A New England - Maritimes Offshore Energy Corridor Builds Regional Resilience for a Clean Energy Future

NEMOEC Coalition

May 4, 2023

NEMOEC Coalition

- The NEMOEC coalition consists of developers of offshore wind, green hydrogen, and transmission solutions who are seeking to promote the development of offshore transmission to support the realization of New England and the Maritimes offshore wind and green hydrogen ambitions.
- Coalition members include:
  - DP Energy
  - Total Energies SBE US
  - Northland Power
  - Hexicon
  - Atlantic Canada Offshore Developments
  - Bear Head Energy
  - Grid United
- The coalition has a collective vision of building out shared infrastructure to help achieve 2050 climate goals.

Acknowledgements

- Power Advisory and DNV would like to recognize the support provided by the NEMOEC coalition and industry stakeholders, including Mike Spector, PE. Coalition members and stakeholders offered comments and insight that aided the development and review of this offshore wind transmission white paper.

- Abby Watson, President Groundwire Strategies, acted as the coordinator and spokesperson for the NEMOEC coalition, administering communication between Power Advisory, DNV, and coalition members.

Contents

Purpose

- This White Paper presents the high-level case for the proposed New England-Maritimes Offshore Energy Corridor (NEMOEC) transmission facilities between Nova Scotia and New England to connect two distinct offshore wind resource areas with the two load centers in each respective region, highlighting the economic and environmental benefits.

- A technical review of the feasibility, scalability, modularity and other considerations for these transmission facilities is included, along with an overview of relevant policy and regulatory processes for developing such facilities.

- The White Paper is not meant to be a business case. As such, the analyses are generally higher level and the assessment of benefits is more a demonstration that these benefits are offered, rather than a detailed assessment of the quantum of the benefit.

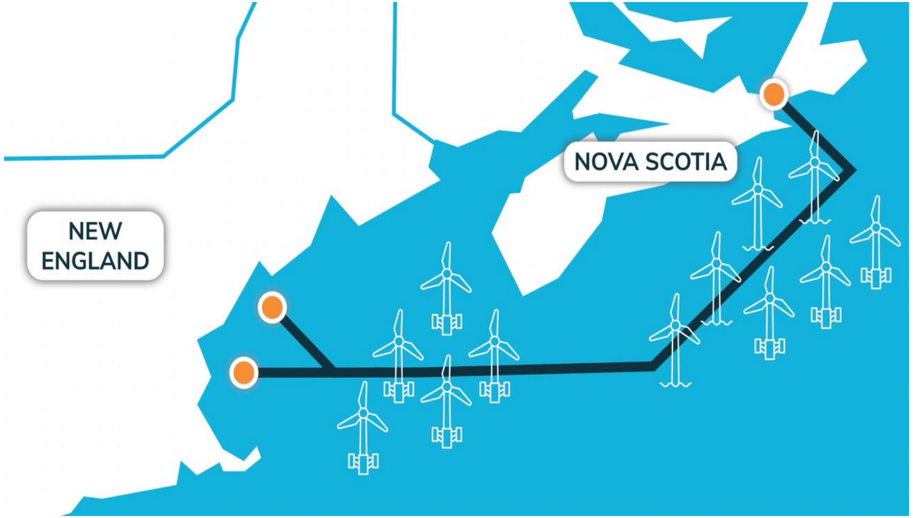
- The White Paper's contents are intended to be used in policymaker and other pertinent stakeholder discussions as an aid to policy development and regulatory action.

Executive Summary

Coordinating Efforts for Mutual Benefits

- This whitepaper outlines the benefits of connecting offshore wind in the Gulf of Maine (New England) and in Nova Scotia with load centers in the two regions via a new HVDC transmission intertie.
  - New England: offshore wind is a critical resource to achieve New England's decarbonization goals. The Massachusetts Energy Pathways to Deep Decarbonization report indicates that the region will need up to 30,000 MW of offshore wind to achieve 2050 climate targets. Achieving this target will require the development of additional lease areas. The next wind energy area scheduled for development in New England is the Gulf of Maine.
  - Nova Scotia: The province has set a target to offer leases for 5 GW of offshore wind by 2025 to support green hydrogen development. However, integrating this volume of generation to the Nova Scotia electricity grid will be a challenge and the incremental demand for renewable energy from offshore wind in Nova Scotia is likely to be relatively modest given provincial electricity demand. A transmission interconnection with New England could reduce renewable energy supply costs and provide valuable optionality.
- Secondary market opportunities – such as Nova Scotia offshore wind exports to ISO-NE during high priced hours and Gulf of Maine offshore wind exports to Nova Scotia to reduce curtailment – can enhance the cost-effectiveness of the offshore wind facilities and the NEMOEC transmission facilities buildout.

A 2021 review of Atlantic OSW transmission literature by the DOE's Energy Efficiency and Renewable Energy office noted the majority of studies to date were for a single state or RTO/ISO, and that coordination was lacking between OSW generation and transmission. This white paper overcomes that narrow scope.



Source: NEMOEC Coalition

Valuing Transmission Benefits for NEMOEC

- New transmission facilities offer a broad range of benefits, with the scope of these benefits varying depending on the role that the transmission facility plays as well as the resources that it interconnects.
  - In the past transmission projects (upgrades or new facilities) were typically driven by system operators' requirements to maintain reliability standards, with a more recent shift in focus towards the potential range of economic benefits new transmission facilities could provide (e.g., to reduce congestion).
  - However, in many instances transmission facilities serve multiple roles: both enhancing reliability and delivering economic benefits. This is the case for the NEMOEC facilities.
- The NEMOEC facilities would be built to interconnect offshore wind in Nova Scotia and in the Gulf of Maine and deliver this renewable energy to load centers in Nova Scotia and New England, producing the associated economic benefits offered by the delivery of this clean energy. In addition, these facilities would enhance reliability in both Nova Scotia and New England.
- An important contributor to the challenges of developing and building new transmission facilities is that the benefits typically are realized by different parties. With transmission benefits more diffuse, there's a greater likelihood of reduced transmission investment; that is, unless there is a deliberate effort to quantify each of these benefits, especially those not realized by the transmission rights holder. By quantifying the benefits, those values can be recognized in the cost allocation process or when the investment decision is made. This issue is likely to be particularly important for the NEMOEC project given the investment required and the fact that the facilities span the US and Canada.

Benefits From NEMOEC Transmission Facilities

Economic Benefits

1) **Grid connection** from the OSW facilities to the onshore grid;
2) **Market integration** from increased electricity trade between the Maritimes and New England and resulting price reductions;
3) **Market optimization** allowing OSW developers to access the highest value market whether it be producing hydrogen or exporting electricity to ISO-NE during high-price hours;
4) **Reduced reliance on natural gas** reducing the fuel security risk, market price volatility and overall emissions;
5) **Fewer transmission upgrades** needed onshore from planned offshore transmission to directly deliver to load centers further south in New England;
6) **Capacity benefit** from enhanced wind resource diversity between New England and Nova Scotia as well as the load diversity between the two jurisdictions;
7) **Balancing benefits** such as balancing cost and forecast error reductions from the wind resource diversity due to lower variability of the wind resource, and reduced curtailment from the use of the NEMOEC facilities to flow excess power to load centers;
8) **Enhanced reliability** in Nova Scotia to provide additional energy via the NEMOEC facilities and in New England from ancillary services that the HVDC project could provide; and
9) **Economic benefits** such as jobs and tax revenue.

- There are numerous economic, environmental, technical and other benefits that would flow from an offshore transmission backbone shared by Nova Scotia and New England. This section is focused on the economic and environmental benefits. However, it should be noted that there are complexities associated with permitting a multi-jurisdictional HVDC transmission line.

Environmental Benefits

1) **Reduced GHG emissions** from displacing gas-fired generation in ISO-NE with OSW from Nova Scotia;
2) **Reduced disruption** of marine environment by reducing marine trenching and grouping OSW cabling;
3) **Reduced number of landfalls** recognizing higher transfer capability as well as reduced likelihood of multiple construction cycles, with the resulting benefits of reduced impact on local fisheries;
4) **Reduced opposition** since using a single offshore transmission corridor would be less impactful than multiple corridors; and
5) **Reduced project permitting risks** from the enhanced environmental benefits, by addressing a critical project pinch point.

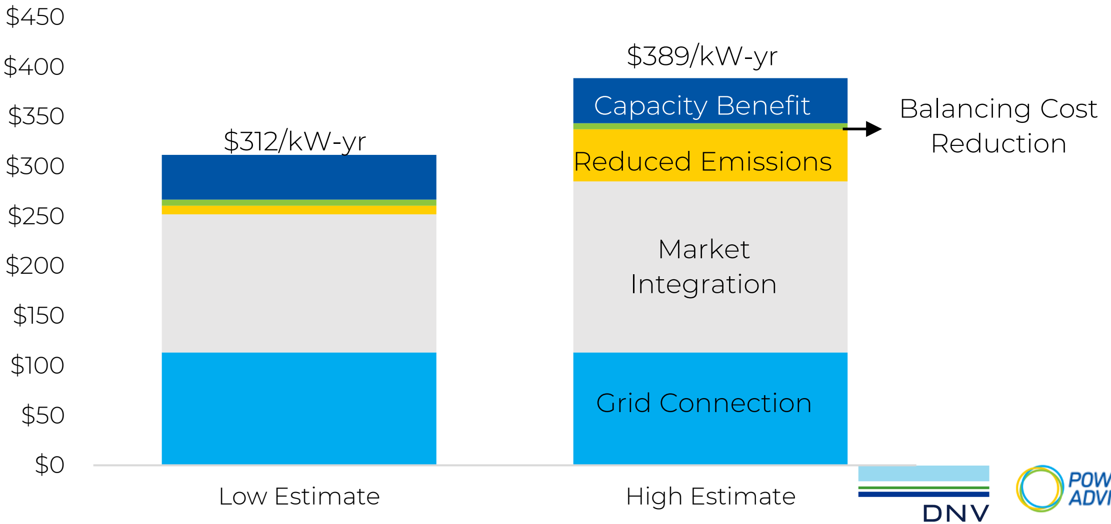
Monetized Benefits Summary

- A summary of the economic and environmental benefits for the NEMOEC facilities and their estimated value are shown below. **Total Economic and Environmental Benefits for a 2,000 MW transmission line are estimated to be between US$0.62-$0.78 billion per year.** All benefits shown are inflated to 2032 US dollars.

- These monetized economic benefits can be expressed in a manner that allows them to be compared to the NEMOEC facilities' estimated capital costs. Assuming an 8% capital recovery factor and operations and maintenance expenses of about 1.5% of capital costs, the level of economic benefits estimated would support a project capital cost of $6 to $8 billion. This suggests that based on these initial benefit estimates the NEMOEC facilities are cost-effective.

Benefit	Low Estimate	High Estimate
Capacity Benefit	$45/kW-yr	
Balancing Cost Reduction	$6/kW-yr	
Reduced GHG Emissions	$9/kW-yr	$52/kW-yr
Market Optimization	*Not reflected in stack*	
Market Integration	$139/kW-yr	$172/kW-yr
Grid Connection	$113/kW-yr	
Total Stack	$312/kW-yr	$389/kW-yr

Estimated Value Stack



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Non-Monetized Benefits Summary

- The following provides a summary of the economic and environmental benefits for the NEMOEC facilities whose values are not easily quantified. Nonetheless, these benefits represent significant advantages of the NEMOEC facilities and must be considered by government agencies, stakeholders, the public, and decision makers in order for the true value of the NEMOEC facilities to be considered.

Type of Benefit	Benefit	Description
Economic	Reduced Reliance on Natural Gas	Reduce the fuel security risk, market price volatility and overall emissions. OSW has a higher capacity during winter months when fuel usage is higher.
	Fewer Transmission Upgrades	Avoid transmission constraints in Maine and deliver energy to load centers further south in New England.
	Enhanced Reliability	Increase import capabilities and supply diversity to Nova Scotia and provide ancillary services to New England through HVDC technology.
	Community Benefits	Provide extensive local and state/provincial economic benefits.
Environmental	Reduced Disruption	Minimize disruption to the local marine environments and communities.
	Reduced Number of Landfalls	A holistic approach to offshore transmission reduces the number of landfalls and required network assets.
	Reduced Opposition	Reduced beach crossing, construction cycles, and permanent structures decreases the likely public opposition.
	Reduced Project Permitting Risks	Fewer landfalls and a single transmission corridor reduces the number of permits and regulatory approval required.

Reduced Ecological Disruption

- An important environmental benefit of coordinated offshore transmission development, such as NEMOEC offers, is the reduced number of landfalls and resulting disruption to the local marine environments and communities. The net result is reduced negative impacts on the marine environment, reduced opposition from stakeholders, and reduced permitting risk.

- Coordinated offshore transmission reduces impacts to local fisheries and disturbance of the marine environment. The Brattle Group report, *Offshore Transmission in New England: The Benefits of a Better Planned Grid*, estimates that under a planned offshore-grid approach to enable offshore wind development in New England, marine trenching can be reduced by almost 50%. Multiple offshore cables can be grouped in the same transmission corridors together to minimize impact; this is not achievable under a project by project, unplanned approach. A coordinated offshore transmission system such as NEMOEC will also minimize the number of offshore platforms, cabling, and onshore substations.

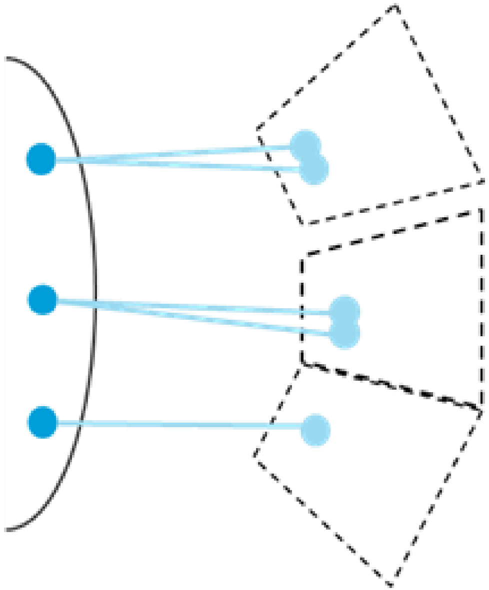
- An additional benefit of NEMOEC is the use of HVDC technology. HVDC allows for greater sub-sea cable lengths which enables greater flexibility on where landing points can be located and allowing landings at less environmentally sensitive sites.

Standard Modular Multi-Terminal HVDC Design Enables Future Growth of NEMOEC Connections

Forward-thinking offshore transmission design is leading policymakers – including the New England States Regional Transmission Initiative – to favor modular multi-terminal HVDC offshore networks that are designed with future growth in mind. The modular approach allows platform designs to be replicated between different projects. This can lead to substantial efficiency gains during project execution, and subsequently during the operational phase, realizing significant CapEx and OpEx reductions.

The standardization and modularization of parameters ensure compatibility between different offshore platforms and enable interconnection of platforms to build out an offshore transmission backbone network. The extension of this network design concept to connect offshore wind resources in Nova Scotia is consistent with the objectives of the New England states.

The report provides indicative options and cost estimates for connecting fixed-bottom Nova Scotia wind energy areas to ISO-NE. These options offer an offshore network framework that could be expanded to include cost estimates for connections to Gulf of Maine or other regional wind areas – a system built with flexibility that seeks to maximize utilization of New England and Maritimes resources. Work underway in other jurisdictions to deploy floating offshore wind will provide cost data that can be included in future modeling efforts.



Cost of Pathways Presented

- Options range in cost from $6-8 billion USD. **This in the range of project cost that could be supported by the monetizable grid benefits.**
- Pathway 1 is an attractive starting point for further exploration of the NEMOEC vision.
- Of the Pathway 2 options considered, Pathway 2a is likely the best option (despite its higher cost) because of its reduced environmental impact and additional interlink between the Nova Scotia POIs.

Pathway	OSW Developed	Technology	Scalable Potential	NS to ISO-NE Transfer	Interlink for NS POIs	High-Level Cost Estimate
1	Sable Island only	**HVDC**: 2 GW, 525 kV Bipole & converter stations	High	Only for Sable Island	No	$6,400 M
2a	Sable Island & South of Halifax	**HVDC**: 2 GW, 525 kV Bipole & converter stations	High	Yes (Sable Island & South Halifax)	Yes	$8,300 M
2b	Sable Island & South of Halifax	**HVDC**: 2 GW, 525 kV Bipole & converter stations **HVAC**: 3x700 MW 275 kV AC, substations	Low	Only for Sable Island	No	$7,500 M
2c	Sable Island & South of Halifax	**HVDC**: 2 GW, 525 kV Bipole & converter stations **HVAC**: 3x700 MW 275 kV AC, substations	Mid	Yes (Sable Island & South Halifax)	Yes	$8,100 M

Potential for Expansion in 2 GW Blocks

- The HVDC systems described in Pathways 1 and 2 could be expanded in 2GW blocks.
- Estimated costs for 2GW expansion between wind area South of Halifax and Boston are shown below.

Equipment	Cost of Equipment ($Millions)
HVDC submarine cables	2760
Offshore platform transport and installation	90
Offshore platform	600
VSC converter offshore	400
VSC converter onshore	350
HVDC Onshore Construction	100
Total (M$)	4300

Standard & Modular HVDC Design Supports the Future Vision of an Open Access HVDC Grid

- Standard and modular designs are consistent with the New England States' vision for an offshore grid.
- Standard and modular designs are best suited for future expansion and enable interconnections with Gulf of Maine wind as it develops.
- A robust offshore HVDC grid creates opportunities for connecting Nova Scotia wind resources to emerging Gulf of Maine sites to take advantage of resource diversity between the New England and Maritimes wind energy zones.

*Illustrative Figure: the need, size and requirements of interlinks should be evaluated based on detailed onshore & offshore techno-economic analysis.

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NEMOEC is Technically Feasible and Scalable

The distances to be covered by an offshore transmission system connecting Nova Scotia wind energy areas to New England make the use of HVDC transmission technology the best choice for those connections. HVDC can transfer electricity over long distances with low losses and also offers flexibility and reliability benefits to the interconnecting onshore grids.

HVDC technology is undergoing rapid advances, and voltage source control (VSC) based multi-terminal HVDC projects have been successfully put into operation. In Europe, a high capacity 2 GW / 525 kV HVDC design standard is being developed to be multi-terminal ready, enabling future extensions to form multi-purpose multi-terminal systems, such as the WindConnector between the Netherlands and the UK, and the Nautilus link between Belgium and the UK.

As offshore wind projects move forward, developers will face supply chain challenges in obtaining HVDC equipment, including undersea cable. The number of manufacturers of the necessary equipment is small but growing – including announcements of new U.S.-based manufacturing capacity. Standardizing and finalizing designs as soon as possible will enable NEMOEC facilities to move forward, taking their places in the supply chain queues.

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Commercial Structures

- Given the NEMOEC corridor's significant capital requirements, multi-jurisdictional span, non-traditional customers and value proposition, a project finance model is likely to be most appropriate for financing. There are a handful commercial structures and funding models that could be employed, and various portions of the corridor could be financed through different structures:
  - Established models such as long-term capacity contracts or selling transmission rights to various parties. This includes selling transmission rights to offshore wind project developers, electric suppliers, and/or participating in state(s) competitive solicitations.
  - The traditional utility funding model where project costs are recovered from customers on a cost-of-service basis.
  - The US Department of Energy's (DOE's) Transmission Facilitation Program (TFP), which offers capacity contracts and loans as a possible route to secure funding. This project finance opportunity will need to be paired with an established commercial model.
- The viability of the NEMOEC project is contingent on securing a stable revenue stream that will allow the recovery of capital invested as well as a return on this investment.

Planning and Permitting Processes

United States

- A transmission developer must propose its project to ISO-NE and complete the interconnection process. The interconnection process consists of four studies completed by or for ISO-NE and normally extends for about 2 years, potentially longer. For the NEMOEC facilities there is a favorable avenue to propose portions of the corridor under the Public Policy Transmission Upgrades (PPTUs) process. This has yet to be employed fully but if successful, a project developer would be able to recover costs from New England ratepayers based on transmission tariff revenues.

- The permitting process in New England includes requirements at the US federal, state, municipal, and private level. Environmental permitting and approvals at the federal level are substantial and time intensive; the process can take 4-5 years to be completed, without major setbacks. State level (i.e., Massachusetts and Maine) requirements and regulations also require an extensive permitting effort.

Canada

- The interconnection framework for Nova Scotia (NS) Power generally follows that used by ISO-NE, as a FERC compliant interconnection process. NS Power doesn't have a specific procedure for external elective transmission upgrades, as such there may be some complexities with interconnection that aren't fully recognized by NS Power's existing interconnection procedures. That being said, the process is expected to take about 2 years.

- The Canadian and Nova Scotia permitting environment is less defined than that of the US and is currently in development. There are a handful of permits and requirements established, which are expected to take 2-3 years. However, the results of several ongoing initiatives and developments will establish the regulations and requirements for an offshore transmission project off the coast of Nova Scotia. For both the US and Canada, delays in permitting should be expected, since the NEMOEC facilities may be one of the first movers in Nova Scotia offshore wind and offshore transmission development.

Road Map to Progressing the NEMOEC Facilities

- This White Paper has detailed the benefits and outlined the technical, policy and regulatory considerations for the NEMOEC facilities. To progress the concept of the NEMOEC facilities, an achievable roadmap has been outlined in the concluding section that details the funding opportunities, regulatory considerations and outlines other potential barriers.

Expand Stakeholder Engagement

Secure productive feedback, including identifying key stakeholders willing to support the initiative or provide feedback.

Identify Champions

Identify a steward for the NEMOEC concept that will advance the NEMOEC.

Identify Funding Opportunities

Development funding from either the US DOE, NRCan and/or Net Zero Atlantic is needed to refine the concept. Long-term financing options include the DOE and the CIB.

Narrow the Scope

Need to understand the OSW development potential prior to detailing the specifics of the corridor (i.e., sizing and location, corridor capacity, preferred POIs, etc.).

Address Areas of Additional Study

Alternative development models should be considered. Expanding and refining the benefits outlined in this White Paper would support further funding.

Identify Market Barriers

Should ensure that OSW in Nova Scotia has viable offtake markets and that the electricity market offers sufficient clean energy liquidity to support both OSW and green hydrogen.

Assess Transmission Planning & Interconnection Challenges

Need to identify preferred POIs to the NS Power and ISO-NE grids. A high-level transmission study should be conducted.

Identify Permitting Ambiguities

In the US, the priority should be pursuing the Right-of-Way grant and then the Presidential Permit. In Canada, many processes remain under development.

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Background

Coordinating Efforts for Mutual Benefits

- This whitepaper outlines the benefits of connecting offshore wind in the Gulf of Maine (New England) and in Nova Scotia with load centers in the two regions via a new HVDC transmission intertie.
  - New England: offshore wind is a critical resource to achieve New England's decarbonization goals. The Massachusetts Energy Pathways to Deep Decarbonization report indicates that the region will need up to 30,000 MW of offshore wind to achieve 2050 climate targets. Achieving this target will require the development of additional lease areas. The next wind energy area scheduled for development in New England is the Gulf of Maine.
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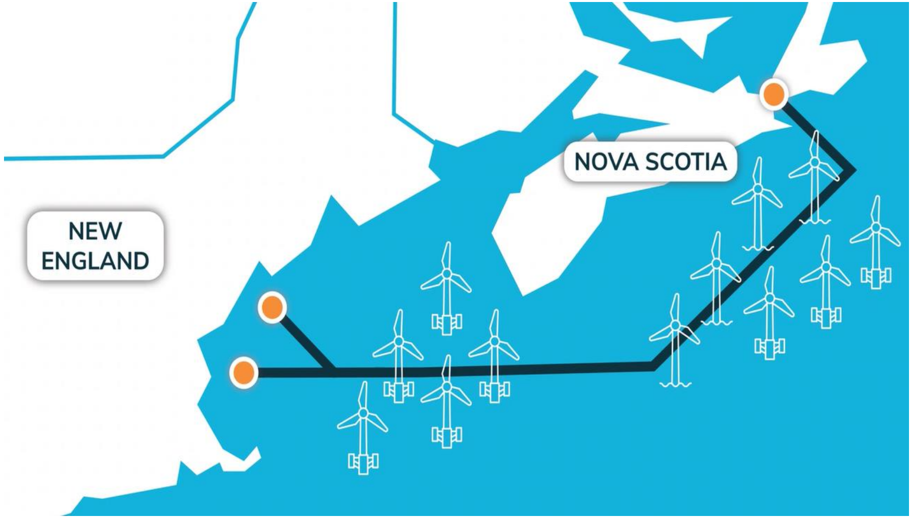

Source: NEMOEC Coalition

Sharing Resources: New England & Maritimes

- There is a need for affordable and clean electricity supply in New England, as well as in the Maritimes, to achieve clean energy goals and reduce GHG emissions cost-effectively, while maintaining reliability. Nearby jurisdictions such as Québec, New Brunswick and New York may also benefit from additional clean energy supply that would be enabled by the NEMOEC facilities.

- Developing onshore wind and utility scale solar in New England is becoming increasingly difficult, leaving offshore wind as the preferred alternative.
    - The Gulf of Maine offers particular promise as a wind energy area, with an auction for lease areas expected by 2025.
    - However, landing this energy in Maine will be challenging given the extensive transmission constraints within the state and the difficulties of building new transmission as evidenced by opposition to the New England Clean Energy Connect (NECEC).

- Nova Scotia has a world class offshore wind resource and bathymetry to support a large amount of fixed foundation offshore wind, a combination that will support large volumes of cost-effective offshore wind generation.
    - However, the electricity requirements and corresponding transmission infrastructure in Atlantic Canada are modest, limiting the ability to integrate large volumes of offshore wind without significant market development.
    - Green hydrogen offers significant promise. However, there are challenges with securing a sufficiently diverse portfolio of clean energy resources to fully utilize production facilities. The NEMOEC facilities can provide access to additional clean energy resources, lowering overall electricity supply costs.

- To capitalize on these opportunities and address these challenges, the New England-Maritimes Offshore Energy Corridor (NEMOEC) coalition has put forward the concept of an offshore transmission grid to connect Nova Scotia and New England.
    - The NEMOEC facilities would connect both areas and enable the transfer of clean energy including offshore wind between these two regions.
    - A 2021 study identified New England (specifically Massachusetts and Connecticut) as the most viable export market for Nova Scotia OSW.

New England and Maritimes Clean Energy Goals

- At the state and provincial level, GHG reduction and clean electricity goals are boosting renewable supply, with specific carveouts for OSW.
    - The table below highlights the state/province level renewable energy policies in New England and the Maritimes that are supporting OSW development.

New England States	Greenhouse Gas Reductions or Clean Electricity Goals	Offshore Wind Goals
Massachusetts	• 2050: Net-zero GHG emissions	• 5,600 MW by 2027 o (3,209 MW contracted)
Connecticut	• 2040: 100% GHG-free electricity	• 2,000 MW by 2030 o (1,108 MW contracted)
Rhode Island	• 2033: 100% renewable electricity	• 1,030-1,430 MW by 2030 o (430 MW contracted)
Maine	• 2050: 80% below 1990 levels, 100% renewable energy	• 5,000 MW by 2030 o Target to be altered in 2023/2024 per ME OSW Roadmap
Vermont	• 2050: 80%-90% below 1990 levels, 90% renewable energy	
New Hampshire	• 2050: 80% below 1990 levels.	
Maritime Provinces		
Nova Scotia	• 2035: net-zero electricity • 2050: Net-zero GHG emissions	• 5,000 MW by 2030
New Brunswick	• 2035: net-zero electricity • 2050: Net-zero GHG emissions	
Prince Edward Island	• 2035: net-zero electricity • 2040: Net-zero GHG emissions	

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More Interties Needed Beyond Québec, New York

- Additional transmission interties can play a valuable role in assisting New England and the Maritimes integrate the large volumes of renewable energy that will be needed to decarbonize their electricity grids.

- ISO-NE is evaluating how the grid will perform in the future, with increased demand and a shift in the supply mix, considering four scenarios for 2040 (a base case, a moderate decarbonization scenario, and two aggressive decarbonization scenarios).
    - Both aggressive decarbonization scenarios contemplated by ISO-NE (Scenario 2 and 3) relied on imports (16%) from the anticipated New England Clean Energy Connect and a hypothetical new 1 GW tie-line with Hydro Québec.

- The 2022 Massachusetts Clean Energy and Climate Plan noted that "in a modeling scenario in which new transmission to Québec was constrained, new transmission to neighboring states to access other clean energy resources emerged as the next most affordable option".

- Nova Scotia's ability to import firm energy and capacity from New Brunswick, Québec and ISO-NE is limited by the configuration of the New Brunswick interface, as discussed in Nova Scotia Power's Evergreen Integrated Resource Plan.

- Considering the difficulty to date in building onshore transmission from Québec, New England and the Maritimes could benefit from additional intertie capacity to new jurisdictions, such as Nova Scotia.

Additional onshore transmission build out such as the Atlantic Loop would improve the business case for the NEMOEC facilities, and vice versa the NEMOEC facilities for onshore transmission.

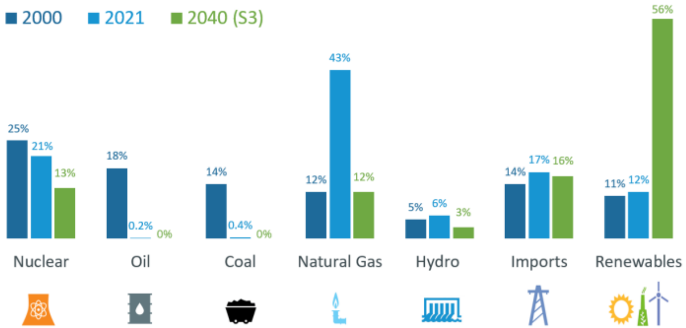


Figure 2-1: Percent of Total System Resources by Fuel Type

Source:

ISO-NE's 2021 Economic Study: Future Grid Reliability

1) Identification of Benefits

Broad-Based Transmission Benefits & NEMOEC

- New transmission facilities offer a broad range of benefits, with the scope of these benefits varying depending on the role that the transmission facility plays as well as the resources that it interconnects.
    - Transmission projects (upgrades or new facilities) were typically driven by system operators' requirements to maintain reliability standards, with a more recent shift in focus towards the potential range of economic benefits new transmission facilities could provide (e.g., to reduce congestion).
    - However, in many instances transmission facilities serve multiple roles: both enhancing reliability and delivering economic benefits. This is the case for the NEMOEC facilities.
- The NEMOEC facilities would be built to interconnect offshore wind in Nova Scotia and in the Gulf of Maine and deliver this renewable energy to load centers in Nova Scotia and New England, producing the associated economic benefits offered by the delivery of this clean energy. In addition, these facilities would enhance reliability in both Nova Scotia and New England.
- Driving greater deployment of offshore wind in the Gulf of Maine and off the coast of Nova Scotia would be an important benefit of the NEMOEC facilities, producing greater economic benefits such as supply chain development, job creation, and increased tax revenues.

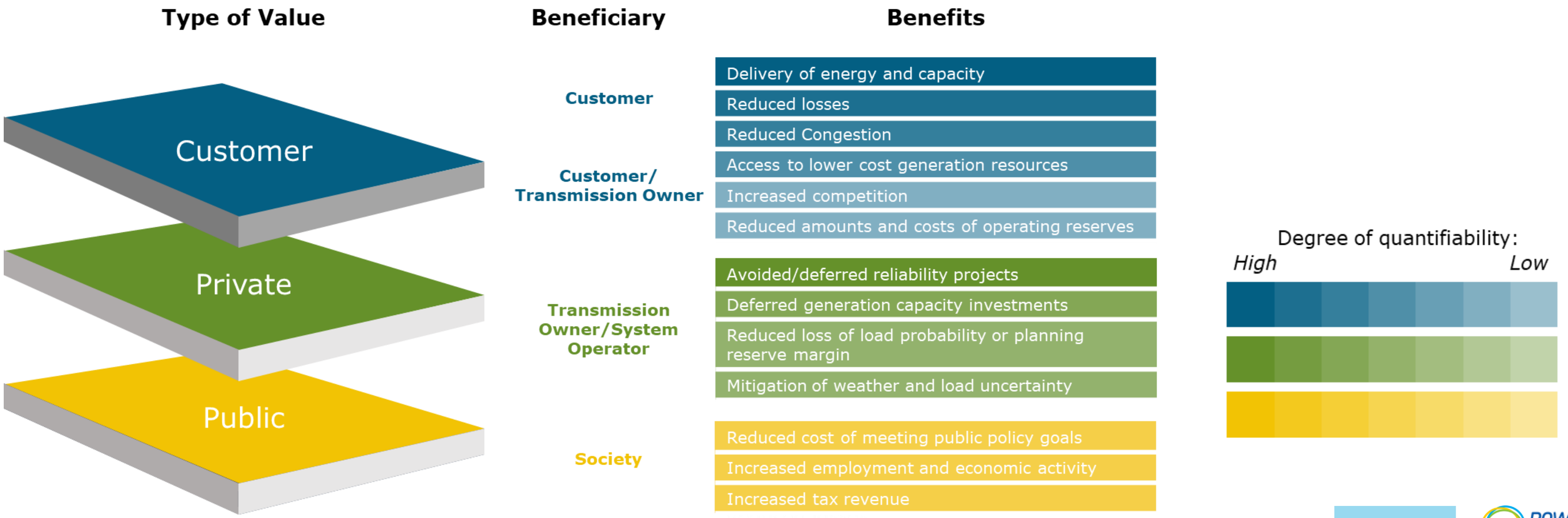
Benefit Dispersion Can Stymie Transmission Development

- An important contributor to the challenges of developing and building new transmission facilities is that the benefits typically are realized by different parties: (1) the customer or transmission rights holder; (2) the transmission system operator or transmission owner; and (3) society.
  - If the benefits were realized by just the transmission rights holder (e.g., an independent power producer who requires transmission service to deliver its product to load serving entities, or a load serving entity that requires transmission to access supply) then it would be easier to ensure an efficient level of transmission development. However, with transmission benefits more diffuse, there's a greater likelihood of reduced transmission investment; that is, unless there is a deliberate effort to quantify each of these benefits, especially those not realized by the transmission rights holder. By quantifying the benefits, those values can be recognized in the cost allocation process or when the investment decision is made.
  - Consideration of these benefits is important given that FERC found in Order 1000 that "The cost of transmission facilities must be allocated […] in a manner that is at least roughly commensurate with estimated benefits".
- This issue is likely to be particularly important for the NEMOEC concept given the investment required and the fact that the facilities span the US and Canada.
  - Another aspect that adds to the challenge of developing transmission is that the parties that realize these benefits typically change depending on the market structure. In competitive wholesale electricity markets such as ISO-NE, a number of these benefits (e.g., congestion and losses, which are reflected in locational marginal price differentials) are monetized and can be captured by market participants. In Nova Scotia's electricity market structure, these benefits aren't monetized.

Dispersion of Benefits for Transmission Projects

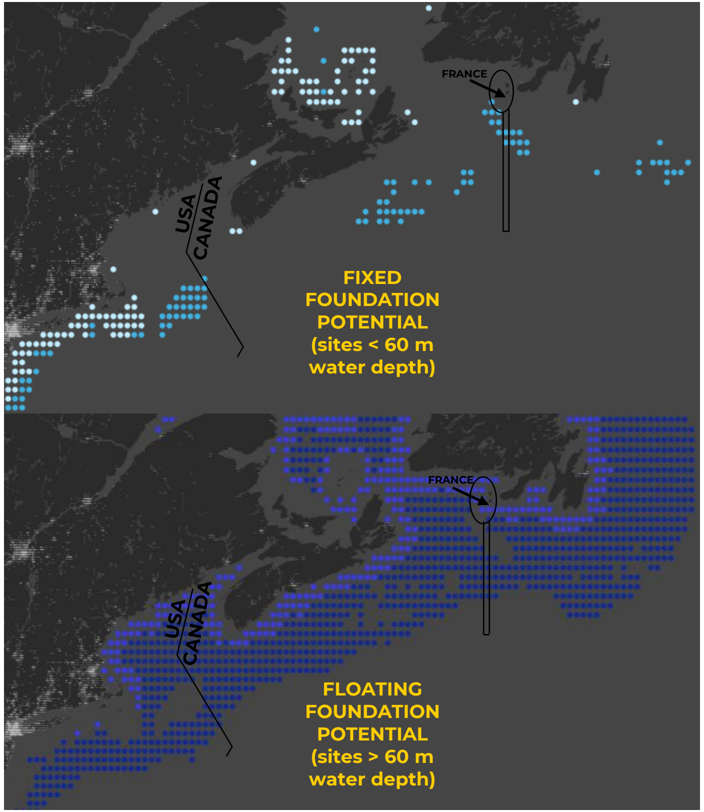
- The graphic below outlines the broad-based benefits of many transmission facilities identifying the category of benefit, specific form of benefit and who typically realizes the benefit.
- The benefits attributable to a transmission project will vary depending on where the transmission project is located, the types of generating resources that it interconnects and the characteristics of the electricity system in which it operates. The categorization of benefits presented below is for a typical transmission project.

The Transmission Value Stack



High Level Assumptions for Benefits Analysis

- To provide a high level overview of the potential benefits from the NEMOEC facilities, high level assumptions were made to quantify benefits.
- These high level assumptions include:
  - Hypothetical development sites within this broad geographic area;
  - Potential Points of Interconnection; and
  - Project sizes for both offshore wind projects and the NEMOEC facilities themselves.
- All dollar figures are in US dollars, unless otherwise indicated.



Source: IEA, Fisheries and Oceans Canada, Power Advisory

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Benefits From NEMOEC Transmission Facilities

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6) **Capacity benefit** from enhanced wind resource diversity between New England and Nova Scotia as well as the load diversity between the two jurisdictions;
7) **Balancing benefits** such as balancing cost and forecast error reductions from the wind resource diversity due to lower variability of the wind resource, and reduced curtailment from the use of the NEMOEC facilities to flow excess power to load centers;
8) **Enhanced reliability** in Nova Scotia to provide additional energy via the NEMOEC facilities and in New England from ancillary services that the HVDC project could provide; and
9) **Economic benefits** such as jobs and tax revenue.

- There are numerous economic, environmental, technical and other benefits that would flow from an offshore transmission backbone shared by Nova Scotia and New England. This section is focused on the economic and environmental benefits. However, it should be noted that there are complexities associated with permitting a multi-jurisdictional HVDC transmission line.

Environmental Benefits

1) **Reduced GHG emissions** from displacing gas-fired generation in ISO-NE with OSW from Nova Scotia;
2) **Reduced disruption** of marine environment by reducing marine trenching and grouping OSW cabling;
3) **Reduced number of landfalls** recognizing higher transfer capability as well as reduced likelihood of multiple construction cycles, with the resulting benefits of reduced impact on local fisheries;
4) **Reduced opposition** since using a single offshore transmission corridor would be less impactful than multiple corridors; and
5) **Reduced project permitting risks** from the enhanced environmental benefits, by addressing a critical project pinch point.

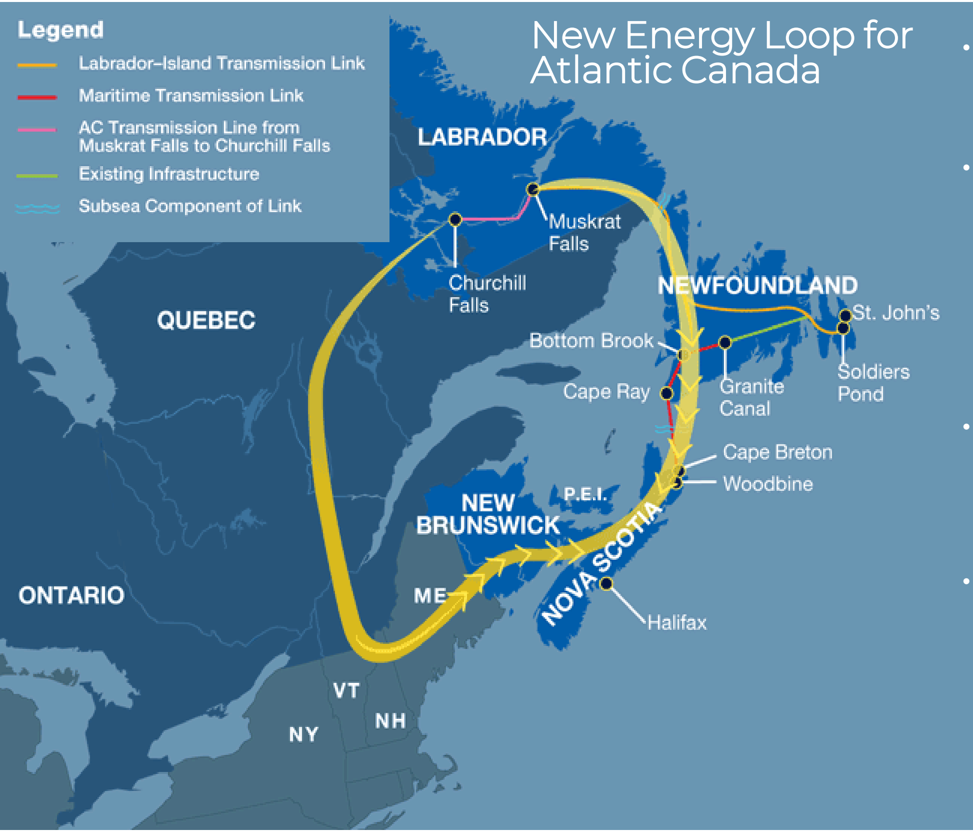
Economic Benefit 1

Connect Offshore Wind to Onshore Grid

- Perhaps the most basic service that the NEMOEC facilities would provide is to connect offshore wind projects to the onshore transmission grid. In this manner, these facilities could act as an alternative to a generator lead line.
    - Therefore, when assessing the value of the NEMOEC facilities, it is appropriate to recognize the value of this service. In essence, this is the revenue that can be expected from connection charges. Considering the NEMOEC facilities as an alternative to a generator lead line, a reasonable estimate of the connection charges for the facilities is the effective cost of the generator lead line, connection to the onshore grid and any associated network upgrades.
    - Based on the AC connection costs presented in this White Paper, a 2 GW connection to offshore wind in South Halifax is estimated to cost $956 million. A comparable connection for the Gulf of Maine area would cost $1,278 million.
    - These avoided costs translate to a benefit (connection cost savings) of $40/kW-yr for a South Halifax connection and $53/kW-yr for a Gulf of Maine connection. These connection cost savings are additive.
    - This potential revenue should be considered when assessing the benefits of the proposed corridor.

Economic Benefit 2

Enhanced Market Integration



- NEMOEC could offer an alternative transmission pathway from Nova Scotia, or more broadly the Maritimes, to New England. This would be more important with the development of the Atlantic Loop.
- Of particular note, the Churchill Falls Contract, which provides Hydro-Québec (HQ) with about 24 TWh of energy per year, expires in 2041 within 5 to 6 years of the anticipated commercial operation date for the NEMOEC. NEMOEC would represent a more direct transmission path for Churchill Falls to access the ISO-NE market than the existing route through the Maritimes, which incurs transmission tariffs in New Brunswick and realizes a lower value when injected into the ISO-NE grid at the Salisbury node.
- This represents significant value for the potentially large volumes of energy that could flow from Newfoundland and Labrador. This could include energy from the proposed Gull Island hydroelectric project (2,250 MW), which would require additional transmission to access export markets.
- The federal government stated in the recent Budget 2023 that it is committed to advancing the Atlantic Loop so that it is delivered by 2030. The CAD $10 billion allotted investments to be made by the CIB will act as the primary financing tool for the project. Recent announcements state these investments will be made in Québec, New Brunswick, and Nova Scotia.

Map Source: Emera

Economic Benefit 2

Enhanced Market Integration

- Exporting electricity from Nova Scotia to New England utilizes the existing onshore transmission path, incurring Nova Scotia and New Brunswick transmission tariffs and losses.

- The applicable Nova Scotia Power and New Brunswick Power transmission tariffs and losses are outlined below. The ISO-NE admin charges for imports are not included as these costs would still be paid with the Nova Scotia – New England offshore transmission backbone. The cumulative transmission losses and transmission tariffs show the impact or rate "pancaking" on the cost of accessing ISO-NE from Nova Scotia.
    - Long-term firm point-to-point transmission service is assumed.

	NS → NB → ISO-NE			
	NS	NB	ISO-NE	Total
$/kW-year	$51.7	$30.9	-	$82.6
On-peak $/MWh	$8.76	$5.35	-	$14.11
Off-peak $/MWh	$5.90	$3.53	-	$9.43
Losses	2.2%	3.3%	-	5.4%

The Nova Scotia Power and New Brunswick Power tariffs are converted to US Dollars using the following conversion: CAD$1 = US$0.75.

- Depending on the terminus of the transmission path, additional value is offered by the NEMOEC facilities by avoiding the lower value of energy realized when injecting into the ISO-NE grid at the Salisbury node, where the ISO-NE and NB Power transmission networks connect. The demand weighted basis differentials – differences in Locational Marginal Prices (LMPs) between the various nodes – are presented in the table below for day-ahead energy transactions.

Salisbury, NB → Yarmouth, ME	Salisbury, NB → Mystic, MA	Yarmouth, ME → Mystic, MA
6.40%	6.46%	0.08%

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Economic Benefit 2

Enhanced Market Integration

- To assess the value NEMOEC offers through avoided transmission tariffs and losses as well as basis differentials, different wholesale market prices realized relative to Mystic, Massachusetts (a potential point of interconnection in the Metropolitan Boston area) are presented below. The delta between Mystic, MA and the various POIs represent the potential value in $/MWh offered by NEMOEC.

- This value is calculated through integrating the basis differentials and transmission losses and tariffs for a netback analysis. The hourly on-peak and off-peak transmission tariffs are assumed, with a 60/40 split between the on-peak and off-peak rate.

Example Netback of Market Prices and Basis Differential Values			
($USD/MWh)			
Market Price	$60	$80	$100
Value of Nova Scotia-Mystic	$19	$21	$24
($/kW-yr)			
Value of Nova Scotia-Mystic at 70% load factor with 3% transmission losses assumed	$114	$128	$141

- Additionally, there is the potential for use of the line by other suppliers, such as Newfoundland and Labrador Hydro (NLH) or possibly Hydro Québec (HQ). New England offers a promising export market for NLH (or HQ) given the region's need to import clean firm capacity and energy to meet state clean energy goals and GHG emission reduction targets. With the potential expiration of Churchill Falls contract with HQ in 2041, NLH may focus on exporting this energy to ISO-NE as a market that often offers the highest net backs.

Economic Benefit 3

Market Optimization (ISO-NE vs Hydrogen)

- While the primary market for offshore wind developed in Nova Scotia is likely to be for the production of green hydrogen as well as electricity sales to NS Power and Nova Scotia customers, direct access to the ISO-NE market is likely to create opportunities for sales that would not otherwise be available. This may be realized by projects that are developed entirely for the export of energy to ISO-NE through PPAs, provided that procurements allow for such contracts.

- During periods when market prices in ISO-NE are high, the NEMOEC corridor would allow offshore wind in Nova Scotia to flow to New England instead of being used for domestic purposes (either green hydrogen or supplying electrical load). This could be a strategy to reduce the effective cost of electricity for green hydrogen production. In essence, wind project developers could require lower sales prices for green hydrogen if they're able to capitalize on higher ISO-NE market prices.
    - This benefit would extend beyond the offshore wind developed in Nova Scotia, as existing hydro generation from Newfoundland and Labrador and Québec could also take advantage of market opportunities in ISO-NE via NEMOEC – when the market price warranted – at a lower price threshold than offshore wind, increasing utilization of the intertie.

- To estimate the potential benefit for a hypothetical offshore wind site in NS (operational as of 2032) to export to ISO-NE, it was assumed that exports would occur during hours when the ISO-NE price exceeded $100/MWh.
    - This price threshold of $100/MWh represented the estimated levelized cost of energy for offshore wind in NS, with a 20% adder to provide a reasonable margin for such sales and account for losses. A portion of the margins earned when the price exceeded $100/MWh could be used to pay for transmission.

- Recognizing the different pricing dynamics of existing hydro resources, a second price threshold of $80/MWh was applied to estimate the value of hydro exports from Newfoundland and Labrador or Québec.

Economic Benefit 3

Market Optimization (ISO-NE vs Hydrogen)

- Nova Scotia offshore wind exported during high ISO-NE market prices could yield a range of benefits from $8/kW-yr to $92/kW-yr, based on recent market price data from 2021 and 2022.

Scenario	Average ISO-NE Price	Hours where price between $80/MWh to $100/MWh	Export Net Margins For Hydro ($80-$100/MWh)	Hours where price exceeds $100/MWh threshold	Export Net Margins For NS OSW (>$100/MWh)
2021 ISO-NE market prices	$45/MWh	5%	$19/kW-yr	4%	$8/kW-yr
2022 ISO-NE market prices	$85/MWh	12%	$44/kW-yr	24%	$92/kW-yr

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Economic Benefit 4

Reduced Reliance on Natural Gas

- In ISO-NE, more than half of the electricity generated came from gas (52%) in 2022, with oil at 2% and coal at 0.3%.
  - ISO-NE's Internal Market Monitor reported in its 2021 Annual Markets Report that gas was the real-time marginal resource setting the market price for 83% of the load* in 2021.

- ISO-NE's 2018 Operational Fuel-Security Analysis offered a number of primary findings, five of which focused on fuel security risks or renewable resources:
  - **Stored fuels**: LNG and electricity imports, and dual-fuel capability are critical to reliability.
  - **Logistics**: fuel delivery timing also plays an important part in ensuring reliability, with inclement weather or sustained cold posing risks.
  - **Risk trends**: with a heavy reliance on gas-fired generation, fuel shortages can lead to load shedding, worsening the fuel-security risk.
  - **Renewables**: the fuel-security risk can be reduced with increased renewables, but the ongoing coal- and oil-fired generation retirements (with the ability to store fuel) will result in increased reliance on LNG imports.
  - **Positive outcomes**: reliability can be achieved with a combination of sufficient LNG, imports, renewables, and transmission expansion.

- The North American Electric Reliability Corporation (NERC) highlighted reliability risks for both New England and the Maritimes in its 2022-2023 winter reliability assessment. Growing winter peak demand in the Maritimes region could strain capacity even under normal conditions; this would be exacerbated by extreme weather events. Extreme weather in New England could lead to "energy emergencies", as cold temperatures drive increased space heating needs that leads to a greater strain on gas transportation infrastructure in New England. This could worsen the risk of fuel-based generator outages.

- Offshore wind has a higher capacity factor during the winter months which will help replace natural gas during cold weather events.

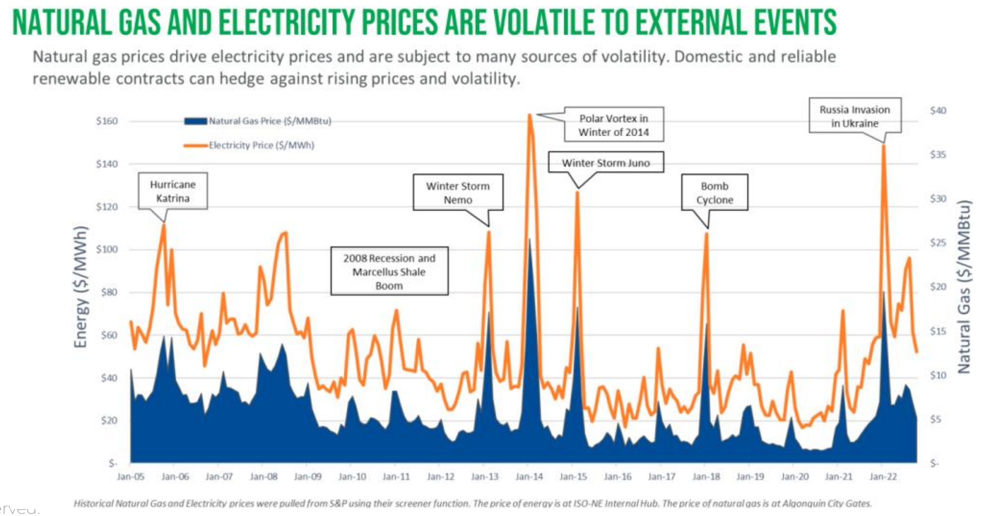
**In ISO-NE, marginal resources set price in terms of percentage of load as opposed to time to more accurately reflect the influence of nodal pricing, since there can be more than one marginal resource setting price when there's transmission congestion.*

Economic Benefit 4

Reduced Reliance on Natural Gas

- According to ISO-NE, “inadequate infrastructure to transport natural gas has at times affected the ability of natural-gas-fired plants to get the fuel they need to perform”. Disruptions to the fuel supply – as was experienced during extreme winter conditions in 2017/2018 in ISO-NE – resulted in increased output from oil generation. ISO-NE has indicated that 5,000 MW of mostly oil-fired generating stations (with some remaining coal generation) could be retiring in the coming years, reducing the available resource adequacy options to offset gas supply constraints or unplanned generator outages.

- Additional supply options, such as offshore wind from Nova Scotia delivered to ISO-NE via the NEMOEC facilities, would help diversify the fuel mix and reduce reliance on natural gas generation for ISO-NE, lower the likelihood of reliability events, reduce system costs and avoid GHG emissions.



Source: RENEW NE Benefits of Wind Energy for New England

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Economic Benefit 5

Avoided Transmission Upgrades

- DNV has estimated that 3.4 to 11.9 GW of offshore wind will be needed from the Gulf of Maine, which offers among the highest and most consistent wind speeds along the US East Coast. As the graphic to the right shows, there are a number of potential transmission constraints in Maine. Transmission constraints have limited onshore wind development in Maine and can be expected to do the same for offshore wind without transmission upgrades. We understand that addressing these transmission constraints is critical to the realizing the state's clean energy ambitions.

- Complicating the interconnection in Maine is the development of the New England Clean Energy Connect project that would deliver about 9.5 TWh of energy per year to the southern terminus in Lewiston, Maine. In addition, Maine has mandated the procurement of renewables equivalent to 14% of Maine's statewide electric load. This volume of energy delivered is likely to increase the potential for transmission congestion in Maine.

- Therefore, landing the full volume of offshore wind to be developed in the Gulf of Maine in Maine would be a major challenge. The NEMOEC initiative represents a viable alternative and would allow some of this energy to be delivered to a Southern New England load center.

Source: Power Advisory

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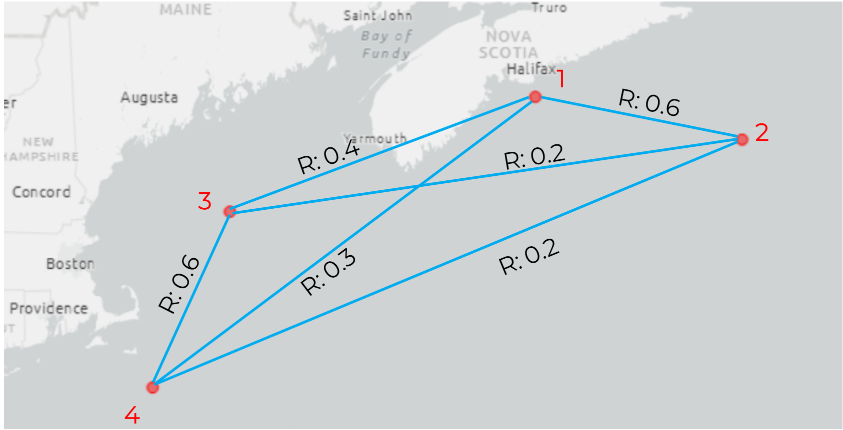
Economic Benefit 6

Capacity Benefit (Wind Resource Diversity)

- By combining the offshore wind from Nova Scotia with that from the Gulf of Maine and Southern New England the cumulative capacity value of offshore wind can increase. A reliable indicator of the potential for such increases is the degree to which the wind output for these sites is not well correlated. This benefit may not be cumulative with other related capacity benefits identified in this White Paper; further study is required to establish the quantified value.

- To analyze the benefit from diverse wind resources, Power Advisory has selected 4 potential offshore wind sites: 2 in Nova Scotia (one off the coast near Halifax, another near Sable Island) and 2 in New England (one in the middle of the Gulf of Maine wind energy area, another south of New England east of existing lease areas). Power Advisory has collaborated with DNV to generate 4 new datasets (with 22 years of hourly data) from the 4 hypothetical offshore wind sites located in New England and Nova Scotia.
    - The greatest wind diversity benefit, as measured by the lowest correlation between the 4 sites, is provided by combining wind output from near Sable Island in Nova Scotia with sites in New England (i.e., both Southern New England and Gulf of Maine, with a correlation coefficient = 0.2). This wind diversity benefit could be enhanced by the shared offshore transmission network.

- Combining sites with more diverse wind resources as evidenced by low correlations such as Sable Island and New England (#2 & #3/#4) reduces the likelihood of low wind speeds across all sites at the same time, improving the capacity contribution of offshore wind.



R value = 1 (positive correlation)
Low wind at site A occurs during periods of low wind at site B

R value = 0 (no correlation)
Low wind at site A while site B could experience either high or low wind, and vice versa.

R value = -1 (inverse correlation)
Low wind at site A with high wind at site B.

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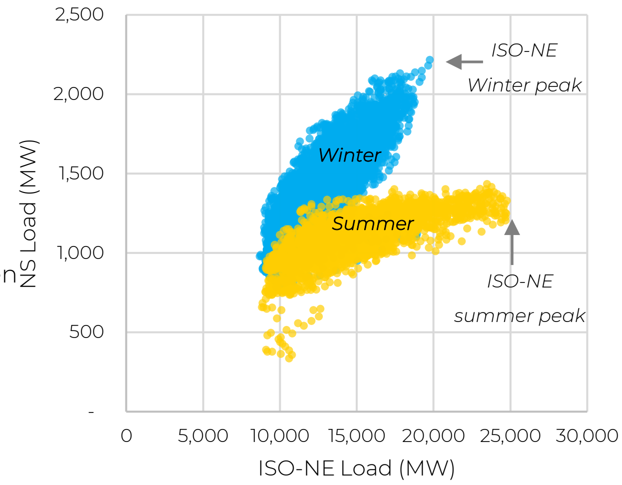
Economic Benefit 6

Capacity Benefit (Load Diversity)

- A transmission interconnection between Nova Scotia and New England also offers a potential load diversity benefit by connecting two jurisdictions that have distinct load profiles.
  - ISO-NE is currently summer peaking and has an average summer system peak demand of approximately 25,200 MW for the past 5 years. With greater electrification, ISO-NE may become winter peaking. On the other hand, Nova Scotia is winter peaking and has much lower peak demand comparatively averaging ~2,080 MW, with the highest demand at 2,215 MW in 2022.
  - In 2022, ISO-NE experienced its greatest demand during times when Nova Scotia load remains below 1,500 MW, far below its 2,200 MW peak. Nova Scotia experienced its greatest demand in 2022 during times when ISO-NE load was below 20,000 MW, about 5,000 MW below its summer peak. The combined non-coincident peak for the two regions would be ~27,000 MW. Based on 2022 loads, the coincident peak for the two regions would be ~26,110 MW, reducing the combined capacity need by ~1,060 MW when a 20% planning reserve is added to the capacity need.
  - This reduced capacity could provide a benefit on the order of $74M (USD) per year, based on the cost of a combustion (frame) turbine from Nova Scotia's Evergreen Integrated Regional Plan.
  - For a 2,000 MW transmission line, this value would equate to $37/kW-yr.
  - This is a high level screening analysis; a more rigorous analysis could be performed by a multi-area simulation model, or more detailed evaluation of historical data.

2022 ISO-NE Load vs NS Load



Source: NS Power, ISO-NE, Power Advisory. Summer is defined as June-September, winter as October-May.

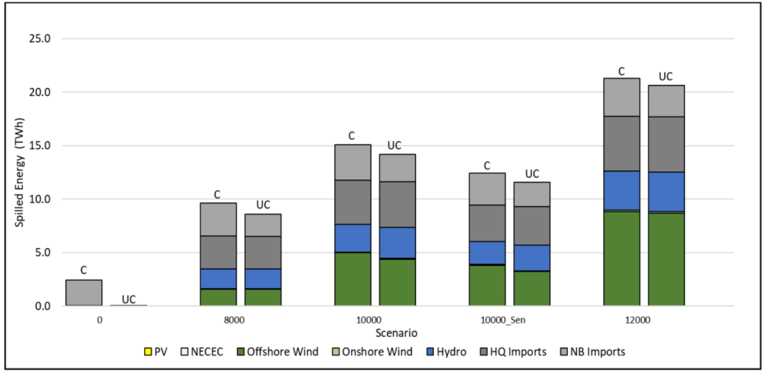
Economic Benefit 7

Balancing (Reduced Curtailment of OSW)

- Curtailment of variable output resources can be caused by transmission congestion or during times when non-dispatchable generation exceeds market demand.
    - ISO-NE completed an analysis showing the amount of curtailment of offshore wind and other renewable resources in future scenarios, as part of its Economic Study as requested by Anbaric.
    - The figure below shows the level of spilled or curtailed offshore wind attributable to transmission congestion (the difference between C and UC volumes) and when the energy is surplus to system requirements (the UC volumes). By providing access to Nova Scotia offshore wind, the NEMOEC project would reduce the amount of spilled energy from offshore wind that is surplus to system requirements.

Total Amount of Spilled Resource Energy (TWh)

For Constrained ("C") and Unconstrained ("UC") Transmission*



Source: ISO-NE Anbaric Economic Study

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Economic Benefit 7

Balancing (Wind Diversity Cost Reduction)

- By connecting wind resources from a diverse geographic area with different operating profiles, there exists enhanced value in reduced variability and reduced forecasting errors, with benefits of reduced balancing costs.
- To provide an indicative estimate of this value we make the following assumptions:
  - (1) balancing costs of approximately $3/MWh,
  - (2) wind diversity could reduce such costs by 1/3,
  - providing a potential $1/MWh benefit.
- This potential benefit translates to a value of about $5/kW-yr.

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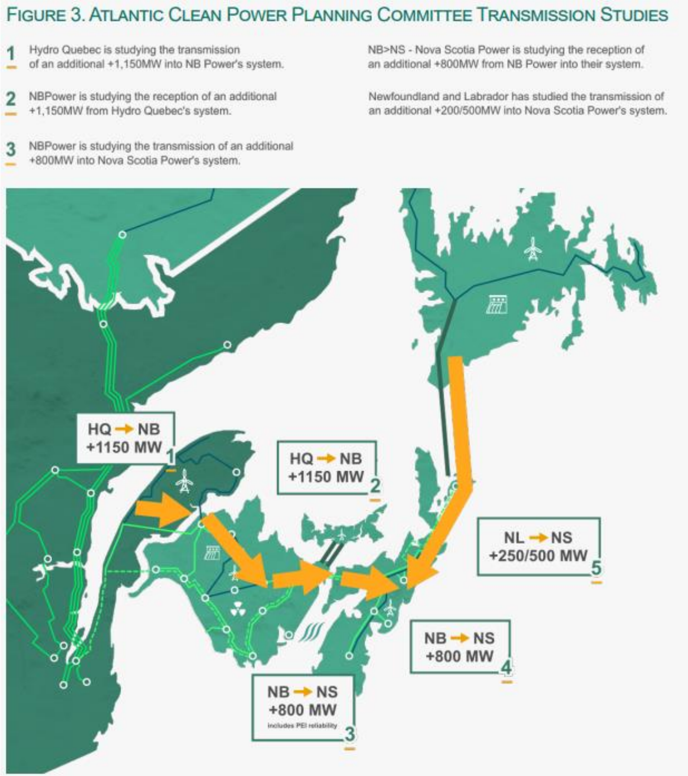
Economic Benefit 8

Enhanced Reliability in Nova Scotia

- Nova Scotia Power's Evergreen Integrated Resource Plan discussed the potential of imports from either New Brunswick or Newfoundland.
    - The configuration of the New Brunswick interface, composed of one 345 kV and two 138 kV lines, has limited the ability of Nova Scotia to import firm energy and capacity from New Brunswick, Québec and ISO-NE.
    - Nova Scotia Power is considering a "Reliability Tie" to reinforce the New Brunswick interface with a second 345 kV line, however, the tie won't provide additional firm import capability without additional investments in New Brunswick.
    - Nova Scotia had planned on 85 MW of firm import capacity from Newfoundland, however, as of October 2022 Newfoundland is expecting to be capacity deficient.
- By providing an additional import option for Nova Scotia with a direct connection to a new market, NEMOEC facilities could enhance reliability of supply and help diversify supply options.



Source: *NRCAN's Clean Power Roadmap for Atlantic Canada*

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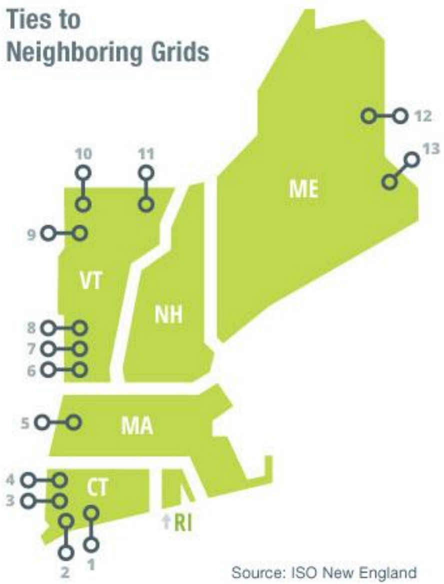
Economic Benefit 8

Enhanced Reliability in New England



New York: 1-9

Québec: 10, 11

New Brunswick: 12, 13

Source: ISO-NE

- ISO-NE currently has 13 interties with neighboring jurisdictions – only 3 of which are DC.
- HVDC interties have benefits that HVAC interties do not have, namely that the technology allows for the provision of ancillary services in addition to transmitting energy.
  - HVDC with Voltage Source Converters provides several features that are useful for grid operations, such as reactive power provision from onshore converter stations at no additional cost, black start capability, and improved voltage quality in the grid.
- The NEMOEC transmission link can become a reliability asset instead of a risk, with the grid better equipped to withstand low probability events due to the increased control that HVDC provides compared to HVAC.

Economic Benefit 9

Local Economic Benefits

- The local economic benefits from the development and construction of offshore wind and a local supply chain are a major driver for states and provinces for the promotion of offshore wind. The NEMOEC facilities can support greater deployment of offshore wind by enabling development of lower cost offshore wind resources; reducing interconnection and delivery risks; and enhancing access to higher value markets. This would support the realization of the following economic benefits:
    - Job Creation
    - Supply Chain Development
    - Increased Tax Revenue
- It is beyond the scope of this study to estimate the additional amount of offshore wind that could be supported by the NEMOEC facilities. However, if these facilities were to support the development of an additional 2 GW of offshore wind, the following economic benefits could be realized.

Expected Level of Economic Benefit for an Additional 2 GW of OSW

Economic Benefit	Value
Installation and Manufacturing Jobs	692 jobs
Operation & Maintenance Jobs	846 jobs
Economic Output (Supply Chain Development)	$272 million
Increased Tax Revenue (Local)	$6 million
Increased Tax Revenue (State)	$6 million

Values are based on the Magnum Economics Report that focuses on the 2.6 GW Coastal Virginia Offshore Wind project.

Environmental Benefit 1

Reduced GHG Emissions

- A secondary effect of the market optimization benefit provided earlier is the associated GHG emission reductions from displacing emitting generation in ISO-NE with offshore wind from Nova Scotia.
    - To assess this potential benefit, Power Advisory calculated the reduced GHG emissions when ISO-NE prices exceeded US$100/MWh, representing 4% of output based on 2021 prices and 24% of output based on 2022 prices.
    - Since the Regional Greenhouse Gas Initiative (RGGI) carbon price is already embedded in ISO-NE market prices, the avoided emissions considered here are net of RGGI (which was modeled as following the emissions containment reserve (ECR) price and assumed reductions in the RGGI cap continue beyond 2030).
- Avoided emission factors were based on the recent Avoided Energy Supply Components in New England study for the year 2032.
- 2,000 MW of offshore wind exports from Nova Scotia during high priced hours in ISO-NE could avoid between 0.11 and 0.62 million metric tonnes (MMT) of GHG emissions. This amount does not account for emissions otherwise avoided if the green hydrogen were produced and the energy were not sold into the ISO-NE market.

Environmental Benefit 1

Reduced GHG Emissions

- GHG abatement rates for green hydrogen are highly variable and depend on the end use. Assuming an electrolysis conversion efficiency of 50 MWh per 1 kg of hydrogen and the GHG abatement figures from the Feasibility Study of Hydrogen Production, Storage, Distribution, and Use in the Maritimes (Natural Gas Transformative Scenario for 2030) leads to an avoided emission rate for green hydrogen of ~73 kg of GHG/MWh, compared to the 2032 range of avoided emissions in New England of between 292 and 351 kg of GHG/MWh.
    - Higher GHG abatement rates are possible for green hydrogen, for example in elements of green transportation. However, natural Gas replacement was applied as this is considered a more likely end use for Nova Scotia than significant uptake in light-duty hydrogen fuel cell electric vehicles (FCEV).
- Potential avoided emissions from 2,000 MW of offshore wind exported to ISO-NE during high priced hours could be between 0.12 and 0.72 MMT, equivalent to $7/kW-yr to $43/kW-yr in potential benefit.
- If the NEMOEC facilities are utilized to connect the Gulf of Maine offshore wind developments, the reduced GHG emission impact would be significantly greater.
    - For 2,000 MW of offshore wind in the Gulf of Maine, approximately 2.3 MMT of GHG emissions could be avoided.
    - This would reflect a benefit of $156/kW-yr.

Environmental Benefit 2

Reduced Ecological Disruption

- An environmental benefit of coordinated offshore transmission development, such as NEMOEC offers, is the reduced number of landfalls and resulting disruption to the local marine environments and communities. The net result is reduced negative impacts on the marine environment, reduced opposition from stakeholders, and reduced permitting risk.

- Coordinated offshore transmission reduces impacts to local fisheries and disturbance of the marine environment. The Brattle Group report, *Offshore Transmission in New England: The Benefits of a Better Planned Grid*, estimates that under a planned offshore-grid approach to enable offshore wind development in New England, marine trenching can be reduced by almost 50%. Multiple offshore cables can be grouped in the same transmission corridors together to minimize impact; this is not achievable under a project by project, unplanned approach. A coordinated offshore transmission system such as NEMOEC will also minimize the number of offshore platforms, cabling, and onshore substations.

- An additional benefit of NEMOEC is the use of HVDC technology. HVDC allows for greater sub-sea cable lengths which enables greater flexibility on where landing points can be located and allowing landings at less environmentally sensitive sites.

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Environmental Benefit 3

Reduced Landfalls

- The UK National Grid ESO *Offshore Coordination Phase 1 Final Report* concluded a holistic approach to offshore transmission planning is likely to significantly reduce the impact on the onshore and offshore environment and community. The report analyzes three scenarios of offshore transmission buildout to interconnect offshore wind: status quo approach (project by project) and integrated approach (transmission asset sharing enabled, one commencing 2025 and the other 2030). An integrated approach, and the sooner it begins, results in less landfalls and network assets compared to the status quo approach (see results in the tables to the right). Network assets refer to onshore substations, export cables and offshore platforms. The NEMOEC facilities will offer similar benefits (i.e., reduced number of landfalls).

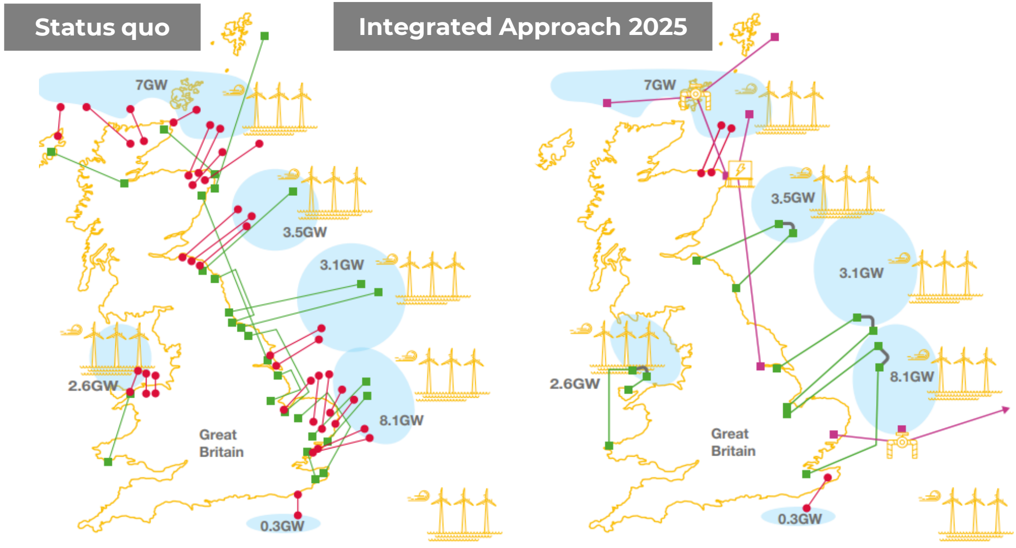
- The figure to the right displays the high-level comparison of the estimated 2030 network designs for offshore transmission and connections in both the status quo and integrated approach starting in 2025. The 2025 integrated approach significantly reduces the number of landfalls in areas with the highest deployment of offshore wind.

Landfalls Required by Year of Integration Commencement

2025	2030	Status quo
30	60	105

Decrease in Network Assets under 2025 Integration compared to Status quo (projected year)

2030	2050
60%	70%



Network Designs in 2030

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Environmental Benefit 4

Reduced Opposition

- Reducing the number of beach crossings and transmission corridors should reduce the level of stakeholder opposition that a transmission project will receive.** Reduced beach crossings, construction cycles, and permanent structures help mitigate public concern of disruption during construction and of long-term visual impacts.

Support from Other Stakeholders

"Separating transmission from generation procurement, while complex, has the potential to deliver optimal outcomes for consumers and the environment."

*- Environmental Stakeholders**

Source: *Offshore Transmission in New England: The Benefits of a Better Planned Grid*

** Environmental Stakeholders include the National Wildlife Federation, Conservation Law Foundation, Sierra Club (Mass. Chapter), and Acadia Center*

- A 2019 planning and analysis study of offshore wind penetration in the North Seas by Wind Europe, Our energy, our future, found that a meshed offshore grid imposes a lower environmental burden on the coastline than multiple single connections and uses the infrastructure in a more efficient way, which increases social acceptance.

*** New Jersey Board of Public Utilities, Order on the State Agreement Approach (SAA) Proposals, Docket No. QO20100630*

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Environmental Benefit 5

Reduced Permitting Risk

- The backbone HVDC transmission corridor that NEMOEC will utilize should over the long-term reduce the level of effort for permitting and minimize the risks of permitting delays. With fewer landfalls and a single transmission corridor, the initiative would reduce the number of permits and regulatory approvals required for individual offshore wind projects and minimizes the environmental disruption that would prompt permitting concerns.

- In the approval of the New Jersey State Agreement Approach (SAA), the New Jersey Board of Public Utilities found that "project development is improved when impacts to communities are reduced. This benefit is maximized if impacts can be limited to a single construction effort along the fewest possible transmission corridors". A comprehensive, more efficient, and proactive planning approach will result in significantly fewer permitting challenges.

- Another benefit of a holistic offshore transmission system is that there will be less required build out of onshore transmission infrastructure. One benefit of this is the reduced risk of cost overruns and project delays from such onshore transmission development.

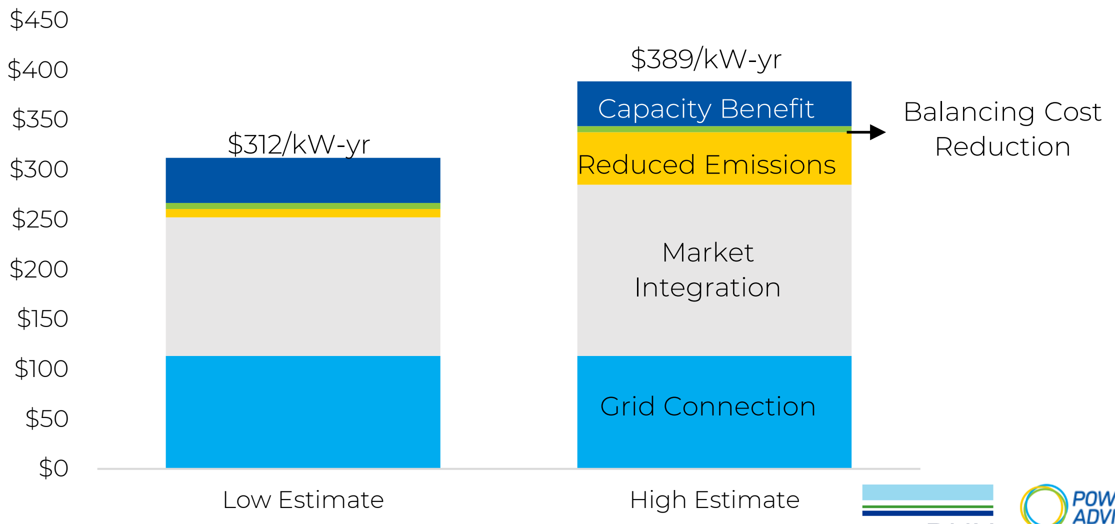
- A caveat to the reduced permitting risk for the NEMOEC facilities is the increased complexity associated with an international offshore transmission line. As discussed in Section 3 of this White Paper (Overview of Policy and Regulatory Environment), the project will be subject to multiple federal and state/provincial level requirements.

Monetized Benefits Summary

- A summary of the economic and environmental benefits for the NEMOEC facilities and their estimated value are shown below. Total Economic and Environmental Benefits for a 2,000 MW transmission line are estimated to be between US$0.62-$0.78 billion per year.
  - All benefits shown are inflated to 2032 US dollars whereas figures in previous slides are not.
  - The benefits shown are additive. For example, the market integration benefit and market optimization benefit would both be using the NEMOEC facilities during high priced hours in ISO-NE. As a result, only the market integration benefit is shown below.

Benefit	Low Estimate	High Estimate
Capacity Benefit	$45/kW-yr	
Balancing Cost Reduction	$6/kW-yr	
Reduced GHG Emissions	$9/kW-yr	$52/kW-yr
Market Optimization	*Not reflected in stack*	
Market Integration	$139/kW-yr	$172/kW-yr
Grid Connection	$113/kW-yr	
Total Stack	$312/kW-yr	$389/kW-yr

Estimated Value Stack



Initial NEMOEC Cost-Effectiveness Assessment

- These monetized economic benefits can be expressed in a manner that allows them to be compared to the NEMOEC facilities' estimated capital costs. To do this, assumptions need to be made regarding the useful life of the facilities; how they would be financed and the underlying tax treatment (e.g., depreciation rates etc.). The financing and tax treatment are likely to vary between Canada and the U.S..

- Assuming an 8% capital recovery factor and operations and maintenance expenses of about 1.5% of capital costs, the level of economic benefits estimated would support a project capital cost of $6 to $8 billion. This aligns with the project capital cost estimates included in Section 2 (Technical Considerations). This suggests that based on these initial benefit estimates, the NEMOEC facilities are cost-effective.
    - Section 4 (the Roadmap) offers thoughts on how these initial benefit estimates could be refined.

Non-Monetized Benefits Summary

- The following provides a summary of the economic and environmental benefits for the NEMOEC facilities whose values are not easily quantified. Nonetheless, these benefits are significant advantages of the NEMOEC facilities and must be considered by government agencies, stakeholders, the public, and decision makers in order for the NEMOEC facilities to be considered at its true value.

Type of Benefit	Benefit	Description
Economic	Reduced Reliance on Natural Gas	Reduce the fuel security risk, market price volatility and overall emissions. OSW has a higher capacity during winter months when fuel usage is higher.
	Fewer Transmission Upgrades	Avoid transmission constraints in Maine and deliver energy to load centers further south in New England.
	Enhanced Reliability	Increase import capabilities and supply diversity to Nova Scotia and provide ancillary services to New England through HVDC technology.
	Community Benefits	Provide extensive local and state/provincial economic benefits.
Environmental	Reduced Disruption	Minimize disruption to the local marine environments and communities.
	Reduced Number of Landfalls	A holistic approach to offshore transmission reduces the number of landfalls and required network assets.
	Reduced Opposition	Reduced beach crossing, construction cycles, and permanent structures decreases the likely public opposition.
	Reduced Project Permitting Risks	Fewer landfalls and a single transmission corridor reduces the number of permits and regulatory approval required.

2) Technical Considerations

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Technical Considerations

An offshore transmission backbone shared by Nova Scotia and New England is technically feasible and could be planned in a manner that scales to support growing offshore wind capacity. The backbone system could be designed in ways that account for specific regional characteristics. Key choices made early in the design process will optimize the system's overall capabilities and costs. These choices must account for several factors discussed in this section:

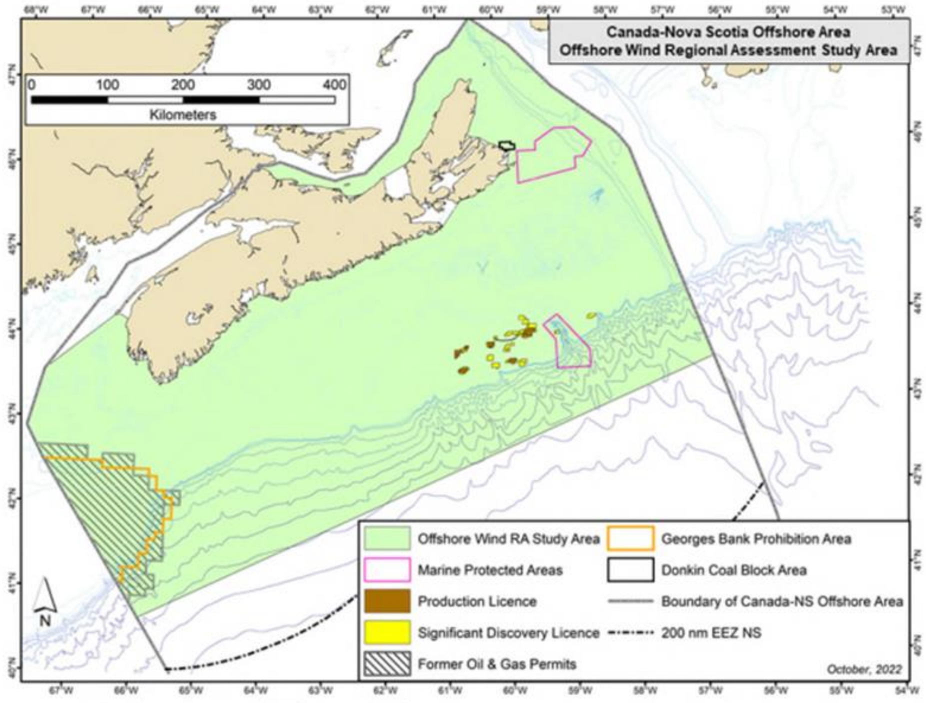
- Location of the Canada-Nova Scotia and US-Gulf of Maine offshore wind areas;
- Undersea cable and efficient use of corridors;
- Offshore network design, including the advanced modular approach contemplated by the New England States;
- Design Choices that account for anticipated phased/modular offshore system growth; and
- Transmission Technology Readiness Levels.

Location of the Canada-Nova Scotia Offshore Wind Areas: Impacts on Technical Choices

- The Canadian federal ministers of Environment and Natural Resources and the provincial Minister of Natural Resources and Renewables are conducting a Regional Assessment of offshore wind energy development in the Canada-Nova Scotia Offshore Area (CNSOA).

- The CNSOA could include sites that extend from the shore of Nova Scotia several hundred kilometers to the south-southwest of Nova Scotia and shorter distances to the north-northeast.

Figure 1.1: Regional Assessment Study Area (Nova Scotia)



Source: *[Draft Agreement To Conduct A Regional Assessment of Offshore Wind Development in Nova Scotia]*

Location Considerations

The location of wind farms within the CNSOA drive two threshold considerations for developing an offshore transmission backbone.

1. Water depth of the offshore sites drives whether the platforms (and associated connecting cabling) can be constructed using fixed or floating equipment. In general, depths to the seabed of up to -60 meters will support fixed platforms. Available information suggests that some offshore wind farm sites under consideration in the CNSOA are in the range of -50 meters, thus supporting use of fixed platforms.

2. Distance to the shoreline significantly impacts the choice between using AC and DC transmission systems. AC solutions are economic for shorter transmission distances (under 60 miles/96 km) and lower capacities (below 500 MW per circuit).

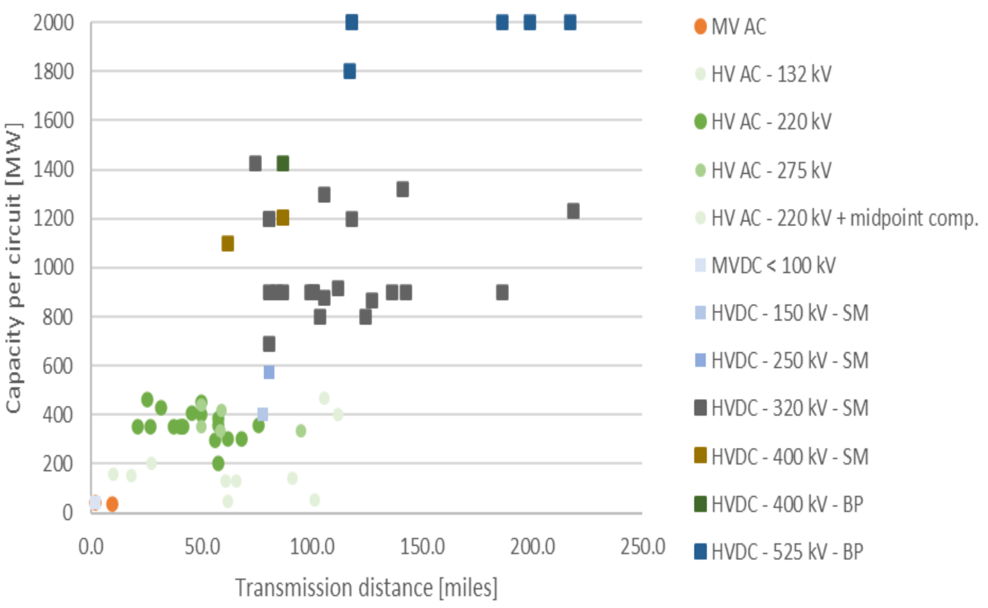
- The wind area in the CNSOA could include sites that are both within the economic range of AC solutions and well beyond them. Sites south of Halifax could involve connections to onshore Points of Interconnection (POIs) within the distance for effective using AC transmission. By contrast, sites near Sable Island may be over 100 km from shore and 180 km from its most logical connecting substation, making HVDC the optimal choice. For a backbone transmission system to connect wind resources in the CNSOA to New England, the distances will undoubtedly exceed the limits of AC systems.

Transmission Technology

- The choices of transmission technology made by offshore wind farms in various global markets is consistent with this approach. Each of the circles in the following chart represents an offshore wind transmission project that chose AC solutions; the DC solutions are designated by squares. The types of projects are also distinguished by the kV level and, for the HVDC projects, by whether the projects chose "Symmetrical Monopole" (SM) configurations or "Bipole" (BP) configurations.

- As is clear from the choices made by these project developers, DC solutions predominate for the longer distance, higher capacity projects. The design of the backbone system should incorporate ways to use the technologies that are most appropriate for CNSOA sites, while not introducing undue technical complexity that would impact the overall goals and efficacy of the backbone system.

Offshore Wind Transmission Technology by Distance and Capacity

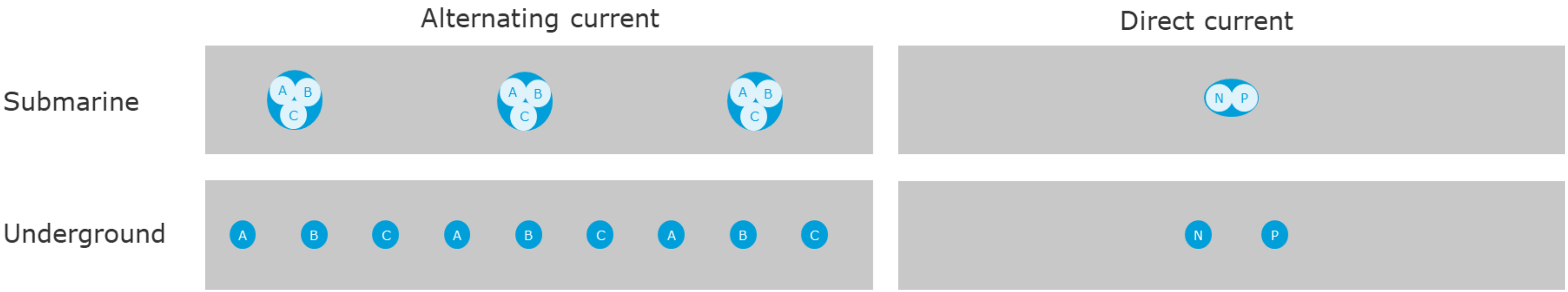


Undersea Cables: Power Capacity and Efficient Use of Corridors

DC technology optimally utilizes every cable by maximizing power rating and effectively eliminating limits on transmission distance. Use of HVDC technology thus reduces the total length of cable required to meet the transmission need. First, by only using two “pole” conductors versus three “phase” conductors, the use of HVDC reduces the amount of conductor and insulation material. Second, due to the increasing reactive power generation with distance, more AC cables are needed in parallel to achieve the same transmission capacity.

In contrast, in DC only two cables are necessary, regardless of the transmission distance. This has an immediate impact on the required cable corridor onshore, and the number of required trenches offshore, as illustrated here.

Comparison of Transmission Corridors Required for Hypothetical 1 GW Transmission Link with a 50-mile (80.5 km) Length



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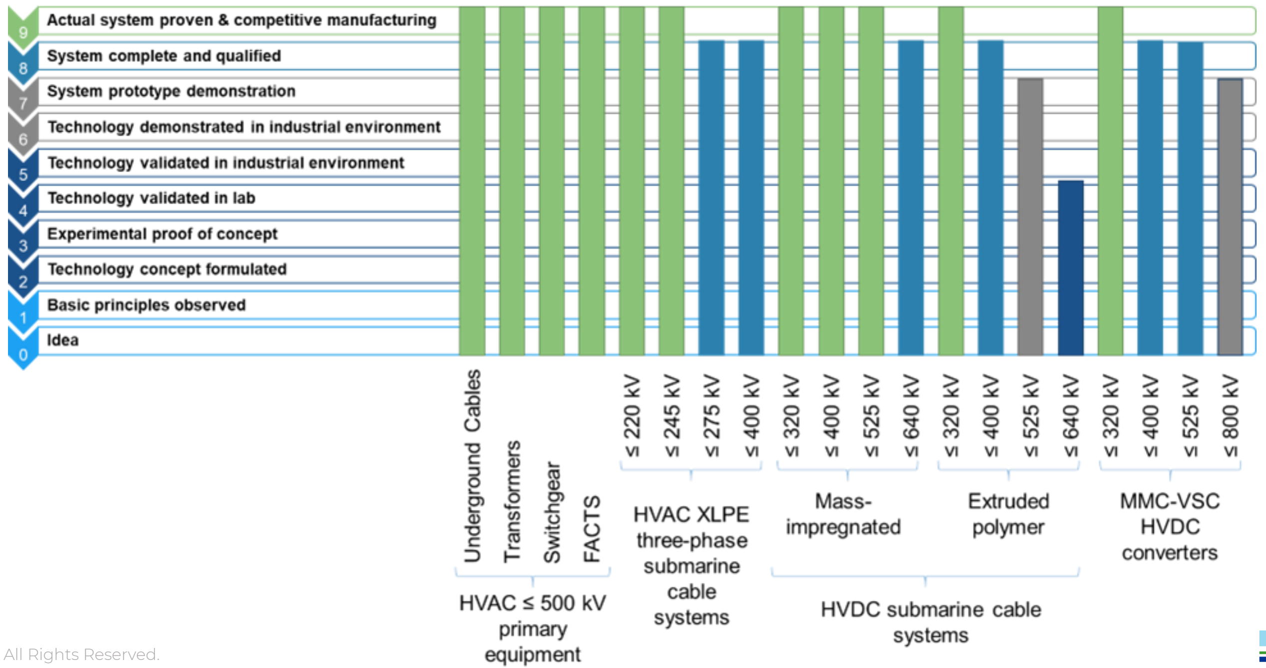
Undersea Cables: Power Capacity and Efficient Use of Corridors

- Restrictions on the available width of a cable corridor, or the number of cable landings that are possible, can be decisive factors in choosing HVDC technology over AC technology. In fact, in countries with a small coastline, such as Germany, the export links of multiple offshore wind farms are combined offshore and connected to the onshore grid by means of single HVDC links for this reason.

- An HVDC backbone system could be designed to deliver power to multiple landing POIs. It would be important to add spare cable in the backbone portion of the system to accommodate connecting additional cable circuits as the number of landing POIs increased. Adding more cable to the backbone after it is constructed would be extremely challenging and expensive, so sufficient spare cable (and an appropriately sized corridor) should be planned for in the initial design and incorporated in initial construction.

Transmission Technology Readiness Levels

- As governments make choices about the technical design of a backbone system, it is important to consider the relative maturity of different transmission technologies. Transmission technology maturity can be quantified and compared using the technology readiness level (TRL) method which divides technology development into nine distinct levels ranging from the idea to fully mature and competitive manufacturing. On this scale, a level of 7 corresponds to a technology that is fully qualified but not yet in operation, which is generally seen as the threshold for consideration in real projects.



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Transmission Technology Readiness Levels

- In general, the primary equipment necessary to realize HV (≤ 500 kV) AC transmission systems for offshore wind farms is mature and competitively available, as indicated by the technology readiness level of 9 in the figure on the previous slide. The system integration, particularly for remote and large offshore wind farms, can be challenging. The identification of requirements for harmonic filtering and dynamic reactive power compensation requires specialized knowledge, tools, and expertise.

- The transmission link ratings are mostly limited by the state-of-the-art in HVDC cable technology. Cables with extruded polymer insulation (in particular XLPE) are gaining popularity, but thus far operational experience is limited to 400 kV. In Europe, the first 525 kV systems have been fully qualified and commercially procured, but not yet put in service.

- Relatively few European and Asian manufacturers are capable of supplying HVDC cable connections. Currently the main names are: NKT (Denmark), Prysmian (Italy), Nexans (France), Sumitomo (Japan), ZTT (China) and Südkabel (Germany). Due to a large demand for HVDC cables and limited production capacity, obtaining a production slot and aligning this with the project schedule is a major concern. Fortunately, several new cable factories are being built in the U.S. and Europe. While it will likely take three to four years to complete these manufacturing facilities, the addition of new suppliers will certainly mitigate this critical supply chain constraint.

Transmission Technology Readiness Levels

- Several VSC based multi-terminal HVDC projects have been successfully put into operation in China, demonstrating the technical viability. In Europe, which has a more comparable transmission development approach to North America, several multi-terminal HVDC grid projects are ongoing. The German ULTRAnet three-terminal 380 kV bipole full-bridge VSC based 2 GW system will be operational from 2023 onwards and will transport offshore wind energy from the north of Germany to the south. In Scotland, the three-terminal radial Caithness-Moray-Shetland system is nearing completion. Between Greece and Crete, both the EuroAsia and Ariadne links are being prepared as multi-terminal ready links. In the Netherlands and Germany, the 2 GW 525 kV design standard is being developed to be multi-terminal ready, enabling future extensions to form multi-purpose multi-terminal systems such as the WindConnector between the Netherlands and the UK, and the Nautilus link between Belgium and the UK (See CIGRE's German HVDC Corridors as Starting Points for a Pan-European HVDC Overlay Grid).

- Relatively few European and Asian manufacturers are capable of supplying MMC-VSC HVDC converters. The main sources are ABB Hitachi, Siemens, GE, NR Electric, RXHK, C-EPRI, XJ, XD, Toshiba, Mitsubishi, and Hitachi.

Advances in HVDC TRL: HVDC Circuit Breakers

- HVDC circuit breakers are a key component of the future of networked HVDC transmission systems. HVDC circuit breakers enable the nearly seamless reconfiguration of the network to support a variety of grid needs, from low frequency events such as loss of an export cable to regular needs including redistributing the flow of power to respond to the real-time needs of the onshore transmission grid.

- Full-scale prototypes of different HDVC circuit breaker technologies from multiple vendors have been successfully demonstrated up to 350 kV in Europe. Pre-standardization activities have been completed and the first commercial application of a 525 kV HVDC circuit breaker is expected to enter service in 2032 in Germany. Other developments in Europe may see HVDC circuit breakers enter operation as early as 2027.

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Offshore Network Design Considerations

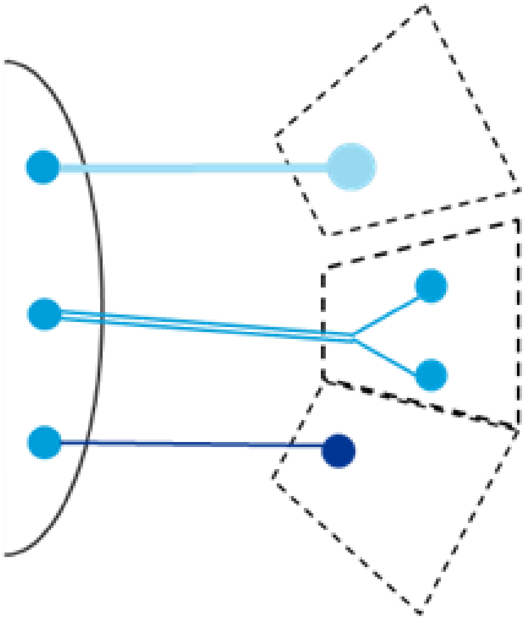
- Offshore grids consist of interconnected transmission elements that can be built at different phases over an extended period. Since the transmission need may change over time, an ideal offshore grid is expected to be flexible with the capability to adjust and grow. This means that it is unlikely that an offshore grid will be completely and centrally planned at the outset, but instead must be able to grow incrementally and organically over time, as the onshore grid itself continues to evolve. There are several different approaches that have emerged as the offshore wind industry has evolved.

- An offshore transmission backbone connecting Nova Scotia to New England can benefit from the evolution of the thinking in North America – and particularly in the New England region – regarding design of the offshore platforms and the transmission systems that connect them.

Project-by-Project Design

- The traditional approach to building offshore wind farm export transmission links was that the offshore wind farm developer would design, build, own, and operate the link to their own installation offshore. This approach was adopted in many early European projects and was used in the first offshore wind farms in the U.S. In this grid building philosophy, each link is optimized for its project, and does not account for other projects unless they are owned by the same developer. As a result, different links have different power ratings, optimized to match the offshore wind farms they connect. The links are likely to have different voltage ratings based on the power and distance of the offshore wind farm, and they may even use different transmission technologies. Consequently, this results in different offshore platform designs.

- This approach may result in an optimal transmission link from a single project developer's perspective as it is custom designed for their offshore wind farm. The downside is that the export cables are rated based on the offshore wind farm power, and not on the maximum available cable rating, which means that scarce cable corridor and POI capacity is not used optimally.



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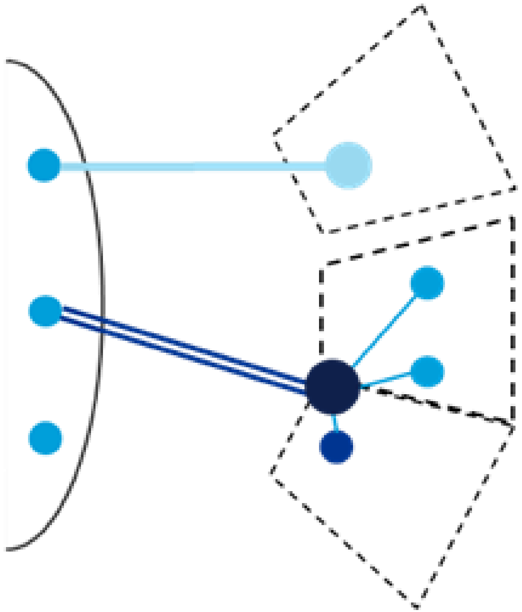
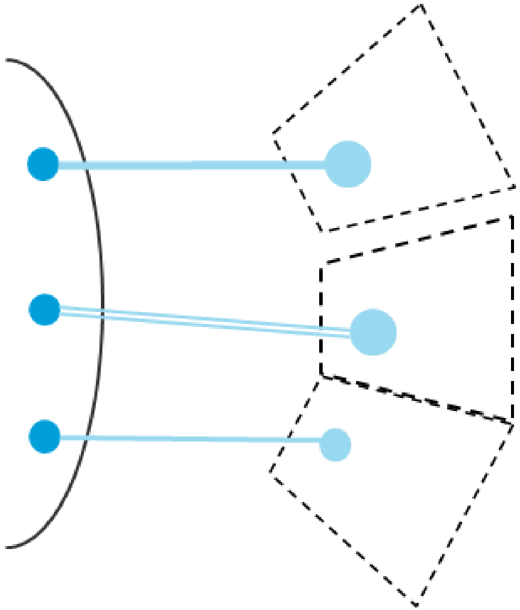
Bundled Design

- To overcome some of the shortcomings of the project-by-project design approach, several European countries have adopted a bundled design philosophy. In this approach, several offshore wind farms share the same export transmission link, which is often designed, built, and operated by a transmission owner (TO). This enables the optimal utilization of the available limited cable corridors (especially in narrow submarine passages) and POIs to maximally exploit their potential capacity. This approach minimizes the number of export transmission cables going onshore, and consequently minimizes adverse impact on the environment and local communities and achieves cost reductions through central coordination, sharing routes and infrastructure between different offshore wind farms.



Standardized Design

- In a standardized design approach, the high-level power system parameters that are necessary to enable compatibility are coordinated between different export links. These parameters include, as a minimum:
  - Common rated voltage and basic insulation level;
  - System grounding philosophy;
  - Protection philosophy;
  - In the case of HVDC, defined grid functional behavior to enable multi-terminal and multi-vendor readiness; and
  - Requirement for platform expandability.



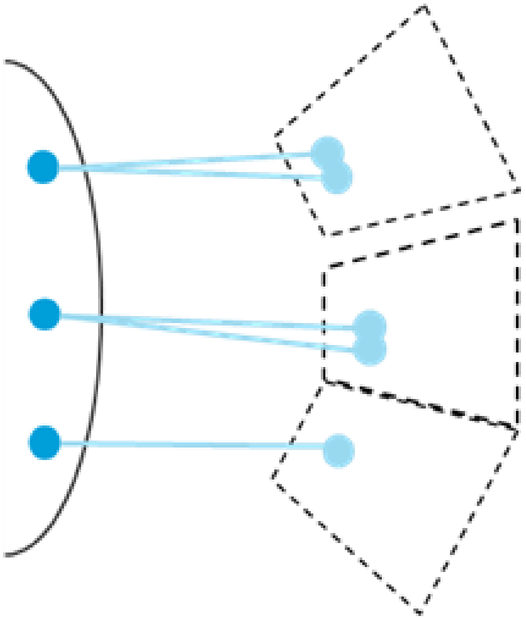
- This standardization of parameters and ratings has the following benefits:
  - Different export links can be linked offshore to improve performance and availability.
  - Procurement and spare parts management can be simplified.
- In this approach, some of the link ratings would still be tailored to meet the power ratings of individual offshore wind farms or clusters of them. This means that offshore platforms have different designs. One implementation of a standardized approach is a system in which different transmission developers design and build different offshore links on a competitive basis, but where a design standard is imposed by another regulating body / authority / or system operator, in a similar way as is done for onshore grid reinforcements today.

Modular Design

- In a further step towards standardization, not only the system parameters but also the individual offshore platform power ratings and designs are standardized. To increase capacity, platforms are simply added in modular fashion, incrementally increasing the overall capacity. Project-specific parameters such as cable lengths and water depths are adjusted for each platform. The modular design should accommodate a design envelope which covers – to the greatest degree possible – ratings and variations that could occur within the possible portfolio of future offshore platforms.

- This modular approach allows platform designs to be replicated between different projects, reducing risks and uncertainties by building experience. If multiple offshore platforms are required within a short time, fabrication can be optimized through series production. The standardized parameters and ratings also enable the simplification and optimization of spare parts management. All together, these factors can lead to a substantial efficiency gain during project execution, and subsequently during the operational phase, realizing significant CapEx and OpEx reductions.

- The standardization and modularization of parameters ensure compatibility between different offshore platforms and enable interconnection of platforms to build out an offshore transmission backbone network.



Modular Design Principles Were Endorsed in Recent Actions by the New England States

- The New England States Regional Transmission Initiative, launched in the fall of 2022, recognized the need to take advantage of the advanced modular offshore transmission design framework when it published for comment the "Modular Offshore Wind Integration Plan: Conceptual Framework for New England" (MOWIP). In the MOWIP, the States solicited solutions that would create an offshore transmission network capable of future regional and interregional growth, and with an eye to the lowest overall cost of development and operation. The parameters for this forward-looking, no-regrets approach included:
    - "Eligible solutions should be scalable, cost-effective, and sufficiently flexible to accommodate up to 8,400 MW from current New England leaseholds. The Participating States are actively considering HVDC transmission solutions in 1,200 MW increments through 2040."
    - "To maximize operational flexibility, reliability, resiliency, and system efficiency, the relevant operational infrastructure, and specifically HVDC converters, should be designed in a manner that future transmission lines can connect in a meshed manner and share the landing points. HVDC transmission topologies that include offshore converters that enable inter-area transfers of offshore wind generation to various network points within ISO-NE and potentially beyond, are encouraged."

Modular Design Principles Were Endorsed in Recent Actions by the New England States

- Four New England States (Connecticut, Maine, Massachusetts, and Rhode Island) followed up the MOWIP outline with a Concept Paper to support a request for federal funding from the Bipartisan Infrastructure Law's Grid Resilience Innovation Partnership (GRIP). The States proposed using GRIP funding to advance a "Joint State Innovation Partnership for Offshore Wind," formed to "proactively plan, identify, and select an initial portfolio of one or more [HVDC] transmission lines, and associated onshore system upgrades, to unlock the region's significant offshore wind potential". The States propose to achieve this objective by:
    - Soliciting a modular development structure that allows for the initial deployment of one or more HVDC systems in the near term while enabling upscaling of the system to accommodate [Multi-Terminal] DC technology as it becomes available both to gain the significant advantage of an MTDC system and to permit intra and interregional transfer capacity.

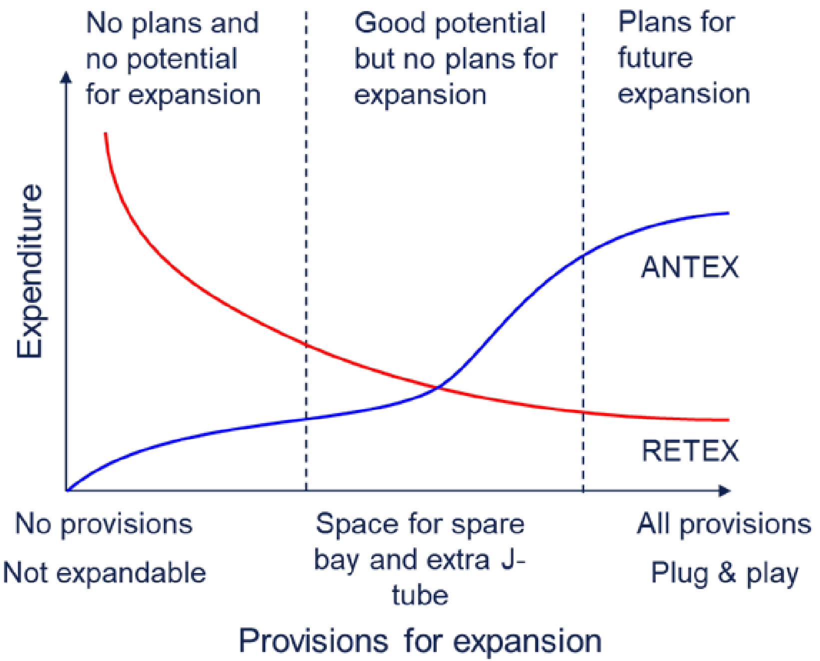
- The extension of the backbone concept developing in New England to connect offshore wind resources in Nova Scotia is consistent with the objectives of the New England states. The timing and opportunity to design a transmission backbone that could achieve that connection is critical, so proposals to incorporate transmission links from Nova Scotia are considered as the New England planning work gets underway.

Developing for Phased/Modular Growth

- One of the principles of a modular offshore grid design approach is to maintain realistic, economical options to expand the system as more offshore wind is brought online in the area served by the offshore transmission backbone.

- The future expandability of an offshore substation depends on the degree to which provisions (e.g., equipment, system and structure ratings, dimensions, SCADA integration) necessary to enable a future expansion are present, and the relationship between the amount of anticipatory and retrofit expenditure that is necessary to realize these provisions, as illustrated in the figure shown on the right.

- Some of these provisions must be in place at the time of manufacturing of the platform and result in a need for anticipatory expenditure (ANTEX) that would not be required if no expansion was anticipated. Without these minimum provisions, such as sufficient space for the installation of an additional cable and switchgear bay, the platform is simply not expandable.



Developing for Phased/Modular Growth

- Provided the basic requirements for expandability are in place, other provisions can be installed during a future retrofit and require retrofit expenditure (RETEX). The offshore retrofitting of the installation and connection of the additional equipment, modules or topsides is typically more expensive than if it was done in the harbor during the original construction but reduces the initial required ANTEX.

- A thorough summary of the equipment and financial considerations that need to be examined when considering expansion is included in a paper delivered at the 2021 CIGRE Canada Conference, entitled "Offshore Substation Platform Expandability".

Risk Factors: Interoperability Standardization & Reliability Standards

- When developing an offshore transmission network that will serve several projects – and have interregional reach like a Nova Scotia to New England connection would – a primary challenge is the coordination and standardization of different projects to enable compatibility and multi-vendor interoperability.

- In Europe, all future energy system visions are based on multi-terminal HVDC network architectures and have resulted in a strong drive to solve the compatibility and interoperability issues. For example, major European utility TenneT has developed and standardized a 2 GW, 525 kV platform design that is multi-terminal ready and that anticipates the development of HVDC circuit breakers. The use of 2,000 MW HVDC circuits optimizes use of the available technology.

- The 2,000 MW, 525 kV standard will be used for at least 13 standardized offshore wind connections to support the German, Dutch, Danish, and Belgian governments with an additional 20 GW of offshore wind by 2030 (on top of their existing targets). The 2,000 MW standard will be 'multi-terminal ready', to enable HVDC mesh connections which offer much higher capacities and transmission distances at lower cost compared to AC mesh connections.

- Establishing a standard such as the 2,000MW, 525kV HVDC standard is a critical first step, so that high-level power system parameters necessary to enable compatibility are coordinated between future transmission export links. Including standard design elements will enable modular export transmission links to be networked together offshore, improving performance, availability, and benefits to the onshore grid.

Standardization: Interoperability Standardization & Reliability Standards

- Another standardization challenge involves reliability standards, the grid code that governs the interconnection of the offshore and onshore grids. North American bulk power system reliability standards were created primarily to address issues facing the AC-based onshore system. HVDC transmission systems exist in the U.S. but are not widespread or networked. offshore wind development is expected to increase the use of HVDC technology substantially, which will drive the need for reliability standards for HVDC-based systems.

- This is an issue of growing awareness in the industry and among advocates of offshore wind deployment. The U.S. Department of Energy (DOE) recently opened a project to examine gaps in HVDC reliability standards to inventory such issues and seek solutions to resolve them. Active work with the DOE, ISO-NE, the Northeast Power Coordinating Council (NPCC), and other standards-setting organizations on these issues is a key mitigation strategy for risks associated with gaps in standards.

Risk Factors: Supply Chain Limitations

- The crush of orders facing manufacturers of cable, converters, and other transmission specific equipment has many reporting that new orders cannot be processed for years. The sooner design decisions can be made, the more quickly the Nova Scotia to New England corridor can get its orders into the Original Equipment Manufacturers (OEMs) and construction professionals who will deploy the backbone network.

Reference Conceptual Design for the Nova Scotia to New England System

- The development of a fully engineered design for the proposed offshore transmission backbone is beyond the scope of this report. To put the technical aspects of the proposed system in some perspective, we have included a high-level design that incorporates hypothetical reference offshore wind farms, one more close and the other more distant from the southern shore of Nova Scotia.

- The reference design seeks to include the advantages of a modular system, while also recognizing opportunities that may be available for different types of connections from the varied locations in the Nova Scotia Regional Assessment Study Area. The reference conceptual design also provides the basis for initial estimates of costs and possible timelines for completion of the limited backbone system modeled here.

- The early stage of commercialization for floating offshore wind technologies makes cost estimates for floating cables and substations less certain. The reference design does not include connections for the Gulf of Maine offshore wind areas.
    - Routing proximal to the Gulf of Maine wind areas would enable further development of an offshore network.
        - Future Gulf of Maine projects could co-locate their transmission cables in the same area already being used by the initial transmission pathway.
        - The existing cable could be connected into a floating offshore platform. This would require some operational downtime to enable cable splicing.
        - Wind projects in the Gulf of Maine will require their own converter stations (offshore and onshore) as well as their own HVDC transmission cables.

NEMOEC Network and Cost Estimates

NEMOEC Network Options

- DNV developed the following maps showing alternatives for transporting power from Nova Scotia wind energy areas to Nova Scotia and to ISO-NE. The diagrams assume POIs in Nova Scotia at Port Hastings and Dartmouth East (near Halifax), and in New England at Mystic (Boston).
- The two options depicted include a rough estimate of overall costs.
  - NOTE: None of the estimates include costs associated with onshore grid reinforcement (in Nova Scotia or New England) and land cables. In addition, DNV does not currently have reliable estimates for floating platforms or dynamic cables, so did not include those deep-water options.
- The diagrams show alternatives for transporting 2 GW of wind from Nova Scotia to New England.

NEMOEC Initial Network Options

- The following diagrams show alternatives for interconnecting Nova Scotia wind energy areas with Nova Scotia and ISO-NE.
- The diagrammed networks would additionally enable the transfer of 2 GW of power between Nova Scotia and New England.
- The assumed POIs are near: Port Hastings, NS; Halifax, NS; and Boston, MA.
- Rough estimates of overall cost are provided for the options shown. NOTE: these cost estimates do not include the cost of land cables or the cost of onshore grid reinforcement.

- Legend for the diagrams:
  - HVDC Converter Station (Onshore/Offshore)
  - HVDC Submarine Cable
  - HVAC Substation (Onshore/Offshore)
  - HVAC Submarine Cable

Pathway 1: OSW Near Sable Island, Nova Scotia

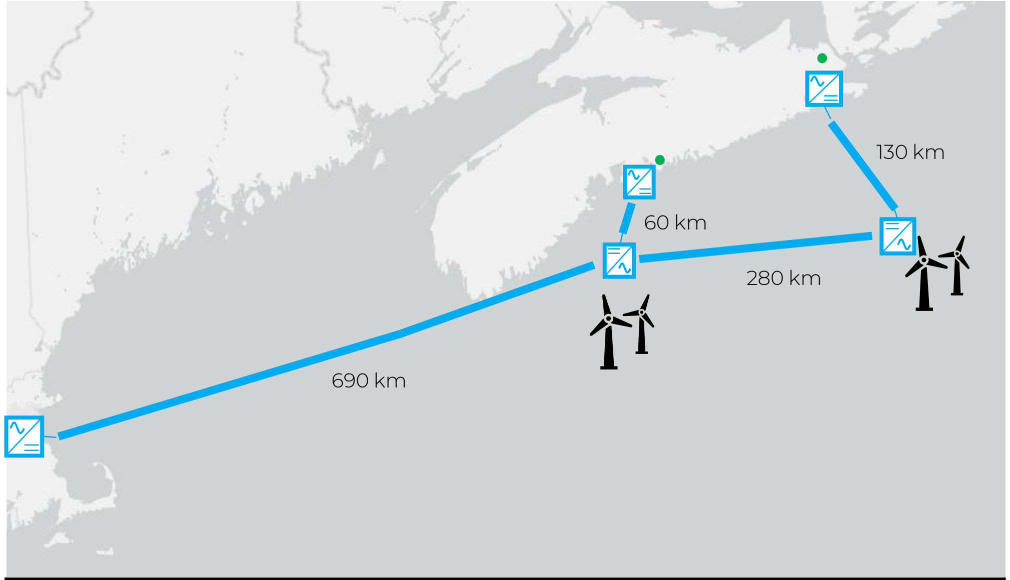
- Standard & Modular Design for a **2 GW, 525 kV Bipole HVDC Solution**, with a potential connection to ISO-NE using an offshore multi-terminal HVDC design.
- This approach would improve grid reliability and energy resource diversity while allowing for bi-directional power transfer between Nova Scotia and ISO-NE.
- This pathway is scalable, with expansion through addition of 2 GW blocks (cost estimates for such expansion are provided in a later slide).
- The standard design enables cost savings in case of expansion (e.g., Engineering & Design, O&M, spare parts, commercial discounts).

Estimated Cost of Pathway 1 - $6,400 M

*Illustrative Figure: the need, size and requirements of interlinks should be evaluated based on detailed onshore & offshore techno-economic analysis.

Pathway 2a: OSW South of Halifax, Nova Scotia

- Standard & Modular Design for a **2 GW, 525 kV Bipole HVDC Solution,** with a potential connection to ISO-NE using an offshore multi-terminal HVDC design.
- The HVDC offshore interlink allows exchange of power between Nova Scotia POIs through the offshore grid.
  - The need, size and requirements should be evaluated based on detailed onshore and offshore techno-economic analysis.
- This approach would improve grid reliability and energy resource diversity, while allowing for bi-directional power transfer between Nova Scotia and ISO-NE.
- The standard design enables cost savings in case of expansion (e.g., Engineering & Design, O&M, spare parts, commercial discounts).

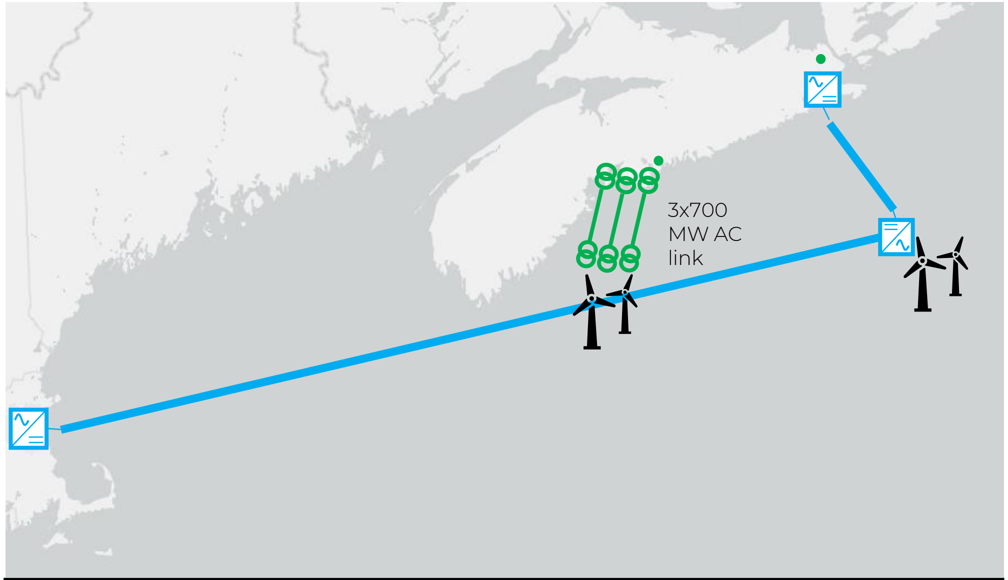


Estimated Cost of Pathway 2a - $8,300 M

*Illustrative Figure: the need, size and requirements of interlinks should be evaluated based on detailed onshore & offshore techno-economic analysis.

Pathway 2b: OSW South of Halifax, Nova Scotia

- Pathway 2b and 2c offer an AC solution for the shorter distance connection of the wind area resource south of Halifax.
- The wind energy area south of Halifax would be connected by 3x 700 MW, 275 kV AC connection.
- The AC connection would provide a lower connection cost for South of Halifax offshore wind compared to the HVDC solution; however, the AC connection requires more submarine cables and offshore platforms than HVDC. As such, the AC connection would have a larger environmental impact.
- In the 2b option, the South of Halifax offshore wind would not be connected to ISO-NE or the neighboring Sable Island offshore wind area.



Estimated Cost of Pathway 2b - $7,500 M

*Illustrative Figure: the need, size and requirements of interlinks should be evaluated based on detailed onshore & offshore techno-economic analysis.

Pathway 2c: OSW South of Halifax, Nova Scotia

- Like Pathway 2b, the wind energy area south of Halifax would be connected by 3x 700 MW, 275 kV AC connection. As for Pathway 2b, the AC connection would provide a lower connection cost with a larger environmental impact (compared to the HVDC solution).

- Unlike Pathway 2b, Pathway 2c would provide a connection to ISO-NE and offshore wind Near Sable Island through the addition of a multi-terminal onshore converter station.
  - The need, size and requirements of interlink should be evaluated based on detailed onshore & offshore techno-economic analysis.

Estimated Cost of Pathway 2c - $8,100 M

*Illustrative Figure: the need, size and requirements of interlinks should be evaluated based on detailed onshore & offshore techno-economic analysis.

Summary of Options Presented

- Options range in cost from $6-8 billion USD. **This in the range of project cost that could be supported by the monetizable grid benefits.**
- Pathway 1 is an attractive starting point for further exploration of the NEMOEC vision.
- Of the Pathway 2 options considered, Pathway 2a is likely the best option (despite its higher cost) because of its reduced environmental impact and additional interlink between the Nova Scotia POIs.

Pathway	OSW Developed	Technology	Scalable Potential	NS to ISO-NE Transfer	Interlink for NS POIs	High-Level Cost Estimate
1	Sable Island only	HVDC: 2 GW, 525 kV Bipole & converter stations	High	Only for Sable Island	No	$6,400 M
2a	Sable Island & South of Halifax	HVDC: 2 GW, 525 kV Bipole & converter stations	High	Yes (Sable Island & South Halifax)	Yes	$8,300 M
2b	Sable Island & South of Halifax	HVDC: 2 GW, 525 kV Bipole & converter stations HVAC: 3x700 MW 275 kV AC, substations	Low	Only for Sable Island	No	$7,500 M
2c	Sable Island & South of Halifax	HVDC: 2 GW, 525 kV Bipole & converter stations HVAC: 3x700 MW 275 kV AC, substations	Mid	Yes (Sable Island & South Halifax)	Yes	$8,100 M

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Standard & Modular HVDC Design Supports the Future Vision of an Open Access HVDC Grid

- Standard and modular designs are consistent with the New England States' vision for an offshore grid.
- Standard and modular designs are best suited for future expansion and enable interconnections with Gulf of Maine wind as it develops.
- A robust offshore HVDC grid creates opportunities for connecting Nova Scotia wind resources to emerging Gulf of Maine sites to take advantage of resource diversity between the New England and Maritimes wind energy zones.

*Illustrative Figure: the need, size and requirements of interlinks should be evaluated based on detailed onshore & offshore techno-economic analysis.

3) Overview of Policy and Regulatory Environment

Overview of Policy and Regulatory Environment

- This section reviews the policy and regulatory environment associated with the development of a large offshore HVDC transmission connection between Canada and the US. There are two primary areas of focus: (1) commercial considerations associated with the development of the NEMOEC corridor including alternative commercial structures that could be employed; and (2) the environmental and broader regulatory permitting processes that the NEMOEC corridor will need to navigate to secure the necessary approvals.

- We first review the various commercial structures that could be employed as well as potential funding opportunities including:
    - Established models such as long-term capacity contracts or selling transmission rights to various parties. There are a range of commercial models and procurement frameworks that could be employed. We review a few salient examples.
    - The traditional utility funding model where project costs are recovered from customers on a cost-of-service basis.
    - The US Department of Energy's (DOE's) Transmission Facilitation Program (TFP), which offers capacity contracts and loans as a possible route to secure funding. This project finance opportunity will need to be paired with an established commercial model.

- We then review the grid and transmission planning processes and permitting processes for offshore transmission development. The regimes are split by the US and Canada given the differences between the two jurisdictions.

Commercial Structures

Possible Commercial Structures

- Given the NEMOEC corridor's significant capital requirements, multi-jurisdictional span, non-traditional customers and value proposition, a project finance model is likely to be most appropriate for financing. There are a handful commercial structures and funding models that could be employed, and various portions of the corridor could be financed through different structures
  - While the entire scope of the NEMOEC corridor isn't well suited to be a traditional utility investment where cost-of-service rate-base financing is employed, it is conceivable that portions of the corridor could financed under such a model. As discussed further below, a portion of the project that serves as the connection facilities from the offshore wind projects to the onshore grid could be financed through a traditional utility investment model.
- With this understanding, there are a range of different commercial structures than can be pursued to allow the NEMOEC corridor to be financed. Procurement models and commercial structures that have been used for other large inter-jurisdictional transmission projects offer insights into possible models.
  - While the multi-jurisdictional nature of the NEMOEC corridor adds complexity to the permitting process, the impact on the commercial structure is relatively modest (e.g., there will need to be separate commercial entities in the US and Canada), with separate transmission tariffs for the facilities in each country.
- A possible ownership model is a Crown-corporation under which the federal or a provincial government is a majority owner of the transmission development company. This may help advance the policy objectives behind offshore wind and develop the NEMOEC facilities faster. It would provide an opportunity to access lower cost of capital. However, challenges with forming such a public transmission company are significant: these include assembling the necessary technical capabilities and project development skills as well as properly assessing the project risk. While the TVA, BPA or NYPA provide historical precedence for state ownership of energy infrastructure, this model is not currently deemed likely on the US side.

Securing Sufficient Revenue Certainty for Financing

- The most obvious financing model for the backbone portions of the NEMOEC corridor is project finance, where the project secures funding from lenders and equity investors based on long-term contracts that provide third parties (i.e., transmission rights holders) with the right to use the transmission facilities to deliver energy to load centers in Southern New England and Nova Scotia.
- As outlined above in the review of benefits, the NEMOEC corridor offers a number of benefits that wouldn't flow to such transmission rights holders. This includes reduced capacity requirements in Nova Scotia from load diversity. If there isn't some form of financial recognition for these benefits then the entire project costs will need to be recovered from these transmission rights holders. This effectively increases the financial threshold for these transmission rights holders and increases the risk that the corridor won't be able to attract sufficient interest to secure financing.
- Therefore, it is important that the value that these benefits offer be recognized and some form of compensation be offered from them.
- There are a range of strategies that could be employed for this.

Likely Commercial Structure: Transmission Rights Sale

- The most obvious commercial structure is the sale of transmission rights to third parties. This is the model that was employed in the Massachusetts 83D procurement in which the Atlantic Link project participated and a contract was ultimately awarded to the New England Clean Energy Connect project.
  - There are a range of variations to this basic commercial structure, which are reviewed in greater detail below.
  - This commercial structure fits well with the Capacity Contract framework that the US DOE has developed under the TFP, which allows the DOE to enter into capacity contracts for up to 50% of the transfer capability of the subject transmission facility. The Joint State Innovation Partnership for Offshore Wind is another example in which offshore transmission may receive federal funding through the GRIP Program.

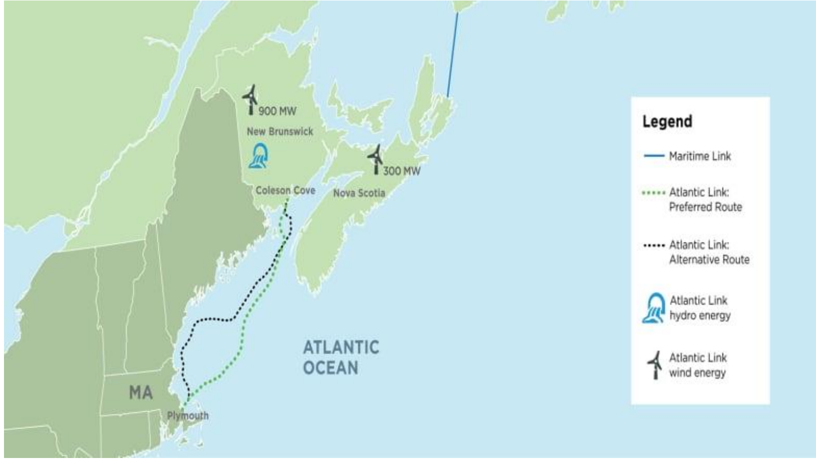
- Another possible structure would be a partnership with or the sale of transmission rights to a utility who could then recover these costs from its ratepayers. This model could be used for “connection facilities” that were used to connect the offshore wind projects to the onshore grid. The Maritime Link was developed by NSP Maritime Link, a subsidiary of Emera and a NS Power affiliate, and was approved by the Nova Scotia Utility and Review Board (UARB) to recover the project’s costs from ratepayers. With this revenue certainty, the project was initially funded primarily through a bond offering.

- International cooperation will be essential to the success of an international offshore transmission project. Offshore transmission development in Europe is proof that the complexity of multi-jurisdictional projects can be managed through close coordination by the various parties.

Atlantic Link: Possible Model

- The Atlantic Link was a proposed 1,000 MW HVDC subsea transmission line that would have delivered wind and hydro in Atlantic Canada to Massachusetts. The $2-billion project was proposed by Emera Inc. in response to the Massachusetts Clean Energy 83D RFP in 2017. The project was not selected and has not advanced further.
- Under the 83D contract structure the transmission service providers (TSPs) were the anticipated counterparties to the Massachusetts electric distribution companies (EDCs). Under this structure the TSPs entered into contracts with renewable project developers and were focused on minimizing the delivered cost of clean energy to the EDCs, by optimizing their power supply portfolio so as to maximize throughput on the transmission line.
- The Atlantic Link was unsuccessful because it did not secure a contract with the EDCs that the 83D procurement process offered. Clearly, the viability of the NEMOEC corridor is contingent on securing a stable revenue stream that will allow the recovery of capital invested as well as a return on this investment. This would be enabled by selling transmission rights to offshore wind developers or electricity suppliers.

Maritime Link/Lower Churchill Hydroelectric Project



Source: Clean Power Northeast Development Inc., Emera

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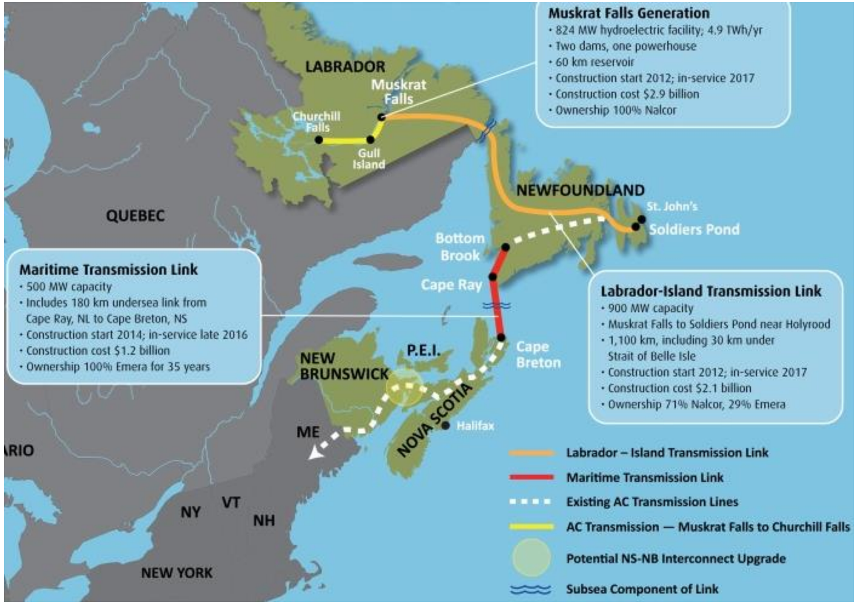
Maritime Link

- The Maritime Link is a 500 MW subsea transmission line that connects Newfoundland and Labrador and allows Nova Scotia to import hydro from the Muskrat Falls generating station in Labrador, developed by Newfoundland and Labrador Hydro (NLH).
- The Emera subsidiary, NSP Maritime Link, built the Maritime Link in return for a long-term power supply commitment (i.e., 35 years) from NLH for power from Muskrat Falls.
- The Nova Scotia UARB approved the Maritime Link in 2013 after finding that the project represented the lowest long-term cost alternative for the supply of clean electricity. In 2014, Emera completed a $1.3 billion bond offering to finance the construction of the Maritime Link. The government of Canada provided a loan guarantee for the financing. Emera received approval from the UARB to recover the entire $1.7-billion project cost from Nova Scotia ratepayers in 2022.
- The project began in 2011 with stakeholder engagement and environmental studies. Once gaining approval, construction began in 2014 and was completed in 2017. The project was completed on time and within budget.

Maritime Link/Lower Churchill Hydroelectric Project



Source: Nova Scotia Natural Resources and Renewables

The project does not represent international trade between the US and Canada but does provide insight to a recently successful undersea transmission project connecting to Nova Scotia.

Commercial Structures

New Jersey State Agreement Approach (SAA)

- In 2022, FERC approved the SAA between PJM and the New Jersey Board of Public Utilities (NJ BPU) to establish a coordinated transmission solution to connect offshore wind being developed pursuant to the state's 7.5 GW procurement target. The SAA is a transmission planning and cost recovery mechanism specified in PJM's Operating Agreement, which permits states to pursue energy and climate policies with the understanding that transmission-related costs will be borne by the state's ratepayers. Under the SAA, the NJ BPU solicited proposals through PJM's competitive transmission planning process and selected an onshore transmission project that will connect 5.5 GW of offshore wind to the onshore grid. The NJ BPU received 80 proposals from 13 different developers, demonstrating the strong market interest. Under this agreement, the selected transmission project will recover its costs from New Jersey customers. If another state within PJM elects to utilize these facilities, its customers would be responsible for these costs as well. With costs directly allocated to participating states' ratepayers, the SAA doesn't address the vexing issue of cost allocation.

NYSERDA Tier 4 Procurement

- NYSERDA issued the Tier 4 RFP to support the development of new transmission facilities that would deliver renewable energy to Zone J (New York City) to reduce reliance on fossil fuel generation. Contracts were awarded to the 1,300 MW Clean Path New York and 1,250 MW Champlain Hudson Power Express transmission projects, which will deliver solar and wind energy from upstate New York and hydro power from Québec, respectively. The commercial structure in the Tier 4 procurement was distinctly different than that employed in Massachusetts 83D RFP. Under the Tier 4 contract structure renewable energy generators are the anticipated counter parties with NYSERDA, not the transmission service providers (TSPs). Therefore, TSPs necessarily have less responsibility for assembling and optimizing the power supply portfolio. Under this structure, TSPs are less focused on maximizing the throughput of their transmission facilities. This is believed to have impaired the ability to secure the lowest total delivered cost of renewable energy.

Transmission Facilitation Program (TFP) Support

- Under the Infrastructure Investment and Jobs Act (IIJA), the US Department of Energy (DOE) developed the TFP to support the construction of new interregional transmission. The financing tools offered through the TFP provide revenue certainty to developers and operators. The DOE is authorized to borrow up to $2.5 billion through three financing tools:
    1. Purchase up to 50% of planned line rating for up to 40 years through capacity contracts and resell the capacity or the contract on a market basis to recover costs;
    2. Provide loans; and
    3. Participate in public-private partnerships that are within a national interest electric transmission corridor (NIETC) and accommodate an increase in electricity demand across more than one state or transmission planning region.
- TFP could support the development of a portion of the NEMOEC transmission facilities (e.g., the transmission facilities that would connect offshore wind in the Gulf of Maine to Southern New England load centers) given the program's evaluation criteria aligns closely with the attributes of the NEMOEC corridor. The table on the following slide presents the evaluation criteria in the program's RFP and NEMOEC's relative position.
    - Power Advisory assumes that the DOE would be interested in only supporting facilities that are in the US and benefit US citizens.
- TFP is geared towards projects that are nearly "shovel ready". Applications for the first round of the TFP closed on February 1, 2023. The number of TFP funding cycles may be limited, which could present challenges for the NEMOEC transmission project to secure funding. However, DOE notes the types and amounts of TFP support offered in 2024 and beyond will be identified in subsequential solicitation documentations. There will likely still be funding opportunities beyond the first two rounds which could better align with NEMOEC's schedule.

NEMOEC Satisfies a Number of TFP Criteria

TFP Criteria	NEMOEC Fit
Sufficient need for DOE support, that is, the project would otherwise not be constructed without federal financial support.	The NEMOEC facilities will be critical to enabling the full development of Maine's OSW potential. A generator-led, project by project, transmission approach is unlikely to build a coordinated transmission line.
Proven reasonableness of the ability of DOE to recover its costs.	NEMOEC offers a valuable alternative transmission path that provides direct access to Canadian hydro resources, which have been identified as an important clean energy resource for Southern New England state's climate change plans.
Favor transmission projects that contribute to federal/state goals to lower electricity sector greenhouse gas emissions	The NEMOEC facilities will help integrate OSW into the New England electricity system.
Improve grid resiliency and reliability	The NEMOEC transmission line will provide increased reliability through the addition of OSW that will reduce reliance on natural gas during the winter period, which has been identified as a reliability risk.
Facilitate interregional transfer capacity	NEMOEC significantly increases the transmission capacity between New England and Atlantic Canada.

Cost Sharing - New England States Transmission Initiative

- The New England States Transmission Initiative is a joint initiative by five of the New England states (Connecticut, Massachusetts, Maine, New Hampshire, and Rhode Island) to explore investment in transmission infrastructure to integrate clean energy resources, such as offshore wind.

- The initiative is geared towards developing a coordinated offshore transmission system to connect offshore wind to ISO-NE at multiple POIs. On January 27, 2022, the participating states submitted a concept paper to the DOE in response to the Funding Opportunity Announcement for the Grid Resilience and Innovation Partnerships (GRIP) Program. The paper proposed the Joint State Innovation Partnership for Offshore Wind, a project under which the participating states would investigate a process to competitively identify a broad set of transmission solutions through an RFP. The initial RFP would allow for the selection of one to three HVDC transmission lines, contingent upon DOE funding, to inject offshore wind to the onshore grid. The transmission line corridors are not predetermined but participating states, ISO-NE, transmission owners, and stakeholders will identify the optimal POIs.

- In March, the participating New England states' proposal was selected as eligible to submit a full application under the GRIP. See slide "DOE Funding Opportunity: Grid Innovation Program (GIP)" in Section 4 for more details on the application process.

- The Joint State Innovation Partnership for Offshore Wind is an immediate project with a different target area than what the NEMOEC project would serve. However, it offers a potential model that could be utilized in the future if the New England states decide to competitively solicit an offshore transmission project focused on integrating offshore wind from the Gulf of Maine into the onshore grid.

International Cooperation and Cost Sharing

- The NEMOEC offshore transmission corridor will span the US and Canada as well as various states and provinces. As with any multi-jurisdictional project, NEMOEC has specific challenges associated with how to allocate costs. The development of the NEMOEC corridor will also pose challenges with coordinating permitting, project reviews and interconnection processes in both the US and Canada, which will require the cooperation between governments, system operators, and utilities.

- Germany, the Netherlands, Belgium and Denmark target 65 GW of offshore wind in the North Sea by 2030; the countries signed a $142 billion offshore wind pact in 2022 which initiates work on a coordinated offshore transmission network. The countries plan to construct an offshore transmission network and four artificial islands to transmit power and green hydrogen across countries.

- In 2020, Energinet and 50Hertz launched the Kriegers Flak - Combined Grid Solution project which connect Denmark and Germany via two offshore wind farms, German Baltic 2 and Danish Kriegers Flak. The project allows bi-directional flow of electricity between the countries. The European Union (EU) recognized the interconnection as a Project of Common Interest (PCI) and provided $168 million in funding. Power Advisory was not able to determine in its research how the costs were allocated and recovered between the two countries.
  - The success of the project relied on the cooperation of many players, including offshore wind developers, transmission system operators, the regulators and authorities responsible for approvals. A shared offshore transmission project between the US and Canada will require similar cooperation between the US and Canada.

- The Cost Allocation Principle 1 in FERC's Order No. 1000 asserts "The cost of transmission facilities must be allocated to those within the transmission planning region that benefit from those facilities in a manner that is at least roughly commensurate with estimated benefits." Priorities of a cost allocation framework for offshore transmission should be preventing cost-shifting across states/provinces, considering differences in state policy goals, and distinguishing between local and regional benefits.

US Planning and Permitting Processes

US Planning and Permitting Processes

Source: US DOE

ISO-NE Interconnection Process

- This section lays out the ISO-NE studies and requirements in its Interconnection Process. There are multiple avenues for a transmission developer to propose its project to ISO-NE:
  - Public Policy Transmission Upgrades (PPTUs), a process which has yet to be employed fully but would drive transmission development to meet public policy goals.
  - Elective Transmission Upgrade (ETUs), which can be external to the system and includes its own benefits.

US Permitting Process

- The US permitting process in New England includes requirements at the US federal, state, municipal, and private level and are detailed in this section. Environmental permitting and approvals at the federal level are substantial and time intensive; the process can take 4-5 years to be completed. At the state level, in both Massachusetts and Maine, regulations also require an extensive permitting effort.
- National interest electric transmission corridors" ("NIETCs") are interstate transmission projects that the DOE and FERC can designate to expedite permitting processes but are likely a last resort given that it bypasses the states' authority, whose support is ultimately likely to be necessary to secure cost recovery for the corridor.

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ISO-NE Interconnection Process

- ISO-NE must assess and approve transmission and generation projects to connect to the New England transmission system to ensure reliability and facilitate wholesale electricity market participation. Once a project developer submits an interconnection request, ISO-NE will perform the following studies:
  - Feasibility Study (FS) – A preliminary evaluation of the system impact and cost of interconnecting the facility to the transmission system (Required unless determined otherwise at the scoping meeting)
  - System Impact Study (SIS) – A study that evaluates the effect of the proposed interconnection on the safety and reliability of the transmission system.
  - Facilities Study (FAC) – A study to determine the equipment and electrical switching configuration necessary to connect the project and estimate the cost, construction, and installation times.
  - Optional Interconnection Study (OIS) – A sensitivity analysis based on the assumption that one or more earlier-queued resources are removed.
- Once ISO-NE identifies any necessary facility upgrades and approves the project, the project owner and ISO-NE will execute an Interconnection Agreement.

Studies Cost & Timeline

100% of the estimated study costs	**FS**	**140 days**
The greater of 100% of the estimated study costs or $250,000	**SIS**	**400 days**
The greater of 100% of the estimated study costs or $250,000	**FAC**	**130-220 days**
100% of the estimated study costs	**OIS**	**Mutually agreed upon time**

ISO-NE Interconnection Process Timeline

- The table below presents the expected schedule for the ISO-NE interconnection procedure and approval process required to be undertaken by the NEMOEC transmission project. The schedule is aligned with the overall permitting process so that ISO-NE is approximated to provide approval around the time in which the environmental permitting efforts begin.

- During the scoping meeting, the developer and ISO-NE can decide to conduct the FS as a separate and distinct study or chose to go straight to the SIS to help expedite the process.

- Any proposed changes to the ISO-NE grid must submit a Proposed Plan Application with supporting documentation and modelling data to the ISO. The level of effort in a proposed plan process varies based on the complexity of the proposed changes. Proposed Plan Applications associated with ETUs must be submitted within 30 days from the end of the developer's comment period following the completion of the SIS. ISO-NE will examine the proposed plans and evaluate the potential for significant adverse impacts on the system.

Agency	Permitting/License/Authority	2025				2026				2027				2028				2029			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
United States - Regional																					
ISO-NE	Feasibility Study (FS)				■	■															
	System Impact Study (SIS)				■	■	■	■	■												
	Facilities Study (FAC)								■	■	■										
	Optional Interconnection Study (OIS)								■	■											
	Proposed Plan Application & Approval								■	■	■	■									

ISO-NE Public Policy Transmission Upgrade Process

- PPTUs are improvements of or additions to the regional transmission system designed to meet state, federal, and local public policy requirements that are driving transmission needs. In the PPTU process, ISO-NE will conduct studies, request stakeholder input, and present information to identify whether a specific statute creates a transmission need based on a Public Policy Requirement (PPR). The first and main criteria for a transmission need is whether a statute explicitly requires the construction of transmission infrastructure.

- The New England States Committee on Electricity (NESCOE) is tasked with reviewing public policy and input from stakeholders then submitting a request and explanation to ISO-NE of which PPRs drive transmission needs or do not.

- ISO-NE initiated a PPTU process on January 13, 2023, with a public notice requesting state, federal and local PPRs that drive transmission needs. Stakeholder input on the PPTU was due by February 27. The last PPTU process concluded in June 2020 (see following slide for details).

PPTU Steps

1. ISO-NE issues a public notice requesting input on PPRs (This must occur every three years or less)
2. NESCOE communicates with ISO-NE and stakeholders regarding PPR. ISO-NE reviews communication.
3. NESCOE, ISO-NE, and stakeholders specify the federal, state and local PPRs, if any, that will be addressed in a Public Policy Transmission Study (PPTS).
4. NESCOE determines whether the identified PPR(s) drive the need for transmission, and if so, requests ISO-NE to perform the PPTS
5. If a PPTU is pursued based on the PPTS, ISO-NE will publicly issue an RFP inviting Qualified Transmission Project Sponsors (QTPSs) to submit proposals
6. ISO-NE selects the project(s) and execute the Selected Qualified Transmission Project Sponsor Agreement (SQTPSA).
7. As applicable, ISO-NE notices the transmission developer to proceed with upgrades on its existing transmission system required by the proposal.

ISO-NE Public Policy Transmission Upgrade Process

- During the last two planning cycles (2017 and 2020), NESCOE did not request that ISO-NE initiate a PPTU for the planning cycle. Comments from multiple stakeholders, including Avangrid, National Grid, NextEra Energy Transmission, and TDI New England, cited the need for transmission based on the renewable portfolio standards (RPS) of New England states, the required solicitations for clean energy, and greenhouse gas (GHG) emission targets. For instance, one specified need was transmission to deliver hydro power from Québec and wind energy from northern Maine.

- The developer of the selected bid under a PPTU RFP will be able to recover costs from ISO-NE based on transmission tariff revenues. ISO-NE employs a special cost allocation for public policy projects selected through a RFP:
  - 70% of the costs of upgrades are spread throughout the region on a load-ratio basis. They are included in the Pool Transmission Facilities costs recoverable under the ISO-NE OATT.
  - 30% of the costs are allocated on a load-ratio basis among states with public policies driving the need for the project. The Regional Network Load of each state is based on the estimate of the MWhs of electric energy (or MWs of capacity, if applicable) needed over the requested study period to satisfy the state's policy goals.

- Given the ambitious offshore wind targets and extensive offshore wind development activities, industry stakeholders have argued that there is a need for offshore transmission and the reinforcement of various POIs. The most accessible offshore wind POIs in Southern New England have been utilized. Stakeholders argue that to meet New England's offshore wind goals cost-effectively and without undue delays from major onshore transmission upgrades, ISO-NE and states will need to consider coordinated offshore transmission development.

- NEMOEC may be positioned to submit a proposal for offshore transmission to connect offshore wind in the Gulf of Maine to the onshore grid if a RFP is issued by ISO-NE or the New England states.

ISO-NE Public Policy Transmission Upgrade Process

- On March 2nd, 2023, Shell Energy North America (Shell) submitted a request to ISO-NE to activate the 2023 PPTU process for the purpose of facilitating the integration of offshore wind and achieving state and federal climate goals. Shell argues in its PPTU request that the process would advance the timely, efficient and coordinated transmission needed for offshore wind development and create the conditions for holistic and comprehensive planning not otherwise available in ISO-NE today or in the near future. The request suggests that the process advance in parallel with the development of offshore wind already underway in order to develop a transmission buildout in the most cost-effective manner. Rhode Island Energy also submitted a concurrent request in which one of their cited transmission needs is to allow the transfer of offshore wind generation to Rhode Island customers as well as the rest of New England.

- Shell's request asks ISO-NE and NESCOE to consider the following transmission needs:
  - upgrades to onshore grid infrastructure to increase injection capacity of POIs and allow for growth in offshore wind integration, and
  - reducing the number of cables and POIs to shore from offshore wind in BOEM's leasehold areas off the coast of Rhode Island and Massachusetts.

- ISO-NE has released the PPTU requests and must decide on whether it will initiate the process. NESCOE's decision on whether the included policy goals and integrating offshore wind to the grid drives a transmission need will be a strong indicator of the results for a similar process of analyzing offshore wind transmission in the Gulf of Maine.

External Elective Transmission Upgrade (ETU)

- If the NEMOEC corridor is not able to qualify as a PPTU, the alternative path to connect to the ISO-NE grid is an external ETU.

- The Atlantic Link project was bid into the Massachusetts RFP as a controllable external ETU. An external ETU is a merchant-funded transmission project that interconnects the New England control area with another control area and is subject to ISO-NE's operational control through an operating agreement. Even as an external line, the ETU can participate in ISO-NE's forward capacity market (FCM) and receive Capacity Network Import Interconnection Service for capacity and energy.

- The advantages of being an external ETU is that, even with interconnection to Nova Scotia, the NEMOEC corridor and suppliers can still realize the benefits of participating in the ISO-NE market. To execute the operating agreement with ISO-NE, coordination with NS Power will be necessary. The costs for ETUs are not recoverable under ISO-NE's transmission tariff but are allocated to the entities volunteering to pay for the upgrades (i.e., transmission right holders). This is a major disadvantage compared to a PPTU.

- The interconnection procedures for ETUs are similar to those of generating facilities and are laid out on the following slide.

Permitting Requirements – Timetable

- The tables on the following slides present the expected schedule for the federal permitting processes and the expected schedule for the US state, municipal, and private permitting processes required to be undertaken by the NEMOEC transmission corridor. The schedule focuses on major permitting requirements and is not intended to be all inclusive.

- The entire permitting process is estimated to take 4-5 years, but it should be noted that environmental permitting and regulatory delays should be expected when establishing a project schedule.

- In addition, the schedule shown does not account for time to draft applications for permits. It assumes applications for subsequent permits are filed promptly once a successor permit is approved. Leeway between drafting applications should be recognized.

- Because the NEMOEC facilities will provide access to shore for more than one offshore wind lease area, the corridor will be required to obtain a Right-of-Way (ROW) grant from BOEM in a separate ROW grant process. A BOEM ROW or Easement Grant request may be submitted as an unsolicited application, then BOEM will determine if there is a competitive interest before granting the ROW. A ROW grant is required prior to the initiation of other environmental permitting processes.

- The permitting timeline estimates are based on previous applications of offshore transmission projects such as the Atlantic Link and Southern New England OceanGrid Project, BOEM approvals, the timetables for offshore wind projects on the US federal permitting dashboard, and Massachusetts government regulations.

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Permitting Requirements – US Federal Level

Agency	Permitting/License/Authority	2025				2026				2027				2028				2029			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
United States - Federal																					
Bureau of Ocean Energy Management (BOEM), National Park Service (NPS)	ROW Offshore Grant*	■	■	■	■	■	■	■													
BOEM	General Activities Plan							■	■	■	■	■									
BOEM	Construction and Operations Plan								■	■	■	■	■	■	■	■	■	■	■		
BOEM	National Environmental Policy Act, Environmental Impact Statement								■	■	■	■	■	■	■	■	■	■	■		
Department of Energy	Presidential Permit									■	■	■	■	■	■	■	■	■	■		
Army Corps of Engineers (ACE)	Clean Water Act - Section 404											■	■	■	■	■	■	■	■		
ACE	Clean Water Act - Section 10											■	■	■	■	■	■	■	■		
ACE	Section 10 of the Rivers and Harbors Act													■	■	■	■	■	■		
Environmental Protection Agency (EPA)	Outer Continental Shelf Lands Act, Clean Air Act										■	■	■	■	■	■	■	■	■		
Various agencies	Section 106 of the National Historic Preservation Act										■	■	■	■	■	■	■	■	■		
Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS)	Federal Endangered Species Act Consultation															■	■	■	■		
National Oceanic and Atmospheric Administration (NOAA) Fisheries, NMFS	Magnuson-Stevens Fishery Conservation and Management Act															■	■	■	■		
FWS, NMFS	Fish and Wildlife Coordination Act Review															■	■	■	■		
NMFS, NOAA	Marine Mammal Protection Act											■	■	■	■	■	■	■	■		
FWS	Migratory Bird Treaty Act permits															■	■	■	■		
FWS	Bald and Golden Eagle Protection Permit															■	■	■	■		

Permitting Requirements – US State and Municipal

Agency	Permitting/License/Authority	2025				2026				2027				2028				2029			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
United States - Massachusetts																					
Massachusetts Environmental Policy Act Office (MEPA)	Massachusetts Environmental Policy Act									■	■	■	■	■	■	■	■	■	■		
EFSB	Massachusetts Energy Facilities Siting Board (EFSB) Approval												■	■	■	■	■	■	■		
Department of Environmental Protection (DEP)	Chapter 91 Waterways Regulations													■	■	■	■	■	■		
DEP	Section 401 Water Quality Certification													■	■	■	■	■	■		
CZM	Federal Consistency Review													■	■	■	■				
Massachusetts Office of Coastal Zone Management (CZM)	Wetlands Protection Act																■				
MA Endangered Species Act (MESA)	Conservation & Management Permit																■				
United States - Maine																					
Maine Department of Environmental Protection (MDEP)	Site Location of Development, Natural Resources Protection App									■	■	■	■	■	■	■	■	■	■		
Maine Public Utilities Commission (MPUC)	Certificate of Public Convenience and Necessity (CPCN)											■	■	■	■	■	■	■	■		
Maine Land Use Planning Commission (LPUC)	Certification for Transmission Facilities in Unorganized Territories											■	■	■	■	■	■	■	■		
MDEP	401 Water Quality Cert./Construction General Permit																■	■	■		
United States - Municipal/Private																					
	Zoning Variance Approval and Permit																■	■	■		
	Converter Station Agreement																		■		
	Underground Cable Agreement																		■		

National Interest Electric Transmission Corridors

- The Energy Policy Act of 2005 (EPAct) first authorized FERC if a state withheld its approval or did not move fast enough to approve interstate transmission projects in "national interest electric transmission corridors" ("NIETCs") identified by the DOE. This "backstop" authority was nullified by two court cases and FERC has not received applications for permits to site transmission facilities under this process. However, in addition to establishing new funding mechanisms for transmission development, the IIJA strengthened the federal government's authority to site electricity transmission lines.

- The DOE can now designate NIETCs based on future "transmission capacity constraints or congestion," and now may consider (in addition to "economic growth", "energy independence", and "diversification" of energy supplies) two new factors. Whether:

    1. A site "maximizes existing rights-of-way"; and
    2. "The designation would enhance the ability of facilities that generate or transmit firm or intermittent energy to connect to the electric grid."

- This second criterion appears to apply to the NEMOEC corridor.

National Interest Electric Transmission Corridors

- The DOE intends to provide a process for the designation of NIETCs on a route-specific, applicant-driven basis, with the goal of designating facilities the developer has already assessed as an attractive investment. Once the DOE has designated a NIETC, FERC can issue construction permits in that corridor if it finds the project meets certain criteria (which covers the same issues the DOE considers). For the interconnection of the NEMOEC corridor to the ISO-NE grid, the DOE could designate the area of the project as a NIETC, allowing the possibility for FERC to approve the corridor for construction more expeditiously than the state authority. Clearly, requesting FERC to designate the NEMOEC transmission path a NIETC would be a last resort given that such a designation is unlikely to be supported by either Maine or Massachusetts, the support of which is likely to be crucial to the success of the initiative.

- The DOE may designate a NIETC in federal waters which would allow it to enter into a partnership under the TFP and qualify for transmission facility financing. The significant permitting value a NIETC provides aids with onshore permitting. BOEM's permitting requirements will still apply to a project located in a designated NIETC in federal waters.

- It is important to note the exercise of the backstop authority will most likely invoke NEPA and require an EIS to be considered by FERC for approval.

Canada Planning and Permitting Processes

Canada Planning and Permitting Processes

NS Power Interconnection Process

- The interconnection framework for NS Power generally follows that used by ISO-NE, with both following the FERC large generator interconnection standards. NS Power doesn't have a specific procedure for external elective transmission upgrades, as such there may be some complexities with interconnection that aren't fully recognized by NS Power existing interconnection procedures.

- This section outlines the studies and requirements in the NS Power Interconnection Procedure of a large generating facility, which is the assumed process the NEMOEC corridor will be required to complete.

Canada Permitting Process

- The permitting regime of Canada is not as clearly defined as that of the US. With no development of offshore wind energy to date, Canada is still developing its regulatory policies. However, there are a handful of permits and requirements which are already established. There are currently several initiatives and developments which, once completed, will institute the regulations and requirements for an offshore transmission corridor off the coast of Nova Scotia.

Nova Scotia Power Transmission Planning Process

- NS Power has interconnection procedures for generators and load requests, but a process is not specified for external transmission facilities. However, the interconnection procedures for NS Power are similar to ISO-NE's, both follow relevant FERC orders. Power Advisory expects that an external transmission line, such as the NEMOEC transmission corridor, would be required to complete a similar planning process to what is outlined for large generating facilities. The procedure includes:
    - Feasibility Study (FS) – Preliminary evaluation of the proposed interconnection to the system.. The FS also functions to uncover any unexpected result(s) not contemplated during the Scoping Meeting.
    - System Impact Study (SIS) – Evaluation of the impact of the proposed interconnection on the reliability of the system, consisting of a short circuit analysis, a stability analysis, and a power flow analysis. The SIS provides the requirements or potential impediments to providing the requested connection service and the necessary upgrades.
    - Facilities Study (FAC) – Specification and estimation of the cost of the equipment, engineering, procurement, and construction work needed to implement the conclusions of the SIS to interconnect to the system.
    - Optional Interconnection Study (OIS) - Sensitivity analysis based on the assumptions provided by developer, estimating the cost to provide interconnection service.
- Following the studies, the developer and NS Power may execute the Generation Interconnection Agreement (GIA), accompanied by a deposit or letter of credit acceptable to NS Power equal to the estimated upgrade costs identified.

Studies Cost & Timeline

Cost	Study	Timeline
100% of the estimated study costs ($15,000 deposit)	**FS**	**100 days**
Deposit: $150,000 Re-Study Deposit: $300,000	**SIS**	**200 days**
Deposit: $75,000 Re-Study Deposit: $75,000	**FAC**	**180 days**
100% of the estimated study costs ($50,000 deposit)	**OIS**	**Mutually agreed upon time**

Re-studies may be required if higher queued projects drop out of the queue. This may extend the timeline by 45-60 days depending on the study and the developer will be responsible for all additional costs.

NS Power Interconnection Process Timeline

- The table below presents the expected schedule for NS Power's interconnection procedure and approval process required to be undertaken by the NEMOEC transmission corridor. The schedule is aligned with the overall permitting process so that NS Power would provide approval around the time in which the environmental permitting efforts begin.
- To expedite the corridor's interconnection, NS Power may offer and sign with the developer an Engineering & Procurement (E&P) Agreement. The optional procedure allows NS Power to begin engineering and procurement of long lead-time items necessary for the establishment of the interconnection.
- The submission of the Interconnection Request initiates the interconnection procedure. The developer must submit the required form with a refundable deposit of $15,000, which is to be allocated to the cost of the FS. NS Power assigns an initial queue position based upon the date and time of receipt of the valid Interconnection Request. Once the required studies are completed and the GIA is signed by both parties, the project is approved to begin construction planning.

Agency	Permitting/License/Authority	2025				2026				2027				2028				2029			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Canada - Regional																					
NS Power	Feasibility Study (FS)				■	■															
	System Impact Study (SIS)					■	■	■													
	Facilities Study (FAC)							■	■												
	Optional Interconnection Study (OIS)					■	■	■	■												
	Approval (Generation Interconnection Agreement)								■												

Nova Scotia Regulatory Approval

NSUARB Support for Interconnection Facilities

- As discussed in the Lessons Learned from the Maritime Link, under the Maritime Link Act, there is specific criteria that the transmission project was required to meet to be approved by the NSUARB. The NEMOEC transmission corridor is not expected to apply for ratepayer funding to recover all costs. However, NS Power could elect to own the interconnection facilities and may apply for ratepayer funding, recognizing that these facilities are a more traditional utility investment that would enable the interconnection of multiple projects that are offering their output to Nova Scotia customers. These facilities will need to be approved in an application to the NSUARB.

Permitting Requirements - Canada

- The table on the following slide presents the expected schedule for the Canadian permitting processes required to be undertaken by the NEMOEC corridor at all levels of jurisdiction. The schedule focuses on major permitting requirements and is not intended to be all inclusive.

- The current permitting and regulatory regime in Canada for offshore development is less defined than that of the US. Currently, there are several initiatives under way to establish the regulations, overseeing authorities, and requirements for offshore development in Canada and specifically Nova Scotia. The NEMOEC transmission corridor will likely be subject to the new authority and requirements once they are put in place. Those initiatives are explained in detail on the following slides.

- Similar to the US schedule, environmental permitting and regulatory delays in Canada are to be expected. There may be even a higher risk of delays given that part of the regulations and requirements will be new. First movers in the offshore development industry must account for this risk and an extended project development schedule.

- In addition, the schedule does not account for time to draft applications for permits. It is less clear which applications require the fulfillment of other permits to be initiated, but leeway between drafting applications should be recognized.

- The permitting timeline estimates are based on the previous application of the offshore transmission project, the Atlantic Link, and Canadian government regulations.

Permitting Requirements - Canada

Agency	Permitting/License/Authority	2025				2026				2027				2028				2029			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Canada - Federal																					
CER	International Power Lines Permit																				
Minister of Environment and Climate Change	Canadian Environmental Assessment																				
CER, Public Services and Procurement Canada, NS Department of Natural Resources	Canadian Waters Real Property Licensing																				
Canada Energy Regulator (CER)	Electricity Export Permit																				
Minster of Fisheries and Oceans	Fisheries Act Authorization																				
Minster of Fisheries and Oceans	Species at Risk Act Auhtorization																				
Canada - Nova Scotia																					
NS Environment and Climate Change	Nova Scotia Environmental Assessment																				
Canada - Municipal/Private																					
	Canadian Construction Permits																				
	Converter Station and Interconnection Point																				

Offshore Renewable Energy Regulations

- Natural Resources Canada (NRCan) is developing Offshore Renewable Energy Regulations (ORER) under the Canadian Energy Regulator Act to develop safety and environmental protection regulations that will apply to exploration, construction, operation and decommissioning activities related to renewable energy projects and transmission lines in Canada's offshore areas.

- In August 2019, Part 5 – Offshore Renewable Energy Projects and Offshore Power Lines - of the Canadian Energy Regulator Act was enacted and enables the Canada Energy Regulator (CER) to review and authorize activities related to offshore renewable energy. The ORER outlines how the CER will implement its responsibilities for overseeing the development of offshore renewable energy and associated transmission projects which includes site characterization activities, construction, certification, operation, maintenance and decommissioning of offshore renewable energy facilities and offshore transmission lines.

- NRCan is working to ensure the development of these regulations is coordinated with coastal provinces so that they may serve as a model in any potential future joint management arrangements for offshore renewable energy projects. See the following slide for more on joint management related to Nova Scotia.

- The initiative completed the first phase by releasing a discussion paper on the proposed approach to regulating offshore energy activities. The paper proposes using outcome-based requirements or prescriptive requirements depending on the proponent and activity. The initiative is currently in its second phase, a pre-engagement on technical requirements based on the draft paper.

- The current timeline estimates a pre-publication of the ORER in Part 1 of the Canada Gazette for public comments in 2023 and a Final Publication of ORER / Entry Into Force in 2024.

Canada-Nova Scotia Offshore Energy Board

- The Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation Act ("Accords Act") established the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) with the task of regulating oil and gas exploration and development activities that take place in the Canada-Nova Scotia offshore area. In April 2022, the federal and provincial government announced its intent to expand the CNSOPB's mandate to include the regulation of offshore renewable energy development. The agency will become the Canada-Nova Scotia Offshore Energy Board (CNSOEB).

- Currently, the CNSOPB reviews oil and gas activity for environmental risks and hazards, implements health and safety legislation, and authorizes operators to conduct their offshore activities. As the life cycle regulator, the Board is responsible for ensuring that developers and operators have submitted the appropriate application materials.

- The authorization process requires a project specific environmental assessment (EA) by the CNSOPB or an impact assessment (IA) by the Impact Assessment Agency. This process can be completed between six months and three years. The advantage of the combined approach is that the nature of the proposed offshore activity dictates which regulatory stream proponents are to follow. For activities that require an IA, the CNSOPB typically accepts the IA as fulfilling its Accord Acts authorization requirement for an EA.
    - To receive authorization, the operator must develop a series of comprehensive plans and procedures.

- The CNSOEB's approach will leverage the existing petroleum regime and make changes where necessary to address offshore renewable energy requirements. This will also result in a scheduled land tenure / licensing system for offshore wind in the NS and NL offshore areas.

- The ORER established by NRCan will be used to finalize the regulatory regime that is enforced by the CNSOEB.

Atlantic Provinces Offshore Wind Development

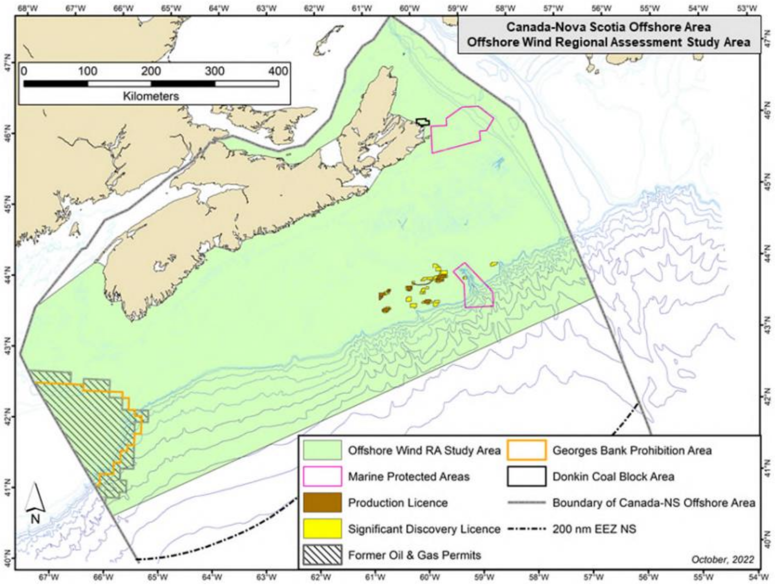
Regional Assessment of Offshore Wind Development in Newfoundland and Labrador and Nova Scotia

- The Impact Assessment Agency of Canada (IAAC) is working with the Newfoundland & Labrador and Nova Scotia governments, Indigenous groups, federal authorities, non-governmental organizations and the public to plan the Regional Assessment of Offshore Wind Development in these provinces. The assessment will define the goal, objectives, geographic boundaries, activities, outcomes and governance structure of offshore development and inform future federal impact assessment decisions. The impact assessment requirements are currently described under Section 44 of the *Physical Activities Regulations*.

- The overall objective of the Regional Assessment is improving the effectiveness and efficiency of future planning and impact assessments for offshore wind development activities through providing information and analysis on existing conditions, potential effects, and mitigation. These activities include the transmission of electricity to shore. Regional analysis will help identify areas for future wind development and any key constraints. This may determine the areas in which and how NEMOEC can develop transmission off the coast of Nova Scotia.

- Regional assessments for Newfoundland and Labrador and Nova Scotia, are expected to start in early 2023 and last 18 months, with phased deliverables.

Figure 1.1: Regional Assessment Study Area (Nova Scotia)



Source: Impact Assessment Agency of Canada

Key Takeaways

- For the NEMOEC facilities secure funding it will be important to find a way to secure value for the benefits that do not flow to transmission rights holders and receive compensation for these benefits in addition to selling the right to use the transmission facilities to deliver energy to various markets. Another important revenue stream is to recognize the value that these facilities offer as interconnection facilities and secure a stable revenue stream for this service.

- Securing funding from various federal programs and the Canada and US will reduce financing challenges for an investment of this magnitude.

- Additional cost sharing models exist between states through agreements with transmission system operators or collaboration between multiple states or provinces.

4) Roadmap for Deployment of Offshore Wind and NEMOEC Facilities

Next Steps to Progressing the NEMOEC Facilities

- This White Paper has detailed the benefits and outlined the technical, policy and regulatory considerations for the NEMOEC facilities.
- To progress the concept of the NEMOEC facilities, an achievable roadmap has been outlined in the following section that details the necessary regulatory approvals and outlines other potential barriers.

Expand Stakeholder Engagement	**Identify Champions**	**Identify Funding Opportunities and Related Research**	**Refine the Scope Based on Feedback, Champions and Funding**
Address Areas of Additional Study	**Identify Market Barriers**	**Assess Transmission Planning & Interconnection Challenges**	**Identify Permitting Ambiguities**

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Stakeholder Engagement and Champions

Key Parties in Nova Scotia

- Nova Scotia Government
- Federal Government
- Nova Scotia Power
- Green Hydrogen Developers
- NGOs
- First Nations
- Fisheries
- Economic development agencies
- CNSOEB

- Expanding the stakeholder engagement process should focus on securing productive feedback on the NEMOEC concept, including identifying champions from key stakeholders. Key stakeholders are identified for both Nova Scotia and New England.
    - Champions would be parties that are likely to be willing to support the initiative or become engaged and provide feedback to refine the concept to enhance the prospects for success.

Key Parties in New England

- New England state Governments
- Federal Government
- Electric Utilities
- Floating offshore wind developers in Maine
- NGOs
- Tribal communities
- Fisheries
- ISO-NE
- Research Institutions

Coordination with Critical Parties Impacting NEMOEC Development Prospects

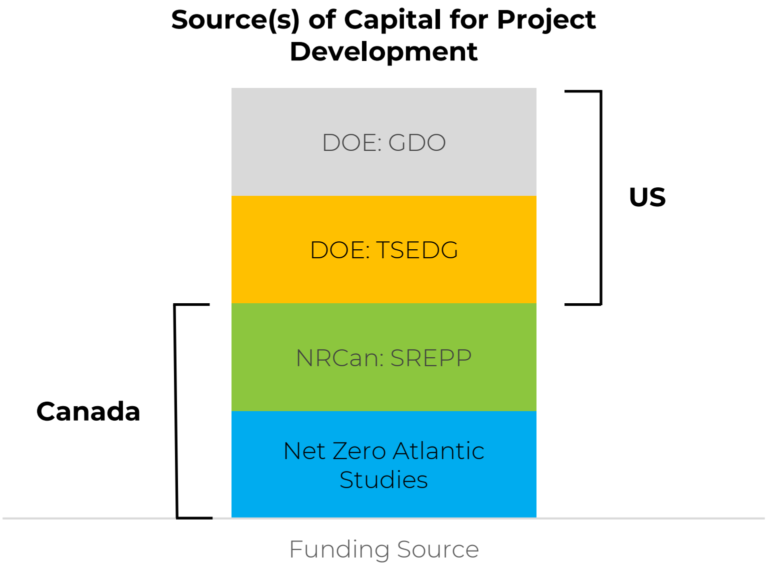
- There are a wide range of parties that will influence the development prospects of the NEMOEC corridor. Securing input from these parties as well as informing these parties about the role that the NEMOEC corridor can play in supporting the realization of their offshore wind ambitions as well as broader clean energy goals will be critical to both assessing the opportunity offered by the NEMOEC corridor as well as advancing the prospects for the project.

- Earlier we identified the need to identify champions. There is also a need to identify a steward for the NEMOEC corridor (i.e., a party or consortium that will seek to advance the NEMOEC). Without such support the project is more likely to languish.

- The NEMOEC corridor is a well-suited initiative for the recently created Energy Transformation Task Force established by the U.S. and Canada. The Energy Transformation Task Force is tasked to work across the clean energy economy and accelerate cooperation on critical clean energy opportunities including grid integration and resilience.

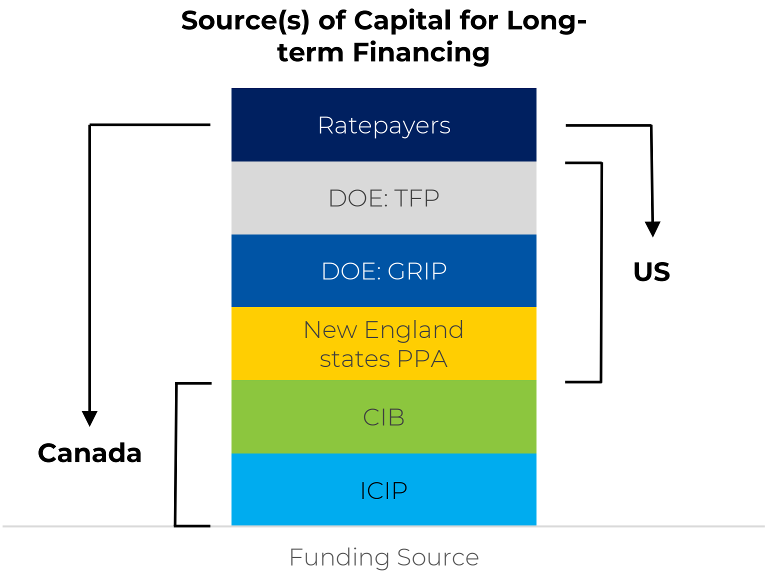
Funding Opportunities: Project Development

- If the NEMOEC coalition is interested in progressing the initiative, it will be important to identify funding opportunities to: (1) further develop the concept (project development funding); and (2) secure long-term financing.
- There will likely be a need for some development funding from one or more members of the coalition at a minimum to pursue funding from other sources.
- Potential development funding sources include the DOE's Grid Development Office (GDO): Transmission Loans and the Transmission Siting and Economic Development Grants (TSEDG) to support states and local communities in the siting and permitting of interstate and offshore electricity transmission lines; NRCan's Smart Renewables and Electrification Pathways Program (SREPP); Net Zero Atlantic funding for studies to assess the market opportunities.



Funding Opportunities: Long-Term Financing

- There are a range of alternative long-term financing options.
- In the US, there are federal funding opportunities provided by the DOE, including the TFP and GRIP. The following slide explains the process by which entities can apply and source funding under the GRIP through the Grid Innovation Program (GIP). GRIP funding would require a state sponsor as outlined in the next slide.
- The federal government in Canada currently provides funding for activities that support inter-provincial electricity transmission projects and infrastructure projects that increase the capacity to integrate renewable energy to the grid. The newly presented Budget 2023, highlights of which are included in this section, offers several different financing opportunities which will likely be accessed through the CIB. The NEMOEC coalition may need to partner with the Nova Scotia government to access federal financial support.
- As discussed, another funding source is utility ratepayers. This would likely be for parts of the NEMOEC line that were deemed connection facilities that could used to avoid generator lead line investments by offshore wind developers.



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DOE Funding Opportunity: Grid Innovation Program (GIP)

- Funded through the Bipartisan Infrastructure Law, the GIP provides $5 billion for fiscal years (FY) 2022-2026 ($1 billion/year) to support projects that use innovative approaches to transmission, storage, and distribution infrastructure to enhance grid resilience and reliability. Eligible projects include interregional transmission projects and investments that accelerate interconnection of clean energy generation two criteria that apply to the NEMOEC facilities.

- Eligible entities include states (individual or combined), tribes and territories , local governments, and public utility commissions. Projects are subject to a 50% cost share minimum and must come from non-federal sources.

- To apply project proponents must submit a concept paper and an application for the specific GIP funding. The concept paper should include project's eligible uses and technical approaches, the grid-benefitting outcomes to be delivered by the project, the impact that DOE funding would have on the proposed project, and the expected timing of the project. The full application consists of submitting of list of components such as project site location, a technical volume, resumes, community partnership documentation, a summary/abstract, and more.

DOE Funding Opportunity: Grid Innovation Program (Cont'd)

- The first funding cycle, announced on November 29, 2022, and in which concept papers were due January 23, 2023, will include both FY22 and FY23, up to $2 billion. The DOE provided responses to concept papers in March and applications are due May 19, 2023. The DOE anticipates announcing subsequent funding opportunities during the October – December 2023 timeframe. Therefore, the next funding cycle will likely occur in 2024.

- The NEMOEC coalition may wish to consider exploring participation in future GIP funding rounds. However, considerable work is required to mature the initiative as well as the prospects for offshore wind projects that would use the corridor before funding is likely to be secured from a program such as GIP where the evaluation criteria assign 20% of the weight to the "Project Plan and Project Financial Feasibility". This includes describing the approach, workplan, and deliverables. In addition, the major market uncertainties that are constraining the development of offshore wind in Nova Scotia and the Gulf of Maine must be resolved. This includes making available lease areas and demonstrating a market for the output of offshore wind projects (e.g., in the GoM establishing offshore wind procurement authority for Maine and increasing Massachusetts' procurement authority).

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Canadian Funding Opportunities

NRCan Funding

- Budget 2022 provided CAD $250 million over four years, starting in 2022-23, to NRCan to support pre-development activities of clean electricity projects of national significance, such as inter-provincial electricity transmission projects and small modular reactors. It also proposes CAD $600 million in funding over seven years starting in 2022-2023 to NRCan for the Smart Renewables and Electrification Pathways Program (SREPP) to support additional renewable electricity and grid modernization projects. Additional funding was provided in the 2023 budget discussed on the next slide.

- To formally apply for the program, applicants are required to complete and submit a Project Registration Form to NRCan, followed by a Technical and Financial Project Application. The federal government is using this funding to advance similar transmission projects such as the Atlantic Loop and Prairie Link. Additional investigation is necessary to determine whether an inter-regional connection between Nova Scotia and New England would be eligible.

Investing in Canada Infrastructure Program (ICIP)

- The ICIP is a federal program started in 2016 to provide long-term funding delivered by Infrastructure Canada to help reduce air and water pollution, increase resilience to climate change and create a clean-growth economy. Over $33-billion in funding is still to be delivered through bilateral agreements between Infrastructure Canada and each of the provinces and territories. The Green Infrastructure stream of the program includes supporting projects that increase the capacity to manage more renewable energy and improved production of clean energy.

- Infrastructure Canada will invest up to 50% for provincial projects and 25% for for-profit private sector projects. Under the bilateral agreements, project will be assessed on their environmental outcomes with the goal of building climate-smart infrastructure that will help combat climate change, reduce energy costs and provide Canadians with safer and more resilient communities.

Canadian Funding Opportunities (Cont'd)

- The recently presented Budget 2023 introduces "Canada's Plan for a Clean Economy" to prioritize investing in sectors including but not limited to electrification, clean energy, emissions reduction, and infrastructure. The plan includes three tiers of federal financial incentives:

  1. Investment Tax Credit (ITC)
  2. Low-cost strategic financing; and
  3. Targeted investments and programming to respond to the unique needs of sectors or projects of national economic significance

- Canada Infrastructure Bank (CIB) is to invest at least CAD $20 billion to support the building of major clean electricity and clean growth infrastructure projects, CAD $10 billion through its Clean Power priority area and CAD $10 billion through its Green Infrastructure priority area.

  - The CIB has proven its willingness to invest in US-Canada interties, exemplified through its agreement to invest up to $655 million (40% of the project cost) in the Lake Erie Connector project. The CIB cited the economic benefits of exporting non-emitting power as the primary incentive. The NEMOEC facilities offer similar benefits.

  - CIB funding under the Clean Power and Green Infrastructure priority areas is an interesting funding opportunity for the NEMOEC initiative that warrants further investigation.

- Budget 2023 also provides $3 billion to NRCan to distribute over 13 years to several initiatives: funding for the SREPP to support critical regional priorities and Indigenous-led projects, adding transmission projects to the program's eligibility, the Renew the Smart Grid program to continue to support electricity grid innovation; and new investments in science-based activities to help capitalize on Canada's offshore potential, particularly off the coasts of Nova Scotia and Newfoundland and Labrador. This is the first time offshore wind has been highlighted for specific funding with an extended period for this funding.

- The newly proposed ITCs include two that are relevant: the 30% Clean Technology ITC, available to offshore wind projects, and the 15% Clean Electricity ITC, available to transmission projects. In addition, the Budget allows for a project to stack its baseline ITC with a 10% Atlantic ITC.

Refining the Project Scope

- As feedback about the effort is gathered, the NEMOEC coalition will need to more clearly outline the anticipated scope (location of facilities, sizing and phasing) of the corridor. This will require additional work and a better understanding of the anticipated offshore wind development potential in both Nova Scotia and the Gulf of Maine (GoM).

- The primary constraint on offshore wind development in Atlantic Canada is likely to be market-related, i.e., what's the viable size of the market given offtake commitments from green hydrogen developers and NS Power.
  - The timing and scope of the green hydrogen market is relatively uncertain, as evidenced by the Joint Declaration of Intent establishing a Canada-Germany Hydrogen Alliance and the recent approval of the Point Tupper green hydrogen and ammonia development.
  - The green hydrogen market will depend in part on the policy environment established in the various Atlantic Canada provinces to support it. This includes putting in place electricity market rules that enhance the liquidity and depth of provincial renewable energy markets so that there is a portfolio of clean energy resources that can be relied upon to provide competitively priced clean energy to electrolyzers. Securing additional understanding regarding these issues will help in assessing the growth potential for offshore wind in Atlantic Canada and Nova Scotia.

- Ultimately, further understanding of the offshore wind market potential in Atlantic Canada is likely to be gained over time. This could be a critical determinant of the pace of development for the NEMOEC facilities.

- The primary constraint on offshore wind development in the GoM initially will be the size of the lease areas made available by the Bureau of Ocean Energy Management. With a GoM lease auction scheduled for 2024, additional clarity on this issue will be available relatively soon.

Refining the Scope

- With the size of the offshore wind development potential better understood, the NEMOEC coalition will be able to better establish:
  - Optimized sizing of facilities to detail what will be connected from the Gulf of Maine and Nova Scotia areas;
  - Corridor capacity to more accurately assess the benefits;
  - Sequencing relative to offshore wind developments in Nova Scotia and in the Gulf of Maine (and Southern New England) to determine whether the scope would include connecting as much offshore wind as possible to the onshore grid or whether it would act more as an offshore intertie between jurisdictions;
  - Corridor location to be able to consider all offshore constraints to optimize the pathway;
  - Preferred Points of Interconnection (POI) for the corridor to evaluate the potential upgrades required; and
  - Transmission technology to be utilized based on the relative maturity of different technologies that would ultimately influence the technical design of the backbone system.

Transmission Planning and Interconnection

- As discussed, there are a number of outstanding issues with respect to the configuration of the NEMOEC corridor. One critical issue is identifying preferred POIs to the NS Power and ISO-NE grids. We selected POIs that are located near major load centers (Halifax and Port Hasting where green hydrogen development activity is located in Nova Scotia, Mystic in the Metropolitan Boston area), but haven't assessed the need or cost for any system upgrades. Furthermore, Mystic is being considered as a POI for other projects, indicating that its viability of as a POI may change based on the timing of any such projects.

US Permitting Requirements and Considerations

- There exists overlap within federal and state permitting authorities. The Federal Consistency Review by Massachusetts will require data and information to be presented before the conclusion of the federal environmental approval. This overlap can complicate project permitting efforts.

- As discussed in Section 3, a ROW grant is required for an offshore transmission project to initiate its environmental permitting processes, namely approval under the National Environmental Policy Act and the Environmental Impact Statement by BOEM. Approval of the ROW will also impact how the corridor plans to interconnect to ISO-NE. NEMOEC should recognize that the ROW grant process is considered essential before it can embark on all other required permitting and planning processes.

- A critical permit for international transmission lines is the Presidential Permit. Under Executive Order 11423, as amended, the DOE must review the construction, connection, operation, or maintenance of any international electric transmission lines in order to grant a Presidential Permit. To grant a permit, the DOE must work with other federal agencies to determine whether the project is in the US national interest under two main criteria: impact on electric reliability and environmental impact. The application requires technical descriptions, interconnection details, transmission system maps, and environmental impacts that addressed in other permits. This information will need to be prepared well before other studies have been completed. It will be important to coordinate with the DOE and other agencies to avoid the duplication of requests and activities.

Canada Permitting Requirements and Considerations

- The permitting process in a number of areas is undeveloped and still being defined. Therefore, there is uncertainty with respect to the regulations that the NEMOEC corridor will be subject to. It will be important to monitor the ORER, CNSOEB, and regional assessments for changes to regulations. Power Advisory expects that the ORER and CNSOEB will utilize the existing oil and gas regime for offshore development.
  - NRCan is responsible for developing ORER to develop safety and environmental protection for activities related to renewable energy and transmission lines in Canada's offshore areas. Phase 3, the pre-publication of the ORER in Part 1 of the Canada Gazette is to occur in 2023, followed by a Final Publication of ORER / Entry Into Force in 2024.
  - The CNSOEB is likely to take a combined approach in which the environmental assessments of the federal government will satisfy the Nova Scotia's requirements. The final approach will depend on the results of ORER.
  - The Regional Assessment of Offshore Wind Development in Nova Scotia will determine the areas in which and how NEMOEC can develop transmission. The Impact Assessment Agency of Canada, NRCan, the Nova Scotia Department of Natural Resources and Renewables, the 5 committee members, and industry players are all stakeholders. NEMOEC Coalition may wish to stay in touch with some of these key stakeholders.
- Clearly, there are challenges associated with assessing the implications of a permitting regime that is under development. Monitoring the development of the permitting process will assist Coalition members in understanding specific requirements and estimating development schedules, implications, and overall risks.

Areas of Additional Study / Next Steps

- The economic and environmental benefits outlined in Section 1 generally are high-level indications of the value offered, with many of these values based on historical information. More refined estimates will provide the confidence that is needed to support further funding that is required to progress the development of the concept. For benefits that were not quantified, including for benefits beyond what is outlined in this White Paper, additional analysis would be required.
    - Capacity Benefit: consider quantifying the wind diversity capacity benefit, possibly by modeling the wind resources within the broader integrated power system. Can also confirm load diversity benefit based on capacity of the offshore transmission facilities.
    - Balancing Cost: estimate the balancing costs and quantify the potential cost reduction from wind diversity.
    - Reduced GHG Emissions: determine whether GHG emission reductions from Gulf of Maine could be attributed to the project or not based on scope, as well as confirm the appropriate end use for the green hydrogen comparison.
    - Market Optimization: Consider the potential impact of the EU rules on green hydrogen around "additionality" of clean energy with respect to the production of green hydrogen. These rules currently apply to external countries wanting to export to the EU – including Canada in its agreement with Germany – and whether such rules may be replicated within Canada going forward. This analysis should be done carefully to avoid double counting with other benefits.
    - Market Integration: analysis should be based on prospective view of market prices (as opposed to historical price differences). The study could also explore use of the facilities by neighboring jurisdictions like Newfoundland and Québec.
    - Grid Connection: a reasonable estimate of the avoided investment that would result from not relying on a gen-tie to connect to the grid, based on the size of the project.

Areas of Additional Study / Next Steps

- Market barriers should be explored to ensure that offshore wind development in Nova Scotia has viable offtake markets, and that the Nova Scotia electricity market offers sufficient clean energy liquidity to support both offshore wind development and its role as an electricity input to green hydrogen.

- Alternative development models should also be considered. For example, a portion of corridor could be treated as an offshore wind connector where (a) in Nova Scotia, traditional rate-base cost of service (COS) funding could apply; (b) in ISO-NE, a portion of the corridor could be considered as a Public Policy Transmission Upgrade (PPTU) for facilities needed to connect Gulf of Maine offshore wind to onshore grid. The backbone portion of corridor could be treated as merchant transmission, with transmission rights holders securing rights based on many of the monetized benefits identified above. Additionally, some support provided by other entities recognizing the broad-based benefits offered (e.g., given capacity benefits offered, could allow a portion of the costs to be rolled into the transmission tariff in both NS and ISO-NE).

- A high-level transmission study should be conducted identifying viable Points of Interconnection. This would also consider needed transmission upgrades in both Nova Scotia by NS Power and in New England by ISO-NE. The study could also consider integrating floating resources into the corridor.

- The economic development value of the NEMOEC facilities should be considered, comparing the potential deployment of larger volumes of offshore wind with alternative scenarios and the associated jobs and supply chain benefits that would result.

- The NEMOEC coalition and interested stakeholders should follow studies evaluating the opportunities offered by such projects along the Atlantic coast. One such study is being developed by Net Zero Atlantic: “Creating a Workplan for Offshore Wind Pathways to Market Studies”. This study will identify the studies required to analyze potential pathways to markets as well as an offshore wind grid integration study to identify grid constraints and necessary investments for the identified routes to market.

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