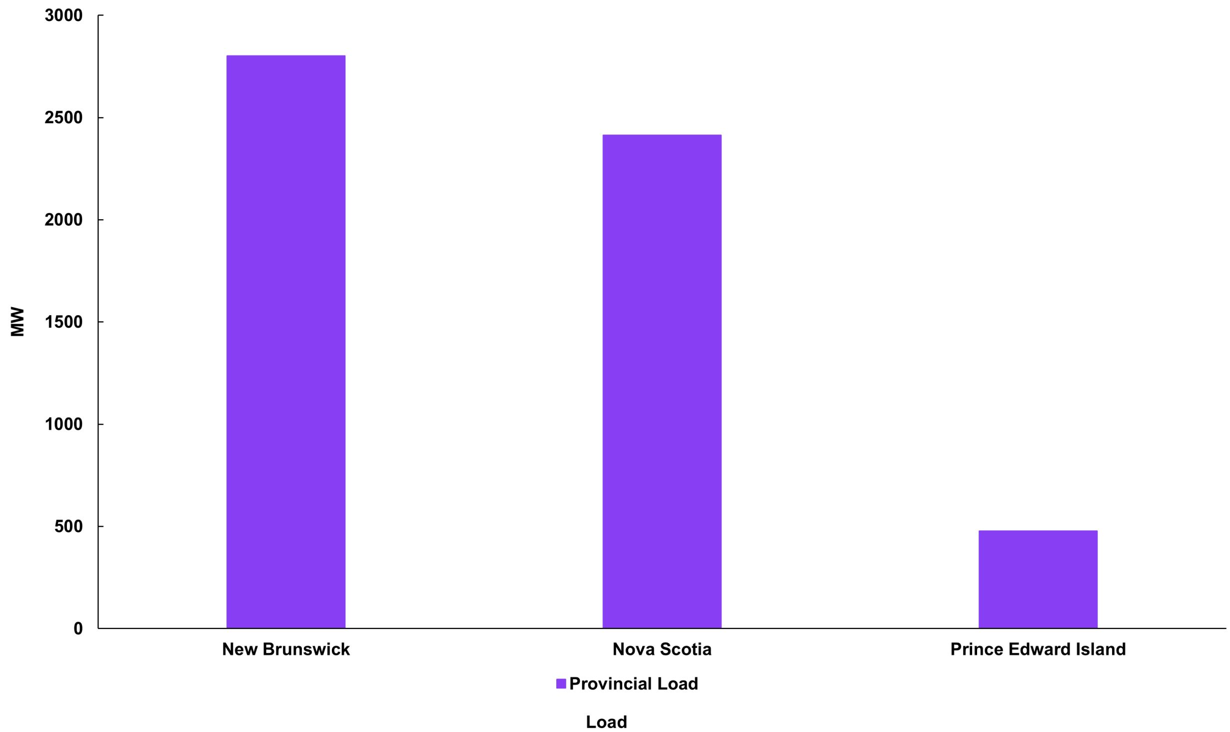

Figure 5.B C1-1 Scenario – Provincial Load Modeling

Scenario C1-1 builds on the Phases 1 and 2 findings by modeling a high offshore wind build-out to serve domestic electrification loads with dispatchable thermal resources providing reliability during peak periods. The scenario reflects the evolving resource mix and operational strategies needed to achieve net zero in the Atlantic Provinces, emphasizing the importance of offshore wind, system diversity, and transmission coordination.

5.2 2035 Scenario C1-2: Domestic – Only (Low Thermal, High Onshore Wind)

Scenario C1-2 is the second sub-scenario derived from the Domestic-only Market framework developed in Phases 1 and 2. This scenario explores a contrasting operational condition to C1-1, focusing on periods of low thermal generation and high onshore wind availability. It represents a system state where renewable resources, particularly onshore wind plays a dominant role in meeting regional electricity demand, while dispatchable thermal generation is minimized.

- **Offshore Wind Deployment:** Same as C1-1 – 1,000 MW at Sydney Bight (Woodbine 345 kV), providing the offshore wind component.
- **Dispatch Hour:** Phase 2 Market Opportunities results for January 6, 2035, 17:00 (winter evening), chosen for high offshore wind (875 MW) and exceptional onshore wind conditions. Thermal generation in NS and NB is at minimum economic levels in this hour (many units off or at idle).

- **Generation Mix:** The renewables dominate in this hour. Nova Scotia's onshore wind is over 1,540 MW (near maximum output), so combined with offshore wind (~876 MW), the majority of load is met by wind and hydro. NB's nuclear (597 MW) and biomass (~499 MW in NB) continue to provide steady output. Fossil generation is almost nil: NB uses an oil SCCT (~397 MW, presumably to support PEI's import) and a small amount of diesel on PEI (102 MW); NS has no coal or gas running. This scenario achieved an overall ~75% renewable supply. Hydro output was maximized to balance the system.
- **Transmission Coordination:** The increased reliance on variable renewable energy sources underscores the importance of transmission flexibility and regional coordination. As in C1-1, the interprovincial ties, especially between NS and NB, remain critical for balancing supply and demand and minimizing curtailment.

The total offshore wind build-out assumed for the C1-2 scenario is described in Table 5-3.

Table 5-3 C1-2 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2035 Scenario C1-2	C1 Domestic-only Market	NS: Sydney Bight Fixed	Sydney (Woodbine 345 kV Substation)	NS: Low thermal generation and high onshore wind based on Market Opportunities results for January 6, 2035, 17:00	875	1,000

Generation dispatch and loads for the selected hour are based on Phase 2 Market Opportunities results and presented in Table 5-4.

Table 5-4 C1-2 Generation Dispatch and Provincial Load from Market Opportunities results

Generation/ Load	Newfoundland and Labrador (MW)	New Brunswick (MW)	Nova Scotia (MW)	Prince Edward Island (MW)	Total (MW)
Gas - CCS	-	-	-	-	-
Gas - CCGT	-	-	-	-	-
Gas - CT	-	-	-	-	-
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	102	102
Oil - SCCT	-	397	16	98	511
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass	-	499	28	-	527
Nuclear	-	597	-	-	597
Hydro	2031	602	347	-	2980

Generation/ Load	Newfoundland and Labrador (MW)	New Brunswick (MW)	Nova Scotia (MW)	Prince Edward Island (MW)	Total (MW)
Solar	-	-	-	-	-
Onshore Wind	-	136	1543	37	1715
Offshore Wind	-	-	876	-	876
Storage	-	-	-	-	-
Provincial Load	2031	3064	2509	537	8141

Figure 5.C visualizes the modeled generation dispatch across provinces for the C1-2 scenario in PSS®E, showing the contribution of each fuel type and highlighting the dominance of offshore wind and hydro resources.

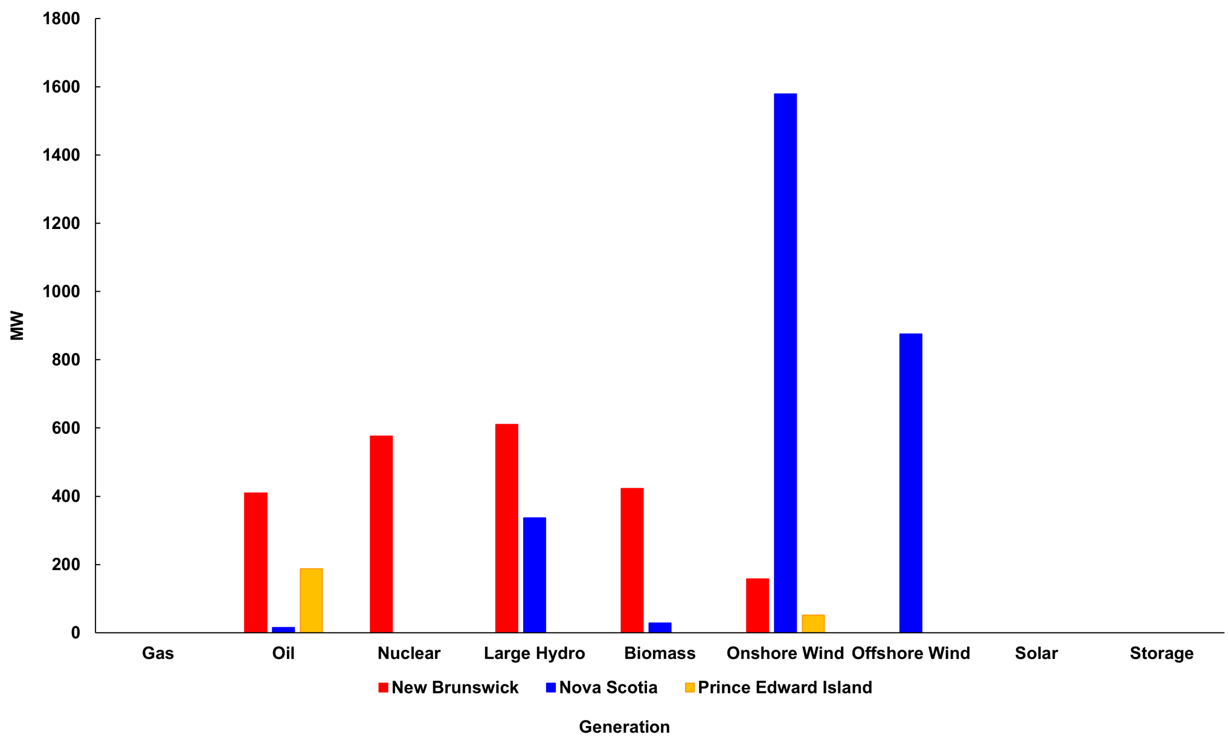

Figure 5.C C1-2 Scenario – Generation Dispatch in PSS®E Case

Figure 5.D illustrates the electricity demand across the three provinces during the selected dispatch hour. It provides context for how generation resources are allocated to meet regional loads.

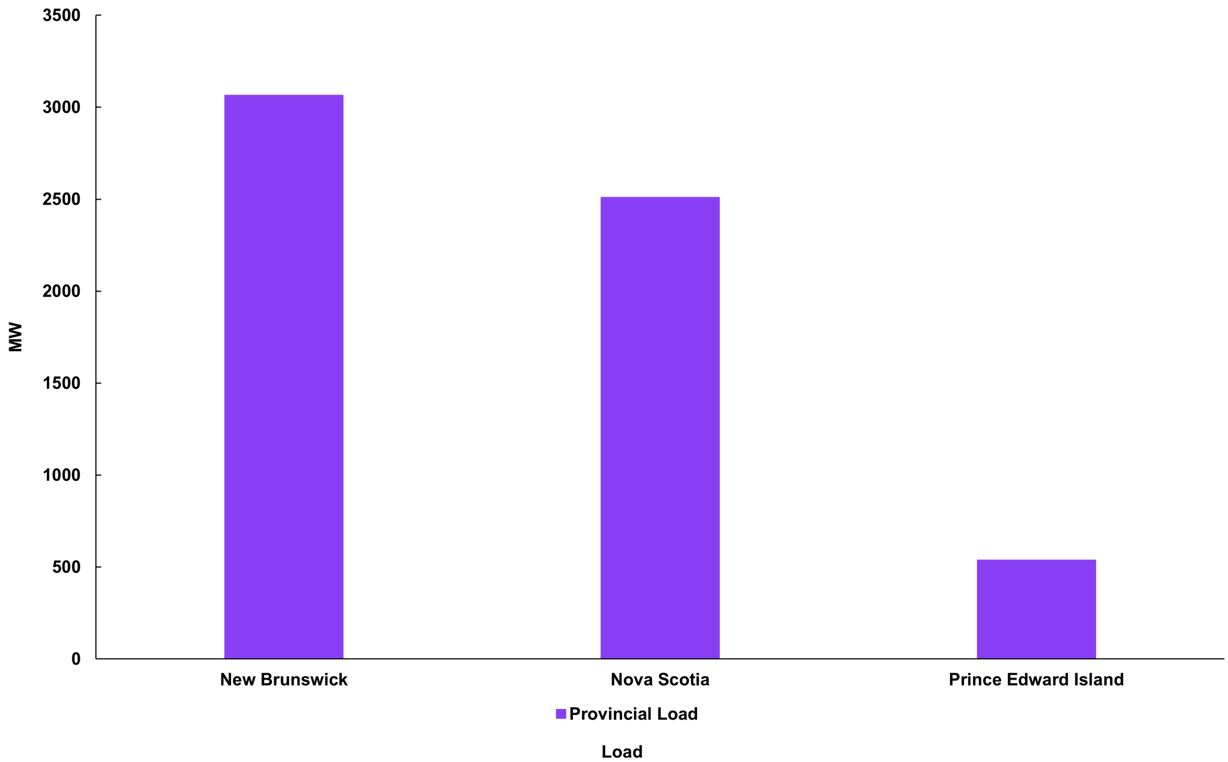

Figure 5.D C1-2 Scenario – Provincial Load Modeling

Scenario C1-2 illustrates a high-renewables operational state within the Domestic-only Market framework, emphasizing the role of onshore wind and hydro in meeting regional demand. While offshore wind continues to provide substantial support, the reduced reliance on thermal generation highlights the potential for deeper decarbonization. This scenario reinforces the importance of transmission infrastructure and regional coordination to ensure reliable and efficient integration of variable renewable resources.

5.3 2035 Scenario C1-3: Domestic – Only Market

Scenario C1-3 represents the Domestic-only market configuration for the 2035 planning horizon. It builds upon the base case generation dispatch used in the hosting capacity study, as discussed in Section 3, while maintaining offshore wind development levels similar to those in Scenarios C1-1 and C1-2. This scenario assumes no export commitments and focuses solely on meeting domestic electricity demand within the NB–NS–PEI region.

The intent of this scenario was to assess the impacts to the onshore system due to the injection of offshore wind, considering the generation dispatch from the hosting capacity study, to compare the results to the other generation dispatches considered in scenarios C1-1 and C-2.

Table 5-5 outlines the key parameters of the C1-3 scenario.

Table 5-5 C1-3 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2035 Scenario C1-3	C1 Domestic-only Market	NS: Sydney Bight Fixed	Sydney (Woodbine 345 kV Substation)	Similar to hosting capacity	875	1,000

5.4 2035 Scenario C2-1: Domestic + Export Markets (High Thermal, Low Onshore Wind)

Scenario C2-1 represents the Domestic + Export Markets case[28], where offshore wind development is scaled to support both regional electrification and clean energy exports. This scenario builds on the Phase 1 findings that highlight the strategic opportunity for Atlantic Canada to serve external markets such as ISO-New England, leveraging its high-performing offshore wind resources.

The scenario includes two major offshore wind sites, Sydney Bight (1,540 MW) and Middle Bank (1,421 MW), interconnected via the Sydney (Woodbine 345 kV) and Lakeside (345 kV) substations, respectively. The selected dispatch hour (Phase 2 Market Opportunities results for December 5, 2035, at 20:00) reflects conditions of high renewable output, particularly from offshore wind.

The total offshore wind dispatch reaches 2,535 MW with a combined installed capacity of 3,000 MW. This high level of offshore wind generation supports both domestic load and export potential, while minimizing reliance on fossil fuels.

Thermal generation is limited, with only modest dispatch from units in both NB and NS. Biomass and hydro continue to provide firm capacity, and onshore wind contributes significantly across all provinces.

This scenario underscores the importance of transmission infrastructure and interprovincial coordination to enable efficient energy flows and maximize offshore wind utilization, especially when serving both domestic and export markets.

Table 5-6 outlines the key parameters of the C2-1 scenario, including the offshore wind locations, POIs, generation adjustments, and the resulting offshore wind dispatch and capacity.

[28] The proposed HVDC link between Nova Scotia and New England considered in Phase 1 was not included in Scenarios C2-1 and C2-2, as the focus of the transmission expansion needs analysis is to assess the onshore systems in Atlantic Canada.

Table 5-6 C2-1 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2035 Scenario C2-1	C2 Domestic + Export Markets	NS: Sydney Bight Fixed NS: Middle Bank Fixed	Sydney (Woodbine 345 kV Substation) Middle Bank (Lakeside 345 kV Substation)	NS: Low thermal generation and high onshore wind based on Market Opportunities results for December 5, 2035, 20:00	2,535	3,000

Table 5-7 presents the generation dispatch by fuel type and province for the selected hour, as well as the provincial loads. It highlights the dominance of renewable sources, particularly offshore and onshore wind, and the limited use of thermal generation.

Table 5-7 C2-1 Generation Dispatch and Provincial Load from Market Opportunities Results

Generation/ Load	Newfoundland and Labrador (MW)	New Brunswick (MW)	Nova Scotia (MW)	Prince Edward Island (MW)	Total (MW)
Gas - CCS	-	-	-	-	-
Gas - CCGT	-	-	194	-	194
Gas - CT	-	-	-	-	-
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-
Oil - SCCT	-	397	-	-	397
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass	-	499	93	-	592
Nuclear	-	597	-	-	597
Hydro	2126	162	348	-	2636
Solar	-	-	-	-	-
Onshore Wind	10	691	55	206	962
Offshore Wind	30	-	2535	1	2567
Storage	-	-	-	-	-
Provincial Load	1657	2343	2154	436	6590

Figure 5.E visualizes the modeled generation dispatch across provinces for the C2-1 scenario in PSS®E, showing the contribution of each fuel type and highlighting the dominance of offshore wind and hydro resources.

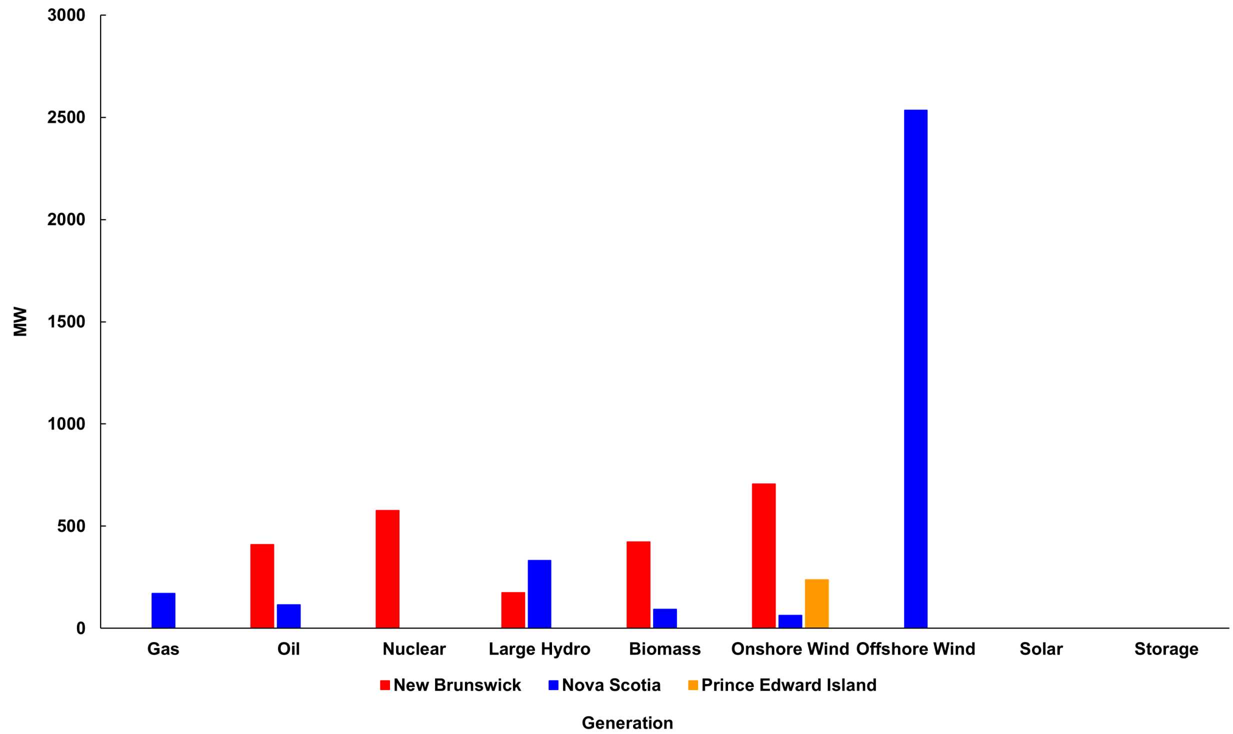

Figure 5.E C2-1 Scenario – Generation Dispatch in PSS®E Case

Figure 5.F illustrates the electricity demand across the three provinces during the selected dispatch hour. It provides context for how generation resources are allocated to meet regional loads and export opportunities.

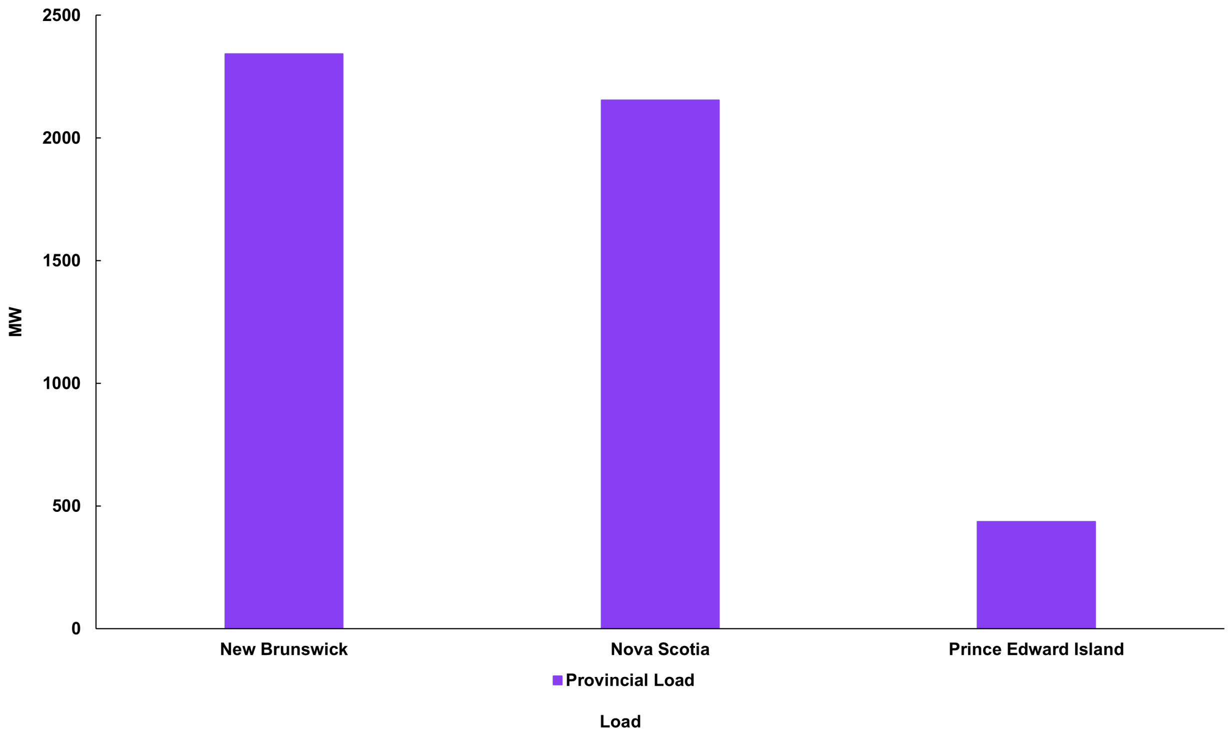

Figure 5.F C2-1 Scenario – Provincial Load Modeling

5.5 2035 Scenario C2-2: Domestic + Export Markets (Low Thermal, High Onshore Wind)

Scenario C2-2 is a continuation of the Domestic + Export Markets framework, modeled to evaluate system performance during early morning winter conditions. It reflects a high offshore wind output hour, based on Phase 2 Market Opportunities results for December 11, 2035, at 5:00, characterized by low thermal generation and strong renewable dispatch.

The scenario includes two major offshore wind sites: Sydney Bight (1,540 MW) and Middle Bank (1,421 MW), interconnected via the Sydney (Woodbine 345 kV) and Lakeside (345 kV) substations, respectively. Offshore wind dispatch reaches 2,595 MW, nearly utilizing the full 3,000 MW installed capacity.

Thermal generation is minimal, with only a small contribution from CCGT in Nova Scotia (~44 MW). Biomass and hydro remain key firm resources, while onshore wind dispatch is notably high across all provinces, especially in Nova Scotia and Prince Edward Island. This scenario demonstrates the system's ability to rely heavily on renewables while maintaining reliability and further emphasizes the importance of transmission coordination to support export flows.

Table 5-8 summarizes the key configuration of the C2-2 scenario, including offshore wind locations, POIs, generation adjustments, and offshore wind performance.

Table 5-8 C2-2 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2035 Scenario C2-2	C2 Domestic + Export Markets	NS: Sydney Bight Fixed 1,540 MW NS: Middle Bank Fixed 1,421 MW	Sydney (Woodbine 345 kV Substation) Middle Bank (Lakeside 345 kV Substation)	NS: Low thermal generation and high onshore wind based on Market Opportunities results for December 11, 2035, 5:00	2,595	3,000

Table 5-9 presents the generation dispatch by fuel type and province for the selected hour, highlighting the dominance of wind and hydro resources and minimal thermal generation; provincial loads are also included in the table.

Table 5-9 C2-2 Generation Dispatch and Provincial Load from Market Opportunities results

Generation/ Load	Newfoundland and Labrador (MW)	New Brunswick (MW)	Nova Scotia (MW)	Prince Edward Island (MW)	Total (MW)
Gas - CCS	-	-	-	-	-
Gas - CCGT	-	-	44	-	44
Gas - CT	-	-	-	-	-
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-
Oil - SCCT	-	-	-	-	-
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass[29]	-	451	93	-	544
Nuclear	-	597	-	-	597
Hydro	2116	423	112	-	2651
Solar	-	-	-	-	-
Onshore Wind	-	928	714	296	1948
Offshore Wind	-	-	2593	-	2595
Storage	-	-	-	-	-
Provincial Load	1780	2391	2147	376	6694

[29] Note by 2035, all emitting generators see a substantial carbon price, tied to the federally legislated carbon price of $170 CAD/tCO2 by 2030. Biomass is modeled as carbon neutral, and as such it does not incur this price. This is an important element of dispatch results in both 2035 and later years

Figure 5.G illustrates the modeled generation mix across provinces, emphasizing the high contribution of offshore and onshore wind, and the limited role of thermal resources.

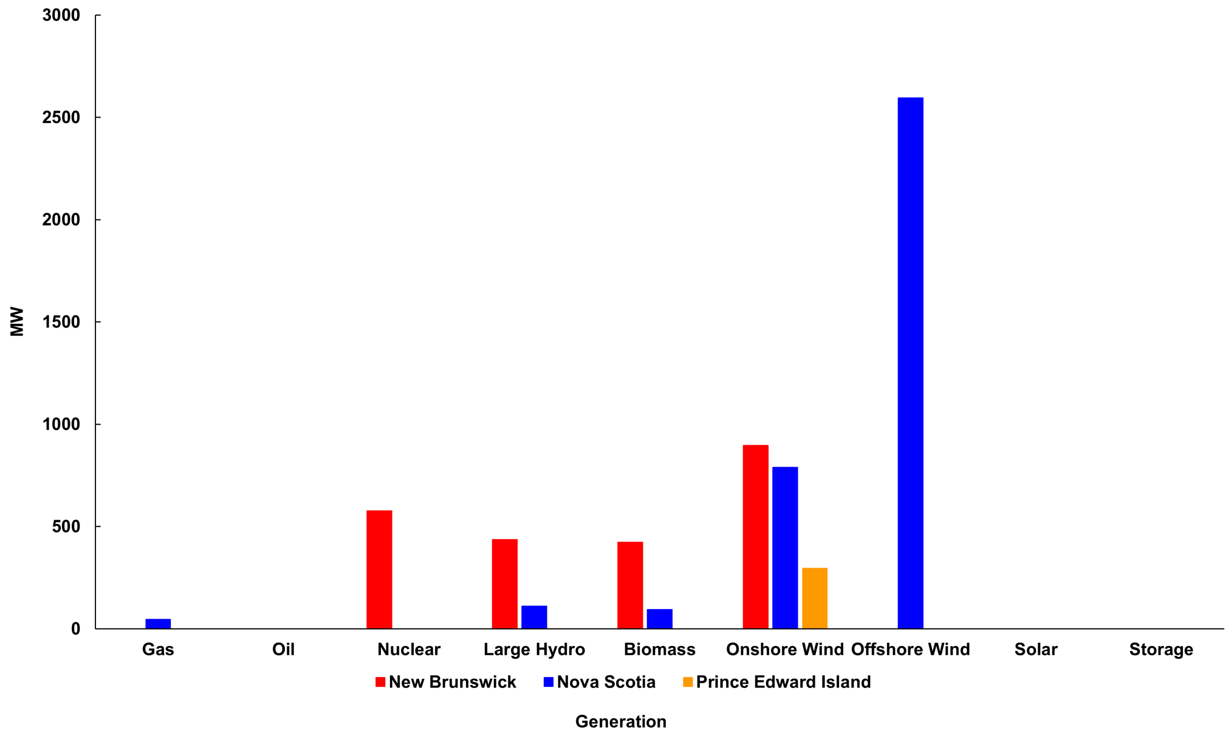

Figure 5.G C2-2 Scenario – Generation Dispatch in PSS®E Case

Figure 5.H shows the electricity demand distribution across the three provinces during the selected dispatch hour, providing context for how generation resources are allocated to meet regional and export needs.

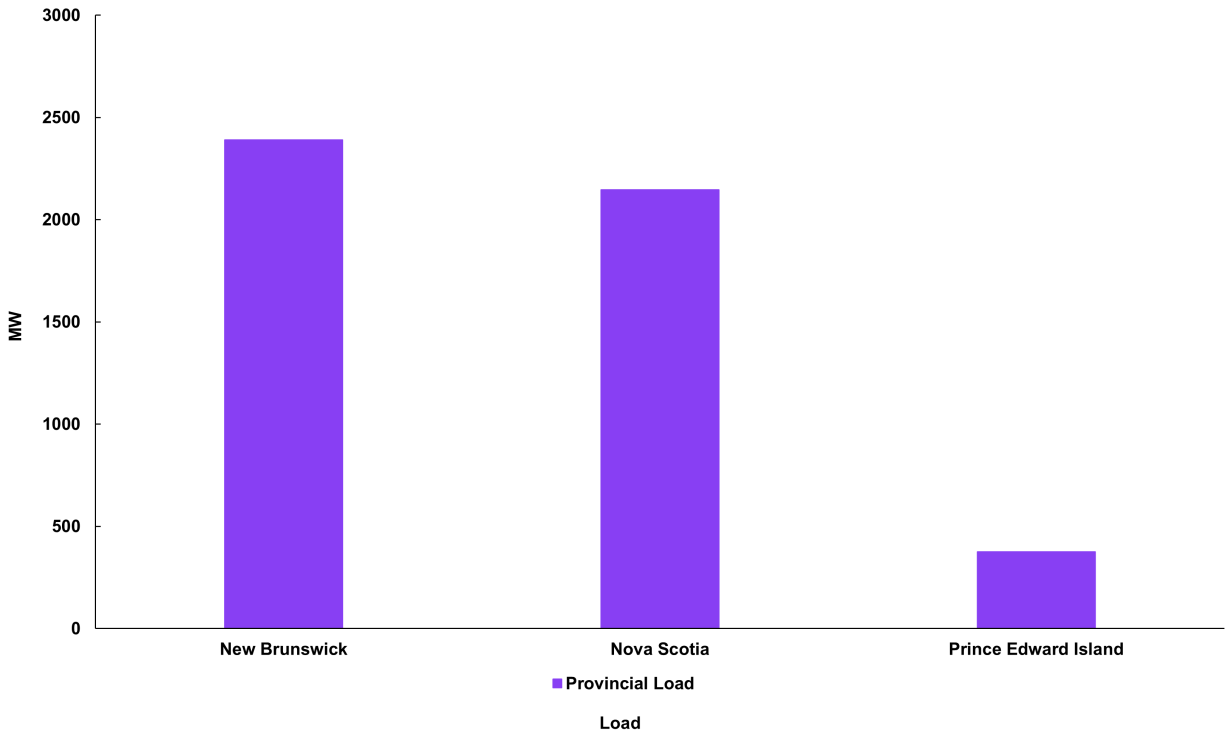

Figure 5.H C2-2 Scenario – Provincial Load Modeling

5.6 2035 Scenario C3-1: Domestic + Base Hydrogen

Scenario C3-1 explores the Domestic + Base Hydrogen case, where offshore wind development is scaled to support both regional electrification and emerging hydrogen production. This scenario builds on Phase 1 insights that highlight the potential for offshore wind to power electrolyzers and enable green hydrogen as part of Atlantic Canada's decarbonization strategy.

The scenario includes five offshore wind sites:

- NS C11 Fixed Sydney Bight
- PEI C22 Fixed
- NL C25 Fixed
- NL C4 Floating
- NS C11 Floating Sydney Bight

These offshore sites are interconnected to the onshore grid via four POIs: Sydney (Woodbine 345 kV), Lakeside (345 kV), West Royalty (138 kV Tap), and Oxen Pond (230 kV). The selected dispatch hour, January 7, 2035, at 00:00, captures high offshore wind output and moderate thermal generation.

Offshore wind dispatch reaches 3,900 MW, with a total installed capacity of 4,500 MW. This robust renewable generation supports both electricity demand and base-level hydrogen loads. Thermal generation is limited to Oil-SCCT and CCGT in New Brunswick and Nova Scotia. Biomass and hydro remain essential firm resources, while onshore wind contributes across all provinces. Notably, PEI and NL show meaningful offshore wind dispatch, reflecting broader regional participation in hydrogen-linked offshore wind development.

Hydrogen Load Context

In this scenario, hydrogen production is modeled[30] as a new electricity-consuming load, powered primarily by offshore wind. Consistent with Phase 1 modeling, hydrogen loads are distributed across provinces based on offshore wind availability and proximity to planned electrolyzer sites (where applicable and commercial interest indicators are available). The high offshore wind dispatch in this hour supports the operation of electrolyzers, which require consistent and high-capacity renewable input to produce green hydrogen efficiently. This scenario demonstrates the feasibility of integrating hydrogen production into the regional grid without compromising reliability, while leveraging offshore wind to decarbonize hard-to-abate sectors such as industry and transportation.

For 2035 study scenarios that include new hydrogen production (the C3 and C4 series), hydrogen electrolyzer demand was modeled as a separate load on top of the baseline provincial demand in the PSS®E power flow cases. In practice, this means that in scenarios C3-1, C4-1, and C4-2, the Newfoundland and Labrador, New Brunswick, Nova Scotia, and PEI models each have an additional load representing hydrogen demand (e.g. ~821 MW in NL, ~456 MW in NB and ~823 MW in NS for the Base Hydrogen cases) apart from their normal 2035 load forecast. As a result, the total modeled demand in those provinces is higher than the “provincial load” values reported from Phase 1 PLEXOS, which had already included the hydrogen consumption.

Table 5-10 outlines the configuration of the C3-1 scenario, including offshore wind locations, POIs, generation adjustments, and offshore wind performance.

[30] Please refer to Table 9, “List of Existing Hydrogen Projects in Atlantic Provinces,” in the Phase 1 report for hydrogen project locations. A representative set of hydrogen electrolyzer projects was modeled at nearby substations corresponding to the listed sites.

Table 5-10 C3-1 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2035 Scenario C3-1	C3 Domestic + Base Hydrogen	NS: Sydney Bight Fixed NS: Middle Bank fixed PEI: C22 Fixed (North of PE) NL: C25 Fixed (Corner Brook) NL: C4 Floating (St. John's)	Sydney (Woodbine 345 kV Substation) Middle Bank (Lakeside 345 kV Substation) North of PEI (West Royalty 138 kV Tap) St. John's (Oxen Pond 230 kV Substation)	Based on Market Opportunities results for January 7, 2035, 0:00	3,900	4,500

Table 5-11 presents the generation dispatch by fuel type and province for the selected hour, highlighting the dominance of offshore wind and hydro, with limited thermal generation and growing wind contributions; provincial and hydrogen loads are also shown in the table.

Table 5-11 C3-1 Generation Dispatch and Loads from Market Opportunities results

Generation/ Loads	Newfoundland and Labrador (MW)	New Brunswick (MW)	Nova Scotia (MW)	Prince Edward Island (MW)	Total (MW)
Gas - CCS	-	-	-	-	-
Gas - CCGT	-	234	-	-	234
Gas - CT	-	-	-	-	-
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-
Oil - SCCT	-	397	16	-	413
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass	-	499	28	-	527
Nuclear	-	597	-	-	597
Hydro[31]	1608	577	-	-	2185
Solar	-	-	-	-	-

[31] Hydro is modeled as a flexible resource in PLEXOS, with daily and seasonal budgets that must be met to capture pondage constraints and seasonal variability, but that can be dispatched during the periods of highest system need. As such, hourly results such as those shown here can vary considerably across a given day or week.

Generation/ Loads	Newfoundland and Labrador (MW)	New Brunswick (MW)	Nova Scotia (MW)	Prince Edward Island (MW)	Total (MW)
Onshore Wind	151	30	309	2	492
Offshore Wind	839	7	2828	241	3915
Storage	-	-	-	-	-
Provincial Load	2516	3216	2781	447	8960
Hydrogen Load	821	456	823	-	2100

Figure 5.I visualizes the modeled generation mix across provinces, emphasizing the high contribution of offshore wind and hydro resources, and the limited role of thermal generation.

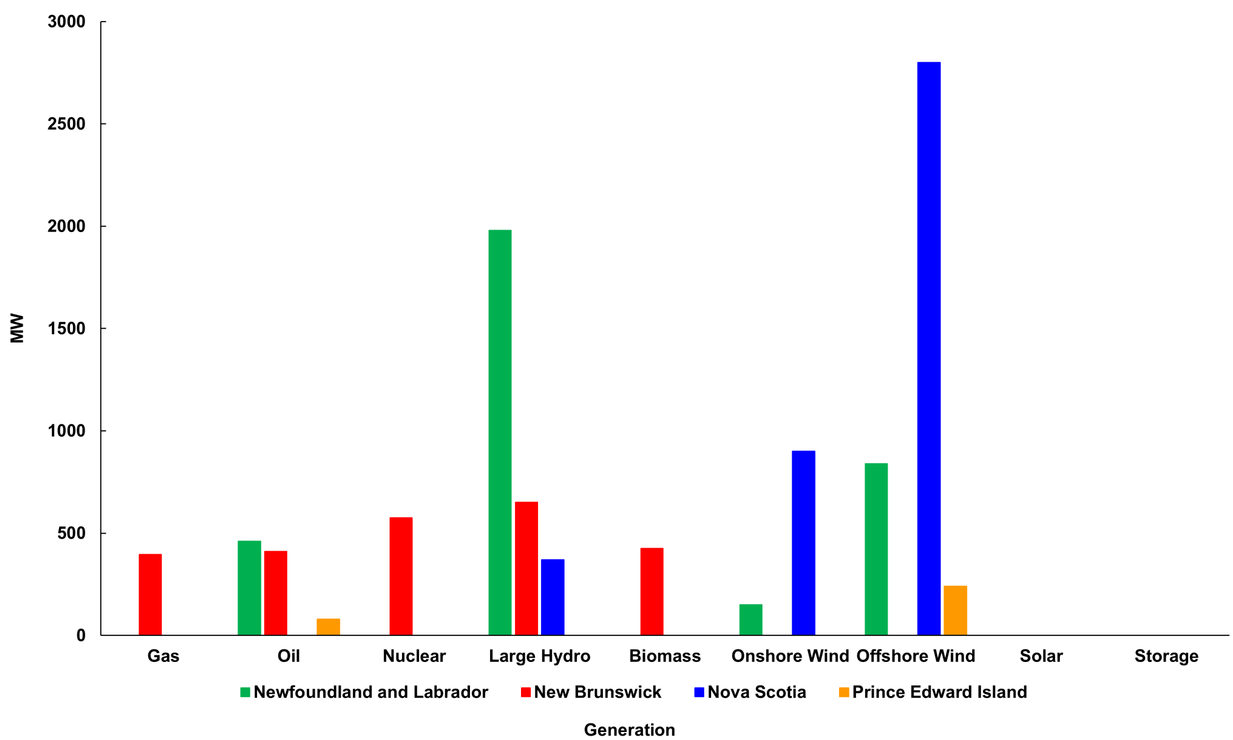

Figure 5.I C3-1 Scenario – Generation Dispatch in PSS®E Case

Note:
In the PSS®E model, generation dispatch was adjusted based on provincial load and hydrogen load.

Figure 5.J shows the electricity demand distribution across the four provinces during the selected dispatch hour, providing context for how generation resources are allocated to meet regional loads and hydrogen production needs.

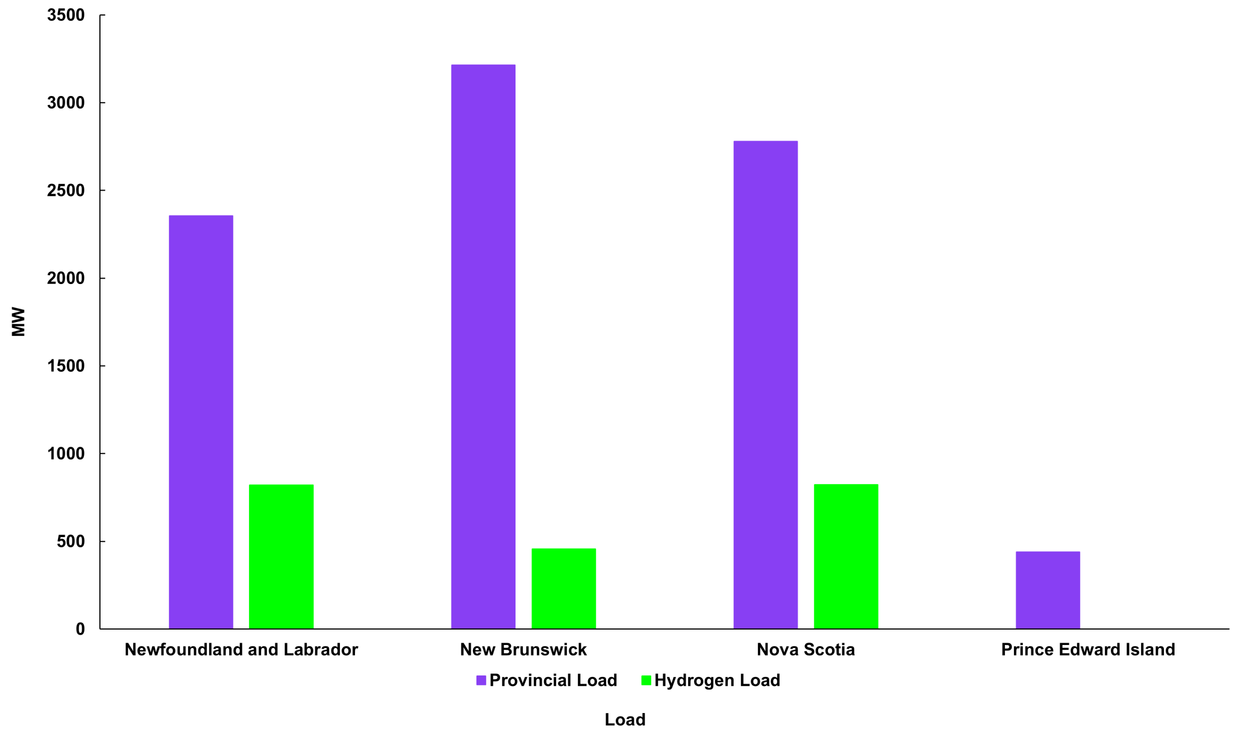

Figure 5.J C3-1 Scenario – Provincial and Hydrogen Load Modeling

Note:

This figure illustrates the modeled hydrogen load distribution across four Atlantic Provinces—NL, NB, NS, and PEI for the Domestic + Base Hydrogen scenario in 2035. As noted earlier, hydrogen demand in PLEXOS was modeled at the provincial level, as the forecasted demand profile was more moderate than that assumed in the earlier market scenario.

The hydrogen load shown in Figure 5.J represents the electricity demand from electrolyzers used to produce green hydrogen, which would be powered primarily by offshore wind. The distribution in the figure is based on proximity to offshore wind resources, existing infrastructure, and planned hydrogen projects. This figure underscores the strategic role of Nova Scotia and New Brunswick in early-stage hydrogen development, aligning with Phase 1 findings that identified these provinces as key hubs for domestic hydrogen consumption and export readiness.

5.7 2035 Scenario C4-1: All Markets (Domestic, Base Hydrogen and Exports)

Scenario C4-1 represents the most expansive case, integrating offshore wind development to serve domestic electricity demand, base hydrogen production, and export markets. The selected dispatch hour - Phase 2 Market Opportunities results for December 9, 2035, at 15:00 - captures peak offshore wind output and strong renewable integration across the region. This scenario builds on earlier phases by scaling offshore wind capacity and interconnections to enable Atlantic Canada’s role as a renewable energy and hydrogen export hub.

The scenario includes seven offshore wind sites:

- NS C11 Fixed Sydney Bight
- PE C22 Fixed
- NS C27 Fixed Middle Bank
- NL C4 Floating
- NS C11 Floating Sydney
- NS C14 Floating Canso Bank
- NS C17 Floating French Bank

These offshore sites are interconnected to the onshore grid via four POIs: Sydney (Woodbine 345 kV), Lakeside (345 kV), West Royalty (138 kV Tap), and Oxen Pond (230 kV).

This high dispatch level demonstrates the ability of offshore wind to meet multi-market demands while maintaining system reliability. The additional floating sites (Canso Bank and French Bank) significantly increase Nova Scotia's offshore wind contribution, positioning the province as a central hub for hydrogen production and export.

Hydrogen and Export Integration

In C4-1, hydrogen production is modeled at high demand levels, reflecting domestic consumption, base hydrogen requirements, and export commitments. Electrolyzers operate at near-full capacity during this hour, enabled by strong offshore wind output. This scenario demonstrates:

- Feasibility of large-scale hydrogen integration without compromising grid reliability.
- Strategic positioning of Nova Scotia and Newfoundland and Labrador as export-oriented offshore wind hubs.
- Alignment with Atlantic Canada's long-term decarbonization and energy export strategy.

Table 5-12 C4-1 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2035 Scenario C4-1	C4 All Markets (Domestic, Base Hydrogen and Exports)	NS: Sydney Bight Fixed NS: Middle Bank Fixed NS: Canso Bank Floating NS: French Bank Floating PE: C22 Fixed (North of PE) NL: C4 Floating (St. John's)	Sydney and Canso (Woodbine 345 kV Substation) Middle Bank and French Bank (Lakeside 345 kV Substation) North of PEI (West Royalty 138 kV Tap) St. John's (Oxen Pond 230 kV Substation)	Based on Market Opportunities results for December 9, 2035, 15:00	5,500	6,500

Table 5-13 presents the generation dispatch by fuel type and province for the selected hour, highlighting the dominance of offshore wind and hydro, with limited thermal generation; provincial and hydrogen loads are also shown in the table.

Table 5-13 C4-1 Generation Dispatch and Loads from Market Opportunities Results

Generation/ Loads	Newfoundland and Labrador (MW)	New Brunswick (MW)	Nova Scotia (MW)	Prince Edward Island (MW)	Total (MW)
Gas – CCS	-	-	-	-	-
Gas - CCGT	-	-	-	-	-
Gas - CT	-	-	-	-	-
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-
Oil - SCCT	-	397	16	-	413
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass	-	460	28	-	488
Nuclear	-	597	-	-	597
Hydro	1582	561	101	-	2244
Solar	-	-	22	8	30
Onshore Wind	290	137	786	24	1237
Offshore Wind	893	43	4382	249	5567
Storage	-	-	-	-	-
Provincial Load	2684	2811	2952	413	8860
Hydrogen Load	821	456	823		

Key Observations:

- Offshore wind dominates the generation mix, supplying over 60% of total dispatch.
- Hydro and biomass remain critical firm resources, ensuring system stability.
- Thermal generation is minimal, limited to Oil-SCCT in NB and NS.
- Solar and onshore wind provide additional renewable diversity, though their contribution is modest compared to offshore wind.

Figure 5.K visualizes the modeled generation mix and Figure 5.L shows regional loads during the selected hour and hydrogen demand across NL, NS, NB, and PEI, with NS leading due to proximity to offshore wind resources and planned electrolyzer sites.

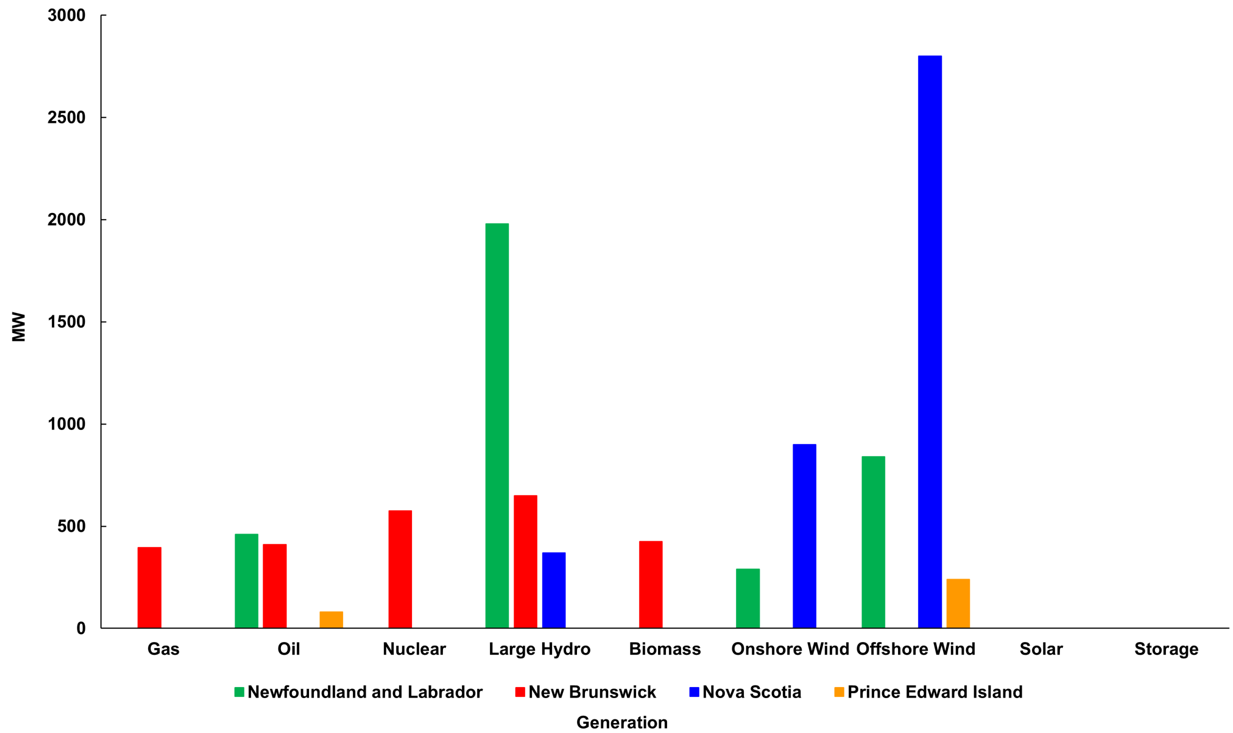

Figure 5.K C4-1 Scenario – Generation Dispatch in PSS®E Case

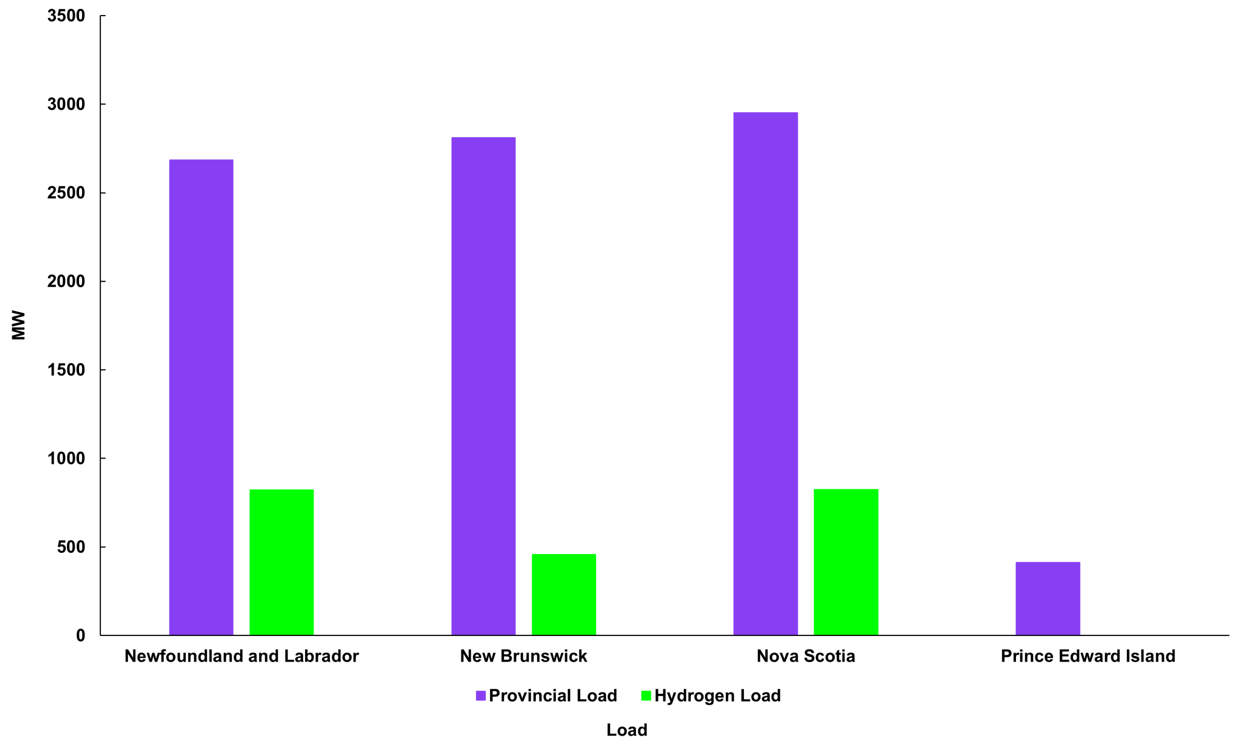

Figure 5.L C4-1 Scenario – Provincial and Hydrogen Load Modeling

5.8 2035 Scenario C4-2: All Markets (Domestic, High Hydrogen and Exports)

Scenario C4-2 represents the highest offshore wind penetration 2035 case. It scales offshore wind development to serve domestic electricity needs, a high level of hydrogen production, and export commitments. Building on C4-1, this scenario adds more offshore wind capacity (total 7,500 MW installed, vs. 6,500 MW in C4-1) and introduces an offshore wind site in New Brunswick, reflecting an all-markets, high-hydrogen future. The dispatch hour, Phase 2 Market Opportunities results for December 18, 2035, at 05:00, captures peak offshore wind output in pre-dawn conditions, when strong winds coincide with moderate traditional loads and elevated hydrogen demand.

The scenario includes seven offshore wind sites:

- NS C11 Fixed Sydney Bight
- PEI C22 Fixed
- NL C25 Fixed
- NL C4 Floating
- NS Middle Bank Fixed
- NS C14 Floating Canso Bank
- NB C24 Floating

These offshore sites are interconnected to the onshore grid via five POIs: Sydney (Woodbine 345 kV), Lakeside (345 kV), West Royalty (138 kV Tap), Oxen Pond (230 kV), and Bathurst (230 kV).

Offshore Wind Performance: Offshore wind dispatch reaches 6,300 MW out of 7,500 MW installed (~84% utilization) during this hour. This surge of renewable generation is critical to meet the high hydrogen load while supplying all provincial demands and enabling some exports. Nova Scotia and Newfoundland and Labrador remain the largest offshore wind producers, and New Brunswick contributes significant offshore wind generation from the Bathurst site.

Hydrogen Load Integration

Scenario C4-2 assumes "High Hydrogen" demand, significantly higher than in C4-1. Hydrogen production facilities (electrolyzers) in Nova Scotia and New Brunswick are running at high capacity, absorbing a large portion of the offshore wind output. In this 05:00 hour, offshore wind generation well exceeds normal electricity loads, and the excess generation is directed to hydrogen production rather than being exported. Nova Scotia, with its extensive offshore wind assets, carries the largest hydrogen load (considerably above the ~800 MW in the base hydrogen case, likely on the order of ~1,200+ MW). New Brunswick also sees a substantial hydrogen load (hundreds of MW, perhaps nearly double the ~450 MW from base case). Prince Edward Island remains a minor player in hydrogen (negligible load, given its smaller offshore wind capacity). Newfoundland and Labrador, however, show a marked shift in this scenario: hydrogen load rises from ~821 MW in the C3-1 and C4-1 cases to approximately 2,232 MW in C4-2, indicating a significant expansion of hydrogen production activity in the province.

Despite the surge in electricity demand from electrolyzers, the grid meets this new load without additional fossil generation. Instead, the expanded offshore wind capacity and strong onshore wind enable green hydrogen production entirely from renewables. This demonstrates that even under high hydrogen demand, the system could remain reliable and net zero, if sufficient offshore wind and onshore grid infrastructure are in place. It also implies that exports of electricity might be lower in this scenario since more offshore wind generation is consumed internally for hydrogen loads. However, any offshore wind generation beyond hydrogen needs can flow to export markets as a revenue source.

Overall, Scenario C4-2 showcases Atlantic Canada's ability to simultaneously power its grids, produce large volumes of green hydrogen, and support export capabilities by 2035 – all while minimizing carbon emissions. The heavy reliance on offshore wind (and other renewables) and minimal use of thermal plants highlight a pathway to deep decarbonization even under maximized multi-sector demand.

Table 5-14 shows the summary for the scenario, including POIs, generation adjustments, and offshore wind dispatch and capacity.

Table 5-14 C4-2 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2035 Scenario C4-2	C4 All Markets (Domestic, High Hydrogen and Exports)	NS: Sydney Bight Fixed NS: Canso Bank Floating NS: Middle Bank Fixed PE: C22 Fixed (North of PE) NL: C4 Floating (St. John's) NL: C25 Fixed (Corner Brook) NB: C24 Floating (Bathurst)	Sydney and Canso (Woodbine 345 kV Substation) Middle Bank (Lakeside 345 kV Substation) North of PE (West Royalty 138 kV Tap) St. John's (Oxen Pond 230 kV Substation)	Based on Market Opportunities results for December 18, 2035, 5:00	6,300	7,500

Table 5-15 presents the generation dispatch by fuel type and province for the selected hour, highlighting the dominance of offshore wind and hydro, with limited thermal generation; provincial and hydrogen loads are also shown in the table.

Table 5-15 C4-2 Generation Dispatch and Loads from Market Opportunities results

Generation/ Load	Newfoundland and Labrador (MW)	New Brunswick (MW)	Nova Scotia (MW)	Prince Edward Island (MW)	Total (MW)
Gas - CCS	-	-	-	-	-
Gas - CCGT	-	-	23	-	23
Gas - CT	-	-	-	-	-
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-
Oil - SCCT	-	-	-	-	-
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass	-	-	39	-	39
Nuclear	-	597	-	-	597
Hydro	1740	443	52	-	2235
Solar	-	-	-	-	-
Onshore Wind	487	1652	1578	206	3922
Offshore Wind	1484	845	4000	97	6427
Storage	-	-	-301	-9	-310
Provincial Load	3562	3094	3538	294	10488

Generation/ Load	Newfoundland and Labrador (MW)	New Brunswick (MW)	Nova Scotia (MW)	Prince Edward Island (MW)	Total (MW)
Hydrogen Load	2232	1246	1880		5362

Figure 5.M visualizes the modeled generation mix and Figure 5.N shows regional loads during the selected hour and hydrogen demand across NL, NS, NB, and PEI, with NS leading due to proximity to offshore wind resources and planned electrolyzer sites.

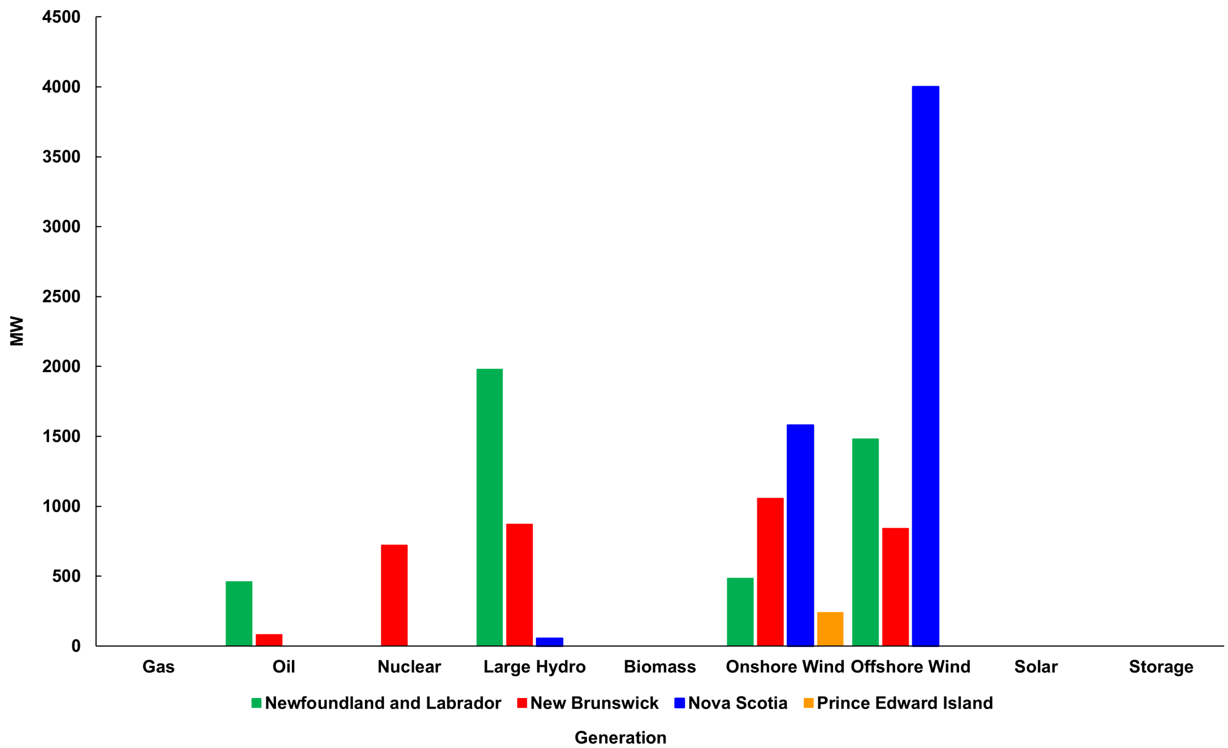

Figure 5.M C4-2 Scenario – Generation Dispatch in PSS®E Case

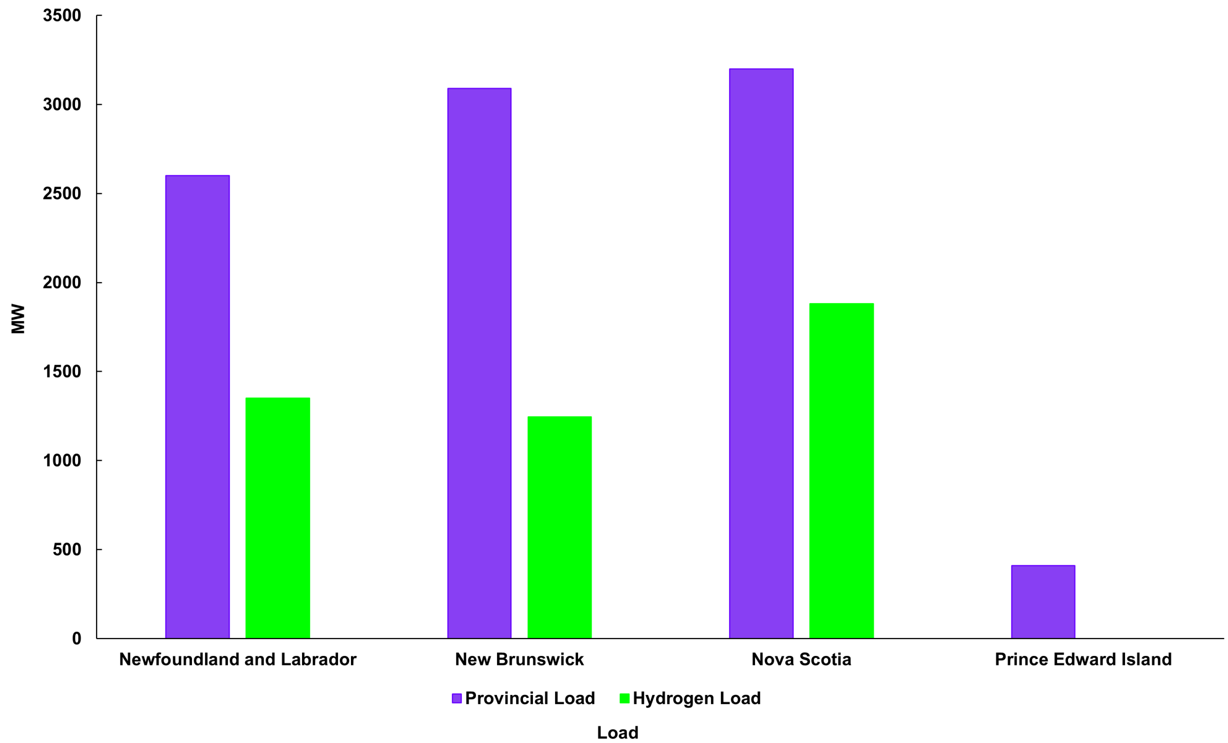

Figure 5.N C4-2 Scenario – Provincial and Hydrogen Load Modeling

6 2035 Power Flow Results

This section presents the results of steady state power flow analyses conducted for the 2035 planning horizon under multiple offshore wind integration scenarios. The objective was to evaluate the ability of the existing and planned transmission network to accommodate large-scale renewable generation, emerging hydrogen loads, and interprovincial/export transfers while maintaining reliability in the system.

Thermal overloads are denoted as:

- N-0 overloads: Thermal violations under system normal operating conditions.
- N-1 overloads: Violations under contingency (single element outage) conditions.

The scenarios analyzed C1-1 through C4-2 represent progressively complex market and operational conditions, ranging from domestic supply with moderate exports to high offshore wind penetration combined with significant hydrogen demand and large-scale exports.

Key metrics assessed include:

- Thermal loading of transmission lines and transformers across major voltage levels (345 kV, 230 kV, and 138 kV).
- Severity and distribution of overloads under N-0 and N-1 conditions.

- Identification of critical corridors and transmission equipment requiring reinforcement to enable the integration of offshore wind.

The steady state power flow analysis revealed that as offshore wind and hydrogen levels rise, thermal overloads (transmission line or transformer over-capacity) become widespread unless major upgrades are implemented. In moderate scenarios (C1, C2), overloads are fewer and mostly on 138 kV transmission lines, often mitigable by operational measures. In the heavier scenarios (C3, C4), multiple circuits exceed 120% loading under contingencies, requiring new infrastructure to be built. The most stressed areas are:

NB–NS–PEI 138 kV Network: The interconnected grid of NB, NS, and PEI observes numerous 138 kV line overloads when offshore wind injections exceed ~1 GW. In Scenario C1, up to 35 transmission elements exceed their thermal limits under N-1 contingency conditions, with most overloads occurring on 138 kV feeders across the three provinces. In Scenario C4, dozens of 138 kV and 345 kV elements are overloaded. The NB–NS intertie (345 kV transmission line) becomes a bottleneck in the C2 Scenario as the double-circuit Salisbury–Onslow 345 kV line runs near capacity. This suggests that an additional NB–NS 345 kV interconnection may be required to support higher transfer levels. Similarly, PEI's tie to NB (138 kV level) could approach its ~300 MW limit with high exports or offshore wind injection, implying a potential second link would be required.

Nova Scotia 345 kV Backbone: The 345 kV lines from Cape Breton (Woodbine/Lingan) to mainland NS (Onslow, Hopewell) are critical for moving offshore wind output. With injections of more than 1 GW offshore wind (C2, C3, and C4 scenarios), loss of one 345 kV line overloads the other parallel line and related 230 kV lines. In C4 scenarios, the NS 345 kV system is beyond its limits (multiple >140% overloads).

- **Recommendation:** Strengthening the NS 345 kV system is necessary—either by adding parallel 345 kV infrastructure or by introducing an HVDC export path to relieve internal bottlenecks. The study suggests a twin 345 kV NB–NS line as a near-term fix (forming a NB–NS 345 kV loop), and in the longer term a high-capacity HVDC link to New England (bypassing NS internal constraints) as envisioned in 2050 planning.

Newfoundland and Labrador 230 kV Backbone: In scenarios with NL offshore wind (C3, C4), Newfoundland and Labrador's island portion west-to-east 230 kV corridor (Buchans–Deer Lake–Western Avalon) becomes heavily loaded[32]. In Scenario C4, 33 overloads occur under N-1 contingency conditions on NL's 230 kV lines, especially if NL is exporting power off-island (via Labrador or future links). The 900 MW Labrador-Island Link (not explicitly modeled, but conceptually present) might also limit exports.

- **Recommendation:** Reinforce NL's 230 kV network (e.g. new parallel lines Bottom Brook–Buchans, etc.) and consider a second HVDC link if exporting >900 MW to the mainland. The plan also assumes voltage support (FACTS or synchronous condensers) will be needed in NL due to long distances – power flow results are closely tied to system stability in this regard.

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[32] Congestion in the Avalon area requires detailed analysis to understand the system implications of injecting offshore wind at the Oxen Pond POI.

Transformers and Reactive Limits: Many transformers (e.g. 345/138 kV at Lakeside, 230/138 kV at Western Avalon, 345/230 kV at Salisbury/Memramcook) hit emergency limits under high transfers. Solutions include higher-capacity transformers or additional parallel units. Based on reactive power, no widespread voltage violations were observed in steady state conditions (assuming all existing capacitor/reactor banks in service). However, heavy loading of lines indicates potential low voltages if a line trips, which is examined in the transient stability results in Section 1.

Overload Mitigations: Operations vs. Infrastructure

Not every thermal overload requires building new lines or installing new equipment. The overloads are categorized by severity to identify how to address them, as follows:

- **Mild Overloads (Loading Between 100 and 110% of Equipment Rating)** can often be managed with operational measures – adjusting generation dispatch, reconfiguring the network, employing Remedial Action Schemes (RAS), or temporarily curtailing wind. For example, in C2-1, 19 of 31 overloads under N-1 conditions are mild and could be mitigated by re-dispatch of generation or RAS (e.g. tripping some offshore wind during a contingency). These are considered "no-cost" mitigations, requiring no new capital investment. However, as offshore wind grows, relying on operations alone can lead to frequent curtailment, so it is a stopgap.
- **Moderate Overloads (Loading Between ~110 and 120% of Equipment Rating)** may be fixed by upgrading existing lines (reconductoring with higher-capacity conductors) or adding parallel transformers. For instance, NB and NS have many 138 kV lines in the 110–120% range in the C3 scenario results; uprating or reconductoring these lines (some are old and lower-capacity) is an expected solution. The plan includes several such upgrades: e.g. reconductoring key 138 kV feeders in NS's Western Valley and Northeastern NB and adding a second Memramcook 345/138 kV transformer.
- **Severe Overloads (≥120% or Overloads)** necessitate new infrastructure – new transmission lines or entirely new corridors. In C4, many overloads fall in this category, indicating that without major build-out of the onshore systems, the full offshore wind/hydrogen scenario is not feasible. Examples of recommended new buildouts are:
  - **A Third NB–NS 345 kV Line:** This would improve transfer capability and provide N-1 security for the NB–NS interface, which is critical in the C2 scenario.
  - **New 345 kV Lines in NS:** E.g. loop the Hopewell–Onslow–Woodbine path via a separate route. Also, a 345 kV tie from Cape Breton to New England via offshore or HVDC is discussed for post-2035 reliability.
  - **230 kV Reinforcements in NL:** A new parallel line from western to eastern Newfoundland island (e.g. Massey Drive to Soldiers Pond) or upgrading existing lines to higher voltages. The study suggests a future "super-grid" aligned with prevailing system voltage classes or additional HVDC links for NL exports if offshore wind capacity expands significantly.
  - **Install Synchronous Condensers/STATCOMs** as necessary to provide voltage support, particularly to improve system stability in Nova Scotia as thermal units retire.

6.1 System-Wide Overload Trends

The 2035 power flow analysis demonstrates that as offshore wind and hydrogen loads scale up, the transmission system in the Atlantic Canada provinces faces a sharp increase in thermal stress. The scenarios C1 and C2 show manageable overloads, but as hydrogen and exports grow (in scenarios C3 and C4), widespread and severe violations emerge, especially on 138 kV and 230 kV networks in NB–NS–PEI and on the 230 kV backbone in Newfoundland and Labrador. The C4-2 scenario highlights the need for large-scale grid upgrades to support high-capacity offshore wind scenarios.

Figure 6.A shows the number of overloads under N-0 and N-1 conditions for the studied grid integration scenarios. The overview of the results is as follows:

- C1 and C2: Overloads are concentrated in NB–NS–PEI, peaking at 35 (C1-1 scenario under N-1 conditions).
- C3 and C4: Newfoundland and Labrador becomes a critical region with up to 42 N-1 overloads.

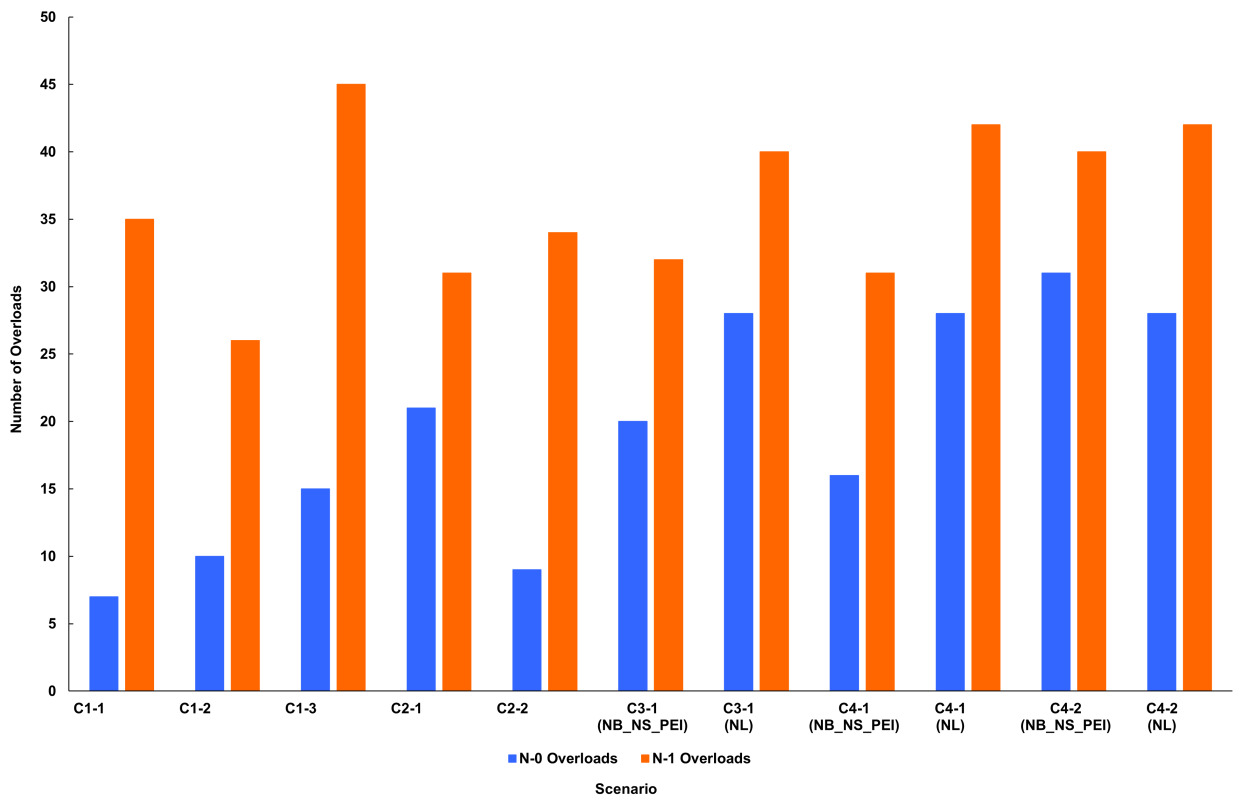


Figure 6.A N-0 and N-1 Overload Counts by Scenario and Region

Figure 6.B shows the overload distribution by voltage level under N-1 conditions for the studied grid integration scenarios.

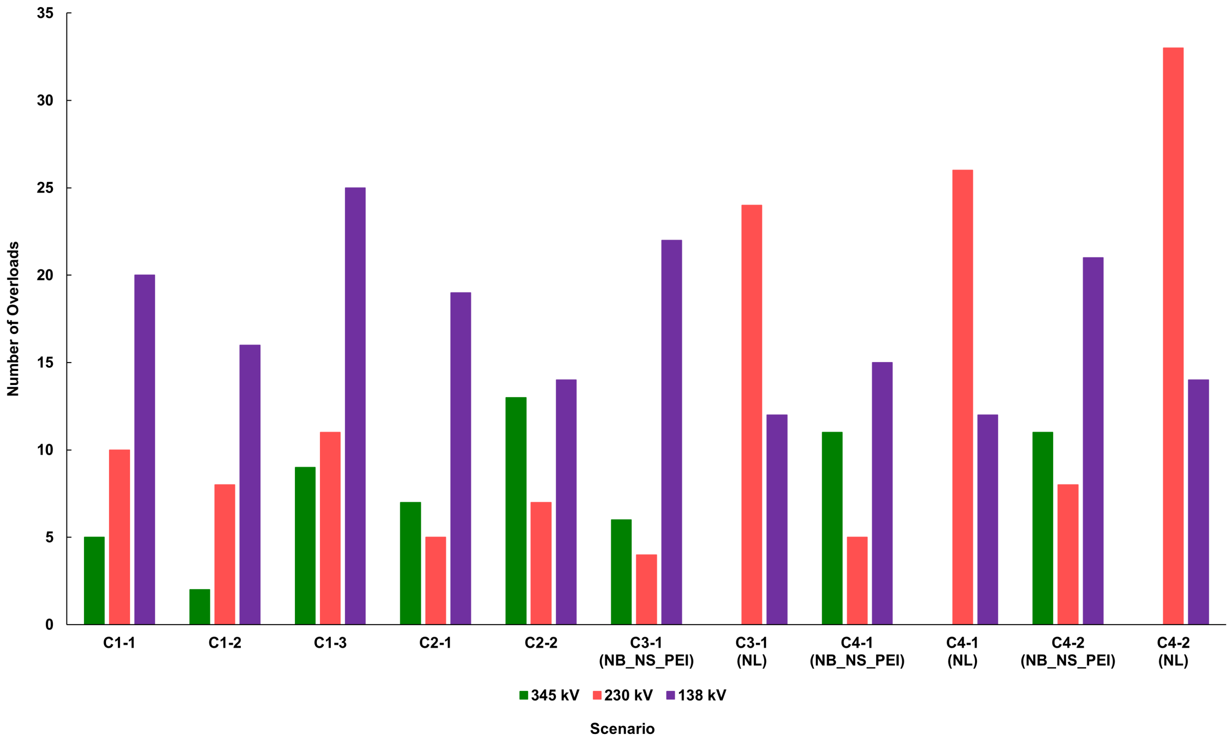


Figure 6.B N-1 Overload Distribution by Voltage Level

Figure 6.C shows the number of overloads by severity under N-1 conditions for the studied grid integration scenarios. The C4-2 scenario in NL has mostly severe overloads (≥120%), indicating critical need for new transmission lines and transformers. The C2-1 scenario has predominantly mild overloads, manageable with operational measures.

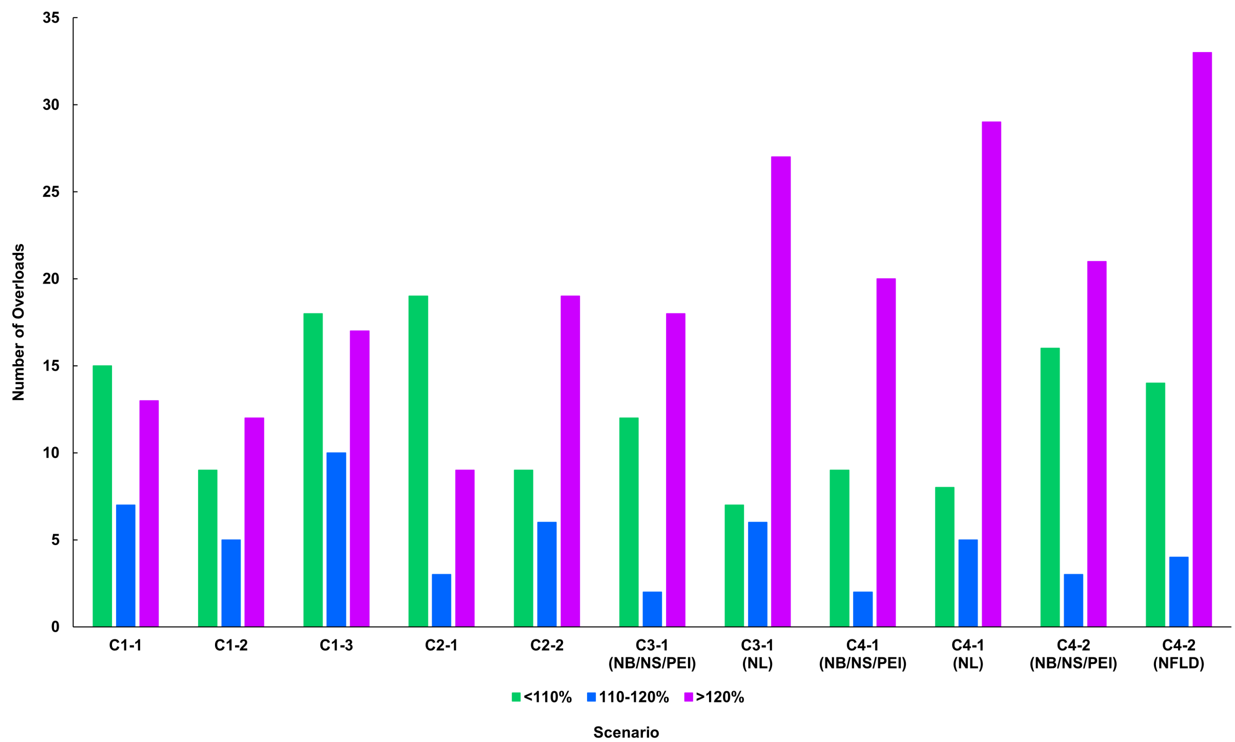


Figure 6.C Overload Severity Breakdown by 2035 Scenario

6.2 The Role of Operating Procedures ("No-Cost" Mitigations)

Operating procedures, such as generation re-dispatch, network reconfiguration, voltage control, and temporary load transfers are the first line of defense against mild overloads (typically overloads <110% of equipment rating). These actions are considered "no-cost" mitigations because they do not require capital investment and can be implemented rapidly by system operators.

Operating procedures are important for the following reasons:

- Immediate flexibility: They allow the system to respond to routine or infrequent overloads without delay.
- Cost-effectiveness: No new infrastructure is required, making them the most economical solution for minor issues.
- Reliability buffer: They provide a buffer while longer-term upgrades are planned and constructed.
- Limits: Their effectiveness is limited to mild overloads, and they cannot address persistent or severe violations. Over-reliance can lead to operational risk, especially as offshore wind and hydrogen loads grow.

Figure 6.D compares between the no-cost and cost-impact mitigation for the overloads observed for the studied grid integration scenarios.

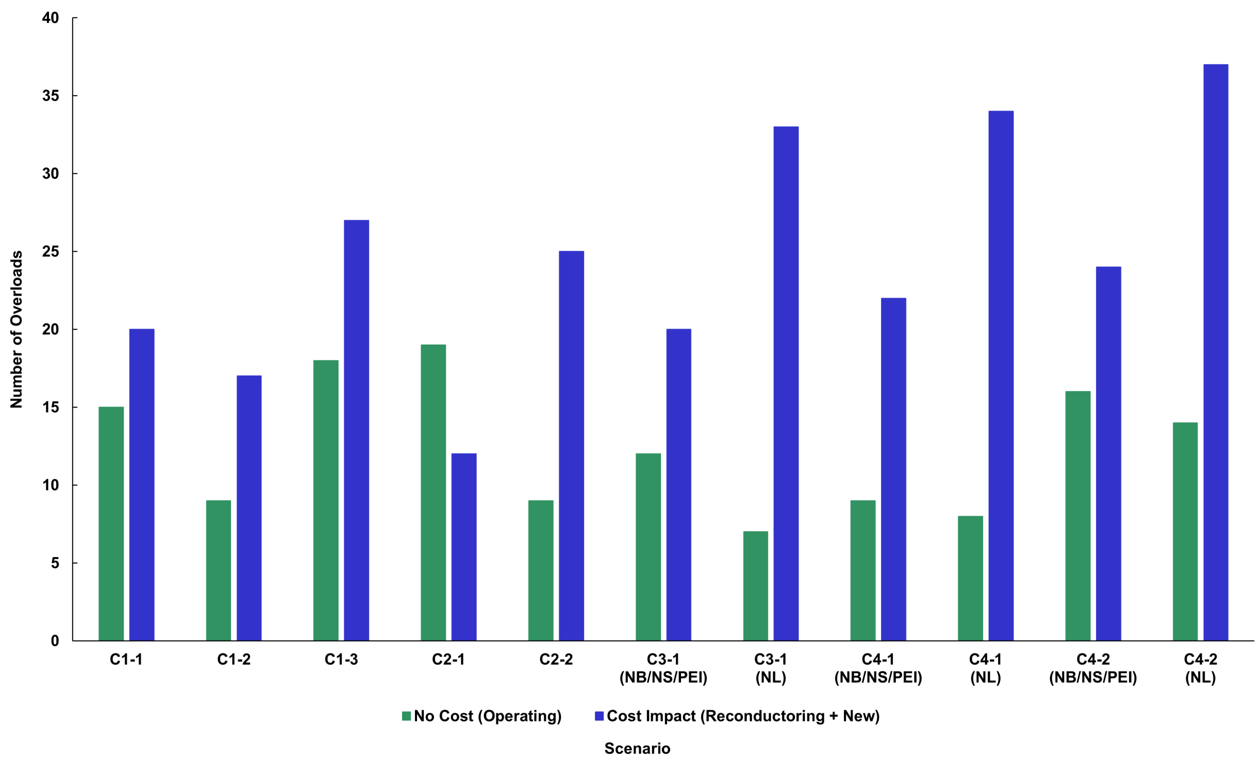


Figure 6.D No-Cost vs. Cost-Impact by Scenario

6.3 2035 Grid Integration Study Scenario Results

6.3.1 C1-1: Domestic – Only Market

The power flow results for the 2035 C1-1 domestic only market scenario are as follows:

- N-0/N-1 Overloads: 7/35 (NB–NS–PEI)
- Overloads by Voltage Distribution: 138 kV (20), 230 kV (10), 345 kV (5)
- Severity/Mitigation: 15 operating measures (<110%), 7 reconductoring (110–120%), 12 new circuits (≥120%), and 1 new transformer (≥110%).
- Key Insights: Most overloads are on 138 kV feeders and 230 kV corridors, reflecting local network stress under high renewables. 345 kV backbone is generally adequate.
- Actions:
    - Operational measures for mild overloads
    - Reconductor 138 kV and 230 kV lines
    - Plan new circuits and transformer upgrades for persistent bottlenecks

Figure 6.E shows the key system overloads and offshore wind location in NS for Scenario C1-1.

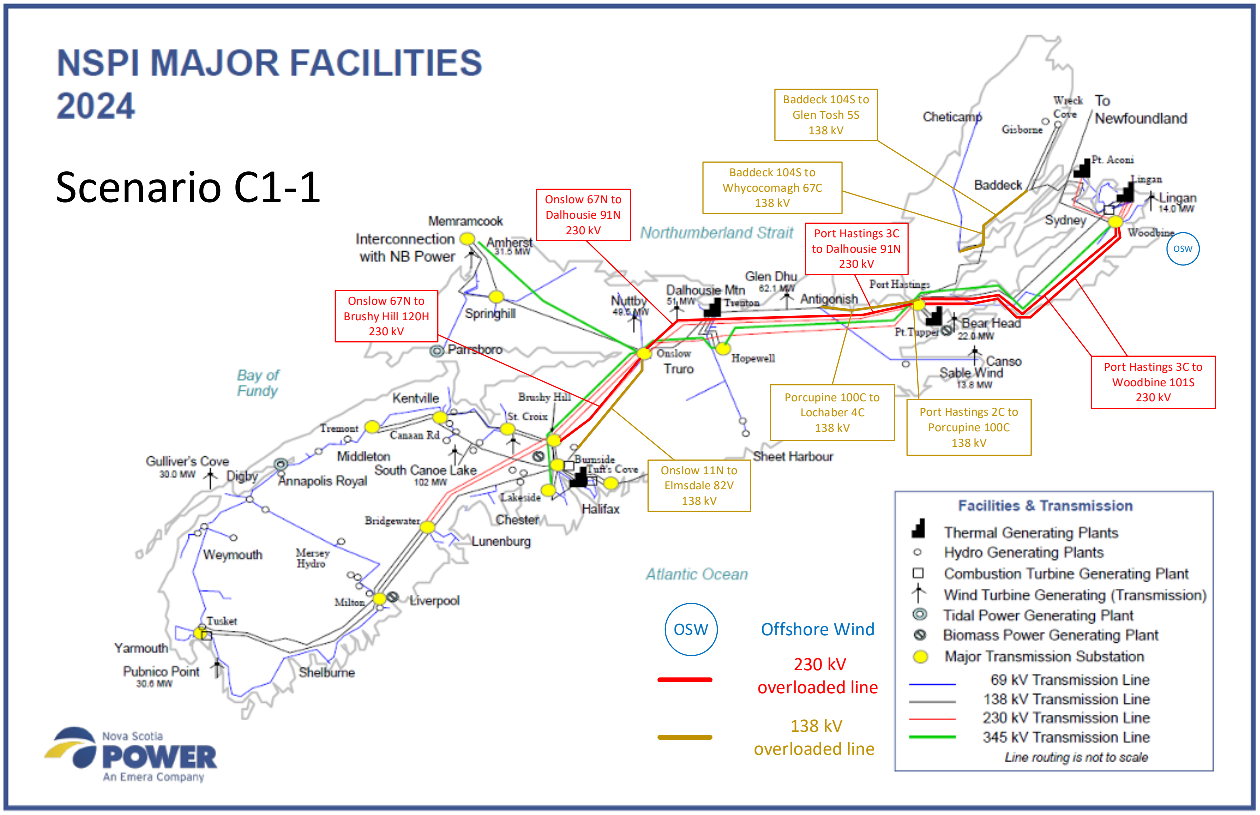


Figure 6.E Scenario C1-1: Key System Overloads in Nova Scotia

6.3.2 C1-2: Domestic – Only Market

The power flow results for the 2035 C1-2 domestic only market scenario are as follows:

- N-0/N-1 Overloads: 10/26 (NB–NS–PEI)
- Overloads by Voltage Distribution: 138 kV (16), 230 kV (8), 345 kV (2)
- Severity/Mitigation: 9 operating measures, 5 reconductoring, 7 new circuits (≥120%), and 5 new transformers (≥110%)
- Key Insights: 230 kV corridors show the most severe overloads (>140%), with 138 kV feeders also frequently overloaded. Transformer stress at 345/230/138 kV interfaces.
- Actions:
  - Operational measures and tap-changing
  - Reconductor and add transformers
  - Build new 230 kV loops and 138 kV feeders ahead of offshore wind development

Figure 6.F and Figure 6.G show the key system overloads and offshore wind locations in NS and NB, respectively, for Scenario C1-2.

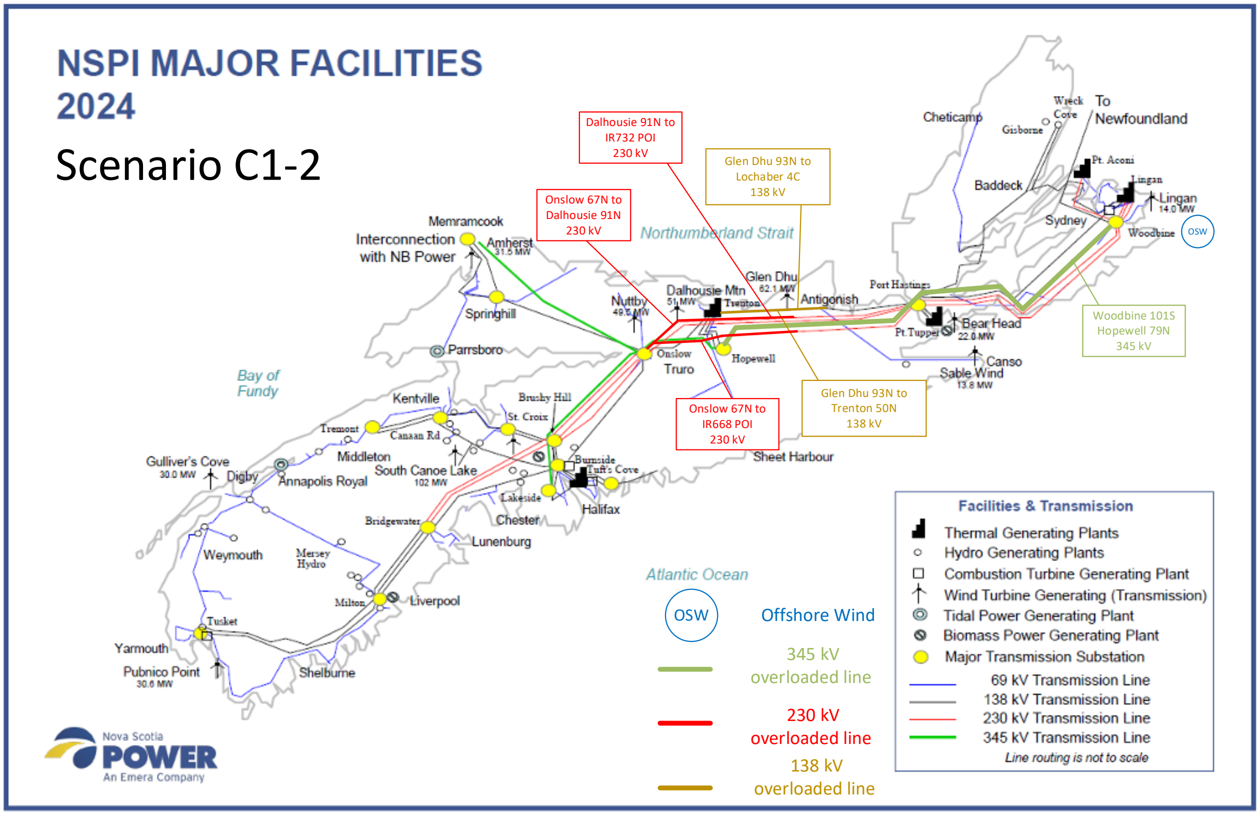


Figure 6.F Scenario C1-2: Key System Overloads in Nova Scotia

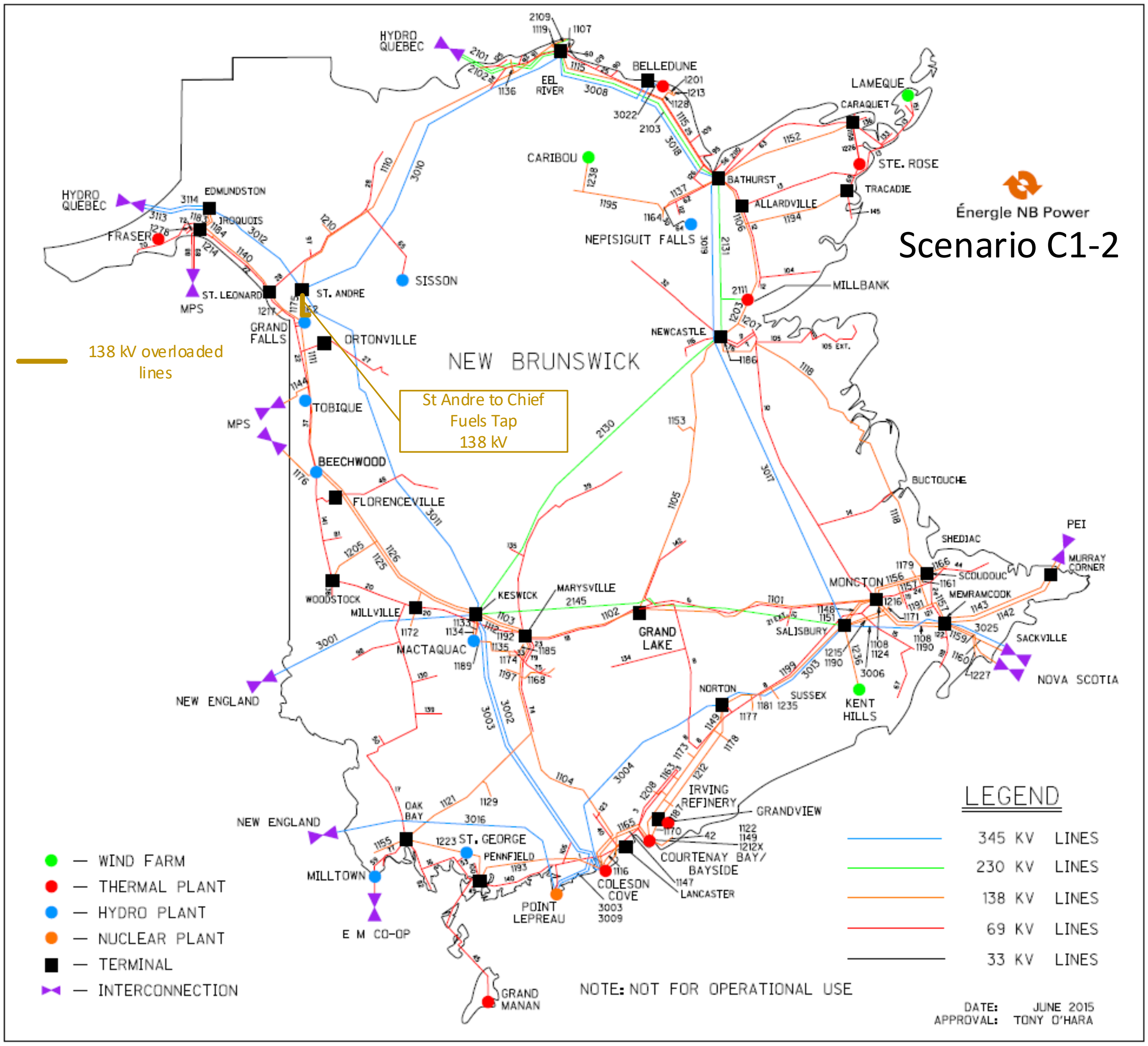


Figure 6.G Scenario C1-2: Key System Overloads in New Brunswick

6.3.3 C1-3: Domestic – Base Case Dispatch

The power flow results for the 2035 C1-3 domestic only market scenario with generation dispatched as in the hosting capacity base case are as follows:

- N-0/N-1 Overloads: 15/45 (NB–NS–PEI)
- Overloads by Voltage Distribution: 138 kV (25), 230 kV (11), 345 kV (9)
- Severity/Mitigation: 18 operating measures, 10 reconductoring, 15 new circuits (≥120%), and 2 new transformers (≥110%)

- Key Insights: Severe congestion on 345 kV backbone and 230 kV ties; 138 kV feeders and transformers are heavily loaded. High renewables expose all network weaknesses.
- Actions:
    - Targeted curtailment and contingency plans
    - Reconductor and upgrade transformers
    - Expand 345 kV and 230 kV lines and 138 kV feeders in advance of offshore wind development

Figure 6.H and Figure 6.I show the key system overloads and offshore wind locations in NS and NB, respectively, for Scenario C1-3.

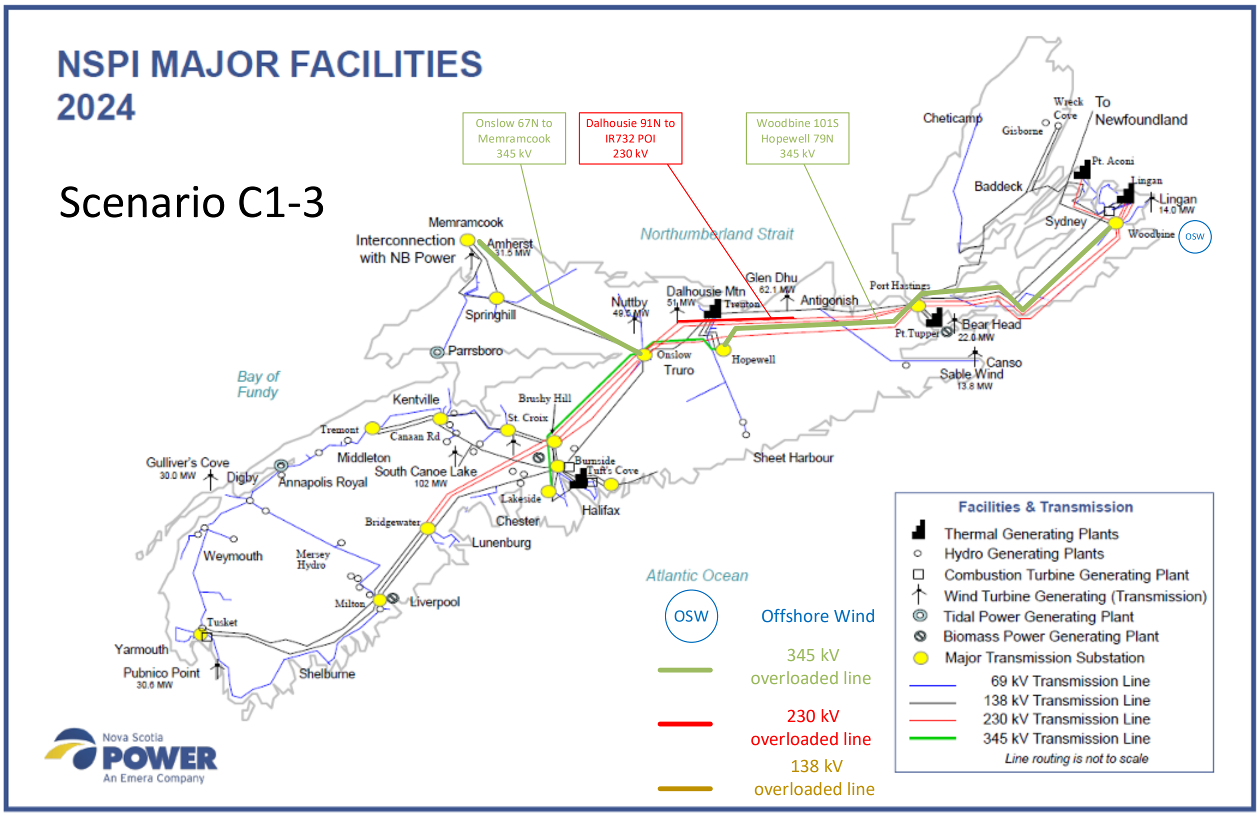


Figure 6.H Scenario C1-3: Key System Overloads in Nova Scotia

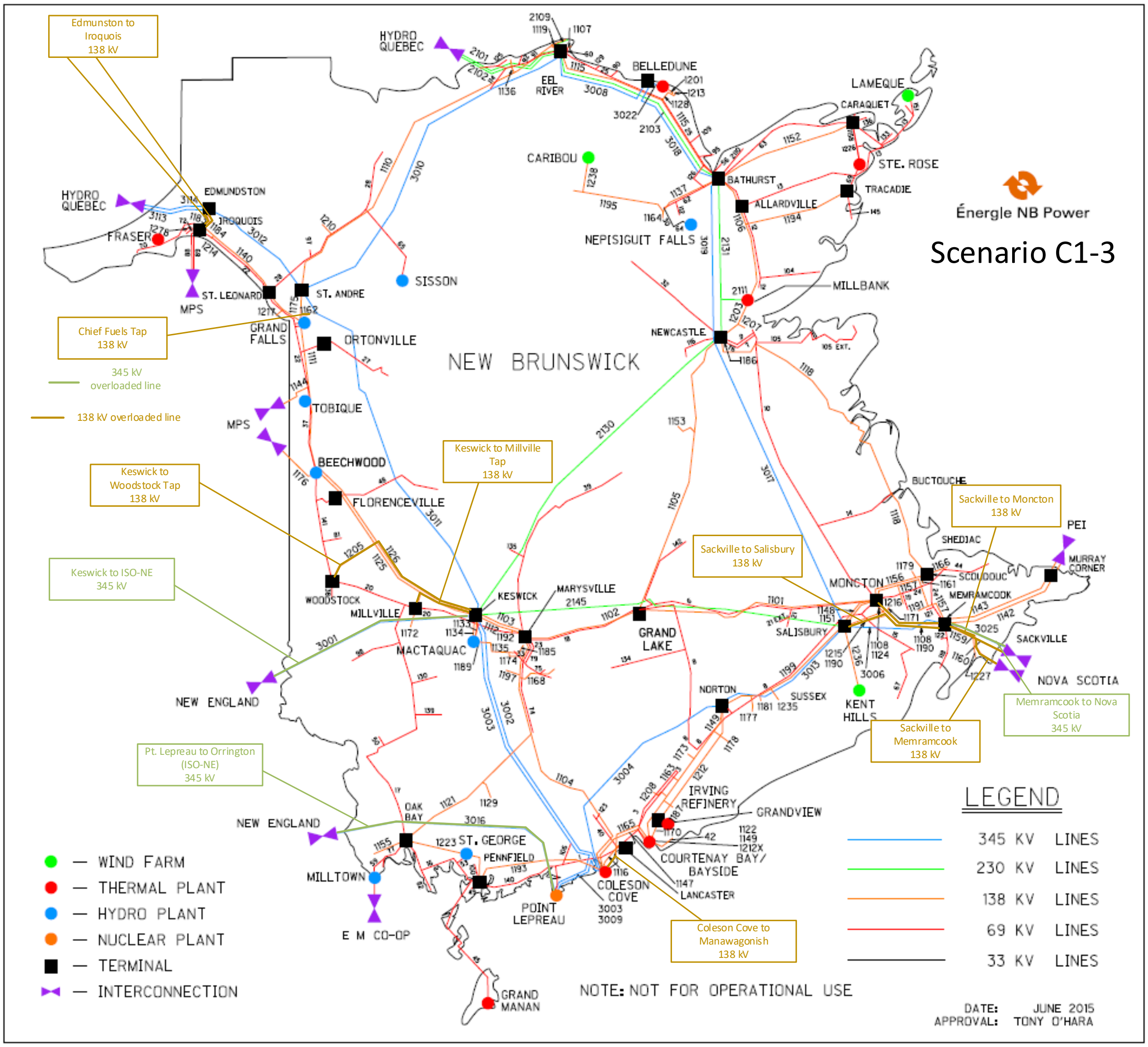


Figure 6.I Scenario C1-3: Key System Overloads in New Brunswick

6.3.4 C2-1: Domestic + Export Markets

The power flow results for the 2035 C2-1 domestic and export markets scenario are as follows:

- N-0/N-1 Overloads: 21/31 (NB–NS–PEI)
- Overloads by Voltage Distribution: 138 kV (19), 230 kV (5), 345 kV (7)
- Severity/Mitigation: 19 operating measures, 3 reconductoring, 5 new circuits (≥120%), and 4 new transformers (≥110%)
- Key Insights: The NB–NS 345 kV tie lines are identified as the transmission bottleneck; 138 kV feeders are stressed during contingencies. Transformer overloads occur at intertie substations.

- Actions:
    - Curtailing of exports and RAS
    - Reconductor 138 kV, transformer upgrades
    - Build new NB–NS 345 kV line and 138 kV circuits ahead of export growth

Figure 6.J shows the key system overloads and offshore wind location in NS for Scenario C2-1.

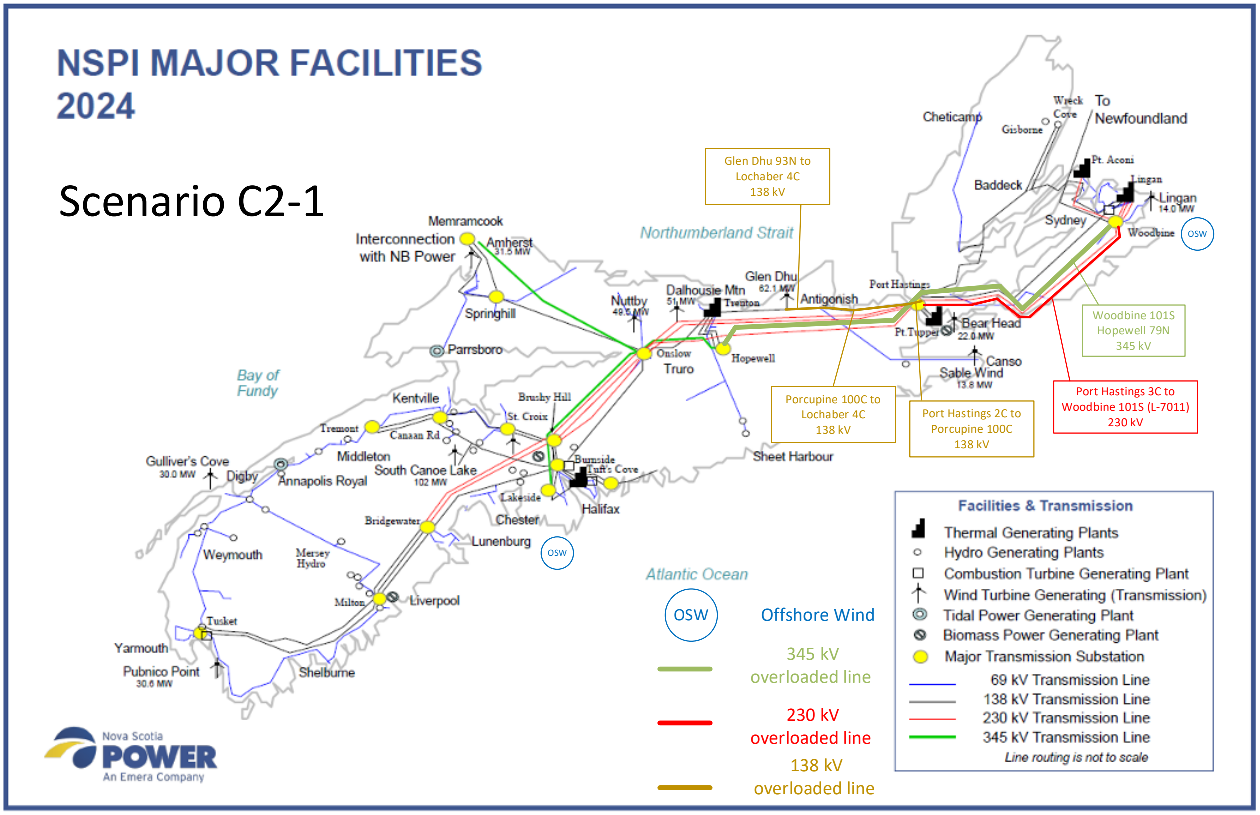


Figure 6.J Scenario C2-1: Key System Overloads in Nova Scotia

6.3.5 C2-2: Domestic + Export Markets

The power flow results for the 2035 C2-2 domestic and export markets scenario are as follows:

- N-0/N-1 Overloads: 9/34 (NB–NS–PEI)
- N-1 Overloads by Voltage Distribution: 138 kV (14), 230 kV (7), 345 kV (13)
- Severity/Mitigation: 9 operating measures, 6 reconductoring, 15 new circuits (≥120%), and 4 new transformers (≥110%)
- Key Insights: 345 kV backbone is highly vulnerable; 138 kV and 230 kV networks are overstressed during contingencies. Transformer overloads are pervasive.
- Actions:
    - Enhanced RAS and operational limits

- Transformer upgrades, reconductoring
- Redundant 345 kV and 138 kV paths built ahead of export expansion

Figure 6.K and Figure 6.L show the key system overloads and offshore wind location in NS and NB, respectively, for Scenario C2-2.

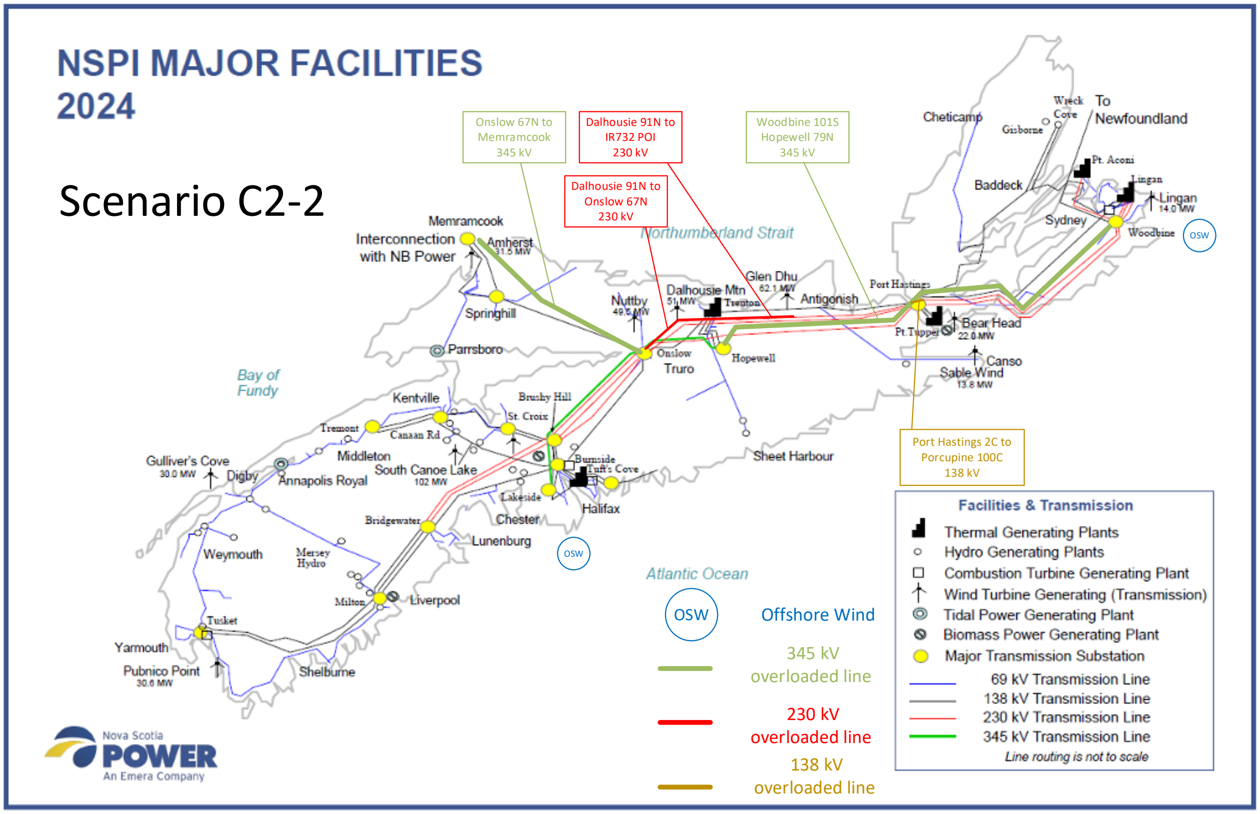


Figure 6.K Scenario C2-2: Key System Overloads in Nova Scotia

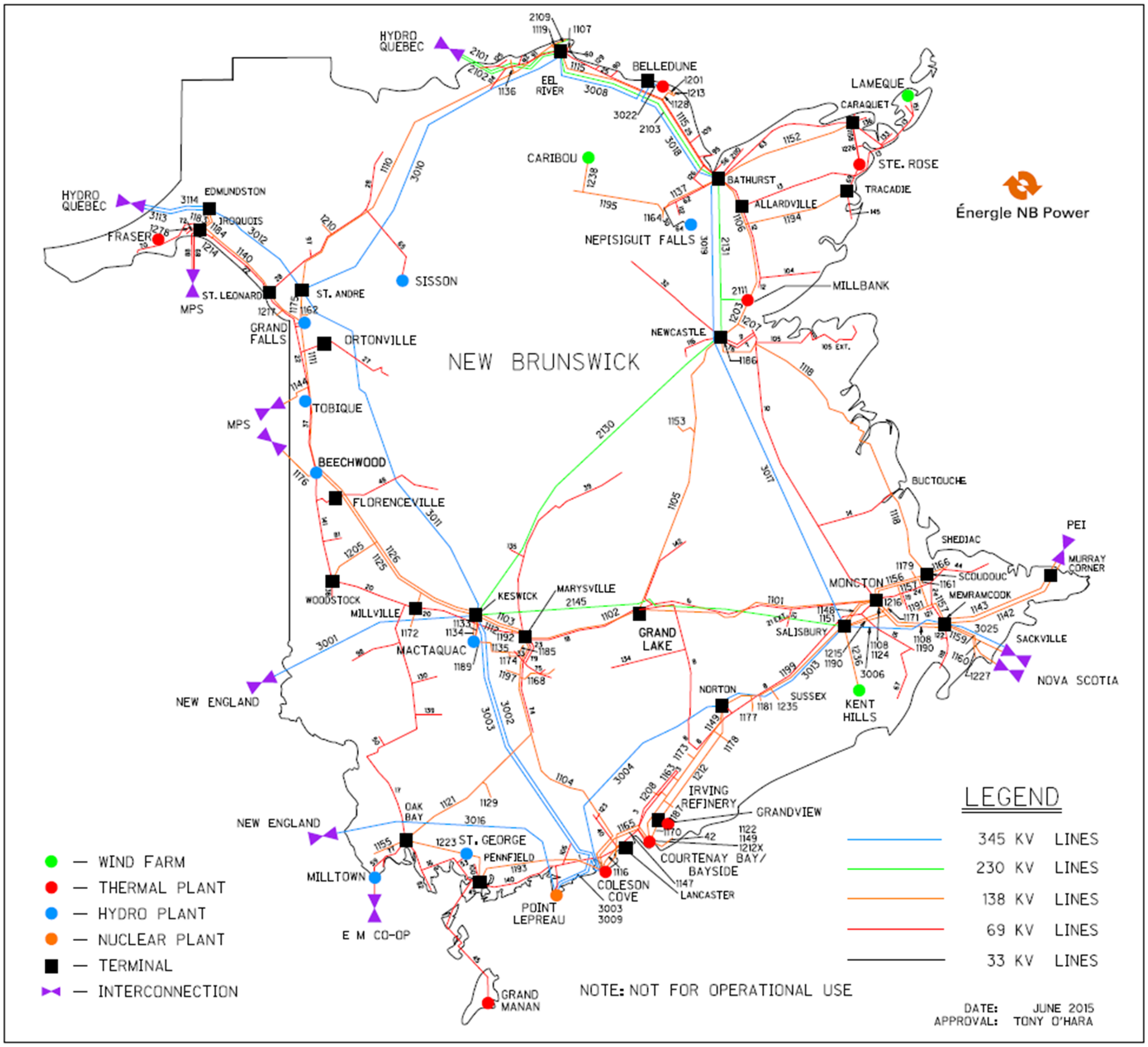


Figure 6.L Scenario C2-2: Key System Overloads in New Brunswick

6.3.6 C3-1: Domestic + Base Hydrogen

The power flow results for the 2035 C3-1 domestic markets and base hydrogen scenario are as follows:

- NB–NS–PEI: N-0/N-1 = 20/32
- NL: N-0/N-1 = 28/40
- Overloads by Voltage Distribution: NB–NS–PEI: 138 kV (22), 230 kV (4), 345 kV (6); NL: 230 kV (24), 138 kV (12)

- Severity/Mitigation: NB–NS–PEI: 12 operating measures, 2 reconductoring, 11 new circuits, and 7 new transformers; NL: 3 operating measures, 6 reconductoring, 16 new circuits (≥120%), and 11 new transformers (≥110%)
- Key Insights: Hydrogen load shifts stress to 138 kV and transformers in NB–NS–PEI; NL's 230 kV grid is the main bottleneck.
- Actions:
  - Electrolyzer load flexibility, offshore wind curtailment
  - 138 kV upgrades, transformer additions, NL 230 kV expansion
  - New 138 kV feeders, 230 kV lines, voltage support devices planned in parallel with hydrogen ramp-up

Figure 6.M, Figure 6.N, and Figure 6.O show the key system overloads and offshore wind locations in NS, NB, and NL, respectively, for Scenario C3-1.

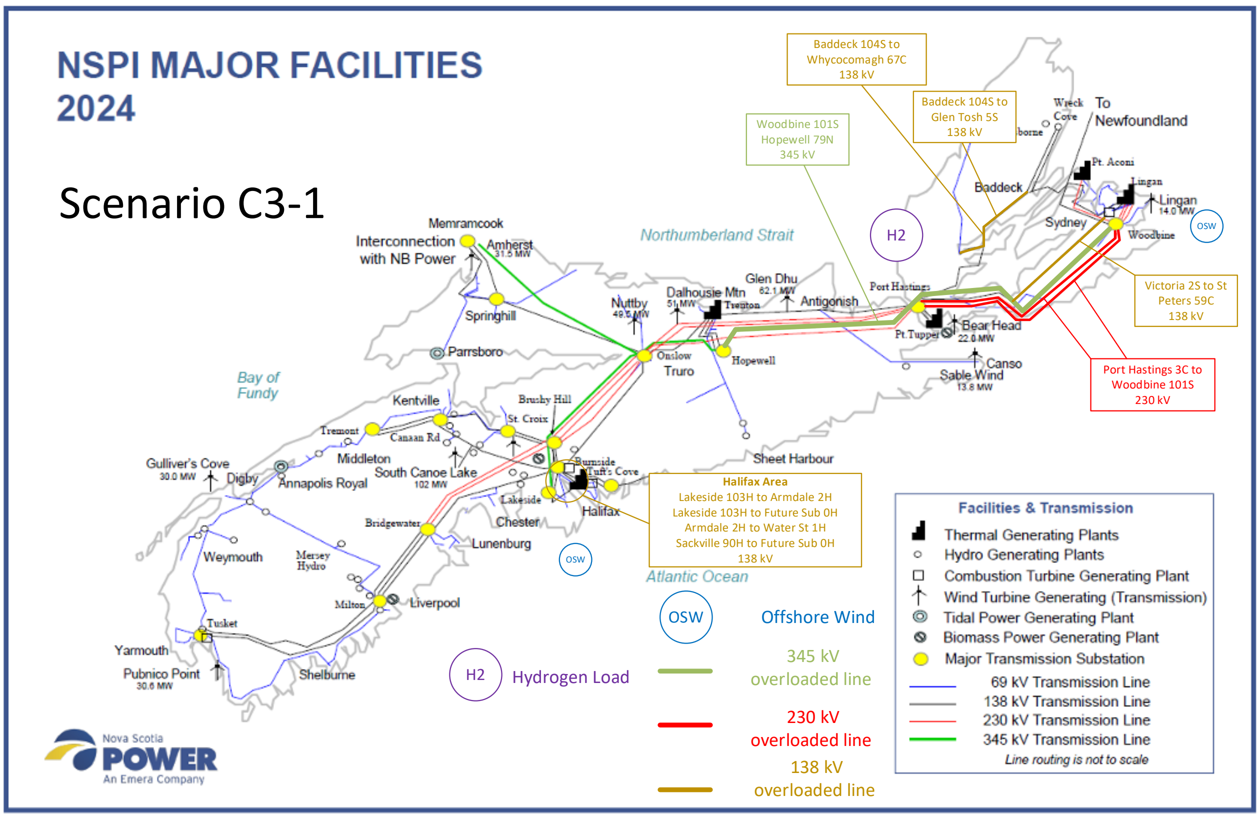


Figure 6.M Scenario C3-1: Key System Overloads in Nova Scotia

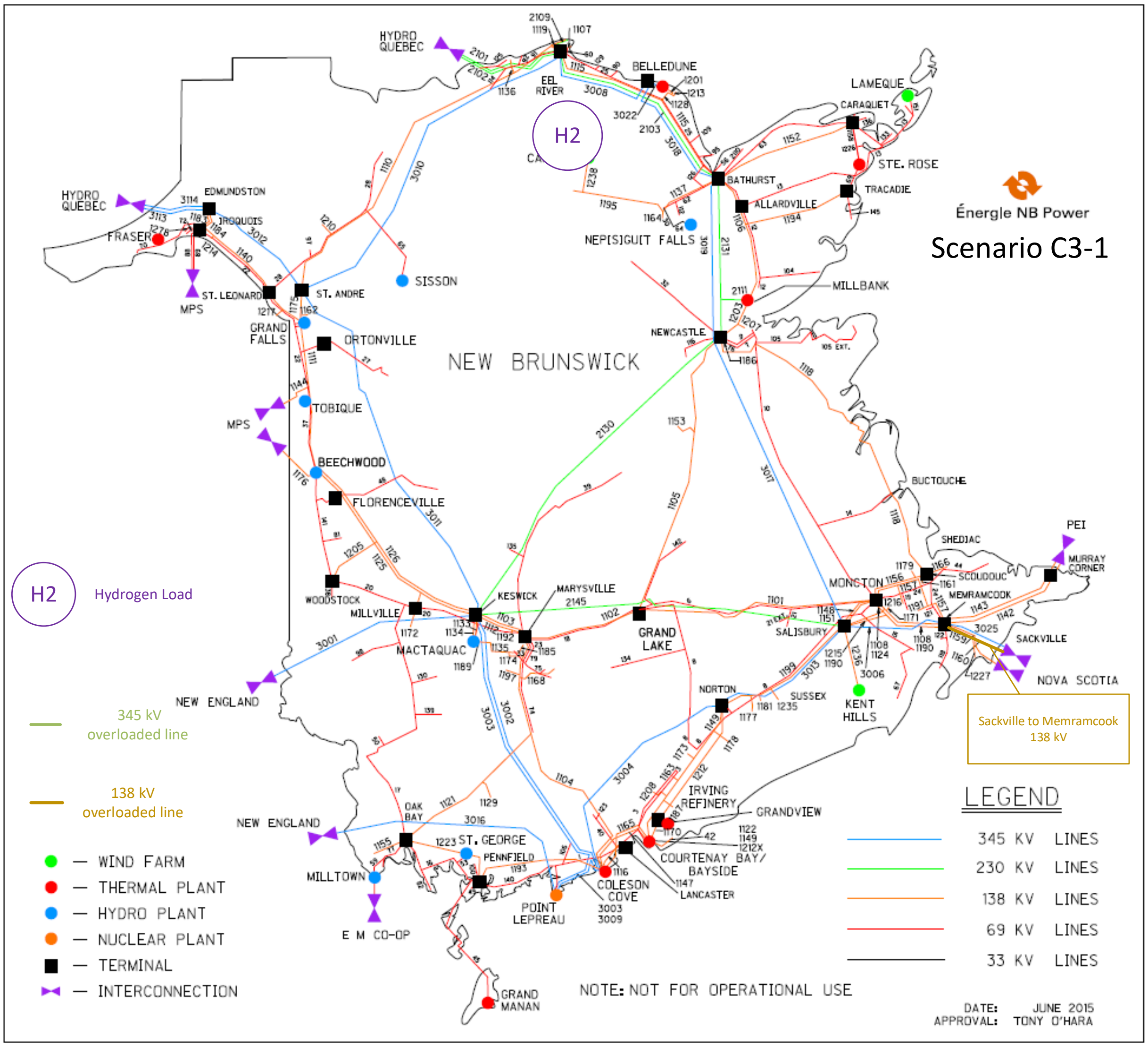


Figure 6.N Scenario C3-1: Key System Overloads in New Brunswick

Figure 6.O Scenario C3-1: Key System Overloads in Newfoundland and Labrador

6.3.7 C4-1: All Markets (Domestic + Base Hydrogen + Exports)

The power flow results for the 2035 C4-1 all markets scenario are as follows:

- NB–NS–PEI: N-0/N-1 = 16/31
- NL: N-0/N-1 = 28/42
- Overloads by Voltage Distribution: NB–NS–PEI: 138 kV (15), 230 kV (5), 345 kV (11); NL: 230 kV (26), 138 kV (12)
- Severity/Mitigation: NB–NS–PEI: 9 operating measures, 2 reconductoring, 15 new circuits (≥120%), and 5 new transformers (≥110%); NL: 4 operating measures, 5 reconductoring, 18 new circuits (≥120%), and 11 new transformers (≥110%)
- Key Insights: 345 kV backbone and 138 kV networks are at their limits; NL's 230 kV system is severely overloaded.
- Actions:
  - Targeted curtailment, hydrogen load management
  - Twin 345 kV tie, expand 138 kV, transformer upgrades, NL 230 kV rebuild
  - New HVDC link, grid modernization, energy storage planned ahead of full market integration

Figure 6.P, Figure 6.Q, and Figure 6.R show the key system overloads and offshore wind location in NS, NB, and NL, respectively, for Scenario C4-1.

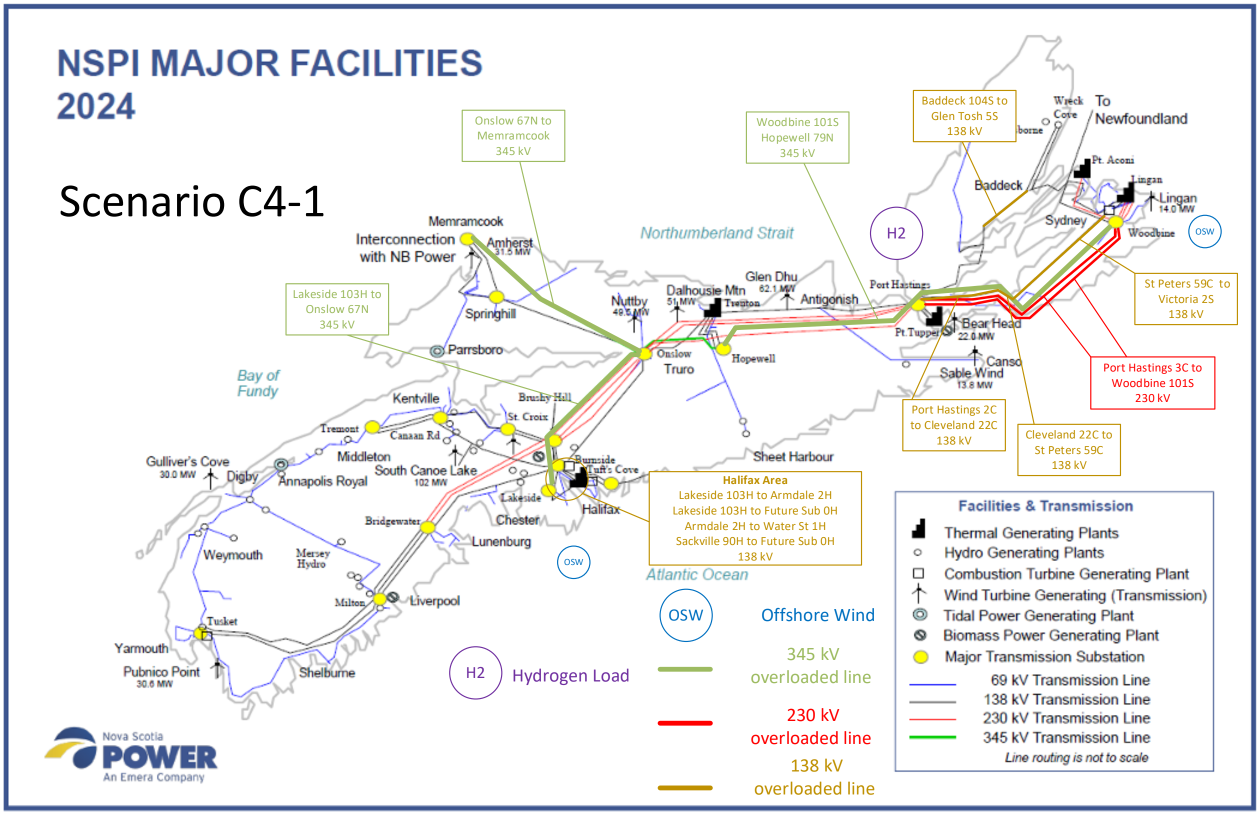


Figure 6.P Scenario C4-1: Key System Overloads in Nova Scotia

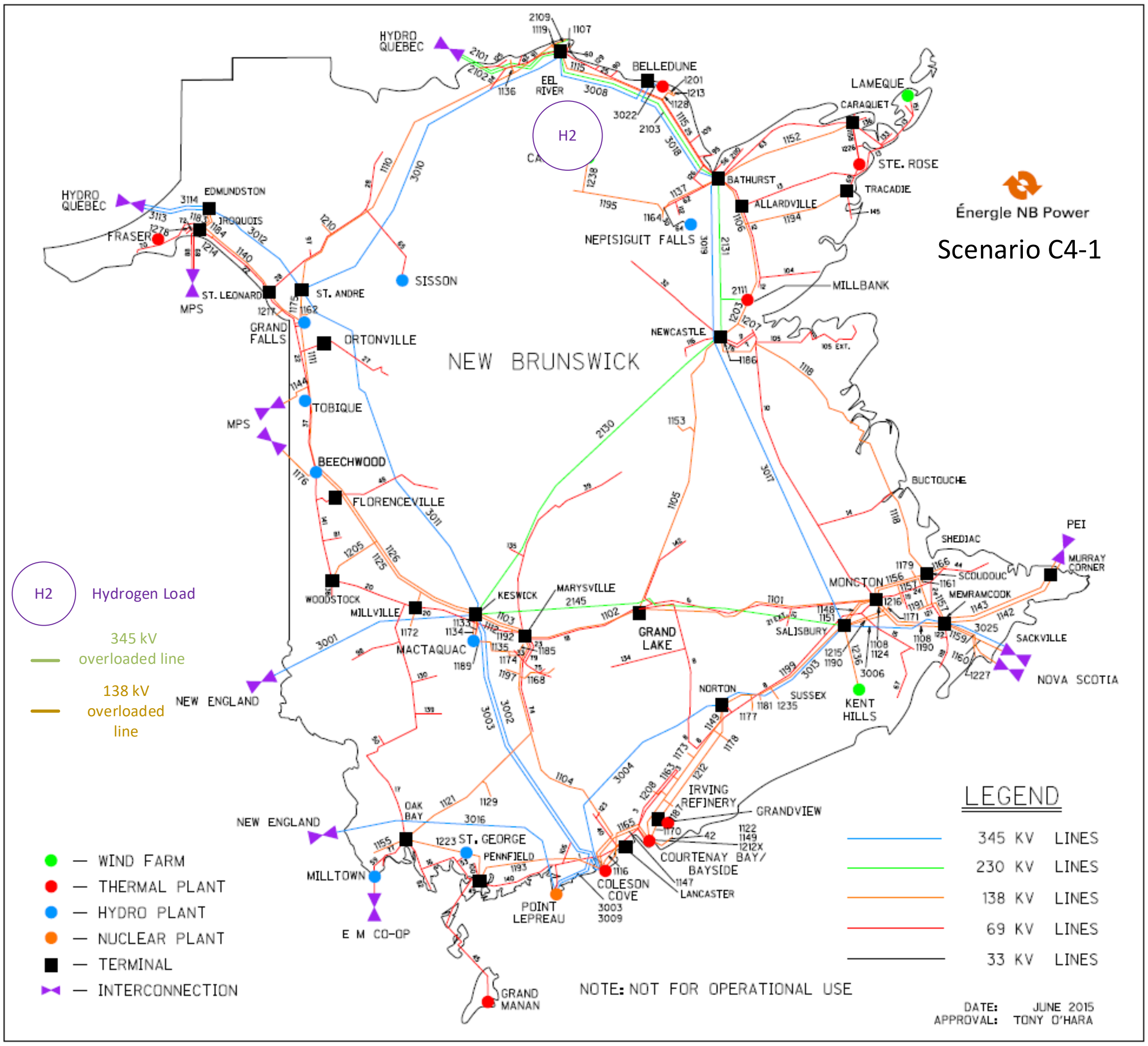


Figure 6.Q Scenario C4-1: Key System Overloads in New Brunswick

Figure 6.R Scenario C4-1: Key System Overloads in Newfoundland and Labrador

6.3.8 C4-2: All Markets (Domestic + High Hydrogen + Exports)

The power flow results for the 2035 C4-2 all markets scenario are as follows:

- NB–NS–PEI: N-0/N-1 = 31/40
- NL: N-0/N-1 = 28/42
- Overloads by Voltage Distribution: NB–NS–PEI: 138 kV (21), 230 kV (8), 345 kV (11); NL: 230 kV (33), 138 kV (14)
- Severity/Mitigation: NB–NS–PEI: 16 operating measures, 3 reconductoring, 12 new circuits (≥120%), and 9 new transformers (≥110%); NL: 10 operating measures, 4 reconductoring, 20 new circuits (≥120%), and 13 new transformers (≥110%)
- Key Insights: All voltage levels are maxed out; even normal operation violates criteria. NL's 230 kV grid is critically overloaded.
- Actions:
    - Severe curtailment, hydrogen modulation, emergency islanding
    - Multiple new 345 kV and 230 kV lines, transformers, and wide-area protection
    - 500 kV super-grid, HVDC overlay, large-scale storage, dynamic hydrogen control planned as part of long-term vision

Figure 6.S, Figure 6.T, and Figure 6.U show the key system overloads and offshore wind locations in NS, NB, and NL for Scenario C4-2.

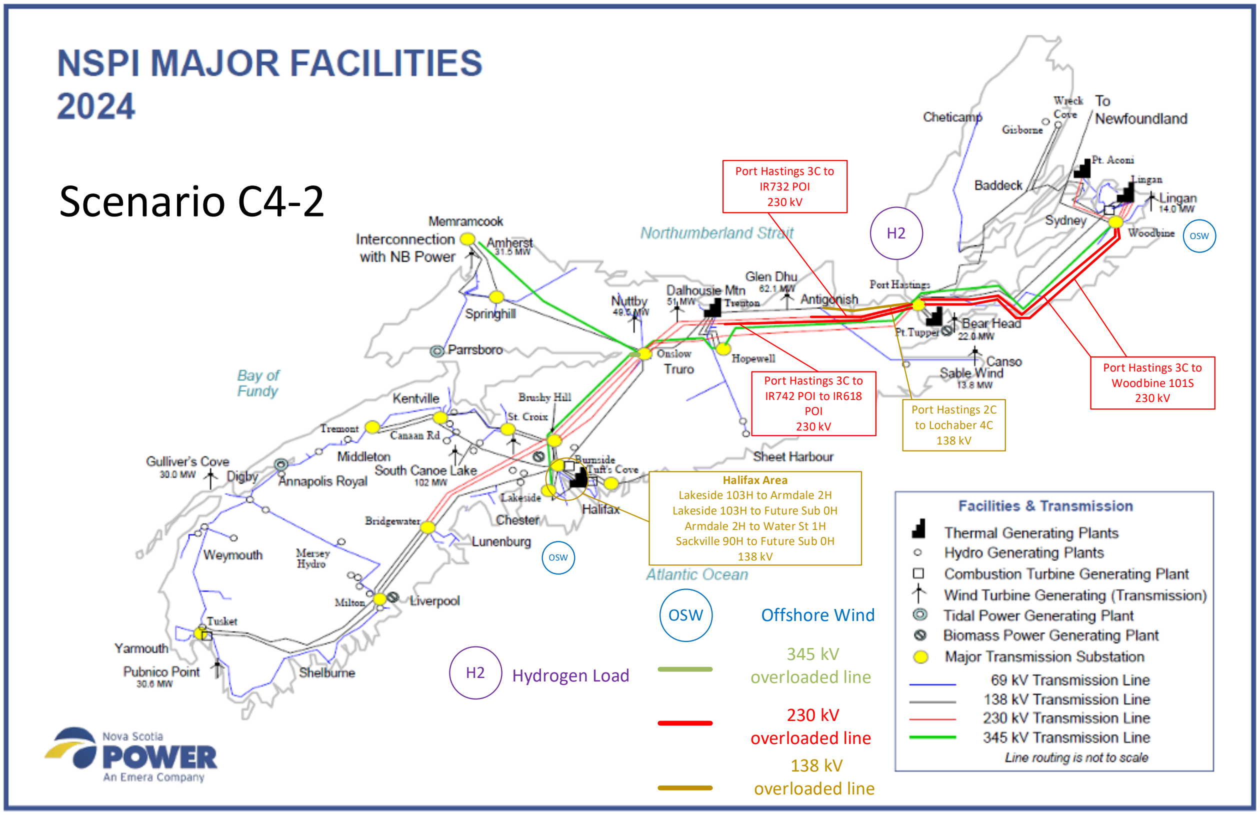


Figure 6.S. Scenario C4-2: Key System Overloads in Nova Scotia

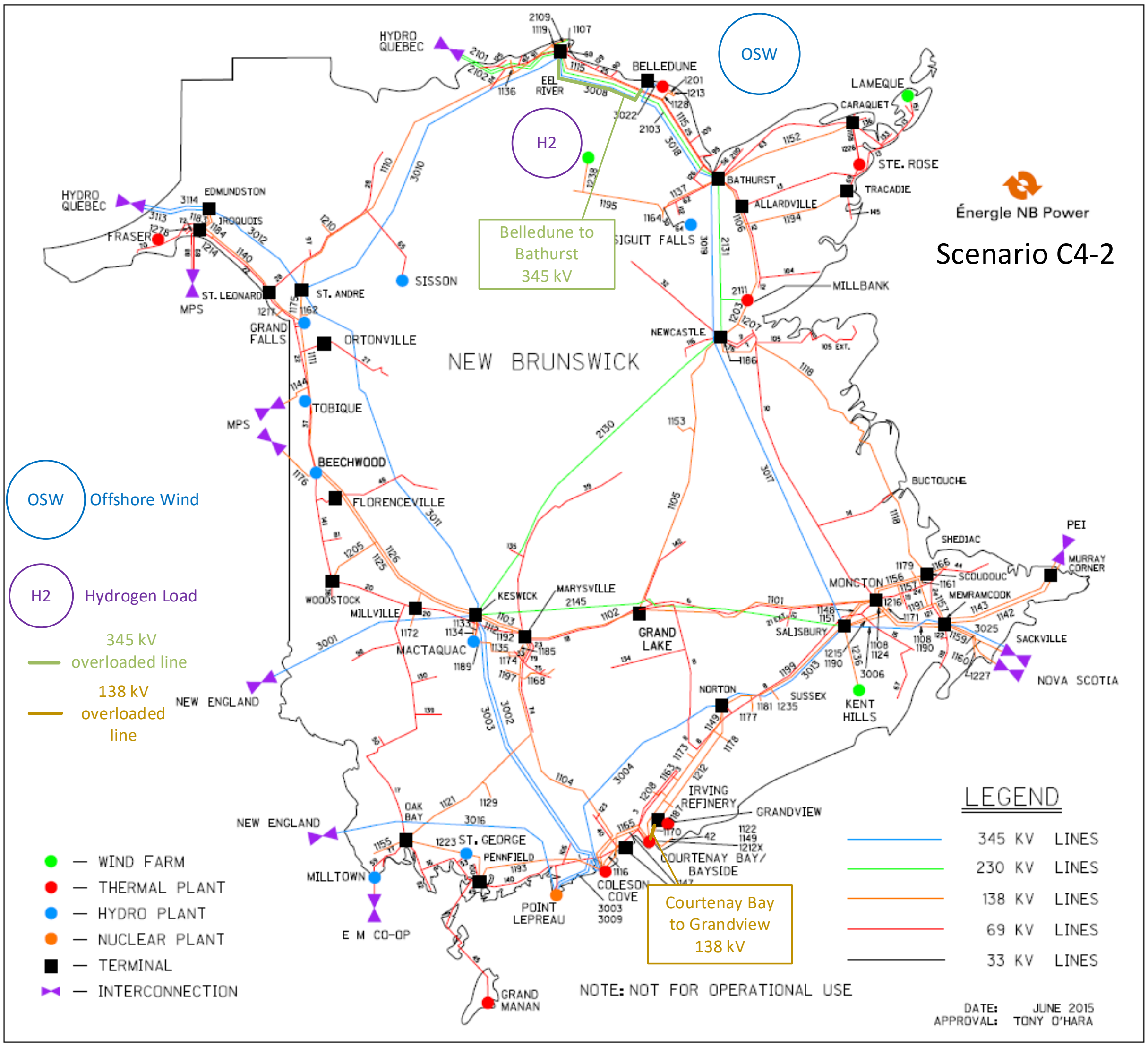


Figure 6.T. Scenario C4-2: Key System Overloads in New Brunswick

Figure 6.U. Scenario C4-2: Key System Overloads in Newfoundland and Labrador

6.4 Cost Estimates for 2035 Transmission System Upgrades

A cost estimate was prepared to quantity the transmission system upgrades identified in the grid integration scenarios for the planning year 2035. The power flow and transient stability results discussed in the preceding sections identified thermal overloads on transmission lines and transformers under both normal N-0 and single contingency N-1 conditions. Overloads that required infrastructure upgrades have been included in the cost estimate developed to quantify the transmission system upgrades for each of the scenarios in the study. As discussed in Section 6.1, overloads that were 110 to 120% of the rating of the transmission line were considered moderate and could be resolved by reconductoring transmission lines. Overloads that were more than 120% of the line rating were considered severe and would require new transmission lines to be built to accommodate the additional power flows. Similarly, overloads greater than 110% of a transformer rating would require another parallel transformer to be installed to mitigate the overload. Cost estimates were developed for overloaded lines and transformers identified in Section 6.3 based on the preceding assumptions.

As well, the cost estimates included the synchronous condensers that were added to the power system cases to provide voltage support to the system and to improve power system stability, as identified in Table 7-1.

The high-level cost estimates developed for the 2035 scenarios are shown in Table 6-1. The cost estimates are in 2025 Canadian dollars and have an accuracy of +100%/-50% according to Class 5 of the Association for the Advancement of Cost Engineering (AACE).

The differences in costs between the planning study scenarios within market scenarios C1 and C2, i.e. between C1-1, C1-2, and C1-3, and between C2-1 and C2-2, are due to the differences in location and dispatch amounts of onshore generation that were considered in each of the planning study scenarios. The intent in studying different onshore generation dispatches was to assess the impacts to the onshore transmission system of the different onshore generation dispatches and offshore wind integrations for each particular transmission planning scenario. The costs shown in Table 6-1 indicate that the impacts of integrating offshore wind at particular points of interconnection in the onshore network are closely related to the location of onshore generation and retirements, and both of the preceding have a significant impact on the system upgrades required to support the integration of offshore wind into the system.

Table 6-1 Cost Estimate for 2035 Transmission System Upgrades

Transmission Planning Scenario	High Level Cost Estimate for Transmission System Upgrades (2025 Canadian Dollars)	Transmission System Upgrades (Refer to Section 6.3 for Additional Details)
C1-1 NS, NB, PEI	$2,000,000,000	~1000 km of new or reconductored 138, 230, and 345 kV transmission lines 7 transmission line reconductoring 12 new transmission lines 1 new transformer

Transmission Planning Scenario	High Level Cost Estimate for Transmission System Upgrades (2025 Canadian Dollars)	Transmission System Upgrades (Refer to Section 6.3 for Additional Details)
C1-2 NS, NB, PEI	$1,500,000,000	~700 km of new or reconductored 138, 230, and 345 kV transmission lines 5 transmission line reconductoring 7 new transmission lines 5 new transformers
C1-3 NS, NB, PEI	$5,500,000,000	~2600 km of new or reconductored 138, 230, and 345 kV transmission lines 10 transmission line reconductoring 15 new transmission lines 2 new transformers
C2-1 NS, NB, PEI	$2,500,000,000	~900 km of new or reconductored 138, 230, and 345 kV transmission lines 3 transmission line reconductoring 5 new transmission lines 4 new transformers FACTS/Synchronous condensers
C2-2 NS, NB, PEI	$4,000,000,000	~1600 km of new or reconductored 138, 230, and 345 kV transmission lines 6 transmission line reconductoring 15 new transmission lines 4 new transformers FACTS/Synchronous condensers
C3-1 NS, NB, PEI	$3,600,000,000	~650 km of new or reconductored 138, 230, and 345 kV transmission lines 2 transmission line reconductoring 11 new transmission lines 7 new transformers FACTS/Synchronous condensers
C3-1 NL	$600,000,000	~270 km of new or reconductored 230 kV transmission lines 6 transmission line reconductoring 16 new transmission lines 11 new transformers
C4-1 NS, NB, PEI	$3,000,000,000	~750 km of new or reconductored 138, 230, and 345 kV transmission lines 2 transmission line reconductoring 15 new transmission lines 5 new transformers FACTS/Synchronous condensers
C4-1 NL	$900,000,000	~400 km of new or reconductored 230 kV transmission lines 5 transmission line reconductoring 18 new transmission lines 11 new transformers
C4-2 NS, NB, PEI	$3,500,000,000	~1100 km of new or reconductored 138, 230, and 345 kV transmission lines 3 transmission line reconductoring 12 new transmission lines 9 new transformers FACTS/Synchronous condensers

Transmission Planning Scenario	High Level Cost Estimate for Transmission System Upgrades (2025 Canadian Dollars)	Transmission System Upgrades (Refer to Section 6.3 for Additional Details)
C4-2 NL	$1,500,000,000	~300 km of new or reconductored 230 kV transmission lines 4 transmission line reconductoring 20 new transmission lines 13 new transformers FACTS/Synchronous condensers

6.5 Recommendations

By 2035, the regional transmission network will require additional capacity across all major voltage levels to support offshore wind integration, growing electricity demand, additional onshore renewable energy integration and enhanced interprovincial power transfers across Atlantic Canada.

Key transmission system recommendations that were identified from the preliminary transmission needs analysis carried out for this project include the following:

- Expansion of the New Brunswick–Nova Scotia (NB–NS) interface to approximately 1,000 MW to improve interprovincial transfer capability, enhance operational flexibility, and support offshore wind integration.
- Reinforcement of Nova Scotia's onshore transmission system through the development of an additional 345 kV path to strengthen the provincial grid backbone, improve reliability, and facilitate delivery of new generation to major load centers.
- Augmentation of the New Brunswick–Prince Edward Island (NB–PEI) interconnection to support higher transfer capability and meet PEI's growing energy needs. The new NB–PEI link represents an initial step toward this goal.
- Substantial upgrades to Newfoundland and Labrador's transmission system to accommodate increased generation development, improve system reliability, and enable greater integration with the broader Atlantic Canada regional grid.

Beyond physical infrastructure, operational readiness and system planning practices must evolve to maintain system stability as the generation mix shifts. The gradual retirement of conventional thermal generating units—which have historically provided inertia and voltage support—necessitates careful management of retirement schedules to ensure that sufficient system inertia and essential reliability services remain available.

To address the reduced contribution of traditional synchronous generators, system operators may need to deploy a range of advanced grid-support technologies, including:

- **Grid-Forming Inverters:** Installed at wind, solar, or battery energy storage facilities, these inverters can emulate the behavior of synchronous machines by providing synthetic inertia and frequency regulation, helping stabilize the grid during disturbances.

- **Synchronous condensers:** Rotating machines that provide real inertia, short-circuit strength, and dynamic voltage support without active power generation. They are particularly valuable in weak-grid areas.
- **Static Synchronous Compensators (STATCOMs):** Power electronics-based devices that provide fast-acting dynamic reactive power support to maintain voltage stability and improve power quality.
- **Battery Energy Storage Systems (BESS):** Can provide fast frequency response, synthetic inertia, and voltage support, while also offering energy shifting and peak shaving capabilities.
- **Flexible AC Transmission Systems (FACTS):** Technologies such as Static Var Compensators (SVCs) and Thyristor-Controlled Series Capacitors (TCSCs) can enhance controllability and increase power transfer capability of existing transmission infrastructure.
- **Advanced Protection and Control Systems:** Wide-area monitoring, protection, and control (WAMPAC) systems using synchrophasor data can improve situational awareness and enable faster, more coordinated system responses.

Together, these technologies will help maintain reliable system operation while enabling the integration of higher levels of renewable generation across the region.

7 2035 Transient Stability Study Results

To provide a high level indication of where high offshore wind injections might impact system stability, a preliminary transient stability screening was conducted. This broad assessment used time-domain simulations to explore how the Atlantic grid, as configured in 2035 scenarios, could tolerate “N-1” events such as faults or the loss of a major transmission element. The results helped identify conditions under which system stability could become challenging, signalling where more detailed stability studies and targeted reinforcements may be warranted.

7.1 Key Stability Insights

Distributing offshore wind generation across multiple POIs improves overall system stability. Globally, it is common practice to avoid concentrating very large generation blocks at a single substation in order to minimize the impact of potential loss-of-infeed events on the network. Splitting offshore wind injections among multiple 345 kV nodes help reduce stress on the transmission system and makes it easier for the grid to withstand routine contingencies. This approach reduced the severity of stability issues and provided alternative pathways for power flow, while highlighting that detailed studies would be needed to define precise limits and assess equipment-specific mitigation measures.

NB’s Support is Crucial for NS Offshore Wind Development: Nova Scotia’s ability to integrate very large offshore wind injections is constrained by its connection to the wider grid through New Brunswick. Preliminary analysis shows that, in the absence of any new upgrades, injecting more than about 2-3 GW into Nova Scotia via a single corridor causes voltage-stability issues. This does not imply that Nova Scotia is inherently incapable of large wind development; rather, it highlights that additional grid investment—such as a third NB-NS intertie, strengthened 345 kV corridors, extra reactive-power resources, and possibly new HVDC links to New England or Québec—is essential to maintain stability as offshore wind scales up.

Routing a portion of offshore wind through New Brunswick or directly to external markets, supported by appropriate transmission reinforcements, would help alleviate single-point transmission stresses and enhance the ability of the broader Eastern Interconnection to support offshore wind development in Nova Scotia.

Inertia and Grid-Forming Technology: As offshore wind and other inverter-based resources displace conventional synchronous generators, the grid's natural "spinning" inertia declines. In this preliminary stability screening, low-inertia conditions led to deeper frequency and voltage dips under certain contingencies than in cases with more synchronous support. To ensure reliable operation, the assessment therefore calls for maintaining some combination of inertia across the system—either by keeping a modest amount of thermal or hydro units online during high-wind periods, or by deploying advanced solutions such as battery storage or wind turbines with grid-forming converters that can provide synthetic inertia. Over time, as grid-forming technologies mature and become widely deployed, they could progressively replace today's conventional inertia. Until then, it would be prudent to retain a few hundred megawatts of synchronous generation or its synthetic equivalent in Nova Scotia and New Brunswick to help the system ride through faults and line trips.

7.2 Stability Status by Scenario

A set of ten N-1 contingencies on critical 230 kV and 345 kV lines in NS and NB were simulated in PSS®E to assess transient voltage stability under 2035 operating conditions with progressively higher offshore wind injections. Each contingency consists of tripping a single interprovincial or intraprovincial transmission element in the 2035 base case. Stability was evaluated against standard transient stability criteria: a case is "Stable" if bus voltages remain above the transient threshold (no drop below ~0.8 p.u., duration-dependent) and recover to ≥ 0.9 p.u. within ~20–30 s with well-damped oscillations; "Voltage Instability (Collapse)" indicates voltages do not recover.

In C1 and C2 scenarios (~1–3 GW offshore wind), the system was stable for most N-1 events. System collapse occurred only for the specific loss of the main NS 345 kV line, which can be addressed by the transmission upgrades noted (additional NS 345 kV path or fast post-contingency action). In C3 (4.5 GW offshore wind + hydrogen), some instabilities were observed, and in C4 (6.5+ GW) significant stability issues were noted without mitigation. Table 7-1 shows stable vs. unstable outcomes per scenario, confirming that up to 3 GW of offshore wind was manageable with planned upgrades (and synchronous condensers); however, integrating higher levels will require further mitigation measures. These could include devices that provide dynamic reactive support (such as STATCOMs and synchronous condensers), integrating grid-forming capabilities in wind plants or battery energy storage to supply synthetic inertia, spreading offshore wind injections among multiple POIs, and strengthening onshore or HVDC links to neighbouring regions. Such measures would enhance system inertia, reactive power and transfer capacity, helping the network ride through contingencies as offshore wind scales up.

In operational terms, Nova Scotia needs a stronger backbone or additional support to handle large swings. For example, the outage of the Onslow–Lakeside 345 kV in the simulation led to a cascading voltage drop in mainland NS with ~0.8 p.u. voltages that did not recover. This underscores that building a loop (Onslow–Lakeside #2 or an HVDC link from Woodbine/Lakeside to the New England) is not just increasing thermal capacity but also providing an alternate path to prevent voltage collapse. Operational protocols like fast generation shedding or load shedding schemes can also provide system stability support during contingencies.

Ten single contingencies were evaluated for 2035 transient stability studies. Each involves tripping a major interprovincial or intraprovincial transmission line in the 2035 base case. Table 7-1 presents the 2035 transient stability results.

Table 7.1 2035 Transient Stability Results

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Capacity (MW)	Offshore Wind Locations	Key Observations
2035 Scenario C1-1	C1 Domestic-only Market	1,000	NS: Sydney Bight Fixed	System Stable
2035 Scenario C1-2	C1 Domestic-only Market	1,000	NS: Sydney Bight Fixed	System Stable
2035 Scenario C2-1	C2 Domestic + Export Markets	3,000	NS: Sydney Bight Fixed NS: Middle Bank Fixed	System stable with synchronous condenser and required transmission upgrades.
2035 Scenario C2-2	C2 Domestic + Export Markets	3,000	NS: Sydney Bight Fixed NS: Middle Bank Fixed	System stable with synchronous condenser and required transmission upgrades.
2035 Scenario C3-1	C3 Domestic + Base Hydrogen	4,500	NS: Sydney Bight Fixed NS: Middle Bank Fixed PE: C22 Fixed (North of PEI)	Stability issue identified. Voltage collapsed at post-fault.
2035 Scenario C4-1	C4 All Markets (Domestic, Base Hydrogen and Exports)	6,500	NS: Sydney Bight Fixed NS: Middle Bank Fixed NS: Canso Bank Floating NS: French Bank Floating PE: C22 Fixed (North of PEI) NL: C4 Floating (St. John's)	Stability issue identified. Voltage collapsed at post-fault.
2035 Scenario C4-2	C4 All Markets (Domestic, High Hydrogen and Exports)	7,500	NS: Sydney Bight Fixed NS: Middle Bank Fixed NS: Canso Bank Floating PE: C22 Fixed (North of PEI) NB: C24 Floating (Bathurst)	Stability issue identified. Voltage collapsed at post-fault.

Recommended Stability Measures:

- **Diversify Offshore Wind Injection:** Spread wind farms across multiple POIs. The plan explicitly suggests not concentrating more than ~3,000 MW of offshore wind into Nova Scotia without additional export outlets.
- **Strengthen NB–NS Ties:** In addition to the second 345 kV line which is currently approved and under construction, the assessment indicates that Nova Scotia's radial interconnection through New

Brunswick requires further reinforcement. This could involve augmenting transfer capacity on other NB-NS transmission paths and strengthening the New Brunswick grid westward from Salisbury to bring more inertia and reactive power support into Nova Scotia from the rest of the Eastern Interconnect. Such investments would raise stability margins and enable higher levels of offshore wind injection while maintaining reliability.

- **Explore Grid-Forming Controls and Storage Options:** At present, commercially available grid-forming controls for large offshore wind plants are limited; most grid-forming inverters are used in small islanded microgrids, and research into their deployment in grid-connected systems is still in its early stages. Consequently, rather than requiring grid-forming offshore turbines by 2035, it would be prudent to focus on near-term solutions such as synchronous condensers and utility-scale battery storage to provide synthetic inertia and arrest voltage or frequency dips. The Phase 1 study recommended exploring about 300 MW of battery capacity in Nova Scotia by 2035. At the same time, policymakers and system planners should monitor developments in grid-forming technology and consider pilot projects, so that when commercially viable grid-forming offshore wind or hybrid systems become available, they can be incorporated into the future resource mix.
- **Remedial Action Schemes for Stability:** Implement automatic schemes to trip some offshore wind generation if a critical line trips to avoid an uncontrolled collapse.
- **Consider HVDC-Based Offshore Wind Integration (Longer-Term Option):** Large-scale offshore wind developments (≥1 GW) are often integrated using VSC-HVDC transmission, which can decouple offshore generation from onshore grid disturbances and provide fast voltage and active and reactive power control, and may also be able to provide grid-forming support to the system. Dedicated offshore HVDC export systems were not assumed in this preliminary assessment, as the focus was on the analysis of power flows, voltage, and stability within the onshore network. HVDC-based integration should be considered in future detailed studies, including impact to the onshore network from loss of offshore generation, once offshore wind locations and capacities are more clearly defined and decisions regarding required onshore system upgrades and potential direct transmission to other markets are further developed.

The analysis indicates that system stability could be maintained up to the studied offshore wind levels in cases where the recommended transmission reinforcements are implemented and appropriate operational measures are available to mitigate identified stability risks. However, in higher-stress scenarios (C3-1, C4-1, and C4-2), stability issues were identified and were not fully resolved within the scope of this assessment. These results suggest that additional transmission capacity, increased system redundancy, and targeted stability-enhancing measures would be required to support reliable operation under those scenarios.

Nova Scotia's radial system increases its sensitivity to contingencies, underscoring the importance of added capacity and redundancy, strong NB–NS interconnections, geographic diversity of offshore wind development, and retention of critical rotating machines in the generation mix. While these measures are directionally expected to improve system performance, detailed studies would be required to confirm that voltages and frequencies remain within acceptable limits under N-1 contingencies, particularly for the highest offshore wind and export cases.

8 Conclusions and Next Steps for 2035 Transmission Expansion Needs Analysis

This needs assessment outlines a preliminary pathway to integrate on the order of 5 to 6 GW of offshore wind by 2035, alongside new green hydrogen production and increased interprovincial and export power flows, subject to detailed stability and control studies. Achieving this outcome would require proactive grid investments, including upgrades to existing lines, new transmission corridors, and the deployment of modern grid technologies. The studies indicate that, with appropriate coordination, planning, and network investments, Atlantic Canada's grid could accommodate the planned offshore wind growth. However, additional detailed studies including EMT analyses are required to confirm performance related to fast control interactions, low voltage ride through (LVRT) behavior, and other dynamic phenomena prior to implementation, once the offshore wind project details have been determined.

Transmission infrastructure to support domestic and export pathways may need to be developed in advance of offshore wind deployment, depending on the scale and timing of project development. Accordingly, transmission upgrade planning would benefit from early coordination with offshore wind and hydrogen development planning, to ensure that anticipated future power flow requirements are considered and potential upgrades are progressed in a timely manner. This coordinated approach is expected to support system reliability and market access while reducing the risk of transmission bottlenecks that could otherwise limit renewable integration.

New Brunswick could act as a regional hub, with strong ties west to Québec and New England and east to NS and PEI. Many offshore wind scenarios rely on NB's network to route power (e.g. exporting NS wind via NB). As such, reinforcing NB's interprovincial ties—both west and east—emerges as a key enabling consideration. The assessment indicates that New Brunswick's internal system, benefiting from prior 345 kV development, could accommodate new injections largely through upgrades to existing infrastructure (e.g., 138 kV reconductoring and a second Memramcook transformer).

Nova Scotia could host several large offshore wind projects, though integration beyond approximately 2–3 GW would require an additional export outlet or increased system support from NB. Concepts such as looping the 345-kV system and potential future interconnections toward New England are directionally aligned with enabling higher levels of offshore wind development. The retention of dispatchable thermal resources, including converted coal units and existing and new natural gas units, is required. The results of this study demonstrate that these dispatchable resources play a critical role in maintaining grid strength and supporting reliable system operation under higher levels of offshore wind development.

Prince Edward Island could benefit significantly from additional interconnections. With a second NB link, PEI could transition from being import-constrained to having the capability to export wind generation. The analysis suggests that, with sufficient transmission strength, PEI could accommodate approximately 700 MW of offshore wind (or accommodate power from nearby offshore projects) at the West Royalty point of interconnection. Continued close coordination with NB—which operates PEI's interties—would be required, particularly to manage voltage control on the islanded system.

Newfoundland and Labrador could integrate a few large offshore wind projects in eastern regions, where load is concentrated. However, exporting this power off-island or transferring it across the island would require major transmission reinforcements or new export infrastructure (e.g., new transmission link to NS). In the 2035 timeframe, prioritizing on-island load consumption (such as hydrogen production in the Avalon region) may be prudent where transmission remains a limiting factor. This assessment assumed no additional NL–NS link by 2035; should policy or market conditions change, a second HVDC link could be considered in future studies to enable broader export capability.

Regional Planning Alignment: The recommendations presented here are consistent with and extend current utility planning efforts. The study findings highlight the importance of strategic reinforcements to the NB–NS transmission interface and strengthened interconnections with neighboring systems as enabling measures for offshore wind integration. The assessment also identifies the potential need for advanced controls and updated operational standards to support a high-renewable system. Updates to protection schemes, stability criteria, and operator training will be important to manage increased variability associated with renewable generation.

Next Steps: Going forward, we recommend the following:

- **Additional Transmission Planning Studies** to further assess onshore injection points, additional contingencies (including loss of offshore generation), and alternative dispatch scenarios once offshore wind locations and capacities are more clearly defined.
- **Detailed Design Studies:** This Phase 3 report is based on a high level study. Follow-up engineering studies (short-circuit analysis, protection coordination, electromagnetic transient (EMT) simulations for HVDC, etc.) are needed to establish details for the specific upgrades (e.g. designing the exact route and specs of transmission lines or verifying dynamic performance of a particular wind plant interconnection).
- **Stakeholder Collaboration:** Coordinate with neighboring jurisdictions, including ISO-NE and Hydro-Québec, to advance potential export pathways. Should Nova Scotia or New Brunswick pursue exports of surplus wind generation, agreements and technical studies will need to commence by the late 2020s to enable infrastructure deployment by 2035. Engagement with the Federal Government should continue to evaluate funding opportunities that support economic development while advancing decarbonization.
- **Policy and Regulatory Support:** Work with regulators to establish cost-recovery mechanisms for transmission investments that deliver multi-provincial benefits. Facilities such as the NB–NS and NB–PEI interties serve multiple objectives—reliability, clean energy integration, and economic development—and will require coordinated cost-sharing approaches.
- **Innovation Deployment:** The study identifies the potential role of stability-supporting technologies, such as synchronous condensers, or grid-forming inverter functionality, as longer-term options to manage increasing levels of inverter-based generation. This Phase 3 assessment does not include a cost evaluation of these measures and does not recommend immediate pilot or first-of-a-kind deployments. Any consideration of such technologies would require detailed cost-benefit analysis and comparison against conventional transmission and operational solutions in subsequent planning stages.
- **Phased Wind Interconnection:** Staged addition of offshore wind with interim checkpoints – e.g. integrate the first 1 GW and assess system performance, then proceed with the next 2 GW with

upgrades in place, etc. This "learn and adjust" approach allows the plan to be refined over time based on observed system performance.

9 2050 Grid Integration Scenarios

Based on the 2050 results from Phases 1 and 2, Phase 3 screening explores scenarios in which offshore wind integration in Atlantic Canada expands significantly beyond the 2035 timeframe, with higher offshore wind capacity levels, increased electrolyzer (hydrogen) demand, and additional conceptual points of interconnection introduced for assessment purposes. The 2050 scenarios (C1–C4) are the same as the 2035 cases—Domestic-Only, Domestic + Export, Domestic + Hydrogen, and All Markets—but reflect mid-century scales and assumptions. These scenarios build on the 2035 cases by scaling offshore wind from approximately 1 GW in the C1 (2035) case to as much as 16.5 GW in the C4-High scenario by 2050. Collectively, the 2050 scenarios are intended to illustrate the range of potential system conditions associated with Atlantic Canada's evolving role as a regional clean-energy supplier, including domestic supply, exports, and green hydrogen production. Key characteristics of these scenarios include substantially larger offshore wind buildouts, gigawatt-scale hydrogen demand, and the need for significant conceptual transmission reinforcements to enable interprovincial transfers and export capability.

Table 9-1 shows the summary of 2050 offshore wind deployment scenarios for the Phase 3 transmission planning studies, aligned with Phases 1 and 2 assumptions and results. Each scenario lists total offshore wind capacity, the main offshore wind project locations (by province), their POIs, provincial load assumptions, any new hydrogen load added, and a descriptor of the generation mix during the representative dispatch hour used for power system analysis.

Table 9-1 Summary of 2050 Offshore Wind Scenarios

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Capacity (MW)	Offshore Wind Locations	POIs	Provincial Loads Modeled	New Hydrogen Load (MW)	Generation Mix (Dispatch Hour)
2050 Scenario C1-1	C1 Domestic-only Market	2500	NS: Sydney Bight Fixed PE: C22 Fixed (North of PE)	NS: Woodbine 345 kV PEI: Scotchfort 138 kV	Market Opportunity Report Scenario Forecasts[33]	None	High offshore wind, high thermal, low onshore wind
2050 Scenario C1-2	C1 Domestic-only Market	2500	NS: Sydney Bight Fixed PE: C22 Fixed (North of PE)	NS: Woodbine 345 kV PEI: Scotchfort 138 kV	Market Opportunity Report Scenario Forecasts[33])	None	High offshore wind, low thermal, high onshore wind

[33] Load scenarios were designed in Phase 1 and have been consistent throughout the full study. Additional details on these load scenarios can be found in the Market Opportunities report, accessible at https://netzeroatlantic.ca/research/atlantic-canada-offshore-wind-grid-integration-and-transmission-study

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Capacity (MW)	Offshore Wind Locations	POIs	Provincial Loads Modeled	New Hydrogen Load (MW)	Generation Mix (Dispatch Hour)
2050 Scenario C2-1	C2 Domestic + Export Markets	8500	NS: Sydney Bight Fixed NS: Middle Bank Fixed NS: Sydney Bight Floating PE: C22 Fixed (North of PE) NL: C25 Fixed (Corner Brook)	NS: Woodbine 345 kV NS: Lakeside 345 kV PEI: Scotchfort 138 kV NL: Massey Drive 230 kV	Market Opportunity Report Scenario Forecasts[33]	None	High offshore wind, high thermal, low onshore wind
2050 Scenario C2-2	C2 Domestic + Export Markets	8500	NS: Sydney Bight Fixed NS: Middle Bank Fixed NS: Sydney Bight Floating PE: C22 Fixed (North of PE) NL: C25 Fixed (Corner Brook)	NS: Woodbine 345 kV NS: Lakeside 345 kV PEI: Scotchfort 138 kV NL: Massey Drive 230 kV	Market Opportunity Report Scenario Forecasts[33]	None	High offshore wind, low thermal, high onshore wind
2050 Scenario C3-1	C3 Domestic + Base Hydrogen	6500	NS: Sydney Bight Fixed NS: Middle Bank Fixed NS: Sydney Bight Floating PE: C22 Fixed (North of PE) NL: C25 Fixed (Corner Brook) NL: C4 Floating (St. John's) NB: C21 Fixed (Saint John)	NS: Woodbine 345 kV NS: Lakeside 345 kV PEI: Scotchfort 138 kV NL: Massey Drive 230 kV NL: St. John's 230 kV NB: Coleson Cove 345 kV	Market Opportunity Report Scenario Forecasts[33]	NS: 1,481 NL: 1,678 NB: 410 Total: 3,568	High offshore wind, with base hydrogen load
2050 Scenario C4-1	C4 All Markets (Domestic, Base Hydrogen and Exports)	12500	NS: Sydney Bight Fixed 1778 MW NS: Sable Island Fixed 368 MW NS: Middle Bank Fixed 3288 MW NS: Sydney Bight Floating 1421 MW NS: Canso Bank Floating 1026 MW NS: French Bank Floating 544 MW PE: C22 Fixed (North of PE) 983 MW NL: C25 Fixed (Corner Brook) 1319 MW NL: C4 Floating (St. John's) 992 MW NB: C21 Fixed (Saint John) 619 MW	NS: Woodbine 345 kV NS: Lakeside 345 kV PEI: Scotchfort 138 kV NL: Massey Drive 230 kV NL: St. John's 230 kV NB: Coleson Cove 345 kV	Market Opportunity Report Scenario Forecasts[33]	NS: 1,481 NL: 1,678 NB: 410 Total: 3,568	High offshore wind, with base hydrogen and export

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Capacity (MW)	Offshore Wind Locations	POIs	Provincial Loads Modeled	New Hydrogen Load (MW)	Generation Mix (Dispatch Hour)
2050 Scenario C4-2	C4 All Markets (Domestic, High Hydrogen and Exports)	16500	NS: Sydney Bight Fixed NS: Sable Island Fixed NS: Sydney Bight Floating NS: Middle Bank Fixed NS: Canso Bank Floating PE: C22 Fixed (North of PE) NL: C25 Fixed (Corner Brook) NL: C4 Floating (St. John's) NB: C24 Floating (Bathurst) NB: C21 Fixed (Saint John)	NS: Woodbine 345 kV NS: Lakeside 345 kV PEI: Scotchfort 138 kV NL: Massey Drive 230 kV NL: St. John's 230 kV NB: Bathurst 345 kV NB: Coleson Cove 345 kV	Market Opportunity Report Scenario Forecasts[33]	NS: 2,436 NL: 4,017 NB: 1,832 Total: 8,285	High offshore wind, with elevated hydrogen and export

Figure 9.A to Figure 9.D illustrate the geographical distribution of offshore wind capacity for each scenario based on the Phase 2 results across NB, NS, PEI, and NL.

See next page for figure

Figure 9.A Grid Integration 2050 Scenario C1

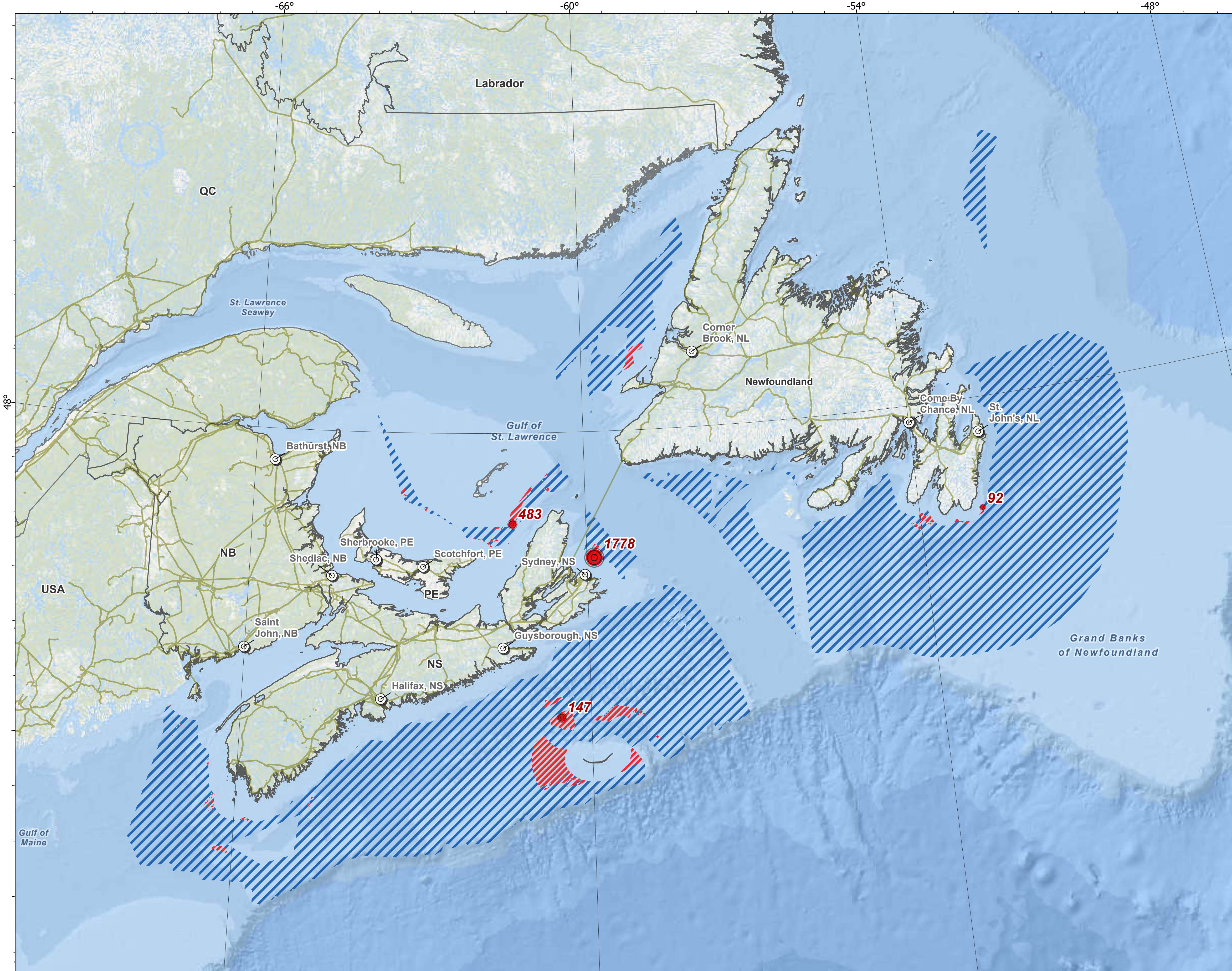


Figure No.
9.A

Title
Grid Integration 2050
Scenario C1

Client/Project 126560144_307

Net Zero Atlantic
Offshore Wind Resource Potential Study

Project Location Prepared by NW on 2025-09-04

Atlantic Canada

N

0 100 200 Kilometers
(At original document size of 11x17)
1:5,500,000

Legend

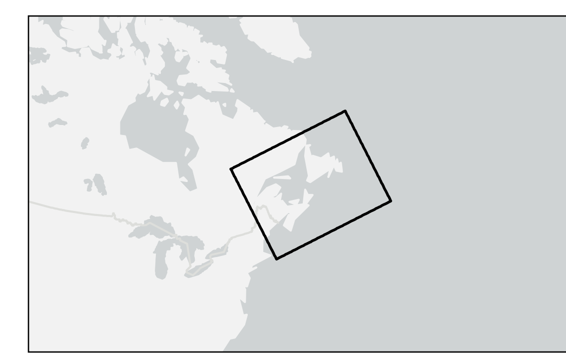
- Point of Interconnection
- Transmission Line

Turbine Approximate Deployment Locations[3]

- Fixed Platform
- Floating Platform
- Buildable Area - Fixed Platform
- Buildable Area - Floating Platform

Installed Capacity (MW)

- 0 - 100
- 101 - 500
- 501 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 2500
- 2501 - 3000
- 3001 - 3500



Notes
1. Coordinate System: WGS84 Azimuthal Equidistant Projection, Central Meridian -62
2. Data Sources: Stantec; Windsim / NASA MERRA reanalysis dataset
3. Turbine locations do not indicate specific deployment sites
4. Background: NRCan CanVec; OpenStreetMap; Statistics Canada; Basemap Service Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, CHS, Esri, GEBCO, Garmin, NaturalVue

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Figure 9.B Grid Integration 2050 Scenario C2

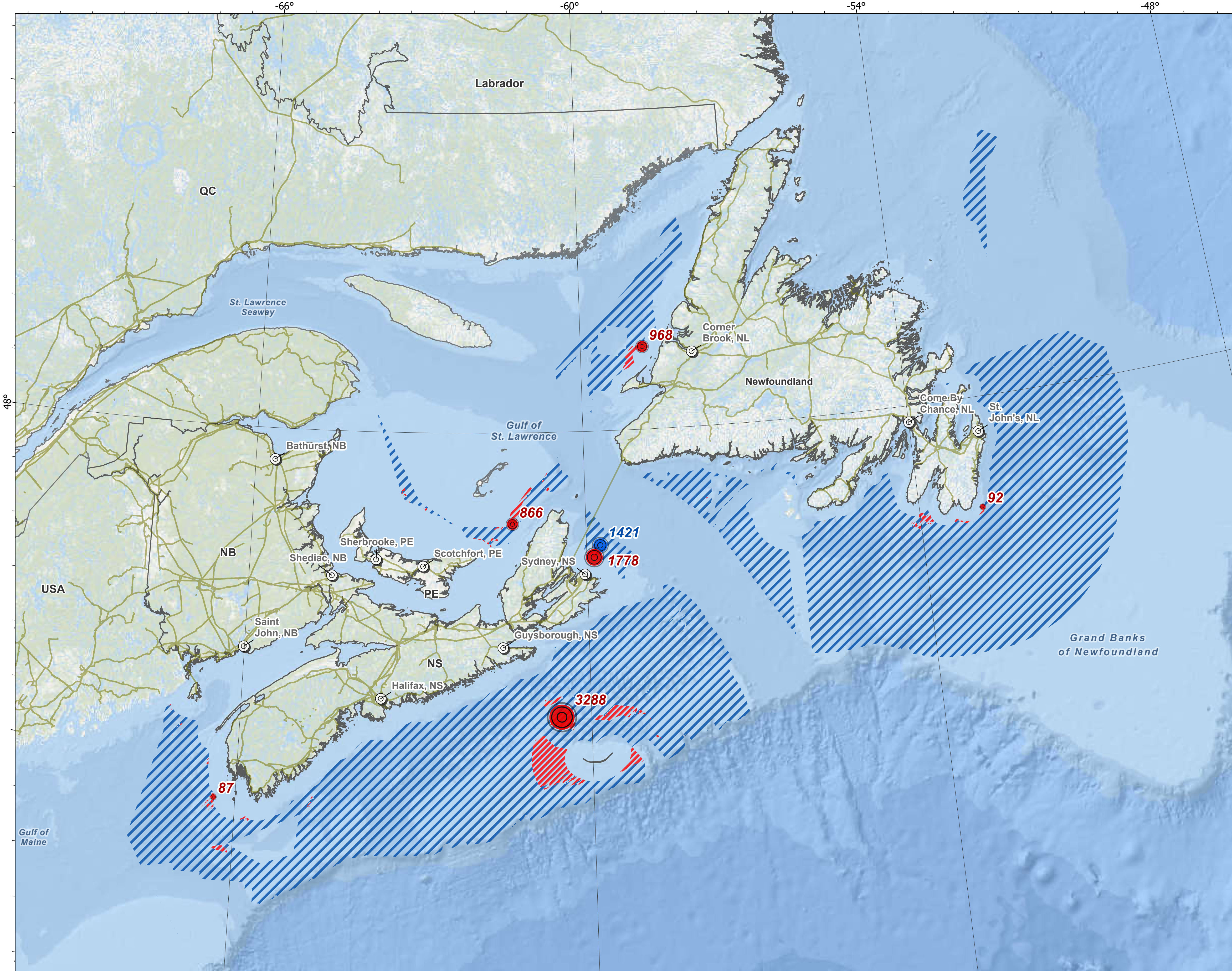


Figure No.
9.B

Title
Grid Integration 2050
Scenario C2

Client/Project 126560144_307

Net Zero Atlantic
Offshore Wind Resource Potential Study

Project Location
Prepared by NW on 2025-09-04

Atlantic Canada

N

0 100 200 Kilometers
(At original document size of 11x17)
1:5,500,000

Legend

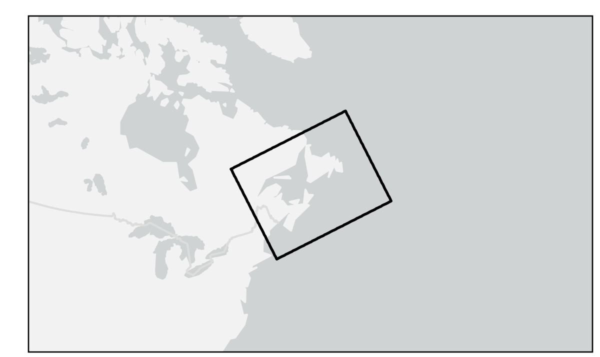
- Point of Interconnection
- Transmission Line

Turbine Approximate Deployment Locations[3]

- Fixed Platform
- Floating Platform
- Buildable Area - Fixed Platform
- Buildable Area - Floating Platform

Installed Capacity (MW)

- 0 - 100
- 101 - 500
- 501 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 2500
- 2501 - 3000
- 3001 - 3500



Notes
1. Coordinate System: WGS84 Azimuthal Equidistant Projection, Central Meridian -62
2. Data Sources: Stantec; Windsim / NASA MERRA reanalysis dataset
3. Turbine locations do not indicate specific deployment sites
4. Background: NRCan CanVec; OpenStreetMap; Statistics Canada; Basemap Service Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, CHS, Esri, GEBCO, Garmin, NaturalVue

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Figure 9.C Grid Integration 2050 Scenario C3

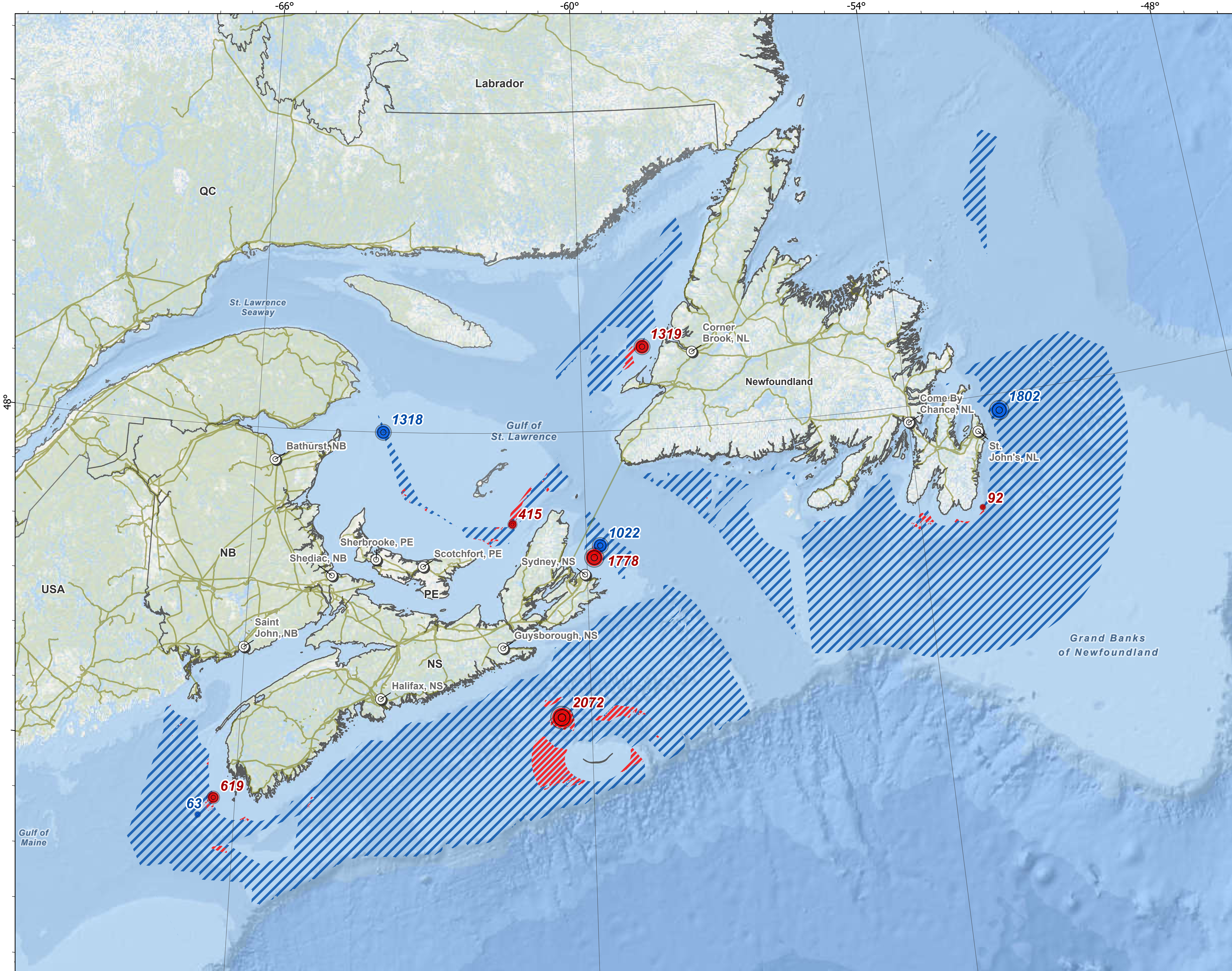


Figure No.
9.C
Title

Grid Integration 2050 Scenario C3

Client/Project 126560144_307

Net Zero Atlantic
Offshore Wind Resource Potential Study

Project Location Prepared by NW on 2025-09-04

Atlantic Canada

N

0 100 200 Kilometers
(At original document size of 11x17)
1:5,500,000

Legend

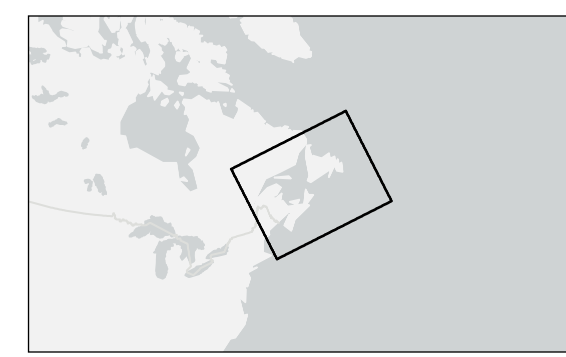
- Point of Interconnection
- Transmission Line

Turbine Approximate Deployment Locations[3]

- Fixed Platform
- Floating Platform
- Buildable Area - Fixed Platform
- Buildable Area - Floating Platform

Installed Capacity (MW)

- 0 - 100
- 101 - 500
- 501 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 2500
- 2501 - 3000
- 3001 - 3500



Notes

1. Coordinate System: WGS84 Azimuthal Equidistant Projection, Central Meridian -62
2. Data Sources: Stantec; Windsim / NASA MERRA reanalysis dataset
3. Turbine locations do not indicate specific deployment sites
4. Background: NRCan CanVec; OpenStreetMap; Statistics Canada; Basemap Service Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, CHS, Esri, GEBCO, Garmin, NaturalVue

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Figure 9.D Grid Integration 2050 Scenario C4

Figure No.
9.D

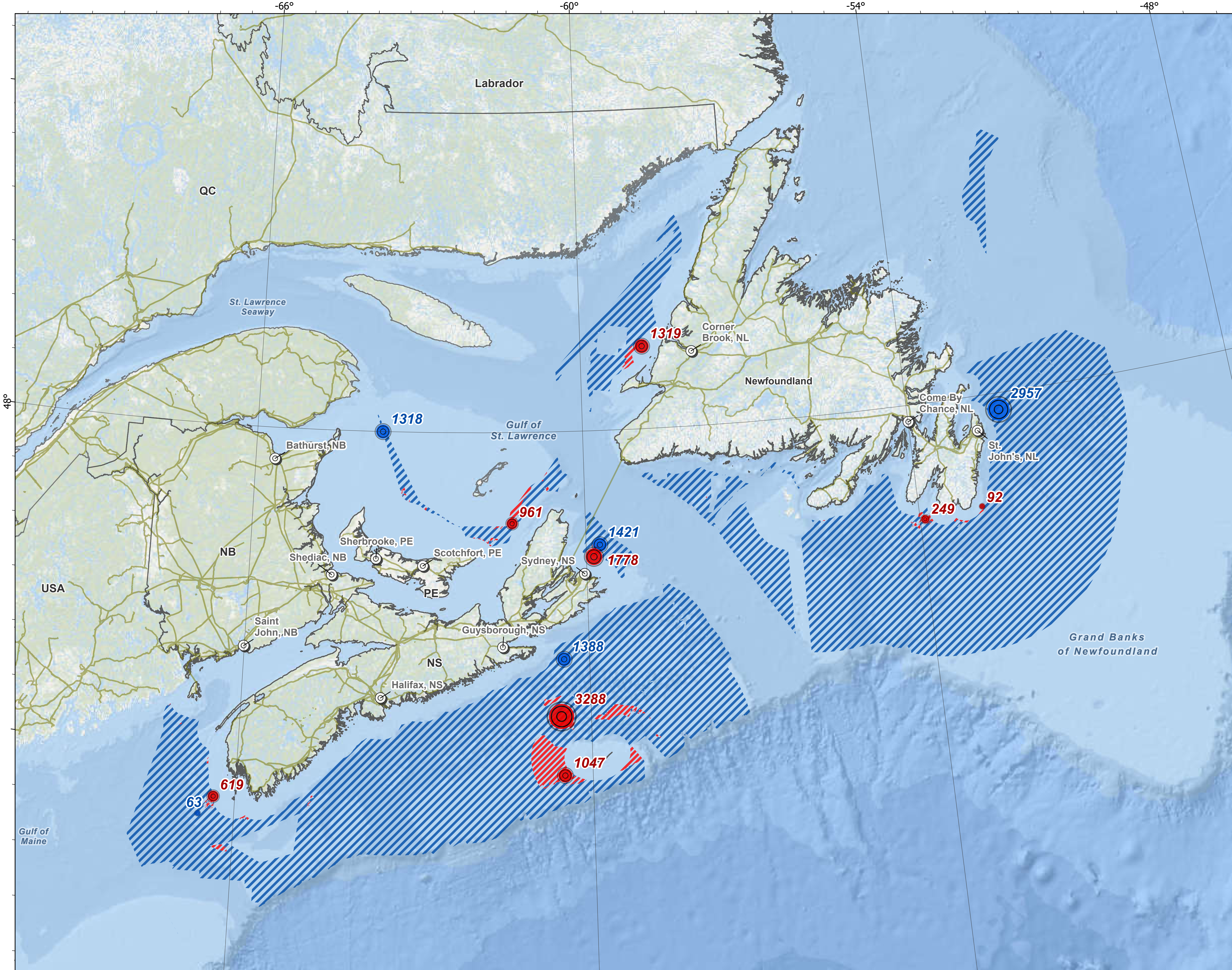
Title
Grid Integration 2050 Scenario C4

Client/Project 126560144_307

Net Zero Atlantic
Offshore Wind Resource Potential Study

Project Location Prepared by NW on 2025-09-04

Atlantic Canada



N

0 100 200 Kilometers
(At original document size of 11x17)
1:5,500,000

Legend

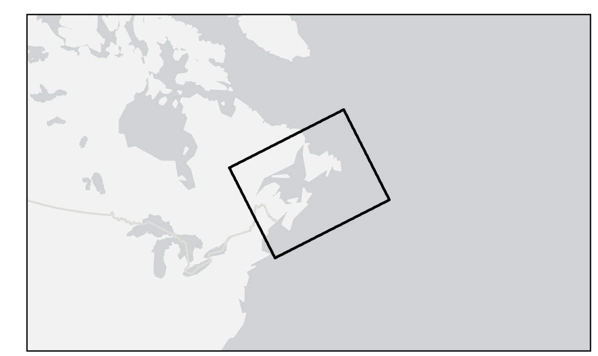
- Point of Interconnection
- Transmission Line

Turbine Approximate Deployment Locations[3]

- Fixed Platform
- Floating Platform
- Buildable Area - Fixed Platform
- Buildable Area - Floating Platform

Installed Capacity (MW)

- 0 - 100
- 101 - 500
- 501 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 2500
- 2501 - 3000
- 3001 - 3500



Notes
1. Coordinate System: WGS84 Azimuthal Equidistant Projection, Central Meridian -62
2. Data Sources: Stantec; Windsim / NASA MERRA reanalysis dataset
3. Turbine locations do not indicate specific deployment sites
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The scenario definitions are as follows[34]:

C1: Domestic-Only: In the Domestic-Only scenario, approximately 2.5 GW of offshore wind is considered in Nova Scotia and Prince Edward Island. All offshore wind output is injected within provincial systems, with no electricity exports and no new hydrogen production. Transmission upgrades focus on strengthening local 345 kV infrastructure around Woodbine (NS) and improving PEI's interconnection capability at Scotchfort (138 kV). This scenario represents a low-growth trajectory in which offshore wind primarily displaces remaining fossil generation and supports full provincial decarbonization.

C2: Domestic + Export: This scenario features a significant increase to ~8.5 GW of offshore wind across Nova Scotia, PEI, and Newfoundland and Labrador. With no added hydrogen load, the region exports large volumes of surplus offshore wind power to external markets, primarily New England. Transmission assumptions include major reinforcements in NS and NB 345 kV networks and the introduction of at least one multi-GW HVDC export corridor. The scenario positions Atlantic Canada as a regional clean electricity exporter.

C3: Domestic + Hydrogen (Base Hydrogen): Scenario C3 combines ~6.5 GW of offshore wind with ~3.6 GW of new hydrogen electrolyzer load across Nova Scotia, Newfoundland and Labrador, and New Brunswick. Offshore wind supports both domestic electricity needs and growing hydrogen production facilities. New POIs, including St. John's (230 kV) and Coleson Cove (345 kV), are added or upgraded to integrate offshore wind and industrial hydrogen loads. This scenario reflects the emergence of a regional hydrogen economy and reduces curtailment by allowing electrolyzers to absorb excess offshore wind, which supplies both provincial grids and hydrogen production. The upgraded POIs in all provinces and strong internal 345 kV corridors are required to facilitate the injection of offshore wind.

C4: All Markets (Base Hydrogen + Export): In this integrated scenario, regional offshore wind deployment increases to approximately 12.5 GW, spanning all Atlantic provinces with large clusters in Nova Scotia (Sydney Bight, Sable Island, Middle Bank, Canso Bank, French Bank), PEI, Newfoundland and Labrador, and New Brunswick. The ~3.6 GW hydrogen load from C3 is retained. The grid must support simultaneous domestic supply, hydrogen production, and electricity exports, requiring a robust provincial 345 kV network and multi-GW HVDC export capacity. This scenario illustrates the region functioning as a fully integrated clean-energy hub.

C4: All Markets (High Hydrogen + Export): The C4 scenario represents a conceptual upper-bound case examined for screening purposes, combining elevated offshore wind development with hydrogen production and export activity across Nova Scotia, Newfoundland and Labrador, and New Brunswick. Relative to the 2035 cases, this scenario explores higher offshore wind integration levels, additional electrolyzer demand, and expanded points of interconnection to understand potential long-term system implications. The analysis indicates that accommodating such a scenario would require substantial and coordinated transmission reinforcements, including enhanced interprovincial transfer capability and advanced system support measures. This scenario is not intended to reflect a committed or expected development pathway under

[34] Full portfolio details for each scenario are included in the Market Opportunities report, accessible at https://netzeroatlantic.ca/research/atlantic-canada-offshore-wind-grid-integration-and-transmission-study

current Wind West discussions, but rather to illustrate the types of network reinforcements that could be required should offshore wind, hydrogen, and export markets expand concurrently over the longer term.

10 Development of Grid Integration Study Cases (Phase 3 – 2050)

10.1 2050 Scenario C1-1: Domestic – Only (High Thermal, Low Onshore Wind)

The 2050 Scenario C1-1[35] is a continuation of the Domestic-Only market framework, representing a winter morning condition (Phase 2 Market Opportunities results for January 7, 2050 at 09:00) with 2,500 MW of offshore wind capacity in Nova Scotia and PEI, dispatched at 2,200 MW. Despite strong offshore wind and hydro output, low onshore wind and high demand necessitate significant thermal generation, particularly in New Brunswick, which runs ~1,265 MW of gas and oil units to meet its own load and support PEI. Nova Scotia contributes most of the offshore wind and onshore wind, while PEI relies on imports. Solar contributes modestly. Transmission coordination between NS, NB, and PEI remains critical to balance supply and minimize curtailment. Table 10-1 shows the summary for the scenario, including POIs, generation adjustments, and offshore wind dispatch and capacity.

Table 10-1 C1-1 Study Case Summary

PSSE Scenario Name	Market Opportunity Report Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2050 Scenario C1-1	C1 Domestic-only Market	NS: Sydney Bight Fixed PEI: C22 Fixed (North of PEI)	Sydney (Woodbine 345 kV Substation) North of PEI (Scotchfort 138 kV Tap)	Based on Market Opportunities results for January 7, 2050, 9:00	2,200	2,500

Generation dispatch and provincial loads for the selected hour is based on Market Opportunities results and presented below in Table 10-2.

[35] This Scenario C1-1 dispatch hour, along with all subsequent scenario hours, was selected to represent conditions of maximum offshore wind output.

Table 10-2 C1-1 Generation Dispatch and Loads from Market Opportunities results

Generation/Load	Newfoundland and Labrador	New Brunswick	Nova Scotia	Prince Edward Island	Total
Gas - CCS	-	-	-	-	-
Gas - CCGT	-	498	138	-	636
Gas - CT	-	769	-	-	769
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-
Oil - SCCT	-	397	-	-	397
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass	-	124	93	-	217
Nuclear	-	-	-	-	-
Hydro	1,950[36]	886	128	-	2964
Solar	-	83	33	25	140
Onshore Wind[37]	32	-	1464	-	1496
Offshore Wind	75[38]	-	1678	448	2202
Storage	-	-	-	-	-
Provincial Load	2,393	3802	2899	590	9684

These generation dispatches were modeled in PSS®E to closely match the selected PLEXOS dispatch hour, as illustrated in Figure 10.A. This stacked bar chart visualizes how different fuel types contribute to electricity generation across three Atlantic provinces—New Brunswick (NB), Nova Scotia (NS), and Prince Edward Island (PEI) for a selected hour in the 2050 Scenario C1-1 (Domestic-only Market). Each bar represents a fuel type, and the segments within each bar show how much each province contributes to that fuel's total dispatch.

[36] Note, hydro reporting for Newfoundland and Labrador represents generation from the full hydro fleet on the Island of Newfoundland, plus imports over the Labrador-Island Link. Additional detail on how the Newfoundland Island System is modeled can be found in the Market Opportunities report, accessible at https://netzeroatlantic.ca/research/atlantic-canada-offshore-wind-grid-integration-and-transmission-study

[37] Note, onshore wind profiles for both Nova Scotia and PEI that are used in this study were provided to the study team from utility representatives on the technical committee. For New Brunswick and Newfoundland and Labrador, publicly available data were sourced, drawing from the Canadian Renewable Energy Association and provincial specific datasets. Though weather-matched, certain hours show poor correlation across these profiles, which may stem from that disparate sourcing of these profile inputs. The study team recommends the sourcing of updated onshore wind profiles in subsequent analyses of the region.

[38] Note the C1: Domestic Only case selects limited offshore wind resources for interconnection with the Newfoundland island system despite substantial technical potential. Other scenarios evaluate futures with larger capacities of offshore wind injecting in Newfoundland and Labrador

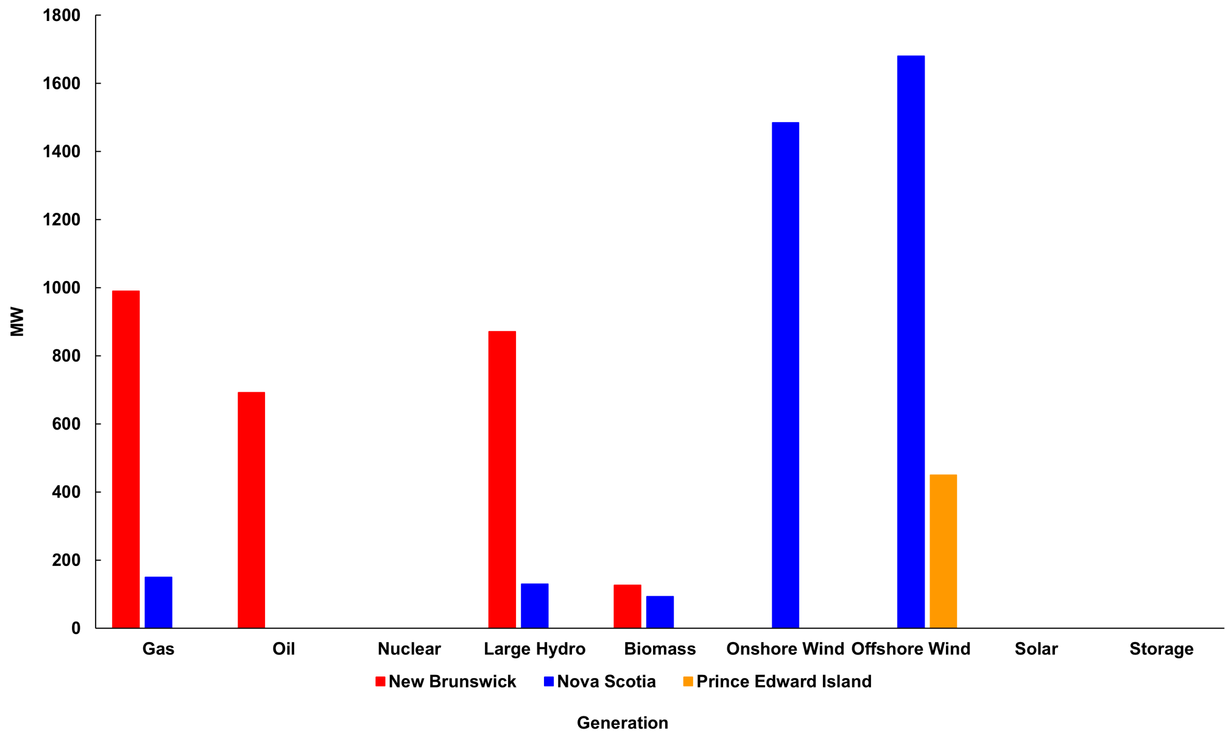

Figure 10.A C1-1 Scenario – Generation Dispatch in PSS®E Case

Note:
The Newfoundland and Labrador system model was provided to Stantec as a separate PSS®E sav file, so all analyses has been performed independently for Newfoundland and Labrador-specific study scenarios.

Figure 10.B illustrates the electricity demand across the three provinces during the selected dispatch hour. It provides context for how generation resources are allocated to meet regional loads.

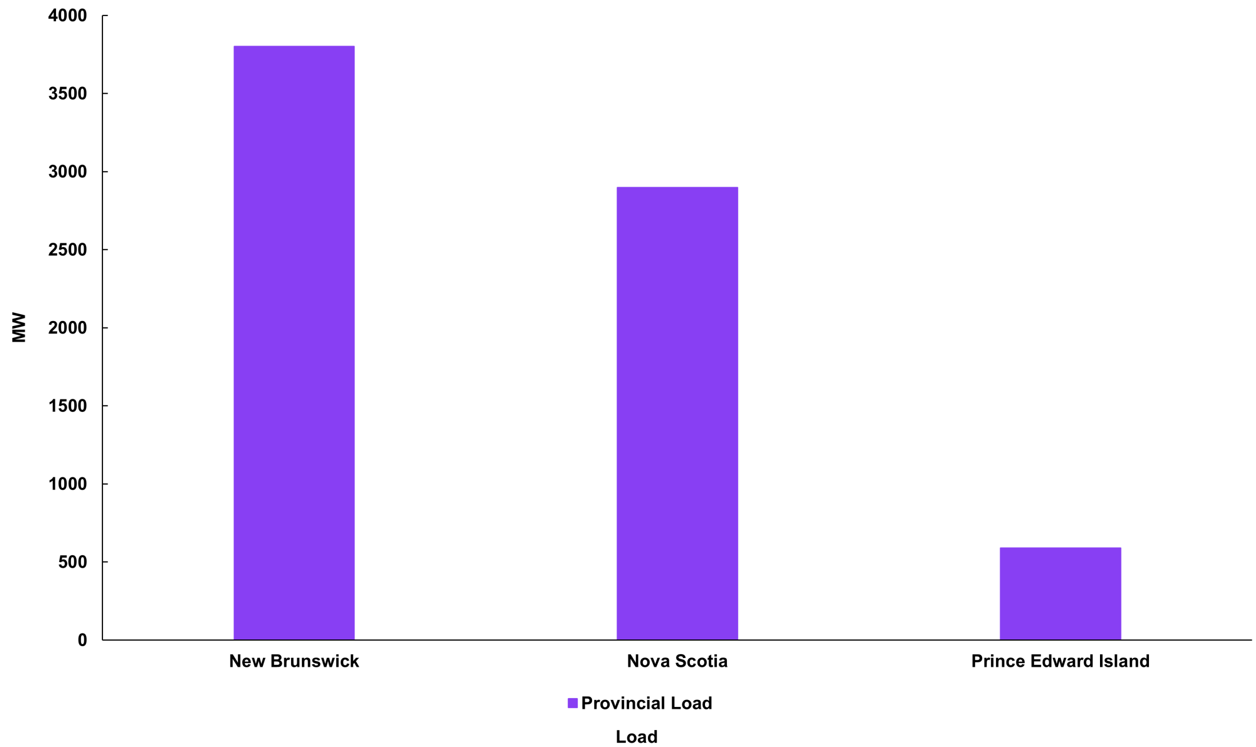

Figure 10.B C1-1 Scenario – Provincial Load Modeling

10.2 2050 Scenario C1-2: Domestic – Only (Low Thermal, High Onshore Wind)

The 2050 C1-2 scenario captures a high-renewables hour (Phase 2 Market Opportunities results for January 22, 2050, at 07:00) with strong onshore and offshore wind across the region. Offshore wind dispatch matches the C1-1 scenario dispatch at 2,200 MW, while onshore wind surges to over 2 GW. Hydro and biomass provide firm capacity, and thermal generation is minimal—only ~1.08 GW regionally, with Nova Scotia nearly fossil-free. Solar is absent due to the early morning hour. The scenario demonstrates the grid's ability to operate with ~85% renewable supply, emphasizing the importance of transmission flexibility and interprovincial coordination to manage variability and share surplus wind generation.
Table 10-3 shows the summary for the scenario, including POIs, generation adjustments, and offshore wind dispatch and capacity.

Table 10-3 C1-2 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2050 Scenario C1-2	C1 Domestic-only Market	NS: Sydney Bight Fixed PEI: C22 Fixed (North of PEI)	Sydney (Woodbine 345 kV Substation) North of PEI (Scotchfort 138 kV Tap)	Based on Market Opportunities results for January 22, 2050, 7:00	2,200	2,500

Generation dispatch and loads for the selected hour is based on Market Opportunities results and presented below in Table 10-4.

Table 10-4 C1-2 Generation Dispatch and Loads from Market Opportunities results

Generation/Load	Newfoundland and Labrador	New Brunswick	Nova Scotia	Prince Edward Island	Total
Gas - CCS	-	-	-	-	-
Gas - CCGT	37	498	147	-	682
Gas - CT	-	-	-	-	-
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-
Oil - SCCT	-	397	-	-	397
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass	-	124	93	-	217
Nuclear	-	-	-	-	-
Hydro	1905	553	77	-	2535
Solar	-	-	-	-	-
Onshore Wind	91	590	1259	93	2034
Offshore Wind	76	-	1678	448	2202
Storage	-	-	-	-	-
Provincial Load	2293	3256	2770	521	8840

These generation dispatches were modeled in PSS®E to closely match the selected PLEXOS dispatch hour, as illustrated in Figure 10.C.

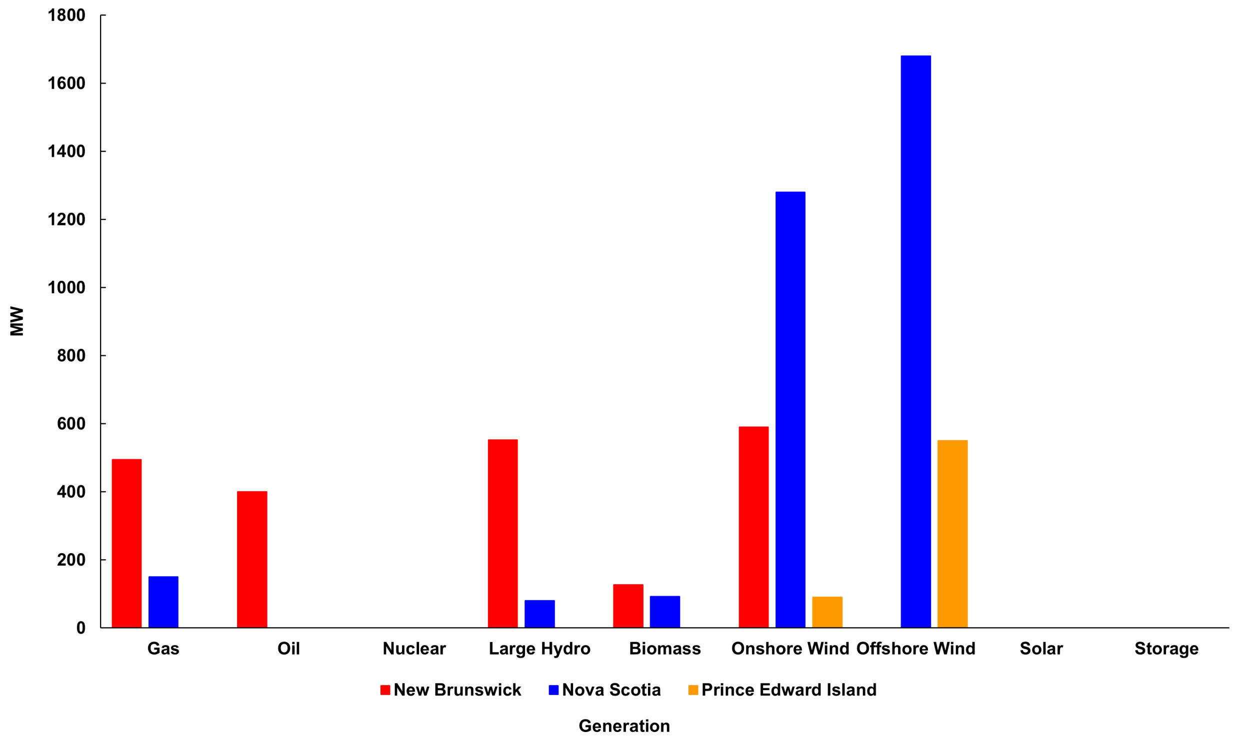

Figure 10.C C1-2 Scenario – Generation Dispatch in PSS®E Case

Figure 10.D illustrates the electricity demand across the three provinces during the selected dispatch hour. It provides context for how generation resources are allocated to meet regional loads.

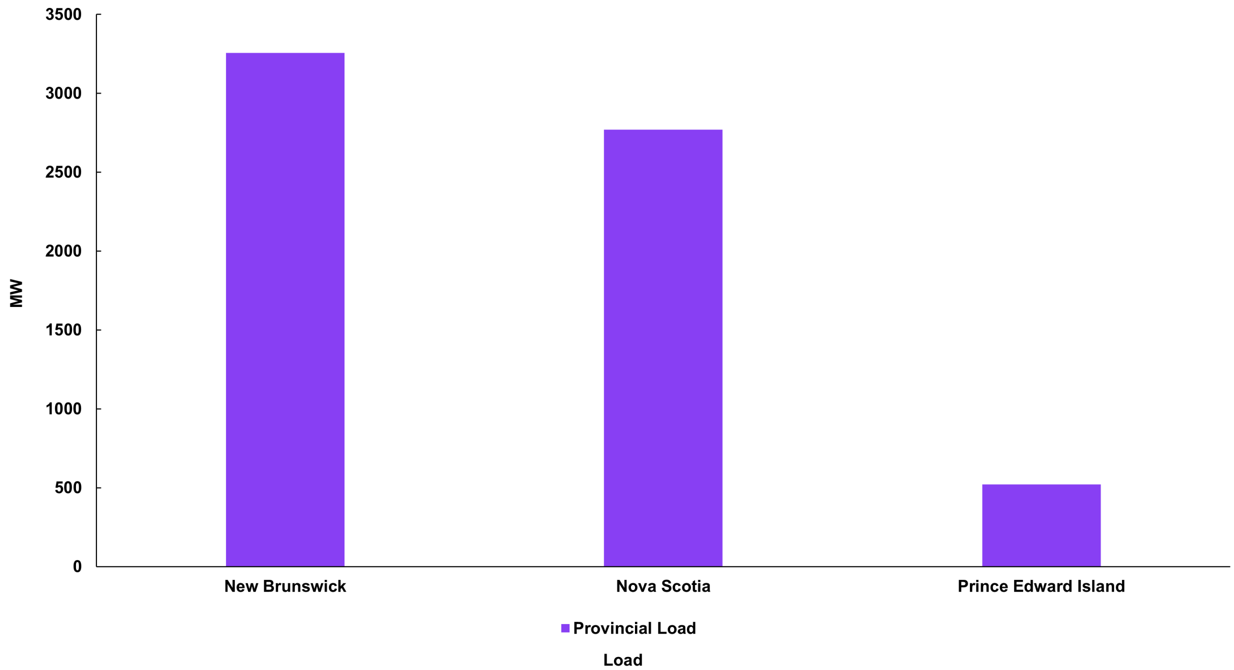

Figure 10.D C1-2 Scenario – Provincial Load Modeling

10.3 2050 Scenario C2-1: Domestic + Export Markets (High Thermal, Low Onshore Wind)

The 2050 C2-1 scenario models a winter morning (Phase 2 Market Opportunities results for January 7, 2050, at 09:00) under a Domestic + Export Markets framework. Offshore wind capacity expands to 8,500 MW across Nova Scotia, PEI, and Newfoundland and Labrador, with 6,815 MW dispatched. Onshore wind is nearly 1.5 GW in NS, and thermal generation is high, especially in New Brunswick, which supports both domestic demand and exports. Nova Scotia remains nearly fossil-free, while PEI exports power to New Brunswick to accommodate offshore wind.

Table 10-5 shows the summary for the scenario, including POIs, generation adjustments, and offshore wind dispatch and capacity.

Table 10-5 C2-1 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2050 Scenario C2-1	C2 Domestic + Export Market	NS: Sydney Bight Fixed NS: Sydney Bight Floating NS: Middle Bank Fixed PEI: C22 Fixed (North of PEI) NL: C25 Fixed (Corner Brook)	Sydney (Woodbine 345 kV Substation) Middle Bank (Lakeside 345 kV Substation) North of PEI (Scotchfort 138 kV Tap) Corner Brook (Massey Drive 230 kV Substation)	Based on Market Opportunities results for January 7, 2050, 9:00	6,815	8,500

Generation dispatch and loads for the selected hour is based on Market Opportunities results and presented below in Table 10-6.

Table 10-6 C2-1 Generation Dispatch and Load from Market Opportunities results

Generation/Load	Newfoundland and Labrador	New Brunswick	Nova Scotia	Prince Edward Island	Total
Gas - CCS	-	-	-	-	-
Gas - CCGT	-	376	-	-	376
Gas - CT	-	891	-	-	891
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-
Oil - SCCT	-	397	16	-	413
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass	-	124	3	-	127
Nuclear	-	-	-	-	-
Hydro	1972	406	112	-	2489
Solar	-	66	33	25	124
Onshore Wind	-	-	1468	-	1468
Offshore Wind	421	71	5520	803	6815
Storage	-	-	-	-	-
Provincial Load	2393	3802	2899	590	9684

These generation dispatches were modeled in PSS®E to closely match the selected PLEXOS dispatch hour, as illustrated in Figure 10.E.

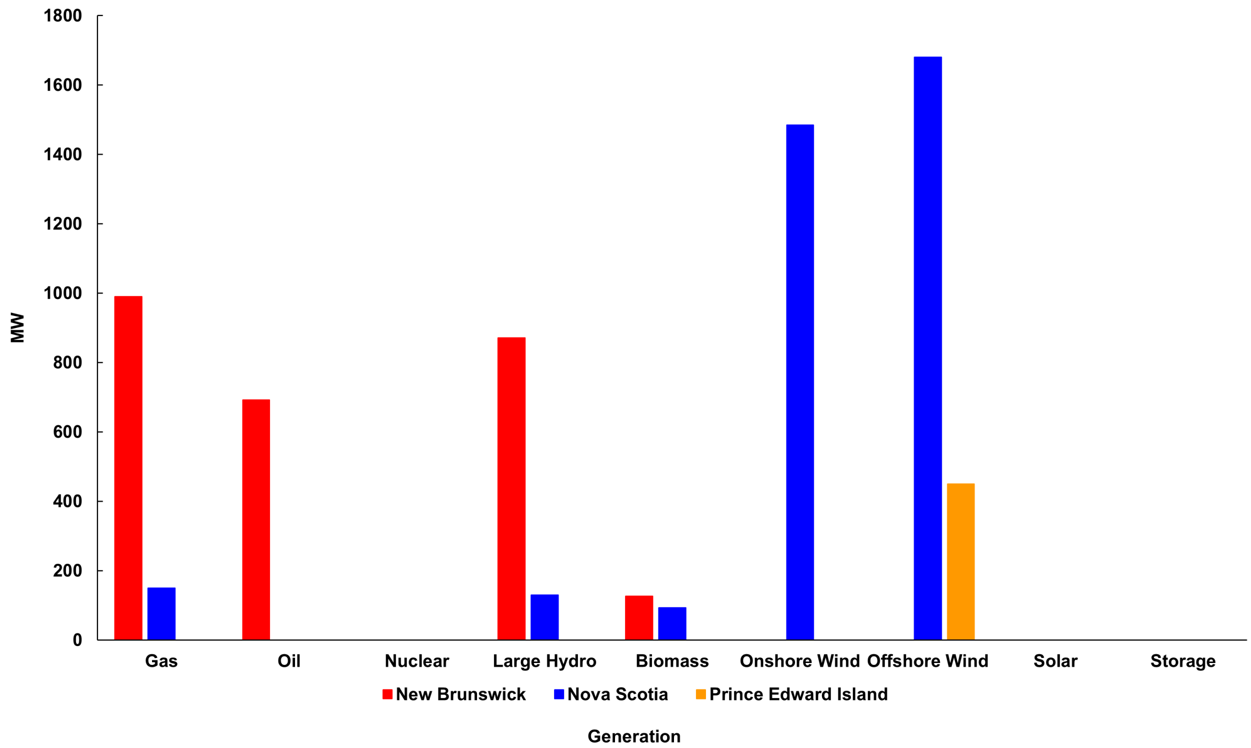

Figure 10.E C2-1 Scenario – Generation Dispatch in PSS®E Case

Figure 10.F illustrates the electricity demand across the three provinces during the selected dispatch hour. It provides context for how generation resources are allocated to meet regional loads.

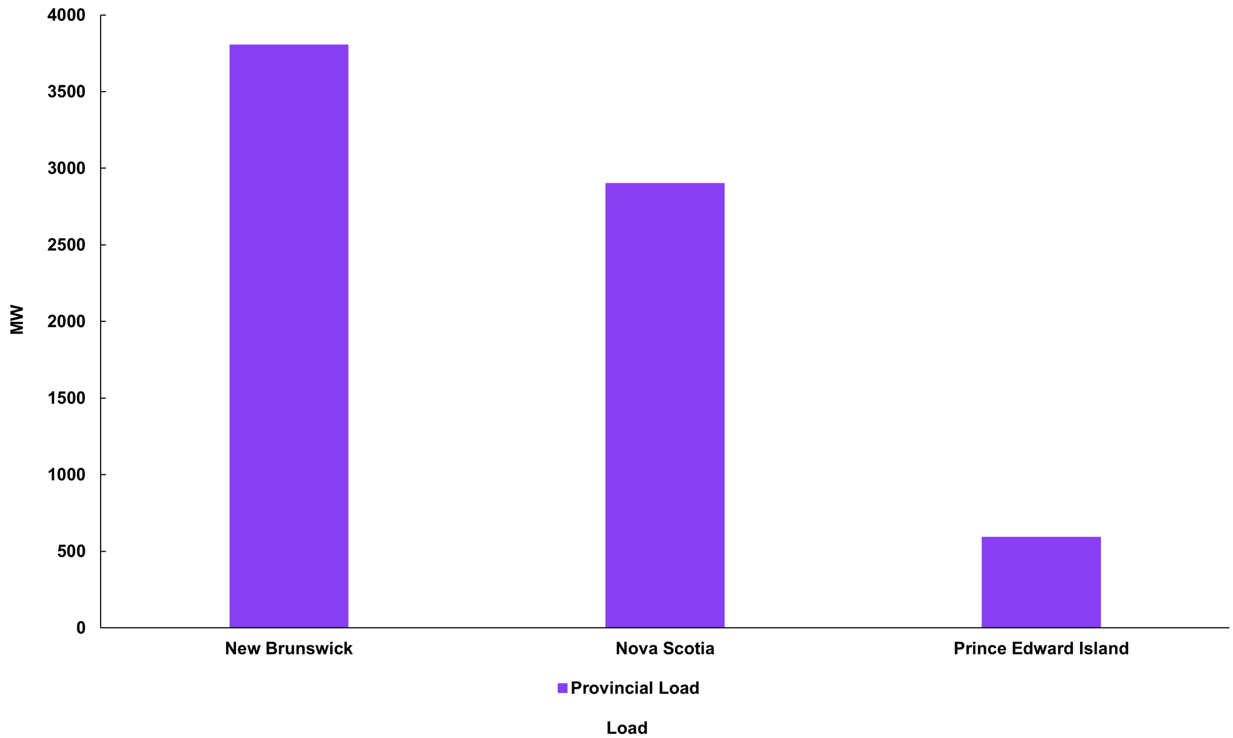

Figure 10.F C2-1 Scenario – Provincial Load Modeling

10.4 2050 Scenario C2-2: Domestic + Export Markets (Low Thermal, High Onshore Wind)

The 2050 C2-2 scenario models a high-renewables winter morning (Phase 2 Market Opportunities results for January 22, 2050, at 07:00) under a Domestic + Export Markets framework. Offshore wind capacity reaches 8,500 MW, with 6,500 MW dispatched. Onshore wind contributes over 1.85 GW, enabling ~85–90% renewable supply across the region. Thermal generation is minimal (~0.76 GW), with Nova Scotia nearly fossil-free. Newfoundland and Labrador meets its load with hydro and offshore wind, while PEI exports surplus offshore wind. New Brunswick supports regional balancing with limited thermal and biomass, relying on imports from Nova Scotia.

Table 10-7 shows the summary for the scenario, including POIs, generation adjustments, and offshore wind dispatch and capacity.

Table 10-7 C2-2 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2050 Scenario C2-2	C2 Domestic + Export Market	NS: Sydney Bight Fixed NS: Sydney Bight Floating NS: Middle Bank Fixed PEI: C22 Fixed (North of PEI) NL: C25 Fixed (Corner Brook)	Sydney (Woodbine 345 kV Substation) Middle Bank (Lakeside 345 kV Substation) North of PEI (Scotchfort 138 kV Tap) Corner Brook (Massey Drive 230 kV Substation)	Based on Market Opportunities results for January 22, 2050, 7:00	6,500	8,500

Generation dispatch and loads for the selected hour are based on Market Opportunities results and presented below in Table 10-8.

Table 10-8 C2-2 Generation Dispatch and Loads from Market Opportunities results

Dispatch Snapshot	Newfoundland and Labrador	New Brunswick	Nova Scotia	Prince Edward Island	Total
Gas - CCS	-	-	-	-	-
Gas - CCGT	-	362	-	-	362
Gas - CT	-	-	-	-	-
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-
Oil - SCCT	-	397	16	-	413
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass	-	124	28	-	152
Nuclear	-	-	-	-	-
Hydro	2120	412	81	-	2612
Solar	-	-	-	-	-
Onshore Wind	-	576	1261	18	1855
Offshore Wind	173	12	5520	803	6508
Storage	-	-	-	-	-
Provincial Load	2393	3802	2899	590	9684

These generation dispatches were modeled in PSS®E to closely match the selected PLEXOS dispatch hour, as illustrated in Figure 10.G.

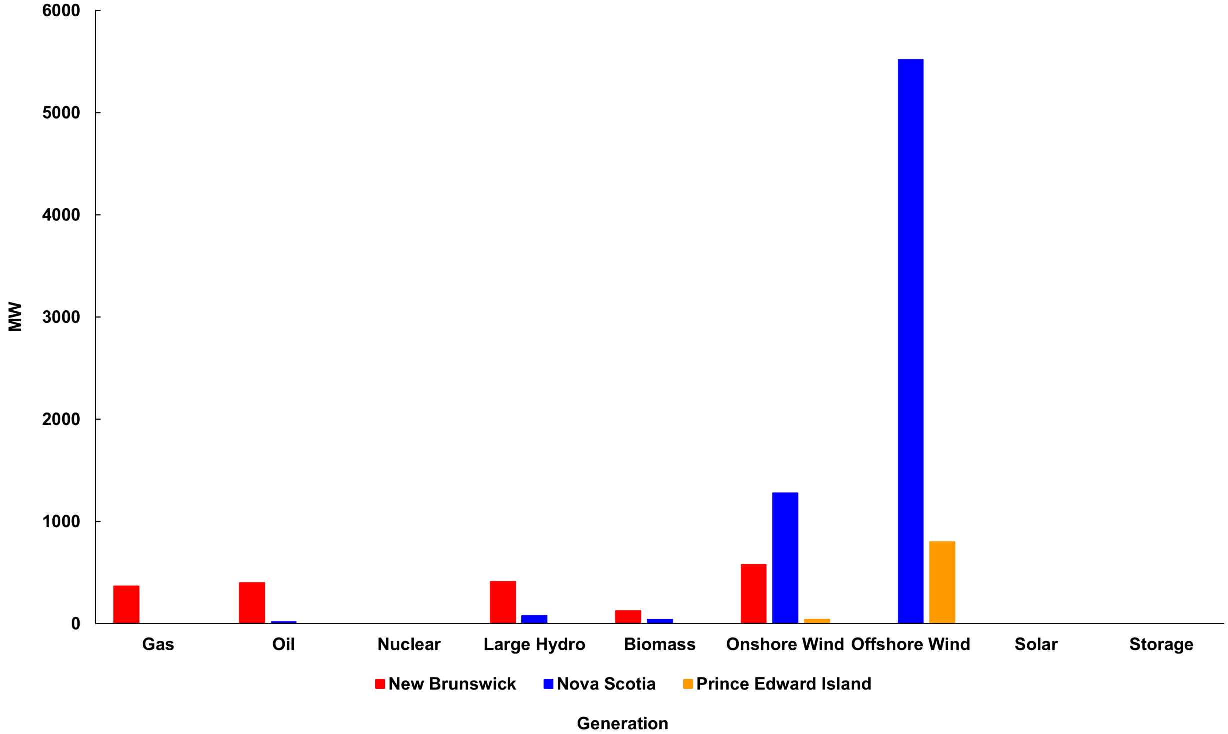

Figure 10.G C2-2 Scenario – Generation Dispatch in PSS®E Case

Figure 10.H illustrates the electricity demand across the three provinces during the selected dispatch hour. It provides context for how generation resources are allocated to meet regional loads.

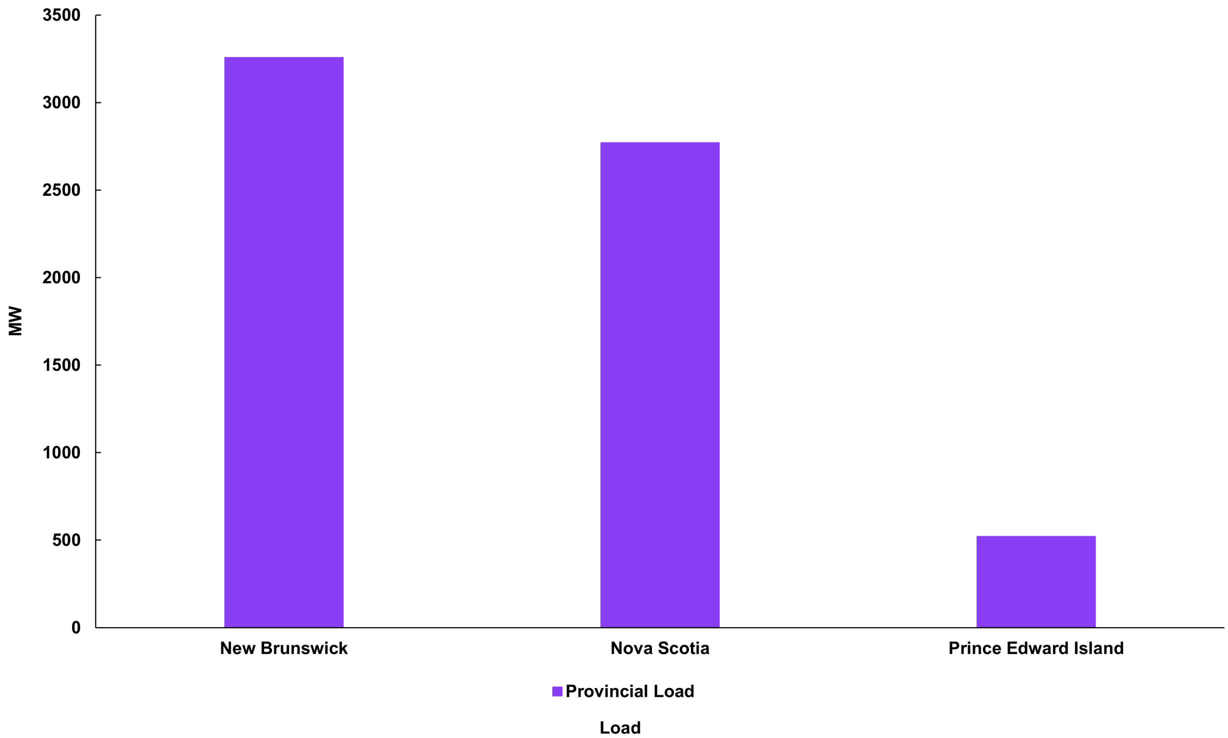

Figure 10.H C2-2 Scenario – Provincial Load Modeling

10.5 2050 Scenario C3-1: Domestic + Base Hydrogen

The 2050 C3-1 scenario models a winter peak hour (Phase 2 Market Opportunities results for January 7, 2050, at 09:00) with baseline hydrogen production added to regional electricity demand. Offshore wind capacity is 6,500 MW, fully dispatched at the selected hour. Onshore wind output is moderate (~0.9 GW), and solar and biomass contribute modestly. Hydrogen electrolysis adds ~3.6 GW to the total load, raising regional demand to over 13 GW.

Renewables supply most of the region's needs, with Nova Scotia and Newfoundland and Labrador nearly fossil-free. New Brunswick relies on gas (~1.6 GW) and oil (~0.4 GW) units to balance its higher demand, while also importing surplus wind from Nova Scotia and PEI. Table 10-9 shows the summary for the scenario, including POIs, generation adjustments, and offshore wind dispatch and capacity.

Generation dispatch and loads for the selected hour are based on Market Opportunities results and presented below in Table 10-10.

Table 10-9 C3-1 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2050 Scenario C3-1	C3 Domestic + Base Hydrogen	NS: Sydney Bight Fixed NS: Sydney Bight Floating NS: Middle Bank Fixed PEI: C22 Fixed (North of PEI) NL: C25 Fixed (Corner Brook) NL: C4 Floating (St. John's) NB: C21 Fixed (Saint John) 127 MW	Sydney (Woodbine 345 kV Substation) Middle Bank (Lakeside 345 kV Substation) North of PEI (Scotchfort 138 kV Tap) Corner Brook (Massey Drive 230 kV Substation) St. John's (Oxen Pond 230 kV Substation) NB: Coleson Cove 345 kV	Based on Market Opportunities results for January 7, 2050, 9:00	6,500	6,500

Table 10-10 C3-1 Generation Dispatch and Loads from Market Opportunities results

Dispatch Snapshot	Newfoundland and Labrador	New Brunswick	Nova Scotia	Prince Edward Island	Total
Gas - CCS	-	-	-	-	-
Gas - CCGT	-	617	-	-	617
Gas - CT	-	980	-	-	980
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-
Oil - SCCT	-	397	16	-	413
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass	-	124	28	-	152
Nuclear	-	-	-	-	-
Hydro	1924	638	100	-	2662
Solar	-	133	33	25	191
Onshore Wind	408	-	497	-	905
Offshore Wind	1740	104	4055	609	6507
Storage	-	-	-50	1	-49
Provincial Load	4071	4144	4380	590	13185
Hydrogen Load	1678	410	1481	-	3568

Newfoundland and Labrador, New Brunswick, Nova Scotia, and Prince Edward Island System Conditions

These generation dispatches were modeled in PSS®E to closely match the selected PLEXOS dispatch hour, as illustrated in Figure 10.I.

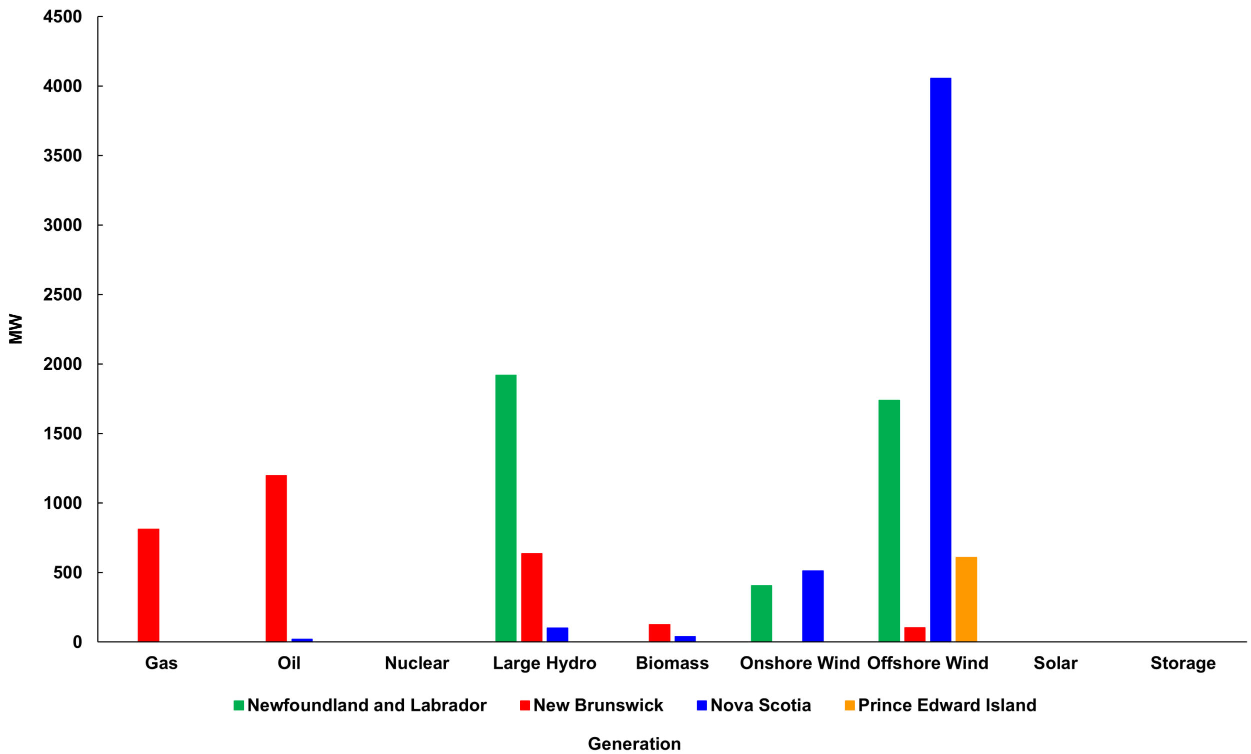

Figure 10.I C3-1 Scenario – Generation Dispatch in PSS®E Case

Figure 10.J illustrates the electricity demand across the four provinces during the selected dispatch hour, providing context for how generation resources are allocated to meet regional loads and hydrogen production needs.

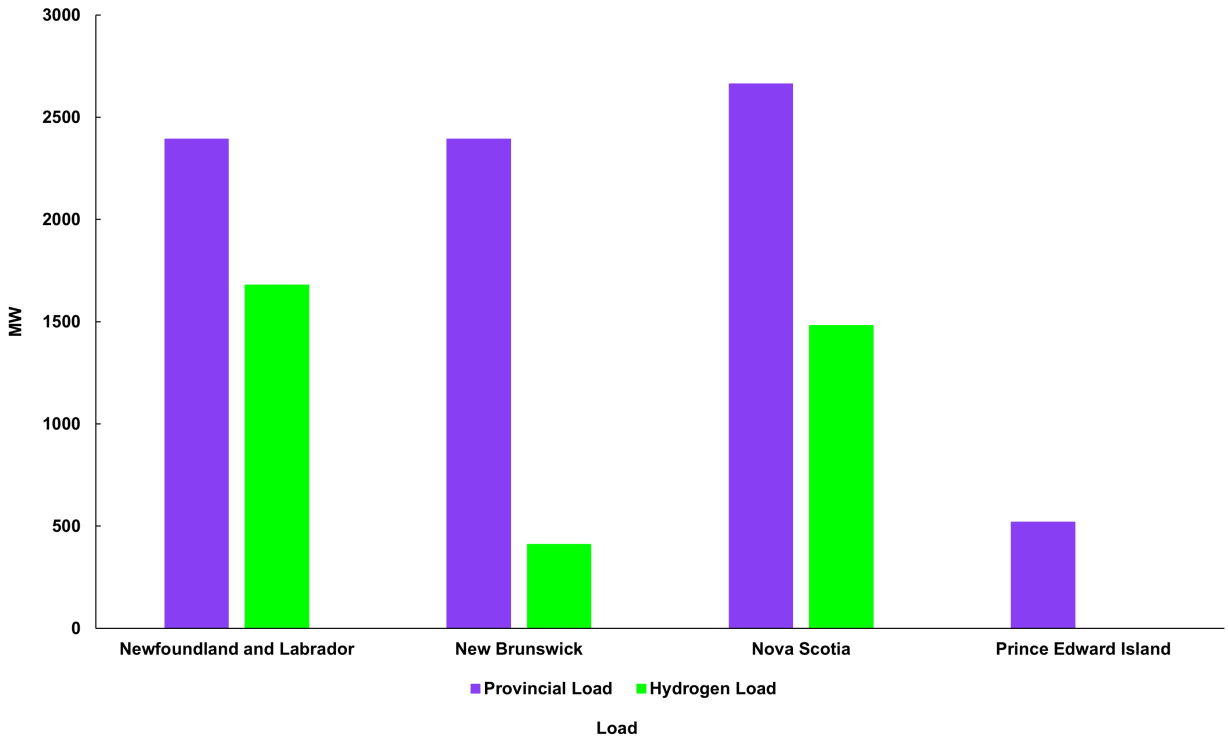

Figure 10.J C3-1 Scenario – Provincial and Hydrogen Load Modeling

The existing 230 kV and 138 kV Newfoundland and Labrador network cannot handle a large amount of renewable generation and hydrogen load flows without severe thermal and voltage issues. A higher voltage class AC backbone is essential for bulk transfer, stability, and operational flexibility, for the following reasons:

- Existing 230 kV corridors max out at ~720 MW east and ~280 MW west even after upgrades.
- Planned injections exceed 4 GW, requiring higher voltage for thermal and stability margins.
- Higher voltage class reduces thermal overload count, improves N-1 security, and future-proofs the grid.

Proposed Infrastructure Layout

- New higher voltage class hub at Come By Chance (CBC) for ~1,000 MW hydrogen.
- Two 315 kV or higher voltage lines CBC → Oxen Pond (east cluster, ~1,200 MW offshore wind).
- One 315 kV or higher voltage line CBC → Massey Drive (west cluster, ~540 MW offshore wind).
- One 315 kV or higher voltage line Massey Drive → Stony Brook (678 MW hydrogen).
- New transformers at all new stations for integration with 230/138 kV network.

Table 10-11 presents the summary of proposed NL transmission developments for C3-1 scenario.

Table 10-11 Summary of Proposed NL Transmission Development for Scenario C3-1

Component	Details	Justification
Voltage Level	315 kV or higher voltage backbone	Required for multi-GW transfers and stability
Total New Lines	4 circuits (2 east, 1 west, 1 spur)	Matches reduced resource totals, maintains N-0
Line Rating	650 MVA for proposed 345 kV transmission lines	Provides ~1.3 GW east, ~650 MW west N-0 capacity
Reactive Support	350–500 MVAr (synchronous condensers + STATCOMs)	Prevents voltage collapse, improve stability
Existing Grid Upgrades	Key 230/138 kV reinforcements east and west	Eliminates bottlenecks under contingencies

10.6 2050 Scenario C4-1: All Markets (Domestic, Base Hydrogen and Exports)

This scenario models a winter peak hour (Phase 2 Market Opportunities results for January 7, 2050, at 09:00) with baseline hydrogen production added to regional electricity demand and significant renewable exports. Offshore wind capacity is 12,500 MW, with about 10,650 MW dispatched at the selected hour. Onshore wind output is moderate (~2.3 GW), and solar and biomass contribute modestly. Hydrogen electrolysis adds ~3.6 GW to the total load, raising regional demand to over 13.5 GW.

Renewables supply most of the region's needs, with Nova Scotia and Newfoundland and Labrador nearly fossil-free. New Brunswick relies on gas (~0.88 GW) and oil (~0.40 GW) units to balance its higher demand, while also importing surplus wind from Nova Scotia and PEI. These assumptions reflect current provincial plans, which do not mandate complete decarbonisation by 2050. Table 10-12 shows the summary for the scenario, including POIs, generation adjustments, and offshore wind dispatch and capacity.

Table 10-12 C4-1 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2050 Scenario C4-1	C4 All Markets (Domestic, Base Hydrogen and Exports)	NS: Sydney Bight Fixed NS: Sable Island Fixed NS: Middle Bank Fixed NS: Sydney Bight Floating NS: Canso Bank Floating	Sydney (Woodbine 345 kV Substation) Middle Bank (Lakeside 345 kV Substation) North of PEI (Scotchfort 138kV Tap) Corner Brook	Based on Market Opportunities results for January 7, 2050, 9:00	10,650	12,500

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
		NS: French Bank Floating PEI: C22 Fixed (North of PEI) NL: C25 Fixed (Corner Brook) NL: C4 Floating (St. John's) NB: C21 Fixed (Saint John)	(Massey Drive 230 kV Substation) St. John's (Oxen Pond 230 kV Substation) Saint John (Coleson Cove 345 kV)			

Generation dispatch and loads for the selected hour are based on Market Opportunities results and presented below in Table 10-13.

Table 10-13 C4-1 Generation Dispatch and Loads from Market Opportunities results

Generation/ Load	Newfoundland and Labrador	New Brunswick	Nova Scotia	Prince Edward Island	Total
Gas - CCS	-	-	-	-	-
Gas - CCGT	-	465	-	-	465
Gas - CT	-	412	-	-	412
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-
Oil - SCCT	-	397	16	-	413
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass	-	124	3	-	127
Nuclear	-	-	-	-	-
Hydro	1771	694	17	-	2481
Solar	-	74	33	25	132
Onshore Wind	408	-	1877	-	2285
Offshore Wind	2079	563	7150	865	10657
Storage	-	8	-118	-	-110
Provincial Load	4257	4144	4544	590	13536
Hydrogen Load	1678	410	1481	-	3568

Newfoundland and Labrador, New Brunswick, Nova Scotia, and Prince Edward Island System Conditions

These generation dispatches were modeled in PSS®E to closely match the selected PLEXOS dispatch hour, as illustrated in Figure 10.K.

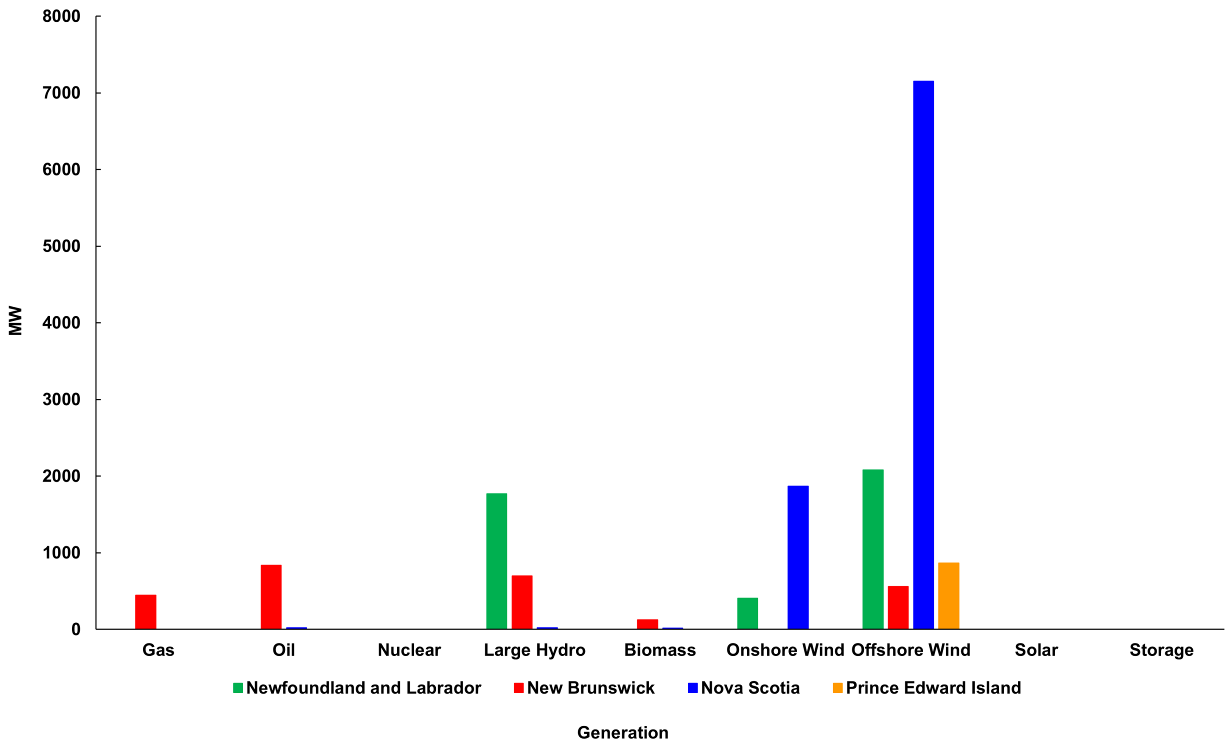

Figure 10.K C4-1 Scenario – Generation Dispatch in PSS®E Case

Figure 10.L illustrates the electricity demand across the four provinces during the selected dispatch hour, providing context for how generation resources are allocated to meet regional loads and hydrogen production needs.

The existing 230 kV and 138 kV Newfoundland and Labrador network cannot handle a large amount of renewable generation and hydrogen load flows without severe thermal and voltage issues. A higher voltage class AC backbone is essential for bulk transfer, stability, and operational flexibility.

Proposed Infrastructure Layout

- New higher voltage class hub at Come By Chance for ~1,000 MW hydrogen (scaled down from 3,000 MW).
- Three 315 kV or higher voltage lines CBC → Oxen Pond (east cluster, ~1,000 MW offshore wind).
- One 315 kV or higher voltage lines CBC → Massey Drive (west cluster, ~1000 MW offshore wind).
- One 315 kV or higher voltage line Massey Drive → Stony Brook (678 MW hydrogen).
- New transformers at all new stations for integration with 230/138 kV network.

Table 10-14 presents the summary of proposed NL transmission developments for C4-1 scenario.

Table 10-14 Summary of Proposed NL Transmission Development for Scenario C4-1

Component	Details	Justification
Voltage Level	315 kV or higher voltage backbone	Required for multi-GW transfers and stability
Total New Lines	5 circuits (3 east, 1 west, 1 spur)	Matches reduced resource totals, maintains N-0
Line Rating	650 MVA for proposed 345 kV transmission lines	Provides ~1.95 GW east, ~650 MW west N-0 capacity
Reactive Support	400–600 MVAr (condensers + STATCOMs)	Prevents voltage collapse, improve stability
Existing Grid Upgrades	Key 230/138 kV reinforcements east and west	Eliminates bottlenecks during contingencies

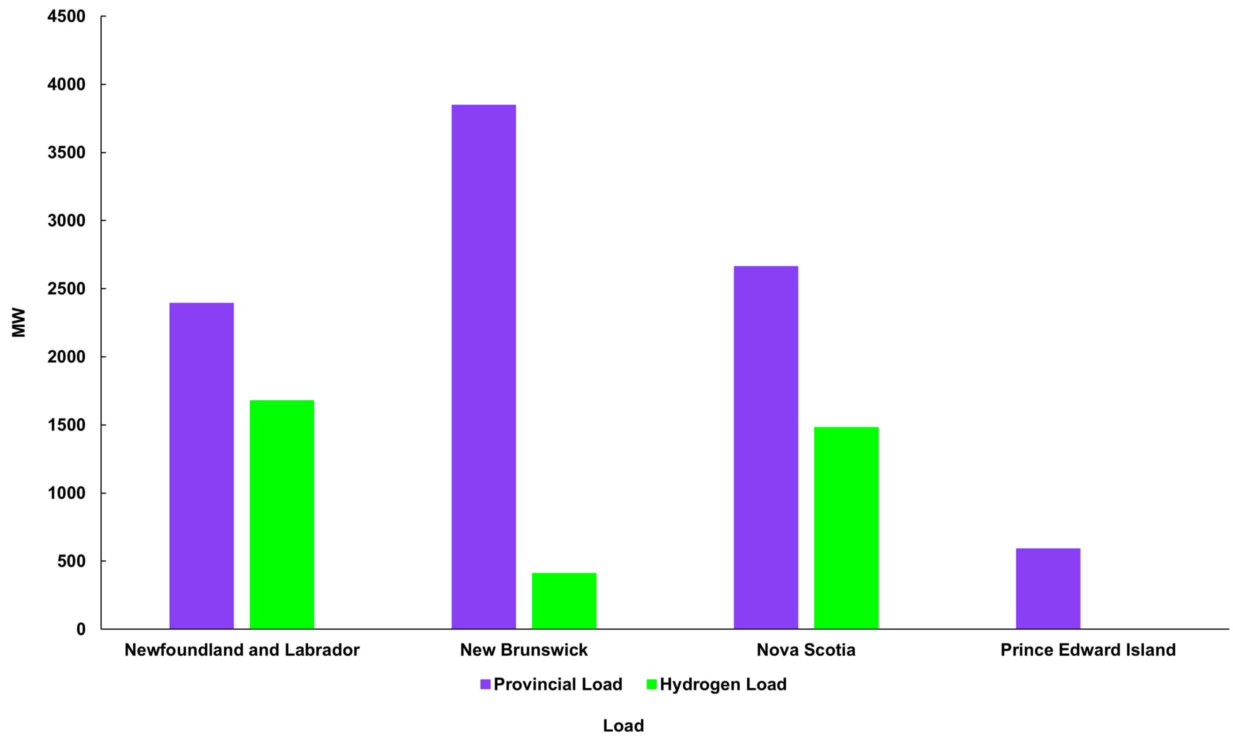

Figure 10.L C4-1 Scenario – Provincial and Hydrogen Load Modeling

This figure illustrates the modeled hydrogen load distribution across four Atlantic Provinces—NL, NB, NS, and PEI for the Domestic + Base Hydrogen + Export scenario in 2050.

10.7 2050 Scenario C4-2: All Markets (Domestic, High Hydrogen and Exports)

This scenario models a winter peak hour (Phase 2 Market Opportunities results for January 7, 2050, at 09:00) with high hydrogen production and significant renewable exports. Offshore wind capacity is

16,500 MW, with 13,730 MW dispatched. Onshore wind output is strong (~4.35 GW), and solar and biomass contribute modestly. Hydrogen electrolysis adds ~8.2 GW to the total load, raising regional demand to nearly 18 GW.

Renewables supply most of the region's needs, with Nova Scotia and Newfoundland and Labrador operating nearly fossil-free. New Brunswick relies on gas (~0.86 GW) and oil (~0.4 GW) units to balance its higher demand, while importing surplus wind from Nova Scotia and PEI. Interprovincial coordination enables the region to meet domestic and hydrogen loads, minimize curtailment, and export over 3 GW of clean energy. Table 10-15 shows the summary for the scenario, including POIs, generation adjustments, and offshore wind dispatch and capacity.

Generation dispatch and loads for the selected hour are based on Market Opportunities results and presented below in Table 10-16.

Table 10-15 C4-2 Study Case Summary

Scenario Name	PLEXOS Market Scenario Name	Offshore Wind Locations	POIs	Generation Adjustments	Offshore Wind Dispatch (MW)	Offshore Wind Capacity (MW)
2050 Scenario C4-2	C4 All Markets (Domestic, High Hydrogen and Exports)	NS: Sydney Bight Fixed NS: Sable Island Fixed NS: Middle Bank Fixed NS: Sydney Bight Floating NS: Canso Bank Floating NS: French Bank Floating PEI: C22 Fixed (North of PEI) NL: C25 Fixed (Corner Brook) NL: C4 Floating (St. John's) NB: C21 Fixed (Saint John) NB: C24 Floating (Bathurst)	Sydney (Woodbine 345 kV Substation) Middle Bank (Lakeside 345 kV Substation) North of PEI (Scotchfort 138kV Tap) Corner Brook (Massey Drive 230 kV Substation) St. John's (Oxen Pond 230 kV Substation) Saint John (Coleson Cove 345 kV Substation) Bathurst (Bathurst 345 kV Substation)	Based on PLEXOS results for January 7, 2050, 9:00	13,730	16,500

Table 10-16 C4-2 Generation Dispatch and Loads from Market Opportunities Results

Dispatch Snapshot	Newfoundland and Labrador	New Brunswick	Nova Scotia	Prince Edward Island	Total
Gas - CCS	-	-	-	-	-
Gas - CCGT	-	857	-	-	857
Gas - CT	-	-	-	-	-
Gas - SCCT	-	-	-	-	-
Oil - ICE	-	-	-	-	-

Dispatch Snapshot	Newfoundland and Labrador	New Brunswick	Nova Scotia	Prince Edward Island	Total
Oil - SCCT	-	397	16	-	413
Oil - ST	-	-	-	-	-
Coal	-	-	-	-	-
Biomass	-	124	3	-	127
Nuclear	-	-	-	-	-
Hydro	1200	682	81	-	1964
Solar	-	193	33	25	251
Wind	1650	-	2696	-	4346
Offshore Wind	3618	1669	7580	865	13732
Storage	-	-	-	-	-
Provincial Load	6410	5329	5606	590	17935
Hydrogen Load	4017	1832	2436	-	8285

Newfoundland and Labrador, New Brunswick, Nova Scotia, and Prince Edward Island System Conditions

These generation dispatches were modeled in PSS®E to closely match the selected PLEXOS dispatch hour, as illustrated in Figure 10.M.

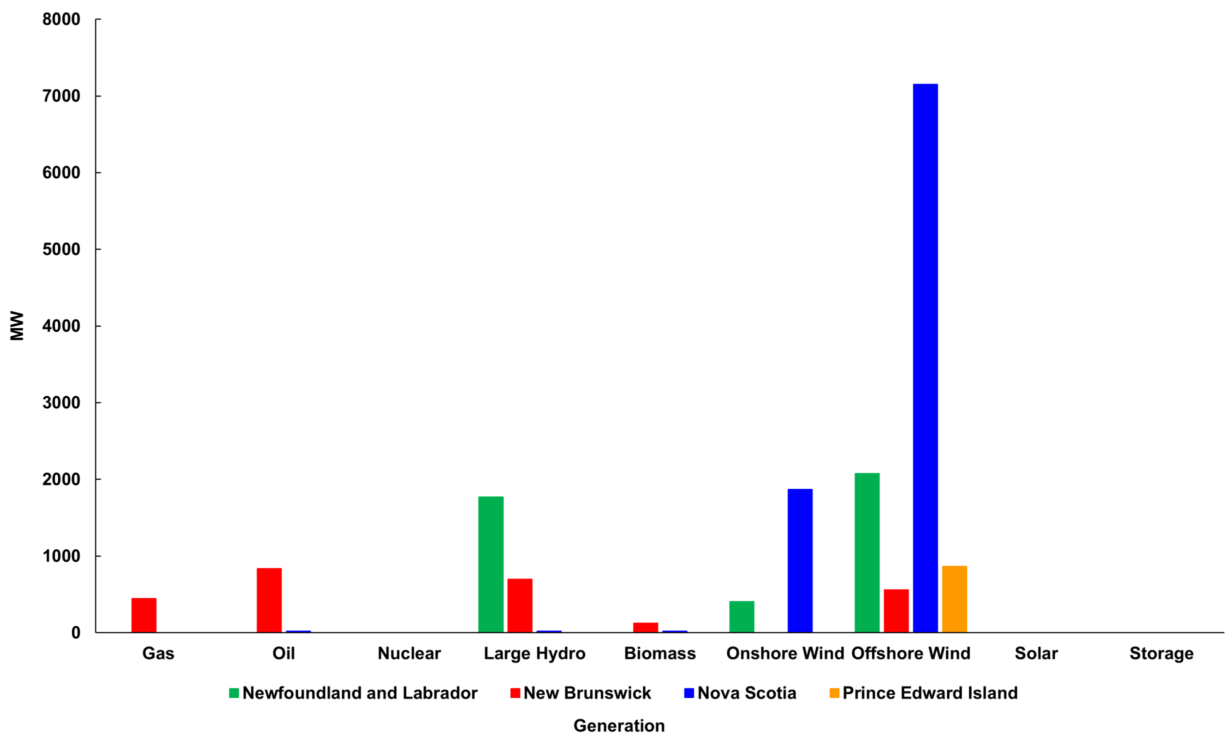

Figure 10.M C4-2 Scenario - Generation Dispatch in PSS®E Case

Figure 10.N illustrates the electricity demand across the four provinces during the selected dispatch hour, providing context for how generation resources are allocated to meet regional loads and hydrogen production needs.

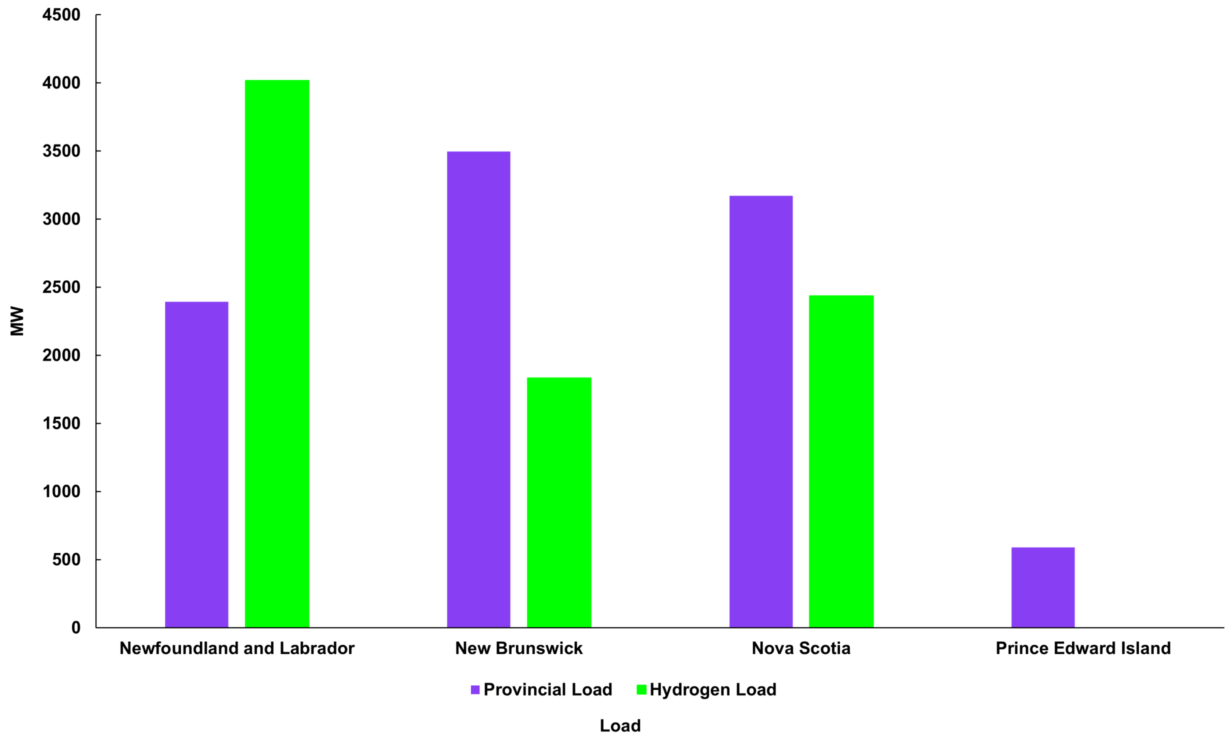

Figure 10.N C4-2 Scenario – Provincial and Hydrogen Load Modeling

Under Scenario C4-2, Newfoundland and Labrador operates with a fully renewable supply mix during the winter morning peak (Phase 2 Market Opportunities results for January 7, 2050, at 09:00). The total load reaches approximately 6,410 MW, including a substantial 4,020 MW[39] of hydrogen electrolysis demand.

This need assessment proposes a higher voltage class AC backbone as the most practical solution to deliver bulk power reliably, maintain system stability, and enable operational flexibility.

Proposed Infrastructure Layout

- New higher voltage class hub at Come By Chance (CBC) for ~3,000 MW hydrogen.
- Four 315 kV or higher voltage lines CBC → Oxen Pond (east cluster, ~2,500 MW offshore wind).
- Two 315 kV or higher voltage lines CBC → Massey Drive (west cluster, ~1,100 MW offshore wind).
- One 315 kV or higher voltage line Massey Drive → Stony Brook (~1,000 MW hydrogen).

[39] Load forecasting for all cases was conducted in consultation with the advisory committees during Phase 1 of this study. This included assumptions around both core case hydrogen electrolysis load adoption, as well as the high hydrogen sensitivity as referenced here. Additional details on these load forecasts are included in the Market Opportunities report, accessible at https://netzeroatlantic.ca/research/atlantic-canada-offshore-wind-grid-integration-and-transmission-study

- New transformers at all new stations for integration with 230/138 kV network.

Table 10-17 presents the summary of proposed NL transmission developments for C4-2 scenario.

Table 10-17 Summary of Proposed NL Transmission Development for Scenario C4-2

Component	Details	Justification
Voltage Level	315 kV or higher voltage backbone	Required for multi-GW transfers and stability
Total New Lines	7 circuits (4 east, 2 west, 1 spur)	Reduces congestion, improves N-1 security
Line Rating	650 MVA for proposed 345 kV transmission lines	Provides ~2.6 GW east, ~1.3 GW west N-0 capacity
Reactive Support	500–800 MVAr (condensers + STATCOMs)	Prevents voltage collapse, improve stability
Existing Grid Upgrades	Key 230/138 kV reinforcements east and west	Eliminate bottlenecks during contingencies

11 2050 Power Flow Results

This section presents the results of the steady state power flow analyses conducted for the 2050 planning horizon under multiple offshore wind integration scenarios. The objective was to evaluate the ability of the existing and planned transmission network to accommodate large-scale renewable generation, emerging hydrogen loads, and interprovincial/export transfers while maintaining reliability under both normal (N-0) and contingency (N-1) conditions.

The C1-1 through C4-2 scenarios analyzed represent progressively complex market and operational conditions from moderate offshore wind and exports to high offshore wind penetration combined with hydrogen demand and large-scale exports.

Key metrics assessed include:

- Thermal loading of transmission lines and transformers across major voltage levels (345 kV, 230 kV, and 138 kV).
- Severity and distribution of overloads under N-0 and N-1 conditions.
- Identification of critical corridors and equipment requiring reinforcement.

Key Findings and Strategic Recommendations (2050)

By 2050, the analysis indicates that accommodating higher offshore wind deployment levels would place increased demands on the transmission system and may require significant grid reinforcements to maintain reliable operation. Without these reinforcements, the assessment indicates an elevated risk of thermal loading in the system. The following summarizes the key findings and preliminary considerations arising from this analysis.

- **NB–NS–PEI 138 kV Network** experiences numerous line overloads even in moderate cases (hundreds of MW of offshore wind). The existing NB–NS 345 kV intertie (Salisbury–Onslow) becomes a bottleneck in Scenario C2 (~1 GW transfer). The new NB–PEI 138 kV link (300 MW) also reaches its limit under high export or offshore wind injection, suggesting future consideration of an additional link or an upgrade to 230 or 345 kV in the PEI transmission system.

- **Nova Scotia 345 kV Backbone** (Lingan/Woodbine – Onslow – Hopewell loop) is pushed to 140%+ loading in C4 scenarios. Loss of any one 345 kV line in NS overloads the parallel path and underlying 230 kV system.
- **Newfoundland and Labrador 230 kV Backbone** (Stephenville/Buchans – Soldier's Pond) faces heavy stress with large offshore wind injection (33 N-1 overloads in C4-2). The single 900 MW Labrador-Island HVDC Link provides limited relief, so internal NL lines run over capacity when NL exports or when supplying new island demand.
- **Many Interface Transformers** (e.g., 345→138 kV at Salisbury, 230→138 kV at Western Avalon) hit emergency ratings under high-flow scenarios. While voltage profiles remain acceptable in steady state (due to two existing shunt capacitors/reactors), low voltages could occur if heavily loaded lines trip, linking thermal issues to stability concerns.

Mitigation Strategies:

- **Operational Measures ("No-Cost" Fixes):** In the near term, leveraging generation dispatch, dynamic line ratings, System Operating Limits, and Remedial Action Schemes can manage mild overloads. However, by 2050 these are insufficient for the majority of cases – over-reliance would lead to frequent offshore wind curtailment and hydrogen shutdowns.
- **Upgrading Existing Infrastructure:** Many moderate overloads (110–120%) can be alleviated by reconductoring lines with higher capacity conductors, raising clearance on thermally limited spans, or replacing aging transformers with larger units. Upgrades are notably effective on 138 kV networks in NB and NS (many lines in the 110–120% range in C3 scenario can be uprated). These upgrades are already in the long-term plans for several key corridors (e.g., a second Memramcook 345/138 kV transformer by 2028 is a part of plan).
- **New Infrastructure:** Severe overloads (≥120%) necessitate new transmission corridors or transformer additions. By 2050, numerous new lines are required: a second 345 kV NB–NS intertie, additional 345 kV lines in Nova Scotia (to create a loop and possibly an HVDC link to New England), new 230 kV lines in Newfoundland and Labrador (e.g. Bottom Brook–Buchans upgrade), and multiple 138 kV reinforcements across all provinces. Planning also includes installing synchronous condensers/STATCOMs for voltage support as conventional generation retires.
- **Strategic Note:** Transmission infrastructure to support domestic supply and export pathways may need to be advanced ahead of offshore wind development, depending on timing and scale of development. The analysis indicates that timely transmission reinforcements would support the effective utilization of renewable generation and facilitate access to export markets. Delays in advancing grid infrastructure could increase the risk of congestion and curtailment, potentially limiting system benefits. A coordinated and forward-looking approach to transmission development would support the system's ability to securely accommodate new resources as they are introduced.

Recommendations

By 2050, new transmission capacity will be needed at all voltage levels to maintain reliability. Key recommended projects and actions include:

- **NB–NS Interface:** Build out the New Brunswick–Nova Scotia intertie to approximately 1,000 MW transfer capacity (adding a second 345 kV line in parallel). This provides N-1 security for the provincial interface and greatly reduces 138 kV overloads in both provinces.
- **Nova Scotia Backbone:** Strengthen Nova Scotia's internal grid with an additional 345 kV path (or loop) tying together the backbone. In the long term, consider an HVDC link from NS to New England to export surplus offshore wind directly and bypass internal network constraints (envisioned as part of the 2050 plan).
- **NB–PEI and Regional 230 kV:** Augment the NB–PEI transfer capability – the new 138 kV link in service by 2030 is a first step, but by 2050 either a second parallel circuit or an upgrade to 230 kV might be required to handle PEI wind exports. Continue upgrading NB and NS 230 kV loops (e.g., Northern NB 230 kV and eastern NS 230 kV lines) as they serve as alternate paths during 345 kV outages.
- **Newfoundland and Labrador Upgrades:** Undertake significant upgrades on the Newfoundland and Labrador grid. This includes adding new 230 kV lines to reinforce the west-to-east corridor (doubling circuits where necessary) and potentially implementing a 315 kV or higher voltage "super-grid" or an additional HVDC link from Newfoundland and Labrador to Nova Scotia to export large surpluses. Also, increase on-island support by installing high-capacity transformers and dynamic reactive support to manage long-distance power flows.
- **Operational Readiness:** Evolve operational practices alongside infrastructure. System operators should ensure adequate inertia is maintained (e.g., by retaining some synchronous generation online or using synthetic inertia from wind farms) to prevent stability issues. Invest in grid-forming inverters at offshore wind plants and deploy large STATCOMs/synchronous condensers in both NS and NL to support voltages and stability as traditional generators retire. Develop advanced control schemes for hydrogen electrolyzers so they can act as flexible load resources to buffer the grid.

The combination of these upgrades and strategies will enable the Atlantic Canada transmission system to securely accommodate the ambitious 2050 portfolio of offshore wind, clean hydrogen production, interprovincial power trade, and power exports.

11.1 System-Wide Overload Trends (2050)

11.1.1 NS, NB, and PEI Model[40]

The 2050 power flow analysis demonstrates that as offshore wind and hydrogen loads scale up, the Atlantic transmission system faces a sharp increase in thermal stress compared to 2035. The following trends are observed across all scenarios:

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[40] The Newfoundland and Labrador 2050 system incorporated the major transmission system upgrades identified in the 2035 results prior to modeling the offshore wind and hydrogen load in the 2050 case, since the scale of MW of offshore wind and hydrogen load is significant compared to the Newfoundland and Labrador existing system. These assumed upgrades are discussed in Section 10.

- **Overload Counts Rise Sharply:** In moderate scenarios (C1, C2), thermal overloads are present but mostly manageable. As hydrogen and exports grow (C3, C4), widespread and severe violations emerge, especially on the 138 kV and 230 kV networks in NB–NS–PEI and on the 230 kV backbone in Newfoundland and Labrador.
- **All Voltage Levels Impacted:** Overloads are distributed across 138 kV, 230 kV, and 345 kV systems, with the most severe cases requiring new infrastructure. In the C4-2 scenario, all voltage levels are maxed out, and even normal operation violates criteria.
- **Regional Patterns:**
    - **NB–NS–PEI:** 138 kV feeders and 345 kV backbone are the most stressed with overloads peaking in high offshore wind and export scenarios.
- **Severity and Mitigation:** Mild overloads (<110%) can often be managed with operational measures, but moderate (110–120%) and severe (≥120%) overloads require reconductoring or new circuits. In C4-2 scenario, the majority of the overloads are severe, indicating the need for major upgrades.

Figure 11.A shows the number of overloads under N-0 and N-1 conditions for the studied grid integration scenarios.

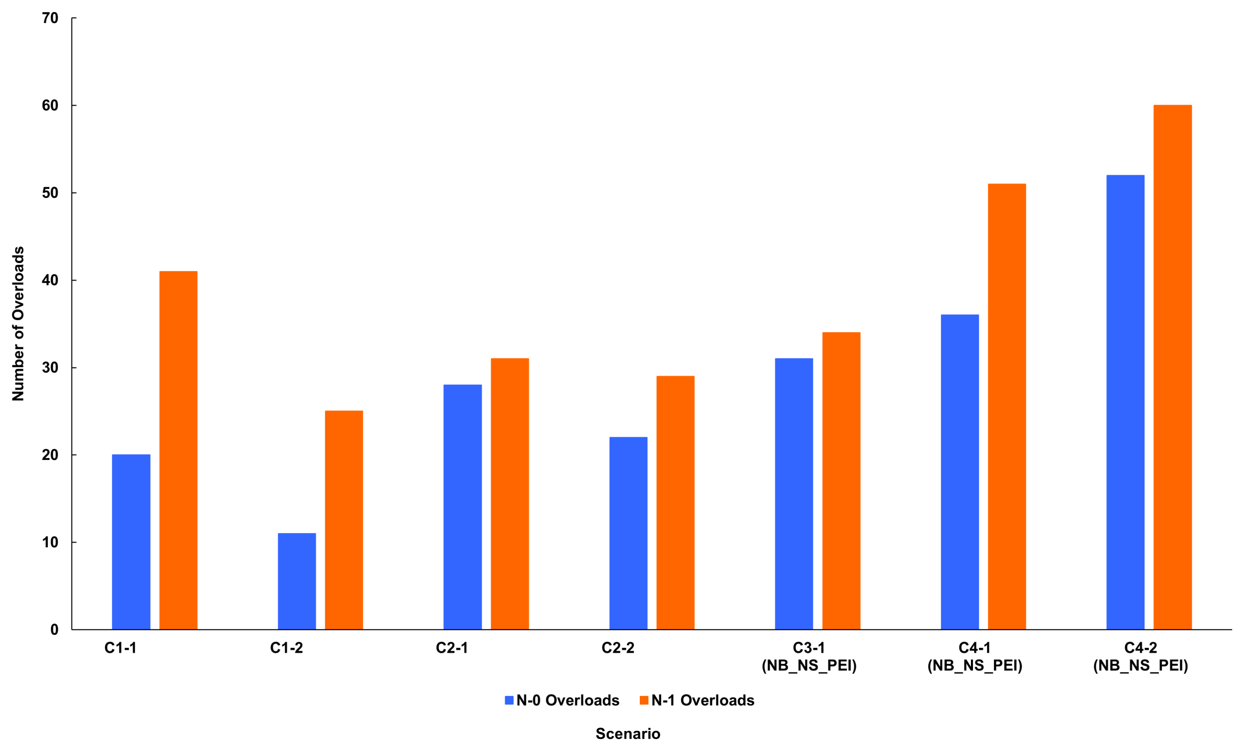

Figure 11.A 2050 N-0 and N-1 Overload Counts by Scenario and Region

Figure 11.B shows the overload distribution by voltage level under N-1 conditions for the studied grid integration scenarios.

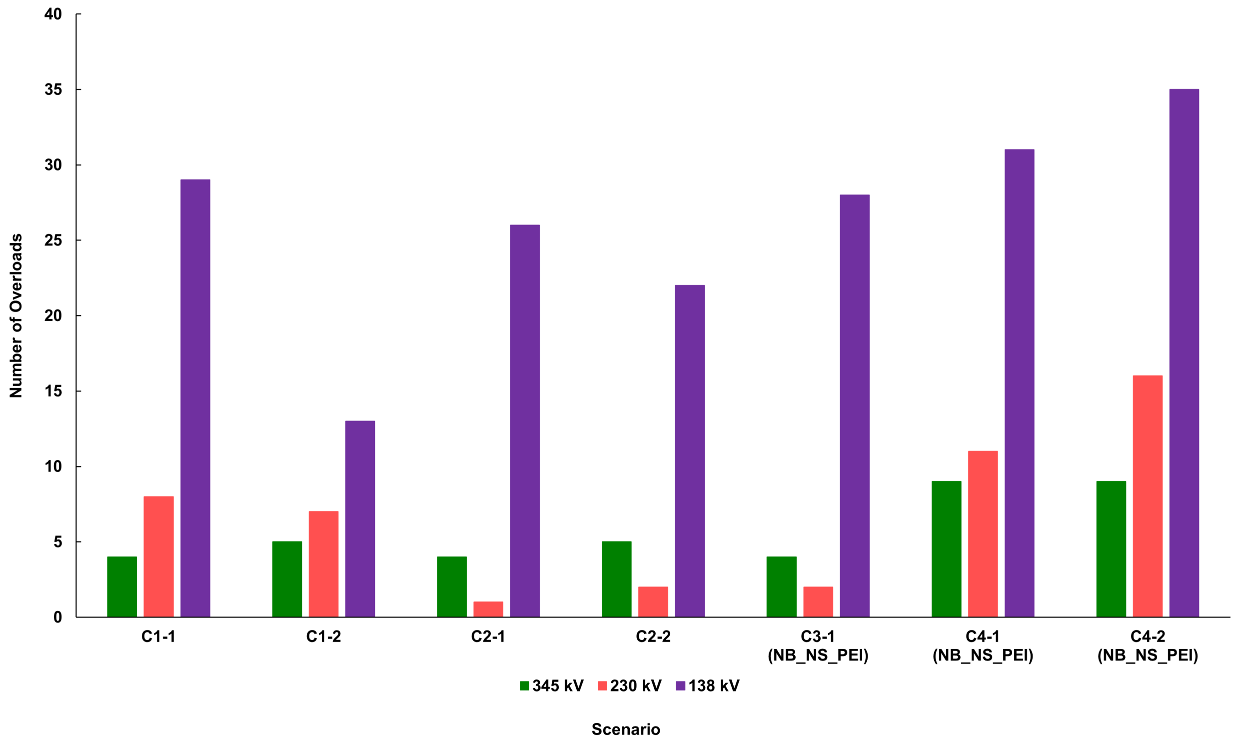

Figure 11.B 2050 Overload Distribution by Voltage Level

Figure 11.C shows the number of overloads under N-1 conditions for the studied grid integration scenarios.

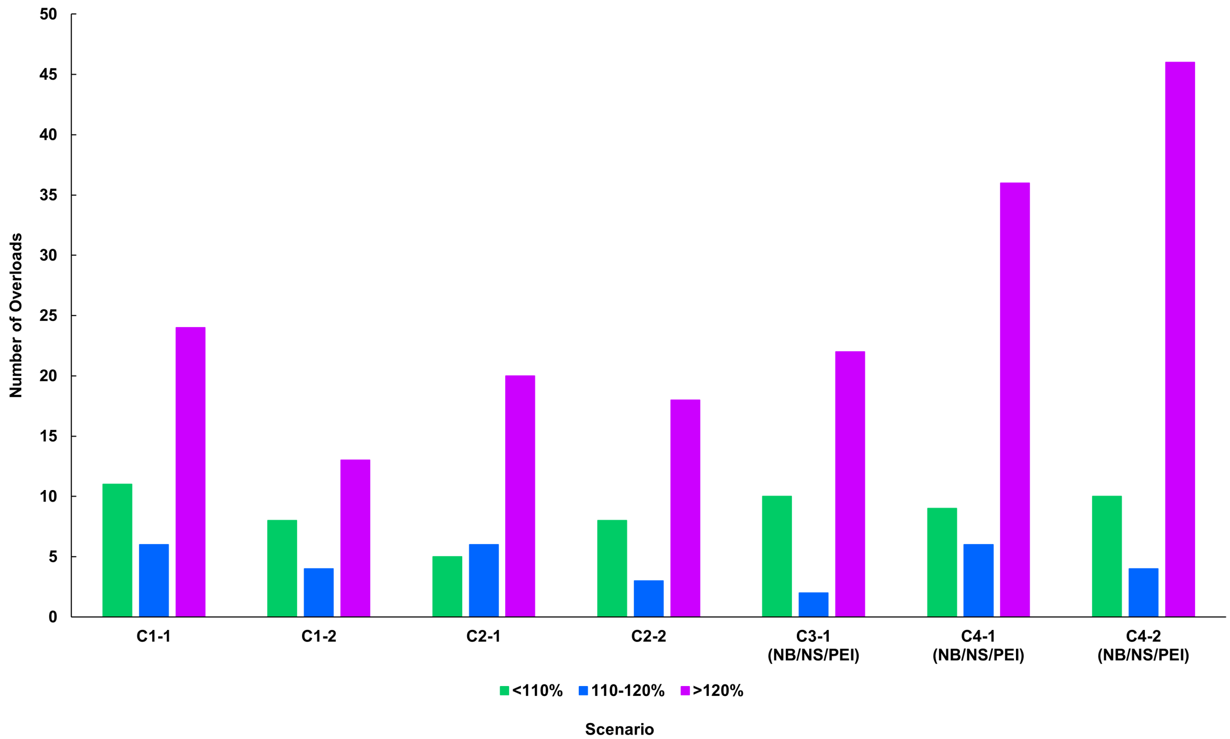

Figure 11.C 2050 Severity Breakdown by Scenario

Figure 11.D compares between the no-cost and cost-impact mitigation for the overload observed for the studied grid integration scenarios.

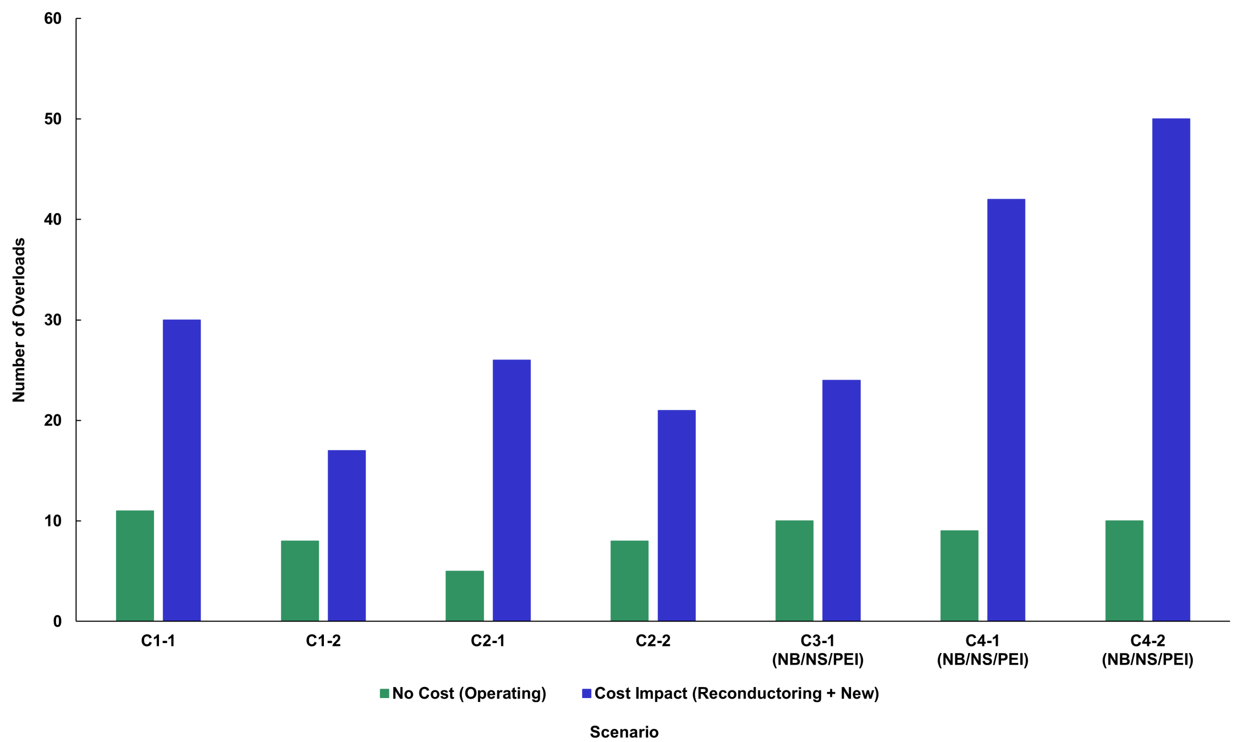

Figure 11.D 2050 No-Cost vs. Cost-Impact by Scenario

11.2 2050 Grid Integration Study Scenario Results

11.2.1 C1-1: Domestic – Only Market

The power flow results for the 2050 C1-1 domestic only market scenario are as follows:

- N-0/N-1 Overloads: 20/41 (NB–NS–PEI).
- Overloads by Voltage Distribution: 138 kV (29), 230 kV (8), 345 kV (4).
- Severity/Mitigation: 9 operating measures (<110%), 6 reconductoring (110–120%), 13 new circuits (≥120%), and 11 new transformers (≥110%).
- Key Insights: Most overloads are on 138 kV feeders and 230 kV corridors, reflecting local network stress under high renewables. 345 kV backbone is generally adequate.
- Actions:
    - Operational measures for minor overloads
    - Reconductor 138 kV and 230 kV lines
    - Plan new circuits and transformer upgrades for persistent bottlenecks

11.2.2 C1-2: Domestic – Only Market

The power flow results for the 2050 C1-2 domestic only market scenario are as follows:

- N-0/N-1 Overloads: 11/25 (NB–NS–PEI).
- Overloads by Voltage Distribution: 138 kV (13), 230 kV (7), 345 kV (5).
- Severity/Mitigation: 3 operating measures (<110%), 4 reconductoring (110–120%), 9 new circuits (≥120%), and 4 new transformers (≥110%).
- Key Insights: Overloads shift toward 230 kV corridors; 345 kV backbone remains mostly sufficient.
- Actions:
    - Operational measures for minor overloads
    - Reconductor 230 kV lines
    - Add new circuits/transformers at critical locations

11.2.3 C2-1: Domestic + Export Markets

The power flow results for the 2050 C2-1 domestic and export markets scenario are as follows:

- N-0/N-1 Overloads: 28/31 (NB–NS–PEI).
- Overloads by Voltage Distribution: 138 kV (26), 230 kV (1), 345 kV (4).
- Severity/Mitigation: 3 operating measures (<110%), 6 reconductoring (110–120%), 7 new circuits (≥120%), and 13 new transformers (≥110%).
- Key Insights: NB–NS 345 kV tie becomes a bottleneck for exports; 138 kV feeders stressed during contingencies.
- Actions:
    - Export throttling and RAS
    - Reconductor 138 kV lines, transformer upgrades
    - Build new NB–NS 345 kV line and 138 kV circuits ahead of export growth

11.2.4 C2-2: Domestic + Export Markets

The power flow results for the 2050 C2-2 domestic and export markets scenario are as follows:

- N-0/N-1 Overloads: 22/29 (NB–NS–PEI).
- Overloads by Voltage Distribution: 138 kV (22), 230 kV (2), 345 kV (5).
- Severity/Mitigation: 1 operating measure (<110%), 3 reconductoring (110–120%), 12 new circuits (≥120%), and 6 new transformers (≥110%).
- Key Insights: 345 kV backbone highly vulnerable; transformer overloads are pervasive.
- Actions:
    - Enhanced RAS and operational limits
    - Transformer upgrades, reconductoring
    - Redundant 345 kV and 138 kV paths built ahead of export expansion

11.2.5 C3-1: Domestic + Base Hydrogen

The power flow results for the 2050 C3-1 domestic and base hydrogen market scenario are as follows:

- N-0/N-1 Overloads: NB–NS–PEI: 31/34; NL: 4/7.
- Overloads by Voltage Distribution: NB–NS–PEI: 138 kV (28), 230 kV (2), 345 kV (4)
- Severity/Mitigation: NB–NS–PEI: 10 operating measures, 2 reconductoring, 9 new circuits, and 13 new transformers.
- Key Insights: Hydrogen load shifts stress to 138 kV and transformers in NB–NS–PEI; NL's 230 kV grid is the main bottleneck.
- Actions:
    - Hydrogen demand response, offshore wind curtailment
    - 138 kV upgrades, transformer additions, NL 230 kV expansion
    - New 138 kV feeders, 230 kV lines, voltage support devices planned in parallel with hydrogen ramp-up

11.2.6 C4-1: All Markets (Domestic + Base Hydrogen + Exports)

The power flow results for the 2050 C4-1 domestic and base hydrogen and exports market scenario are as follows:

- N-0/N-1 Overloads: NB–NS–PEI: 36/51; NL: 28/42.
- Overloads by Voltage Distribution: NB–NS–PEI: 138 kV (31), 230 kV (11), 345 kV (9).
- Severity/Mitigation: NB–NS–PEI: 9 operating measures, 6 reconductoring, 20 new circuits, and 16 new transformers.
- Key Insights: 345 kV backbone and 138 kV networks are at their limits; NL's 230 kV system is severely overloaded.
- Actions:
    - Targeted curtailment, hydrogen load management
    - Twin 345 kV tie, expand 138 kV, transformer upgrades, NL 230 kV rebuild
    - HVDC overlay, grid modernization (e.g., smart grid technologies, advanced inverter controls, and real-time monitoring) energy storage planned ahead of full market integration

11.2.7 C4-2: All Markets (Domestic + High Hydrogen + Exports)

The power flow results for the 2050 C4-2 domestic and high hydrogen and exports market scenario are as follows:

- N-0/N-1 Overloads: NB–NS–PEI: 52/60; NL: 28/42.
- Overloads by Voltage Distribution: NB–NS–PEI: 138 kV (35), 230 kV (16), 345 kV (9).
- Severity/Mitigation: NB–NS–PEI: 10 operating measures, 4 reconductoring, 31 new circuits, and 15 new transformers.

- Key Insights: All voltage levels are maxed out; even normal operation violates criteria; NL's 230 kV system is critically overloaded.
- Actions:
  - Severe curtailment, hydrogen modulation, emergency islanding
  - Multiple new 345 kV and 230 kV lines, transformers, wide-area protection
  - 345 kV super-grid, HVDC overlay, large-scale storage, dynamic hydrogen control planned as part of long-term vision, NL 230 kV rebuild

11.3 Cost Estimates for 2050 Transmission System Upgrades

The high-level cost estimates developed for the transmission system upgrades identified for the 2050 scenarios are shown in Table 11-1. The basis and assumptions for the estimates are the same as for the 2035 scenarios, as discussed in Section 6.4. Since the base cases for the 2050 scenarios included the transmission upgrades identified in the 2035 analysis before any 2050 contingency analysis was carried out, the 2050 cost estimates do not include the costs for those 2035 upgrades. The cost estimates are in 2025 Canadian dollars and have an accuracy of +100%/-50% according to Class 5 of the Association for the Advancement of Cost Engineering (AACE).

Table 11-1 2050 Transmission System Upgrades Cost Estimates

Transmission Planning Scenario	High Level Cost Estimate for Transmission System Upgrades (2025 Canadian Dollars)	Transmission System Upgrades (Refer to Section 11.2 for Additional Details)
C1-1 NS, NB, PEI	$3,800,000,000	~2000 km of new or reconductored 138, 230, and 345 kV transmission lines 6 transmission line reconductoring 13 new transmission lines 11 new transformers
C1-2 NS, NB, PEI	$2,700,000,000	~1200 km of new or reconductored 138, 230, and 345 kV transmission lines 4 transmission line reconductoring 9 new transmission lines 4 new transformers
C2-1 NS, NB, PEI	$3,100,000,000	~1300 km of new or reconductored 138, 230, and 345 kV transmission lines in NB, NS, and PEI ~3400 km of new or reconductored 138 and 230 kV transmission lines in NL 6 transmission line reconductoring 7 new transmission lines 13 new transformers
C2-1 NL	$8,500,000,000	
C2-2 NS, NB, PEI	$3,500,000,000	~1400 km of new or reconductored 138, 230, and 345 kV transmission lines in NB, NS, and PEI ~2700 km of new or reconductored 138 and 230 kV transmission lines in NL 3 transmission line reconductoring 12 new transmission lines 6 new transformers
C2-2 NL	$7,400,000,000	

Transmission Planning Scenario	High Level Cost Estimate for Transmission System Upgrades (2025 Canadian Dollars)	Transmission System Upgrades (Refer to Section 11.2 for Additional Details)
C3-1 NS, NB, PEI	$2,300,000,000	~800 km of new or reconductored 138, 230, and 345 kV transmission lines ~3400 km of new or reconductored 138 and 230 kV transmission lines in NL 2 transmission line reconductoring 9 new transmission lines 13 new transformers
C3-1 NL	$8,500,000,000	
C4-1 NS, NB, PEI	$6,900,000,000	~3000 km of new or reconductored 138, 230, and 345 kV transmission lines in NB, NS, and PEI ~3100 km of new or reconductored 138 and 230 kV transmission lines in NL 6 transmission line reconductoring 20 new transmission lines 16 new transformers
C4-1 NL	$8,400,000,000	
C4-2 NS, NB, PEI	$10,300,000,000	~4300 km of new or reconductored 138, 230, and 345 kV transmission lines in NB, NS, and PEI ~3000 km of new or reconductored 138 and 230 kV transmission lines in NL 4 transmission line reconductoring 31 new transmission lines 15 new transformers
C4-2 NL	$8,100,000,000	

11.4 2050 Recommendations

By 2050, the scale of offshore wind integration contemplated under the studied scenarios will require new transmission capacity across all voltage levels of the Atlantic regional grid. The existing infrastructure, while adequate for current operating conditions, will be insufficient to accommodate the magnitude of generation injection associated with higher offshore wind deployment. The following transmission needs have been identified as necessary to enable reliable and efficient delivery of offshore wind energy across the region:

Build-Out of the NB–NS Interface (to Approximately 1,000 MW Capacity): The New Brunswick–Nova Scotia interface represents one of the most critical inter-provincial transmission corridors in Atlantic Canada. Expanding this interface to approximately 1,000 MW of transfer capacity would significantly enhance the ability to move offshore wind energy between provinces, improve regional energy sharing, and reduce the risk of localized congestion that could otherwise curtail wind generation. This reinforcement is foundational to enabling a well-integrated Atlantic grid capable of supporting large-scale renewable energy flows.

Strengthening Nova Scotia's Internal Grid with an Additional 345 kV Path: Nova Scotia's internal transmission network will require substantial reinforcement to absorb and redistribute the volumes of offshore wind generation expected to connect along its coastline. The addition of a new 345 kV transmission path would provide the backbone capacity necessary to move power from offshore injection points to load centers and interprovincial export interfaces. This higher voltage pathway would also improve overall system voltage stability and reduce transmission losses associated with moving large quantities of power across the province.

Augmenting NB–PEI Transfer Capacity: The existing transmission link between New Brunswick and Prince Edward Island will need to be augmented to support PEI's growing offshore wind ambitions and its ability to export surplus generation to the broader regional grid. The development of a new interconnection link represents a critical first step in establishing the transfer capacity necessary to move PEI's offshore wind output beyond its own load base. Given PEI's relatively small load relative to its renewable energy potential, robust export capacity is essential for the province to fully realize the value of its offshore wind resources.

Significant Newfoundland and Labrador System Upgrades: Newfoundland and Labrador will require extensive system-wide upgrades to accommodate the level of offshore wind development projected under the 2050 scenarios. These upgrades will need to address both the internal transmission network, to collect and aggregate offshore wind output, and the interprovincial interconnection capacity necessary to deliver that energy to markets in Atlantic Canada and potentially beyond. Given NL's geographic position and the scale of its offshore wind resource potential, investment in its transmission infrastructure is critical to unlocking the full regional benefit of offshore wind development.

Operational Readiness and System Stability Evolution: Beyond physical infrastructure expansion, the operational characteristics of the Atlantic grid must evolve in parallel to ensure reliable system operation as the generation mix transitions toward a higher proportion of inverter-based renewable resources. Two areas of operational readiness are particularly critical:

> **Maintaining Adequate System Inertia** — As offshore wind displaces conventional thermal generation, the grid will lose the natural inertia provided by synchronous machines, which plays a vital role in stabilizing system frequency following disturbances. It is therefore essential that thermal retirements be managed carefully and strategically, avoiding rapid decommissioning that could leave the system without sufficient inertia to maintain frequency stability. A deliberate and phased retirement schedule, aligned with the commissioning of replacement stability resources, will be necessary to manage this transition responsibly.
>
> **Procurement of Advanced Grid-Forming and Reactive Support Resources** — As the share of traditional synchronous generators diminishes, the system must compensate through the procurement of grid-forming inverters at offshore wind plants, which are capable of actively supporting grid voltage and frequency rather than simply following the existing grid signal. Complementing this, the installation of large-scale STATCOMs and synchronous condensers at strategic locations across the network will be essential for maintaining voltage stability, providing reactive power support, and ensuring the system retains the dynamic response characteristics necessary for secure operation under high renewable penetration conditions.

Augmenting NB–PEI Transfer Capacity: The existing transmission link between New Brunswick and Prince Edward Island will need to be augmented to support PEI's growing offshore wind ambitions and its ability to export surplus generation to the broader regional grid. The development of a new interconnection link represents a critical first step in establishing the transfer capacity necessary to move PEI's offshore wind output beyond its own load base, given PEI's relatively small load relative to its renewable.

12 2050 Transient Stability Study Results

The 2050 transient stability analysis evaluated seven scenarios (C1-1, C1-2, C2-1, C2-2, C3-1, C4-1, C4-2) under different market frameworks and offshore wind buildouts. Overall, stability performance deteriorates as offshore wind capacity and electrolysis load increase. The Domestic-only Market case (C1-1, 2.5 GW offshore wind) demonstrated stable system performance, with 80% of tested contingencies converging without loss of synchronism. In contrast, the C4-2 scenario (16.5 GW offshore wind + high hydrogen + exports) was unable to reach a stable initial condition, with all simulated contingencies resulting in immediate voltage collapse. These results underscore the critical need for substantial system upgrades and advance controls to ensure transient stability under high offshore wind and hydrogen integration.

Key Stability Insights and Weak Links

Despite the varied conditions, several common weak links emerged across scenarios:

- **NS–NB Intertie (Woodbine–Hopewell 345 kV):** This interprovincial tie-line is critically loaded in high-wind cases. Faults on it caused immediate collapse in 5 of the scenarios (C1-1, C1-2, C2-1, C3-1, C2-2 as a delayed collapse). Even with all thermal units on (C2-1 scenario), tripping this line led to Nova Scotia separating from NB and collapsing. It is a single corridor carrying multi-GW exchanges; when it fails, Nova Scotia cannot support itself unless another strong path exists.
    - Reinforcement: A second 345 kV tie or converting this AC tie to HVDC (with fast power controls) could prevent a single fault from isolating NS.
- **Cape Breton Export Corridor (IR742–Port Hastings 230 kV and Related Lines):** Large amount of offshore wind feed into Cape Breton. The IR742–Port Hastings 230 kV line appears in almost every scenario as a collapse trigger. With so much offshore wind, losing one path overloads the remaining paths and causes an immediate voltage collapse in Cape Breton. Dynamic plots show that when this line trips in high-wind cases, the Port Hastings 345 kV bus voltage collapses, forcing wind generation to trip. Strengthening this corridor (e.g., new 345 kV lines from Cape Breton to mainland, or local synchronous condensers) would help maintain stability for an outage in that area.
- **Mainland NS 345 kV Corridor (Onslow–Lakeside):** Tripping this Halifax supply line caused post-fault collapse in high onshore wind scenarios (C1-2, C2-2, C3-1). The dynamic response indicates a slow voltage decay in the area when this line is lost, due to heavy reliance on that single path. In C2-1 scenario (with high inertia) it only caused oscillations, but lower inertia led to collapse.
    - Reinforcement: Installing a parallel 345 kV link or fast reactive support (STATCOMs) at Lakeside could mitigate this.
- **New Brunswick North–South Lines (Salisbury–Bathurst 345 kV, etc.):** Outages on NB's long 345 kV lines (which carry power between north, central, and south NB and to PEI) caused instability in multiple cases. The Salisbury–Bathurst 345 kV line trip led to collapse in C1-2 and C2-2 scenarios (but was successfully withstood in C3-1 scenario, perhaps due to different flow patterns). The Coleson Cove–Norton 345 kV outage (connecting NB's big generator to the grid) caused immediate collapse in several scenarios. These lines are vital for moving power across NB and handling imports/exports. If one line is lost, the others may not be able to hold voltage. NB might need additional parallel lines or sectionalizing (splitting north vs south under certain conditions) to prevent province-wide impacts from a single fault.

- **PEI Offshore Wind POI (Scotchfort 138 kV):** In oscillatory cases (C2-1), the PEI offshore wind contributed to a poorly damped mode. While faults on the PEI subsea cable were not the worst-case collapse initiators, the dynamic plots show oscillations associated with this weak link, which could result in instability if not addressed. Adding damping controllers or upgrading the PEI-NB interconnection to a stronger link would likely be necessary as PEI's wind generation grows.
- Newfoundland and Labrador Grid:
  - C3-1: Newfoundland and Labrador's grid remained stable for all N-1 contingencies. The most severe event (Western Avalon–Soldiers Pond 230 kV outage) caused a ~30% voltage dip and brief oscillations, but voltages recovered quickly. No major mitigation needed.
  - C4-1: Under high export and wind conditions, the grid had no transient stability margin. All tested contingencies led to voltage collapse with Western Avalon–Soldiers Pond being the most critical. Significant transmission and dynamic reactive support upgrades are required.
  - C4-2: The system was not operable; no stable solution could be reached. The combination of high offshore wind, hydrogen demand, and export levels would require substantial infrastructure expansion and advanced controls to maintain system stability.

Recurring Instability Mechanisms: The dominant mode of failure in most scenarios was voltage instability – either immediate (a fast transient voltage collapse) or slower voltage collapse (a steady decline after an initial disturbance). In immediate collapses, voltages drop below ~0.5–0.6 p.u. system-wide within 1–2 seconds, causing inverters to trip offline. In delayed collapses, initial recovery is followed by a gradual voltage decline (often at load centers) as reactive power support is insufficient in those areas. The dynamic plots for unstable cases consistently show one region's voltage drifting down until generators disconnect. Rotor angle instability (loss of synchronism) was often a consequence of the voltage collapse, not an independent swing; however, in cases like C2-1, machine angle oscillations did appear (the undamped 0.5 Hz mode). That indicates a need for damping even if voltage holds.

Table 12-1 summarizes the transient stability assessment for each scenario, where ten single contingencies were evaluated by tripping major interprovincial or intra-provincial transmission lines in the 2050 study cases.

Table 12-1 Summary of Transient Stability Results

Scenario Name	Framework	Offshore Wind Capacity (MW and Locations)	Number of Stable Cases (No Collapse)	Number of Oscillatory Cases (Survived but Poorly Damped)	Collapses (Post-Fault or at Fault)	Key Observations
C1-1	Domestic-Only (High Thermal, Low Wind)	2,500 (NS Sydney Bight; PEI C22)	8/10	0/10 (minor swings only)	2/10 – collapse at fault	Most stable
C1-2	Domestic-Only (Low Thermal, High Wind)	2,500 (same sites as C1-1)	4/10	0/10	6/10 – 2 at fault; 4 post-fault collapse	Stability margin shrinks with less thermal

Scenario Name	Framework	Offshore Wind Capacity (MW and Locations)	Number of Stable Cases (No Collapse)	Number of Oscillatory Cases (Survived but Poorly Damped)	Collapses (Post-Fault or at Fault)	Key Observations
C2-1	Domestic + Export (High Thermal, Low Wind)	8,500 (3×NS, 1×PEI, 1×NL)	1/10 (no oscillation)	6/10 – undamped oscillations	3/10 – collapse at fault	Oscillatory stability in PEI system
C2-2	Domestic + Export (Low Thermal, High Wind)	8,500 (same as C2-1)	5/10	0/10	5/10 – 1 at fault; 4 post-fault collapse	Delayed collapses, better damping
C3-1	Domestic + Base Hydrogen (Moderate offshore wind)	~6,500 (expanded NS and NL offshore wind)	5/10	0/10 (some small swings)	5/10 – collapse at fault	NB_NS_PEI: Hydrogen load stresses recovery. NL: stable for all N-1; Western Avalon–Soldiers Pond is critical but damped
C4-1	All Markets (Base Hydrogen + Export)	12,500 (maximum offshore wind, multi-site)	0/10	0/10	10/10 – collapse at fault	NB_NS_PEI: No stability margin. NL: collapses under all N-1; no transient margin
C4-2	All Markets (High Hydrogen + Export)	16,500 (full build-out)	N/A (flat start fail)	N/A	No secure operating point	NB_NS_PEI: System not operable. NL: grid inoperable without major upgrades

Recommended Stability Measures

Grid Reinforcement is Essential:

- **Transmission Upgrades:** The study shows that key transmission corridors (especially the NS–NB intertie and Cape Breton export lines) are critical weak points. Planners must prioritize building additional lines, upgrading existing ones, or converting AC interties to HVDC to provide alternate paths and prevent single faults from causing widespread collapse.
- **Network Redundancy:** Creating more network (looped) transmission paths, especially in New Brunswick, will help localize faults and prevent province-wide instability. Implementing HVDC systems within the networks can also help improve system reliability and stability.

Dynamic Voltage and Inertia Support:

- **Synchronous Condensers and FACTS:** As conventional generators retire, their stabilizing functions (voltage support, inertia) must be replaced. Installing synchronous condensers and fast-acting voltage support devices (FACTS such as STATCOMs/SVCs) at strategic locations (e.g., Halifax, Moncton, Saint John) will help the grid ride through faults and recover voltages.
- **Grid-Forming Inverters:** Requiring advanced controls on new wind farms (grid-forming inverters) and other inverter-based resources can provide synthetic inertia and voltage support, improving stability in high-renewable scenarios.

- **VSC HVDC Systems:** The various control modes and ability to independently control active and reactive power in VSC HVDC systems, as well as other HVDC system functionality such as grid forming controls, black-start, and STATCOM operation, can provide additional voltage support to the network.

Active Damping of Oscillations:

- **Power Oscillation Dampers:** Large wind farms and interties (especially PEI–NB) should be equipped with damping controllers to suppress electromechanical oscillations that can arise after faults.
- **Wide-Area Monitoring:** Deploying Phasor Measurement Units and wide-area control systems will allow operators to detect and respond to growing oscillations in real time.

Flexible Hydrogen Load Management:

- **Fast Load Shedding:** Hydrogen electrolyzers can be rapidly disconnected during grid disturbances, acting as a stabilizing resource. Planning should include schemes for automatic under-voltage or under-frequency load shedding of hydrogen plants.
- **Demand Response Integration:** Hydrogen facilities should participate in grid emergency controls, providing fast demand response to support stability during faults.

Operational Controls and Protection Schemes:

- **Special Protection Schemes:** Automated remedial actions (e.g., curtailing wind, shedding hydrogen load) should be designed to trigger critical contingencies, preventing cascading failures.
- **Preemptive Curtailment:** Operators may need to reduce wind output or limit interprovincial transfers during periods of grid stress or maintenance to comply stability margins.

Review and Update Planning Criteria:

- **N-1 Security:** The study shows that high-renewable, high-hydrogen scenarios fail traditional N-1 criteria (surviving any single contingency). Planners may need to redefine criteria or invest in infrastructure to maintain reliability.
- **Phased Implementation:** Renewable and hydrogen targets should be matched with phased grid upgrades, ensuring stability is maintained as new resources come online.

Investment in Advanced Controls and Technologies:

- **Grid Modernization:** Investments in smart grid technologies, advanced inverter controls, and real-time monitoring will be crucial for operating a stable, flexible, and resilient grid in future.

Interprovincial Planning and Coordination:

- **Provincial Collaboration:** Effective integration of high levels of offshore wind and hydrogen will require close collaboration among Atlantic provinces. Coordinated planning, shared infrastructure development, and harmonized operational strategies will be essential to ensure system-wide reliability and cost-effective implementation.

- **Coordination Across Provinces:** The 2050 high offshore wind and high hydrogen scenarios will require significant investments in grid infrastructure, advanced controls, and strong interprovincial coordination to avoid instability and ensure a resilient energy future.

The 2050 grid can support moderate renewable growth, but high offshore wind and high hydrogen scenarios will require significant investments in grid infrastructure and smarter controls to avoid instability and blackouts.

13 Conclusions and Next Steps for 2050 Transmission Expansion Needs Analysis

Phase 3 Outcomes (2050): The 2050 Transmission Expansion Needs Analysis outlines how Atlantic Canada could integrate on the order of 10–15 GW of offshore wind generation by mid-century—a threefold increase over 2035 levels alongside multi-GW new hydrogen production and sustained export flows. Achieving this vision while maintaining reliability will require substantial proactive grid investments than the 2035 plan: building new high-capacity transmission corridors (potentially including HVDC links), reinforcing provincial networks, and deploying advanced grid technologies on a large scale. The studies indicate that, with coordinated planning and significant infrastructure enhancements, the electricity grid in Atlantic Canada has the potential to support the projected growth in offshore wind and clean energy development by 2050. However, the scale of required expansion is notably larger, and the available margin for operational flexibility appears more constrained, compared to the 2035 outlook. Key conclusions by province are as follows:

- **New Brunswick:** NB continues to serve as the regional transmission hub, interconnecting all four Atlantic provinces and their export pathways. By 2050, however, its network is expected to accommodate higher power flows. The studies suggest that the 345 kV interties—particularly those facilitating the transfer of wind generation from Nova Scotia and Prince Edward Island westward, and enabling resource sharing with Québec and New England—approach their operational limits under high offshore wind scenarios. As such, enhancing New Brunswick's interconnections to both the west and east emerges as a key priority. This includes a recommended third 345 kV line to Nova Scotia and potential upgrades to the NB–PEI link—either to 230 kV or through the addition of a second circuit—to support higher power flows by 2050. Internally, NB's 345 kV backbone from past developments serves it well. However, further reinforcements—such as reconductoring of higher-capacity 138 kV lines and transformer upgrades at critical nodes like Salisbury and Memramcook—will be necessary to manage the anticipated increases in load and export volumes. With these enhancements, New Brunswick would be well-positioned to continue facilitating reliable regional power transfers, including large-scale offshore wind integration.
- **Nova Scotia:** NS has the potential to support a substantial increase in offshore wind development by 2050—estimated in this study at approximately 8 to 9 GW across multiple sites—contingent on the establishment of a second major export pathway and significant enhancements to the province's internal transmission infrastructure. While this estimate reflects the scale of development assessed in the current analysis, it does not preclude the possibility of additional future capacity.

Beyond approximately 2 to 3 GW of local offshore wind—already identified as a threshold for 2035—the province's predominantly radial transmission system may face increasing stability challenges without the development of new transmission corridors.

Accordingly, the assessment highlights the importance of establishing a parallel 345 kV backbone within Nova Scotia and pursuing a new high-capacity interconnection to external markets. By 2050, a likely option includes a HVDC transmission link between Nova Scotia and New England (or an equivalent alternative), enabling direct export of surplus offshore wind generation to the New England grid and complementing expanded interties through New Brunswick. This approach aligns with long-term utility planning frameworks and would help alleviate pressure on New Brunswick's system while providing Nova Scotia offshore winds with access to broader markets. Within the province, the studies recommend reinforcing the 345 kV network—such as by extending the Salisbury–Onslow line through the Cape Breton and Halifax regions—to address projected constraints under high offshore wind scenarios, where existing 345 kV lines may exceed their rated capacities and become vulnerable to single-contingency overloads. Additionally, Nova Scotia will need to maintain or enhance system stability through measures such as retrofitting retired thermal facilities as synchronous condensers and deploying grid-forming inverter technologies to support voltage and frequency stability in a system with high integrations of inverter-based generation. With these infrastructure and operational enhancements, Nova Scotia would be well-positioned to harness its significant offshore wind resource by 2050, supporting both domestic electricity needs and clean energy exports while maintaining system reliability.

- **Prince Edward Island:** PEI has the potential to become a net exporter of wind energy by 2050, but realizing this outcome will depend on significantly strengthening its transmission links to NB. By 2050, the assessment suggests upgrading the NB–PEI interconnection to 230 kV or installing a parallel subsea cable. These reinforcements would enable PEI to reliably export surplus wind generation to New Brunswick. The 2050 scenarios also highlight the need for continued close operational coordination with NB's grid, as NB's system will remain essential for voltage support and contingency response under N-1 conditions. With the proposed upgrades in place, PEI could transition from an import-constrained endpoint to an active contributor of offshore wind power in the regional system.
- **Newfoundland and Labrador:** By 2050, Newfoundland and Labrador could accommodate multiple large-scale offshore wind projects—estimated at approximately 2–5 GW in total—capable of meeting domestic energy needs (including large-scale hydrogen production) and contributing to regional exports. Achieving this level of integration would require substantial expansion of the province's transmission infrastructure. Under high offshore wind development scenarios, the existing transmission corridors (notably the 230 kV east–west backbone on the island and the 900 MW Labrador–Island HVDC link) are projected to experience voltage stress and thermal loading. In particular, the analysis identified instances where the 230 kV network would be pushed beyond its limits under peak wind output and hydrogen demand conditions, indicating a need for higher-capacity pathways to deliver power from wind-rich areas in eastern and western Newfoundland to major load centers and export points.

  To address these challenges, the assessment identifies the development of a new 315 kV or higher-voltage transmission backbone across the island of Newfoundland as a potential solution.

This may include establishing new high-voltage hubs near the Avalon Peninsula to support large industrial loads, integrating major wind interconnection points in western Newfoundland, and adding multiple high-voltage links into the Soldier's Pond area (with sufficient transformer capacity to tie into the existing 230 kV system). Even with strengthened on-island transmission, exporting significant volumes of offshore wind would require additional capacity beyond the existing Maritime Link. Consequently, a new high-capacity interconnection to external markets by 2050 is considered a viable development option—potentially an additional HVDC link to Nova Scotia, or alternatively a direct HVDC link to New Brunswick or New England—subject to further policy direction and detailed technical assessment. A combination of internal transmission reinforcements and expanded export capabilities would position Newfoundland and Labrador to play a significant role in long-term clean energy development while maintaining compliance with NPCC and NERC reliability standards.

Regional Planning Alignment: The 2050 planning considerations outlined in this assessment build upon ongoing regional transmission and utility planning initiatives. In particular, the recommendations to expand the New Brunswick–Nova Scotia interface and enhance the New Brunswick–Québec interconnections underscore the strategic importance of interprovincial and cross-border transmission in enabling large-scale renewable energy integration.

Looking ahead to 2050, further interjurisdictional coordination—such as the potential development of a HVDC link between Nova Scotia and New England—would align with broader regional and international energy strategies focused on clean electricity exports. From an operational standpoint, the evolving grid will require advanced coordination and control frameworks to manage the increasing share of variable renewable generation and emerging demand sources. This includes advanced protection systems and stability criteria to accommodate faster system dynamics, enhancing operator training, and potentially updating reliability standards to reflect the characteristics of inverter-based resources.

The assessment indicates that the 2050 grid can accommodate moderate levels of renewable growth; however, scenarios involving high offshore wind deployment and large-scale hydrogen production would necessitate substantial investment in transmission infrastructure and advanced control systems to maintain system stability and avoid reliability risks.

With coordinated policy development, effective offshore wind integration strategies, and a phased implementation approach supported by detailed technical studies, the 2050 expansion needs, represents a continuation of current planning efforts. It provides a structured pathway toward achieving net-zero objectives across Atlantic Canada.

Next Steps (2050): To translate these findings into action, the following key steps are recommended for Atlantic Canada's 2050 grid transition and integration of offshore wind:

Accelerate Critical Transmission Projects: Initiate planning and approvals for new transmission infrastructure well before offshore wind projects come online. Add a second 345 kV New Brunswick–Nova Scotia intertie to boost interface capacity to ~1,000 MW and upgrade the New Brunswick–PEI connection (e.g. a 230 kV line or a second 138 kV circuit) to support two-way energy flow for PEI's wind exports. Likewise, begin design options for an HVDC link from Nova Scotia to New England to be in place by the 2040s, as this will be pivotal for handling surplus generation in high offshore wind scenarios.

Reinforce Provincial Grids: Proceed with major internal reinforcements identified for each province in conjunction with the planning of offshore wind integration. For Nova Scotia, develop an additional 345 kV loop tying together its backbone (e.g. linking the Onslow–Cape Breton corridor with southern NS) and add high-capacity transformers to integrate new offshore wind POIs. For New Brunswick, continue upgrading its 138 kV network and add transformer capacity (the second Memramcook 345/138 kV transformer by 2028 is assumed as a given) to accommodate increased flows. In Newfoundland and Labrador, undertake a comprehensive transmission upgrade program: build a new high-voltage AC backbone (likely 315 kV or higher) across the island and consider a 315 kV or higher voltage "super-grid" for the strongest west-to-east corridors. Make double circuit of critical 230 kV lines and install additional synchronous condensers or STATCOMs at weak points for voltage support. These projects will raise the thermal limits of the network and provide N-1 security as renewable penetration grows.

Enhance Operational Preparedness: Evolve grid operations and standards in parallel with infrastructure. Ensure adequate inertia and frequency support by leveraging solutions like synchronous condensers (e.g. convert units at Lingan or Holyrood to provide inertia) and grid-forming inverters on large wind or battery installations. Deploy fast-responding reactive support (STATCOMs, SVCs) at key busses in NS and NL to maintain voltage stability as conventional generation retires. Develop coordinated control schemes so that hydrogen electrolysers can ramp down or adjust demand quickly during grid stress – effectively using hydrogen plants as flexible load to help balance variability. These operational measures will be crucial to meet NPCC and NERC criteria in a system with high inverter-based resource penetration.

Policy and Regulatory Collaboration: Work closely with regulators, governments, and regional partners to enable the above investments. This includes establishing cost-sharing frameworks for multi-province projects (e.g. the NB–NS and NB–PEI ties benefit multiple jurisdictions and will require cooperative funding arrangements) and securing federal support or transmission tariffs that recognize the broad economic and reliability benefits. Regulatory approval processes should be aligned across provinces to streamline the development of the Atlantic regional grid. Also, engagement with ISO New England, Hydro Québec, and U.S. counterparts should intensify in the 2030s to explore the potential for a Nova Scotia–New England HVDC interconnection, and to ensure inter-regional reliability protocols are updated for 2050 conditions.

Phased Implementation and Monitoring: Adopt a staged approach to deploying 2050 infrastructure and generation, similar to the 2035 plan's "learn and adjust" strategy. For example, integrate the next increment of offshore wind (say, +2 GW by the late 2030s) once the initial upgrades (NB–NS second line, etc.) are in place and validate system performance at that stage. Use those insights to inform the design and timing of subsequent phases (additional offshore wind and hydrogen in the 2040s, plus the HVDC export link). This iterative approach ensures that operational experience is fed back into planning, reducing risk as the system scales up. By 2050, this phased execution – combined with the bold infrastructure investments and policy support outlined above could position Atlantic Canada as a leader in reliable, carbon-free power. The region will have a robust, interconnected transmission system ready to deliver vast offshore wind energy to its own communities and to export markets, all while adhering to the highest reliability standards and driving toward net zero objectives.

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