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

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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

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

Purpose

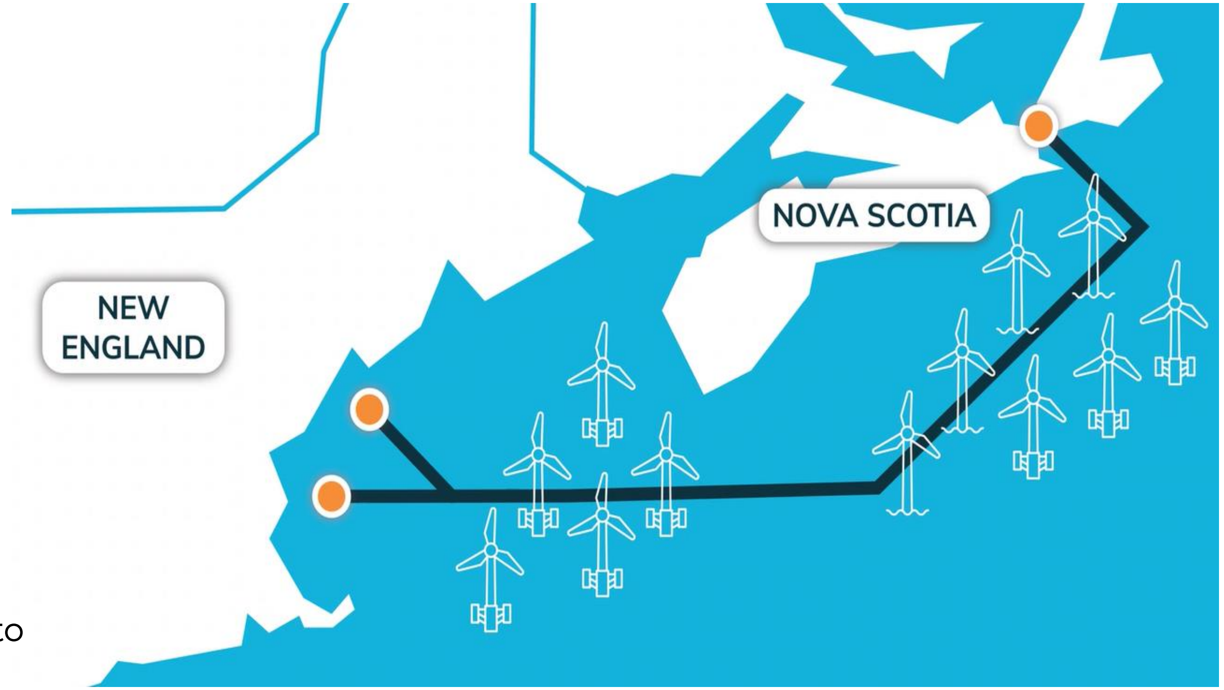
- This White Paper presents the high-level case for the proposed New England-Maritimes Offshore Energy Corridor (NEMOEC) transmission facilities between Nova Scotia and New England to connect two distinct offshore wind resource areas with the two load centers in each respective region, highlighting the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

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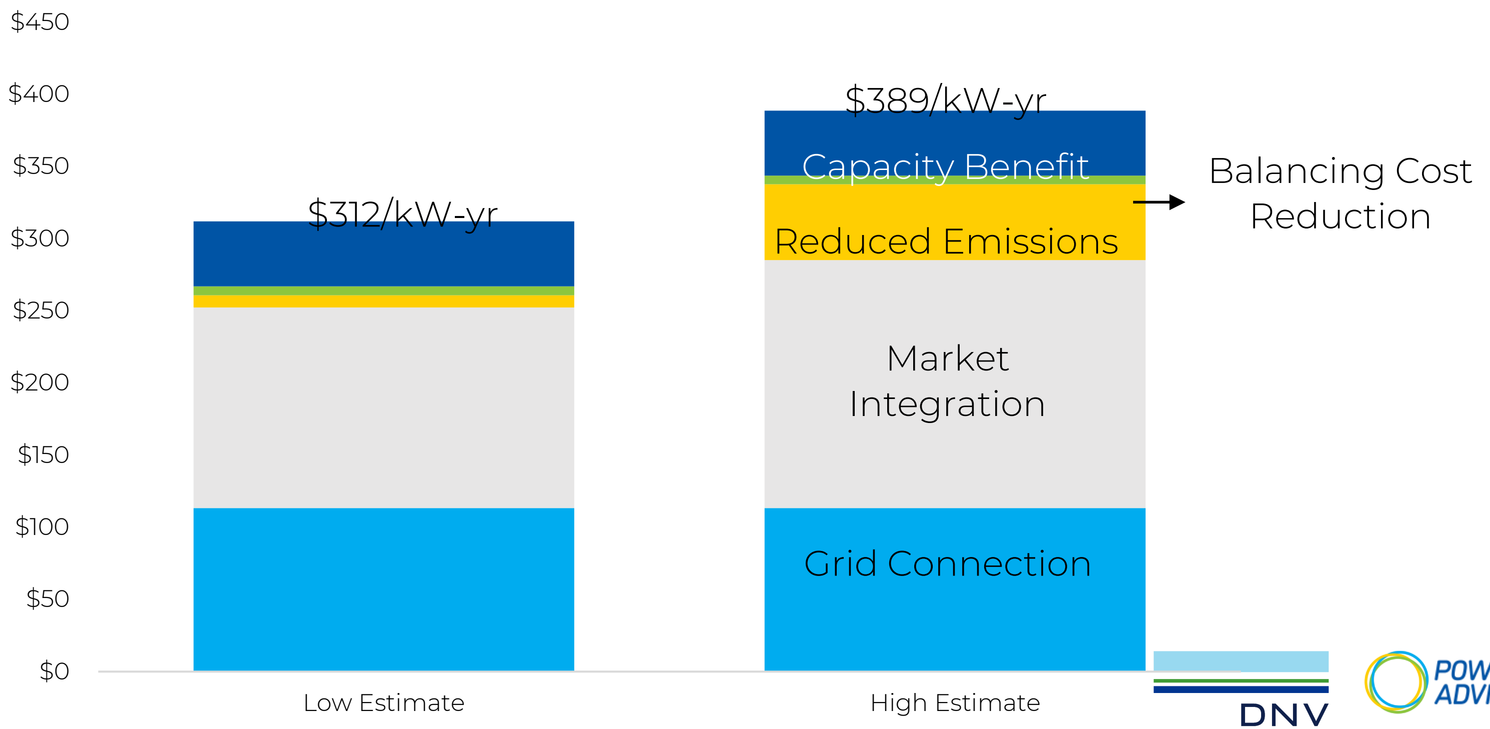
Monetized Benefits Summary

- 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



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.

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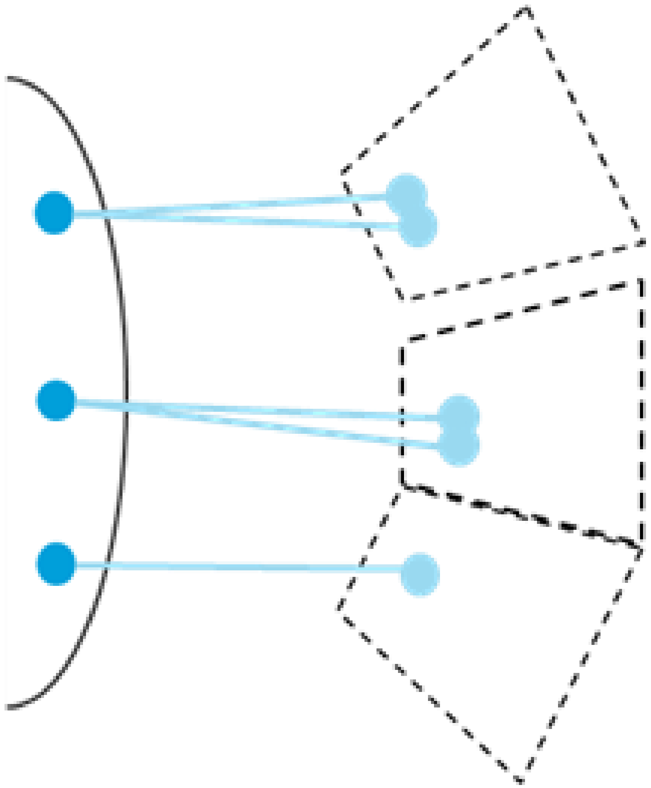
Standard Modular Multi-Terminal HVDC Design Enables Future Growth of NEMOEC Connections

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.



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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

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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.

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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