Marine Renewables Canada

Atlantic Canada Wind Energy Supply Chain Assessment

Final Report

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ABOUT

This study was commissioned by Marine Renewables Canada with support from the Atlantic Canada Opportunities Agency, the Nova Scotia Department of Energy, and the Prince Edward Island Energy Corporation. The project committee would like to thank the many individuals and organizations that provided input to the study through participation in workshops, surveys, and individual interviews. The study represents views and recommendations from the study authors and parties consulted throughout the project and should therefore not be construed as the position of the Atlantic Canada Opportunities Agency, the Nova Scotia Department of Energy, the Prince Edward Island Energy Corporation, and Marine Renewables Canada.

Xodus Group, with Nova Scotia-based Envigour Policy Consulting, Newfoundland and Labrador-based partners Angler Solutions and Caron Hawco Group, along with New Brunswick-based Roxham Advisory & Consulting Services, and Indigenous-relations expert Eric Christmas, have joined their expertise together to conduct a wind energy supply chain assessment of the Atlantic Canadian provinces. The project team would also like to express gratitude to everyone that participated in this research and contributed to this scope of work.

Xodus Group is a leading global energy consultancy, with established expertise in the offshore wind (OSW), hydrogen, and offshore oil and gas sectors. Formed in 2005 and headquartered in Scotland, Xodus currently employs over 500 multi-disciplinary engineers and specialist advisors.

Angler Solutions is an innovation-focused consulting firm based in St. John's, NL, with international experience delivering strategic advisory and project development services for the energy and ocean technology sectors. Angler specializes in early-stage project services, including feasibility studies, energy systems modelling, and techno-economic analysis.

Caron Hawco Group provides strategic advice on stakeholder engagement, socio-economic matters, reputation management, local content, regulatory affairs, and diversity for large energy projects and industries, including petroleum, hydrogen, wind and the clean/ocean tech sectors.

Envigour Policy Consulting was started in 2016 located in Nova Scotia. Principal Consultant Bruce Cameron has more than 40 years of experience in public policy critique, analysis, and development.

Roxham Advisory & Consulting Services was established with the goal of building resilient, sustainable businesses and communities. President and lead consultant Neil Jacobsen has spent the last three decades advancing Atlantic Canada's energy sector, specializing in energy policy, regulatory affairs, and economic development.

EXECUTIVE SUMMARY

INTRODUCTION

Atlantic Canada possesses among the strongest wind resources in the world, both offshore and onshore. With strong capabilities in marine industry and technology, an existing onshore wind supply chain poised for growth, a capable workforce, and a track record of Indigenous participation, this region is set to see significant economic benefits from the ongoing development of offshore and onshore wind energy sectors.

Atlantic Canada Bulk Terminal, Sydney, NS (Credit: Christopher Morrison)

Offshore wind (OSW), still nascent in many geographies, is rapidly becoming a mainstream energy generation technology. With both bottom-fixed and floating OSW options, wind energy can now access the stronger, more consistent winds found offshore. The desire for green hydrogen and increasing renewable penetration in regional energy systems are key sources of demand driving wind energy development. The wind resource potential both onshore and offshore in Atlantic Canada has attracted the attention of wind energy developers to the region, where marine industrial knowledge, deep water ports, extensive experience in major civil construction, significant quayside development space, and a skilled workforce present a major opportunity.

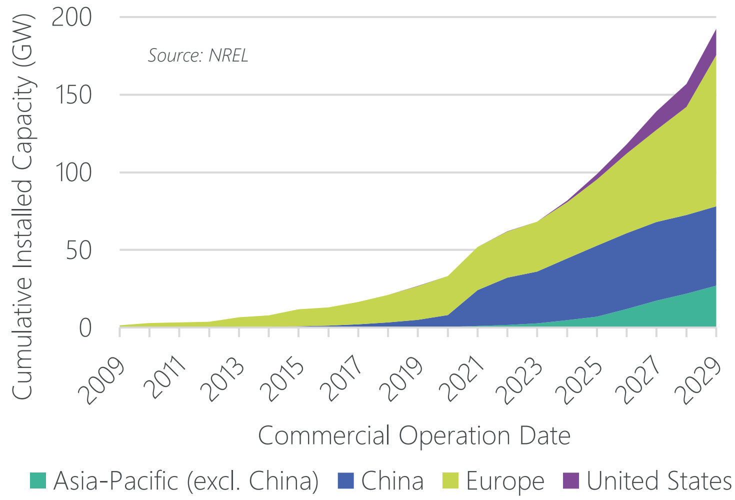
In addition to performing a supply chain assessment of local companies across Atlantic Canada for onshore and offshore wind, this report provides background on the status of wind industry development and actionable recommendations for supply chain growth. The assessment of the offshore and onshore wind energy supply chain potential in Atlantic Canada identifies strengths and gaps, leading to the development of strategies and actions to support existing regional companies. The goal of this scope of work was to conduct research, engage with stakeholders and rights holders, and develop evidence-based insights to assist industry, suppliers, governments, Indigenous community members, and Atlantic Canadian residents with understanding pathways for supply chain development that will result in sustainable offshore and onshore wind industries, while realizing significant local benefits for the provinces and their communities. A summary of the recommended actions for supply chain development based on short-term (2025), medium-term (2026-2030) and long-term timeframes (2030+), along with proposed action owners, is provided below, followed by key details and findings from the analysis. Additional information can be found in the full version of this report.

RECOMMENDATIONS SUMMARY

#		Offshore	Onshore	Timeline S	Timeline M	Timeline L	Owner
	Supply Chain			S	M	L	
	Leverage Existing Supply Chain Strengths						
1	Long-Term Value Creation in Supply Chain Investments	x	x		M		Government/Utilities/Regulators, Developers and/or Tier 1s, Ports
2	Explore Manufacturing Interest to Encourage Supply Chain Clustering	x	x			L	Government/Utilities/Regulators, Developers and/or Tier 1s, Ports
	Strengthen Wind Industry Ecosystem Support						
3	Streamlined Supply Chain Development Program	x	x	S			Economic Development/Industry Organizations
4	Promote and Assist Rural Businesses		x		M		Government/Utilities/Regulators, Economic Development/Industry Organizations
	Encourage Supply Chain Diversity						
5	Establish and Communicate Industry Diversity Expectations	x	x	S			Government/Utilities/Regulators, Economic Development/Industry Organizations
6	Establish Provincial or Regional Diversity Entities/Entity	x	x		M		Government/Utilities/Regulators, Economic Development/Industry Organizations
7	Diversity Plans For Large-Scale Projects (>500 MW)	x	x			L	Government/Utilities/Regulators
	Facilitate Indigenous Involvement in Offshore and Onshore Wind Industry						
8	Educate Developers on Indigenous Equity Options	x	x	S			Government/Utilities/Regulators, Economic Development/Industry Organizations, Developers and Tier 1s
9	Create an Indigenous Supply Chain Hub	x	x		M		Government, Economic Development/Industry Organizations, Developers and Tier 1s
	Workforce						
	Strengthen Workforce Support Structures						
10	Commitment to Coordination Between Training Entities	x	x	S			Training/Academia
11	Industry-Funded Training Initiatives	x	x		M		Training/Academia, Developers/Tier 1s
	Improve Access to Training and Workforce Development						
12	Community Career Opportunity Outreach	x	x	S	M		Training/Academia, Economic Development/Industry Organizations
13	Strengthen Apprenticeship Initiatives	x	x			L	Government/Utilities/Regulators, Training/Academia
	Connect Workers with Jobs in Wind Industry						
14	Adjacent Industry Workforce Attraction	x	x		M		Government/Utilities/Regulators, Training/Academia, Economic Development/Industry Organizations
	Policy						
	Send Positive Market Signals for Regional Wind Energy Development						
15	Explore Electricity Export Opportunities	x		S	M	L	Government/Utilities/Regulators
16	Set Capacity Targets for Wind Energy Development	x	x		M		Government/Utilities/Regulators
17	Establish Transparent and Predictable Permitting and Offtake Processes	x		S	M	L	Government/Utilities/Regulators, Developers and Tier 1s, Economic Development/Industry Organizations
18	Establish Investable Value of Offshore Wind	x		S	M	L	Government/Utilities/Regulators
19	Explore Reductions in Cost of Doing Business in Atlantic Canada	x				L	Government/Utilities/Regulators
	Policy Support for Local Economic Benefits						
20	Direct Licensing Funds to Build Needed Infrastructure	x				L	Government/Utilities/Regulators
	Leadership and Communication						
	Build Industry Awareness and Support						
21	Public Wind Industry Educational Campaign	x	x	S			Economic Development/Industry Organizations
	Create Supply Chain Development Momentum						
22	Interprovincial Collaboration on Wind	x	x		M		Government/Utilities/Regulators, Economic Development/Industry Organizations
	Innovation						
23	Innovation for Next Generation Wind Technology	x	x	S			Training/Academia, Developers and Tier 1s
24	Carbon Footprint Management in Wind Energy Supply Chain	x	x	S			Training/Academia, Developers and Tier 1s
25	Develop 3D Printing to Support Wind Industry Activities	x	x		M		Training/Academia, Developers and Tier 1s

OFFSHORE WIND

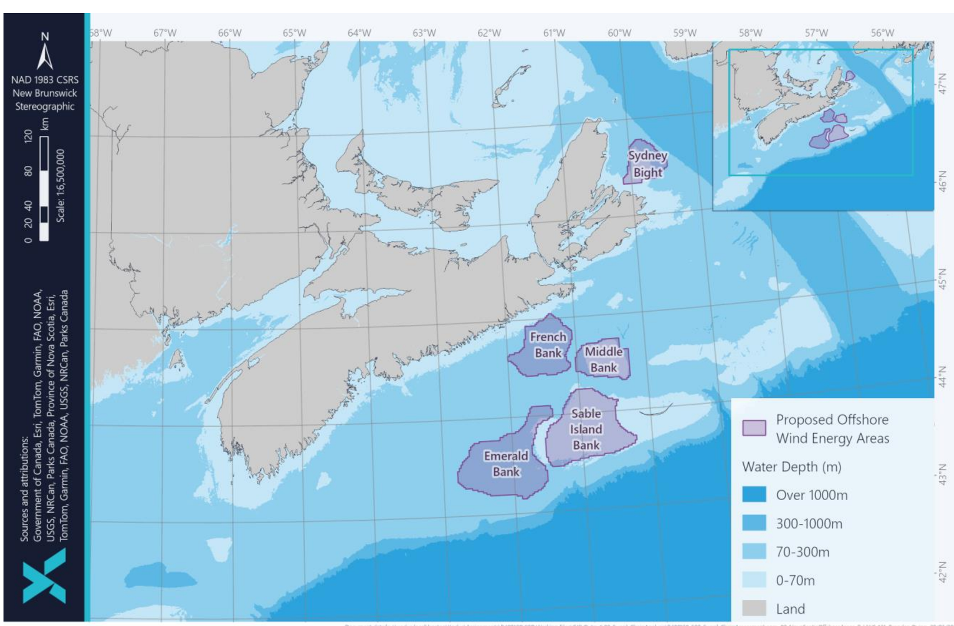
The global OSW industry represents nearly 70 gigawatts (GW) of installed capacity, with up to 190 GW planned to be installed by 2029. Outside of China, the European region dominates OSW activities, both in terms of installation and supply chain capability. Global OSW development is continuing to expand on a global scale, with several countries and continents having ambitious capacity deployment targets set for the 2030s and 2040s. This will continue to create opportunities for supply chain development and expansion in relation to increased demand.



Global Offshore Wind Forecast (Source: NREL, 2024)

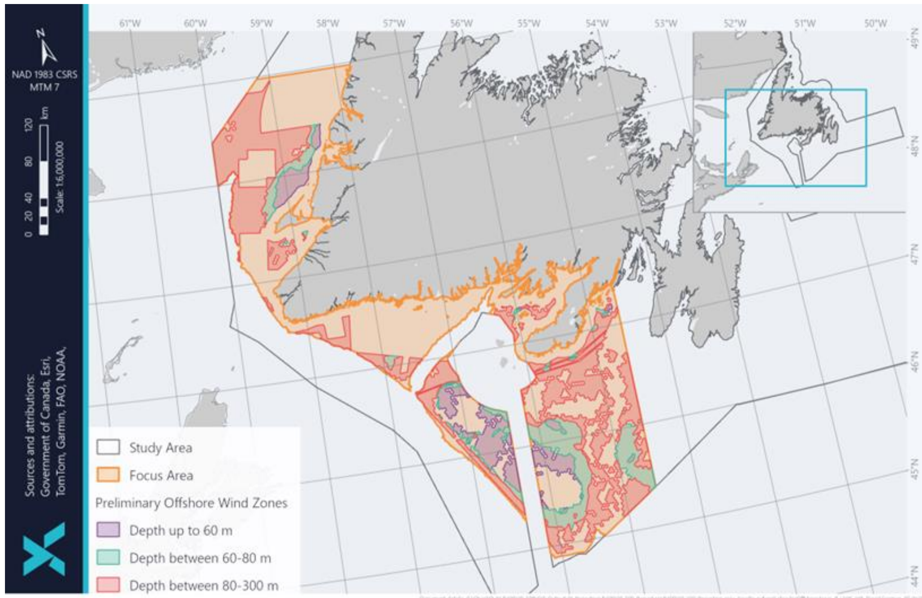
This is truly a global industry, with products being produced and shipped around the world. It has, however, been affected by the rise in supply chain and commodity prices over the past two to three years resulting in a more cautious approach to emerging markets, along with a focus on returns and project certainty to send market confidence signals. Site awards, subsidy mechanisms, and establishing procurement targets are some of the core policy mechanisms that countries use to support industry growth, and are crucial for developing a domestic supply chain.

Atlantic Canada offers ideal environmental conditions for OSW, including consistent speeds in excess of 11 m/s, as well as suitable water depths and bathymetry. Despite this, Canada does not yet have any installed OSW; however, the province of Nova Scotia (NS) has a stated goal of leasing 5 GW of OSW capacity by 2030. Until now, a major challenge to the development of Canada's OSW industry has been the lack of a regulatory framework, however recently passed legislation amending the Atlantic Accord Acts has mandated joint federal-provincial management of offshore renewables in NS and Newfoundland and Labrador (NL)



Nova Scotia Offshore Wind Energy Areas

Currently only NS and NL are pursuing OSW, and have undergone joint federal-provincial Regional Assessment (RA) processes to provide information, knowledge, and analysis that will inform future OSW development processes. Following from the RA recommendations, five Wind Energy Areas were announced by the NS government, with plans for a licensing round sometime in 2025.



Identified Potential Future Development Sites (Regional Assessment of OSW Development in NL, 2025)

While NL has not publicly committed to OSW development, the RA report provided recommended future development areas. Additionally, there are 16 designated bays in NL where joint federal-provincial management is not required for the development of offshore renewables. Both NS and NL have the possibility to develop both fixed-bottom and floating offshore wind. New Brunswick (NB) has no stated plans to develop OSW but may consider it if project economics improve. Prince Edward Island (PEI) also has no current OSW development aspirations.

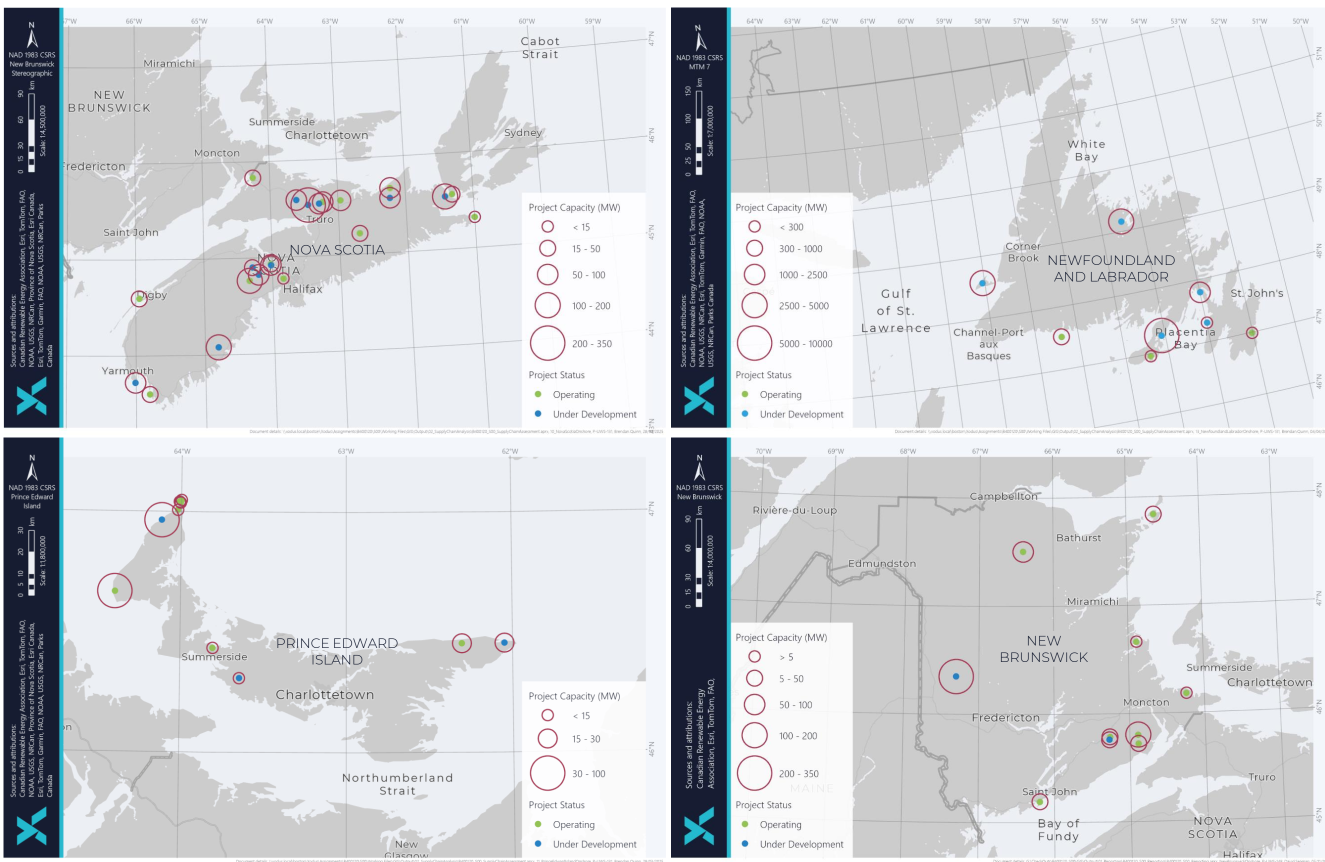
Several ports in NS and NL have already supported projects in the US by marshalling— the process of collecting, storing and preparing wind turbine components before they are transported and installed at the wind farm site—major components such as monopiles, transition pieces, and blades, owing to their existing readiness and capabilities.

Monopiles at the Port of Argentia, NL (Credit: Port of Argentia)

ONSHORE WIND

There is currently in excess of 945 GW of installed onshore wind capacity globally. China and the US continue to dominate as the largest markets for onshore wind installations, followed by Brazil, Germany, and India. With onshore wind now being one of the cheapest sources of energy across markets and offering largely localized supply chain and workforce opportunities, it features prominently in many countries' decarbonisation plans. Similar to OSW, clarity on market access and revenue streams remains a critical focus for supply chain development.

Atlantic Canada has seen significant onshore wind development since PEI's first pilot project in 2001. The region has seen a plateau in onshore wind development over the last decade, although several small-scale projects have been installed during this time. Primary drivers of wind development in Atlantic Canada today are clean electricity goals and, more recently, green hydrogen production. Canada has signed MOUs with Germany and the Netherlands, establishing partnerships for green hydrogen supply and export. The availability of Crown land in NL paired with the lifting of the wind moratorium have created significant onshore wind demand for green hydrogen, with a total of 28.4 GW planned.



	NS	NL	NB	PEI
INSTALLED ONSHORE WIND CAPACITY	623 MW	55 MW	397 MW	204 MW
PLANNED ADDITIONAL CAPACITY FOR GRID	1.4 GW by 2030	500 MW by 2030	1.7 GW by 2035	309 MW by 2032
PLANNED CAPACITY FOR H_2 PRODUCTION	4.4 GW by 2035	28.4 GW by 2035	1.7 GW by 2032	None to date

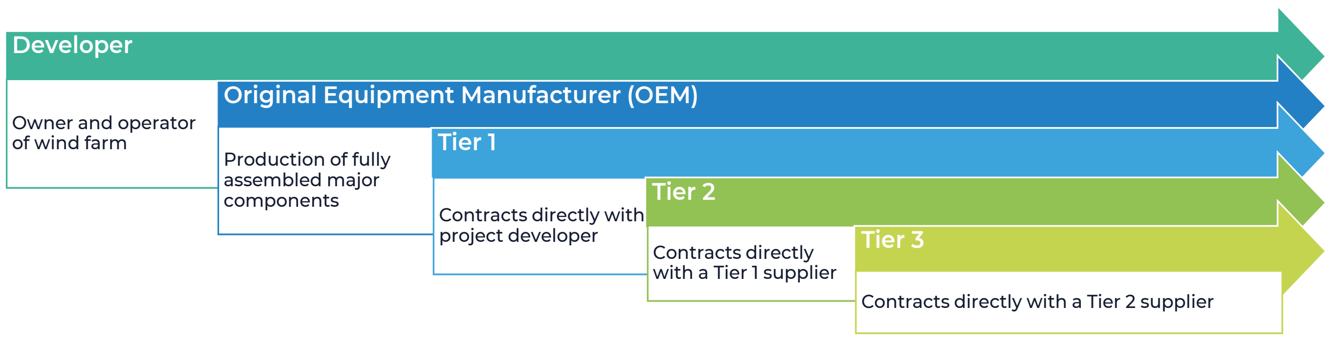
SUPPLY CHAIN ASSESSMENT

When describing the supply chain of an industry, standard terminology, also referred to as taxonomy, is used to categorize companies based on standard contracting structures. Supply Chain Areas, also known as "packages" represent the project development lifecycle. Supply Chain Elements comprise the components, activities, and services required to deliver a project. Companies in this assessment are considered at the Supply Chain Element level.

SUPPLY CHAIN AREA	SUPPLY CHAIN ELEMENT	FIXED/FLOATING/ ONSHORE
PROJECT DEVELOPMENT	Project management	All
	Permitting	All
	Onshore surveys and environmental monitoring	All
	Offshore surveys and environmental monitoring	Fixed, Floating
	Engineering and design	All
MANUFACTURING AND COMPONENT SUPPLY (WTG AND BOP)	Major industrial electrical equipment supply	All
	Minor industrial electrical equipment supply	All
	Industrial motion precision component fabrication	All
	Blade supply	All
	Major steel component supply	All
	Secondary steel component supply	All
	Mooring supply	Floating
	Cable supply	All
	Ancillary equipment supply	All
	Vessel design and build	Fixed, Floating
CONSTRUCTION, TRANSPORTATION INSTALLATION AND COMMISSIONING (CTI&C)	Onshore construction	All
	Onshore tower and turbine installation	Onshore
	Offshore installation works	Fixed, Floating
	Electrical/grid connection and commissioning	All
	Onshore logistics	Onshore
	Vessels and marine logistics	Fixed, Floating
OPERATIONS AND MAINTENANCE (O&M)	Operations	All
	Onshore inspection, maintenance and repair (IMR)	Onshore
	Offshore inspection, maintenance and repair (IMR)	Fixed, Floating
DECOMMISSIONING	Dismantling onshore infrastructure	All
	Removal of subsea infrastructure	Fixed, Floating
	Repowering	All
	Site restoration	All
SECTOR SUPPORT	Government, industry associations, non-profit organizations	All
	Training, Academia, Labour Organizations (Unions) and R&D	All
	Other professional services	All

The desk-based portion of the supply chain assessment focused on analysing existing companies in Atlantic Canada for their ability to support offshore and onshore wind supply chains. The goal of this exercise was to establish an understanding of the strengths and gaps that exist in Atlantic Canada, providing proponents with an informed idea of suitable supply chain activity and where it would take place, and identifying opportunities where outside investment/partnerships could stimulate supply chain growth. This consisted of categorizing a list of companies—sourced through regional industry associations, economic development organizations, and other entities—according to the respective wind energy taxonomy, and then individually assessing relevant companies to determine to what degree they would be able participate.

The assessment was carried out using publicly available data about the company, including websites, press releases, news articles, social media, etc. The supply chain of companies necessitates use of standard terminology, including Developers, OEMs, and Tiered suppliers, defined below. The scope of this supply chain assessment looks primarily at local opportunities for Tier 1 to Tier 3 companies. A total of approximately 1,070 companies were assessed to have some level of applicability in OSW, onshore wind, or both.

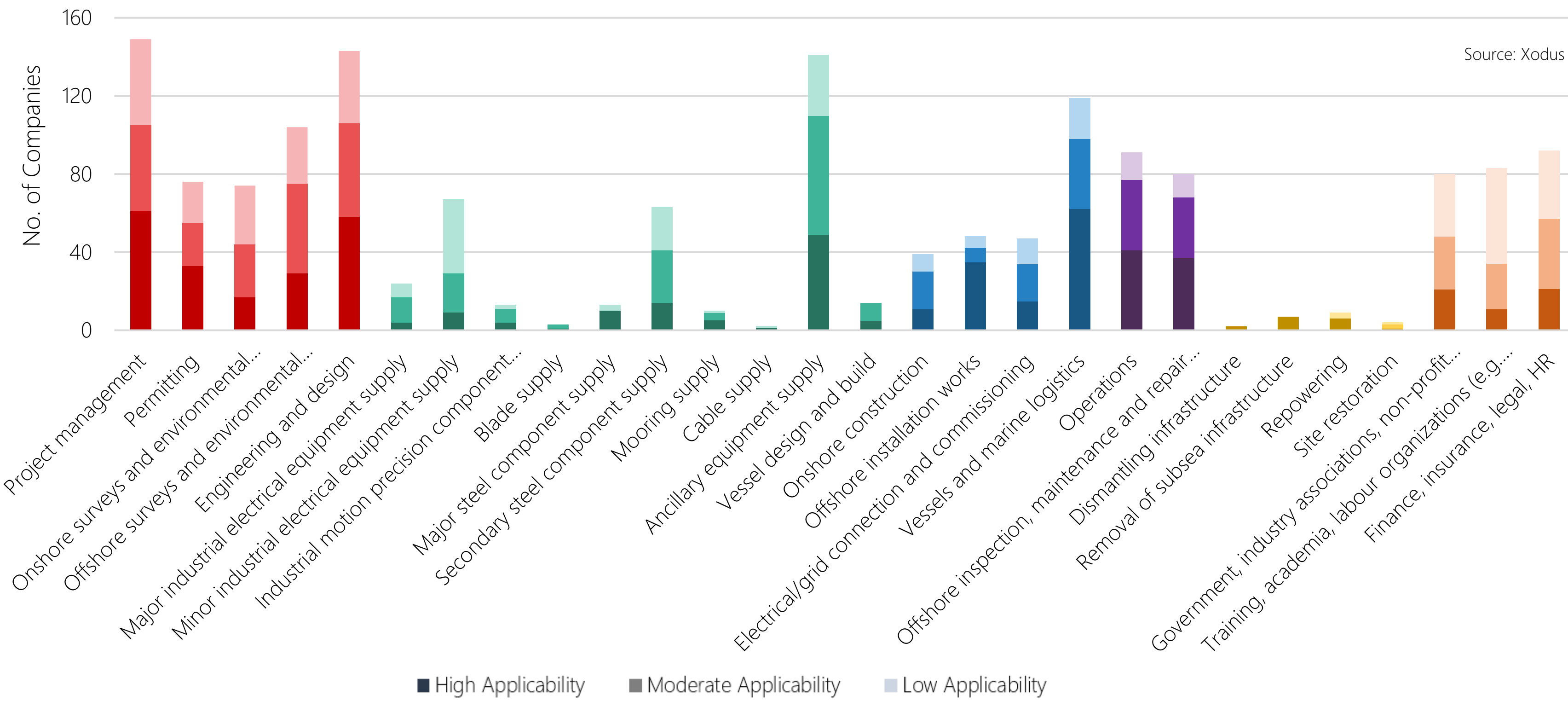


All companies were assessed for high, moderate, or low applicability according to the supply elements they are mapped to, as follows:

- **High applicability:** Company has direct experience in offshore/onshore wind or provides products/services that are highly relevant to offshore/onshore wind in design, scale and production volume; investment required to transition company into offshore/onshore wind is minimal, and/or would be directly applied to scaling/qualification operations;
- **Moderate applicability:** Company has no direct experience in offshore/onshore wind but provides products/services that are like those relevant to offshore/onshore wind in design and scale; investment required is moderate and would be needed to help company retool, meet standards/qualifications, and scale operations;
- **Lower applicability:** Company provides products/services that resemble those needed in offshore/onshore wind but would need to significantly change operations to enter the industry; significant investment in retooling, meeting specifications/qualifications, and scaling would be required.

The results of the supply chain assessment of companies are provided in the following pages, noting observed strengths and gaps. OSW results are presented first, followed by onshore wind. Note that there is a slight difference in the taxonomy used given the differences in supply chain between the two technologies.

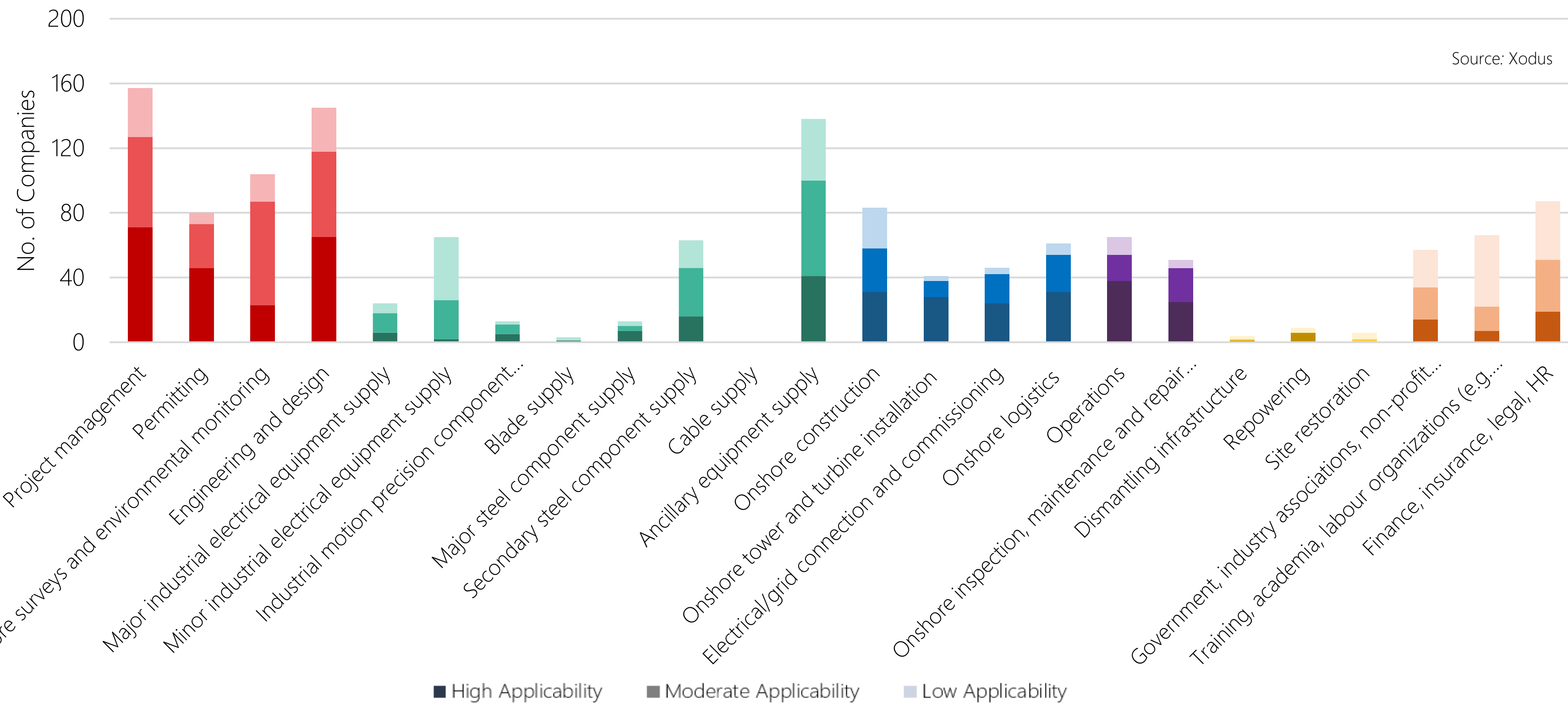
Offshore Wind Supply Chain Assessment Results



Strengths: Atlantic Canada's greatest OSW-related strengths are in Project Development, including **engineering, environmental monitoring, permitting and project management**, with many of these capabilities supporting marine industrial activities. Substantial steel and **secondary steel component fabrication** capabilities exist, with local companies that are capable of fabricating **large steel components**. There is a strong local presence in **marine logistics and vessel services**, along with **offshore installation and maintenance** experience that can be leveraged within the region.

Gaps: There are very **few manufacturing operations** in the Atlantic Canada region, **lacking scale and serial production capabilities** required to produce major OSW components. There is also a gap in companies capable of **decommissioning activities.**

Onshore Wind Supply Chain Assessment Results

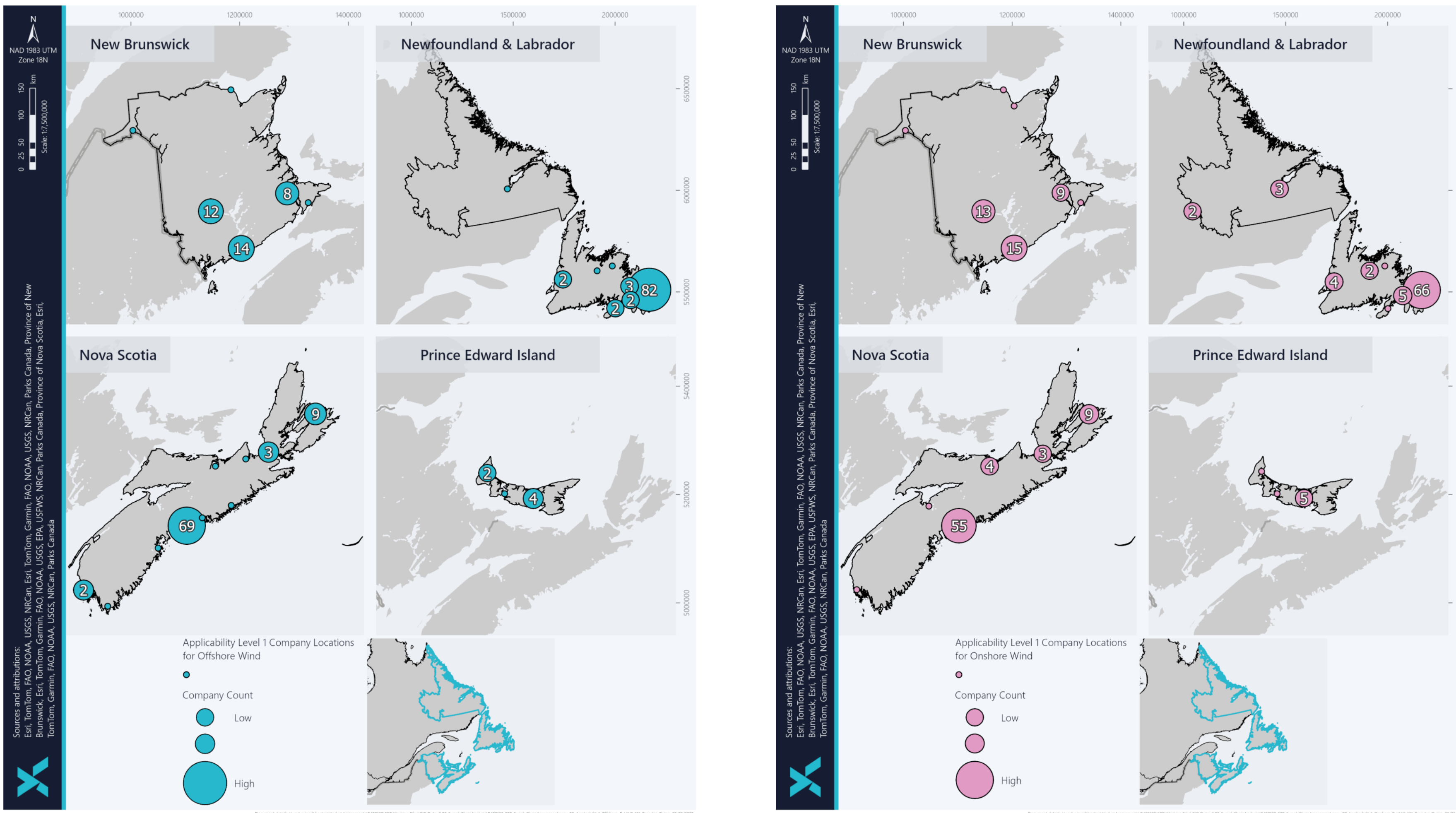


Strengths: Project Development, including **engineering, environmental monitoring, permitting and project management**, are regional strengths, with several companies having direct industry experience. Additional strengths exist in supplying **secondary steel and ancillary equipment** as well as in **onshore construction, logistics, and installation activities.** Approximately 23 independent companies identified as suppliers of **major industrial electrical equipment** (such as control systems, transformers, switchgear, etc.) along with smaller industrial electrical equipment providers.

Gaps: Atlantic Canada **does not produce components** for the onshore wind sector, with **blade and cable supplies notably limited**. There is a gap in companies stating **decommissioning capabilities**, however given strengths in onshore construction and logistics this is likely a non-issue.

Geographic Distribution of High Applicability Companies

Distribution of high applicability companies across the Atlantic Canadian provinces is shown for OSW (left) and onshore wind (right). It is observed that many of the larger, high-applicability companies have offices in most or all Atlantic Provinces, particularly those with direct offshore/onshore wind experience or experience in adjacent industry. Companies are mostly concentrated around major cities: Most companies are coastal, owing to the substantial coastlines possessed by each province, and their reliance on marine commerce. Overall, approximately 21%-28% of companies assessed were assigned high-applicability.



Geographic Distribution of High Applicability Companies for Offshore (left) and Onshore (right) Wind, by Province

OPPORTUNITY ANALYSIS

This analysis considered the results of the supply chain assessment of companies, paired with review of provincial energy literature, and engagement with a broad cross-section of Atlantic Canadian stakeholders and rights holders, including government, utilities, developers, economic development/industry groups, ports, and more. An opportunity analysis was carried out to assess regional strengths and opportunities, as well as weaknesses and threats, with respect to supply chain development for offshore and onshore wind. These were then used to synthesize recommendations that will help the industry to identify priority actions for supply chain development based on short-term (2025), medium-term (2026-2030) and long-term actions (2030+), as well as identify parties to execute on the recommended actions.

Strengths and Opportunities

- **World-class wind speeds, both offshore and onshore**, have already attracted significant developer attention.
- **Growing track record of experience** leveraging port infrastructure for storage, laydown, assembly, and maintenance of OSW projects.
- **Transferable skills from adjacent industries**, including offshore O&G, shipbuilding, civil construction, manufacturing, and structural handling.
- **Strong network of existing workforce development institutions** with potential to develop offshore and onshore wind training programs.
- **Established pathways for Indigenous economic opportunities** on renewable energy and infrastructure projects.
- **Positive market signals from OSW objectives** in NS and early leadership from industry organizations like MRC, Net Zero Atlantic and Energy NL.
- **Potential for local partnerships with global suppliers** to build capacity and enable diversity initiatives.
- **Retired/underused O&G infrastructure** can be repurposed for wind development.
- **Opportunity for universities and R&D clusters** to drive innovation in offshore and onshore wind technology research areas.
- **Adjacent industry workforce** that is familiar with offshore marine industrial operations.
- **Ecosystem of technology-focused innovation** in autonomous systems, advanced 3D printing, digital twins, etc.
- **Opportunity for regional collaboration** around best practices in permitting processes, diverse workforce engagement, and local supply chain incentives.

Weaknesses and Threats

Identified weaknesses and threats to wind industry supply chain development are summarized below, indicating which of the recommendations apply as mitigating measures to these challenges.

CATEGORIES	WEAKNESSES & THREATS	MITIGATING RECOMMEDATION(S)
Supply Chain	Global bottlenecks in workforce and equipment availability across multiple concurrent projects, especially for essential infrastructure like transmission and distribution components (e.g. transformers, cables); No local major component manufacturing.	2, 17, 19, 25
	Port and transportation infrastructure (e.g. bridges) upgrades needed to handle shipments of onshore and OSW components.	1, 20
	High cost of doing business in Canada, including high federal duty on temporary imported vessels impacting project economics.	19
	Stakeholder scepticism and resistance to wind developments in new areas with large-scale rapid rollout with perceived inadequate communication. Lack of formal local content mandates, resulting in a lack of clarity and visibility of benefits.	3, 17, 21
	Complex and onerous procurement systems and certification processes of top tier suppliers could discourage local suppliers from participating.	3, 4, 8, 9
	Difficult to identify diverse-owned companies due to lack of reporting; difficult to confirm diverse-ownership without certification.	5, 6, 7, 8
Workforce	Labour shortages in key roles like technicians, electricians, and grid engineers. Aging local populations impacting workforce availability; Limitations with existing apprenticeship systems.	4, 10, 11, 12,13, 14
	Provincial bottlenecks in workforce and equipment availability across multiple concurrent projects.	2, 11, 16, 22
Policy, Leadership & Communication	Resistance from communities due to 'Not In My Backyard' (NIMBY) attitudes and environmental concerns, including within fishery (re: OSW), community benefits and regarding recyclability of components (blades).	16, 21, 24
	Pathways to market are not obvious – transmission systems and electricity export opportunities are currently limited.	15, 16
	Economic uncertainties, lack of consistent project pipeline, and lack of clear regulatory frameworks impacting investments in wind energy sectors.	2, 3, 15, 16, 22
	Global competition from regions with established wind supply chains and stricter local content policies.	2, 18, 19
	Regional competition among Atlantic provinces creating inefficiencies and missed collaboration opportunities. Regional disparities in labour market and infrastructure readiness between provinces.	10, 22
	Inter-provincial trade barriers limit the ability of provinces to provide mutual supply chain and workforce support.	10, 22
Innovation	Current cost and inflationary pressures may limit investment options within innovation or R&D space.	16, 18

SUPPLY CHAIN RECOMMENDATIONS

Leverage Existing Supply Chain Strengths

1. **Long-Term Value Creation in Supply Chain Investments:** Focus early investment on building long-term services that leverage existing experience and support sustainable industry growth with lower entry costs, such as legal, financial, environmental, engineering, and other professional services. Prioritize timely infrastructure investment in marshaling and O&M ports, like cranes and lifting equipment.

2. **Explore Manufacturing Interest to Encourage Supply Chain Clustering:** Explore opportunities to establish manufacturing operations and co-locate supply chain activity in Atlantic Canada. Develop a realistic and properly timed strategy to attract these manufacturing activities to the region, given a sufficient project pipeline.

Strengthen Wind Industry Ecosystem Support

3. **Streamlined Supply Chain Development Program**: Develop a supply chain program to identify and promote local companies' capabilities and mitigate barriers to entering the offshore and onshore wind supply chains. Establish a searchable supply chain database of local companies vetted for their stated capabilities and diverse or Indigenous ownership status, and collaborate with developers and broader industry to maximize local opportunities.

4. **Promote and Assist Rural Businesses:** Increase awareness of opportunities and understanding of supply chain requirements for rural companies. Establish virtual engagement tools to overcome geographical barriers and allow entry of rural companies into the supply chain through rural municipalities, EDOs, and/or Chambers of Commerce.

Encourage Supply Chain Diversity

5. **Establish and Communicate Industry Diversity Expectations:** Develop supplier diversity initiatives with benchmarks and measurable goals for developers and their subcontractors. Establish grants and subsidies to support diverse-owned businesses in scaling, retooling, and upskilling to encourage development and inclusion.

6. **Establish Provincial or Regional Diversity Entities/Entity:** Establish provincial or regional supplier diversity organizations to guide supplier diversity policies, establish a certification process for diverse-owned companies, and develop a searchable database of certified diverse businesses.

7. **Diversity Plans for Large-Scale Projects (>500 MW):** Require developers to include supplier diversity plans in licensing or offtake procurement processes for projects exceeding 500 MW, mandating engagement with diverse suppliers during early project phases.

Support Indigenous Involvement in Offshore and Onshore Wind Industry

8. **Educate Developers on Indigenous Equity Options:** Identify best practices for Indigenous equity options in wind projects. Educate developers and Tier 1 companies on Indigenous equity structures and associated benefits and ensure cultural alignment around Indigenous engagement and business practices.

9. **Create an Indigenous Supply Chain Hub:** Assist with partnership building for smaller or less experienced Indigenous supply chain companies by building a consortium with industry players and across Indigenous groups. Establish a single point of contact for developers to limit the burden of engagement with multiple entities.

WORKFORCE RECOMMENDATIONS

Strengthen Workforce Support Structures

10. **Commitment to Coordination Between Training Entities**: Streamline the region's wind energy training programs and ensure that they are fully aligned with industry requirements, expectations, and timelines. Coordinate the programs to complement each other and establish awareness of operations across institutions.

11. **Industry-Funded Training Initiatives:** Formalize partnerships between developers/OEMs and training institutions to provide funding, guidance, and curriculum for industry-focused training programs. Establish networks of certified training institutions such that Developers, OEMs, and Tier 1 and 2 suppliers have ready access to a trained local workforce while protecting trade secrets.

Improve Access to Training and Workforce Development

12. **Community Career Opportunity Outreach:** Organize outreach initiatives to highlight career paths in the wind energy field, targeting disadvantaged communities, adjacent industry, rural workers, and other overlooked communities. Inform the Atlantic Canadian workforce of the opportunities, timelines, and requirements in offshore and onshore wind to increase awareness. This outreach should target K-12 schools through to the trades and secondary education institutions.

13. **Strengthen Apprenticeship Initiatives:** Increase and improve apprenticeship opportunities to mitigate the current and anticipated future trades worker shortages. Ensure apprentices can transition into long-term employment in the offshore and onshore wind industries following journeyperson designation.

Connect Workers with Jobs in Wind Industry

14. **Adjacent Industry Workforce Attraction:** Create upskilling initiatives to allow workers to transition from offshore O&G, onshore construction, mining, and other relevant sectors to meet workforce bottleneck challenges while creating supplementary opportunities for the region's existing workforce.

POLICY RECOMMENDATIONS

Send Positive Market Signals for Regional Wind Energy Development

15. **Explore Electricity Export Opportunities:** Explore and firm other offtake pathways and end uses in export markets like the Northeast US states, other Canadian provinces, green fuels, and corporate PPAs to fully capitalize on the wind energy opportunity. Quantify these potential markets and establish timelines for development, given demand.

16. **Set Capacity Targets for Wind Energy Development:** Establish and clearly communicate provincial offshore and onshore wind procurement targets and timelines to drive supply chain planning and growth. Develop regional or provincial roadmaps to demonstrate a robust, long-term development pipeline to investors and developers.
17. **Establish Transparent and Predictable Licensing, Permitting and Offtake Processes:** Establish transparent and predictable licensing, permitting, and offtake processes and communicate relevant timelines to attract developers to the region. Harmonize environmental approval processes with licensing requirements, federal and provincial clean energy goals, and industry standards.

18. **Establish Investable Value of Offshore Wind:** Initiate a publicly funded assessment of Atlantic Canada's offshore wind resource to establish the value of OSW for investors and utilities. Develop a high-quality wind resource database to establish where OSW developments can fill in for onshore wind production.

19. **Explore Reductions in Cost of Doing Business in Atlantic Canada:** Investigate opportunities to remove interprovincial trade barriers and unlock economies of scale in workforce and supply chain development. Revisit the Federal Duty on Temporary Imported Vessels and finalize federal tax incentives for renewable energy development.

Policy Support for Local Economic Benefits

20. **Direct Licensing Funds for Industry Development:** Invest revenue from seabed licensing auctions to fund various industry development activities, such as transmission and infrastructure development, workforce upskilling, and other high priority/high impact recommendations.

LEADERSHIP AND COMMUNICATION RECOMMENDATIONS

Build Industry Awareness and Support

21. **Public Wind Industry Educational Campaign:** Launch regional energy literacy initiatives to inform, educate, engage, and involve communities, Indigenous communities, and businesses about wind energy and the associated economic benefits in Atlantic Canada. Engage as early as possible to communicate development strategies, obtain community input, and build local acceptance and support.

Create Supply Chain Development Momentum

22. **Interprovincial Collaboration on Wind:** Develop a unified approach to marketing, investment attraction, and supply chain development across the Atlantic provinces for the offshore and onshore wind industries to capitalize on efficiencies. Present the region as a cohesive unit to strengthen its value proposition in the global supply chain.

INNOVATION RECOMMENDATIONS

23. **Innovation for Next Generation Wind Technology**: Leverage the existing R&D ecosystem to foster innovation and sector leadership by establishing R&D projects in partnership with universities, public, and private sector entities to address technological and cost challenges in wind energy, such as hydrogen production, harsh weather design, and floating OSW technology.

24. **Carbon Footprint Management in Wind Energy Supply Chain:** Encourage R&D efforts to reduce the carbon footprint of the wind energy supply chain by developing sustainable materials, optimizing processes, and extending lifespan, such as natural fiber composites, bio-based resins, advanced coatings, and alternative fuels for vessels.

25. **Develop 3D Printing to Support Wind Industry Activities:** Develop advanced 3D printing technology to supply custom, hard-to-procure replacement parts for the offshore and onshore wind sectors, as modeled by the offshore O&G industry, thereby reducing reliance on imports.

FINAL REPORT

1 INTRODUCTION

Atlantic Canada possesses among the strongest wind resources in the world, both offshore and onshore, as can be observed in Figure 1-1. Globally, the push to decarbonize electricity generation, paired with technological advances and decreasing costs in wind energy technology, has led to substantial new wind energy capacity being developed.

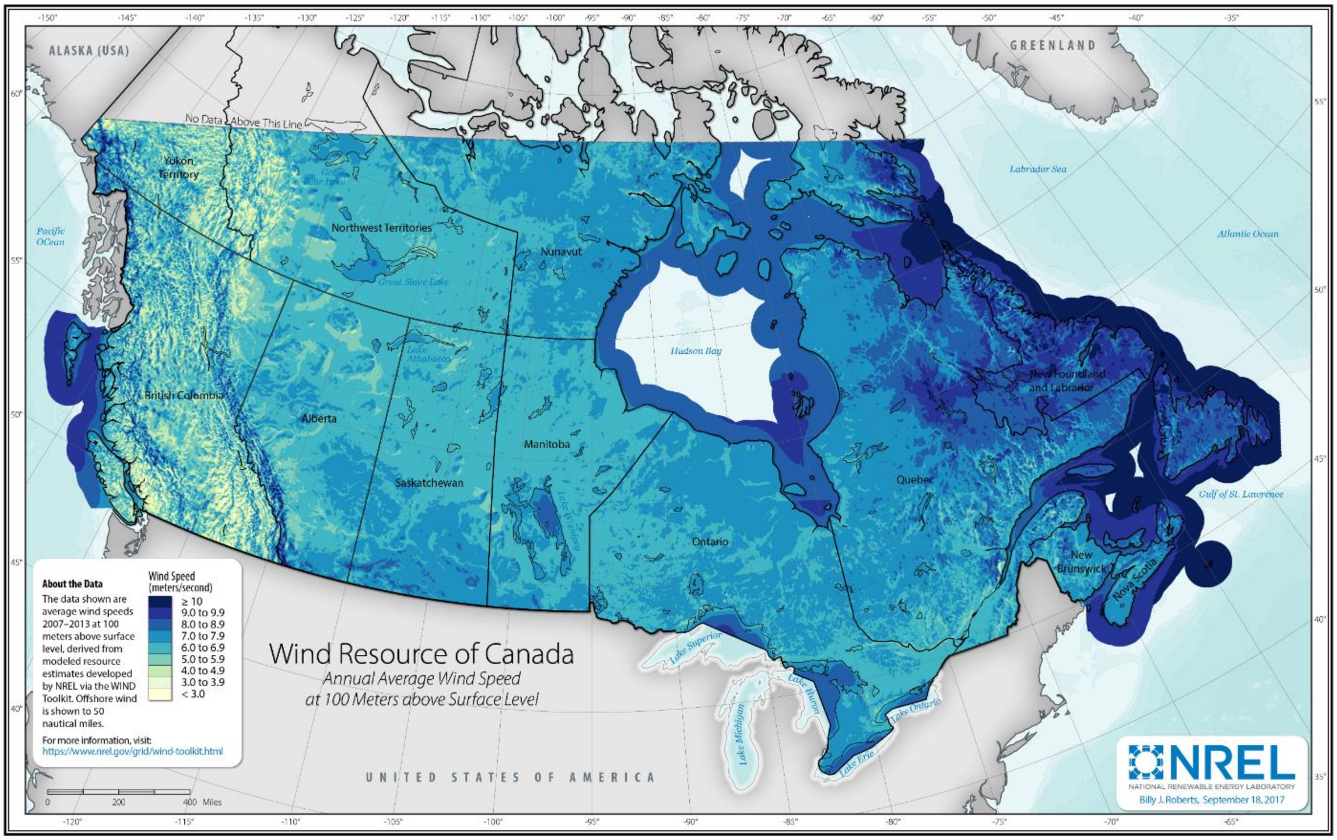


Figure 1-1 - Canadian Wind Resource Map at 100 m Above Surface [1]

Offshore wind (OSW), still nascent in many geographies and experiencing maturity in European and Chinese markets, is rapidly becoming a mainstream energy generation technology. This allows for renewable energy supply near coastal population centers with limited options for onshore generation and provides access to stronger, more consistent wind speeds. The demand for green hydrogen as an alternative fuel stock, as well as a base ingredient in many industrial processes and fertilizers, is also a key source of demand driving wind energy development. The confluence of these factors has attracted the attention of wind energy developers to the Atlantic Canadian provinces, where marine industrial knowledge, deep water harbours, extensive experience in major civil construction, significant quayside development space, and a skilled workforce present a major opportunity for wind energy development.

The Atlantic provinces of Nova Scotia (NS), Newfoundland and Labrador (NL), New Brunswick (NB), and Prince Edward Island (PEI) have seen varying levels of onshore wind development to date. While no OSW capacity has been installed in the region yet, the provinces have already contributed to OSW buildout through engineering and project development services, as well as storage and quayside assembly support, referred to in the industry as "marshalling". Plans to increase onshore wind development and to launch Atlantic Canada's OSW industry are advancing rapidly, and there is a desire by proponents and stakeholders to ensure that maximum economic and social benefits are realized as these industries grow. Marine Renewables Canada (MRC) with funding from the Atlantic Canada Opportunities Agency (ACOA), the NS Department of Energy, and the PEI Energy Corporation, launched this study to assess the potential for supply chain development in the Atlantic provinces to support growing wind energy generation capacity.

Xodus Group, with NL-based partners Angler Solutions and Caron Hawco Group, along with NS-based Envigour Policy Consulting, NB-based Roxham Advisory & Consulting Services, and Indigenous-relations expert Eric Christmas, have joined their expertise together to conduct a supply chain assessment of the Atlantic Canadian provinces. The goal of this scope of work was to conduct research, engage with stakeholders, and develop evidence-based insights to assist industry, suppliers, governments, and Atlantic Canadian residents with understanding pathways for supply chain development that will result in sustainable offshore and onshore wind industries while realizing local benefits for the provinces and their communities.

1.1 Objectives

This report will provide readers with an overview of offshore and onshore wind supply chains, highlighting the differences between the two technologies and detailing the requirements for project development and production activities. In addition to performing a supply chain assessment of companies, background context on global wind energy leaders, development trends, workforce requirements, and component demand will be provided to complete the assessment. This will serve an educational purpose by establishing an understanding of the current status of the industries globally and locally while identifying the existing capabilities of the Atlantic Canadian wind energy supply chain.

The assessment of the offshore and onshore wind energy supply chain potential in Atlantic Canada will identify strengths and gaps, leading to the development of strategies and actions to support existing regional companies. It will also identify the opportunities for them to enter the wind energy supply chain, encourage partnership formation and investment, and develop the workforce necessary to support this supply chain growth. The goal of this scope of work is to conduct research, engage with stakeholders, and develop evidence-based insights to assist industry, suppliers, governments, Indigenous community members, and Atlantic Canadian residents in understanding pathways for supply chain development that will result in sustainable offshore and onshore wind industries while realizing significant local benefits for the provinces and their communities.

1.2 Scope of Study

In addition to achieving the objectives listed in Section 1.1, this document is meant to serve as a reference for information on wind energy technologies and to provide other background information that is relevant to supply chain development. To ensure ease of navigation for readers with varying levels of industry knowledge, hyperlinks have been included throughout. This report is structured as follows:

- Section 1: Introduction – Provides the objectives and scope of the study, as well as acronyms and assumptions used throughout the report.

- Section 2: Stakeholder and Rights Holder Outreach – Provides details of the stakeholder and rights holder outreach approach, as well as the approach taken to assess supply chain diversity.
- Section 3: Wind Energy Technologies – Provides an overview of wind energy technologies by comparing offshore and onshore systems. For OSW, it examines fixed-bottom and floating turbine technologies, as well as delivery and installation processes. Onshore wind is discussed with a focus on turbine and foundation types, along with delivery and installation considerations.
- Section 4: Industry Requirements – Details the taxonomy used to describe supply chains and contracting structures, provides a breakdown of project costs, discusses the requirements within each supply chain element, and provides a high-level overview of workforce requirements for both offshore and onshore wind projects.
- Section 5: Industry Background – Offshore Wind – Provides information on past, current, and future OSW developments both globally and in Atlantic Canada, to provide context for the supply chain assessment. Currently developed and target capacities, regulatory frameworks, existing supply chain strengths and development challenges are discussed for each province.
- Section 6: Industry Background – Onshore Wind – Provides information on past, current, and future onshore wind developments, globally and in Atlantic Canada, to provide context for the supply chain assessment. Currently developed and target capacities, regulatory frameworks, existing supply chain strengths and development challenges are discussed for each province.
- Section 7: Demand Assessment – Presents development scenarios for each province, first for OSW and then for onshore wind, detailing low, medium, and high capacity development timelines and giving an overview of demand for major components, ports, and workforce based on these timelines and capacities.
- Section 8: Supply Chain Assessment – Provides a methodology for assessing the supply chain, then presents the results of the supply chain assessment, first for OSW and then for onshore wind. Results focus on the applicability of existing companies in Atlantic Canada combined with a red-amber-green (RAG) assessment that details overall strengths and gaps across supply elements.
- Section 9: Opportunity Assessment – Assesses the strengths, weaknesses, opportunities, and threats (SWOT) for wind energy supply chain development in Atlantic Canada using the outcomes of the supply chain assessment and stakeholder/rights holders engagement activities. A risk assessment is also carried out to determine the impact and severity of risk factors that would hinder supply chain development efforts.
- Section 10: Recommendations for Supply Chain Development – Outlines short, medium, and long-term recommendations for developing a sustainable wind energy supply chain in Atlantic Canada for offshore and onshore wind. These recommendations are supported by the SWOT assessment and risk assessment in Section 9, as well as through stakeholder validation.
- Appendix A: Stakeholder Engagement Framework – Provides a description of the Stakeholder Engagement Framework and Communications Plan used by the project team for stakeholder and rights holder engagement.
- Appendix B: Indigenous Engagement Framework – Provides a description of the Consultation process between developers and Indigenous Organizations, as well as a list of Indigenous Organizations and partnerships supporting energy sector participation.
- Appendix C: Additional Supply Chain Requirements – Provides a breakdown of project costs for fixed, floating, and onshore wind projects, as well as supplementary information on requirements for major component supply in the OSW and onshore wind sectors.

- **Appendix D**: **Atlantic Canada Onshore Wind Projects** – Provides a database of onshore wind projects in operation or under development for each province, including project name, capacity, developer, anticipated use for green hydrogen, and commercial operations date.
- **Appendix E: Global Industry Overview – Offshore Wind** – Provides additional information on past, current, and future OSW developments globally, with specific details on key markets in Europe and Asia-Pacific.
- **Appendix F: Global Industry Overview – Onshore Wind** – Provides additional information on past, current, and future onshore wind developments globally, with specific details on key markets in Europe, Asia-Pacific, Middle East and Africa, Latin America and Caribbean, and North America.

1.3 Acronyms and Definitions

Acronym	Definition
ACOA	Atlantic Canada Opportunities Agency
APAC	Asia-Pacific
BOP	Balance of Plant
CAD	Canadian Dollars
CAPEX	Capital Expenditure
CfD	Contract for Difference
CIP	Copenhagen Infrastructure Partners
CIB	Canada Infrastructure Bank
CNLOER	Canada – Newfoundland and Labrador Offshore Energy Regulator
CNSOER	Canada – Nova Scotia Offshore Energy Regulator
CNLOPB	Canada – Newfoundland and Labrador Offshore Petroleum Board
CNSOPB	Canada – Nova Scotia Offshore Petroleum Board
COD	Commercial Operations Date
COMFIT	Community Feed-In Tariff
CTI&C	Construction, Transportation, Installation and Commissioning
CTV	Crew Transfer Vessel
DECEX	Decommissioning Expenditure
DEI	Diversity, Equity, and Inclusion
DFO	Fisheries and Oceans Canada
DOE	Department of Energy
EA	Environmental Assessment
EIA	Environmental Impact Assessment
ECC	Department of Environment and Climate Change

Acronym	Definition
EO	Executive Order
EOI	Expression of Interest
EPCI	Engineering, Procurement, Construction, Installation
GEIDP	Gender Equity and Inclusion Plan
GHG	Greenhouse Gas
GW	Gigawatt
GWEC	Global Wind Energy Council
IA	Impact Assessment
IAAC	Impact Assessment Agency of Canada
IBA	Industrial Benefits Agreements
IET	Industry, Energy and Technology
IMR	Inspection, Maintenance and Repair
IRA	Inflation Reduction Act
IRP	Integrated Resource Plan
ITC	Investment Tax Credit
JV	Joint Venture
LATAM	Latin America
LCOE	Levelized Cost of Energy
LORESS	Locally Owned Renewable Energy Projects that are Small Scale
MEA	Middle East and Africa
MOU	Memorandum of Understanding
MRC	Marine Renewables Canada
MRE	Marine Renewable Energy
MW	Megawatt
NB	New Brunswick
NL	Newfoundland and Labrador
NRCan	Natural Resources Canada
NS	Nova Scotia
NSP	NS Power
O&G	Oil and Gas

Acronym	Definition
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
OSW	Offshore Wind
PEI	Prince Edward Island
PPA	Power Purchase Agreement
R&D	Research and Development
RAG	Red-Amber-Green
RFP	Request for Proposal
S&I	Staging and Integration
SOV	Service Operation Vessel
SPMT	Self-Propelled Modular Transporters
SREPs	Smart Renewables and Electrification Pathways Program
SWOT	Strengths, Weaknesses, Opportunities, Threats
TLP	Tension-Leg Platform
UK	United Kingdom
US	United States
WEICan	Wind Energy Institute of Canada
WMA	Wskijinu'k Mtmo'taqnuow Agency Ltd.
WTG	Wind Turbine Generator
WTIV	Wind Turbine Installation Vessel

1.4 Assumptions

This supply chain assessment considers the delivery of all products and services related to the construction of a wind farm up to the point of grid interconnection/other offtake. All costs are in Canadian dollars (CAD) unless otherwise stated. Statistics, policies, and values are current at time of writing.

2 STAKEHOLDER AND RIGHTS HOLDER OUTREACH

As the supply chain assessment of companies is largely carried out using desk-based research techniques (see Section 8.1), it is necessary to supplement the study by engaging with stakeholders and rights holders to develop deeper insights and strengthen recommended actions. Note that Indigenous organizations and governments are herein referred to as rights holders as opposed to stakeholders, and are represented independently (see Section 2.2).

2.1 Stakeholder Engagement

Initial engagement was carried out to establish context, gain insight into the level of knowledge and expectations around wind energy development, assess anticipated opportunities and challenges, and obtain data for the assessment of companies. These insights also contributed to the development of actionable recommendations and ensured that regional nuances were considered throughout the project.

The engagement process followed the Stakeholder Engagement Framework (see Appendix A.1) based on initial stakeholder mapping, targeted engagement through interviews, webinar and survey intake forms, and lastly a customization of engagement using additional feedback and adjusted outreach.

Stakeholder mapping was carried out for the four Atlantic provinces, including some relevant national organizations, across the following categories:

- Government departments and agencies, including regulatory bodies and utilities relevant to the wind industry, and all members of the Project Steering Committee (PSC);
- Industry and economic development organizations representing construction, energy, environmental, and manufacturing companies, as well as building and construction trade associations and institutions;
- Major existing supply chain players, including ports, developers, and Tier 1 suppliers with existing experience in wind energy or significant infrastructure/assets to support supply chain development.

The engagement process was not exhaustive but aimed to represent a broad range of stakeholder categories and geographic areas with each group providing unique inputs based on their areas of expertise and their relationship with the wind industry. The selection of participants was guided by discussions within the project team, input from MRC and the PSC, and opportunities arising from industry events in the region.

During the initial engagement phase, all participants received a comprehensive overview of the project and its funding sources according to the communications plan (see Appendix A.2). They were informed about the project objectives and assured of anonymity in reporting. For this reason no companies are called out specifically in the supply chain assessment. A standardized script was developed for consistency and detailed minutes were recorded for all meetings to ensure the accuracy of the information collected.

In early Q1 2025, the project team and MRC hosted a webinar to engage the supplier community in Atlantic Canada, focusing on offshore and onshore wind supply chains. The session outlined the project development lifecycle and highlighted the types of companies and activities at each stage. Participants could ask questions and provide feedback. To register, companies completed an intake form identifying relevant supply chain elements, industry awareness, company information, and diverse ownership status. They also shared perspectives on challenges and opportunities in wind energy development. This approach fostered supplier engagement, inclusivity, and gathered insights to address supply chain gaps and leverage regional strengths.

2.2 Indigenous Engagement

Key discussions with Indigenous groups, including economic development organizations and band-level investors, were critical to the supply chain assessment process. These discussions also underscored the development of new pathways and options to maximize opportunities for Indigenous participation in the wind energy industry. The project team approached this engagement in an intentional and thoughtful way, with experienced Indigenous liaisons conducting outreach activities.

Interviews were primarily conducted with organizations that support Indigenous economic development. Additionally, stakeholder engagement interviews included a prescribed set of Indigenous engagement questions to gauge participation, commitment, and knowledge. Overall, engagement considered the investment approaches of Indigenous People's Organizations and the role of current and potential Industrial Benefits Agreements (IBAs)to support communities and create supply chain opportunities for the wind energy sector in Atlantic Canada.

Finally, it is noted that engagement with Indigenous Organizations by industry and Consultation by governments is now well-established in law under a Duty to Consult and a principle of Reconciliation. This legal basis is distinct and separate from other benefits arrangements industry makes, or that developers and governments may require. More details on the Consultation process can be found in Appendix B.1.

Outcomes of Indigenous engagement in an offshore and onshore wind supply chain development context are provided in Section 8.5. Additional details on Indigenous organizations and partnerships in support of renewable energy are provided in Appendix B.2.

2.3 Supply Chain Diversity

The methodology for supporting supply chain diversity in Atlantic Canada's offshore and onshore wind industries includes an analysis of the current state of supply chain diversity, identifying challenges and gaps, and providing recommendations for policies, practices, and programs to enhance diversity.

Objectives include promoting equitable access to opportunities for underrepresented groups, including racialized persons, persons with disabilities, women, and members of the 2SLGBTQIA+ community. The study aimed to identify existing barriers to entry and participation, encourage diverse ownership and leadership within the supply chain, and support inclusive hiring practices and workforce development.

An assessment was conducted to identify diverse-owned businesses, workforce demographics, and initiatives promoting diversity, equity, and inclusion (DEI). This analysis drew on multiple sources, including recent research, such as the Atlantic Provinces Economic Council's (APEC) newly released Supply Diversity Study—an evaluation of online supply chain directories of diverse-owned businesses and an analysis of this study's supply chain database, which includes membership lists of the region's industry and business organizations.

Stakeholder interviews were conducted with organizations that support the advancement of diversity in business. Interviews were also conducted with wind industry developers, industry associations, and major supply chain companies using a prescribed set of DEI questions to gauge participation, commitment, and knowledge.

3 WIND ENERGY TECHNOLOGIES

Offshore and onshore wind energy technologies are detailed here to provide a baseline understanding for the supply chain assessment.

3.1 Offshore vs. Onshore Wind

Wind farms located in a body of water as opposed to on land are referred to as OSW. Land-based wind farms are referred to as onshore wind. When generation needs to occur close to a load center, like a city or industrial zone, and there is a lack of developable land for onshore wind, OSW may be selected over onshore.

OSW has the following advantages over onshore wind:

- Wind turbine size is not restricted by road transport limitations as components are transported via water.
- Higher potential generation capacity due to increased wind turbine and overall project size.
- Winds are more consistent offshore, and turbines can access stronger wind resources at increased heights.
- Features impacting wind resource and availability, such as geography and land-based infrastructure, may be excluded from consideration.

Alternatively, onshore wind has the following advantages over OSW:

- Less expensive to construct and operate.
- Broader availability of components and greater competition amongst wind turbine manufacturers due to industry maturity.
- Size limitations due to land transportation result in more straightforward logistics and reduce bespoke infrastructure requirements often required for OSW, resulting in a less restrictive supply chain.

A cost breakdown comparing fixed, floating, and onshore wind is provided in Appendix C.1.

3.2 Offshore Wind

3.2.1 Fixed vs. Floating

The two major types of OSW projects are fixed-bottom OSW, henceforth referred to as “fixed”, and floating OSW. Fixed refers to OSW turbines that have foundations physically embedded in the sea floor in water depths up to 60 m, while floating foundations must be attached to the seabed using mooring lines and anchors and are used in water depths in excess of 60 m.

As shown in Figure 3-1, fixed foundations mainly consist of monopiles, jackets, and gravity-base structures (not shown). Foundation type is typically chosen based on water depth and soil conditions, with monopiles and jackets being the most common. If a region has a strong concrete supply chain, the use of gravity-based foundations may be considered, provided that water depths and soil conditions are suitable, given the large volumes of concrete required for the production of this type of foundation.

Types of floating substructure include semi-submersible, tension-leg platform (TLP), and spar buoy, also shown in Figure 3-1. Given that the floating OSW industry is less developed than fixed, there is no dominant substructure technology. Floating foundations must be attached to the seabed using mooring lines (either synthetic or chain) and anchors. There are a wide variety of options for anchor type and embedment type, again depending on soil conditions and other factors.

There are several components in an OSW farm that have very similar, if not identical, manufacturing processes, regardless of whether they are used for fixed or floating OSW. The wind turbine generator (WTG), including the nacelle, hub, and blades, remains unchanged, while the tower may require increased wall thickness or slight design modifications to accommodate the increased loadings experienced by floating wind turbines. Some floating OSW turbines do not require designated transition pieces, as this may be a function of the substructure. Cables are similar in terms of rated capacity and internal structure; however, for floating turbines, the cables are dynamic rather than static and are suspended using buoyancy modules in the water column, allowing for wave-induced motion. Offshore substations are also unique in floating wind developments as they require floating substructures depending on the water depths but appear like fixed-bottom structures above the waterline.

Several factors influence the Levelized Cost of Energy (LCOE) for the OSW market, including project location, technology selection, associated operation and maintenance costs, and the cost of capital to developers. Fixed OSW globally has greatly benefited from economies of scale, which means that as more fixed OSW wind turbines are required, costs are driven down. Since 2009, the LCOE of OSW has decreased by 66% [2]. Floating OSW, as a newer market entrant, has a higher LCOE than fixed, but it is expected that cost reduction trends will emerge as the industry matures.

Figure 3-1 - OSW Foundation Types. From left to right: Monopile (fixed), Jacket (fixed), Twisted jacket (fixed), Semi-Submersible Platform (floating), Tension-Leg Platform (floating), and Spar-Buoy (floating) [3]

3.2.2 Delivery and Installation

OSW turbine components and foundations are too large to be transported over land, and as such, the primary method of transportation is by water. Major components, including the nacelle, blades, towers, transition pieces, and foundations, can weigh thousands of tons and can require in excess of 20 t/m^2 in live load bearing capacity at quayside [4]. Specialized vessels are required to transport these large components, which are often required to travel significant distances between manufacturing sites, marshalling ports, and final installation sites.

Typically, OSW farm installations follow a standard installation sequence beginning with the onshore infrastructure (onshore substation and export cable), followed by foundations, transition pieces (if applicable), offshore substation foundation, offshore substation, subsea inter-array cables, offshore export cables, and finally, the wind turbines themselves. For floating OSW, turbines are generally assembled at quayside staging and integration (S&I) ports and then floated out to the site, where they are secured by mooring lines to subsea anchors. Quayside water depths for floating OSW integration range from around 8 m for a semisubmersible-type substructure and up to 80 m for the longer spar-type substructure [5].

Heavy-lift vessels, designed to carry large and heavy cargo with high-capacity cranes, can also be used to install foundations. Offshore substations are generally too large to fit on the deck of a heavy lift vessel, so they are likely to be carried to the installation site on a barge. Inter-array cables (IAC, also referred to as "array cables") and export cables are stored on reels on purpose-built cable installation vessels. Wind turbine installation vessels (WTIVs) are jack-up vessels that transport and install wind turbine components. These vessels are equipped with heavy-lift cranes that can extend their legs to make contact with the seabed, stabilizing the vessel for installation activities. Crane capacity requirements for smaller OSW turbines (~8 megawatts (MW)) can be up to 900 t, while requirements for large turbines (up to 20 MW) can be in excess of 2500 t [6]. More information on vessel requirements can be found in Section 7.1.4.

For the installation phase, contracts are often divided by component, with contracts being awarded for cable laying, substation installation, foundation installation, and turbine installation separately (see Section 0 for more details). As companies build track record in the installation space, developers are more likely to consider Engineering, Procurement, Construction, Installation (EPCI) contracts covering multiple, or all, offshore installation activities. This transfers substantial risk from developers to subcontractors, meaning that installation subcontractors require a high level of trust from the developer and typically include a price premium due to the additional risk and project management scopes.

3.3 Onshore Wind

3.3.1 Foundation

Depending on location, onshore wind turbines use different types of foundations, which are typically grouped into two main categories: spread foundations and piled foundations (see Figure 3-2). Spread foundations distribute the weight of the turbine across a large concrete base and are best suited for areas with stable and compact soil conditions. Piled foundations stabilize the turbine by drilling long steel or concrete piles deep into the ground and are commonly utilized in areas with loose soil conditions.

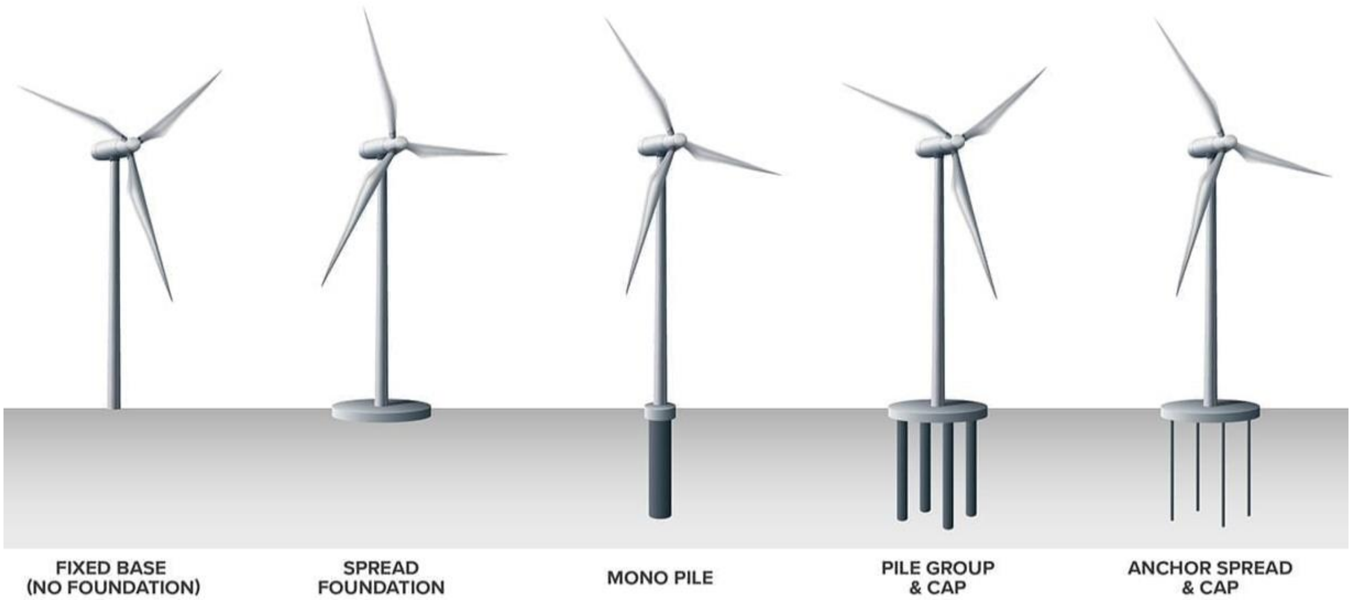


Figure 3-2 – Types of Onshore Wind Turbine Foundations [7]

There are different types of spread foundations, with the most common being shallow (raft, matt, reinforced concrete) and gravity based. Although both types distribute the weight of the turbine across a wide area, gravity-based foundations rely more heavily on the mass of foundation concrete and steel reinforcement than shallow foundations. As such, shallow foundations require more compact soil conditions than gravity-based foundations.

Different types of piled foundations include rock anchors, piled rafts, and driven piles (monopiles). Rock anchor foundations utilize a combination of concrete, steel reinforcement, and rods drilled into bedrock formations to support the weight of the wind turbine. Piled raft foundations, on the other hand, employ piles attached to the bottom of a concrete pad to transfer the load of the wind turbine to lower-lying and more compact ground. Similarly, driven pile foundations use a single pile to transfer the load of the wind turbine to lower-lying and more compact ground. Rock anchor foundations are most suitable for areas where bedrock is relatively shallow and accessible, while piled raft or driven pile foundations are utilized when the bedrock is too deep. A summary of necessary conditions for each foundation type, as well as foundation types found in each province as determined from EAs submitted for onshore wind projects in Atlantic Canada, can be found in Table 3-1 below.

TYPE	SUB-TYPE	SOIL COMPACTION	BEDROCK DEPTH	PROVINCIAL USE
Spread	Shallow (Raft, Mat, Reinforced Concrete)	Compact	Any	NS, NL, NB, PEI
	Gravity-Based	Moderate	Any	NS, NB
Piled	Rock Anchor	Loose	Shallow	NL, NB
	Piled Raft	Moderate	Deep	--
	Driven Pile	Loose	Deep	NS, NL

Table 3-1 - Onshore Wind Foundation Type by Soil Compaction Type and Provincial Use

3.3.2 Delivery and Installation

Onshore wind turbine components are typically delivered via truck, rail, or vessel, depending on project location. Specialized trailers are often required for road travel to handle specific wind turbine components, and each country has its own regulations for vehicle and trailer specifications, which must be adhered to when transporting abnormal loads. When available, rail is typically favoured for transportation across large distances, but it also requires the design of specific cars to accommodate turbine components. Vessels are also commonly used for transport across large distances, particularly for intercontinental transportation.

The installation of onshore wind turbines is a multi-stage process, beginning with site clearing and civil construction works, pending the obtaining of necessary permits, approvals from local authorities, Environmental Assessments (EAs)/Environmental Impact Assessments (EIAs)[1], and community consultations. Once civil works are complete, and foundations have been set, there are typically two different logistics routines adopted for the erection of the turbines: Just in Time Delivery (JIT) and Pre-delivery. For JIT, turbine components are sequentially delivered, offloaded, and erected directly by the crane which is positioned on the pad. For pre-delivery, the pad is widened to accommodate component laydown, and the crane is positioned on the pad after delivery.

The erection of tower sections and rotor blades, as well as the lifting of the nacelle and man baskets, are considered complex lifts and are typically completed by a mobile crane. Mobile cranes are categorized into two types: telescopic cranes and lattice boom cranes, with capacities between 30-1200 t and 100-3500 t, respectively. Crane capacity requirements for onshore wind farms are typically in excess of 1000 t [8]. Tower components are first installed on top of the foundation, followed by the nacelle, and finally, the blades. Once all components of the wind turbine are installed, the electrical system is connected for transmission to the substation, and the system is tested.

[1] *The term EA is used in NS and NL, while EIA is used in NB and PEI. For this reason, they will be referred to as EAs/EIAs unless a specific province is being discussed.*

4 INDUSTRY REQUIREMENTS

When describing the supply chain of an industry, standard terminology is used to categorize companies based on a contracting structure. Within the wind energy industry, there are three primary categories employed to describe the supply chain: developers, OEMs, and tiered subcontractors. The definitions for each, as well as the relationships between them, are described below and visually represented in Figure 4-1.

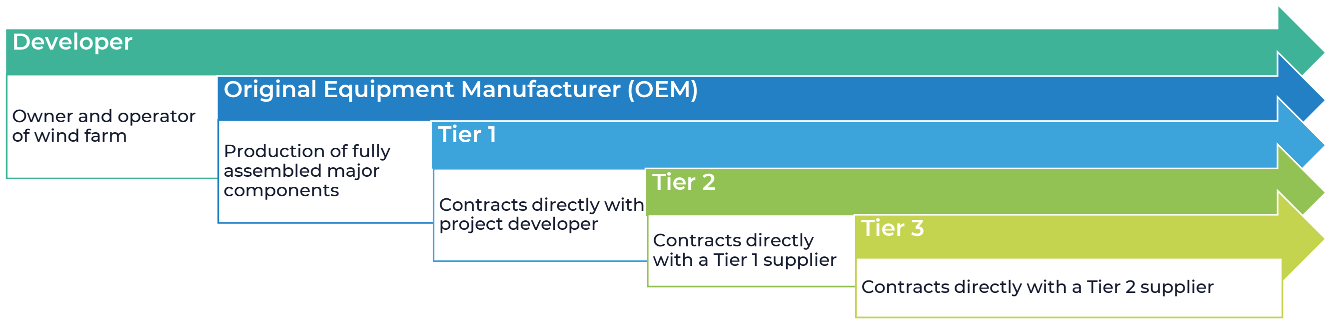


Figure 4-1 - Visual Representation of Supply Chain Terminology

Developer – A developer is the owner and operator of a wind farm. Generally, they are large, often multi-national, energy producers and are responsible for the delivery of the project in alignment with the offtake agreement. They manage project development activities and may conduct this work in-house, subcontract it to an external entity, or a combination of both. They manage all main contracts across the project development life cycle and are responsible for getting the project through from development to a Final Investment Decision (FID), construction, and finally, commissioning and operations. When a consortium of developer companies is involved, one partner may lead more on the development side, while the other takes control of the project's operations, although this is highly dependent on the strategy. In onshore wind, asset management firms may also become involved post-operational.

OEM – An Original Equipment Manufacturer is a company that is responsible for the production of the fully assembled major components of the wind farm. They purchase raw materials, parts, and/or subcomponents/subassemblies from other manufacturers or suppliers, which they use to manufacture and assemble their finished products. OEMs may also be referred to as Tier 1 suppliers, as defined below.

Tier 1 – A Tier 1 supplier contracts directly with the project developer. They are considered the main suppliers of equipment or services to the project and will, in turn, manage subcontractors that will provide them with raw materials, parts, and/or subcomponents. Generally, the Tier 1 contractor assumes the risk for schedule and cost overruns on their contracted products and services and is penalized accordingly if they fail to comply with agreed-upon delivery dates, etc.

Tier 2/3 – Tier 2 contractors supply directly to the Tier 1 contractors. Likewise, Tier 3 contractors supply directly to Tier 2 contractors, and so on. These are likely to provide a more specific component or service, such as turbine towers, secondary steel, cable protection systems, or electrical equipment, for example. Tier 1s will have Tier 2/3s from which they exclusively source certain material/equipment/services (to guarantee price and schedule certainty), however, often, they will issue a competitive tender process to encourage competition in the supply chain.

4.1 Taxonomy

To meaningfully assess the supply chain for offshore and onshore wind in Atlantic Canada, it is necessary to emulate the typical contracting structure of a project. A wind energy project lifecycle is often defined using general categories, or "packages", as defined in Table 4-1.

Table 4-1 - Wind Energy Supply Chain Packages/Supply Chain Areas

<table>
<tr><th colspan="3">Package</th></tr>
<tr><td colspan="3">Project Development</td></tr>
<tr><td rowspan="6">Manufacturing and Component Supply</td><td rowspan="3">Wind Turbine Generator (WTG)</td><td>Nacelle</td></tr>
<tr><td>Rotor</td></tr>
<tr><td>Tower</td></tr>
<tr><td rowspan="3">Balance of Plant (BOP)</td><td>Cables</td></tr>
<tr><td>Foundations</td></tr>
<tr><td>Substations</td></tr>
<tr><td colspan="3">Construction, Transportation, Installation and Commissioning (CTI&C)</td></tr>
<tr><td colspan="3">Operations and Maintenance (O&M)</td></tr>
<tr><td colspan="3">Sector Support</td></tr>
</table>

Table 4-2 provides an expanded wind energy taxonomy, which will be used for the supply chain assessment. It is aligned with the typical contracting supply structure used in the industry for onshore wind, noting whether the taxonomy applies to fixed OSW, floating OSW, onshore wind, all categories, or a subset of the three categories. The taxonomy provides a guideline for how developers and their subcontractors may structure their projects and describes the supply chain elements required in each package. Details of the requirements for each supply chain element are given in Appendix C.2.

Table 4-2 - Combined Wind Energy Industry Taxonomy

Supply Chain Area	Supply Chain Element	Wind Industry Relevance	Details
Project Development	Project management	All	Developers or those subcontracted to manage packages of a project
	Permitting	All	Companies engaged in all or part of permitting and regulatory compliance processes including EAs/EIAs, excluding data collection
	Onshore surveys and environmental monitoring	All	Wind resources assessments, geotechnical surveys, visual impact and socio-economic impact assessments, etc.
	Offshore surveys and environmental monitoring	Fixed, Floating	Wind resources assessments, geotechnical surveys, metocean assessments, protected species observers, etc.
	Engineering and design	All	Front-end engineering and design: turbine layout, electrical and civil infrastructure, feasibility analysis, etc.

Manufacturing and Component Supply (WTG and BOP)	Major industrial electrical equipment supply	All	Wind turbine generator, transformers, switchgear, control systems, power offtake system, etc.
	Minor industrial electrical equipment supply	All	HVAC, lighting systems, fire alarms, etc.
	Industrial motion precision component fabrication	All	Gearbox, main shaft, yaw/pitch motors.
	Blade supply	All	Glass/carbon fiber, polymer foam, balsawood, resin, etc.
	Major steel component supply	All	Tubular steel, steel plate, large gauge welding services, major steel component fabrication facilities, anchors, pin piles, piles, monopiles, towers, floating substructures, etc.
	Secondary steel component supply	All	Ladders, handrails, work platforms, boat landings, walk-to-work platforms, davit cranes, structural fasteners (custom and stock), cable terminations, installation aids, seafastening/grillages, etc.
	Mooring supply	Floating	Chain, synthetic rope, connectors, etc.
	Cable supply	All	Cable raw material supply (lead alloy, copper, aluminum), cable manufacturing facilities, etc.
	Ancillary equipment supply	All	Forklifts, cranes, specialized tools, welding supplies, corrosion protection, concrete supply, scour protection, coating and paint supply etc.
	Vessel design and build	Fixed, Floating	Shipbuilding, ship retrofits, ship repair, vessel specific equipment provision, etc.
Construction, Transportation Installation and Commissioning (CTI&C)	Onshore construction	All	Road building, grading, leveling, landscaping, foundation preparation for tower, onshore substation, etc.
	Onshore tower and turbine installation	Onshore	Foundation laying for tower, installation of tower, mounting of wind turbine on tower, running cables, etc.
	Offshore installation works	Fixed, Floating	Vertical integration and tow-out of floating OSW turbines, foundation installation, tower mounting, OSW turbine installation, cable installation, cable pull-in, etc.
	Electrical/grid connection and commissioning	All	Terminating and connecting electrical infrastructure, energizing systems, commissioning works, calibration, testing, etc.
	Onshore logistics	Onshore	Transportation, logistics planning, port services.
	Vessels and marine logistics	Fixed, Floating	Vessel supply services (CTVs, SOVs, WTIVs, heavy-lift vessels, cable lay vessels, diver boats, pilot/scout boats, barges, etc), ROV's, divers, warranty surveyors, brokerage and customs functions, helicopter services, HSE inspectors, etc.
Operations and Maintenance (O&M)	Operations	All	Facilities management and monitoring, HSE inspectors, weather forecasting and metocean data, communications, emergency response systems, etc. *Note: Many operations critical companies will have been accounted for in 'Onshore logistics' and 'Vessels and marine logistics'.*
	Onshore inspection, maintenance and repair (IMR)	Onshore	Contracting companies representing wind turbine technicians, rope access technicians, engineering services, regulatory services, turbine service kits, major component replacement support, electrical support, maintenance support, etc.

	Offshore inspection, maintenance and repair (IMR)	Fixed, Floating	Contracting companies representing wind turbine technicians, rope access technicians, offshore scaffolding, engineering services, regulatory services, ROVs, AUVs, divers, vessels, turbine service kits, major component replacement support, electrical support, maintenance support, etc.
Decommissioning	Dismantling onshore infrastructure	All	Disassembling onshore turbines, towers, and foundations, transporting equipment to disposal facilities, etc.
	Removal of subsea infrastructure	Fixed, Floating	Towing-back floating OSW turbines, foundation removal, tower dismounting, OSW turbine disassembly, cable removal, etc.
	Repowering	All	Terminating and connecting electrical infrastructure, energizing systems, commissioning works, calibration, testing, etc.
	Site restoration	All	Site leveling, landscaping, tree planting, waste removal, etc.
Sector Support	Government, industry associations, non-profit organizations	All	Government, industry associations, non-profit organizations, Indigenous organizations, diversity offices, advocacy groups, etc.
	Training, Academia, Labour Organizations (Unions) and R&D	All	Universities, trades colleges, technical high schools, unions, wave tanks, piloting facilities, research centers, business incubators/accelerators, etc.
	Other professional services	All	Industry specific accounting, insurance, finance, HR, legal services, etc.

4.2 Contracting Structures

There are three main contracting structures employed in the wind energy industry, influenced by the following factors:

- Size and complexity of the project to be executed.
- Internal strength, experience, and capabilities of the wind farm developer and its Tier 1 suppliers.
- Influence of project financing availability.
- Maturity of the local supply chain.
- Amount of risk the project developer is willing to take.

Figure 4-2 provides an overview of how the three contracting structures, Multi-Contracting, EPCI Contracting, and Hybrid Contracting, either increase or reduce the level of interface, cost and risk the developer will be subjected to in the contracting. Each structure has its own unique strengths and challenges. While every project and its contracting structure are unique, they tend to align with one of the three structures presented here. Note that onshore wind is more likely to operate on an EPCI structure and will typically have 1-2 major packages due to industry maturity and a simpler installation process.

Figure 4-2 - Procurement Strategies and Outcomes

EPCI

An EPCI contracting strategy usually involves fewer main contracts, often referred to as "packages", as shown in Table 4-2. This contracting structure requires experienced Tier 1 suppliers, also known as package owners. Usually, two to four main packages cover larger scopes of work and responsibility for cost, schedule, and interface risk of the project, including coordination with sub-contractors, is transferred from the developer to the package owner.

This type of contract offers a lower risk profile for the developer and allows for the use of a smaller development team; however, it often comes with higher costs and reduced control over lower tier contracting, which may impact local content ambitions. The EPCI contracting structure is usually employed in the more mature onshore wind and the oil and gas (O&G) industry, although in more mature markets like Europe, EPCI contracting strategies are becoming increasingly common for OSW.

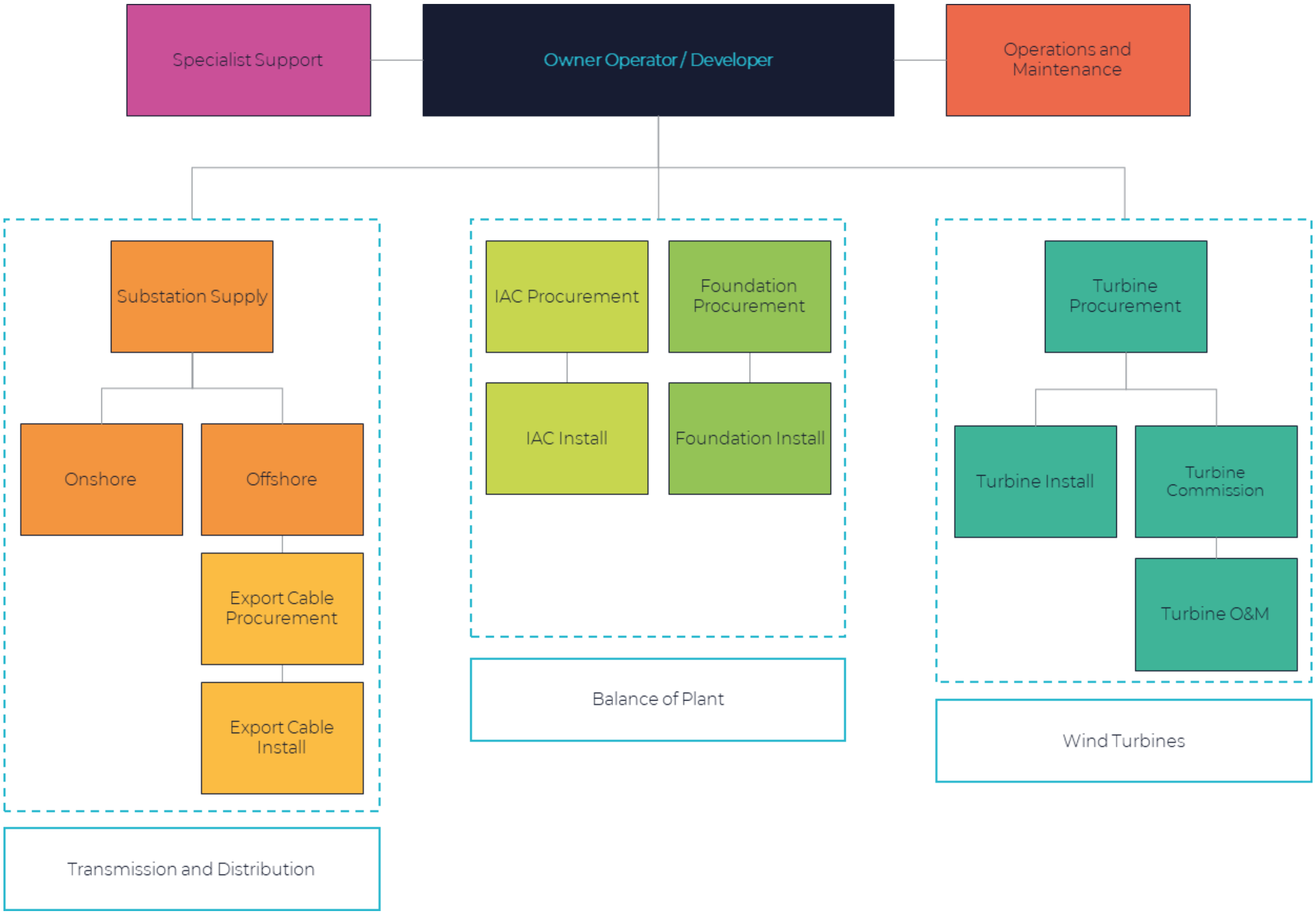


Figure 4-3 - Example of EPCI Contracting Strategy for OSW

Multi-Contracting

In contrast to EPCI contracting, multi-contracting strategy occurs when the developer awards independent contracts for multiple work packages. Typically, contracts are awarded for each key element of the wind farm. A multi-contracting strategy is often more suitable for, and preferred by, large utilities or experienced developers, as they are likely to be reliant on project finance and can take on risks internally rather than paying a premium for an EPCI solution. This type of contract offers developers the greatest control over project development and provides the best opportunities for cost reductions. However, this contracting strategy requires strong in-house engineering and commercial skills, and it necessitates that the developer plays a significant role in coordination.

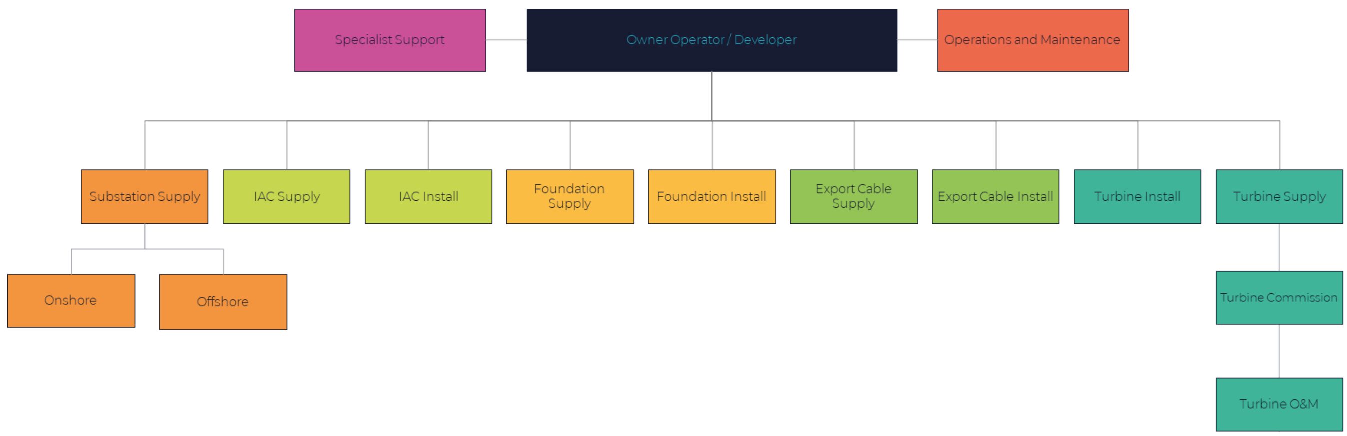


Figure 4-4 - Example of Multi-Contracting Strategy in OSW

Hybrid

A hybrid contracting structure lies between multi-contracting and EPCI. This involves contracting directly for several smaller work packages and combining others into major packages. This approach can help to reduce construction risk while balancing the amount of project oversight held by the developer.

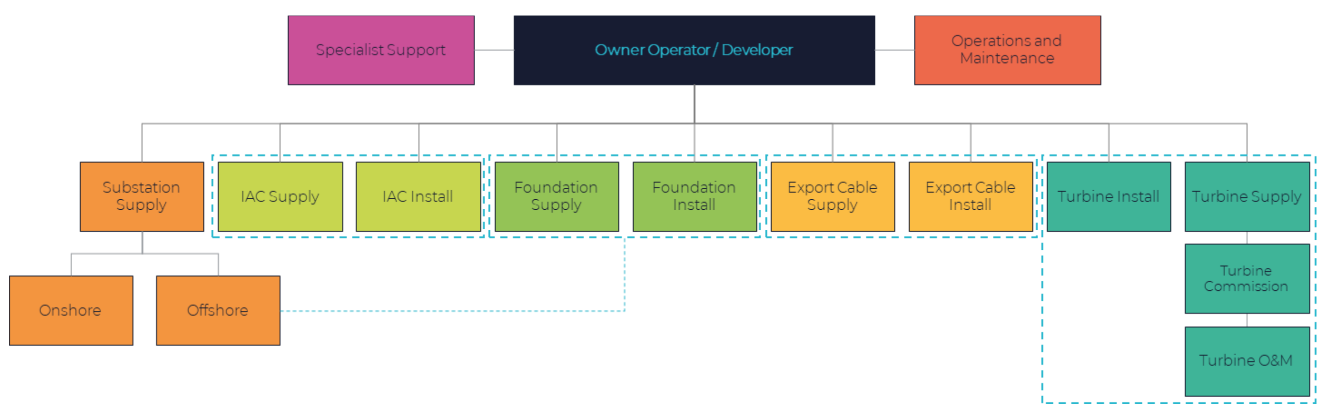


Figure 4-5 - Example of Hybrid Contracting Strategy for OSW

4.3 Workforce Requirements

Workforce requirements for the lifecycle of an OSW farm are highly variable across fixed, floating, and onshore wind. The number of direct and indirect jobs created as a result of a wind energy project's execution is highly dependent on the amount of local content it generates. This refers to the amount of work carried out in the region local to the project site, including direct manufacturing operations, quayside or on-site construction and marshalling activities, the use of local Tier 2 and 3 support companies, and any other work supporting the project that can be carried out locally.

Job role categories have been compiled to cover a range of job roles that may be available to the local workforce. These categories are providing alongside corresponding descriptions; all categories are relevant to both onshore and OSW development, with the exception of 'maritime trade worker,' which is only relevant herein for OSW roles.

- **Building Trade Worker:** A laborer involved in the construction, maintenance, and repair of buildings or infrastructure.
- **Business Professional:** A professional engaged in the finance, legal compliance, and task management of an organization or project.
- **Manufacturing Trade Worker:** A laborer engaged in the production and assembly of goods, typically within a factory or industrial setting.
- **Maritime Trade Worker:** A laborer engaged in the operation and maintenance of seafaring vessels and maritime infrastructure.
- **STEM Professional:** A professional engaged in the design and analysis of a technology or engineering project.
- **Support Staff:** A professional engaged in the administration, human resource management, and operation of an organization or project.

Descriptions of general OSW workforce requirements in each of the supply areas are given below, with job role categories mapped to these requirements where relevant. An overview of workforce demand assumptions and forecasts is discussed further in Section 7.1.3 and 7.2.3.

Project Development workforce includes a developer's internal employees, who carry out permitting, stakeholder and rightsholder engagement, risk management, and administration tasks. Developers create their internal project teams several years in advance of construction, with hiring often ramping up in areas near the future construction site after leases or offtake agreements are awarded. Subcontracted consultants (for tasks such as engineering, advisory, permitting activities, and legal counsel services) play an essential role in applying lessons learned and best practices from the global offshore energy sector into project development work, and local mariners are often utilized for offshore survey work. Job role categories which support this supply area can include those of Business Professional, STEM Professional, and Support Staff.

Manufacturing and Component Supply workforce typically consists of mechanical engineers, electrical engineers, civil engineers, and various specialized tradespeople such as welders, electricians, and machinists working within manufacturing facilities. In addition, health, safety, and environment professionals, operations and project managers, and various other supervisory and support roles are required. Since manufacturing of components largely consists of assembling large steel structures and electrical equipment, teams of several journeypersons such as welders and heavy equipment operators will work together in tandem, alongside apprentices and general trades workers. Shipbuilding requires an additional manufacturing workforce adjacent to the OSW industry. Job role categories that support this supply area can include those of Manufacturing Trade Worker and Support Staff.

Construction, Transportation, Installation and Commissioning also relies on engineers, journeypersons, and apprentices, working in both onshore and offshore environments. For workers installing and commissioning the wind turbines, a wind turbine technician credential is often required. This training may be obtained through a trades college or directly through an OEM. OEMs will typically require some level of in-house training for anyone working on their

WTGs in order to maintain warranty status. Crane and heavy equipment operators are required at the site for installation activities onshore, as are other specialized trades like rope access technicians.

Workers in offshore environments will need OSW-specific Global Wind Organization (GWO) training which teaches offshore safety and survival as well as basic skills required for working with tools at heights, and other relevant skills. These training requirements exceed the current requirements for Basic Offshore Safety Induction and Emergency Training (BOSIET) certifications, ensuring that workers follow safe practices and are prepared in the event of an emergency offshore.

For OSW, the vessel crew and offshore operations personnel comprise a significant portion of the required workforce during this project phase. Port operations workers, such as logistics managers, stevedores, riggers, and crane operators, are also essential. Offshore workers may be required to work on a rotational basis, which means working for a set period offshore, and then having a set period off before repeating the cycle. Job role categories that support this supply area can include those of Maritime Trade Worker, STEM Professional, Building Trade Worker, and Support Staff.

Operations and Maintenance personnel typically include smaller teams of specialized technicians, which include both the onshore teams (such as monitoring engineers, logistics coordinators, and warehouse managers) and workers deployed to the project site (both onshore and offshore) to inspect assets and conduct regular and preventative maintenance, carry out repairs, and perform major component replacements, as required. In OSW, vessel crews are also required throughout the operational lifetime of the project to enable offshore IMR work to be carried out. Throughout the past decade, OEMs have been offering total maintenance packages for onshore wind projects in the Maritimes. Accordingly, the workforce for maintenance is largely employed or contracted by the OEMs.

The additional workforce required in the O&M phase of wind energy projects includes building maintenance staff, logistics and transportation workers for material delivery, security personnel for site protection, and administrative staff for operational support. These roles are essential to the project’s success but do not require specialized certifications or training and have not been assessed as part of this analysis. Job role categories that support this supply area can include those of Building Trade Worker, Maritime Trade Worker, and Support Staff.

5 INDUSTRY BACKGROUND – OFFSHORE WIND

The following section provides a high-level overview of the OSW market, including both floating and fixed-bottom technologies, to provide context for Atlantic Canada's OSW development plans. This section details key information on the global leaders by installed capacity, current OSW development statistics, and forecasts for future OSW development. Furthermore, a focused overview of the United States (US) OSW market is provided, given its proximity and extensive trade relationship with Canada. This section aims to provide the reader with an understanding of the industry's current status, supply chain outputs by country, potential challenges, and notable successes.

5.1 Global Industry Overview

The global OSW industry represents nearly 70 gigawatts (GW) of installed capacity, with up to 190 GW planned to be installed by 2029. The current outlook for global OSW development is shown in Figure 5-1. In 2023, the global leaders in OSW installed capacity were China with 38 GW, the United Kingdom (UK) with 14.7 GW, and Germany with 9.2 GW. Outside of China, the European region dominates OSW activities, both in terms of installation and supply chain capability. Emerging markets and regions are catching up with ambitious targets and supply chains eager to get involved.

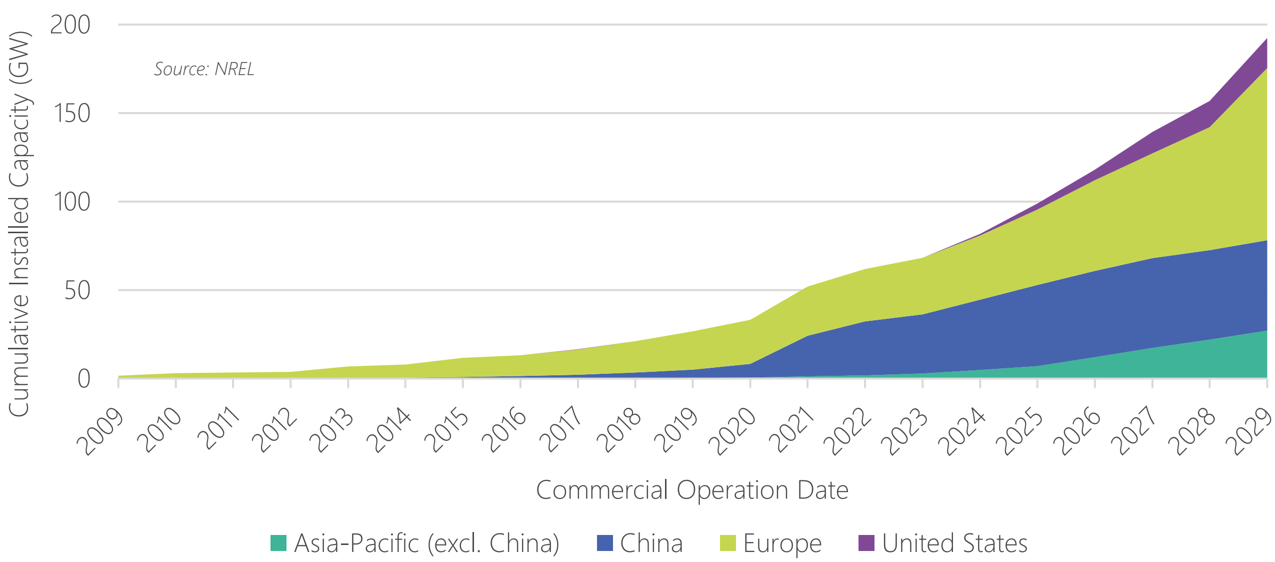


Figure 5-1 - Estimated Cumulative OSW Capacity Installed Globally

The following section details OSW development by region, discussing insights on installed capacity, development pathways, supply chain opportunities, industry successes and challenges.

5.1.1 Europe

Key countries in the European OSW industry include the UK, Germany, Denmark, the Netherlands, France, and Norway for floating OSW, while other European nations such as Italy, Portugal, Sweden, and Poland are emerging as key future markets. Europe played a major role in the development of early OSW and floating OSW technology. Driven by internal decarbonization goals and a desire to diversify their energy supply, Europe is home to several countries with large amounts of installed OSW capacity and a substantial portion of the global OSW supply chain. Given the scale of development, wider industrial decarbonisation plans and challenges with realising sufficient grid build-out, several European countries have also begun setting goals for green hydrogen development and acquisition, driven by offshore and onshore wind development both at home and abroad. Details regarding installed and target capacity for OSW in key European countries is provided in Table 5-1. Additional details can be found in Appendix E.1.

COUNTRY	INSTALLED CAPACITY	TARGET CAPACITY	SUPPLY CHAIN
United Kingdom	14.0 GW	50 GW by 2030	• Relatively well-established supply chain with two blade facilities and a cable facility in operation • XXXL[2] monopile facility and blade facility under development
Germany	8.3 GW	30 GW by 2030 40 GW by 2035 70 GW by 2045	• Robust local supply chain for key components including foundations manufacture, with nacelle facility in operation • XXXL monopile facility under development
Denmark	2.7 GW	12.9 GW by 2030 35 GW by 2050	• Headquarters for major turbine OEM Vestas and global OSW developer Ørsted • XXL monopile facility • Several key ports have supported the majority of European OSW installation
France	1.5 GW	45 GW by 2050	• Two blade facilities, nacelle facility, and electrical substation facility in operation
Norway	0.1 GW	30 GW by 2040	• Several foundation structure facilities under development • HVDC substation EPC and EPCI capabilities

Table 5-1 - Summary of OSW in Key European Countries

5.1.2 Asia-Pacific

In the Asia-Pacific (APAC) region, key markets include China, Taiwan, Japan, South Korea, and Australia, although other Asian countries are pursuing OSW development as well, including Vietnam and the Philippines. Local content and supply chain development feature heavily across these markets. These countries have all committed to meet net-zero carbon emission targets by 2050, which is expected to further promote the expansion of renewable energy and provide significant opportunity for OSW in the delivery of clean electricity. Moreover, the growing interest in using OSW in electrolysis to produce green hydrogen offers a second demand market to the sector, enabling OSW to support

[2] *XL, XXL, and XXXL refer to monopiles of increasing diameter, ranging from about 6 m for XL up to 15 m for XXXL.*

decarbonization in industrial and downstream applications. Details regarding installed and target capacity for OSW in key APAC countries is provided in Table 5-2. Additional details can be found in Appendix E.2.

COUNTRY	INSTALLED CAPACITY	TARGET CAPACITY	SUPPLY CHAIN
China	38.0 GW	1200 GW by 2030 (onshore, offshore, and solar)	• Competitive domestic supply chain with at least 3 major turbine OEMs • Robust supply of subcomponents and raw materials, particularly rare earth minerals, to global OSW industry • Security and track record concerns have limited uptake of Chinese-made turbines in Europe and the US
Taiwan	2.2 GW	5.6 GW by 2025 20.6 GW by 2035	• Minimum 60% local content requirements recently allayed • Nacelle facility in operation
Japan	0.3 GW	10 GW by 2030 Up to 45 GW by 2040	• Partnership between Toshiba and major turbine OEM GE to enhance nacelle production • Monopile and transition piece facility in operation
South Korea	0.1 GW	12 GW by 2030	• Domestic firm contributed over 75% in developing existing OSW capacity, primarily in construction
Australia	0 GW	State of Victoria: 2 GW by 2032 4 GW by 2035 9 GW by 2040	• Immature supply chain requiring significant infrastructure upgrades and partnerships to establish local operations

Table 5-2 - Summary of OSW in Key APAC Countries

5.1.3 North America

The OSW industry in North America is currently substantially less developed than that of Europe and APAC. Developments are driven primarily by decarbonization goals as a way to bring large quantities of renewable energy to population centres with limited space for onshore generation technologies like solar and onshore wind. Green hydrogen development is also a driving force behind the OSW industry's development in certain jurisdictions. Currently, Mexico has no OSW and has not made any public development commitments.

Given the geographic proximity and extensive trade relationship between Canada and the US, as well as the relatively immature OSW industry in both countries, there is substantial opportunity for collaboration. For this reason, the US is considered in greater detail than other jurisdictions in this report, as the development of OSW here will impact the Canadian OSW supply chain, with opportunities to lean into Canada’s strengths to meet US gaps and vice versa. More information on Canada’s OSW industry is provided in Section 5.3

United States

The US currently has 174 MW of operating fixed OSW capacity, with an additional 1.7 GW under construction and 15.2 GW with offtake contracts. The majority of OSW construction is taking place in the Northeast, as well as the Coastal

Virginia Offshore Wind (CVOW) project which is currently being built off the Mid-Atlantic coast. Most planned development to date is for fixed OSW, however Maine, some parts of the Gulf of Mexico, all of the West Coast, and Hawaii will be developing floating OSW.

In early 2021, the Biden-Harris administration announced a target to develop 30 GW of OSW by 2030, and 110 GW by 2050. In addition to the federal goals, individual states have set their own respective procurement targets, currently totalling 83.9 GW by 2045. Figure 5-2 shows the anticipated buildout of the US OSW industry to 2040. Figure 5-3 shows the offshore lease areas established by the US federal OSW regulator, the Bureau of Offshore Energy Management (BOEM), to date in the US.

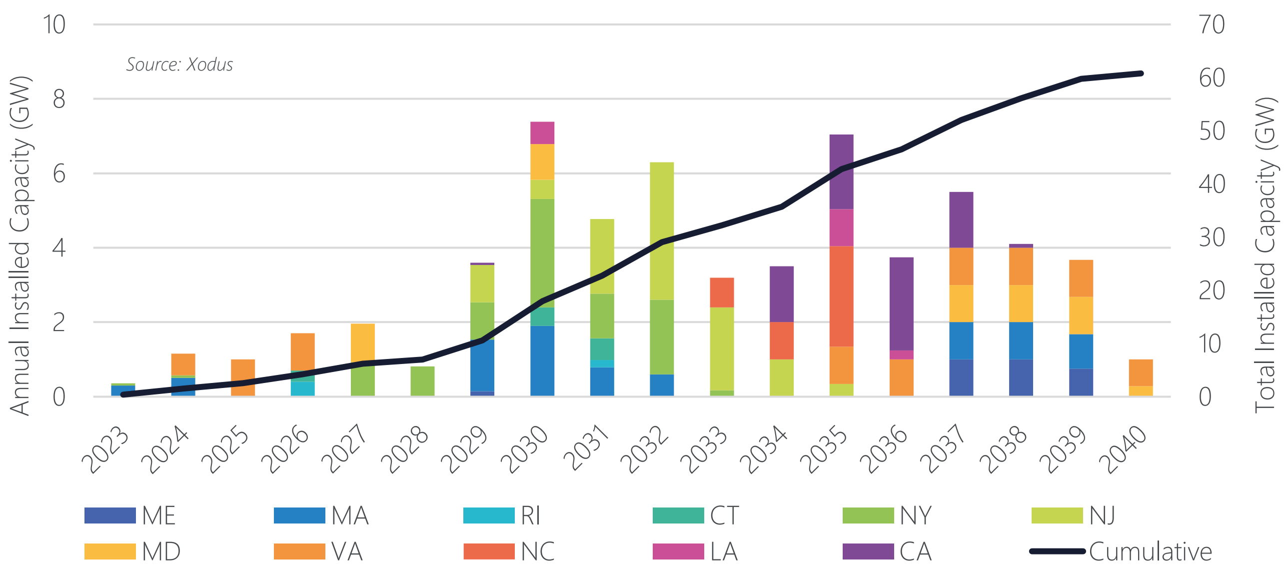


Figure 5-2 - US OSW Installed Capacity by State to 2040

OSW targets have historically stemmed from a state's existing Renewable Portfolio Standard, which requires utilities to ensure that renewable sources generate a determined percentage of the electricity they sell. However, many states have stimulated their respective OSW industries through policy initiatives, specifically through legislation or executive orders (EOs). Some states, including Massachusetts and Maryland, have utilized legislation to establish OSW procurement targets and offer financial incentives for developing an OSW supply chain. Other states, including New York and California, have utilized EOs to establish OSW procurement targets and mandate the development of comprehensive OSW strategies.

Within some states, there have also been significant efforts to localize the OSW supply chain, specifically focusing on the manufacturing of major OSW components. During the competitive offtake solicitation process, some states require developers to propose major investments in infrastructure and supply chain development in their bids. These are then scored based on predetermined criteria against other developers' supply chain development plans. Given the limited ability to compete on cost, these plans have a significant influence on which project wins the right to offtake. In some cases, the state provides significant funding to support the establishment of local manufacturing of major components and/or funds major port upgrades.

The link between offtake contracts and promoting local content has had mixed results in the US regarding supply chain development. Inflation and global supply chain issues have led to the renegotiation or cancellation of several US projects. Supply chain development plans associated with those projects were similarly postponed or canceled, leaving states to consider other ways to incentivize supply chain development.

States also encourage OSW supply chain development outside of a procurement structure by offering standalone tax incentives, grants, and subsidies. Tax incentives can provide a wide range of financial benefits, from offering tax credits to suppliers who establish manufacturing facilities to exempting OSW projects from property taxes. These incentives aim to lessen the upfront private investments in developing an OSW sector.

The Inflation Reduction Act (IRA), a federal tax incentive program designed to stimulate local content in clean energy projects, was signed into law in 2022 and provides significant expansions to renewable energy tax credits for developers and manufacturers. While both a Production Tax Credit (PTC) and an Investment Tax Credit (ITC) program are available to developers, US OSW projects have traditionally utilized the ITC program due to the relatively large capital expenditures (CAPEX) associated with OSW. The clean energy ITC has a base credit of 6% but is increased to 30% if projects meet prevailing wage and registered apprenticeship requirements. The ITC also has two bonus credits, a domestic content credit, and an energy community credit, each valued at 10%.

The Jones Act is another significant consideration for the US supply chain. Formally known as the Merchant Marine Act of 1920, the Jones Act is a U.S. federal law that governs maritime commerce between U.S. ports. Its primary provision mandates that any goods transported by water between U.S. ports must be carried on U.S.-flagged ships that are built, owned, and crewed by U.S. citizens or residents. The law is designed to support the U.S. maritime industry, ensuring that the nation has a robust fleet of vessels and a trained workforce of mariners for both defense and commercial purposes.

While the Jones Act was designed to protect U.S. maritime interests, it creates significant challenges for the OSW industry. Given that OSW installation sites are considered US "ports", WTIVs can not pick up components from a US marshalling port and transport them to the site for installation. Workarounds, such as using jack-up barges to transport components to WTIVs waiting at the installation site, have been employed, in some cases resulting in cost and scheduling impacts. This has also created opportunities to utilize Canadian ports as laydown spaces as a workaround. The US currently has one Jones Act compliant vessel, the Charybdis, which was built in the Gulf of Mexico. Canadian ports have supported all US OSW installations to date in this way, using ports in NS and NL.

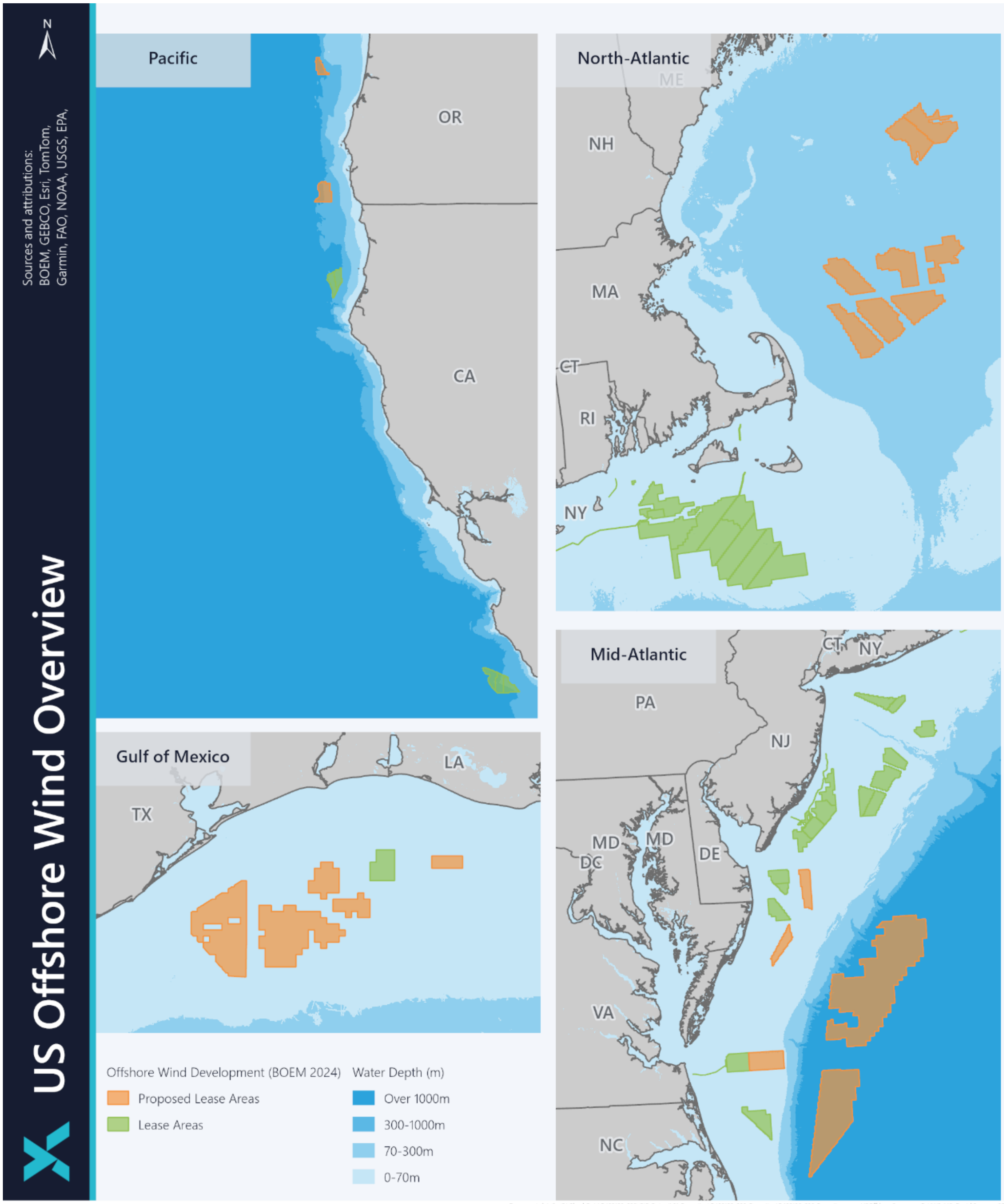


Figure 5-3 - Locations of US OSW Lease Areas

To date, the US has only limited Tier 1 manufacturing capability to supply the OSW sector. Several announcements have been made; however facilities are in various states of development. Operational and announced US Tier 1 OSW manufacturing facilities are summarised along with their publicly announced development costs in Table 5-3.

Table 5-3 - Operational and Announced Tier 1 Manufacturing Facilities in US

COMPONENT	SUPPLIER	FACILITY LOCATION	PUBLICALLY ANNOUNCED INVESTMENT	CONFIDENCE LEVEL
Nacelle	Vestas	Wind Port, NJ	Unknown	Lower
Tower	Marmen Welcon	Port of Albany, NY	$700 million*	Lower
	US Forged Rings	East Coast	$700 million*	Medium
	Haizea Wind Group	Sparrows Point, MD	$150 million	Medium
Monopile	EEW	Paulsboro Marine Terminal, NJ	$250 million	Operational
	Haizea Wind Group	Sparrows Point, MD	$150 million	Medium
Transition Piece	Marmen Welcon	Port of Albany, NY	$700 million*	Lower
Array Cable	Hellenic Cables	Sparrows Point, MD	Unknown	Higher
Export Cable	Nexans	Charleston, SC	$310 million	Operational
	LS Greenlink	East Coast	$99 million	Medium
Substation Electrical Infrastructure	Kiewit	Ingleside, TX	Unknown	Operational

***Total announced investment covers capability to supply more than one component type**

Table 5-4 - Definition of Manufacturing Facility Confidence Levels

CONFIDENCE LEVEL	DEFINITION
Operational	Facility is operational and able to manufacture components.
Higher	Facility under development and has reached final investment decision.
Medium	Facility development plan has been announced, but lack of public updates has made development timeline unclear.
Lower	Facility development needs more funding.

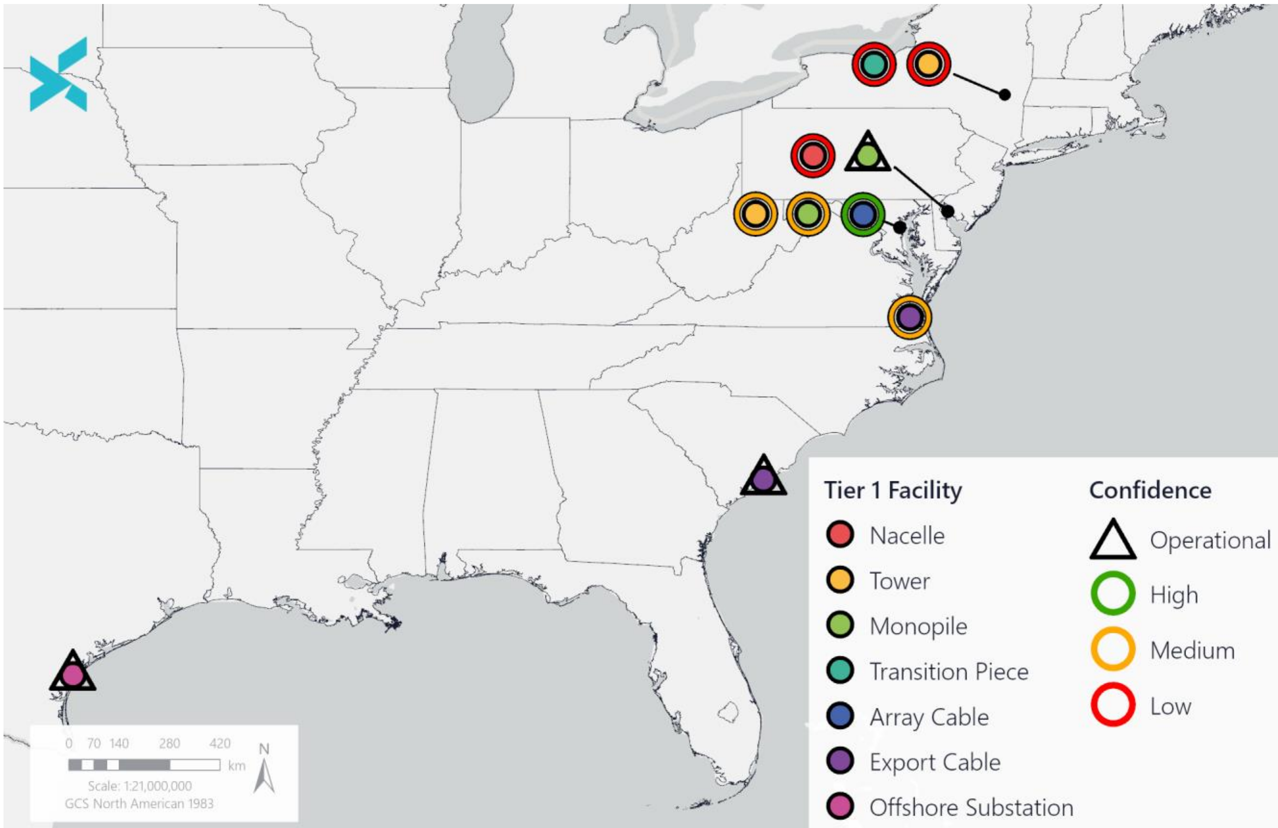


Figure 5-4 - Operational and Announced US Tier 1 Manufacturing Facilities

As can be seen in Figure 5-4, most of the announced facilities are located on the US East Coast, in relative geographic proximity to Atlantic Canada. These investments include Nucor Steel's $1.7 billion investment in steel plate manufacturing in Kentucky, the only facility in the US currently manufacturing steel plates for the OSW industry.

The US OSW industry is currently facing some substantial challenges. Very shortly following his inauguration, President Trump signed the EO "*Temporary Withdrawal of All Areas on the Outer Continental Shelf (OCS) from Offshore Wind Leasing and Review of the Federal Government's Leasing and Permitting Practices for Wind Projects*." The signing of this EO has introduced additional uncertainty into the US OSW market, particularly for projects that remain reliant on or await federal permits and approvals. Specifically, the EO directs the following actions:

1) Temporary withdrawal of offshore areas from consideration for new or renewed wind energy leasing.
2) Review of existing leases to assess ecological, economic, and environmental implications.
3) Temporary cessation and immediate review of Federal wind leasing and permitting practices pending a comprehensive assessment of legal compliance with ecological, economic, and environmental implications, including those related to the costs associated with intermittent power generation and industry tax subsidies.

In the US, this EO has caused several projects to incur impairments as they prepare for potential multi-year delays. While many US states rely on OSW procurement to meet their legislated decarbonization targets, they are also exploring alternative routes to pursue these goals if the development of the OSW industry is significantly delayed in certain regions. For projects that have obtained all necessary federal permits and approvals, the focus will be on securing off-take and commencing construction works as soon as possible.

The Trump Administration has also implemented a series of tariffs on several key trading partners of the US, including Canada, that, if maintained, will have a significant impact on the supply chain and industry investment. Given increasing national and global market uncertainty, these tariffs will likely lead to increased wind energy supply chain costs.

5.2 Global Trends and Observations

Global OSW development is continuing to expand on a global scale, with several countries and continents having ambitious capacity deployment targets set for the 2030s and 2040s in line with their overall decarbonization goals for 2050. This will continue to create opportunities for supply chain development and expansion in relation to increased demand for development services, components, vessels, workers, and port infrastructure. This is truly a global industry, with products being produced and shipped around the world. In Europe and China, the scale of projects, as well as the overall local industry, matched by a mature supply chain for key components, is enabling continued discussions on cost-effectiveness and supply chain investment. If the supply chain is not scaled to meet demand, bottlenecks and supply shortages will slow industry growth and price reduction.

The global industry has, however, been affected and continues to be affected by the rise in supply chain and commodity prices over the past two to three years, with several developers and O&G majors revising their OSW strategies. A more cautious approach to emerging markets, along with a focus on returns and project certainty, has resulted, making policy and government support for the sector increasingly important in establishing crucial stable frameworks and market confidence signals. Several successful best practices that various government agencies have implemented to drive market confidence, described in further detail below, include:

- Providing visibility for developer activity and supplier investment by establishing clear timelines for leasing and subsidy support or offtake award rounds.
- Driving awareness and development of local supply chain capability by tying such initiatives to site awards and subsidy mechanisms.
- Signalling long-term market confidence to developers and investors by establishing binding procurement targets.
- Optimizing economic benefit by striking a balance between establishing appropriate local content requirements and mitigating the impact of price increases on ratepayers.
- Incentivizing environmental justice and supplier diversity by rewarding developers for siting projects in communities impacted by fossil fuel-based power generation and requiring supplier diversity plans.

Whilst approaches to supply chain and market development have differed across OSW markets, key high-level considerations on best practices have focused particularly on establishing the necessary capacity to enable developer activity and associated supplier investments to deliver projects. This includes clear timelines for both leasing and subsidy support, as well as offtake award rounds, ensuring that industry stakeholders have visibility into routes to market. The Netherlands, Germany, Denmark, and France, for example, have offered regular site award rounds in line with established capacity targets. Meanwhile, the UK's annual Contracts for Difference (CfD) allocation rounds provide a key milestone and route to market opportunity for guaranteed pricing support over a 15-year period, enabling developers to plan their supply chain engagement and financing around this.

Site awards and subsidy mechanisms have also been utilized as tools to drive supply chain development and reporting, providing incentives for projects to commit to local benefits while also providing important industry signals on particular supply chain gaps or challenges that individual countries and their stakeholders can then respond to. In France, leasing rounds for sites have included a requirement for a minimum of 6% of expenditure to be awarded to small- and medium-sized enterprises (SMEs), whilst Australia's feasibility licence application for OSW has required applicants to outline the national benefits of the proposed projects, including the use of Australian goods and services.

In Scotland, the requirement by Crown Estate Scotland for OSW projects to submit Supply Chain Development Statements (SCDS) as part of their overall lease agreement process has provided information to industry stakeholders and the Scottish government of areas of local capability and potential investment requirement. This has enabled and enhanced several new and existing initiatives to drive supply chain development, including strategic investment models for port and manufacturing infrastructure, business support programs for companies to enter the OSW market, and supporting an established ecosystem for grant and innovation funding.

Suppliers and any investment in growing their capabilities, particularly in OSW, require clear market confidence. Establishing procurement targets is one of the core policy mechanisms that countries and states use to support the growth of an OSW industry, and it is crucial for developing an internal supply chain. They provide strong market signals to private investors by reducing risk and encouraging investment in OSW projects and supply chain by providing a pipeline that will provide a reliable return on investment.

Creating local content and maximizing economic benefits to regions where OSW projects are being built is an observable trend in many jurisdictions. While creating opportunities for local companies to enter the OSW supply chain is desirable, both for local economic prosperity and job creation, as well as building a social license to operate, requiring the use of local companies and workforce may elevate costs and have an impact on quality if not properly managed and implemented.

There have been substantial efforts, particularly in the US, to encourage environmental justice and supplier diversity in the OSW industry buildout. Developers are rewarded for locating project infrastructure in regions that have previously been subject to fossil fuel industry activities (referred to as "energy communities" in the US IRA). Furthermore, developers are often requested to submit Supplier Diversity Plans with their offtake solicitations, and to include as many diverse-owned companies as possible in their projects.

5.3 Canadian Context

Atlantic Canada offers ideal environmental conditions for OSW, including consistent, world-class wind speeds of up to 11 m/s, as well as suitable water depths and bathymetry [1]. Additionally, due to the Atlantic Region's ongoing involvement in offshore O&G, shipbuilding, and fishing, there are many transferable skills, ports, and existing infrastructure that can be utilized in the emerging OSW sector. This nascent industry has the potential to create new jobs for Canadians, including transferable jobs for individuals employed in adjacent industries.

On a national level, Canada does not currently have any published OSW targets; however, the province of NS has a stated goal of leasing 5 GW of OSW capacity by 2030. Capturing and developing the wind resources in the Atlantic offshore can position Canada to be a leading supplier of clean energy, including the development of green hydrogen that other countries are actively looking to purchase, while also decarbonizing local electricity grids [9]. Despite the vast potential for OSW in Canada, to become a major supplier or global leader additional federal and provincial targets beyond the 5 GW goal set by NS will be necessary to accelerate nationwide development. Federal targets serve to demonstrate that provinces have support for OSW initiatives, decreasing investment risk for potential proponents.

While there may be potential on the West Coast of the country or in the Great Lakes, federal and provincial focus for OSW development is currently focused in NS and NL. The provinces of PEI and NB have no immediate development plans but are still able to support OSW development through their existing and potential supply chain, workforce, and import of energy, and may explore their own OSW developments in the longer term. Ontario had OSW projects proposed in the Great Lakes, however in 2011 the Province of Ontario implemented a moratorium on OSW while further studies were completed. This has not yet been lifted.

In early 2024, Natural Resources Canada's (NRCan) CanmetENERGY—Canada's leading research and technology organization in the field of clean energy— published a report entitled *Preliminary Considerations Analysis of Offshore Wind Energy in Atlantic Canada* in effort to identify Atlantic Canadian regions that could potentially become OSW candidates [10]. Several areas were identified, including regions in the Gulf of St. Lawrence off the southwestern coast of NL, sections of the Northumberland Strait, parts of the Sable Island Bank, Middle Bank, and Banquereau Bank off the southern coast of NS, and areas of Browns Bank and Georges Bank. This analysis focused strictly on resource availability. A more comprehensive analysis of resources and socio-environmental considerations for NS and NL was recently completed through a joint federal-provincial Regional Assessment (RA) in the offshore waters of both provinces, as discussed in Sections 5.3.3 and 0, respectively.

Eastern Canada already supports major component manufacturing for OSW. Wind turbine blades are manufactured in Gaspé, Quebec at a facility owned by LM Wind Power, a subsidiary of GE Vernova, as shown in Figure 5-5. This factory has produced over 10,000 blades for offshore and onshore wind turbines and has plans for expansion.

Figure 5-5 - Wind Turbine Blade Manufacturing in Gaspé, Quebec

In the following sections, Canadian regulatory frameworks and incentive structures are discussed, as well as the status of OSW development in each province and territory. Insights are provided on resource potential as it relates to wind, determination of developable areas, and pathways to market. Provincial policies and regulatory structures are further discussed, detailing implemented and outstanding policies to-date. Supply chain overviews provide a high-level summary of existing infrastructure and assets that may be leveraged in building an OSW supply chain. Note that this will be expanded upon in Section 8. Finally, development plans provide information on anticipated developments and timelines, as well as discussion on the potential for success of such developments.

5.3.1 Regulatory Framework

Until now, a major challenge to the development of Canada's OSW industry has been the lack of a regulatory framework. Historically, joint management agreements for petroleum resources governed the offshore O&G industry in NS and NL, executed by the regulatory bodies the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) and the Canada-Newfoundland and Labrador Offshore Petroleum Board (CNLOPB), respectively. The Provinces of NL and NS and the Government of Canada have now taken a similar approach for OSW.

The foundation for the new OSW regulatory regime is also a joint management approach, under the *Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation Act* and the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Act*. These Acts are collectively known as the "Atlantic Accord Acts", with the respective Acts for NS and NL mirroring each other. Language for the amended Acts, including provisions for OSW, was developed jointly by the governments of NS and NL, and the federal government to apply to offshore renewable energy development. Federal Bill C-49, *An Act to Amend the Canada – Newfoundland and Labrador Atlantic Accord Implementation Act and* *the Canada – Provincial – Nova Scotia Offshore Petroleum Resources Accord Implementation Act and to make consequential amendments to other Acts* received Royal Assent in October 2024.

NRCan promotes and facilitates significant research and innovation across all Atlantic provinces. Under a parallel process, NRCan has been developing Offshore Renewable Energy Regulations (ORER) under the Canadian Energy Regulator Act. These regulations will apply to the complete project lifecycle, including site assessment, construction, operation, and decommissioning activities in Canada's federal offshore areas [11] and through mirror legislation in the provinces of NS and NL under the Accord Acts, a version of the regulations will apply to OSW activities. The ORER evolved from the Frontier and Offshore Regulatory Improvement initiative led by NRCan and the Governments of NS and NL with some assistance provided by BC. The regulations themselves were a collaborative effort of Canada and interested provinces, including NS and NL.

At the federal level, key regulators include the Impact Assessment Agency of Canada (IAAC) for environmental assessments, Fisheries and Oceans Canada (DFO) for marine habitat and species protection, and Transport Canada for navigation safety.

5.3.2 Federal Incentives

Canada is working to implement various federal tax incentives aimed at attracting investment in wind energy and other renewable energy sectors, supporting innovation, creating jobs, and driving the economy towards net zero. These tax incentives fall under the umbrella of Clean Economy Investment Tax Credits, which include the Clean Technology ITC, the Carbon Capture, Utilization, and Storage (CCUS) ITC, the Clean Technology Manufacturing ITC, and the Clean Hydrogen ITC. Legislation for the Clean Electricity ITC has not yet passed, however it would provide a 15% refundable tax credit for investments in non-emitting electricity, including OSW and onshore wind [12]. Both taxable and non-taxable entities, including crown corporations, publicly owned utilities, and Indigenous community-owned corporations, would be eligible for this tax credit, which can be claimed for new projects as well as refurbishment projects [12].

The Clean Technology ITC is a 30% refundable tax credit that supports investment in clean technology [12]. This tax credit is intended to support investments in net-zero technologies, battery storage, and clean hydrogen [12]. Equipment eligible for this tax credit includes generation systems, including wind, clean electricity storage systems, low-carbon heat equipment, industrial zero-emission vehicles, and select geothermal equipment [12].

The Clean Hydrogen ITC was implemented to support investments in clean hydrogen production, ranging from 15% to 40% of eligible project costs, with higher support for projects producing the cleanest hydrogen [13]. Eligible equipment for this tax credit includes both those associated with water electrolysis and natural gas reforming, granted that CCUS is used to abate emissions from the latter [13].

5.3.3 Nova Scotia

Resource Potential

NS is most likely to be the first province to develop its own OSW industry, with a target of 5 GW of developable seabed capacity to be leased by 2030, with a first call for bids expected in 2025. Off the coast of NS, world-class OSW resources have been identified, including areas suitable for both fixed and floating technologies. This wind resource is robust and shows significant promise for OSW development. Wind speeds, measured at 100 m above sea level, average between 9-12 m/s [14], suggesting optimal conditions for energy generation. In NS's Offshore Wind Roadmap (Module 1), four potential routes-to-market were identified for NS's OSW resource [15], as follows:

1) Provincial demand for clean electricity or green fuels,
2) Regional/national demand for clean electricity or green fuels,
3) Demand for clean electricity from the US, and
4) International demand for low carbon, green fuels and chemical feedstock (e.g., ammonia or other e-fuels).

Policy and Regulatory Context

In addition to the joint management areas of the NS offshore under the Atlantic Accord Acts, NS has the *Marine Renewable-energy Act* (MRE) Act, which governs marine renewable energy resources (tidal, wave, and offshore wind energy) in the marine areas of NS with the goal of providing effective and efficient development [16]. The MRE Act is designed to apply only to areas declared to be of marine renewable-energy priority. Currently the declarations have been in the areas where provincial ownership has not been contested by the Government of Canada. Outside these areas the Governments of NS and Canada have agreed to joint-management under the amended Accord Acts. One of the key provisions of the MRE Act is to enable public consultation and engagement in a staged and focused manner by designating the priority areas for MRE development. The only priority areas established under the Act in 2012 were for tidal energy developments within the Bay of Fundy and the Bra d'Or Lakes. This Act can also be used to designate areas for provincial regulation of OSW projects.

Amendments made in 2024 to the MRE Act under Bill-471 (*Advancing Nova Scotia Opportunities Act)* introduced changes to the *Canada-Nova Scotia Offshore Petroleum Resources Implementation Act* and the MRE Act, allowing the CNSOPB to expand its mandate to regulate offshore renewable energy including the issuance of submerged land licenses and changing its name to the Canada-Nova Scotia Offshore Energy Regulator (CNSOER). This bill received Royal Assent in September 2024.

To assist NS in reaching its 5 GW of licensed seabed by 2030 goal, the Province has currently produced two out of three modules of its *NS OSW Roadmap*. The modules that make up the roadmap are as follows:

- Module 1 (completed): maps the work to complete the legislative and regulatory regime for OSW.
- Module 2 (completed): focuses on supply chain and infrastructure opportunities for OSW.
- Module 3 (expected release in 2025) will incorporate input from the Mi'kmaq and other Indigenous peoples, as well as other groups such as the fishing industry, ocean users, environmental organizations, workers, and the research community.

In Module 1 of the OSW roadmap, the timeline presented for potential offshore leasing, or licensing as it is typically referred to in Canada, was from 2025 for the Canada-NS jointly managed jurisdiction and as early as 2026 for nearer shore testing and demonstration projects. Subsequently, NS indicated that it was prioritizing all joint-management areas under the CNOER. Provincially, the NS Department of Energy (DOE) will play a leading role in policy development and oversight for the jointly managed offshore areas. Consultation and engagement with Indigenous peoples will be essential (see Appendix B.1 for more information), along with stakeholder engagement involving fisheries and coastal communities.

Supply Chain Overview

NS has a rich maritime history, including offshore O&G, fishing, ocean technology, shipbuilding, and environmental monitoring. The province has also hosted several projects for tidal energy development. Due to NS's historical and current involvement in maritime industries, there are already numerous pre-established, ice-free ports that have the potential to act as hubs for OSW construction and installation or to serve as storage, staging, and pre-assembly (marshalling) areas both regionally and internationally. The Port of Halifax, Atlantic Canada Bulk Terminal in Sydney, and the Port of Sheet Harbour have already provided logistical support to OSW projects in the US Northeast.

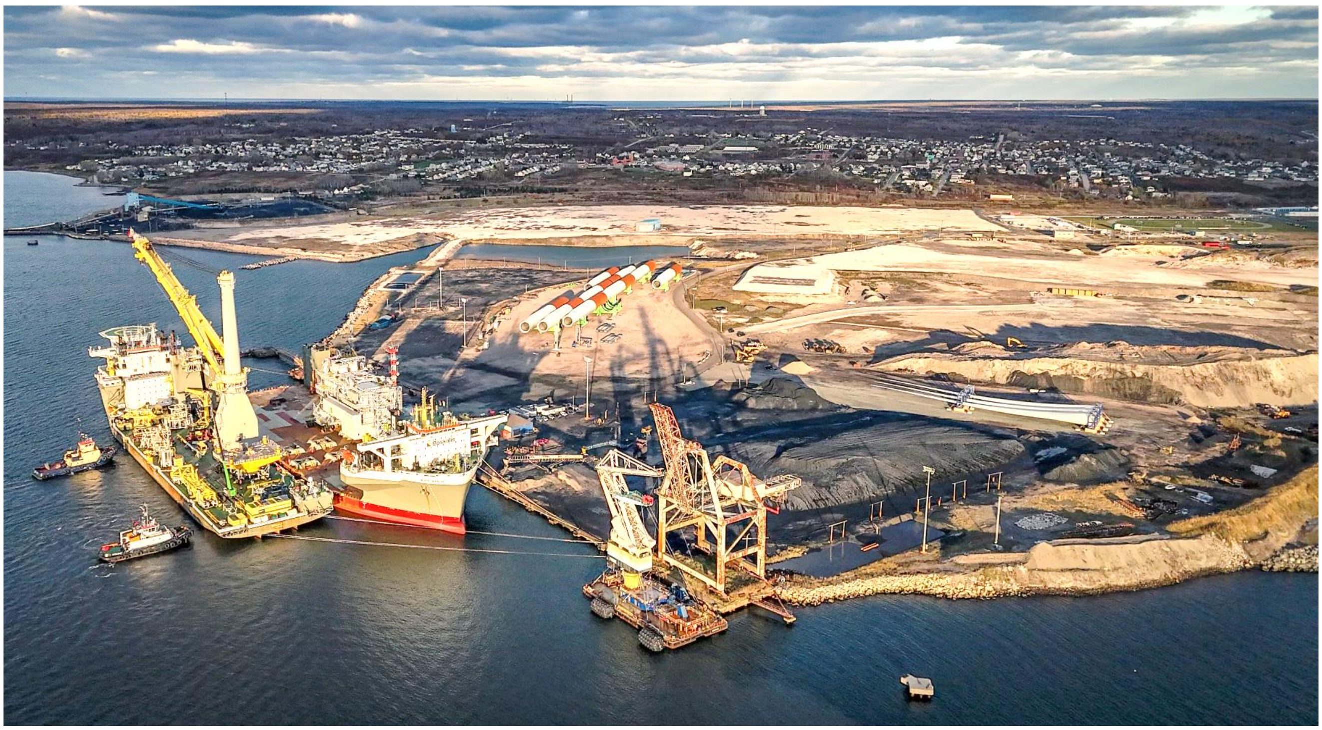


Figure 5-6 – Monopiles and Blades at Atlantic Canada Bulk Terminal in Sydney, NS (Photo Credit: Christopher Morrison)

Nova Scotia excels in ocean technology with advanced competencies in marine sensing and imaging, ocean mapping and data analytics, underwater acoustics and marine communication, 3D printing for the marine environment, subsea robotics and autonomous vehicles, modular power platforms and digital asset integrity solutions, and marine geotechnical and geophysical services. The region also supports defense and security applications through maritime surveillance and underwater threat detection, and boasts a strong shipbuilding industry that is playing a crucial role in the National Shipbuilding Strategy. These diverse capabilities position Nova Scotia as a key player in the ocean technology sector, ready to support various marine-related activities and the growing offshore wind industry.

Nova Scotia's workforce is diverse and skilled, with significant employment in the shipbuilding and fabrication sectors. Its workforce is also experienced in fabrication operations, metal fabrication, welding, and machining, which has supported various industries including renewable energy.

In Module 2 of the NS OSW roadmap, the province recognizes the critical role of local supply chains and infrastructure in supporting the growth of the OSW sector. While the province currently lacks an established OSW supply chain, it can leverage existing local businesses in adjacent industries, particularly those engaged in maritime activities and those with existing experience in NS's legacy offshore O&G industry. Major project components will initially need to be sourced from outside the province. The NS OSW Roadmap also outlines several early strategic actions to support the growth of the local supply chain and maximize regional benefits. One recommendation suggested a comprehensive assessment of local supply chain strengths and weaknesses to help stakeholders identify key areas for improvement—a key driver for this study.

The roadmap emphasizes that addressing workforce needs and identifying skill gaps is crucial for driving the growth of the OSW sector, as well as building partnerships to enhance skills development and foster innovation. Universities and colleges in NS offer numerous facilities that contribute to research and innovation in ocean industries, including the Ocean Frontier Institute, the Canadian Coast Guard College, the Nova Scotia Community College (NSCC), the Centre for Ocean Ventures and Entrepreneurship (COVE), and numerous start-ups and tech companies.

Finally, the roadmap recommends analyzing existing port infrastructure to identify potential upgrades to meet the evolving needs of industries like OSW. By anticipating these future requirements, local ports can better prepare for growth.

Development Plans

As previously mentioned, the Governments of Canada and NS launched an RA of OSW development in the Canada-NS offshore area in March 2023. This assessment focused on gathering information and data to help inform future project-specific impact assessments (IA). The goal of the RA was to investigate a predetermined Study Area, seen in Figure 5-7, to provide information, knowledge, and analysis that will inform future OSW development processes, such as EAs and licensing, and to inform OSW development activities, "… in a way that helps protect the environment and health, social and economic conditions while also creating opportunities for sustainable economic development" [14].

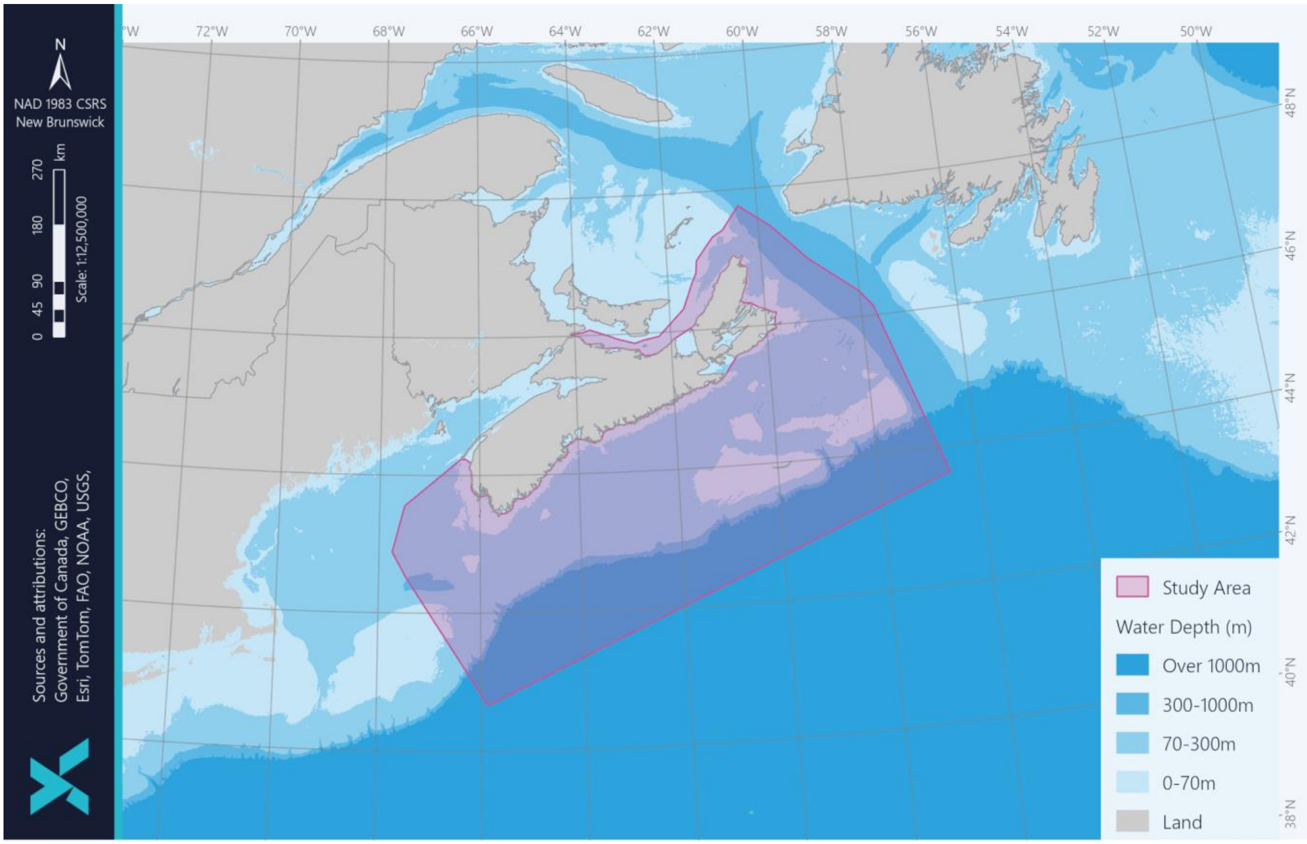


Figure 5-7 - Regional Assessment Study Area for NS

The original RA study area covered approximately 300,000 km^2, encompassing the continental shelf and slope off NS. In the final report, however, this area has been further delineated into eight potential development areas, covering a total of 31,200 km^2.

Constraints that were applied to limit the study area include vessel density and routes, subsea cables and pipelines, aquaculture locations, port locations, commercial fishing zones, inshore lobster fishery zones, surficial geology, sea ice cover, water depth, wind speed, ecological areas, and risk to marine birds [14]. Additionally, Georges Bank has been excluded as a moratorium on offshore wind was put in place. This aligns with the moratorium on O&G development due to calls from the fishing industry. Once these scenarios were run with specific criteria grading, areas resulting with higher scores included portions of Sydney Bight, French Bank, Canso Bank, Middle Bank, Sable Island Bank, Emerald Bank, Misaine Bank, and LaHave Basin as presented in Figure 5-8. The characteristics associated with the development areas are given in Table 5-5.

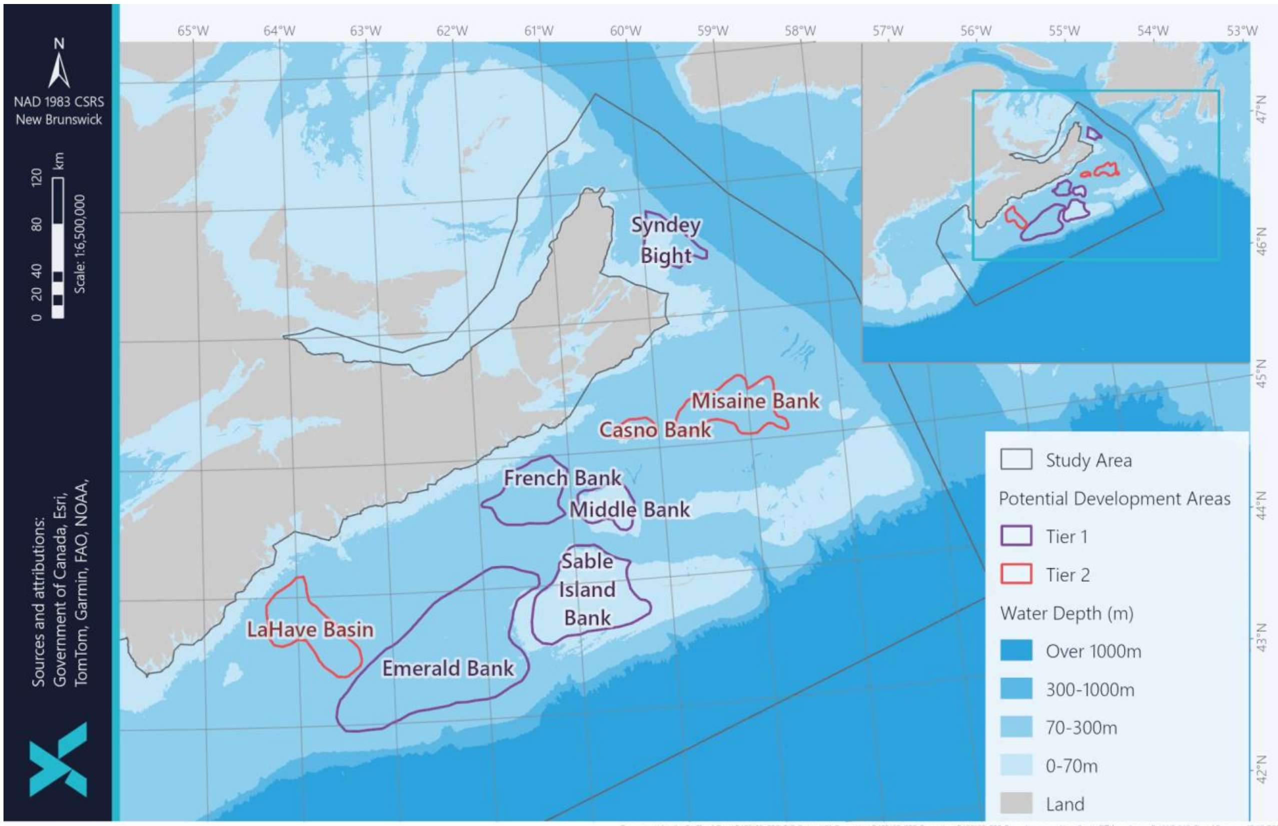


Figure 5-8 - Identified Potential Future Development Areas (Regional Assessment of OSW Development in NS - Final Report, January 2025 [14]

	SYDNEY BIGHT	FRENCH BANK	CANSO BANK	MIDDLE BANK	SABLE ISLAND BANK	WESTERN / EMERALD BANK	MISAINE BANK	LAHAVE BASIN
AREA (km^2)	1,435	2,855	430	1,445	5,620	13,170	2,830	3,415
TURBINE TYPE POTENTIAL	Fixed Floating	Fixed Floating	Fixed Floating	Fixed	Fixed	Fixed Floating	Floating	Fixed Floating
WATER DEPTH (m)	0 – 100 100 – 300	60 – 100 100 – 300	60 – 100	0 – 100	0 – 100	0 – 100 100 – 300	60 – 300	60 – 100

Table 5-5 - Characteristics of Potential Future Development Sites (Regional Assessment of OSW Development in NS - Final Report, January 2025 [14])

The final RA report was released in January 2025, noting that the report is non-binding, and therefore the identified areas are subject to change as the government seeks to identify wind energy areas. The final report contained 34 recommendations developed under the following themes, which have been considered as part of this study where there is relevance to supply chain development:

1) Existing knowledge, gaps and necessary research
2) Socio-economic feasibility and consequences
3) Project development
4) Coexistence and compensation
5) Cumulative effects
6) Governance
7) Education and training

There are several developers who are interested in obtaining a licence, depending upon the yet to be announced terms and conditions. The only project that has described their plans in public detail is Nova East Wind, a partnership between DP Energy and SBM Offshore, who plan on having between 300 and 400 MW of floating OSW capacity in operation by 2030. Recently, the government of NS announced fives wind energy areas (WEAs), with the first call for licensing bids expected in 2025 (see Figure 5-9). At time of writing, no seabed off NS has yet been licensed for the purposes of developing OSW.

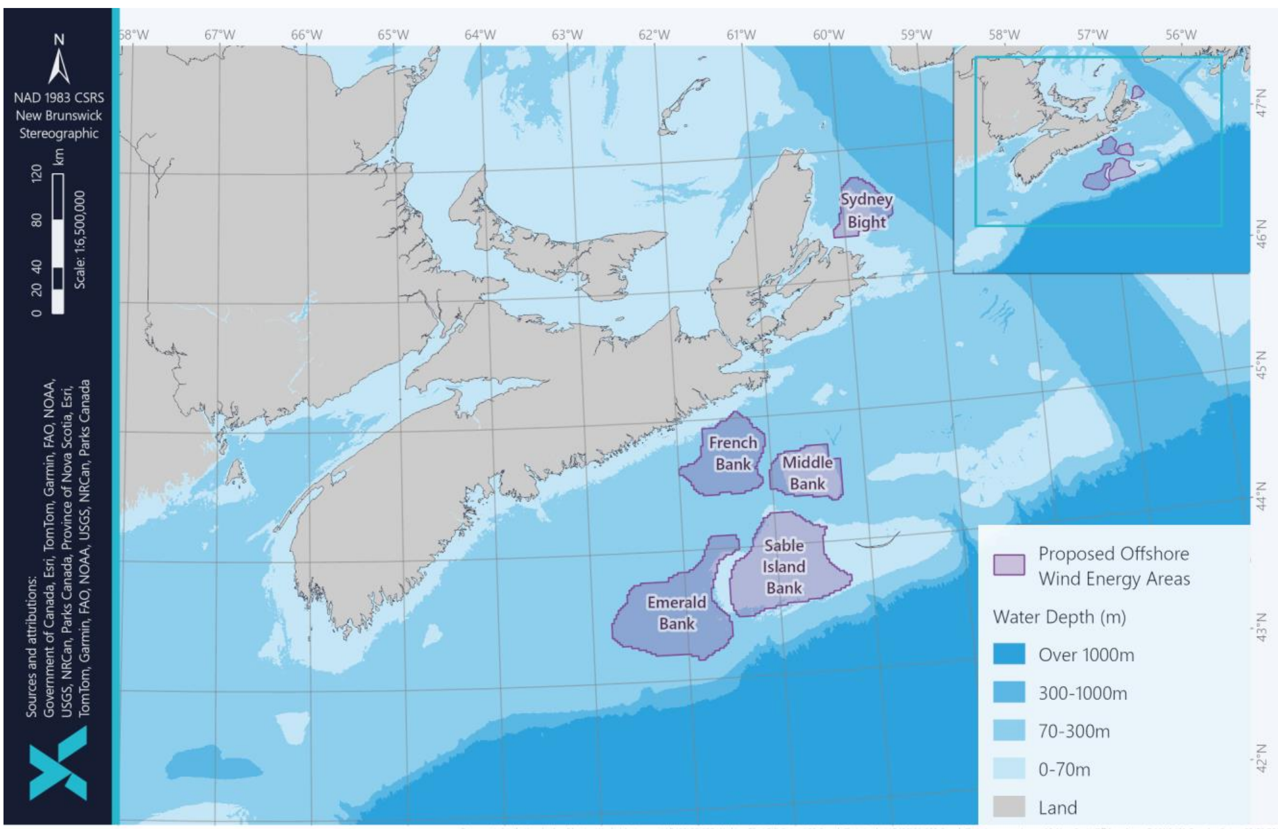


Figure 5-9 - Wind Energy Areas for Offshore Wind Licensing in NS

5.3.4 Newfoundland and Labrador

Resource Potential

One of NL's greatest assets is its untapped wind energy potential with wind speeds comparable to NS, averaging up to 11 m/s. There are currently no existing or planned OSW projects off NL, representing a vast development opportunity for the province for use in export of electricity, or in the generation of other green fuel alternatives. Various developers have previously shown interest in developing OSW projects in Atlantic Canada, particularly in NL, however due to a lack of regulatory framework and with limited pathways for offtake, no development took place. There have been recent efforts to investigate the potential of co-locating OSW with offshore O&G to offset emissions, however to date this has not been implemented.

Policy and Regulatory Context

In December 2023, the Governments of NL and Canada entered a Memorandum of Understanding (MOU) regarding OSW development within non-federal waters that had been defined by the Supreme Court of Canada. This MOU established that NL will have sole authority over the approval of offshore renewable energy projects within designated bays, meaning that in these bays, joint federal-provincial management is not required. This MOU outlines a process whereby the province can administer leases and regulate projects, including the revenue for projects developed [17]. The bays included in this MOU are shown in Figure 5-10.

In NL, the jointly-managed areas will be regulated by the CNLOPB, which is soon to be renamed the Canada-Newfoundland and Labrador Offshore Energy Regulator (CNLOER) under NL Bill 90 *An Act to Amend the Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act*, as previously discussed. This Bill received Royal Assent in March 2025 and will soon result in a name change for the regulatory body.

Provincially, the Department of Industry, Energy, and Technology (IET) will coordinate nearshore developments and support renewable energy initiatives, while the Department of Environment and Climate Change (ECC) will assess environmental impacts. Indigenous Consultation will be central to ensuring regulatory alignment and inclusive processes.

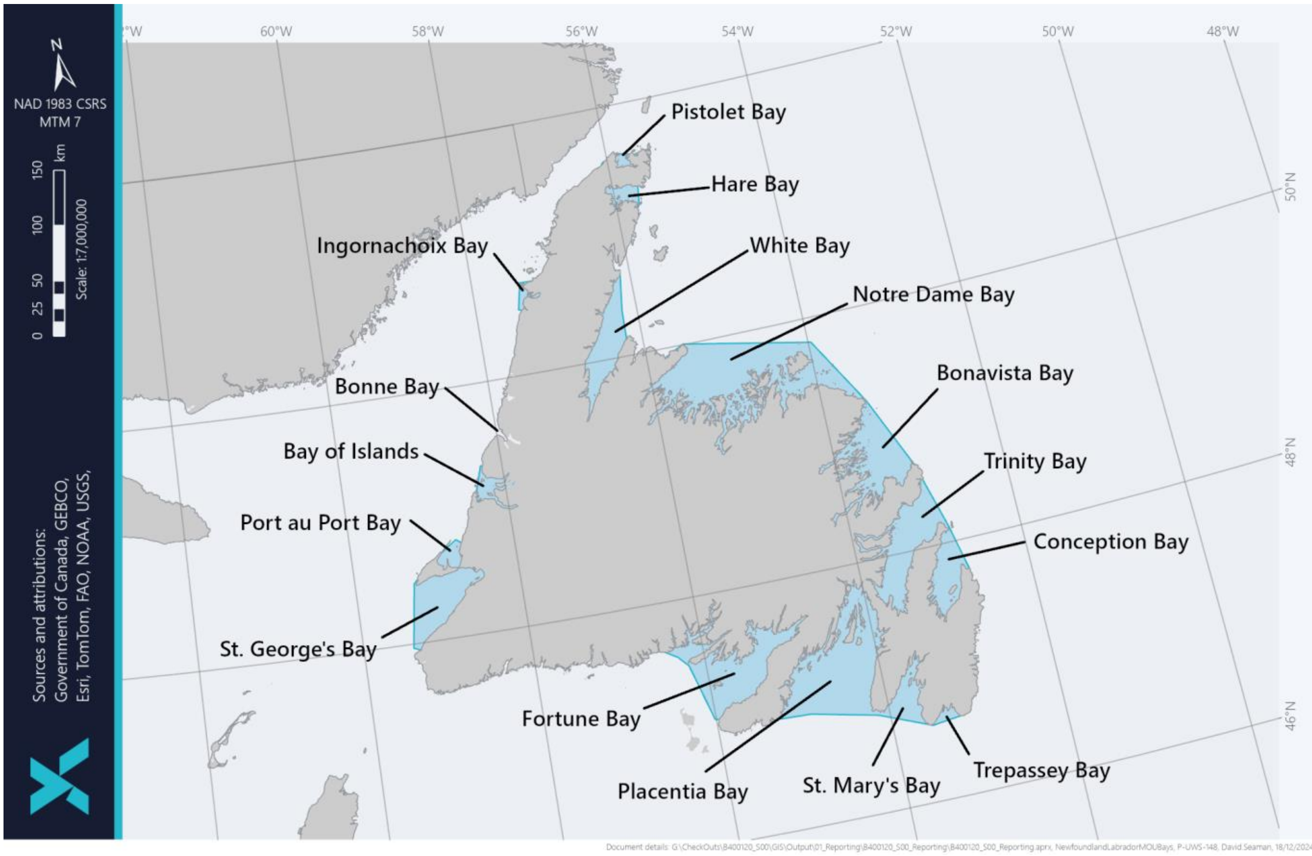


Figure 5-10 - Bays of NL included in the 2023 MOU with the Government of Canada

Supply Chain Overview

Like NS, NL also has a rich history in maritime industries, including an active offshore O&G sector. The island of Newfoundland is strategically positioned between the U.S. and Europe, with strong connections to international shipping routes. Known for its expertise in cold ocean environments, resilience in challenging conditions, and established global trade links, the region is home to a network of companies, institutions, and R&D facilities that develop and export some of the world's most advanced technologies [18].

Notably, the region excels in sensing and imaging, ocean mapping, surveillance, data analytics, underwater acoustics, marine communication, systems monitoring, subsea robotics, autonomous vehicles for remote inspection and maintenance, modular power platforms, and digital asset integrity solutions [18]. It also offers robust marine geotechnical and geophysical services, including site surveys, cable and pipeline inspections, and port infrastructure surveys [18]. NL's competencies in ocean environmental technology are well-positioned to seize new opportunities emerging from the OSW industry [18].

The Port of Argentia in NL is Canada's first monopile marshalling port, supporting US OSW projects. It has over 170 acres of paved runways and an extremely high load-bearing capacity, making it ideal for monopile marshalling without further upgrades.

Figure 5-11- Monopiles at the Port of Argentia, NL (Photo Credit: Port of Argentia)

NL has a large industrial workforce, including up to 10,000 that work in the oil sands of Alberta [19], and extensive experience in the offshore O&G industry including over 8,900 individuals employed in the field [20]. Broad experience in major fabrication operations supports this industry. There are numerous mineral mines in the province, including five metal mines (nickel, iron ore, copper, cobalt, and gold), that employ over 7,000 individuals [21].

Development Plans

In March 2023, the Governments of Canada and NL launched the RA of OSW Development in NL, and in January 2025 a final report [22] was published and delivered to federal and provincial ministers. The RA outlined four objectives to guide OSW development:

1. Providing comprehensive environmental, health, social, and economic data,
2. Understanding regional contexts for assessing potential effects,
3. Recommending mitigation strategies for both positive and negative impacts, and
4. Using these findings to improve future planning and licensing for sustainable development.

The initial study area surrounded the island of Newfoundland and southern Labrador, excluding French-owned areas associated with Saint Pierre and Miquelon, as shown in Figure 5-12. They studied ice and iceberg forecasts and determined that OSW developments should not occur in areas where icebergs may be present until demonstrations are completed to prove technological capabilities within viable development in such areas. Similarly, based on current technology, the committee decided to only include areas with water depths less than 300 m given the limitations of floating OSW technology. In a similar manner, the committee used a constraints analysis to identify OSW licensing areas within this focus area and removed sections of the study area in which OSW development would be less likely in the near future. Once the committee completed a more technical analysis on the feasibility of certain areas, they refined this broad study area into a focus area.

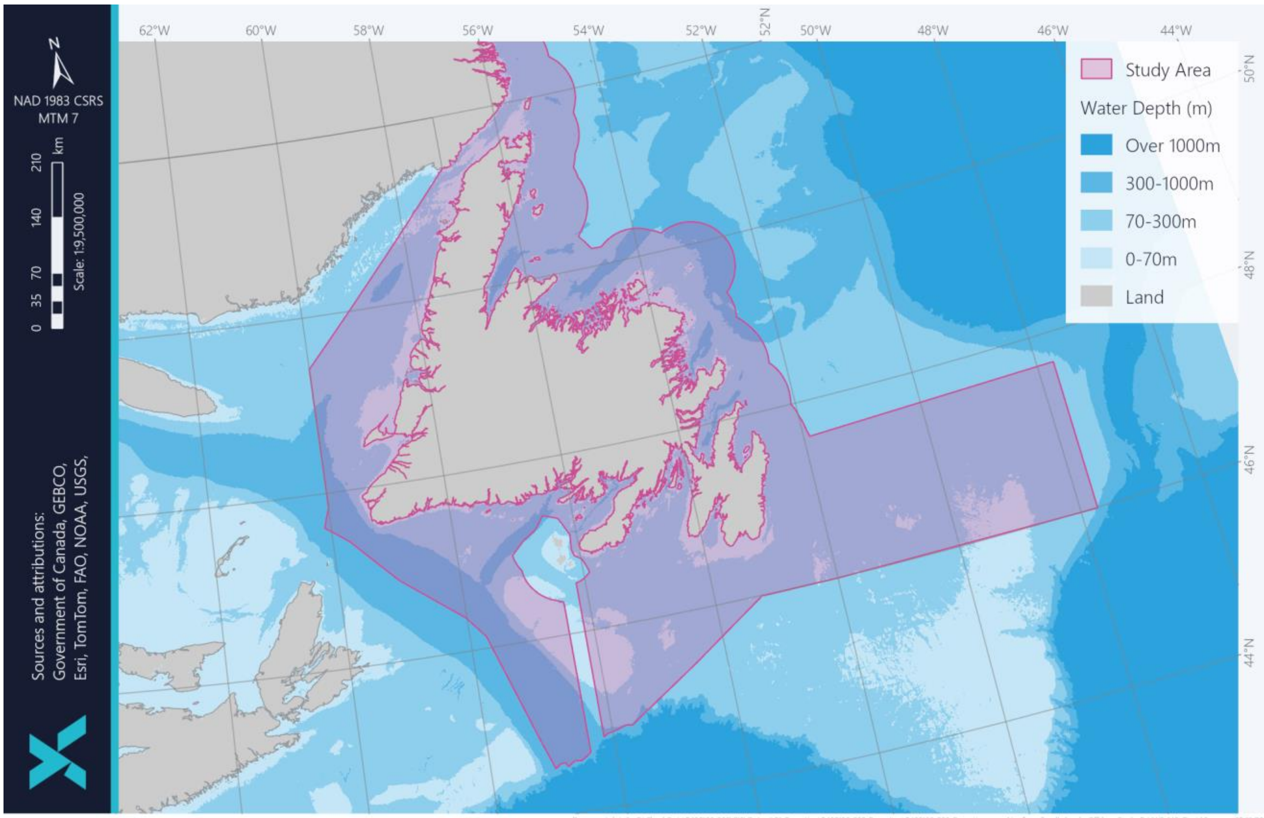


Figure 5-12 - Initial Study Area for the NL Regional Assessment

The constraints used to refine the focus area included a buffer around coastal areas, marine critical habitats and protected areas, high vessel traffic areas, fjords and national marine conservation areas, areas near national parks and world heritage sites, high density fishing areas, and community based coastal resources. Figure 5-13 gives the committee's resultant recommended OSW licensing areas covering a total area of 16,996 km^2. As in NS, the licensing areas recommended in the RA for development are subject to change following the government's determination of Wind Energy Areas that will define the areas/parcels for an eventual call for bids.

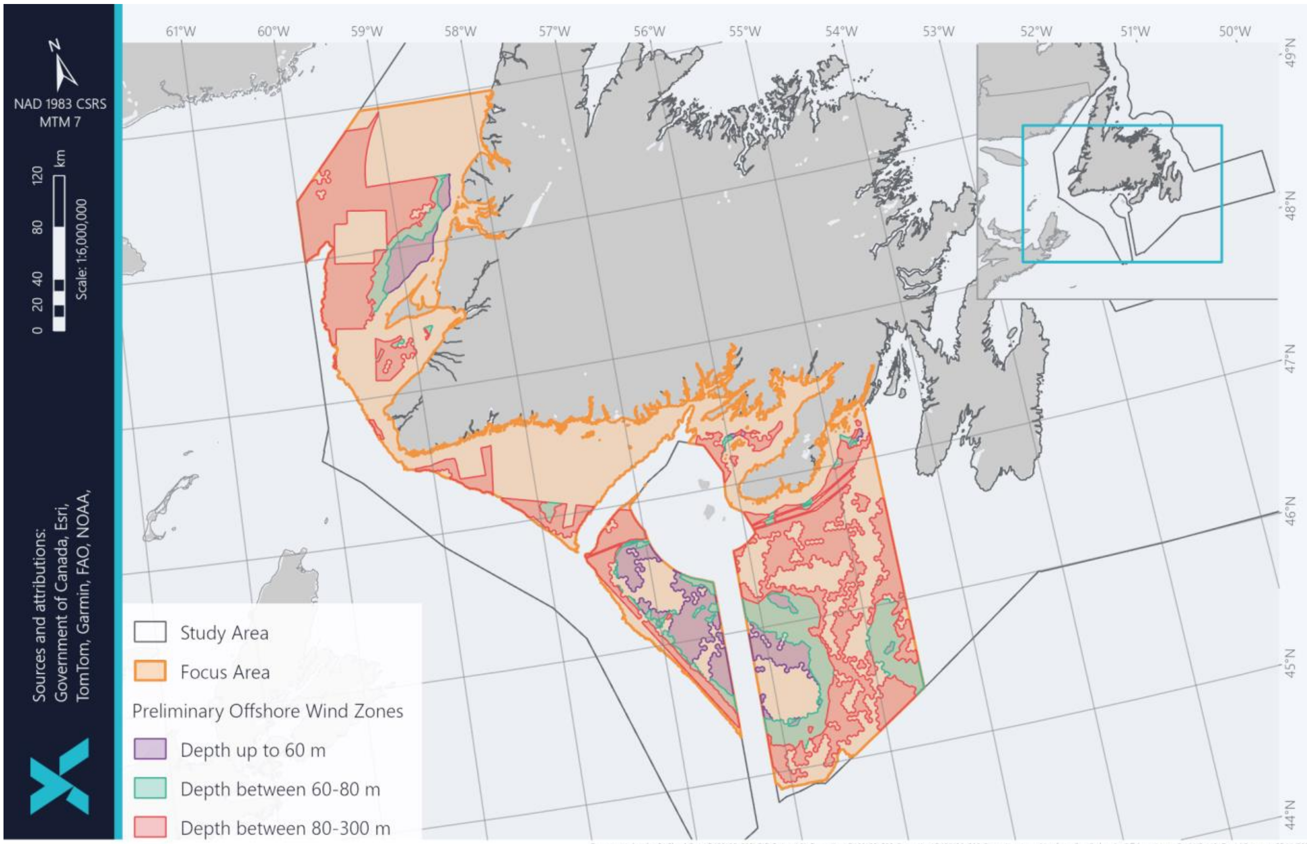


Figure 5-13 - Identified Potential Future Development Sites (Regional Assessment of OSW Development in NL - Final Report, January 2025 [22])

Table 5-6 below describes the individual areas shown in Figure 5-13.

	# OF AREAS	WATER DEPTH	AREA [KM^2]
Purple	24	< 60 m	1,994
Green	19	60 – 80 m	4,942
Red	66	80 – 300 m	10,060

Table 5-6 - Summary of Identified Licensing Areas [22]

5.3.5 New Brunswick

Resource Potential

NB's OSW potential is primarily located in the Bay of Fundy and the Gulf of St. Lawrence—areas known for strong and consistent wind speeds averaging 7-9 m/s [23]. With robust transmission infrastructure and connections to NS, PEI, and northeastern US, NB is strategically positioned to deliver clean OSW power to regional and US markets if it decides to pursue development of this industry. There has not been an RA carried out in NB to date.

Policy and Regulatory Context

NB's first climate change action plan was released in 2007 and has had a series of renewed versions released since. It's latest version, *New Brunswick's Climate Change Action Plan 2022 – 2027*, commits to NB being net-zero by 2050. Within the action plan, the province states that it will develop a *Clean Electricity Strategy* by 2025 to achieve net-zero electricity by 2035. Currently, NB is not explicitly pursuing OSW projects and has not signalled any immediate plans to do so due to the higher costs associated with this technology compared to onshore wind [24]. However, as part of this effort, NB is expected to explore a range of renewable energy options in the coming years. OSW could be considered as a potential avenue for future development, particularly given future cost reductions of the development of a regional supply chain.

In NB, OSW development would require negotiations between the Province and the Government of Canada on a licensing and management regime. Other regulatory matters would primarily be regulated at the federal level by agencies like the IAAC for environmental assessments, DFO for marine resource protection, and Transport Canada for navigational safety. Provincially, the Department of Natural Resources and Energy Development would have leadership on energy policy and related matters. For enclosed bays around the province's nearshore, including the Bay of Fundy, NRED would be the energy policy and licensing lead while the Department of Environment and Local Government (DELG) would manage environmental impact assessments. Indigenous Consultation with the Mi'kmaq and Wolastoqiyik First Nations, and stakeholder engagement with fisheries and local municipalities will be vital to ensure project alignment with regional priorities.

Supply Chain Overview

One of NB's most prominent sectors is advanced manufacturing, including aerospace, defence, mining, marine, and O&G industries. It is home to Canada's largest oil refinery, the Irving Oil Refinery in Saint John. Having received $750,000 from Irving Shipbuilding, and $2.7 million from Lockheed Martin's Aeronautics, the new Marine Additive Manufacturing Centre of Excellence at the University of New Brunswick in Fredericton will use 3D metal printing as a method for manufacturing certified, custom parts for the marine sector. The province has a robust commercial fishery and aquaculture sector. NB also supports smart grids and is investing in small modular reactors, and green hydrogen production at the Port of Belledune Green Energy Hub.

Development Plans

In December 2023, the Government of NB released its strategy for transitioning the province to clean energy, *Powering our Economy and the World with Clean Energy – Our Path Forward to 2035*. While there are no immediate actions regarding OSW, this report states that NB has exceptional wind resources for both onshore and OSW with a total estimated capacity of 20 GW, and that wind generation in NB will ultimately increase as an important part of the province's future energy generation mix [25]. In this strategy, the provincial government discusses the necessity of regulatory reform, and that as the entire energy market changes with new technologies and energy sources, its current regulations need to be modernized to reflect these changes.

In NB's Climate Change Action Plan, "*Our Pathway Towards Decarbonization and Climate Resilience: NB's Climate Change Action Plan 2022 – 2027*", the provincial government set out detailed actions and programs to reach the province's decarbonization goals. The objective of the plan is to achieve the NB 2030 Greenhouse Gas (GHG) reduction target which will help the province reach net zero by 2050. NB's net-zero blueprint will be developed by 2025.

5.3.6 Prince Edward Island

Resource Potential

PEI's OSW potential is concentrated in its nearshore shallow waters, particularly around the North Cape and the Gulf of St. Lawrence, as noted in a report by the University of Alberta's Future Energy Systems group [26]. These areas are well-suited for fixed-bottom turbines. Average wind speeds here range from 7-9 m/s [23], providing a consistent and valuable source of renewable energy. However, considering that wind speeds here are lower than in other Atlantic provinces, and that the nearshore element of the resource potential could pose a sight issue with communities, the feasibility and practicality of OSW wind in PEI remains to be fully evaluated.

PEI's existing energy export infrastructure, with interconnections between NB and PEI, positions the province to meet local energy needs while exporting surplus power to neighboring markets.

Policy and Regulatory Context

PEI's *2040 Net Zero Framework* introduced the province's ambition to reach net-zero energy by 2040. This framework does not include plans for OSW development at this time; instead, PEI is focusing on expanding its onshore wind capacity (further detailed in Section 6.3.6) to meet its energy goals.

In 2023, the Government of PEI published its PEI Energy Blueprint Discussion Paper, which was released for public comment and feedback to kickstart the development of an updated energy strategy. Currently, most of the electricity consumed in PEI is imported from NB, however, 99% of the power that is generated in PEI comes from wind energy [27].

As in NB, OSW development in PEI would require negotiations between the Province and the Government of Canada on a licensing and management regime. Other regulatory matters would be managed at the federal level by agencies such as the IAAC for environmental assessments, DFO for marine resource protection, and Transport Canada for navigational safety. Provincially, the Department of Environment, Energy and Climate Action would have leadership on energy policy and related matters. The PEI Energy Corporation, as the provincial lead for renewable energy, would be expected to play a key role in facilitating OSW projects. Indigenous Consultation with Mi'kmaq First Nations and collaboration with coastal communities and fisheries will also be critical for regulatory approvals.

Supply Chain Overview

PEI is well-positioned to support the OSW industry should it become a priority through its established infrastructure, skilled workforce, and diverse economic sectors. The province already has a strong onshore wind regime, with a well-developed supply chain and a workforce experienced in installation and operations. Some of these skills and expertise from the onshore sector could be transferable to the OSW industry, creating a foundation to expand into this market, however the transferable skills will likely be limited, and this could be an area of necessary growth for the region.

Historically, PEI had a strong shipbuilding sector, and in July 2023, the PEI government began the process of acquiring the Irving-owned shipyard in Georgetown. This facility could serve as a strategic asset for OSW development, potentially being repurposed as a marshalling or laydown area. The presence of this infrastructure would make PEI an attractive site for OSW developers looking for logistics support.

PEI's ocean technology and marine industries are significant contributors to the provincial economy, employing thousands of people. Collaborations between OSW developers and PEI's marine sector could create synergetic relationships, facilitating the growth of a local supply chain that supports OSW projects from installation to ongoing maintenance. PEI also boasts a strong aerospace and defence sector, featuring a highly skilled workforce and access to international markets. The province's ability to tap into these resources further strengthens its potential to play a key role in the OSW supply chain.

Development Plans

PEI is currently not advancing any OSW projects or targets. However, it may consider expanding into the offshore space in the future as part of its global efforts to achieve net-zero emissions.

5.3.7 Supply Chain Challenges

Supply Chain & Workforce Bottlenecks - Despite the many strengths in the local supply chain, there are also several identified challenges. As described in the Section 5.1 of this report, the OSW industry is growing globally. As other regions and nations begin to meet GHG emission reduction targets and develop their OSW sectors, the supply of major components and other equipment will be constrained. According to the Canadian Renewable Energy Association's National Workforce Strategy [28], Canada is currently facing a labour shortage, with nearly one million unfilled jobs across the country. This challenge is observable across many industries, including the renewable energy sector. In a report completed by Nergica in 2022, it was stated that there were multiple compounding factors in the renewable sector specifically, including the number of vacant positions, replacing retired workers, and filling the necessary new positions as a result of the rapidly expanding sector. It is also noted that in 2017, renewable occupations were reported to be the most difficult to hire for [28].

Strong Development Pipeline Required for Investment - As identified already in this study, there will be necessary infrastructure upgrades, additional vessels, specialized workforce, and other expertise and equipment that the provinces do not currently have in place to support projects throughout the overall lifecycle. While investment in upgrades and training, as well as scaling local companies is possible to fill these gaps, there needs to be a sufficient pipeline of projects in place to ensure a consistent long-term volume of activity to support returns on investment. While setting OSW targets is helpful in sending signals to the marketplace, setting OSW requirements for utility purchase is a stronger policy tool that encourages and accelerates OSW development in a region. As such, the commitment to licence 5 GW in NS will require some form of market access, either to the provincial market or others, for development to take place. In any case, 5 GW is enough capacity to spur project development activities in the region, but is unlikely to be sufficient for Tier 1 localization or major manufacturing. Any major investments in manufacturing of project components such as blades, towers, turbines, and cables will require a longer and more robust pipeline of expected activity. Turbine tower fabrication facilities have, for example, quoted a demand requirement of 1-2GW per year to justify the establishment of a new facility.

Complicated Regulatory and Compliance Processes - The complexity of the regulatory regime of OSW can create difficulties in the start-up of this new local sector. Like in the US, each province has its own government agencies and processes, which can lead to confusion and challenges for developers looking to build projects. Complicated permitting processes and long project timelines further complicate things, with project conditions and technology advancing faster than the rate of project development at times. While regulations are still being developed, it can be difficult to ensure that all regulators and industry players are following similar paths to completion.

The industry can be similarly confusing to companies looking to enter the supply chain as they face complex certification processes and must meet new codes and standards in their operations. Being onboarded as a supplier to a Tier 1 OSW company often requires several years and can be a costly endeavour. Companies must carefully time these activities with industry timelines so that they do not find themselves ready to participate in an industry that does not yet exist, or too late to be considered for inclusion.

Routes to Market – Perhaps the most significant impediment to supply chain development in OSW is uncertainty in market opportunities. Grids in Atlantic Canada have limited capacity for additional intermittent resources, like OSW, even if energy demand is anticipated to increase. Upgrades would be required, as would regional collaboration and buy-in from provincial utilities. Given the recent energy partnership MOU between NL and Quebec, which could potentially enable NL to pursue new projects on the Churchill River – including the construction of the Gull Island hydroelectric power generating facility, the second facility near the existing Churchill Falls site, and an increase in the capacity of the Churchill Falls facility – the province's total generation capacity could nearly double, from 5,400MW to 9,190 MW. As a result, the demand for OSW generation may be limited. While green hydrogen development may provide a market for OSW energy, there are high levels of uncertainty on how this will be built out and on what timeline.

6 INDUSTRY BACKGROUND - ONSHORE WIND

The following section provides a high-level overview of the onshore wind market to contextualize the development plans for onshore wind in Atlantic Canada. It provides essential information regarding global leaders and trends regarding installed capacity, current development statistics, and projections for future growth in this sector. Global development will be summarized by region, with a focus on key countries that possess robust development pipelines and substantial installed capacity. The objective of this section is to provide insights into the current state of the industry, potential challenges and opportunities, and the factors driving industry development in Atlantic Canada.

6.1 Global Industry Overview

There is currently 945 GW of installed onshore wind capacity globally. China and the US continued to dominate as the largest markets for onshore wind installations in 2023, followed by Brazil, Germany, and India. Despite the overall growth in capacity worldwide, onshore wind markets outside of China experienced a decline in growth compared with previous years, influenced by factors including inconsistent policies, increased equipment costs, high-interest rates, permitting challenges and transmission upgrade delays [29].

Despite the recent increase, the LCOE has generally seen a downward trend over the past decade driven by economies of scale and technological advancements resulting in increased efficiency and lowered production costs, as well as increased competition for renewable energy resources. In the past few years, onshore wind costs are marked as the lowest average cost per unit of energy generated over the operational lifespan of a new power plant when compared to the other renewable energy sources [30].

The Global Wind Energy Council (GWEC) estimates a compound annual growth rate of 6.6% for onshore wind over the next five (2024-2028) years. China, Europe, and the US are expected to account for over 80% of the total projected 653 GW added capacity to be developed during this time [30]. Onshore wind markets in Europe, Asia-Pacific, and North America are discussed in detail below. Supplementary information on markets in the Middle East and Africa as well as Latin America and the Caribbean can be found in Appendix F.3 and Appendix F.4.

6.1.1 Europe

As of 2024, Europe had an installed onshore wind capacity of approximately 243 GW. Onshore wind accounts for about 90% of Europe's total wind capacity, supports 300,000 jobs, and brings significant benefits to local communities through taxes and financial contributions. Details regarding installed and target capacity for onshore wind in key European countries are provided in Table 6-1. Additional information can be found in Appendix F.1.

COUNTRY	INSTALLED CAPACITY	TARGET CAPACITY	SUPPLY CHAIN
Germany	61.0 GW	115 GW by 2030	• German companies are integral to the supply chain from turbine manufacturing to maintenance and operations • Advanced engineering capabilities • A major supplier of various components, including gearbox and electronic systems
Spain	31.0 GW	62 GW by 2030 (onshore and offshore)	• Strong and significant manufacturing sector for blades, towers, and nacelles • Critical ports and shipyards for transportation and assembly of turbines
United Kingdom	15.4 GW	30 GW by 2030	• Matured and well-established sector • Strong skilled workforce with significant expertise in onshore wind • Imports certain components, such as blades, gearbox, and electronic systems
France	22.2 GW	33.2 GW by 2030	• Home to several leading wind turbine manufacturers and engineering firms • Well established and favourable policies and incentives that encourage investment. • Slow permitting process and the concern of availability of critical raw materials are ongoing challenges
Italy	11.5 GW	19.3 GW by 2030	• Continues adopting advanced wind technology • Owing to project delays and complexity due to permitting process, Italian government has recently changed its renewable energy policy
Denmark	4.8 GW	Quadruple by 2030 (wind and solar)	• Strong in local manufacturing of wind turbine components. Home to leading global suppliers, such as Vestas and LM Wind Power • Continue to improve turbine efficiency and reducing cost by thriving in technology
Norway	5.0 GW	Additional 8 GW by 2030	• Collaboration with international suppliers for advanced technology and expertise to tackle Norway's rough terrain and harsh weather conditions • The licensing process for new onshore wind projects resumed in 2022 after a three-year pause • Bottlenecks related to availability of port infrastructure, and skilled workers which delay project timelines and increase costs

Table 6-1 - Summary of Onshore Wind in Key European Countries

6.1.3 Asia-Pacific

As of 2023, the total installed onshore wind capacity in the APAC region is approximately 540 GW, and it's anticipated that this will double by 2030 [30]. This makes APAC the leading region globally in terms of onshore wind installation, driven largely by significant contributions from China and India. Details regarding installed and target capacity for onshore wind in key APAC countries are provided in Table 6-2. Additional information can be found in Appendix F.2.

COUNTRY	INSTALLED CAPACITY	TARGET CAPACITY	SUPPLY CHAIN
China	490 GW	560 GW by 2030	• Leader in advanced manufacturing with well-developed supply chain • Robust supply of high-capacity wind turbine components, including blades, gearboxes, generators, towers, and advanced control systems • National and energy security concerns regarding critical onshore wind components
India	46 GW	110 GW by 2030	• Local manufacturers with significant presence globally produce a wide range of turbine components, including blades, generators, and control system. • Customized components available suited for India's low wind speed sites. • Indian government supports local manufacturing through policies and incentives
Australia	11 GW	86 GW by 2030 anticipated	• Significant local players support all phases of manufacturing and turbine installation process • Notable strength in continuous advancement of wind turbine technology

Table 6-2 - Summary of Onshore Wind in Key APAC Countries

6.1.4 North America

While North America has very little installed OSW capacity, globally it ranks third in installed onshore wind capacity with 150.5 GW in the US and 15.4 GW in Canada. More information on Canada's OSW industry is provided in Section 6.3. Details regarding installed and target capacity for onshore wind the US and Mexico are provided in Table 6-3. Additional details can be found in Appendix F.5.

COUNTRY	INSTALLED CAPACITY	TARGET CAPACITY	SUPPLY CHAIN
United States	150.5 GW	180 GW by 2026 anticipated	• Well-established onshore wind supply chain • Over 500 manufacturing facilities in operation, including 8 blade facilities, 9 tower facilities, and 4 nacelle assembly facilities

COUNTRY	INSTALLED CAPACITY	TARGET CAPACITY	SUPPLY CHAIN
Mexico	8.1 GW	19 GW	• Reliance on international manufacturers for advanced turbine technology • Increasing movement towards local assembly and production of specific components like towers and electrical parts

Table 6-3 - Summary of Onshore Wind in US and Mexico

6.2 Global Trends and Observations

Despite recent announcements from the new US administration and historic incidences of opposition to onshore wind development in key markets such as the UK and Germany, capacity figures and targets presented in this section indicate a clear global growth trend for the industry. With onshore wind now being one of the cheapest sources of energy across markets and offering largely localized supply chain and workforce opportunities, it features prominently in many countries' decarbonisation plans where resources are required.

Given the scale of future onshore wind in the region, transparent and inclusive permitting processes remain a key element of project development, ensuring that local opposition and 'Not In My Backyard' (NIMBY) perspectives are addressed constructively and respectfully. Supportive spatial planning and community engagement can further facilitate these processes while striving to implement lessons learned and best practices based on a significant portfolio of operational onshore wind projects. Within this context, technological advances in onshore wind turbine size and capacity can help reduce the project's overall footprint.

Similar to OSW, clarity on market access and revenue streams remains a critical focus for the global onshore wind sector. Projects benefit from both power capacity markets and long-term power offtake agreements, alongside subsidies that support commercial viability. An increasing number of onshore wind projects are integrating localized green hydrogen production, initially through demonstration projects. This approach provides a potential energy storage solution while also supporting industrial decarbonization.

Onshore wind supply chains require a mix of global and regional sourcing. Key turbine electrical components rely on global supply chains, while localized manufacturing opportunities exist for components such as blades and nacelles, particularly in Europe, the US, Australia, and emerging markets like India. Like OSW, the onshore wind sector is also focusing on O&M optimization. Advances in software development, artificial intelligence, and remote monitoring are enhancing efficiency and reliability, creating new opportunities for local workforce participation and supplier engagement.

6.3 Canadian Context

Canada is a top ten nation in onshore wind, with over 16.9 GW of installed capacity, and making up 2% of the global total. Between 2010 and 2021, Canada saw a 73% decrease in LCOE for onshore wind [31], driven by economies of scale, improved efficiency, and increased competition in renewables. However, geopolitical forces and the global pandemic have resulted in disrupted supply chains, increased interest rates, and spikes in commodity prices that have impacted this cost reduction trend. As interest rates are lowering and inflation is decreasing, cost improvements are already occurring, however will take time to recover.

As of January 2024, all Canadian provinces and territories, except Nunavut, host onshore wind installations. However, with a 1 MW wind and battery storage project planned in Nunavut for 2025, all provinces and territories will soon have onshore wind [32]. In 2023, 1.7 GW of new wind capacity was installed [33]. Figure 6-1 provides the distribution of existing onshore wind generation across Canada.

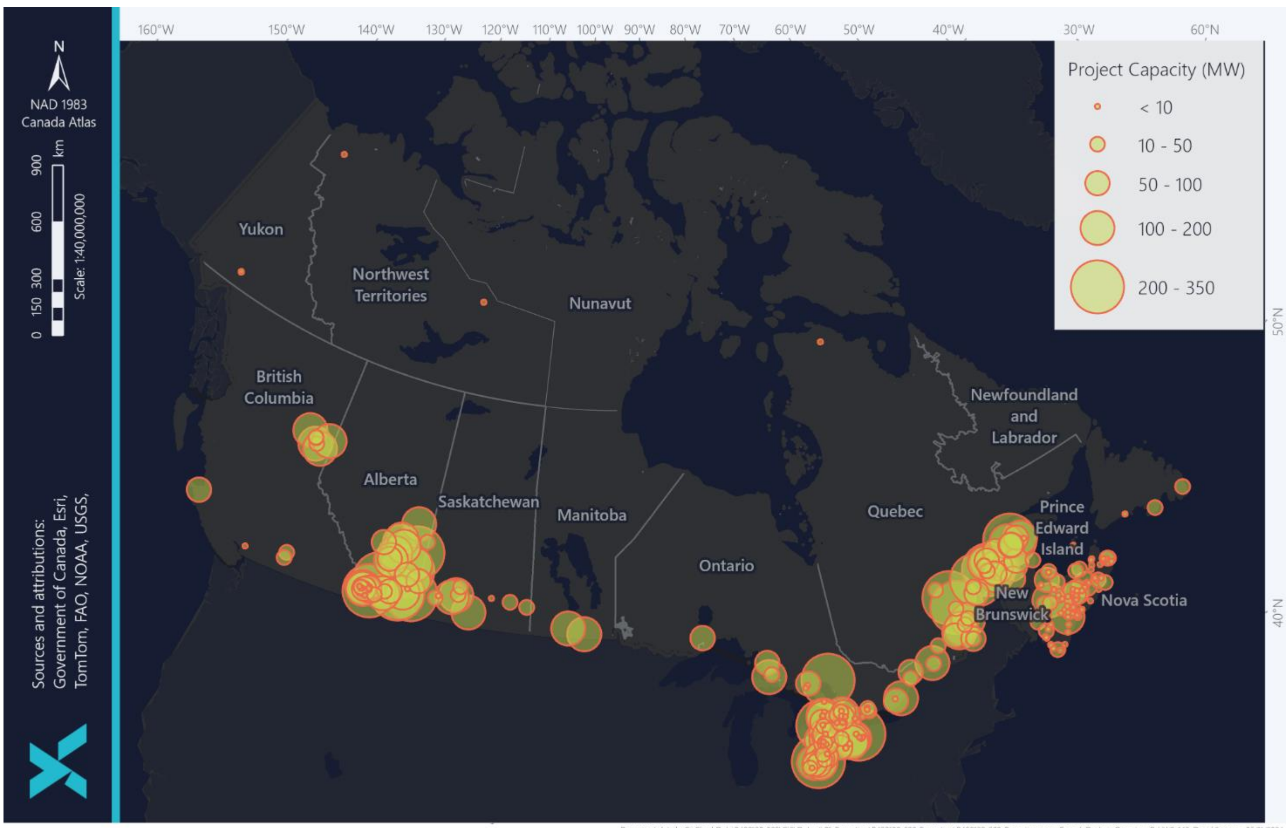


Figure 6-1 - Canadian Installed Onshore Wind [34]

Canada's wind adoption has been policy-driven, with early initiatives like the Stockholm Convention (2001) and the Kyoto Protocol (2002) leading to federal programs such as the Wind Power Production Incentive and ecoENERGY for Renewable Power. Provincial programs followed, like NS's 2010 Community Feed-In Tariff (COMFIT), encouraging small, community-owned projects. Both programs later ended as policy supports evolved.

Figure 6-2 demonstrates the annual and total onshore wind capacity installed in Atlantic Canada since PEI's first pilot project in 2001. Onshore wind development in Atlantic Canada has resulted in just under 1.3 GW of capacity installed to date. Most operational capacity was installed in NS and NB between 2005 and 2015. The region has seen a plateau in onshore wind development over the last decade, although several small-scale projects have been installed during this time.

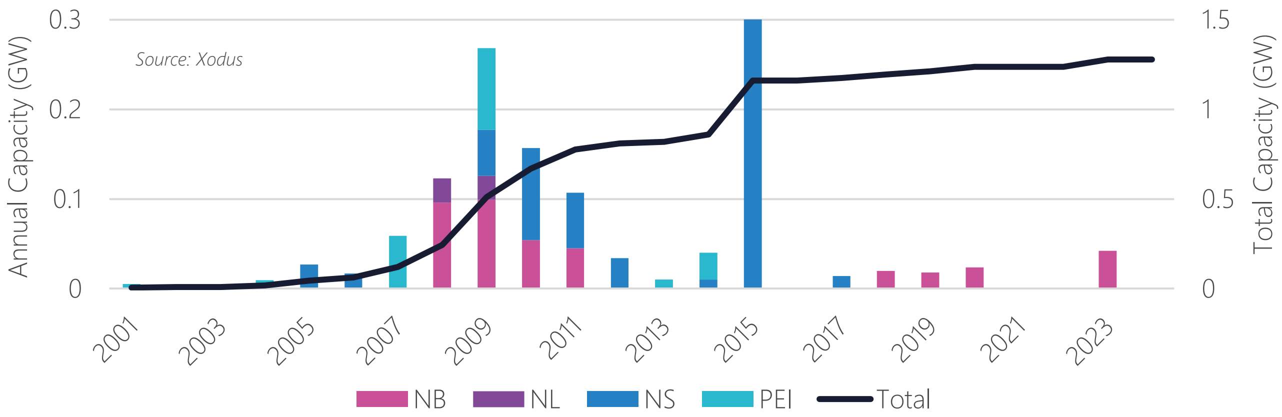


Figure 6-2 – Historical Annual and Total Onshore Wind Capacity Over Time from 2001 to Present

Primary drivers of wind development in Atlantic Canada today are clean electricity goals and, more recently, green hydrogen production. Canada has signed MOUs with Germany and the Netherlands, establishing partnerships for green hydrogen supply and export. These agreements foster collaboration on hydrogen supply chains, and a transatlantic supply corridor to Germany is planned by 2025.

Furthermore, various internship initiatives, including the Clean Leadership Summer Internships, the NS Department of Energy, and Electricity Human Resources Canada (EHRC), have been established to facilitate new internship and job opportunities within the clean energy sector.

6.3.1 Regulatory Framework

The recently released *Clean Electricity Regulations*[3] and *Clean Electricity Strategy* effectively position onshore wind as critical to achieving Canada's clean energy goals, with a unique regional focus. In NL, for example, onshore wind will primarily serve green fuels production for export, while in other Atlantic provinces, it will play a significant role in grid-connected power generation.

The development of onshore wind projects is regulated by municipal and provincial governments and may require a federal IA if the project is located on federal lands or requires a federal permit. Municipal by-laws typically govern zoning constraints and minimum setback distances, while environmental departments of provincial governments administer the EA/EIA process. This is under the jurisdiction of the Department of ECC in NL, the Department of Energy

[3] *Clean Electricity Regulations (CER) is released by the Government of Canada, proposed as part of a suite of federal measures to achieve economy-wide net zero greenhouse gas emissions in the electricity sector by 2050. In December 2024, Canada issued finalized CER as a replacement of the draft regulations released in 2023.*

in NS, the Department of Natural Resources and Energy Development in NB, and the Department of Environment, Energy and Climate Action in PEI.

Additionally, wind turbines are subject to several Canadian codes and standards including requirements for markings for aviators as defined by Transport Canada, international electrical safety guidelines and underlying IEC and ISO safety standards, as well as guidelines on lightning protection. Transport Canada exercises authority over lands included in an Airport Zoning Regulation, which may limit the height of turbines or prohibit specified land uses/facilities that interfere with aircraft communications. There are other specific regulatory and approval subject areas that are overseen by the authority having jurisdiction in each respective province and territory.

The Canada Energy Regulator (CER) oversees interprovincial transmission lines, nuclear power, and electricity exports, while provinces and territories manage intra-provincial generation, transmission, and distribution. Electricity policy, market and regulatory structures, and electricity management and implementation are handled locally by provinces and territories, while the federal government shares jurisdiction over environmental regulations, including carbon pricing. All provinces and territories, except for Saskatchewan, have a designated utility commission or board that sets the rates and regulations for electricity generation, transmission, and distribution within their jurisdictions.

6.3.2 Federal Incentives

In 2019, Canada introduced a minimum price on carbon, starting at $20/t and increasing by $15 per year to 2030, encouraging decarbonization and innovation. The government has announced various federal incentives supporting both offshore and onshore wind, but these are subject to change, dependant on the Canadian political environment. Carbon pricing further incentivizes emissions reduction, in support of Canada's net-zero goals. Effective April 1st, 2025, the Government of Canada is removing requirements for provinces and territories to have a consumer-facing carbon price [35].

In 2021, NRCan launched the $4.5 billion Smart Renewables and Electrification Pathways Program (SREPs) to support the development of clean technologies such as wind turbines, which expected to run until 2036. The aim of the program is to modernize and strengthen the Canadian electricity grid while reducing dependency on fossil fuels. SREPs offers funding to three steams: critical regional priorities (province and territory led), Indigenous-led clean energy, and utility support. Additionally, SREPs coordinates with the Canada Infrastructure Bank (CIB), who has committed $10 billion in Clean Power financing, to support projects which are eligible for both programs.

6.3.3 Nova Scotia

NS leads Atlantic Canada in onshore wind with an installed capacity of 623 MW, making up about 13% of the province's total electricity generation. With a shift away from coal as a thermal power source, there are firm plans and commitments to expand onshore wind to assist in meeting provincial decarbonization goals. A map of current and planned onshore wind projects in NS is given in Figure 6-3.

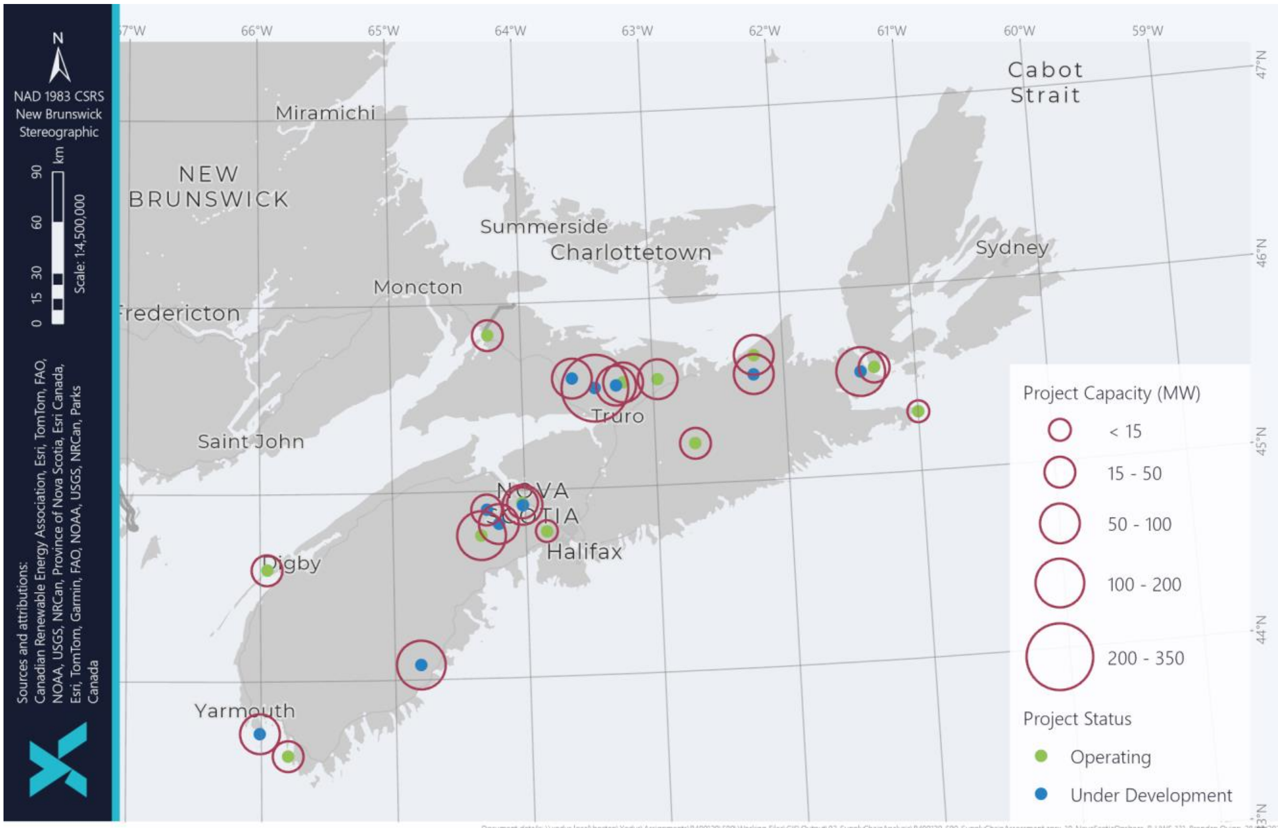


Figure 6-3 - Map of Current and Planned Onshore Wind Projects in NS

Resource Potential

NRCan released the *NS Regional Energy and Resource Table to* assist to identify and accelerate the most promising low-carbon opportunities in the province's clean energy and resource sectors in NS, including clean electricity and marine renewables. This document specifies wind, solar, batteries, and marine renewables as priorities for decarbonizing NS' electricity production, and explores regional transmission interconnection opportunities among Atlantic Canadian provinces. As NS advances towards its decarbonization goals, onshore wind remains attractive. The wind patterns in this area are world-class [36]. NS's first large-scale wind farm (30.6 MW) began operating in 2005 at Pubnico Point. Currently, Smaller projects (under 10 MW) add 177 MW, and are owned by municipalities, Indigenous communities, co-ops, universities, and non-profits [34]. A full list of existing and planned onshore wind projects in NS with capacities and Commercial Operation Dates (CODs) is given in Appendix D.1.

Policy and Regulatory Context

The *Environmental Goals and Climate Change Reduction Act* was passed in 2021 as the provincial government's commitment to achieving a sustainable future. In 2022, the Climate Change Plan for Clean Growth was published, outlining the provincial government's commitment to responding to climate impacts, reducing GHG emissions, pursuing a cleaner sustainable economy, as well as reporting and evaluating progress.

The *Clean Power Plan*, released in 2023, is specific to the power industry in the province, and is designed to allow for flexibility on the path to coal closure, while also opening opportunity for future investment in renewables. There are several goals for wind resource development in the plan, which are summarized in the development plan section, to follow.

From a regulatory standpoint, developers in NS may apply for Crown lands or lease private lands, adhering to all municipal, provincial, and federal regulations. The limited amount of land in NS creates an opportunity for private sector initiatives outside a formal bidding or procurement process. Projects over 2 MW require a well-established and predictable EA review with provincial experts, stakeholders, and the public contributing to final approval decisions. Federal IA may apply if projects receive federal funds, are on federal land, or need federal permits.

NS Power (NSP) is the vertically integrated utility in NS, providing service to all areas except those that are served by municipal utilities. All Independent Power Producers require Power Purchase Agreements (PPAs) that outline the terms of their service, including payments set in the form of cents per kWh. In most cases, the PPAs are standard agreements that vary by program with the rate set under a competitive process.

In March 2025, the government of NS amended the Minimum Planning Requirements Regulations to establish maximum allowable setbacks for wind turbines for Nova Scotia municipalities. Under the amended regulations, the setback for wind turbines cannot be more than four times the turbine height, unless a greater distance is required to ensure that sound levels do not exceed 40 decibels at the exterior of a dwelling and that shadow flicker on nearby residential dwellings does not exceed limits identified in the amendments [37].

Supply Chain Overview

NS has expertise in fabrication and shipbuilding resulting from offshore O&G, military, and R&D activities. The province is strategically located with access to international shipping lanes and has existing commercial port facilities in Cape Breton, Northern NS, Eastern Shore and Halifax. Depending upon the location of the onshore wind farms, these ports and adjacent lands can support the importing and laydown of various onshore wind components.

Through the modernization of its community college electrical technician programs, as well as Dalhousie University's new Hydrogen Applications Research Lab, NS is well positioned to produce a specialized workforce and promote collaboration amongst industry and academia. The Strait of Canso is a key focus for clean fuels development, with multiple developers proposing clean fuels projects (EverWind, Bear Head, and Simply Blue), supported by proposals for anchoring a province-wide Hydrogen/Wind Hub for practical research, led by the NSCC.

The onshore wind industry will require goods and services from non-specialized providers including air travel, catering, workforce, facilities management, financial services, healthcare, communications, insurance services, transportation, legal services, professional and consulting services, safety and security services, shipping services, and short-term accommodations [38]. NS has ample existing firms capable of providing these services. Wind developers report that the supply chain is already responding to the increased volume of work by ordering new cranes to handle the larger turbines expected in the following projects.

At present, specialized turbine components must be outsourced. Past initiatives, like the retrofit of Trenton Works for turbine production and Seaforth Energy's small-scale turbine manufacturing, illustrate the region's potential for local manufacturing. However, the outcomes of those two initiatives were not positive due to an inability to serve a larger market, and both closed in the mid-2010s. NS has existing local capabilities for logistics and civil works to support onshore wind development through its established construction industry. Strong partnerships have been developed between industry and Indigenous communities, which is evident given the strong supply chain for sector support, which can be leveraged for the development and collaboration on future wind projects. For additional specific information, please refer to Section 8.5.

Development Plans

The NS government has set ambitious emissions and renewable energy targets through key policies, including the *Environmental Goals and Climate Change Reduction Act* (2021), *Our Climate, Our Future: NS Climate Change Plan* (2022), and *2030 Clean Power Plan* (2023).

Key goals are summarized below:

- **Short-Term (2025):** The Government-Directed Rate-Based Procurement Program in NS will add 306 MW by the end of 2025.
- **Medium-Term (2026-2030):** The construction of the Port Hawkesbury Paper Wind Project will add 168 MW, and the Renewable to Retail Tariff Program could add as much as 150 MW. The Green Choices Program has secured commitments of 370 MW by 2030. These goals will effectively double the current capacity, resulting in a total onshore wind capacity of 2,222 MW within the next five years. It is possible that the Green Choices Program will have additional projects before 2030.
- **Long-Term (2030+):** NS targets net-zero emissions by 2050, balancing any remaining emissions with offsets.

Similarly, NSP has published the *2023 Evergreen Integrated Resource Plan (IRP)*, which outlines both an action plan and a roadmap for the long-term planning of the NS electricity system, including the procurement of wind generation capacity. They have identified several development scenarios, driven by carbon policy, electrification, and resource strategy, which are further examined through a comprehensive list of sensitivities. For all modeled scenarios, a new buildout of 1.3 GW of wind capacity is expected to be added to the grid by 2030.

Challenges

NS's *Renewable Electricity Regulations* mandate that 80% of electricity be from renewable sources by 2030, up from 42.5% in 2023. Combined with plans to add similar wind capacity in NB and a proportional increase in PEI, the supply chain will see pressures over the course of the next five years. NS also supports green hydrogen and ammonia production, with such production further increasing renewable electricity demand. The 2023 *Green Hydrogen Action Plan* outlined seven goals and 23 actions for this industry, relying on both onshore wind and OSW resources to meet rising demand.

The rapid growth of intermittent renewables expected to meet domestic needs and hydrogen needs present a significant challenge to the management of the province's electricity grid. NS currently has tariffs that reward customers who agree to be interrupted. A soon to be filed Hydrogen Tariff is expected to include a pricing regime that rewards the ramp-up of electricity use during period of excess wind and the ramp-down when wind is not available.

6.3.4 Newfoundland and Labrador

NL has about 55 MW of installed onshore wind capacity. Although the province has not set specific targets for increasing this capacity, the government has granted several large projects the exclusive right to apply for Crown lands to support further wind development. A map of existing and planned onshore wind projects in NL is given in Figure 6-4.

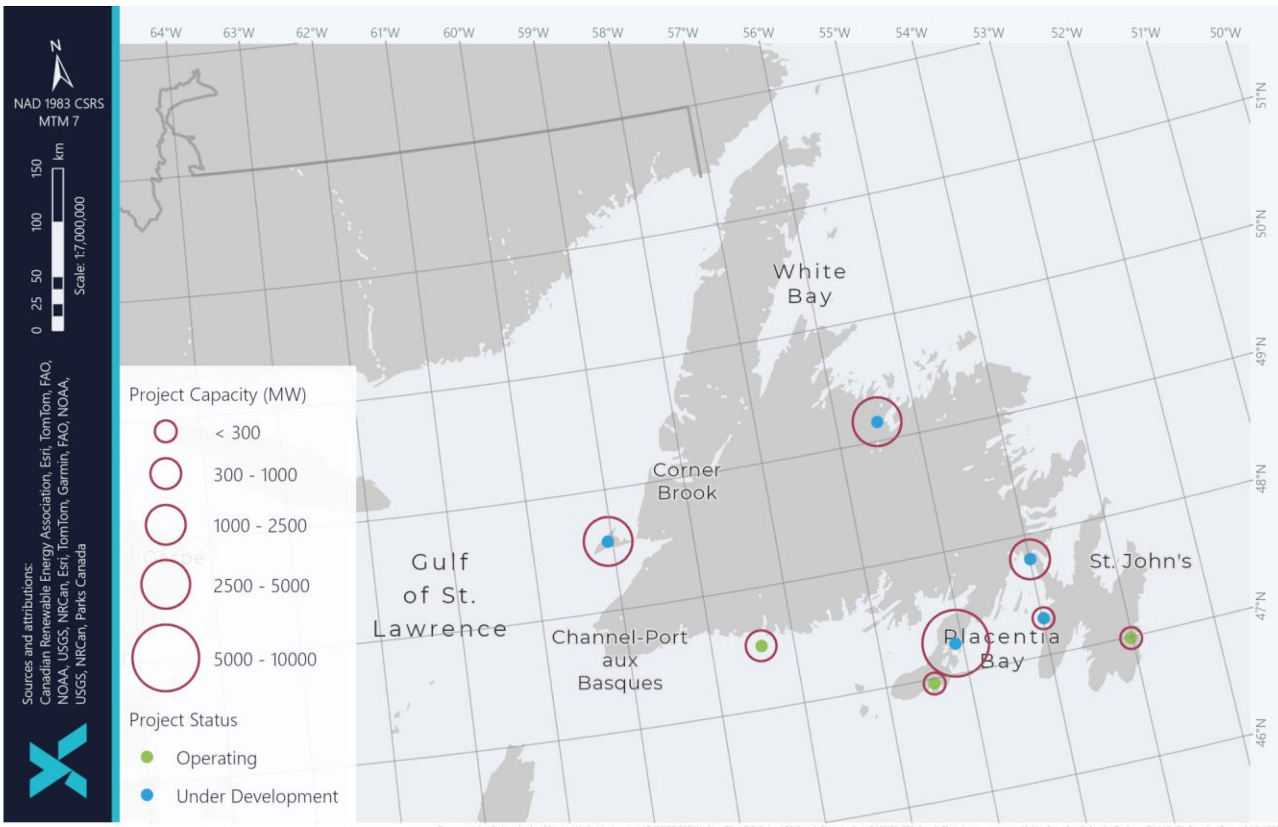


Figure 6-4 - Map of Current and Planned Onshore Wind Projects in NL

Resource Potential

NRCan has released the *NL Regional Energy and Resource Table* to assist in the path towards net-zero in NL. In this framework, NL is described as having the highest wind speeds and most consistent wind in North America, as well as near 350,000 square kilometers of Crown lands available for development [39]. The onshore wind potential in the province is vast, and can be utilized not only for regional electricity, but also for export or green hydrogen production.

NL's first wind project, also Canada's first wind-hydrogen-diesel demonstration, launched in 2004 in the isolated community of Ramea. Initially comprised of six turbines with 390 kW total capacity, it was later expanded to include hydrogen storage and three additional turbines, totaling 690 kW [40]. Although hydrogen storage challenges eventually ended the hydrogen component, the wind turbines continue to supply power. Additionally, Mary's Harbour Renewables project has included the refurbishment of a decommissioned 240 kW run-of-river hydro plant with new 250 kW solar photovoltaic and 500 kW lithium-ion battery capacity and a control system integrated into the existing diesel grid [41].

Besides Ramea, the province's only commercial wind projects to date resulted from an NL Hydro request for proposals (RFP) in 2005. Two 27 MW wind farms, now operated by Elemental Energy, were completed in St. Lawrence and Fermeuse in 2008 and 2009. All currently operational wind projects in NL, as well as projects under development, are listed in Appendix D.

Policy and Regulatory Context

A unique barrier to wind development in NL was a 2007 moratorium, which restricted wind projects to the provincial electricity systems manager, NL Hydro, and prevented developers from accessing Crown lands or completing EAs. In 2017, a net-metering program was introduced, allowing renewable projects under 100 kW, including wind, to connect to the Island Interconnected Grid. This program enables customers to connect their at-home renewable energy systems to the grid to offset their own usage, with surplus generation credited annually.

In April 2022, the moratorium on industrial self-generation and wind energy export was lifted. This decision sparked significant interest in NL's abundant wind resources. In response, the province quickly established guidelines to support proposed wind-hydrogen projects, marking a pivotal step in advancing renewable energy opportunities. The wind development process officially began in July 2022 with a Call for Land Nominations, which allowed developers to identify Crown lands of interest. This process was non-competitive and did not grant developers any rights to the nominated lands.

In December 2023, the government released detailed guidelines for a competitive bidding process, introducing a phased evaluation system designed to ensure a fair and transparent selection process [42]. In August 2023, the Crown Lands bid process culminated in the granting of exclusive rights to four companies. In addition to the four original successful proponents, there have since been two land reserves established by the provincial government for the development of additional wind-hydrogen projects. Also, NL has agreements with the City of Hamburg, Germany, the Port of Rotterdam, Netherlands and the Port of Antwerp-Bruges, Belgium to develop hydrogen supply chains, with onshore wind being the green electricity source.

Successful bidders are awarded a Wind Application Recommendation Letter, which grants them exclusive rights to proceed with Crown lands applications for their wind projects. However, developers must still apply for Crown lands and complete an EA with the ECC. Only after successful EA completion may Crown lands be formally awarded, ensuring that all projects meet the province's environmental standards and regulatory requirements.

The Provincial government requires that developers submit a *Benefits Plan* and a *Gender Equity and Inclusion Plan* (GEIDP), approved by Department of IET. The Benefits Plan must ensure fair opportunities for provincial residents, including with regards to local hiring, training, and service provision, while the GEIDP outlines commitments to include women and underrepresented groups in the project [42].

Supply Chain Overview

NL can leverage its strong technical and industrial base, developed through industries like O&G, mining and the construction of the Muskrat Falls hydroelectric project, which provide expertise in engineering, project management, fabrication, and innovation. The province also has advanced capabilities in environmental monitoring, including sensing technologies, autonomous systems, and extreme-environment operations. NL's supply chain supports a wide range of services from EAs and resource management to pollution control and remediation [18].

The onshore wind and hydrogen sectors will rely on additional, non-specialized services, such as transportation, workforce management, legal services, and accommodations—all of which are readily available in NL, making it a potential hub for these industries [38].

Educational programs, like the College of the North Atlantic's wind turbine and hydrogen technician programs, introduced in 2023, are fostering a specialized workforce and positioning NL as a center for renewable energy training. In the same year, the Qalipu First Nation—an off-reserve band based on the island of Newfoundland—signed deal with a Netherlands-based wind energy academy to establish a full joint venture which will lead to an unprecedented new level of wind energy training capacity [43].

NL's strong construction industry will play a crucial role in supporting the onshore wind supply chain, developing infrastructure needed for wind farms, such as foundations, roads, and other essential facilities. Project Nujio'qonik, led by World Energy GH2, aims to build 164 wind turbines on the Port au Port Peninsula and is expected to create around 1,800 direct construction jobs and 3,500 indirect jobs [44]. Companies like ABO Wind and EverWind Fuels are developing multi-phase wind energy projects to produce and export hydrogen and ammonia. In late 2024, ABO Energy transferred a 90% share of its Toqlukuti'k Wind & Hydrogen Project, located in NL, to the Danish Investor CIP [45].

NL's construction industry has already supported large-scale energy projects like Muskrat Falls—a 824 MW hydroelectric generating facility and over 1,600 km of transmission lines connecting Labrador to the island of Newfoundland and further to NS [46]. Significant civil engineering expertise was needed to manage the complex construction tasks, such as building the dam, power station, and transmission lines [46]. The onshore wind industry can leverage NL's robust construction industry and electricity grid experience to build the necessary infrastructure for onshore wind, including wind farms, production facilities, and electrical transmission/distribution systems.

Development Plans

In 2021, NL launched *Maximizing Our Renewable Future*, a five-year plan with four focus areas: Energy Uses and Markets, Regulatory Framework, Partnerships, and Training and Jobs. Each area includes short-term (within one year), medium-term (two years), and long-term (two to five years) actions aimed at reducing diesel emissions, boosting electrification, increasing renewable energy jobs, and enhancing collaboration among Indigenous groups, industry, and stakeholders. At a high-level, NL's plans for decarbonization and renewable energy integration are summarized below:

- **Short-Term (2025):** No development plans identified for the year 2025.
- **Medium-Term (2026-2030)**: By 2026, goals include cutting diesel emissions, expanding electrification, improving renewable energy training, strengthening partnerships, and supporting clean tech R&D. NL aims to reduce GHG emissions by 30% below 2005 levels by 2030 with a new five-year plan expected in 2026.
- **Long-Term (2030+):** Targets net-zero emissions by 2050 with onshore wind seen as a renewable alternative to replace remaining diesel generators.

In addition, through their 2024 *Resource Adequacy Plan*, NL Hydro plans to issue an Expression of Interest (EOI) in 2025 for wind energy provision. They have also identified three development scenarios, which provide a potential range of wind energy needs for the years 2030-2034. These development scenarios are as follows:

- **Slow Decarbonization:** 100 MW firm requirement in 2030, 400 MW by 2034

- **Reference Case:** 200 MW firm requirement in 2030, 500 MW by 2034
- **Accelerated Decarbonization:** 300 MW firm requirement in 2030, 700 MW by 2034

Challenges

Successful bidders from the Crown Lands Call for Bids for Wind Energy Projects must undergo extensive review, including land use restrictions, municipal zoning, an EA and extensive community and Indigenous consultations, before securing land rights [47]. Any delays in this process could impact the timeline for onshore wind development.

Grid capacity is another challenge. Demand from industrial developers currently exceeds NL's grid capacity. Given the intermittent nature of wind, developers need reliable backup power, which may not be consistently available. Large-scale energy storage or increased transmission infrastructure will be required to stabilize supply and meet growing demand [48] [47]. The recently signed MOU with Quebec and the development of the Gull Island hydroelectric facility may limit future demand for onshore wind, or it may free up grid capacity on the island for additional onshore wind. The full impact of this development is yet to be seen.

The dependency of onshore wind projects on the export of green fuels, combined with the current lack of an established market, poses significant risk to wind developers. As such, export market limitations for green fuels will have a significant impact on the rate at which onshore wind is developed in the province, especially due to the scale of the wind requirement for green fuel production paired with limitations in grid capacity. Recently, World Energy GH2 stated that they are also exploring domestic uses for wind energy and green hydrogen, including green fuels, green steel, and data centres.

6.3.5 New Brunswick

NB currently has an installed onshore wind capacity of 397 MW and a target to develop 1.4 GW by 2035. While NB relies on some fossil fuels for electricity generation, the province is taking steps to accelerate its transition to a non-emitting grid by 2035, including the development of small modular reactors (SMRs) and the accelerated deployment of renewable energy resources. A map of existing and planned onshore wind projects in NB is given in Figure 6-5.

Resource Potential

Similar to the rest of the region, the wind resource potential in NB is very good for onshore wind electricity generation. In a report completed by Ea Energy Analyses for the NB Department of Natural Resources and Energy Development, it is stated that because of the available wind resource in the area, the wind power capacity factor could reach upwards of 40% [49].

In December 2023, the Government of NB released an ambitious energy vision and path to 2035. The plan includes a policy commitment to increase wind and solar capacity by almost five times by adding around 1.4 GW of new wind power, 200 MW of grid scale solar power, and 300 MW of behind the meter solar [50]. Private-sector developers are also exploring the opportunity to add an additional 1.5 GW to 2.5 GW of new wind power associated with the Port of Belledune's Green Energy Hub and plans to produce low carbon intensity hydrogen for both domestic and export markets. NB Power, NB's Crown electric utility, currently supplies the province with 44% renewable energy and 80% non-emitting generation, including nine operating wind farms.

NB's first wind farm, Kent Hills, operated by TransAlta and Natural Forces, began in 2008 and expanded in three phases, reaching a total capacity of 167.3 MW [51]. In June 2023, the City of Saint John's first utility-scale wind farm began injecting locally produced wind energy into the Saint John Energy grid. The Burchill Wind Project, a partnership involving Saint John Energy, Natural Forces, and the Tobique First Nation, consists of ten wind turbines capable of producing up to 42 MW of renewable energy coupled with utility-scale battery energy storage system.

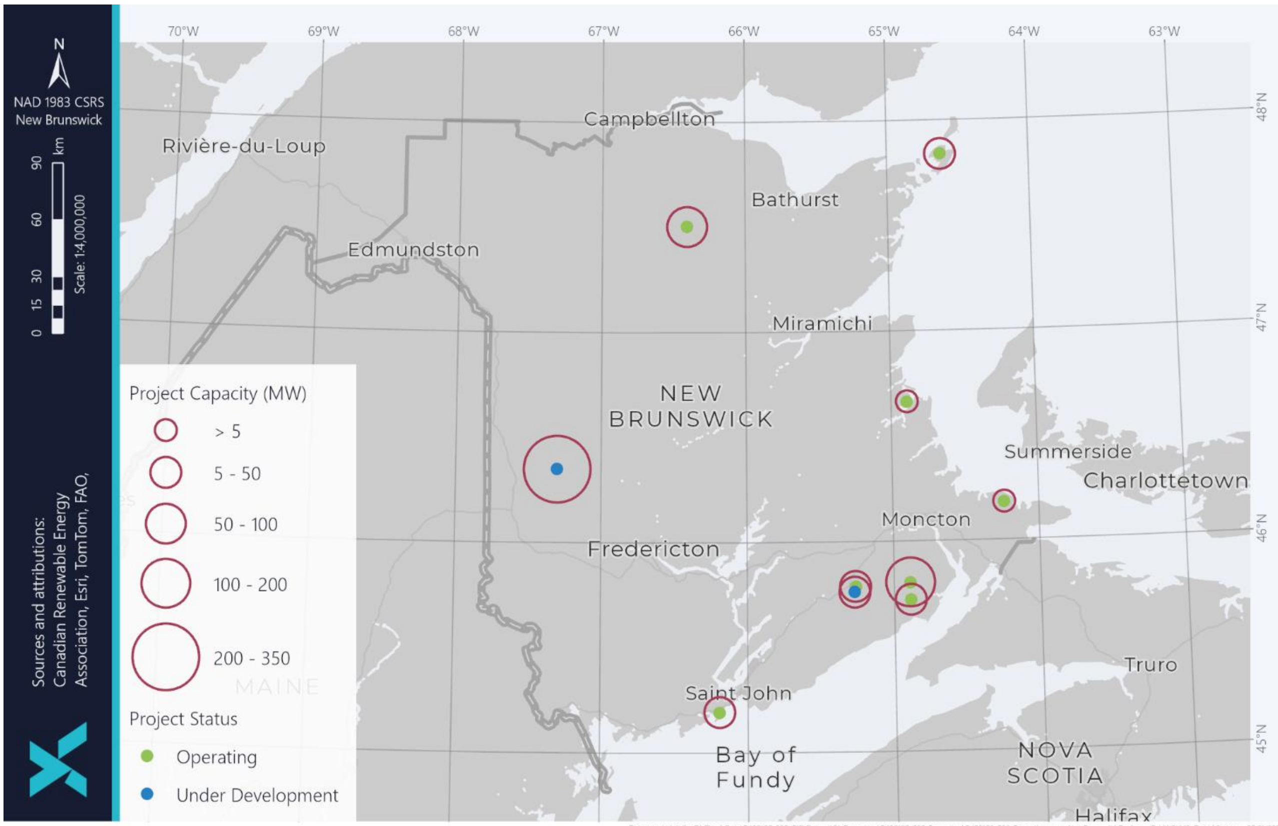


Figure 6-5 - Map of Current and Planned Onshore Wind Projects in NB

Policy and Regulatory Context

Key legislative drivers for NB's wind development include the *Electricity Act*, *Renewable Resources Regulation*, and the *Large Industrial Renewable Energy Purchase Program*. In December 2024, the Government of Canada and Government of NB also announced over $1 billion in additional clean electricity investments, and the reaching of a common understanding on the forthcoming *Clean Electricity Regulations*. The regulations will provide flexibility in decarbonizing the NB electricity system, while also enabling non-emitting capacity growth, maintaining affordability and reliability. This includes fostering opportunities for renewable energy projects, driving demand in supply chains for turbines, logistics, and grid infrastructure upgrades. Provisions like emissions pooling and the use of offsets will facilitate hybrid energy systems and create additional economic incentives for wind energy development, positioning it as a cornerstone of the transition.

The Electricity Act mandates NB Power's IRP, prioritizing cost-effectiveness, environmental sustainability, and risk management, which leads to renewable energy RFPs. Additionally, the *Renewable Resources Regulation* required NB

Power to reach 40% renewable energy by 2020, facilitated by the Locally Owned Renewable Energy Projects that are Small Scale (LORESS) program, which includes specific allotments for Indigenous businesses and local entities [52].

The Large Industrial Renewable Energy Purchase Program allows NB Power to buy renewable energy from large customers, aligning industrial energy costs with other provinces. Wind projects over 3 MW require an EIA, and developers on Crown lands follow a two-stage process under the *Allocation of Crown Lands for Wind Energy Power Projects Policy* [53].

To obtain Crown lands for wind projects, developers must first apply for a License of Occupation to Explore followed by an application for a lease and associated License of Occupation for the proposed wind farm. For wind farm lease approval, developers must secure an NB Power RFP or an approved business plan for non-RFP power use. Municipal distribution utilities may also issue RFPs within their territories, including for projects on Crown lands [53]. The currently operational wind projects in NB, as well as projects under development/construction, are listed in Appendix D.

Supply Chain Overview

NB's supply chain benefits from a skilled workforce, strategic location with access to international shipping lanes, and proximity to the North American electricity grid. While specialized turbine components are typically imported, in-province resources cover collection systems, substations, and civil works, with engineering services from Atlantic Canada [54]. Opportunities for local firms exist in crane and logistical services, with companies positioned to support wind turbine transport and installation.

NB has a strong existing construction industry, which can be leveraged for the development of additional onshore wind capacity. Non-residential engineering construction activities have increased in the last decade, driven by investments in wind farms as well as other civil works. As such, non-residential construction employment is expected to grow by 10% by 2033, indicating a need for workforce development to meet the growing need [55].

Similar to that of NS, NB has established strong relationships between industry and Indigenous communities through several existing onshore wind projects. For additional specific information, please refer to Section 8.5.

Development Plans

NB's 12-year energy roadmap, *Powering our Economy and the World with Clean Energy*, targets affordability, energy security, economic growth, and regulatory reform. This roadmap aims for a net-zero electricity system by 2035.

As part of the short-term path to an accelerated deployment of renewable energy in NB, NB Power issued an EOI for additional wind, solar, tidal power, and storage solutions in 2023 with the goal of adding up 220 MW of additional electricity from renewable resources (wind and solar) and up to 50 MW of energy storage. The generation is scheduled to be added to the NB Power system by July 2027. Results from the EOI have far exceeded initial expectations, including a recent announcement by the Government of Canada in support of 670 MW of new clean energy power projects to be added to the NB grid.

Desired outcomes from the EOI process include the creation of new business and supply chain development opportunities, new jobs and expanded in-province renewable energy expertise. The new projects are also designed to broaden Indigenous and community inclusion, participation, and ownership in the energy sector. Earlier this year the

NB Community College announced the creation of the province's first wind and solar energy technician program to help meet the growing demand for workers in the green-energy sector.

- **Short-Term (2025):** NS-based Natural Forces is partnering with NB Power and eight Mi'kmaq First Nations to commission a 25 MW expansion of the Neweg energy project near Sussex. The wind farm will be operational in early 2025. NB Power will also be laying the groundwork in 2025 for the renewal of its IRP in 2026 and continues to evaluate the conversion of the Belledune Generating Station from coal to woody biomass. The Mactaquac Life Achievement Project is on-going.
- **Medium-Term (2026-2030):** NB Power is moving forward with more than 1,000 MW of new land-based wind energy projects, several yet-to-be announced energy storage projects and a new 400 MW dual fuel (natural gas and liquid fuel) peaking power plant near Moncton. Planning is also underway for an 800 MW transmission line to improve Atlantic interconnectivity, with stages connecting Salisbury, NB to Onslow, NS (2027/28); Salisbury to Point Lepreau (2028/29); and Memramcook to Borden, PE (2029/30).
- **Long-Term (2030+):** The provincial five-year *Climate Change Action Plan* (2022-27) includes a commitment to develop a Net-Zero Blueprint by 2025, focusing on low-carbon technologies and clean electricity, with interim targets to reach net-zero by 2050. NB aims for 1,200 MW in new wind energy resources by 2035, with procurements of 400 MW each continuing in 2031, and 2033.

Challenges

Analysis of two failed wind projects in rural NB highlights the importance of early community consultation and utility support. Delayed community engagement led to distrust, contributing to project failure, but has subsequently reinforced several positive community engagement best practices as evident in Saint John Energy's Burchill Wind Energy Project and NB Power's Neweg wind farm expansion. Indigenous engagement and partnerships are now embedded as a renewable energy best practice in NB.

Similar to the other Atlantic Canadian provinces, NB faces challenges in integrating and balancing intermittent renewable energy resources on the existing grid. However, NB Power is also facing significant and on-going challenges associated with key parts of its legacy electricity generation resources, including life extension issues associated with the Mactaquac hydro plant and the availability and performance of the Point Lepreau nuclear facility.

6.3.6 Prince Edward Island

PEI currently has 204 MW of installed onshore wind capacity and aims to be Canada's first net-zero province by 2040, which will likely involve further wind development. A map of existing and planned onshore wind projects in PEI is given in Figure 6-6.

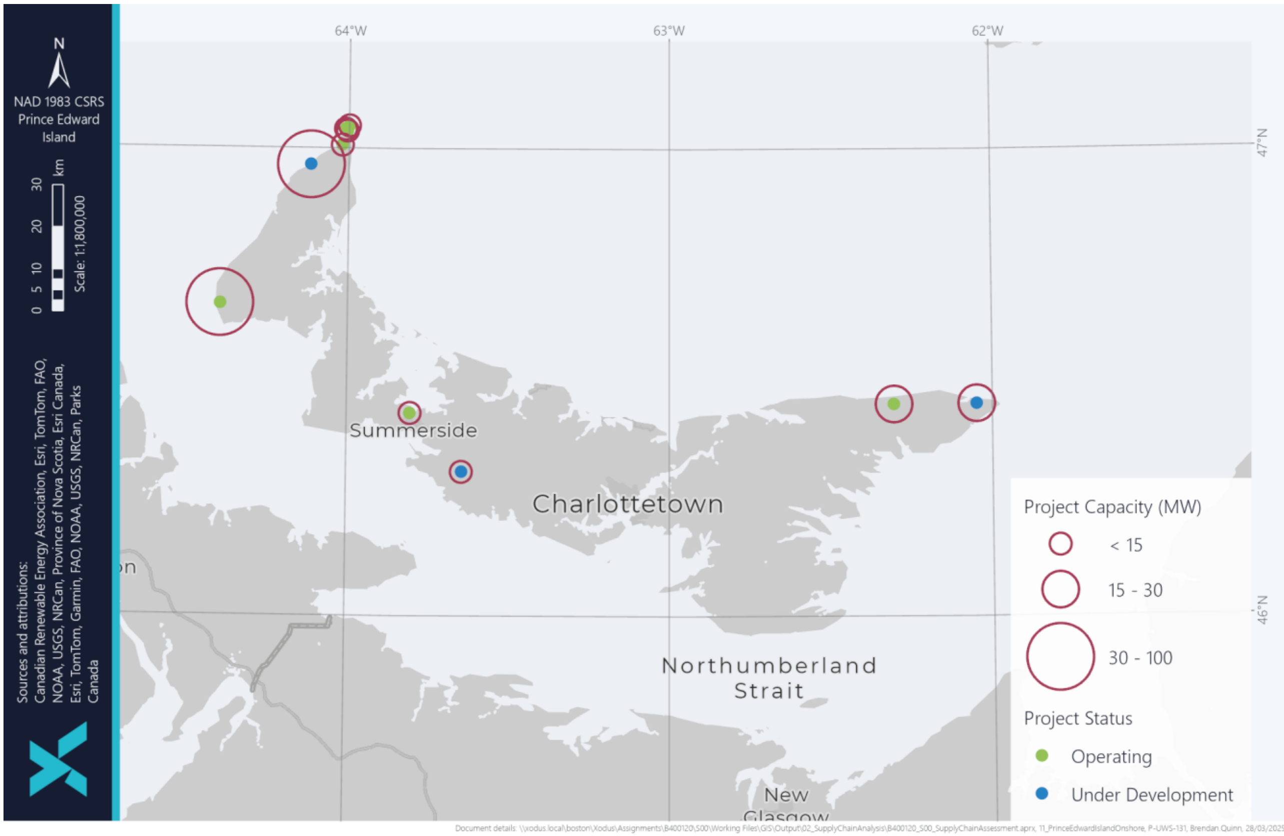


Figure 6-6 - Map of Current and Planned Onshore Wind Projects in PEI

Resource Potential

As proven by its already established onshore wind sector, there is great potential for onshore wind production in PEI. The wind speeds across the island range from 6 – 10 m/s, as demonstrated on the global wind atlas. PEI's first commercial wind farm, built in 2001 by the PEI Energy Corporation, marked the beginning of renewable development on the island, followed by three additional wind farms to meet the *Renewable Energy Act* requirements of 2005 [27]. With wind power making up 99% of local generation capacity, PEI relies on imported electricity for about 75% of its needs, primarily from NB via subsea cables [56].

The currently operational wind projects in PEI, as well as projects under development, are listed in Appendix D.4.

Policy and Regulatory Context

Due to PEI's largely private land ownership (88% privately owned), most wind projects are developed on private lands through lease agreements, with no specific provincial policies for Crown land wind development [53]. Key regulations under the *Renewable Energy Act* include the Minimum Purchase Price Regulations (MPPR) and Designated Areas Regulations [57]. In addition, PEI's Cleantech Academy offers programs in partnership with the university of PEI (starting in 2025) and Holland College (started in 2024). It will be housed in the Cleantech Innovation Centre in Georgetown, PEI, and is part of PEI's cleantech ecosystem [58].

Supply Chain Overview

PEI is a leader in wind energy innovation and home to the Wind Energy Institute of Canada (WEICan), specializing in wind technology testing and validation through operations at their R&D park. They generate data on wind turbine performance, as well as meteorological conditions, which presents a significant opportunity for optimization of wind projects in the province.

Figure 6-7 - Eastern Kings Wind Farm (Photo Credit: PEI Energy Corporation)

The University of PEI also offers a Sustainable Design Engineering program, which supports a skilled local workforce in the wind sector [59], [60]. Similarly, Holland College offers a wind turbine technology program, producing a workforce trained to operate and maintain onshore wind infrastructure.

PEI has a strong technical knowledge base, established through their thriving aerospace and defense industry. PEI has established access to international markets, and existing transportation infrastructure to support their rich agriculture industry. Port Charlottetown has existing commercial capabilities, which can be leveraged for the transportation of onshore wind components.

Development Plans

In 2022, PEI released its *2040 Net Zero Framework*, outlining plans to achieve net-zero energy by 2030 and full net-zero emissions by 2040. Key pillars of this framework include transitioning to low-carbon alternatives, expanding carbon removal through forestry and other measures, supporting clean industry and waste management, and driving transformational change through leadership.

The province has also been working on updating their Energy Strategy with extensive public consultations during 2023. At the end of the process, the Government released a *What we Heard Report* noting that it would help inform an updated energy strategy for the province, which will guide future policy direction for electricity and other energy uses.

- **Short-Term (2025):** PEI is implementing five-year action plans to reach net-zero by 2040. The current plan, *Building Resilience: Climate Adaptation Plan*, includes short-term actions to strengthen the grid, increase local generation and storage, and expand the Climate Challenge Fund. This fund supports innovative projects led by businesses, academic institutions, municipalities, and not-for-profit organizations.
- **Medium-Term (2026-2030):** To reach net-zero energy by 2030, PEI targets increased renewable generation, energy efficiency, and reduced GHG emissions to below 1.2 t. Wind energy, currently supplying 23% of provincial electricity, is central to achieving this goal. Success metrics include national and international recognition, growth in cleantech firms, R&D investment, and 2,000 new clean tech jobs by 2030.
- **Long-Term (2030+):** PEI's 2040 net-zero targets include significant emissions reductions across transportation (55-65%), buildings (85-95%), agriculture (35-40%), and industry (85-95%). Electrification of fuels and thermal

energy for buildings will be required to meet the targets. The remaining emissions will be offset through carbon sinks like forests, farmlands, and wetlands.

Through Maritime Electric's *Capacity Resource Study*, four scenarios were considered to meet additional capacity requirements for the future of the electrical grid in PEI [61]. Each of the four scenarios include the development of an additional 162 MW of onshore wind capacity by 2032, and are summarized below:

- Battery Energy Storage Systems (BESS) + onshore wind + solar (utility scale and rooftop)
- BESS + Reciprocating Internal Combustion Turbines (RICE) + onshore wind + solar (utility scale and rooftop)
- BESS + Combustion Turbines (CTs) + onshore wind + solar (utility scale and rooftop)
- RICE or CTs + onshore wind + solar (utility scale and rooftop)

Challenges

PEI's high proportion of private land ownership presents challenges for securing sites for wind projects. Additionally, the Designated Areas Regulations limit eligible development to areas based on wind speed and may further restrict viable land if forest conservation initiatives expand to support net-zero goals.

6.3.7 Supply Chain Challenges

Supply Chain Bottlenecks - The supply chain for onshore wind is well established, however as the industry expands there are some supply chain concerns that need to be addressed, especially given the ambitious targets that are in place in Atlantic Canada. First and foremost is a concern for workforce availability. As these projects are constructed, the amount of onshore wind that can be installed concurrently may be limited by the availability of skilled workers and equipment, in particular component transportation equipment and cranes.

Additionally, as with any other industrial sector or large-scale project, there will be necessary infrastructure that the province does not currently have in place that will lead to supply chain gaps. In NL, onshore wind projects supporting green hydrogen production require specialized infrastructure, including hydrogen production facilities and export terminals. These projects must align with *Clean Electricity Regulations* objectives for reducing lifecycle emissions.

The *Clean Electricity Regulations* highlight workforce requirements to build and maintain onshore wind farms, with a focus on technical and construction trades. Federal policies support skills training and community engagement to address these gaps.

Stakeholder and Rights Holder Buy-In – Opposition from local stakeholders and Indigenous communities can pose challenges for onshore wind projects, potentially leading to delays or modifications. Some rural communities are hesitant to support large-scale wind farms due to concerns about land disruption, noise, and aesthetic impacts. Early, transparent, and meaningful engagement is essential to building trust, addressing concerns, and ensuring projects align with community priorities.

In Atlantic Canada, partnerships with Indigenous and local communities are increasingly emphasized to support equitable participation and shared economic benefits. Community Benefits Agreements (CBAs) are commonly expected to ensure local advantages from wind developments. However, provincial governments do not facilitate these agreements, and municipal governments often face challenges in negotiating and enforcing them, leaving communities to navigate these arrangements independently with developers.

Grid Connection Upgrades - In some provinces, the strategy emphasizes integrating onshore wind into existing grids to displace fossil fuel generation. Even when onshore wind is destined to provide power to green hydrogen generation, there is likely a need to use the grid as a pass-through. Grid capacity limitations could impact the ability of these projects to be constructed. Investment in transmission capacity and modernization to handle intermittent wind power will be required.

Uncertainty in Green Hydrogen Build Out – Much of the planned development of onshore wind in Atlantic Canada is in support of supplying green hydrogen for export. The anticipated growth in this global industry is unprecedented, with untested and immature supply chains. This paired with global political uncertainty means that the planned build out of green hydrogen technology may face challenges and timeline delays, and has the potential to impede onshore wind development in Atlantic Canada—a concern raised by several stakeholders interviewed for this scope. Federal, Atlantic Canadian, and European governments are actively working to support market development and mitigate this risk. Recently, a Newfoundland developer has stated it has expanded its offtake options to potentially include e-fuels production, green steel production and data centers in addition to hydrogen [62].

Procurement Risk and Local Content Challenges in the Supply Chain – Developers require long-term procurement assurances to secure financing, often relying on fixed-price contracts for major infrastructure components. However, local suppliers may be unable or unwilling to commit to the pricing and volume guarantees needed to support these contracts due to capacity limitations, cost fluctuations, and risk aversion. This creates a supply chain bottleneck, where local content policies mandate regional sourcing, but suppliers cannot provide the stability required for financing. Without clear procurement commitments from both developers and suppliers, projects face higher costs, delays, and increased reliance on imported components. Addressing this challenge will require greater coordination between policymakers, developers, and supply chain stakeholders to align local content objectives with the realities of supply chain capacity and financial risk. This is also a challenge for the OSW industry.

Lead Time on Transformers and Associated Transmission Equipment – Manufacturing capacity for critical components like transformers and cables has not kept pace with demand. Many existing transformers and transmission systems are over 25 years old, necessitating replacements and upgrades. Key materials, such as electrical steel, aluminium, and copper are in short supply, further exacerbating delays.

7 DEMAND ASSESSMENT

A number of development scenarios have been prepared to represent the demand for components and services required to support the build-out of Atlantic Canada's emerging offshore and onshore wind industries. These scenarios are meant to provide a range of supply chain requirements, including major component demand, workforce demand, and port demand, based on varying capacity level buildouts over time. These scenarios provide a planning basis for industry, suppliers, governments, communities, stakeholders and rights holders. They assist in considering the requirements that would be placed on the local supply chain for a range of wind energy capacity buildouts and timelines to predict where the greatest opportunities are and where shortcomings are likely to be seen. Development scenarios are informed by existing projects, public announcements, provincial roadmaps, IRPs, energy tables, and stakeholder/rights holder engagement.

To ensure consistency across this study and the *Atlantic Canada Offshore Wind Integration and Transmission Study*, commissioned by Net Zero Atlantic (NZA) and being led by Stantec, the development scenarios for offshore wind in this report are informed by the contributing E3 study, *Market Opportunities for Offshore Wind in the Atlantic Provinces (January 2025)* [63]. This study projects aggregate OSW build outs for Atlantic Canada as a whole, and makes assumptions about the corresponding onshore wind buildout, including on electricity export amounts to the US. The E3 scenarios consider project and transmission costs, provincial planning documents, input from utilities, etc. These inputs are considered when modelling various options for future development using industry standard software PLEXOS. Development scenarios established for this project consider time periods extending from 2030 to 2050 in five-year increments.

In this report, offshore and onshore wind are considered separately, detailing capacity build by province. In some instances, scenario values from E3 have been appropriately re-scaled based on the assumptions presented in the following sections. The project team has provided low, medium, and high development scenarios for offshore and onshore wind capacity buildout, given in Table 7-2 and Table 7-4. The scenarios are based on incremental market pathway options with increasing capacity development, as follows:

- **Low scenario** – Domestic Use only
- **Medium scenario** – Domestic Use + Electricity Export
- **High scenario** – Domestic Use + Electricity Export + Green Hydrogen Production

For "Electricity Export" it is assumed that electricity generated by wind will be exported to the Northeast US, in particular New England and New York where there is a strong demand for clean energy. A review of provincial planning literature suggests that if Atlantic Canadian provinces were connected through an "Atlantic Loop" transmission system the overall amount of wind energy developed would be likely to decrease, therefore this is not considered in the export case. Assumptions on the amount of electricity that may be exported and the associated timelines for export are given in Table 7-1, noting this refers to wind energy capacity only and not other forms of generation.

While real-world plans are built into the development scenarios, insufficient data exists to accurately predict wind energy buildout for each province out to 2050. Details of the assumptions that have been made to fill information gaps are detailed in the following sections. Note that as projections extend to 2050, capacity numbers may exceed those stated by provinces to date as current deployment plans for wind energy do not look this far into the future.

[MW]	2030	2035	2040	2045	2050
TOTAL	0	2,000	4,000	4,000	6,000
NS	0	1,000	500	0	500
NL	0	0	1,000	0	1,000
NB	0	750	500	0	500
PEI	0	250	0	0	0

Table 7-1 - Assumed Electricity Export Amounts, by Province [63]

This exercise does not intend to predict or dictate what development forecasts should be, but allows for consideration of supply chain requirements under cumulative, incrementally increasing development cases. It also assumes that any required transmission upgrades will be completed to allow for these capacity levels, and that the necessary export conditions (e.g., regulatory frameworks, export infrastructure, etc.) are met to support the amount of electricity and green hydrogen to be exported. Vessel requirements for installation and maintenance activities are provided for OSW in Section 7.1.4.

7.1 Offshore Wind

7.1.1 Development Scenarios

Methodology

As stated in Section 5.3.3, NS is the only province to have announced a target for OSW production thus far, planning to lease the equivalent of 5 GW of seabed by 2030 and host their first licensing call for bids in 2025. Beyond this, there have been no announcements on provincial OSW targets or timelines. While no seabed license has yet been obtained and thus development is not guaranteed, the Nova East Wind project is planning for a maximum of 400 MW to be commissioned by 2030. While this represents a somewhat condensed timeline for project development, which typically takes about 10 years from licence acquisition to COD, DP Energy and SBM Offshore started pre-feasibility and site assessment studies in 2021, giving them a head start. As such, all OSW development scenarios assume that Nova East Wind will achieve a 2030 COD.

Given the absence of planning information beyond 2030, the development scenarios implemented by this project team are mostly aligned with those in the E3 report. It was necessary to make assumptions on the distribution of the aggregate capacity values across provinces. NS was allocated all the "Domestic Only" OSW capacity given it has demand for clean energy domestically, and it has a stated goal of integrating OSW. Electricity export values reference Table 7-1, allocating values to NB and NS ahead of NL given their closer proximity to export markets. OSW developed for green H2 production references E3's "Base H2" scenario but shifts timelines out to account for the development times required for future projects. It is assumed that neither NB or PEI develop OSW for green H2 production.

The OSW development scenarios used for the demand assessment are provided in Table 7-2, along with the assumptions that were considered. Note that each subsequent development scenario contains the capacity amounts from the previous scenario and are cumulative across timelines.

SCENARIOS	ASSUMPTIONS	NB [GW]	PEI [GW]	NS [GW]	NL [GW]	TOTAL [GW]	
Low (Domestic Only)	Nova East Wind project (400 MW) in NS.	0	0	0.4	0	0.4	**2030**
	Assumes 0.6 GW added to NS grid to get to total of 1 GW of OSW for domestic use by 2035 (E3 report).	0	0	1	0	1.0	**2035**
	Assumes the full capacity of OSW serving the Atlantic provinces in the E3 "Domestic-only" case is allocated to NS.	0	0	2.5	0	2.5	**2040**
		0	0	2.5	0	2.5	**2045**
		0	0	2.5	0	2.5	**2050**
Medium (Domestic + Electricity Export)	Nova East Wind project (400 MW) in NS.	0	0	0.4	0	0.4	**2030**
	Additional 1 GW of OSW capacity added in NS for electricity export by 2035.	0	0	2	0	2.0	**2035**
	Additional 2 GW of OSW capacity added in NS for electricity export by 2040. NL and NB each assumed to have 1 GW OSW capacity for electricity export by 2040.	1	0	4	1	6.0	**2040**
	No additional OSW capacity for electricity export out to 2045.	1	0	4	1	6.0	**2045**
	Assumes an additional 0.5 GW of OSW capacity is added for NB and 1 GW for NS by 2050.	1.5	0	5	1	7.5	**2050**
High3 (Domestic+ Electricity Export + H2)	Nova East Wind project (400 MW) in NS.	0	0	0.4	0	0.4	**2030**
	No OSW capacity is added for green H2 production by 2035.	0	0	2	0	2.0	**2035**
	Assumes 1 GW of OSW capacity is added for green H2 production in NS by 2040.	1	0	5	1	7.0	**2040**
	Assumes an additional 1 GW and 2 GW of OSW capacity for green H2 production is added in in NS and NL, respectively, by 2045.	1	0	6	3	10.0	**2045**
	Assumes no additional OSW capacity is added for green H2 production by 2050.	1.5	0	7	3	11.5	**2050**

Table 7-2 - Offshore Wind Development Scenarios, Values and Assumptions

Results

Figure 7-1 illustrates cumulative OSW development over time in the Low, Medium, and High scenarios. In the Low, Medium, and High scenarios, OSW development begins in 2029 with the installation of Nova East Wind. The Low scenario rises again in 2037 until plateauing in 2040. The Medium and High scenarios see OSW development rising in tandem from 2029 to 2040, at which point the rate of development in the High scenario outpaces that of the Medium scenario. The Medium scenario plateaus between 2040 and 2044, while the High scenario rises steadily into 2048 until plateauing.

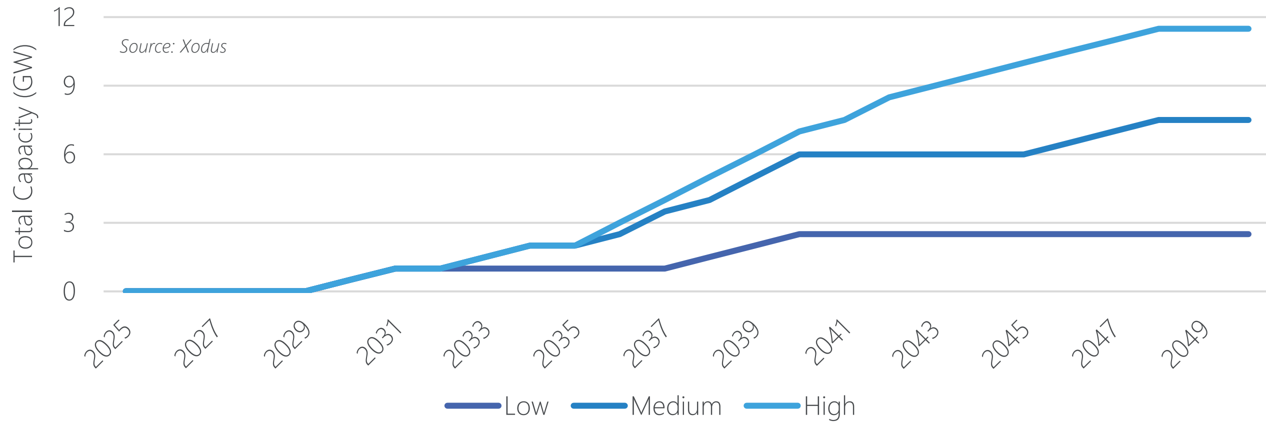


Figure 7-1 - Total Offshore Wind Capacity Over Time in the Low, Medium, and High Scenarios

Low Scenario: Low domestic demand constrains OSW development to NS (Figure 7-2). Its large population, coastal load centers, and ambitious OSW target drive the development of 2.5 GW of capacity by 2040, noting that in this scenario the province does not achieve development of the full 5 GW of seabed capacity that they have planned to license by 2030 due to insufficient domestic-only demand. NB, NL, and PEI do not develop any OSW due to their existing renewable generation capacity and lack of OSW targets.

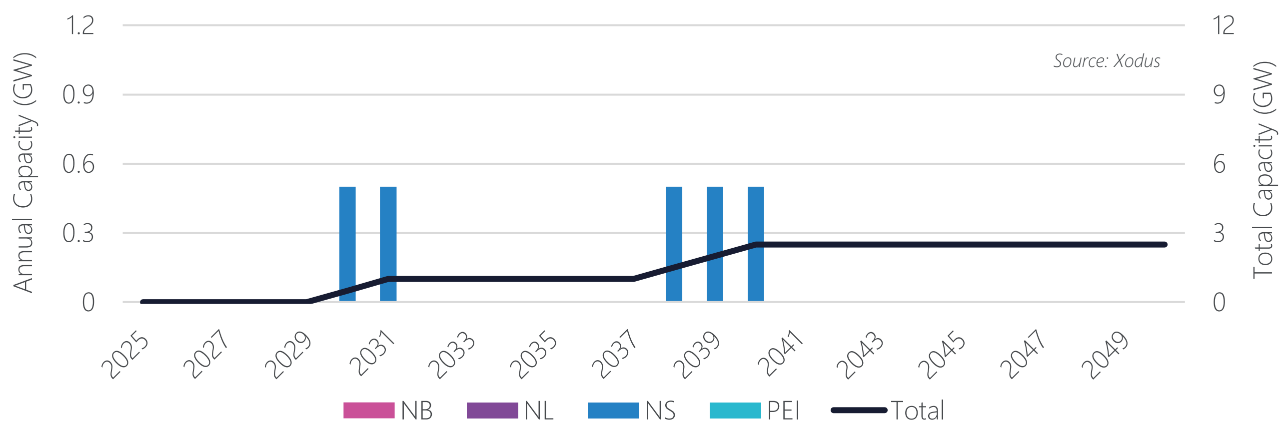


Figure 7-2 - Annual and Total Offshore Wind Capacity Over Time in the Low Scenario

Medium Scenario: Electricity export opportunities drive increased OSW development in NS, NB, and NL (Figure 7-3). NS leads these two provinces by five years and almost five times as much capacity due to its domestic demand market. Half of this capacity and all the capacity from NL and NB are exported to the Northeast U.S. to states like Maine, Massachusetts, and New York, where there is high demand for clean electricity imports due to legally binding renewable portfolio standards and a lack of existing renewable generation. It is assumed that PEI does not develop any OSW for electricity export given it has no stated intention of developing OSW.

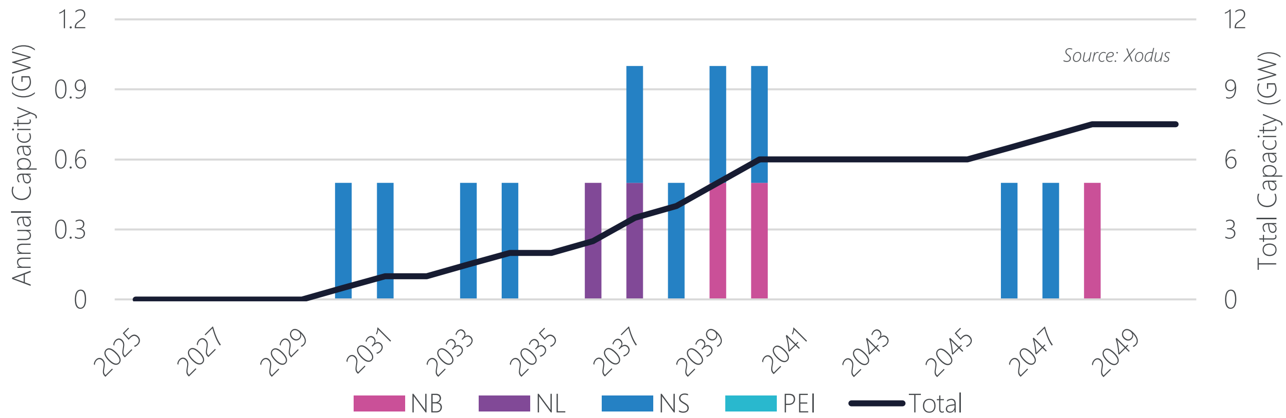


Figure 7-3 - Annual and Total Offshore Wind Capacity Over Time in the Medium Scenario

High Scenario: Offshore wind development is driven by green hydrogen demand in NS, NL, and NB (Figure 7-4). Domestic demand in NS again yields a lead of five years and at least twice as much capacity over NL and NB. More than half of the capacity in NS and all remaining capacity is allocated for hydrogen production, assuming there is sufficient demand in domestic and international markets. Again, it is assumed that PEI does not develop any OSW for electricity export given it has no stated intention of developing OSW.

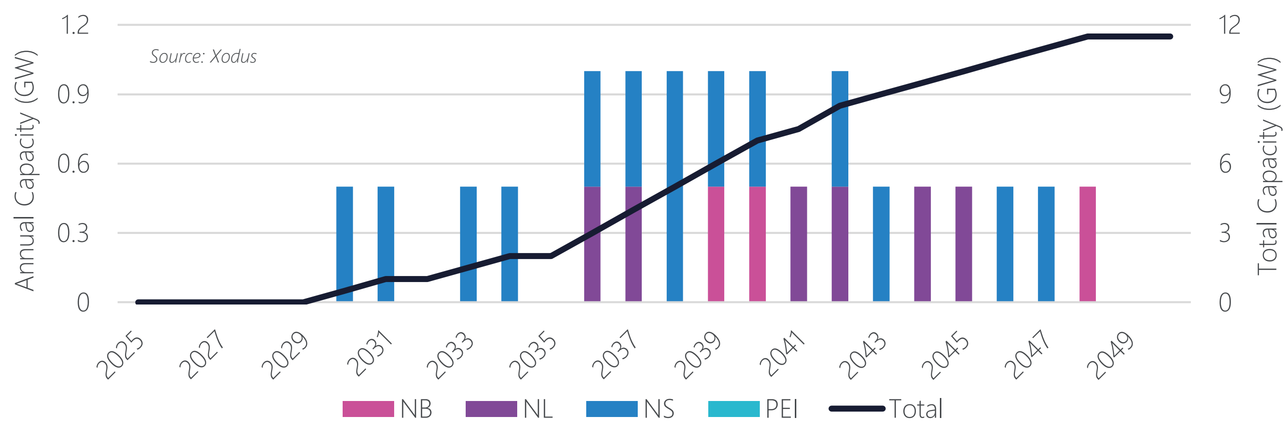


Figure 7-4 - Annual and Total Offshore Wind Capacity Over Time in the High Scenario

7.1.2 Major Component Demand

Methodology

Demand for major components and port sites was assessed for the three scenarios to demonstrate the range of potential supply chain constraints and opportunities in the Atlantic Canadian OSW sector. Major components include wind turbines, fixed foundations, floating foundations, offshore substations, array cables, and export cables.

Components are considered "in demand" in the year in which they are procured for a given project. As such, turbines, fixed foundations, and floating foundations are considered in demand a year prior to installation through the year prior to COD, while offshore substations, array cables, and export cables are considered in demand two years prior to installation until two years prior to COD. Additional simplifying assumptions were required to estimate component demand, which are provided below:

- All turbines have a rated capacity of 18 MW and include a tower, a nacelle, and three blades.
- Approximately 45% of seabed sites require fixed foundation technology, and the remaining 55% require floating foundation technology.
- All substations have a rated capacity of 500 MW.
- Array and export cables are installed at a rate of 200 km per GW and 150 km per substation, respectively.
- Approximately 35% of projects use HVAC technology, while the remaining 65% use HVDC technology.

Port sites include S&I ports and O&M bases. S&I ports are considered in demand in the years in which up to 500 MW of capacity is installed per year per project, such that an S&I port for a 1 GW project is considered in demand in the year prior to COD and the year of COD. An O&M base is considered in demand the year of COD and each subsequent year until a project's decommissioning. Note that this demand assessment does not consider global component availability.

Results

Low Scenario: Component demand remains relatively constant as projects are installed and commissioned over an eight-year period (Figure 7-5). Low demand is unlikely to strain the global supply chain, particularly since recent instability in the U.S. OSW market may create supply gaps for OEMs and Tier 1 suppliers. Only one S&I port is in demand at any given time in this scenario, while demand for O&M bases rises steadily as projects are commissioned (Figure 7-6). It is likely that a single heavy industrial port in Atlantic Canada will be able to stage and install all projects with appropriate infrastructure upgrades. Individual terminals at such a port or several smaller ports can serve as O&M bases with lower investment, as these sites require less laydown acreage, quayside strength, and berth length than an S&I port.

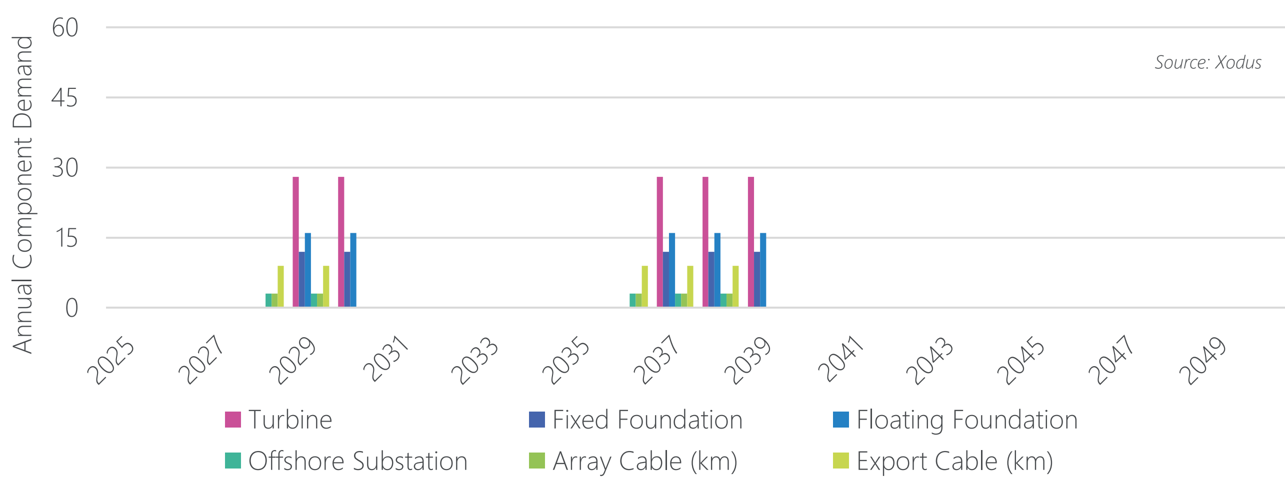


Figure 7-5 - Annual Component Demand Over Time in the Low Scenario

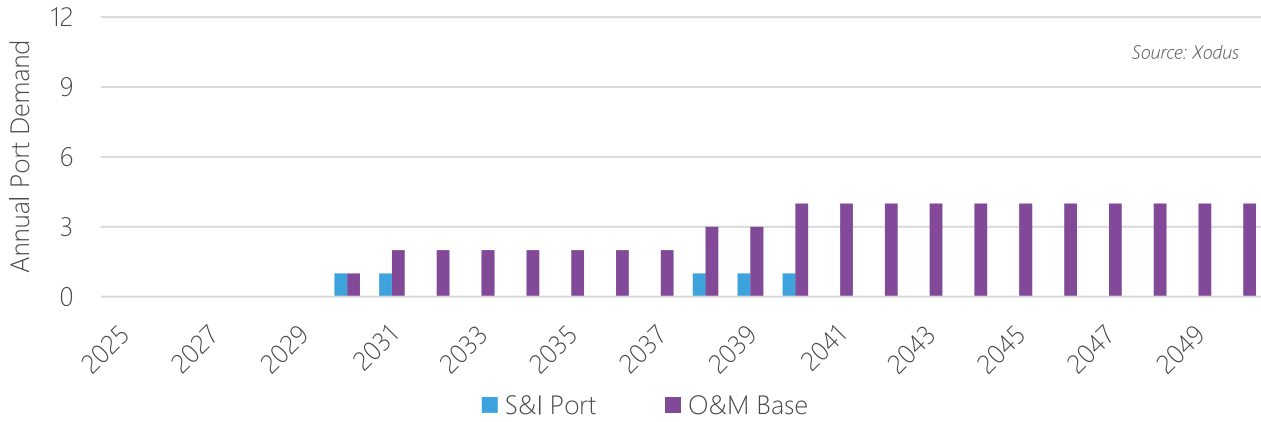


Figure 7-6 - Annual Port Demand Over Time in the Low Scenario

Medium Scenario: Component demand extends over a twenty-year period with peaks in the three years in which two projects are installed simultaneously (see Figure 7-7 and Figure 7-8). Peak demand in these years may be subject to supply chain bottlenecks by 2026, potentially causing project delays and flattening the forecasted demand curve. Developers will need to be proactive with their procurement schedules in this scenario. While a single heavy industrial port with multiple S&I terminals may be able to install all projects, competition between provinces may drive investment in at least two S&I ports. The sheer number of O&M bases in demand by 2050 may create opportunity for economies of scale, particularly if one developer builds multiple projects and can leverage a single O&M base to service all projects.

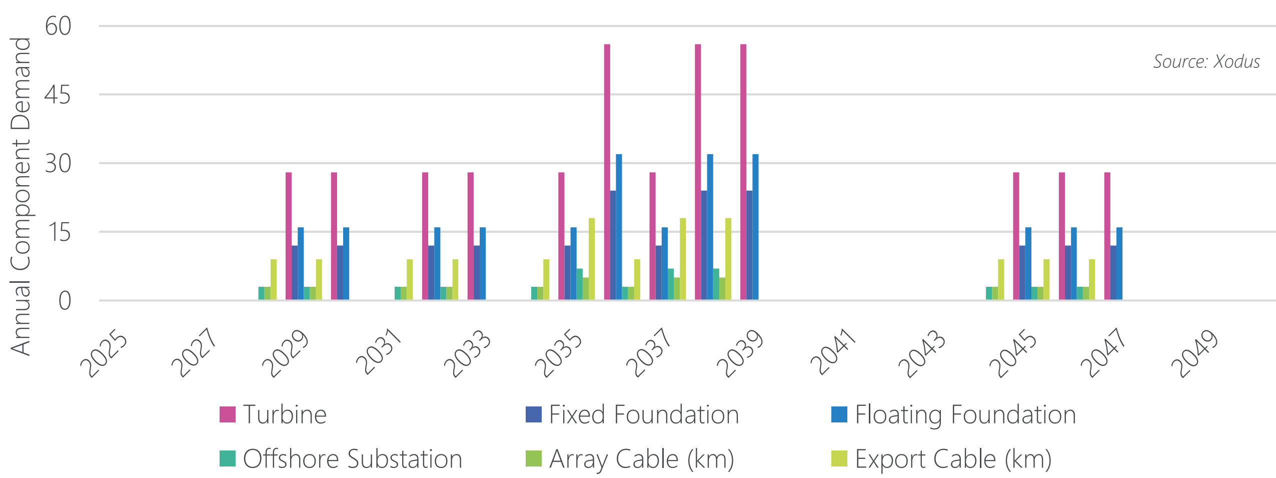


Figure 7-7 - Annual Component Demand Over Time in the Medium Scenario

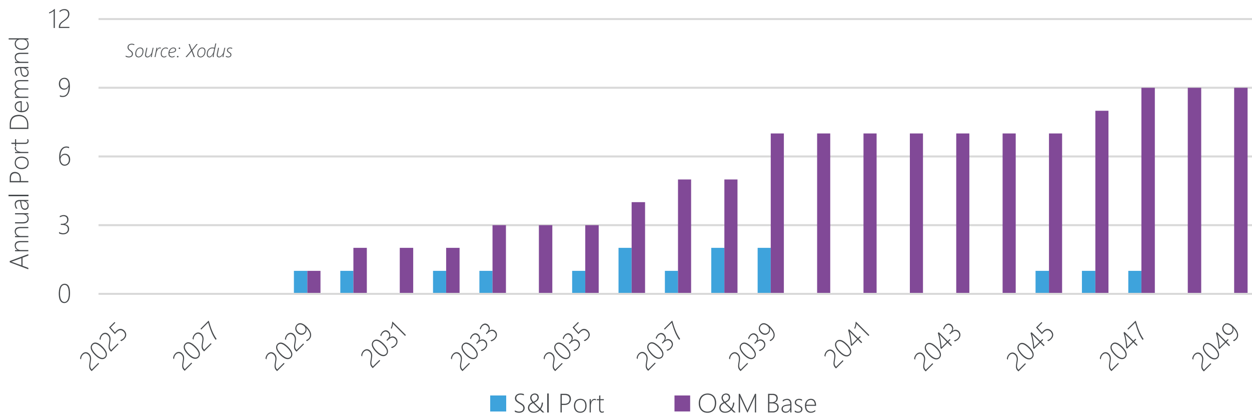


Figure 7-8 - Annual Port Demand Over Time in the Medium Scenario

High Scenario: Component demand experiences peaks in six near-consecutive years with moderate demand persisting before, during, and after these years (Figure 7-9). Consistent high demand is likely to strain the global supply chain and may drive OEMs and Tier 1 suppliers to invest in new facilities to meet growing demand, particularly given the existing project pipeline in Europe and Asia. The size of the project pipeline in each province may support economies of scale for local port investment (Figure 7-10), as several S&I ports and O&M bases are needed to install and maintain this high volume of projects in tandem.

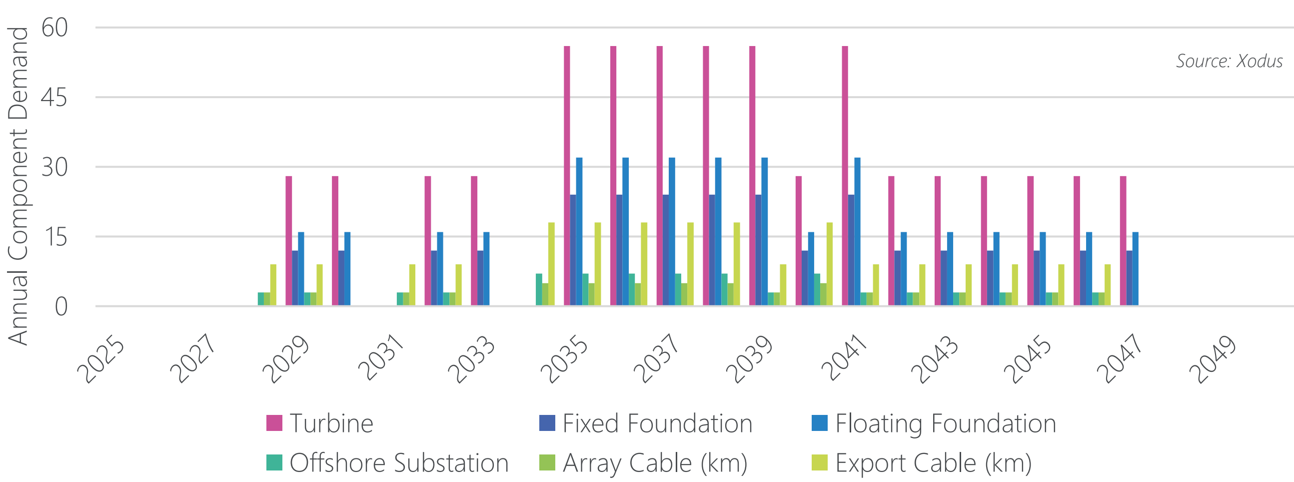


Figure 7-9 - Annual Component Demand Over Time in the High Scenario

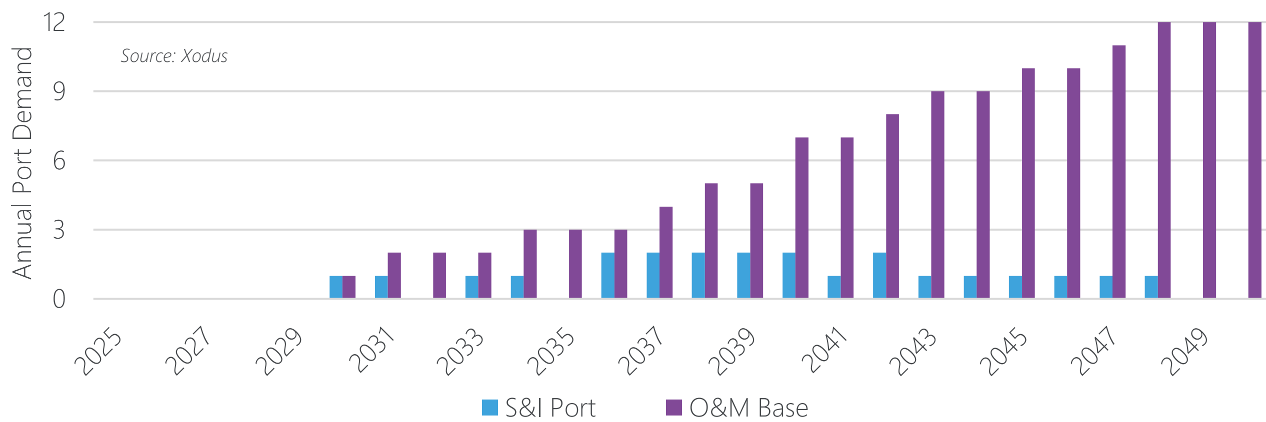


Figure 7-10 - Annual Port Demand Over Time in the High Scenario

Observations

The Medium scenario, with a maximum capacity of 7.5 GW by 2050, introduces the possibility of constrained component demand with potential timeline impacts. The High scenario, with a maximum capacity of 11.5 GW by 2050, shows a consistent demand across the timeline considered, with consistent high demand during the 2030's. This level of demand may be sufficient to make the investment case for local manufacturing of components given geographic supply chain pressures. Even for the High scenario, the demand for simultaneous S&I port operations does not exceed two, limiting demand for major port buildout without additional manufacturing being added. There is significant opportunity for local O&M ports across all scenarios.

7.1.3 Workforce Demand

Methodology

Workforce demand was assessed for the three scenarios to understand the potential constraints and opportunities for OSW workforce development in Atlantic Canada. Xodus leveraged its in-house OSW workforce tool to estimate cumulative workforce demand across all projects in every year of the three scenarios. For each project, workforce demand was evaluated five years before COD until decommissioning to capture the full arc of workforce activity associated with a project, including the ramp-up of development work, the peak during construction and installation, and the plateau during operation.

Figure 7-11 shows a simplified timeline of workforce activity for a floating OSW project. Each supply element is flagged with an in-demand or no-demand value in each year relative to COD, indicating whether workers in that supply element are paid employees in that year. The timeline does not consider the length of employment but rather when the workforce is anticipated to be utilized for a project. For the three scenarios, every project was assigned a workforce timeline in accordance with its COD (Year 0), allowing the cumulative workforce demand to be summed across each year while projects progress through different phases. Note that this demand assessment does not consider workforce availability.

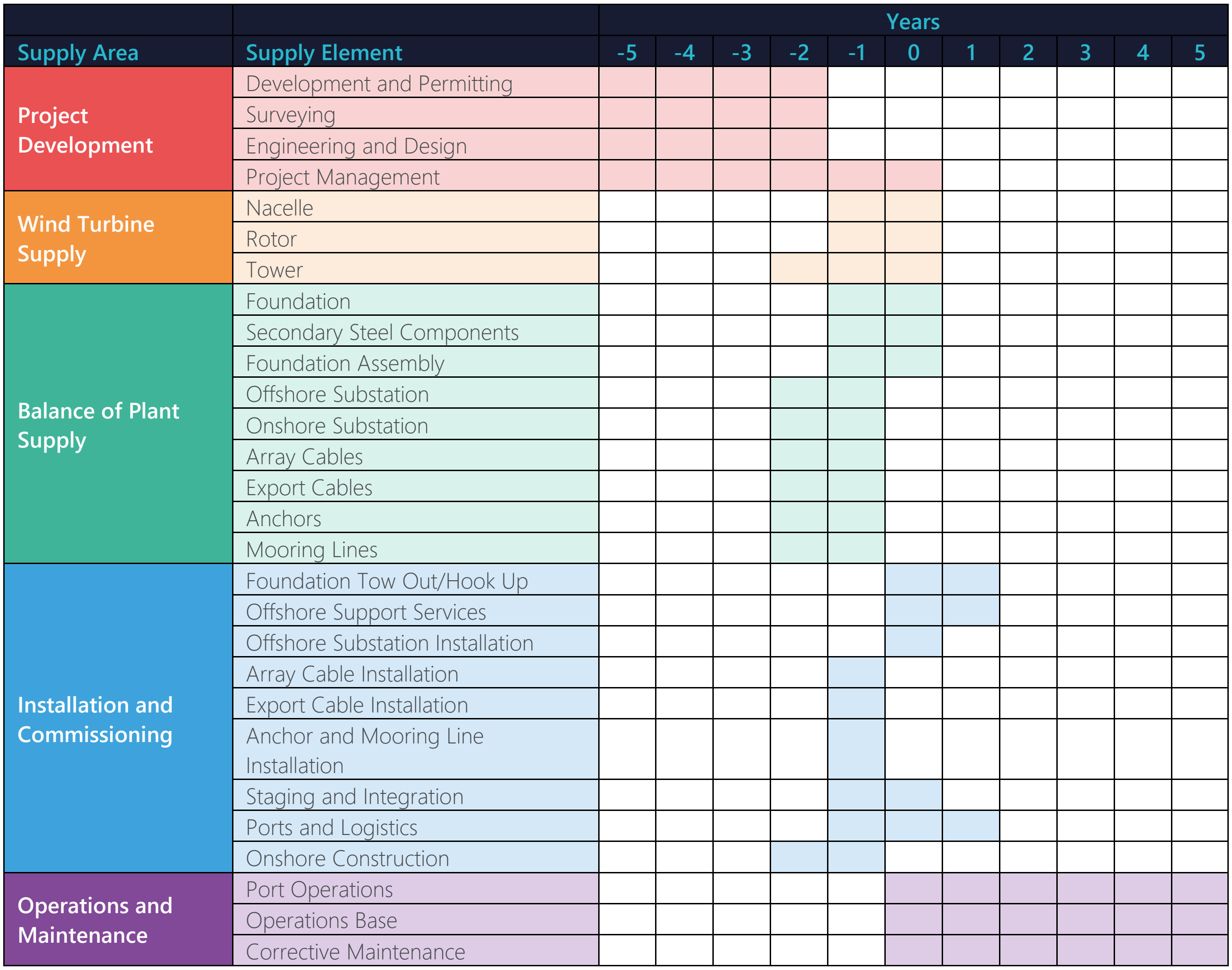


Figure 7-11 - Simplified Workforce Timeline for a Floating Offshore Wind Project

It should be noted that the number of workers presented below represents the headcount required each year and is not equivalent to the number of full-time equivalent employees that would be calculated in an economic impact analysis.

Results

Low Scenario: Workforce demand fluctuates with between 200 and 400 workers in demand during early project development in the late 2020s to a maximum of just under 5,000 workers as several projects are installed concurrently in the early 2030s (Figure 7-12 and Figure 7-13). Project development roles are largely comprised of business and STEM professionals, which can be easily localized to Atlantic Canada. There is very low likelihood that WTG and BOP components will be supplied from Atlantic Canada in this scenario given the small size of the project pipeline, meaning the workforce demand attributed to manufacturing trade workers can be discounted from total demand. Over 1,000 building and maritime trade workers will be in demand per year as projects are installed and begin operations in the early 2030s. The majority of these workers can likely be sourced in local to Atlantic Canada due to its maritime industrial heritage. Nearly 600 building and maritime trades workers will remain in demand during O&M until projects begin decommissioning in the 2060s.

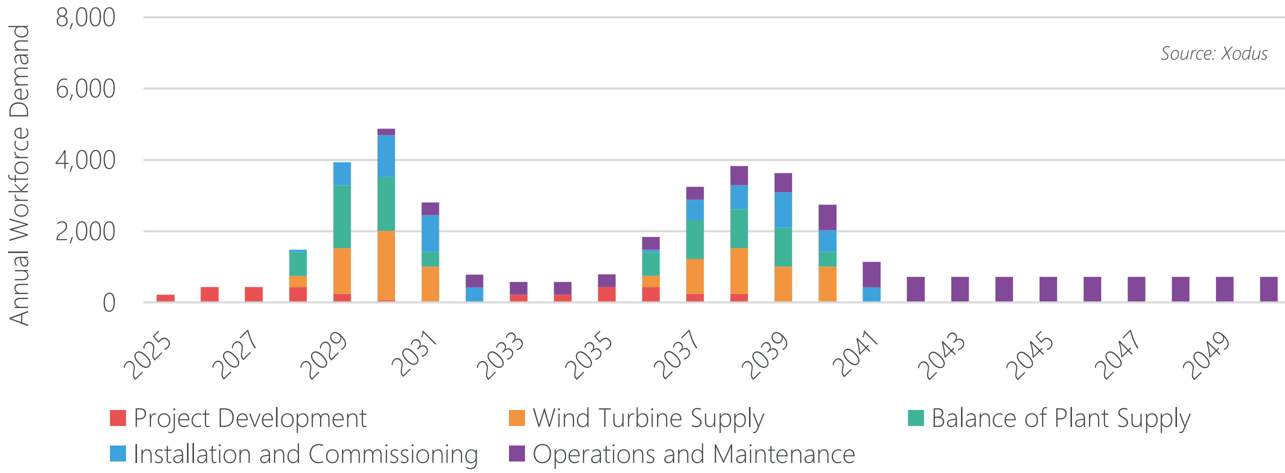


Figure 7-12 - Annual Workforce Demand Over Time by Project Phase in the Low Scenario

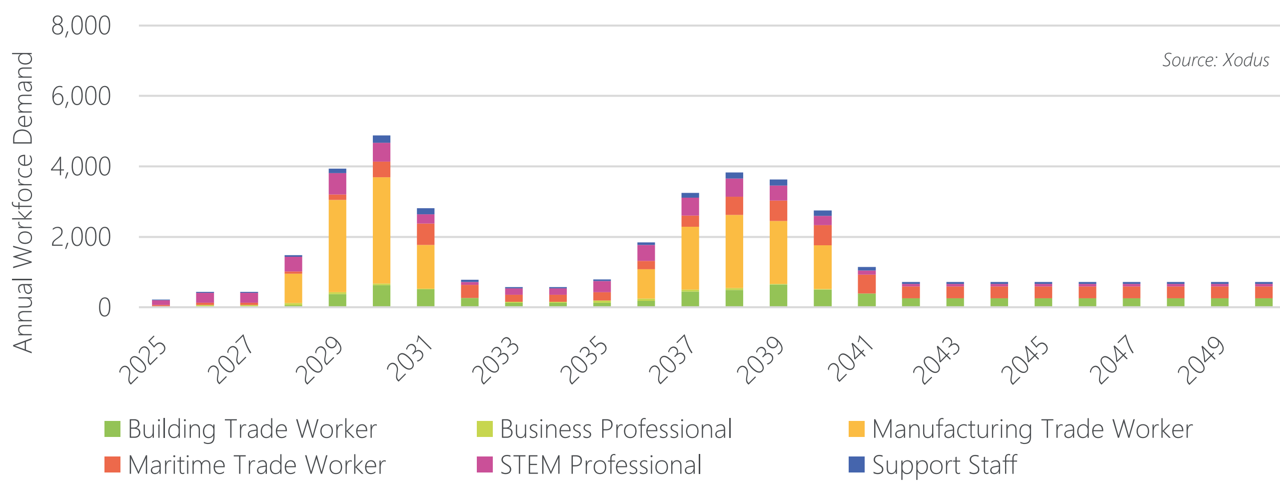


Figure 7-13 - Annual Workforce Demand Over Time by Job Role in the Low Scenario

Medium Scenario: Workforce demand extends over a greater period of time with peaks at over 6,000 as projects are installed (Figure 7-14 and Figure 7-15). The larger pipeline of projects provides greater incentive for project developers to localize business and STEM professionals, although investment in large-scale manufacturing remains unlikely. Lack of manufacturing facilities will reduce workforce demand by up to 3,000 manufacturing trade workers in peak years, although there may be greater manufacturing opportunities for secondary or tertiary components. Notably, workforce demand in the Installation and Commissioning phase extends almost as long as the O&M phase due to the consistency of the project pipeline, providing robust opportunities for building and maritime trade workers.

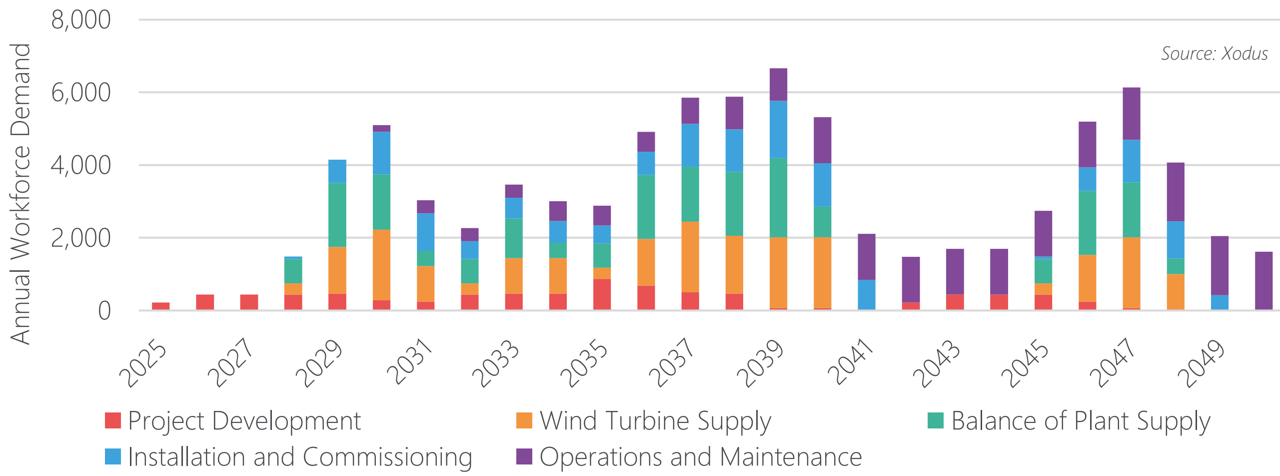


Figure 7-14 - Annual Workforce Demand Over Time by Project Phase in the Medium Scenario

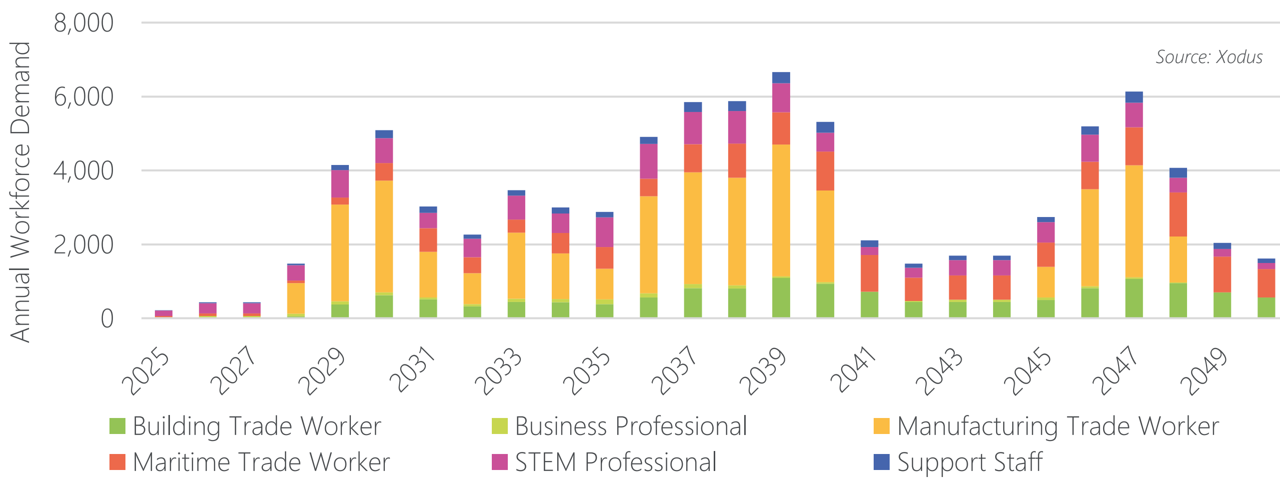


Figure 7-15 - Annual Workforce Demand Over Time by Job Role in the Medium Scenario

High Scenario: Workforce demand rises quickly and becomes more consistent over time (Figure 7-16 and Figure 7-17). Project development opportunities for business and STEM professionals, as well as support staff and maritime trade workers, extend through the 2040s with a peak of approximately 1,000 jobs. Economies of scale from the size of the project pipeline may encourage an OEM or Tier 1 supplier to invest in a facility in Atlantic Canada, although this will only localize a portion of the up to 3,500 job opportunities for manufacturing trade workers and support staff in peak years. Similar to the low and medium scenarios, the Installation and O&M phases each provide peaks of over 2,000 job opportunities for building and maritime trade workers.

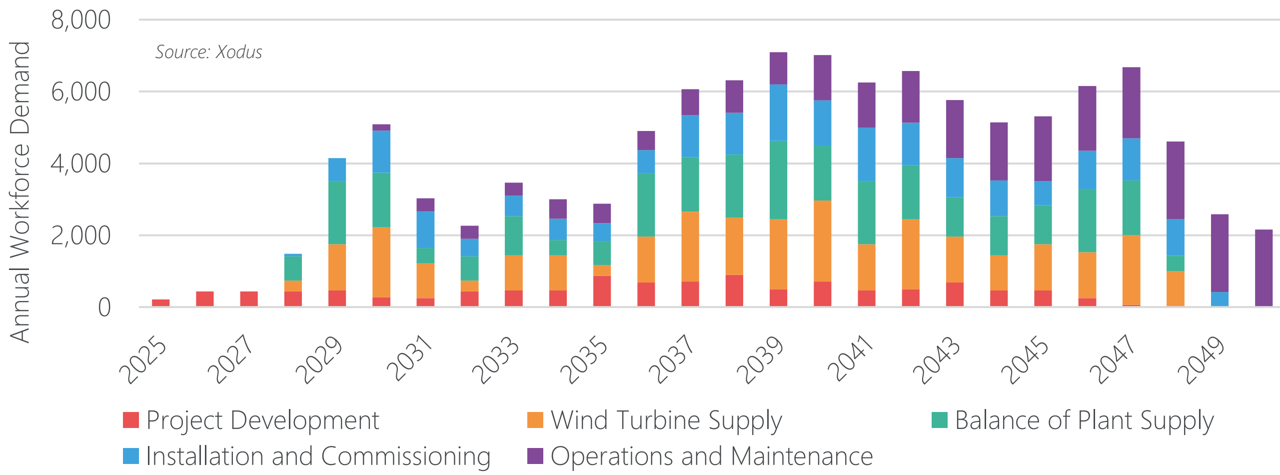


Figure 7-16 - Annual Workforce Demand Over Time by Project Phase in the High Scenario

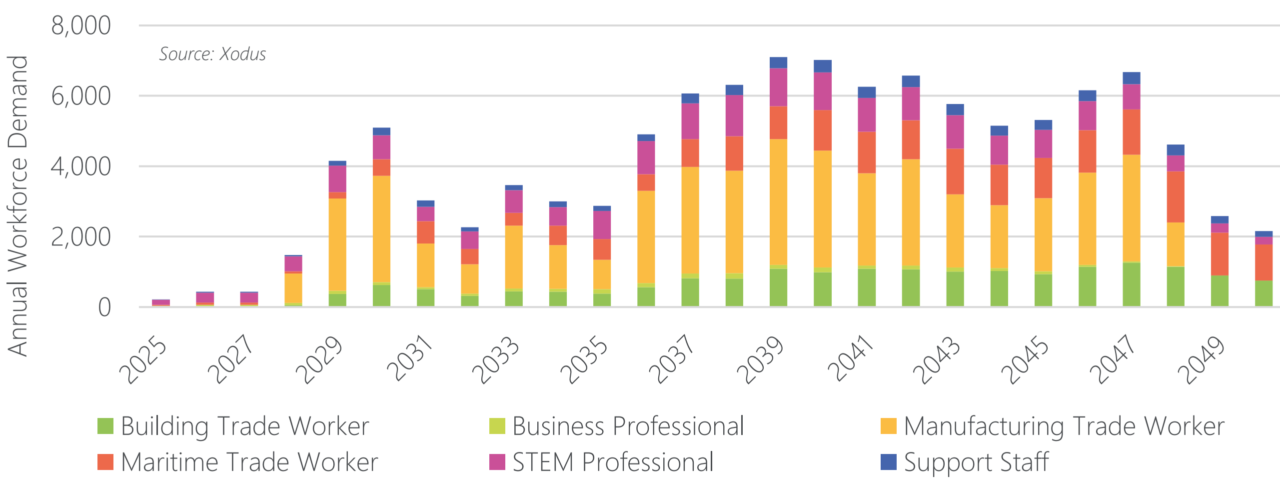


Figure 7-17 - Annual Workforce Demand Over Time by Job Role in the High Scenario

Observations

It is likely that a significant portion of Project Development work could be sourced in the region. Even in the Low scenario at least 70 STEM professionals will be required in a given year. The greatest opportunity for Atlantic Canadian workers is in the building and maritime trades. The demand for these roles grows to over 1,000 by the early 2030's in the Low scenario, however there are periods where lulls in installation mean these opportunities drop below 700 for several years at a time. In the Medium and High scenarios worker demand becomes consistently higher, although the majority of workers required are in the manufacturing trades. As it was observed in Section 7.1.2, component demand for these scenarios may be enough to justify manufacturing operations which would allow some percentage of this total to be localized in Atlantic Canada. Without manufacturing, there remains a potential demand for between about

800 and 2,500 building and maritime trade workers per year, and between another 400 and 1,100 STEM professionals per year, for Medium and High scenarios, respectively.

7.1.4 Vessel Requirements

OSW installation is a complicated process, both for fixed bottom and floating projects. Numerous different types of vessels are required and form a critical part of the supply chain. Vessel bottlenecks and limitations, like the Jones Act in the US, (see Section 5.1.3) can have major impacts on project costs and schedules. The mix of vessels used depends on a number of factors including WTG type and size, vessel availability, vessel size, and more. Details of the types of vessels required for OSW transportation, installation and maintenance are given in Table 7-3. Note that these values are provided for illustrative purposes and may vary on a project-to-project basis depending on factors previously mentioned. Global vessel availability is not considered.

Table 7-3 - Types of Vessels used in OSW Transportation, Installation and Maintenance [64] [65]

VESSEL TYPE	ROLE IN OFFHORE WIND PROJECT	FIXED, FLOATING, BOTH?	VESSEL REQUIREMENT FOR 1 GW PROJECT
Anchor Handling Vessel/Tug (AHT)	Used for the pre-lay of anchors and mooring lines. Three of the AHVs are used for the tow-out and hook-up (cable and mooring lines) of the floating turbines.	Floating	3
Barge/Amphibious Vehicle	Cable pull-in for export cables my be completed by the CLV, however depending on the landfall site it may be required to have a shallow draft barge or an amphibious vehicle to bring the cable to shore. Some barges have jack up capability to assist with turbine installation.	Both	1
Cable Burial Vessel (CBV)	Buries cable when the cable must be buried post-lay.	Both	2
Cable Lay Vessel (CLV)	Installs (lays and buries) export and array cables. Unless the conditions require post lay burial, in which case the cable lay vessel only lays the cable.	Both	2
Component Transport Vessel	Transports turbine components from manufacturing site to marshalling port.	Both	5
Crew Transfer Vessel (CTV)	Transport crew members from the onshore O&M base to the turbine or substation locations. CTVs are the preferred method of transport for projects closer to shore.	Both	5
Feeder Barge	Transports components from the marshalling port to the installation vessel.	Fixed	2

VESSEL TYPE	ROLE IN OFFHORE WIND PROJECT	FIXED, FLOATING, BOTH?	VESSEL REQUIREMENT FOR 1 GW PROJECT
Foundation Installation Vessel	Transports the foundations from the port to the site and installs foundation into the seafloor. Heavy lift vessels, floating sheerleg vessels and self-propelled jack-up vessels are all used.	Fixed	1
Large Component Repair Vessel	Complete the replacement of large components (nacelle or rotor components) that require a stable connection at hub height.	Both	1
Rock Installation Vessels	Used to rock dump for cable protection or scour protection.	Fixed	1
Service Operation Vessel (SOV)	Creates an offshore O&M base allowing the crew to work from the vessel for long-term rotations. SOVs are the preferred method to service and maintain OSW farms.	Both	1
Substation Installation Vessel	Transports and installs the substation.	Both	1
Support Vessels	These include guard vessels, safety vessels, scout vessels, anchor handling tugs, barges, dive support, ROV handling vessels and walk-to-work vessels. All of these vessels provide support to the installation process or provide security services to unprotected assets.	Both	Up to 30 (varies)
Survey Vessels	These vessels can be used to carry out several types of surveys required for an OSW farm. These surveys include Geophysical, Geotechnical, Environmental, Fish and Shellfish, and Offshore Ornithological and Mammal surveys.	Both	Up to 50 (varies)
Wind Turbine Installation Vessel (WTIV)	Jack-up vessels that transport the turbine components to the installation site and support the assembly of the turbine on the foundation. Similar jack-up vessels are used to those for foundation installation. Sometimes used in conjunction with jack-up barges.	Fixed	1

7.2 Onshore Wind

7.2.1 Development Scenarios

Methodology

To populate the onshore wind development scenarios all projects, both operating and planned, were mapped by province according to capacity and COD. Tables listing all current and planned projects by province, along with associated CODs, capacity amounts, and details on end use (i.e. grid, green hydrogen, sustainable fuel, etc.) are available in Appendix D. It was possible to accurately represent onshore wind capacity development out to 2035 based on current plans, however beyond this date values were influenced by public announcements, provincial roadmaps, IRPs, energy tables, stakeholder/rightsholder engagement, and E3's reporting [63].

Onshore wind developed for "Electricity Export" assumes the values given in Table 7-1. The capacity amounts for hydrogen development are based on announced projects to date that will be used for green hydrogen production. NL has plans to develop 28.4 GW of onshore wind for green hydrogen production by 2035. This represents an ambitious undertaking as this would equate to installing approximately 4,700 onshore wind turbines[4] at an average rate of 470 turbines being installed each year. While this is not unprecedented globally, it will put major pressure on the Atlantic Canadian supply chain and workforce to achieve these numbers, especially given NL's lack of onshore wind experience to date with only 55 MW installed. For this reason, in addition to Low and Medium scenarios, two High scenarios were developed. The High 1 scenario represents the planned NL onshore wind buildout based on current onshore wind for green hydrogen projects achieving their stated CODs. The High 2 scenario assumes an installation limit of 2 GW (approximately 330 turbines) per year, smoothing demand and pushing out planned project CODs. Revised project CODs are available in Appendix D.2.

The onshore wind development scenarios used for the demand assessment are provided in Table 7-4, along with the assumptions that were considered. Note that each subsequent development scenario contains the capacity amounts from the previous scenario and are cumulative across timelines.

SCENARIOS	ASSUMPTIONS	NB [MW]	PEI [MW]	NS [MW]	NL [MW]	TOTAL [GW]	
Low (Domestic Only)	Currently installed onshore wind capacity.	397	204	623	55	1.3	2025
	Planned installation capacity for domestic use out to 2030.	772	252	1945	555	3.5	2030
	Planned installation capacity for domestic use out to 2035.	2172	414	1945	555	5.1	2035
	Assumes maximum onshore development attained in 2035 due to domestic demand constraints.	2172	414	1945	555	5.1	2040
		2172	414	1945	555	5.1	2045
		2172	414	1945	555	5.1	2050
Medium (Domestic + Electricity Export)	No onshore wind capacity for electricity export assumed out to 2030.	397	204	623	55	1.3	2025
		772	252	1945	555	3.5	2030
	Planned installation capacity for domestic plus onshore capacity assumed for	2922	664	2945	555	7.1	2035
		3422	664	3445	1555	9.1	2040

[4] *Calculation assumes 6 MW wind turbines are installed onshore.*

	electricity export, per province, out to indicated year.	3422	664	3445	1555	9.1	2045
		3922	664	3945	2555	11.1	2050
High 1 (Domestic + Electricity Export + Limited H2 development)	Currently installed onshore wind capacity.	397	204	623	55	1.3	2025
	Planned installation capacity for domestic use plus onshore wind capacity assumed for electricity export, per province, out to indicated year. Onshore wind capacity for green H2 production is added, assuming that a maximum of 2 GW of onshore wind can be installed per year, per province.	772	252	3772	4555	9.4	2030
		4622	664	7272	11555	24.1	2035
		5122	664	7772	15855	29.4	2040
		5122	664	7772	21855	35.4	2045
		5622	664	8272	25955	40.5	2050
High 2 (Domestic + Electricity Export + H2)	Currently installed onshore wind capacity.	397	204	623	55	1.3	2025
	Planned installation capacity for domestic use plus onshore capacity assumed for electricity export and green H2 production, per province, out to indicated year.	772	252	3772	10055	14.9	2030
		4622	664	7272	28955	41.5	2035
		5122	664	7772	29955	43.5	2040
		5122	664	7772	29955	43.5	2045
		5622	664	8272	30955	45.5	2050

Table 7-4 - Onshore Wind Development Scenarios, Values and Assumptions

Results

Figure 7-18 demonstrates onshore wind development over time in the Low, Medium, High 1, and High 2 scenarios. Onshore wind capacity is anticipated to increase approximately four-fold in the Low scenario, nine-fold in the Medium scenario, and thirty-six-fold in both High scenarios over the next twenty-five years. Development rises steadily in the Low and Medium scenarios, while both High scenarios see a steep incline in development beginning in 2027 and lasting between ten and fifteen years, providing minimal lead-time for the industry to scale appropriately.

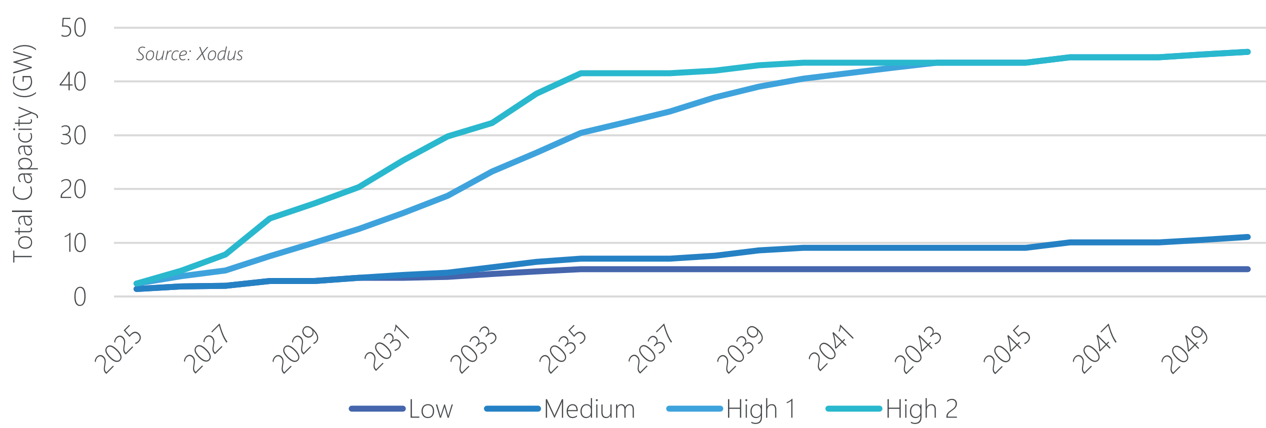


Figure 7-18 - Total Onshore Wind Capacity Over Time in the Low, Medium, High 1, And High 2 Scenarios

Low Scenario: Domestic demand drives onshore wind development in this scenario, with stated procurement targets of provincial utilities being included in addition to planned projects (see Figure 7-19). Capacity grows steadily until 2035, at which time the added capacity is assumed to satisfy domestic demand across all provinces in conjunction with other power generation sources. It is possible that transmission upgrades and increased electricity demand may drive additional onshore wind build out.

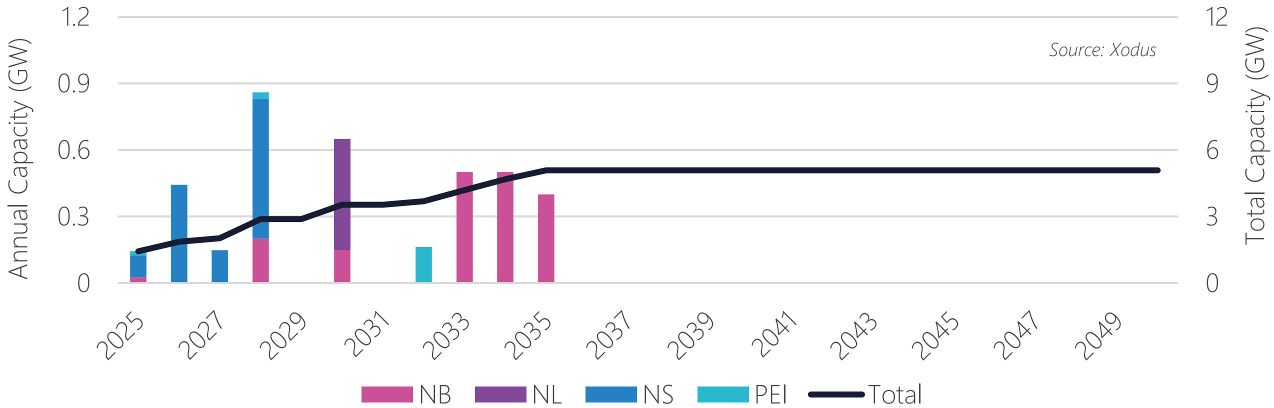


Figure 7-19 - Annual and Total Onshore Wind Capacity Over Time in the Low Scenario

Medium Scenario: Electricity export markets drive onshore wind development beyond 2035 into 2050 (see Figure 7-20). Additional capacity is added in all four provinces, although the pace of development slows between 2035 and 2050.

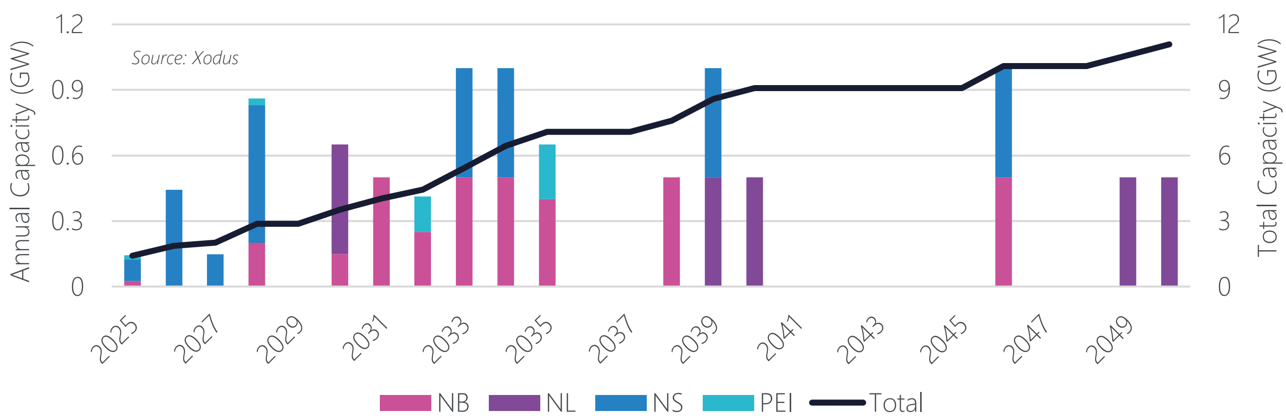


Figure 7-20 - Annual and Total Offshore Wind Capacity Over Time for Medium Scenario

High Scenarios: Onshore wind development in both High scenarios rapidly outpace that of the low and medium scenarios (Figure 7-21 and Figure 7-22). The High 1 scenario sees a slower pace of development, with a peak of just over 4 GW installed in a single year across all provinces, whereas the High 2 scenario sees a peak of over 6 GW of capacity installed in a single year. While both scenarios assume over 45 GW of onshore wind are installed by 2050, most of the capacity buildout in the High 1 scenario takes place over a period of twenty years, whereas this capacity is installed in a period of just ten years in the High 2 scenario. Note that Figure 7-21 and Figure 7-22 have greater x-axis limits than Figure 7-19 and Figure 7-20 due to the large amount of capacity developed in the High scenarios.

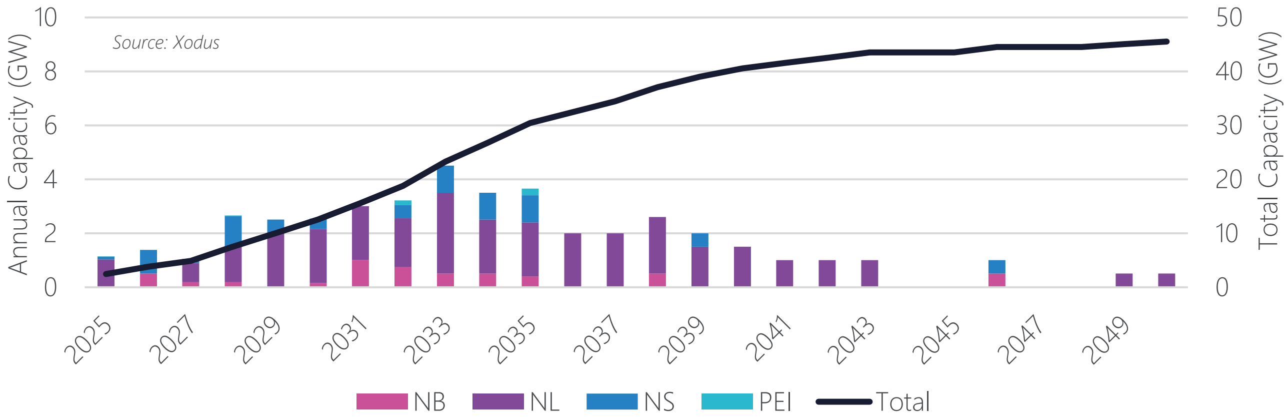


Figure 7-21 - Annual and Total Onshore Wind Capacity Over Time for High 1 Scenario

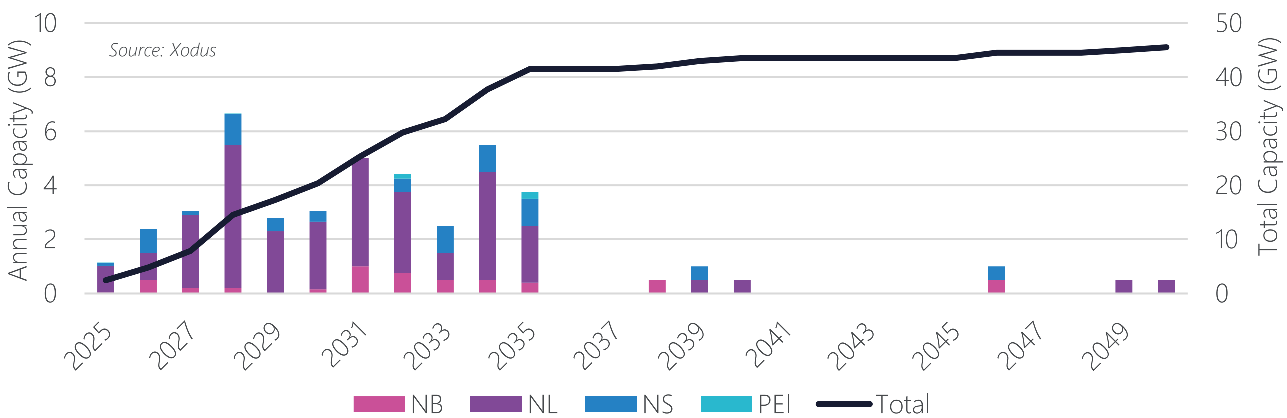


Figure 7-22 - Annual and Total Onshore Wind Capacity Over Time for High 2 Scenario

7.2.2 Major Component Demand

Methodology

Demand for WTGs was assessed for the four development scenarios. These are considered in demand in the year in which they are procured for a given project, which is the year prior to their installation. All turbines are assumed to have a rated capacity of 6 MW and include a foundation, tower, a nacelle, and three blades. Individual projects are assumed to have a limit of up to 500 MW installed per year, such that an 800 MW project would be installed in 2 years, for example. However, it was necessary in the High 1 and High 2 scenarios to adjust this limit to a maximum of 1 GW installed per year per project for NL's green hydrogen onshore wind projects to accurately represent proposed CODs. Note that this demand assessment does not consider global component availability.

Results

Low, Medium Scenarios: Demand for turbines varies significantly across the four scenarios. In the Low and Medium scenarios, no more than two hundred turbines are in demand in any given year (Figure 7-23 and Figure 7-24). This demand is unlikely to strain the supply chain for onshore turbines or transmission equipment. In the Medium scenario demand for components is increasing in consistency, and the case could potentially be made to justify an investment in local manufacturing.

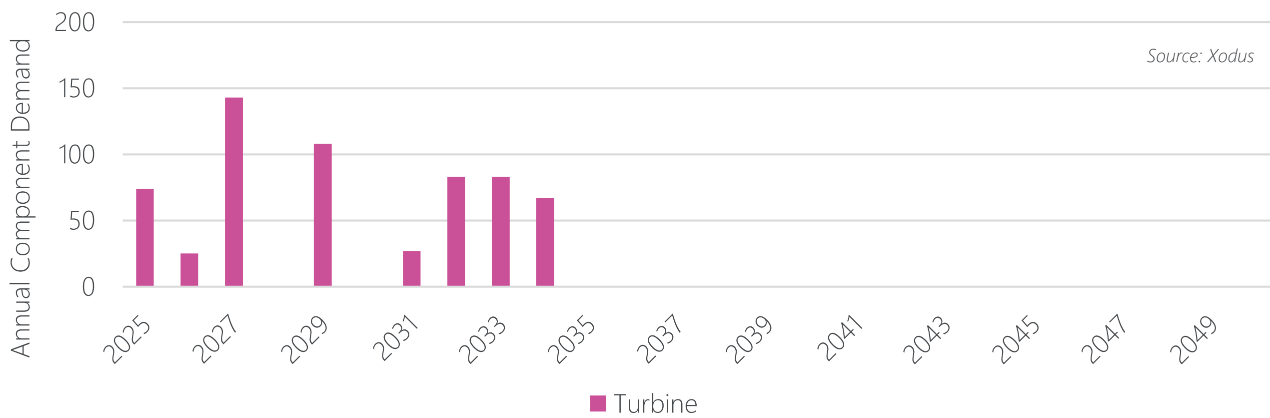


Figure 7-23 - Annual Component Demand Over Time in the Low Scenario

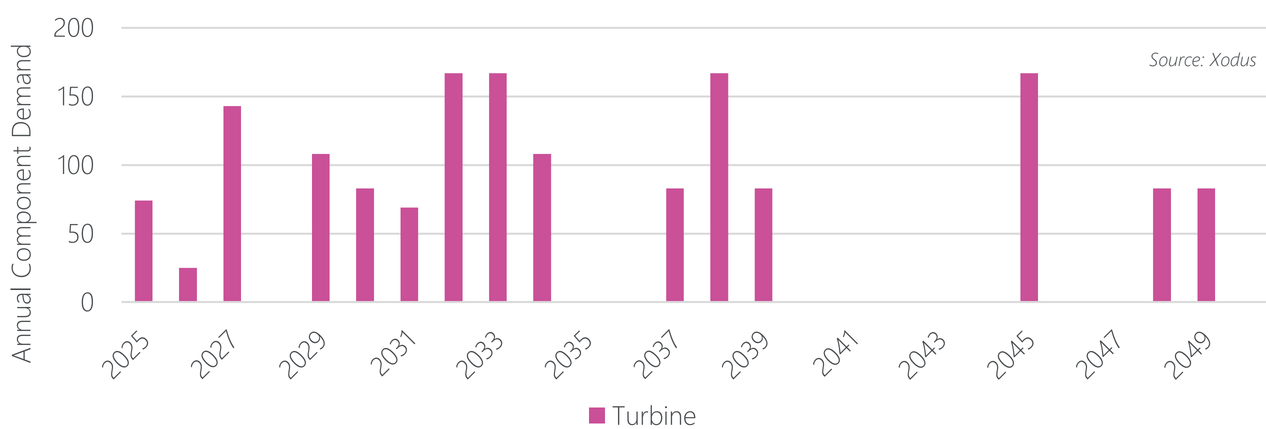


Figure 7-24 - Annual Component Demand Over Time in the Medium Scenario

High Scenarios: In contrast, the High 1 and High 2 scenarios see peak demand of 700 and 1,100 turbines in a single year, respectively (Figure 7-25 and Figure 7-26). Such high demand will almost certainly be impacted by global and local strain on supply chains and workforce, and has the potential to cause significant project delays, possibly even preventing the full realization of either scenario. It is likely that proportionally high demand for high-voltage substation equipment, like transformers and transmission cables, will cause further strain on the global supply chain and diminish projects' ability to connect with the grid, thereby further delaying project CODs. There will need to be a substantial workforce development push to achieve these capacities even with mitigating factors, like accounting for long lead times. Note that Figure 7-25 and Figure 7-26 have a greater y-axis limits than Figure 7-23 and Figure 7-24 due to the large volume of turbines demanded in the High scenarios.

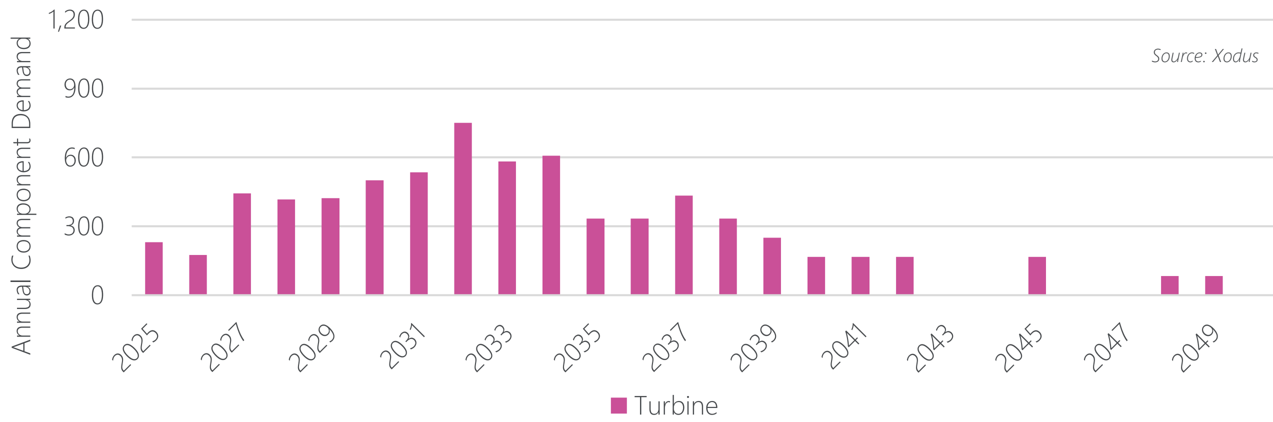


Figure 7-25 - Annual Component Demand Over Time in the High 1 Scenario

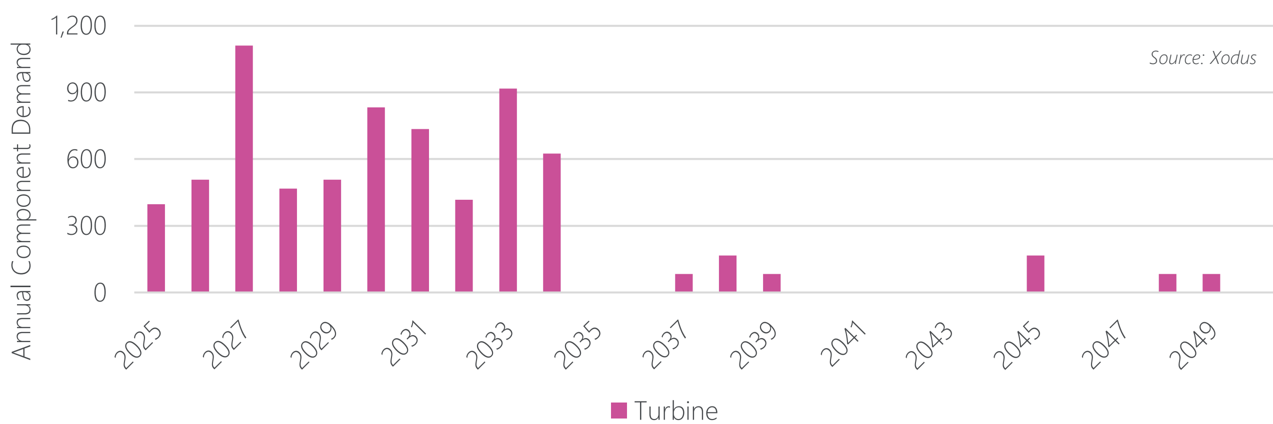


Figure 7-26 - Annual Component Demand Over Time in the High 2 Scenario

Observations

Component demands in the High 1 and High 2 scenarios have the potential to suffer from supply chain bottlenecks given WTG demand consistently exceeds 500 units per year. While this has the potential to result in impacts to project timelines, it's possible that the region could consider attracting investment in manufacturing to both de-risk project timelines, and capture the higher revenue CAPEX portion of the industry.

7.2.3 Workforce Demand

Methodology

Workforce demand for the onshore wind sector in Atlantic Canada was assessed with the methodology outlined in Section 4.3. An in-house onshore wind workforce tool was developed to estimate cumulative workforce demand across all projects in every year of the four scenarios, with workforce demand evaluated five years before COD until decommissioning for each project.

Figure 7-27 provides a simplified timeline of workforce activity for an onshore wind project up to 500 MW in capacity, with specific job roles and numbers associated with each supply element. Workers in each supply element are considered in-demand in a given year when the workforce is anticipated to be utilized for a project in that year. Every project is assigned a unique development timeline based on its planned capacity and COD (Year 0) for all four scenarios, allowing the cumulative workforce demand to be summed across each year. Note that this demand assessment does not consider workforce availability.

		Years										
Supply Area	Supply Element	-5	-4	-3	-2	-1	0	1	2	3	4	5
Project Development	Development and Permitting											
	Surveying											
	Engineering and Design											
	Project Management											
Wind Turbine Supply	Nacelle											
	Rotor											
	Tower											
Balance of Plant Supply	Foundation Components											
	Onshore Substation											
	Onshore Cables											
Installation and Commissioning	Site Preparation											
	Foundation Construction											
	Turbine Installation											
	Electrical Commissioning											
	Transportation Logistics											
Operations and Maintenance	Operations Base											
	Corrective Maintenance											

Figure 7-27 - Simplified Workforce Timeline for an Onshore Wind Project

Results

Low Scenario: Most of the workforce demand occurs in the coming decade (Figure 7-28 and Figure 7-29). There may be relatively fewer long-term job opportunities for STEM professionals, since the project development phase of most projects will end in the early 2030s. A workforce of over 6,000 manufacturing trade workers will be required to manufacture turbines and transmission components over the next ten years, however it is assumed that these jobs will be located elsewhere as components will most likely be imported in a Low scenario. Once projects are installed by 2035, only the O&M workforce—largely consisting of building trade workers with some STEM professionals and support staff—will be retained by developers through project decommissioning.

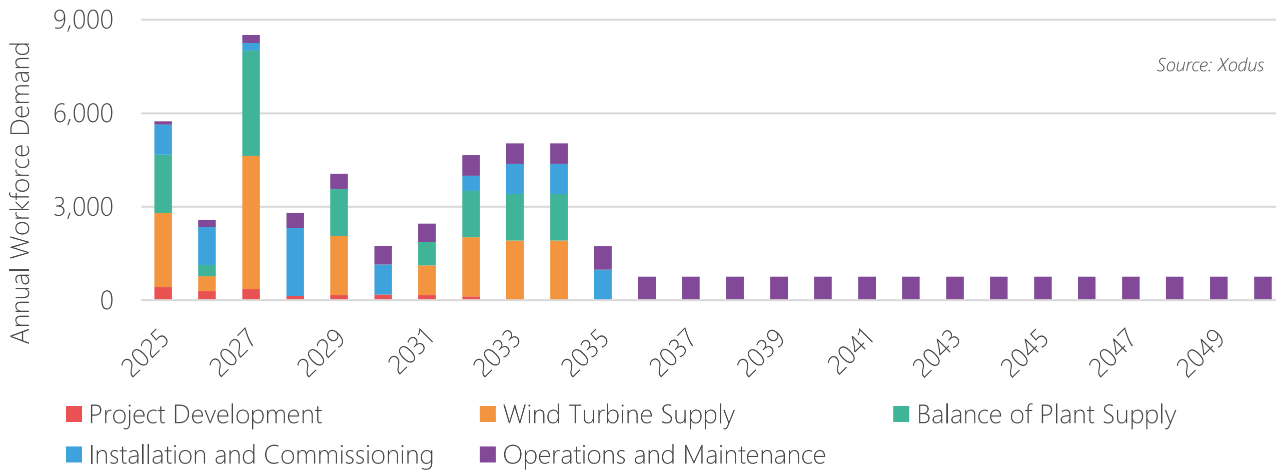


Figure 7-28 - Annual Workforce Demand Over Time by Project Phase in the Low Scenario

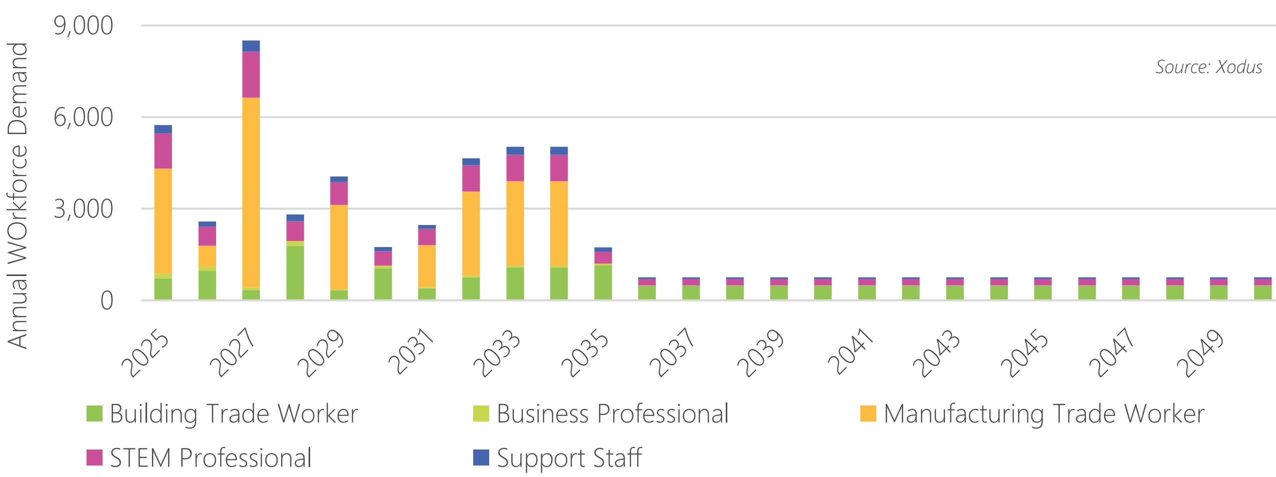


Figure 7-29 - Annual Workforce Demand by Job Role Over Time in the Low Scenario

Medium Scenario: Here, a trend of high workforce demand is still observable in the next decade, in addition to disparate peaks in manufacturing and installation workforce demand until 2050 (Figure 7-30 and Figure 7-31). The larger and somewhat more even pipeline provides greater job opportunities across all project phases as well as more consistent demand trends over time. There will need to be up to 5,000 manufacturing trade workers to support the component buildout, however manufacturing operations would need to be localized to Atlantic Canada to fill these roles regionally. Even without manufacturing, the long-term demand will provide local job opportunities for business and STEM professionals, building trade workers, and support staff through the Project Development, CTI&C, and O&M phases of the anticipated projects.

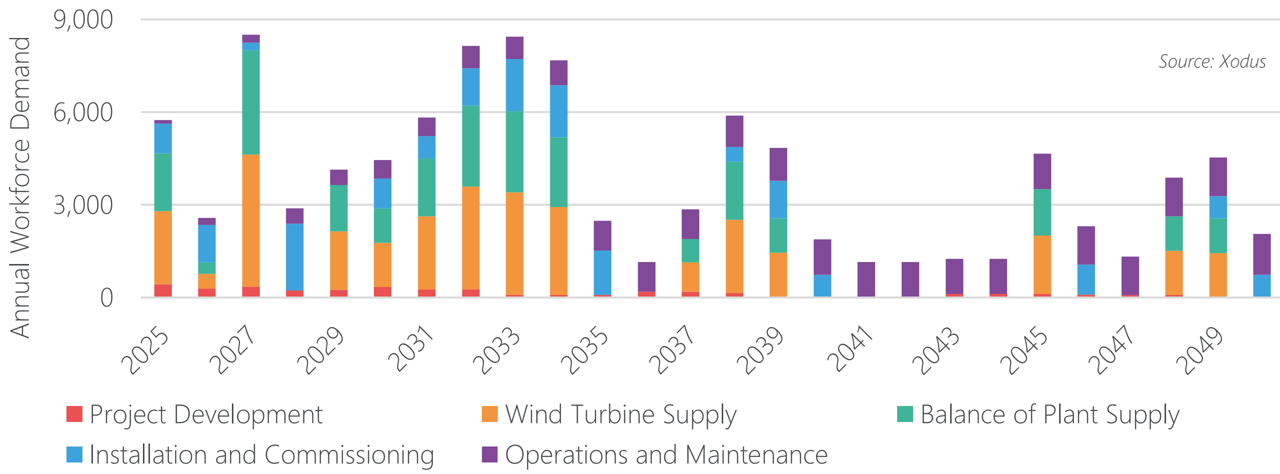


Figure 7-30 - Annual Workforce Demand Over Time by Project Phase in the Medium Scenario

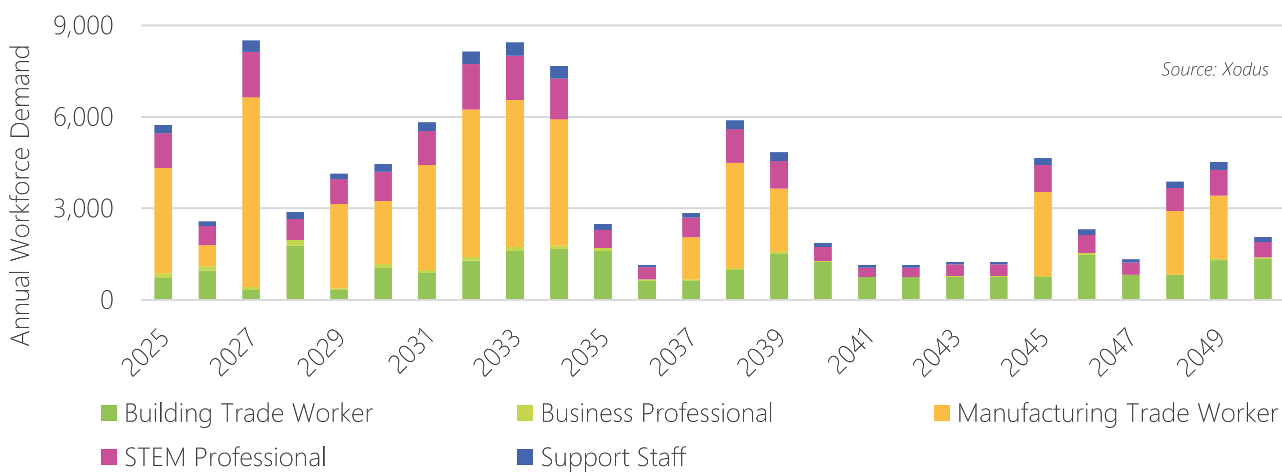


Figure 7-31 - Annual Workforce Demand Over Time by Job Role in the Medium Scenario

High Scenarios: Peak workforce demand in both High scenarios is projected to be three- to four-fold greater than that of the Low and Medium scenarios (see Figure 7-32, Figure 7-33, Figure 7-34 and Figure 7-35). Up to 14,000 and 22,000 manufacturing trade workers are required to supply the necessary onshore turbine and transmission equipment in the High 1 and High 2 scenarios, respectively. Beyond manufacturing, the CTI&C workforce reaches peaks of 5,000 building trade workers, STEM professionals, and support staff in both scenarios. Likewise, Project Development and O&M workforce reach peaks of 1,000 and 3,000, respectively. Note that Figure 7-32, Figure 7-33, Figure 7-34 and Figure 7-35 have greater x-axis scales than Figure 7-28, Figure 7-29, Figure 7-30, and Figure 7-31 due to the large number of workers demanded in the High scenarios.

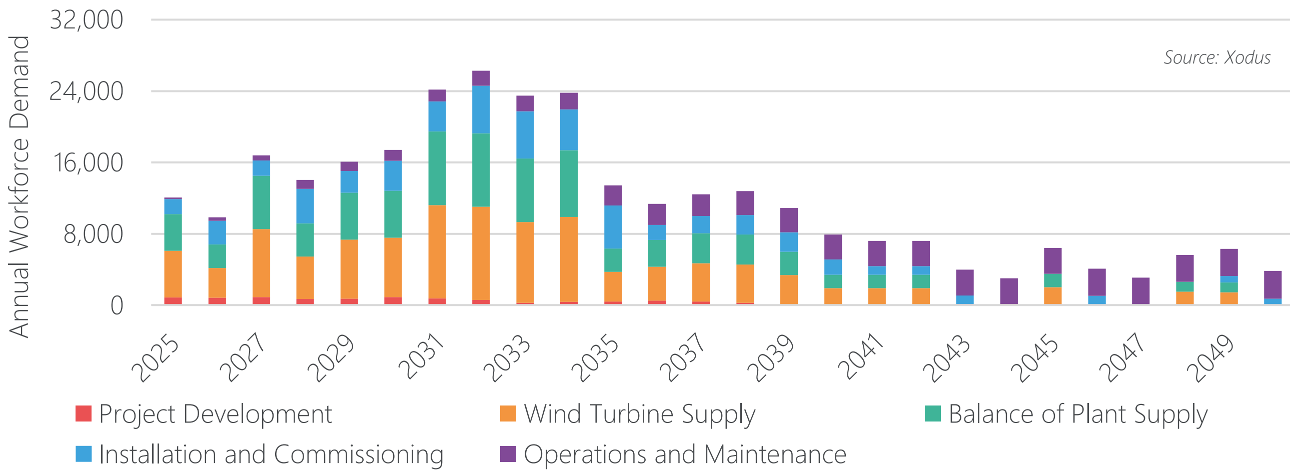


Figure 7-32 - Annual Workforce Demand Over Time by Project Phase in the High 1 Scenario

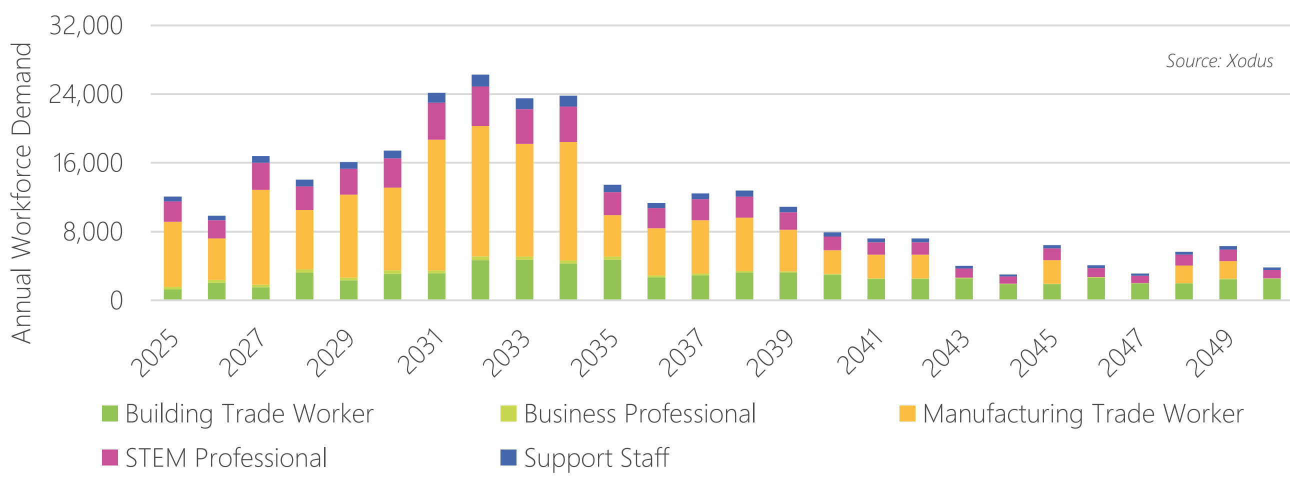


Figure 7-33 - Annual Workforce Demand Over Time by Job Role in the High 1 Scenario

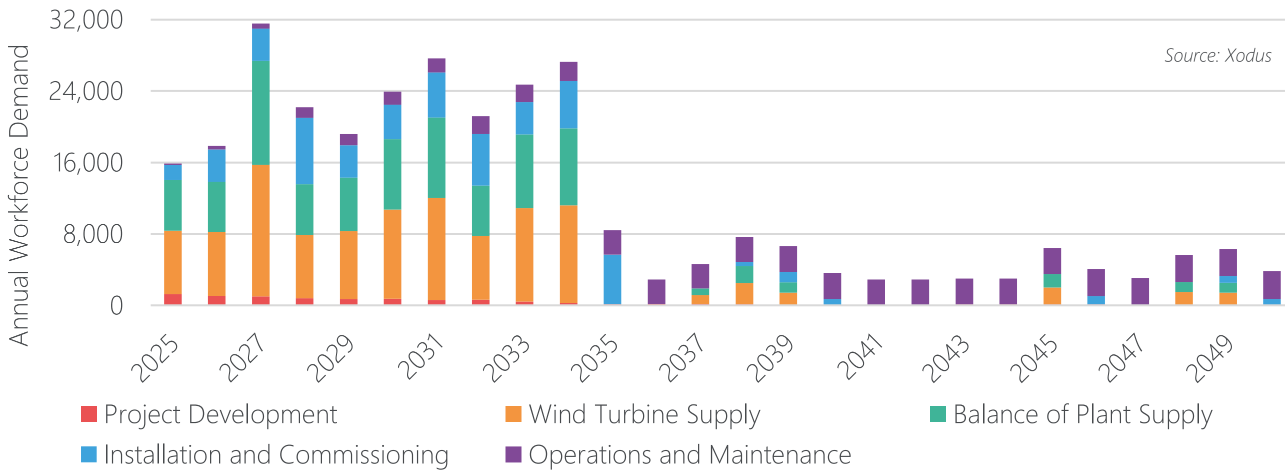


Figure 7-34 - Annual Workforce Demand Over Time by Project Phase in the High 2 Scenario

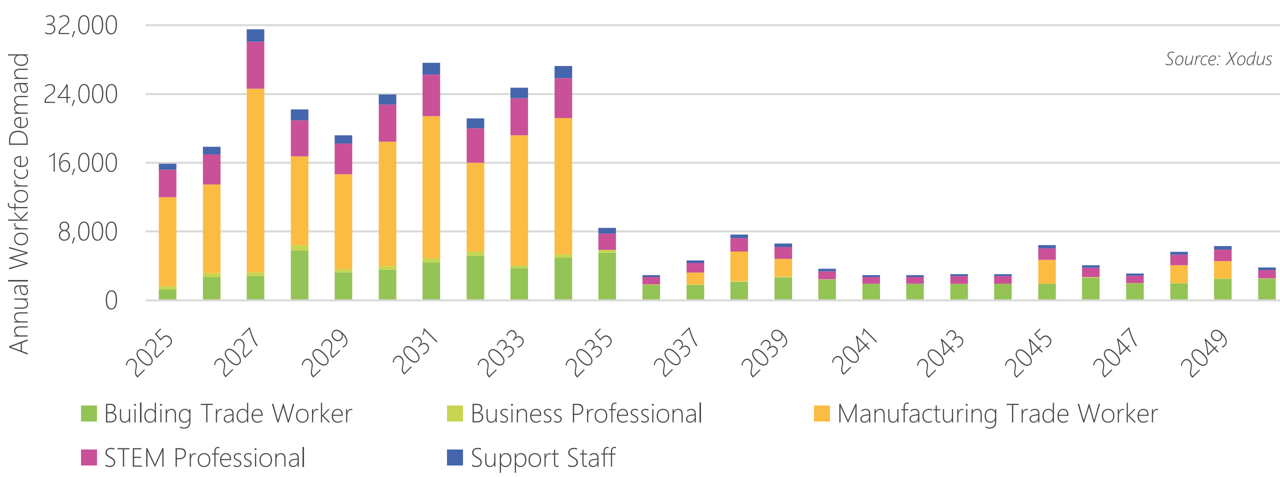


Figure 7-35 - Annual Workforce Demand Over Time by Job Role in the High 2 Scenario

Observations

The consistent, long-term capacity demand of the High 1 scenario is likely to provide more stable workforce requirements than the High 2 scenario, driving more consistent demand for easy-to-localize roles in the Project Development, CTI&C, and O&M phases. Consistent demand for capacity also sends a positive, stable market signal to developers, OEMs, and Tier 1 suppliers, which may encourage investment in the local supply chain, including in new manufacturing facilities, bringing the opportunity to localize even more jobs. However, it should be noted that the sheer quantity of workforce demand in both high scenarios will significantly strain the workforce supply in Atlantic Canada, particularly for stable, well-paying jobs like those in the project development and operations phases.

8 SUPPLY CHAIN ASSESSMENT

8.1 Methodology

8.1.1 Supply Chain Assessment Methodology

The goal of this exercise was to establish an understanding of the strengths and gaps that exist in Atlantic Canada, providing proponents with an informed idea of suitable supply chain activity and where it would take place, and identifying opportunities where outside investment/partnerships could stimulate supply chain growth. Data on Atlantic Canadian companies was collected from the following sources:

- Atlantica Centre for Energy (ACE)
- Canadian Renewable Energy Association
- Canadian Manufacturers and Exporters (CME-NL)
- Construction Association of NB
- Construction Association of NS
- Construction Association of PEI
- Black Business Initiative Directory
- Centre for Women in Business Directory
- B Corp Directory
- Centre for Ocean Ventures & Entrepreneurship (COVE)
- econext
- Energy NL
- EverWind
- Joint Economic Development Initiative (JEDI)
- MRC Supply Chain Database
- New Brunswick Business Council
- NL Construction Association
- Newfoundland and Labrador Organization of Women Entrepreneurs (NLOWE)
- Nunatsiavut Group of Companies Online Directory
- Innu Nation Business Directory Business Directory
- Stakeholder Outreach

The desk-based portion of the supply chain assessment focused on analyzing existing companies in Atlantic Canada for their ability to support offshore and onshore wind supply chains. This consisted of categorizing a list of companies according to the respective wind energy taxonomy, and then individually assessing relevant companies to determine to what degree they would be able participate.

The assessment was carried out using publicly available data about the company, including websites, press releases, news articles, etc. To begin, companies with no relevancy to the offshore or onshore wind supply chain were screened out. Remaining companies were mapped to the supply chain elements provided in Table 4-2 as appropriate, meaning companies were often mapped to multiple elements at once. This was done by looking at the stated capabilities of the companies on their websites, reviewing their past projects, assessing the companies' size and reach, and using the project team's expertise in wind energy supply chains to make judgments on the company's potential to support wind industries. Where companies have multiple locations in Atlantic Canada, they have all been included separately to better ascertain regional capabilities. Companies that have only satellite offices in Atlantic Canada were assessed for their global capabilities, assuming they would be able to leverage the wider offerings of the business.

All companies were assessed for high, moderate, or low applicability according to the supply elements they are mapped to, as follows:

- **Higher applicability:** Company has direct experience in offshore/onshore wind or provides products/services that are highly relevant to offshore/onshore wind in design, scale and production volume; investment required to transition company into offshore/onshore wind is minimal, and/or would be directly applied to scaling/qualification operations;
- **Moderate applicability:** Company has no direct experience in offshore/onshore wind but provides products/services that are like those relevant to offshore/onshore wind in design and scale; investment required is moderate and would be needed to help company retool, meet standards/qualifications, and scale operations;
- **Lower applicability:** Company provides products/services that resemble those needed in offshore/onshore wind but would need to significantly change operations to enter the industry; significant investment in retooling, meeting specifications/qualifications, and scaling would be required.

A total of approximately 1,070 companies were assessed to have some level of applicability in OSW, onshore wind, or both. These outputs were used to generate a bar graph showing the distribution of strengths and gaps with applicability displayed visually, as shown in Figure 8-1 and Figure 8-9 for OSW and onshore wind, respectively. A summary of observed strengths and gaps is presented along with the graphical results to contextualize the results. Here, the experience of the project team is applied in tandem with the results and outcomes of stakeholder engagement activities.

8.1.2 Red-Amber-Green Assessment

A red-amber-green (RAG) assessment was carried out based on criteria determined to be relevant to supply chain development in the Atlantic Canadian wind energy context. The opportunity for the Atlantic Canada supply chain to benefit from the growth of the offshore and onshore wind industries depends on a range of factors, including which major supply element within a project is being procured, the capability of Atlantic Canadian companies against the established US and global supply chain, the dynamics of project capacity pipeline and procurement, and the investment landscape for local and international businesses. The outputs of the supply chain capability assessment were analyzed to identify areas where Atlantic Canadian companies are well positioned to support or quickly adapt to the needs of the offshore and/or onshore wind industries. The opportunity analysis was carried out using a consistent set of criteria applied to each supply chain element that describes some of the influencing forces facing supplier procurement and investment decisions. These criteria were:

- **Strength of existing capabilities:** Considers the ability of Atlantic Canada to provide support for activities under the given supply chain area, when assessed out to a Tier 3 level of supply.
- **Demand case**: Considers the demand for products/services given available domestic supply, competitor environment, incentive implications, etc.
- **Investment case:** Considers the level of investment and market confidence needed to transition supply chain and infrastructure capabilities.

- **Opportunity for export supply:** Considers the potential benefits for Atlantic Canada to supply projects by considering logistics, and the level of existing or planned competition to supply the product/service.
- **Potential for partnerships/collaboration:** Considers the degree to which partnership formation and collaboration could impact supply chain development in Atlantic Canada, as well as the ability of the region to attract external partners and collaboration opportunities.

A scoring system was applied to each criterion as described in Table 8-1.

CRITERIA	SCORE 1	SCORE 2	SCORE 3	SCORE 4
Strength of existing capabilities	No known local companies with relevant experience in offshore/onshore wind or an adjacent industry when assessed to Tier 3 level.	Local companies with some relevant experience but are unlikely to offer a competitive solution when assessed to Tier 3 level, even with change in strategy and/or additional investment.	Local companies with some relevant experience will need significant change in strategy and/or additional investment to offer a competitive solution when assessed to Tier 3 level.	Local companies with relevant experience are likely to provide a competitive solution with minimal change in strategy or additional investment when assessed to Tier 3 level.
Demand case	Demand for components/services is easily met by existing global supply chain.	Demand for components/services is met by global supply chain, but there is preference for local supply.	Demand for components/services is sufficient but strained, and sensitive to global supply chain disruptions.	Demand for components/services not currently met by domestic or global supply chain, resulting in project delivery concerns.
Investment case	Investment required to supply is significant enough to need public support and requires long-term confidence in offshore/onshore wind market.	Investment required to enable supply triggered by long-term confidence in offshore/onshore wind market.	Investment required to enable supply can be triggered by single offshore/onshore wind contract.	Little or no further investment needed to enable supply.
Opportunity for export supply	Clear logistics benefits to local supply and/or established competing global supply harms export opportunity.	Some logistics benefit to local supply or established competing global supply limits export opportunity.	No particular logistics benefit to local supply or lack of established competing global supply means non-local suppliers are not disadvantaged.	No particular logistics benefit to local supply and lack of established competing supply means non-local suppliers will be required to export.
Potential for partnerships/ collaboration	Difficult or impossible to attract potential partners/collaboration opportunities to the region.	Some opportunity for partnership/collaboration opportunities exists but significant attraction and educational efforts are necessary to form connections.	Opportunity for partnership/collaboration opportunities exists but efforts to form connections with local businesses must be fostered.	Potential partners/collaborators are actively seeking opportunities in Atlantic Canada. Existing local businesses are eager to form partnerships.

Table 8-1 - Scoring System for RAG Assessment

8.2 Offshore Wind - Results and Observations

In this section the results of the supply chain assessment, paired with insight from stakeholder and rightsholder engagement, are drawn upon to present observations by supply chain area, or package. Figure 8-1 shows the outcomes of the supply chain assessment of companies for OSW. A total of about 1,070 companies were assessed as having some applicability to OSW.

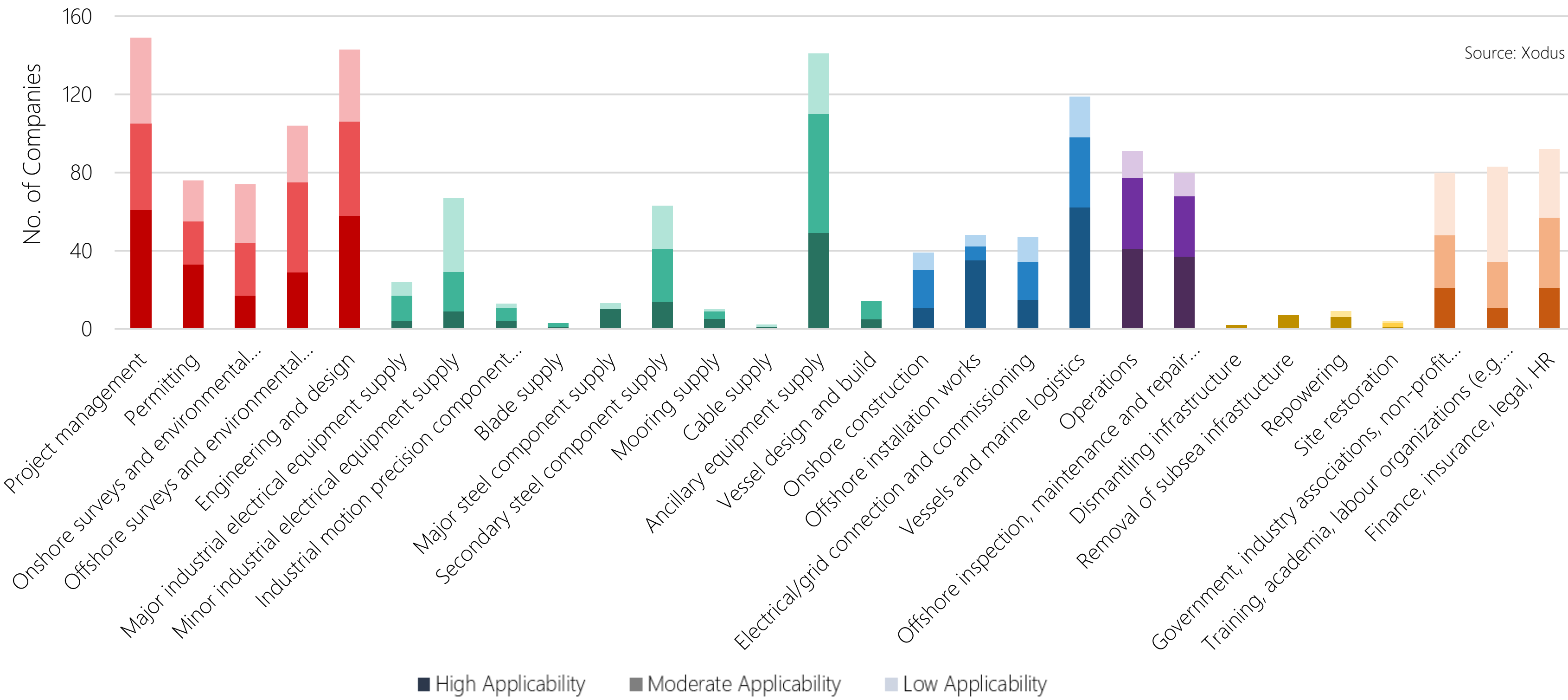


Figure 8-1 - Offshore Wind Supply Chain Assessment Results

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Project Development	4	2	4	3	4
Manufacturing and Component Supply (WTG & BOP)	3	4	1	4	2
Construction, Transportation Installation and Commissioning (CTI&C)	4	3	3	2	3
Operations and Maintenance (O&M)	3	2	3	2	4
Decommissioning	2	2	2	2	3
Sector Support	3	3	4	1	3

Table 8-2 - Offshore Wind RAG Assessment Results

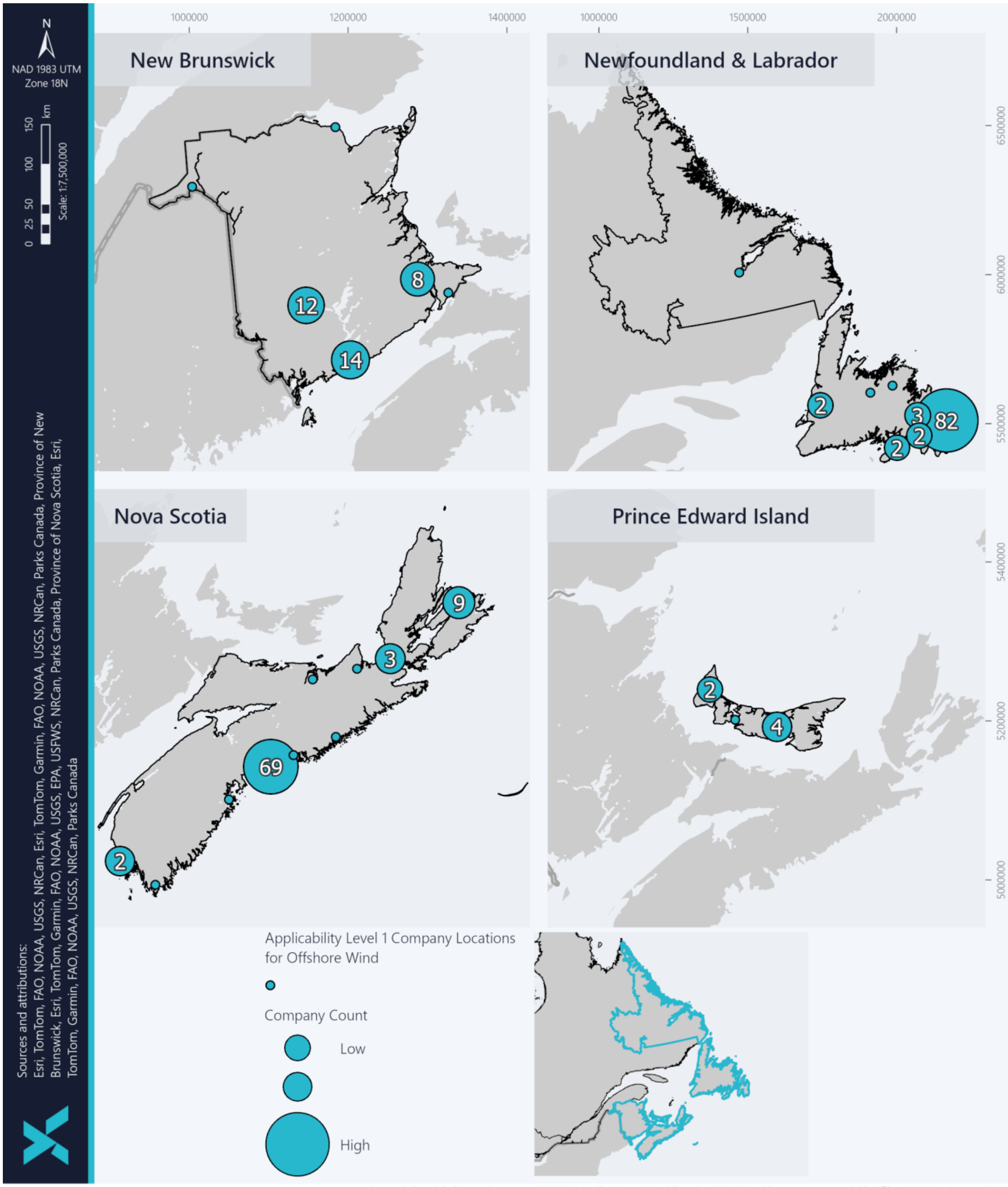


Figure 8-2 - Provincial Distribution of High Applicability Offshore Wind Supply Chain Companies

8.2.1 Results by Province

Breaking out the results of the OSW supply chain analysis of companies by province yields the distribution shown in Figure 8-2 (high applicability companies, only). It is observed that many of the larger, high-applicability companies have offices in most or all Atlantic Provinces, particularly the higher-applicability companies with direct OSW experience or experience in adjacent industry.

Companies are mostly concentrated around major cities: Halifax and Dartmouth in NS; St. John's and Mount Pearl in NL; Saint John, Fredericton and Moncton in NB; and across Charlottetown and Summerside in PEI. Most companies are coastal, owing to the substantial coastlines possessed by each province, and their reliance on marine commerce. Overall, approximately 21%-28% of companies assessed were assigned high-applicability.

Nova Scotia

Of the companies assessed for OSW in NS, 92 were assigned high-applicability (~24%). Overall, NS has a very similar distribution of strengths as NL, with Halifax also having a significant concentration of companies. Unlike St. John's, Halifax has ready access to the future development areas proposed in the NS RA (see Figure 5-8). NS also has a concentration of high applicability companies in Cape Breton and along the Strait of Canso, primarily related to vessels, marine logistics, and operations. This positive trait in terms of geographical distribution, should allow NS to effectively support projects across the proposed future development areas.

NS has a small margin of Manufacturing and Component Supply companies over Project Development companies. Most companies in this category are distributors of minor industrial electrical and ancillary equipment (e.g. construction equipment, coatings, welding supplies, scaffolding, control systems, etc.), however there are also some raw material providers (e.g. steel plate) and steel fabricators that have the potential to scale.

Newfoundland and Labrador

In NL, 96 companies were assigned high-applicability (~21%) for OSW. Its primary strengths are in Project Development, particularly project management, engineering, and design, Manufacturing & Component Supply, as well as Construction, Transportation, Installation & Commissioning, specifically for projects involving vessels and marine logistics. NL also ranks highly in Operations & Maintenance, with additional competencies in ancillary equipment supply, secondary steel component supply, and onshore construction.

In NL, there is a major concentration of companies around St. John's that is more pronounced than in other Atlantic provinces, where companies are more evenly distributed. Many of these companies support offshore O&G activity on the Grand Banks, roughly 350 km East of St. John's.

The Grand Banks and eastern coast of NL were omitted from consideration for OSW in the NL RA (see Figure). As a result of the NL RA, sections of the ice-free southern and western coasts of Newfoundland were prioritized for OSW. This location discrepancy between companies located in St. John's, versus NL's prioritized OSW lease areas could limit operational and support efficiencies; however, given the long distances components and vessels tend to travel in OSW, these distances are unlikely to impact any major operational decisions.

New Brunswick

Of the companies assessed for OSW in NB, 37 were assigned high-applicability (~28%) representing a greater proportion of total companies than NL and NS. Again, strengths in Project Development can be observed, with the greatest number of companies being in the ancillary equipment supply category.

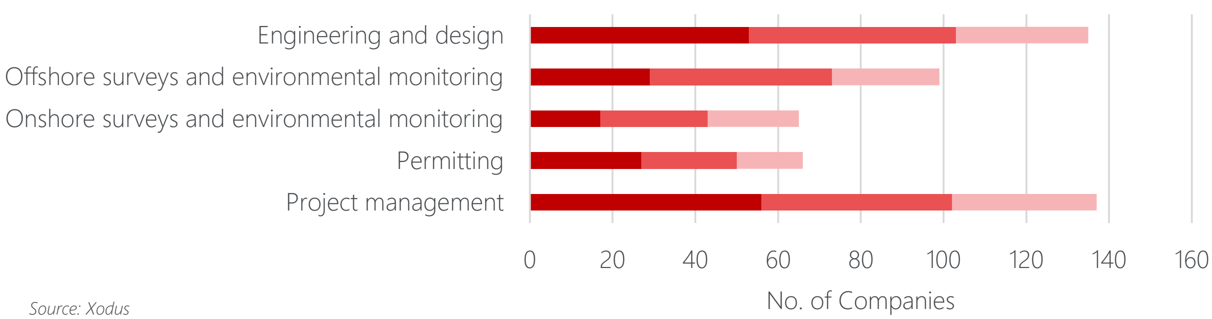
NB has a broader geographic distribution of companies compared to NS and NL but has not undertaken a regional assessment or determined where it could develop OSW given it has not expressed OSW development aspirations, to date.

Prince Edward Island

Of the companies assessed for OSW in PEI, 7 were assigned high applicability (~21%). PEI has not expressed any aspirations to build OSW and, despite the presence of some observable strengths in OSW in Project Development companies as well as ancillary equipment supply. The province does offer experience in onshore wind and it offers Atlantic Canada's first wind turbine technician training program.

8.2.2 Project Development

The results of the supply chain assessment for existing Project Development companies are provided in Figure 8-3. Project Development is the strongest supply area for OSW in Atlantic Canada. Primary strengths are in project management activities, and engineering and design. Given the strong marine industrial capacity of the region, and particularly, the prominence of offshore O&G operations, this is an expected outcome.



Source: Xodus

Figure 8-3 – Project Development - Supply Chain Assessment Results, Offshore Wind

The results of the RAG assessment for Project Development are given in Table 8-3 and are described below.

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Project Development	4	2	4	3	4

Table 8-3 – Project Development RAG Assessment Results, Offshore Wind

Strength of Existing Capabilities

There are significant existing capabilities in this supply area. Approximately 40 independent companies were identified as high applicability in both project management, and engineering and design, with just under half of noted locations found NL, and the remainder primarily split between NS and NB. These companies are primarily large, multi-national engineering consultancies, specialized project management companies, developers, and specialized service providers that have locations in Atlantic Canada to support regional O&G developments. While the lack of OSW development in Atlantic Canada means that local teams and suppliers will not have the full experience so far, the ability the leverage experience of sister offices in other OSW markets and the track record of working on the O&G sector justifies their scoring as highly applicable.

The prominence of offshore O&G also means that there are regional strengths with regards to permitting, as well as offshore surveys and environmental monitoring. Some of the world's leading subsea survey companies are present in Atlantic Canada, with several existing local companies poised to support this industry in this space as it develops. There are many local firms that could expand their services to meet the needs of the OSW industry with minimal investment, given the similarities of project development activities in offshore O&G and OSW.

Demand Case

While project development is a strength in Atlantic Canada, the demand case for these services is limited given the OSW industry is more developed outside of North America and thus competition exists amongst more experienced companies. Consulting services like engineering and design can be performed anywhere, therefore geographic proximity does not alleviate competitive pressures. Services like project management, permitting and surveying often benefit from local knowledge so local companies can offer operational efficiencies given their familiarity with local geography, permitting requirements, stakeholder engagement, and overall environmental sensitivities. The current limitations in wider OSW targets beyond NS's 5GW make the long-term demand case difficult.

Investment Case

Project management, permitting, and engineering and design are not capital-intensive services. Survey activities may require specialized data collection equipment and vessel support, however compared to manufacturing or installation activities, the associated costs are low and there is a secondary use for wider offshore energy and O&G sectors. Given the existing regional strengths in project development, minimal investment is required to establish Atlantic Canadian as a supplier.

Opportunity for Export Supply

The OSW industry operates within a global supply chain, including the service-driven Project Development sector. While permitting and survey activities may often be preferred locally, and project management can benefit from proximity to the project site, many subcontracted services—such as engineering, design, and project administration—can be efficiently conducted remotely. Atlantic Canada has the potential to leverage its strengths in this area and export these services globally, provided a strong local track record is established. Although competition in this sector is intense, the region's existing expertise in the adjacent offshore O&G industry presents a valuable opportunity for local companies to transition and compete effectively.

Potential for Partnerships/Collaboration

Many strengths that exist in Atlantic Canada in the Project Development sector are a result of partnerships and collaborations resulting from O&G development activities that attracted multi-national companies to the region. Companies that perform these services in OSW globally are already located in Atlantic Canada, facilitating partnership formation with local firms that may lack track record in OSW or need to scale to meet industry requirements. Companies that are familiar with offshore O&G will benefit from experience designing projects for harsh weather conditions and strict safety standards, which will be attractive to more experienced OSW companies that wish to establish local development offices in Atlantic Canada.

8.2.3 Manufacturing and Component Supply

The supply chain assessment of existing Manufacturing and Component Supply companies is illustrated in Figure 8-4. The strongest supply areas in this category include ancillary equipment, secondary steel components, and both minor and major industrial electrical equipment. These strengths are typical in regions with established industrial operations, Where many assessed companies have experience in offshore O&G, hydropower developments, mining, and processing/refining. This existing expertise provides a solid foundation for further growth in the OSW sector.

While Atlantic Canada does not currently have strong capabilities in major component manufacturing—such as cable, mooring, or blade production—the region has a robust base of secondary steel fabrication companies. Many of these firms could scale up to manufacture monopile or jacket structures with the right investment. Additionally, the presence of iron ore and nickel mines in the region presents an opportunity to integrate local raw materials into the OSW supply chain, particularly for major steel-based components.

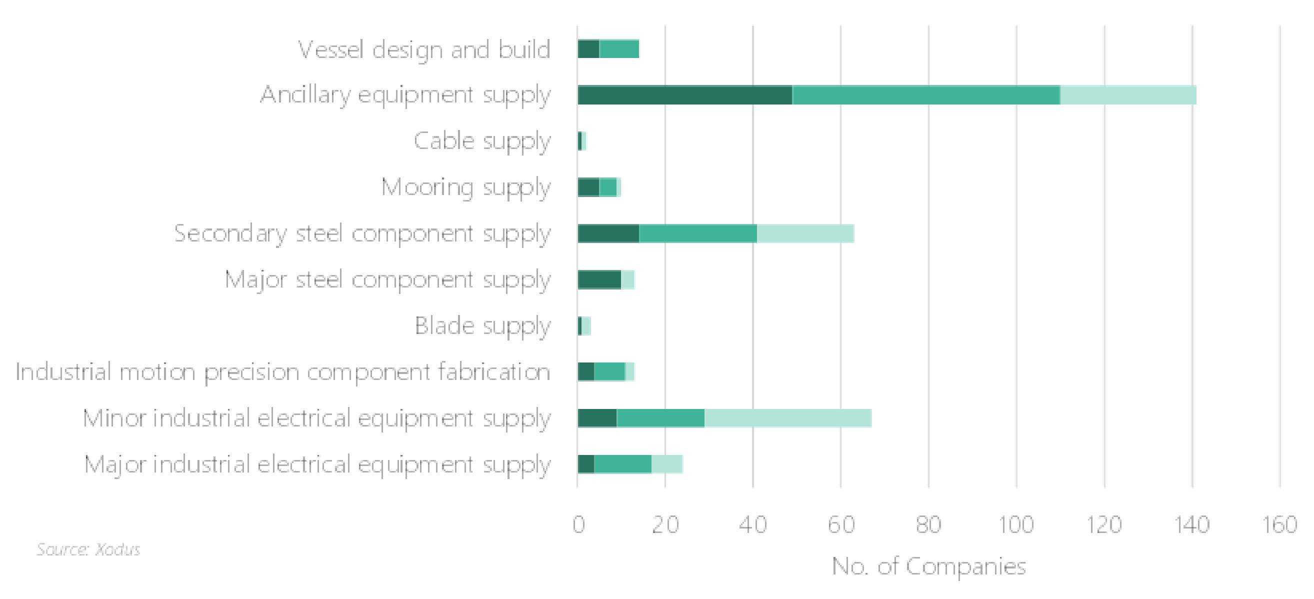


Figure 8-4 - Manufacturing and Component Supply - Supply Chain Assessment Results, Offshore Wind

The results of the RAG assessment for Manufacturing and Component Supply are given in Table 8-4 and are described below.

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Manufacturing and Component Supply (WTG & BOP)	3	4	1	4	2

Table 8-4 - Manufacturing and Component Supply - RAG Assessment Results, Offshore Wind

Strength of Existing Capabilities

This is a very broad category, comprising around 40% of fixed and 70% of floating OSW total project costs. It looks at manufacturing of both major components of the WTG and BOP, but also supply of subcomponents, component parts, raw materials, ancillary equipment and enabling services (e.g. welding, inspection, etc.). Atlantic Canada does not currently manufacture components for the OSW industry, however there are substantial steel and secondary steel component fabrication capabilities in Atlantic Canada. Local companies exist that are capable of fabricating large steel components.

Atlantic Canada is home to companies capable of supplying major industrial electrical equipment, along with several locally owned businesses specializing in custom monitoring and control systems for industrial operations. The region also has expertise in fabricating large-scale gravity-based structures, demonstrated by the nearly completed West White Rose gravity base structure at the Port of Argentia. Additionally, several companies possess the capabilities to produce secondary steel components and precision-manufactured parts, though serial production capacity remains limited.

Demand Case

The demand for manufactured components in the OSW sector is strong. With a significant global pipeline of OSW projects expected in the future, existing supply chain capabilities are insufficient to meet demand, leading to supply bottlenecks and project delays. Major OSW components are routinely shipped worldwide, as transportation costs have minimal impact relative to the high capital costs of manufacturing. However, steel supply remains a critical constraint, particularly for raw materials and plates with the necessary thickness and quality standards for offshore environments.

While there is strong demand for WTGs and BOP components, cost pressures must be carefully managed. The market has a threshold for pricing, and if costs become too high, project delays are more likely than cost absorption. Increased costs would likely be passed on to utility customers, potentially limiting public support for OSW development. As the floating OSW industry grows there will be additional demand for mooring lines, chains and anchors. In order to establish any local manufacturing, there must be sufficient local demand, as well as global demand, to justify investments.

Investment Case

The investment costs for serial manufacturing operations are substantial, particularly for major OSW components that require large quayside facilities. However, establishing these operations could generate significant job creation and stimulate adjacent industries, further strengthening the regional economy. Given the high costs associated with setting up manufacturing facilities and securing raw materials for OSW components, long-term industry confidence is essential. Companies need assurance that they can recover their investments within a reasonable timeframe and will require financing to support operations. Without a well-defined project pipeline demonstrating sustained component demand and market visibility, securing financing will be challenging. In order to support the case for investment governments, industry and Indigenous partners would need to ensure support of local communities and their leaders. Failure to secure that support raises the risk of project delays and diminishes the investment case for manufacturing.

Opportunity for Export Supply

With substantial global demand and a rapidly expanding OSW industry, there is a strong opportunity for exporting major WTG and BOP components. As OSW development accelerates worldwide, the need for these key components continues to grow. While the U.S. had been actively pursuing investment in OSW manufacturing, recent policy shifts and industry setbacks—including the cancellation of at least one announced facility and challenges such as renegotiated or withdrawn offtake agreements—have created uncertainty in its domestic supply chain. In addition, the recent rise of tariffs on imported goods in the US has unsettled investment certainty for sales into that market.

Establishing major component manufacturing in Atlantic Canada would require significant upfront investment, but the region is strategically positioned with the necessary port infrastructure to support export supply. A comprehensive economic analysis would be needed to assess the feasibility and potential return on investment for OEMs and other manufacturers. However, developing local production capabilities could help alleviate supply chain bottlenecks and reduce lead times, making Atlantic Canada a competitive player in the global OSW market.

Potential for Partnerships/Collaboration

While Atlantic Canada offers significant opportunities for major fabrication, serial production remains critical for large-scale OSW component manufacturing. Existing companies specializing in ancillary equipment supply and secondary steel fabrication provide some local advantages but are unlikely to serve as strong candidates for mutually beneficial partnerships or joint ventures. However, companies with experience in large-scale fabrication, access to appropriately sized quayside facilities, and a commitment to growth may be well-positioned to attract partnerships by leveraging local content benefits. While the high costs of local production may present challenges to a standalone business case, strategic partnerships with local firms could enable companies to access tax incentives and other benefits, potentially making collaboration a viable and competitive option.

Local companies could collaborate with major manufacturers by providing essential assembly and commissioning services. They can support seafastening and transportation by supplying components such as grillages, lifting aids, and storage frames. Additionally, they can play a key role in pre-installation preparations, including integrating lighting and safety systems, as well as adding secondary steel components. These partnerships could enhance local supply chain participation while streamlining OSW project execution.

8.2.4 Construction, Transportation, Installation and Commissioning

The supply chain assessment for Construction, Transport, Installation & Commissioning (CTI&C) companies, shown in Figure 8-5, highlights a strong regional track record in OSW-related activities, despite a lower number of identified companies. Many assessed supply elements were rated as highly or moderately applicable, particularly in offshore installation, vessels, and marine logistics—a strength rooted in Atlantic Canada's long-standing marine industries, including offshore O&G, shipbuilding, and fisheries.

NL's active offshore O&G sector requires 24/7 vessel coordination, complex logistics, and specialized offshore support services such as ROVs, customs brokerage, helicopter services, and HSE inspections. The region's marine workforce is well-equipped for OSW installation, familiar with rotational work and experienced in heavy lifts, cable-laying, and trenching under strict offshore safety standards and regulations. With a highly skilled workforce and transferable capabilities, Atlantic Canada is well-positioned to play a key role in OSW project execution.

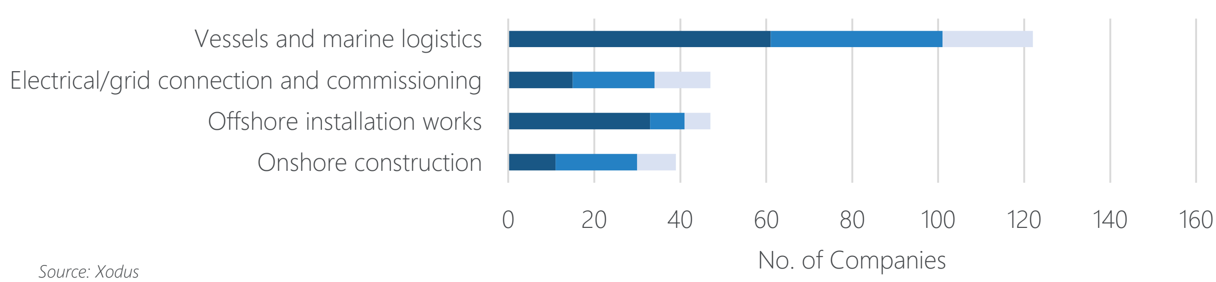


Figure 8-5 - Construction, Transportation, Installation and Commissioning - Supply Chain Assessment Results, Offshore Wind

The results of the RAG assessment for CTI&C are given in Table 8-5 and are described below.

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Construction, Transportation Installation and Commissioning (CTI&C)	4	3	3	2	3

Table 8-5 - Construction, Transportation, Installation and Commissioning - RAG Assessment Results, Offshore Wind

Strength of Existing Capabilities

Atlantic Canada has notable strengths in this supply chain area. While local companies and workers will need to familiarize themselves with OSW CTI&C standards and processes, they are well-positioned to compete at a Tier 2-3 level with minimal additional investment. Established firms already have a strong local and global presence in marine logistics and vessel services, along with direct OSW experience that can be leveraged within the region.

The region also boasts a highly skilled marine and quayside workforce, many of whom already hold the necessary certifications for offshore installation activities. While installing towers, nacelles, and blades presents a steeper learning curve compared to subsea structures, workers are already familiar with key offshore procedures such as toolbox talks and shift handovers, easing the transition to OSW. However, additional training—often specific to the turbine make and model—will be required for personnel to fully integrate into OSW installation and commissioning roles.

Demand Case

CTI&C services are typically required near OSW project sites, creating a natural local preference for these operations. There is strong demand for quayside and marine trades workers to handle, assemble, and transport components, as well as to perform installation and commissioning activities at sea. However, some regions developing OSW projects lack experience in marine industrial operations, face skilled labour shortages, or have a limited workforce to draw from. Similarly, a shortage of purpose-built installation and support vessels has already impacted project timelines, a challenge expected to worsen as the industry scales up.

As global OSW development accelerates, demand for CTI&C services and vessels will continue to grow, increasing pressure on supply chains. This presents an opportunity for mobile maritime trades workers to apply their skills internationally, much like they currently do in the global O&G and shipping industries. Additionally, expertise in offshore installation protocols and heavy lifts may become highly sought after in jurisdictions with less experience in large-scale marine operations.

Investment Case

Atlantic Canada has a strong supply chain in this area, with relatively low investment requirements compared to the CAPEX-intensive Manufacturing and Component Supply package. A single contract can trigger the necessary investment to enable supply in CTI&C. Ports such as Argentia (NL), Sheet Harbour (NS), Halifax Harbour (NS), Port of Sydney (NS) and the Atlantic Canada Bulk Terminal (NS) have already supported OSW storage and marshalling operations efforts in the US Northeast with minimal upgrades.

The main investment gaps are in turbine installation and commissioning. There is a shortage of wind turbine technicians, and electricians require specialized training for cable connection and commissioning. Additional training and on-the-job experience will be essential to ensure these roles can be filled locally.

While many existing ports meet OSW requirements, some upgrades will still be needed. However, costly interventions such as dredging, bridge raising, and quay reinforcement are unlikely, as existing conditions are largely sufficient. Again, a single contract could justify the necessary investment.

Opportunity for Export Supply

Most companies in the offshore CTI&C space operate globally, due to the nature of the work and the high CAPEX costs of vessels. Given the need to be near the installation site for most of the CTI&C work, and competition in global marine transportation, it is unlikely that the strengths in this supply area are going to yield significant local benefits through export. While the region is experienced in marine logistics, the major companies that manage this are multi-national, benefits would not necessarily flow to the region if successful in winning work abroad.

While port infrastructure must be local, vessels, personnel and know-how are exportable. There is an opportunity for Atlantic Canada's experienced workforce, particularly marine trades workers, wind turbine technicians, experienced electricians, etc. to travel to perform installation and commissioning scopes in other jurisdictions. This may or may not be desirable for the workers themselves depending on remuneration, which would likely be less than that provided for offshore work in the O&G sector, and time spent away from home.

Potential for Partnerships/Collaboration

There is significant opportunity for partnerships in CTI&C. While Atlantic Canada has strengths in this supply area, the region lacks an extensive track record—aside from ports involved in marshalling and storage of OSW components and some companies with experience in international projects. Given the growing OSW sector, foreign companies will likely seek local content for the buildout. Since major manufacturing facilities are unlikely to be established in the near term, CTI&C firms will be eager to partner with local businesses that offer regional expertise, offshore and quayside experience, and a skilled workforce.

8.2.5 Operations and Maintenance

The results of the supply chain assessment of existing O&M companies are provided in Figure 8-6. While only two primary supply elements were considered under O&M, both align with major strengths in Atlantic Canada. Operations require ongoing monitoring, communications, and both scheduled and unplanned maintenance. Additionally, major component repairs or replacements may be needed. In the case of floating OSW, this could involve towing entire turbines with their substructures back to installation ports. Several supply elements from CTI&C—such as robust vessels and marine logistics—are also critical to O&M but are not assessed in this section.

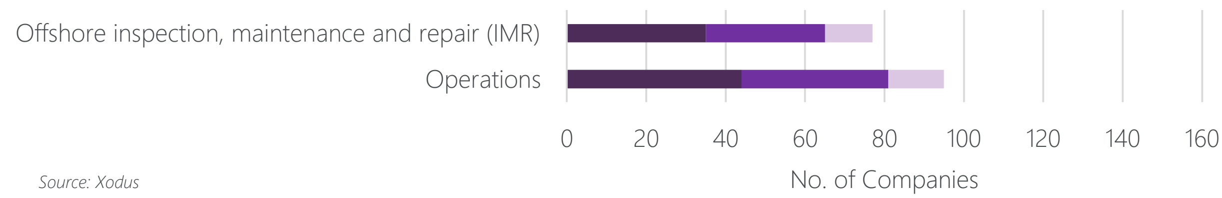


Figure 8-6 - Operations and Maintenance - Supply Chain Assessment Results, Offshore Wind

The results of the RAG assessment for O&M companies are given in Table 8-6 and are described below.

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Operations and Maintenance (O&M)	3	2	3	2	4

Table 8-6 - Operations and Maintenance - RAG Assessment Results, Offshore Wind

Strength of Existing Capabilities

Several areas of offshore O&G expertise translate well to OSW, creating strong crossover opportunities. Local companies have developed advanced digital twins and monitoring software that can optimize OSW operations. The region also has experienced weather forecasting services, HSE professionals, marine logistics and vessel coordination firms, and emergency response providers with substantial operational expertise. However, to successfully bridge the gap between existing competencies and OSW requirements, companies will need to adopt a strategic shift and invest in targeted capabilities.

With regards to maintenance work, many Atlantic Canadian companies providing services to the offshore O&G industry and can provide ROV/AUV monitoring support, infrastructure and cable repairs including coatings and rope access work, electrical interventions, etc. Some of these companies would need additional certification or training to perform industry-specific tasks like blade repair or replacement, or to work on the complex systems within the nacelle or offshore substations.

Demand Case

While the O&M phase of an OSW project is the longest lasting, it requires the fewest number of personnel working concurrently and is primarily service based (with the exception of major component replacements). As more projects come online, the demand for O&M services will compound. Still, O&M activities require an experienced workforce both in the control room and during maintenance work, and there will be a contingent of non-local developer personnel on site, at least initially, until locals can be appropriately trained. As a result, there is limited but long-term demand for local personnel and services unless Atlantic Canada's OSW deployment targets significantly increase.

With the growing global demand for O&M services, gaps in the supply chain may create opportunities for companies and personnel, particularly in technological innovation, which is less constrained by geography. Given the region's existing capabilities, it is essential to leverage local expertise to support this long-term project phase. At the same time, ensuring that locally developed technological innovations are well-adapted to industry needs will be key to maximizing their impact and competitiveness.

Investment Case

With the region's well-developed ports and strong marine industrial expertise, a single project could catalyze the establishment of a local O&M base. The extent of local company participation in O&M activities will depend on the level of investment in upskilling and certification, enabling them to take on maintenance and other critical interventions.

Opportunity for Export Supply

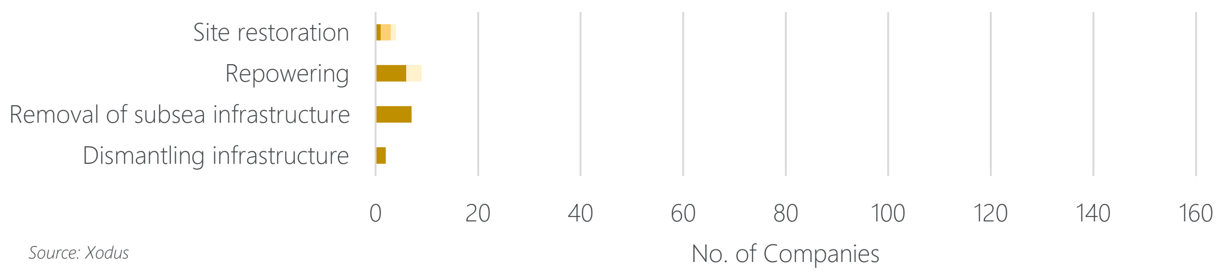
While some offshore activities can be monitored remotely, O&M bases are typically located near wind farms to enable rapid response when needed. As a result, export opportunities for O&M services are limited. However, companies that have invested in specialized monitoring or maintenance expertise—or have the experience to train and lead OSW farm O&M activities—may find export opportunities. These would likely require either a physical presence at the site or the transfer of personnel to carry out the work.

Potential for Partnerships/Collaboration

This project phase offers significant opportunities for partnerships and collaboration. Given the long operational lifespan of wind farms, developers have a strong incentive to build lasting relationships with reliable local companies. Additionally, if local content requirements are mandated by license or contract terms, the region's existing capabilities provide an accessible and strategic solution. While developers and major contractors can establish local offices or encourage the formation of support companies, Atlantic Canada's strong foundation in this sector means that local firms, developers, OEMs, and Tier 1 contractors will be eager to collaborate. These partnerships will allow them to leverage regional expertise while meeting project requirements for local benefits.

8.2.6 Decommissioning

The results of the supply chain assessment of existing companies in Decommissioning are provided in Figure 8-7. At the end of a project's life, it may be either decommissioned or repowered. Since OSW is still a relatively young industry, few companies worldwide actively market their decommissioning expertise. In contrast, offshore O&G has seen numerous decommissioning projects, and some companies have the capability to remove infrastructure and restore sites to their original condition. Many firms involved in installation are likely equipped to handle recovery operations. Some Atlantic Canadian companies have experience repowering onshore wind projects or conducting OSW repowering through their foreign subsidiaries. These firms may be well-positioned to apply their expertise to OSW repowering efforts in the region. Only those with demonstrated decommissioning experience have been included in the supply chain assessment.



Source: Xodus

Figure 8-7 - Decommissioning - Supply Chain Assessment Results, Offshore Wind

The results of the RAG assessment for Decommissioning companies are given in Table 8-7 and are described below.

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Decommissioning	3	2	2	2	3

Table 8-7 - Decommissioning – RAG Assessment Results, Offshore Wind

Strength of Existing Capabilities

While there are local companies that have experience in the offshore O&G industry and have the capabilities to perform removal of subsea infrastructure, few have actual OSW decommissioning experience and fewer have stated repowering experience. Overall, similar strengths would be identified compared to CTI&C capabilities, given a potential for reverse installation approaches during decommissioning.

Demand Case

Globally, there is currently limited demand for decommissioning services, however this will grow with time as a greater number of projects reach end of design life.

Investment Case

Currently, it would be difficult to make an investment case for decommissioning given Canada does not currently have any functioning OSW turbines, meaning decommissioning activities will not be required for at least 30 years. Likelihood is greater that focus will be on promoting investment in CTI&C capabilities, which can then find application during the decommissioning stages.

Opportunity for Export Supply

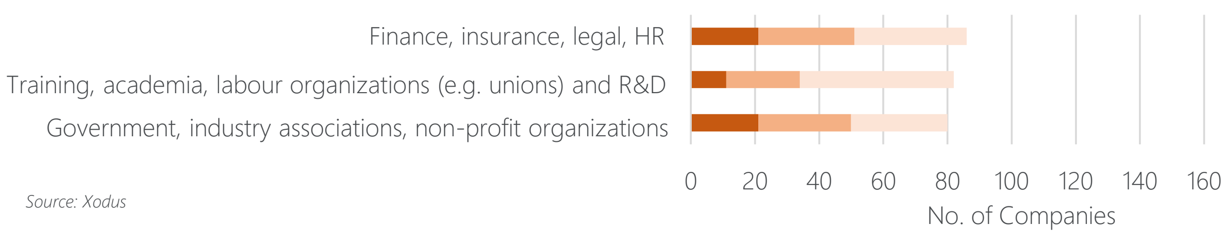
Given decommissioning occurs at the project site, only workforce and vessels are exportable for decommissioning activities. If significant capabilities were developed in Atlantic Canada, it is possible that these could be exported, however it would not yield true local benefits as the companies/personnel would need to travel to access non-local decommissioning sites.

Potential for Partnerships/Collaboration

There is an opportunity for partnership/collaboration in the decommissioning space. Again, the region's CTI&C strengths make partnership attractive for these types of activities. Given that decommissioning activities will not be required until later, companies will have the chance to develop experience handling OSW components and may make more attractive partners.

8.2.7 Sector Support

The results of the supply chain assessment of existing Sector Support companies are provided in Figure 8-8. Sector support functions extend beyond the Tier 3 level of the supply chain and encompass a wide range of services. To maintain focus and relevance in the Sector Support analysis, only companies with ties to OSW, onshore wind, or adjacent industries were considered. The assessment found a strong presence of supporting companies, organizations, and entities in the region. However, financial, legal, and insurance firms with expertise in OSW economics, regulations, and project timelines are essential, as these services are critical for project viability and progression.



Source: Xodus

Figure 8-8 - Sector Support Supply Chain Assessment Results, Offshore Wind

The results of the RAG assessment for Sector Support companies are given in Table 8-8 and are described below.

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Sector Support	3	3	4	1	3

Table 8-8 - Sector Support RAG Assessment, Offshore Wind

Strength of Existing Capabilities

Atlantic Canada's strong marine industrial sector provides a solid foundation for OSW development. Government organizations like CNSOER and CNLOPB are transitioning from regulating offshore O&G to overseeing all offshore energy projects, demonstrating how existing institutions can adapt to support this emerging industry. Industry groups are leveraging their expertise in offshore and renewable energy to drive industry growth. Additionally, several universities, training institutions, and labor organizations offer programs in engineering, building trades, and electrical trades—critical skills for OSW workforce development.

Canada's well-established banking and regulatory sectors extend to OSW, providing a strong framework for industry expansion. While local financial, legal, and insurance entities will face a learning curve, their experience in marine industries, large-scale energy projects, and mining offers a solid foundation to build upon.

Demand Case

Sector support services are generally very local. There is generally a strong demand for support services to enable industry coordination, collaboration and sustainable development. Furthermore, without supporting financial, insurance, and legal services, projects would not be able to occur.

Investment Case

Investing in sector support services is highly beneficial, particularly in workforce training and enabling local industry organizations and economic development entities to strengthen the supply chain, conduct industry studies, and identify opportunities for growth. While Atlantic Canada has a strong foundation in sector support, targeted investments can help address existing supply chain gaps by identifying needs, directing funding, and ensuring that training programs align with industry timelines. Developers seeking to provide local benefits as part of a license or offtake contract often prioritize investments in training and sector support, as these initiatives create lasting economic and workforce advantages at the local level.

Opportunity for Export Supply

While there is an opportunity for knowledge sharing between local and non-local sector support entities, there is very little opportunity to export these services as they are typically locally focused.

Potential for Partnerships/Collaboration

Partnerships and opportunities for collaboration in the sector support supply element are possible but may not result in significant efficiencies or experience transfer compared to the more technical supply elements. Sector support is typically further out in the supply chain and therefore companies are more likely to support more than one industry. While it is possible that non-local companies will wish to form partnerships to build local content, they are more likely to invest than to partner in sector support. There may be partnership opportunities within the training or labour space due to efficiencies in developing curriculum.

8.3 Onshore Wind – Results and Observations

In this section, results from the supply chain assessment are paired with insights from stakeholder and rightsholder engagement, to present observations by supply chain area or package. Figure 8-9 shows outcomes from the supply chain assessment related to onshore wind. A total of about 950 companies were assessed as having some applicability to onshore wind. Table 8-9 gives the results of the RAG assessment for onshore wind. Figure 8-10 shows the geographic distribution of high-applicability onshore wind supply chain companies, by province.

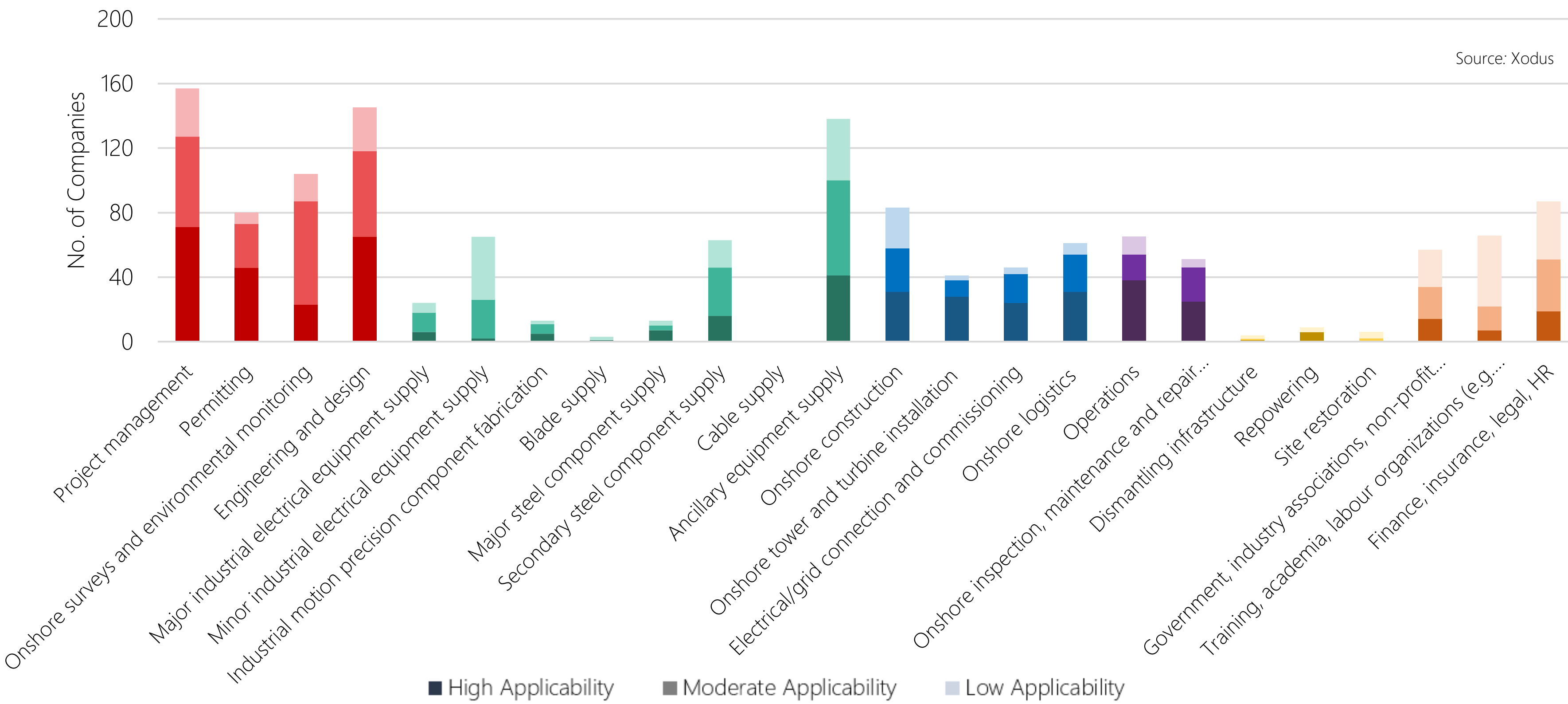


Figure 8-9 - Onshore Wind Supply Chain Assessment Results

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Project Development	4	3	4	1	4
Manufacturing and Component Supply (WTG & BOP)	2	3	2	4	3
Construction, Transportation Installation and Commissioning (CTI&C)	4	3	3	2	3
Operations and Maintenance (O&M)	3	3	2	2	4
Decommissioning	2	3	3	2	3
Sector Support	4	2	4	1	1

Table 8-9 - Onshore Wind RAG Assessment Results

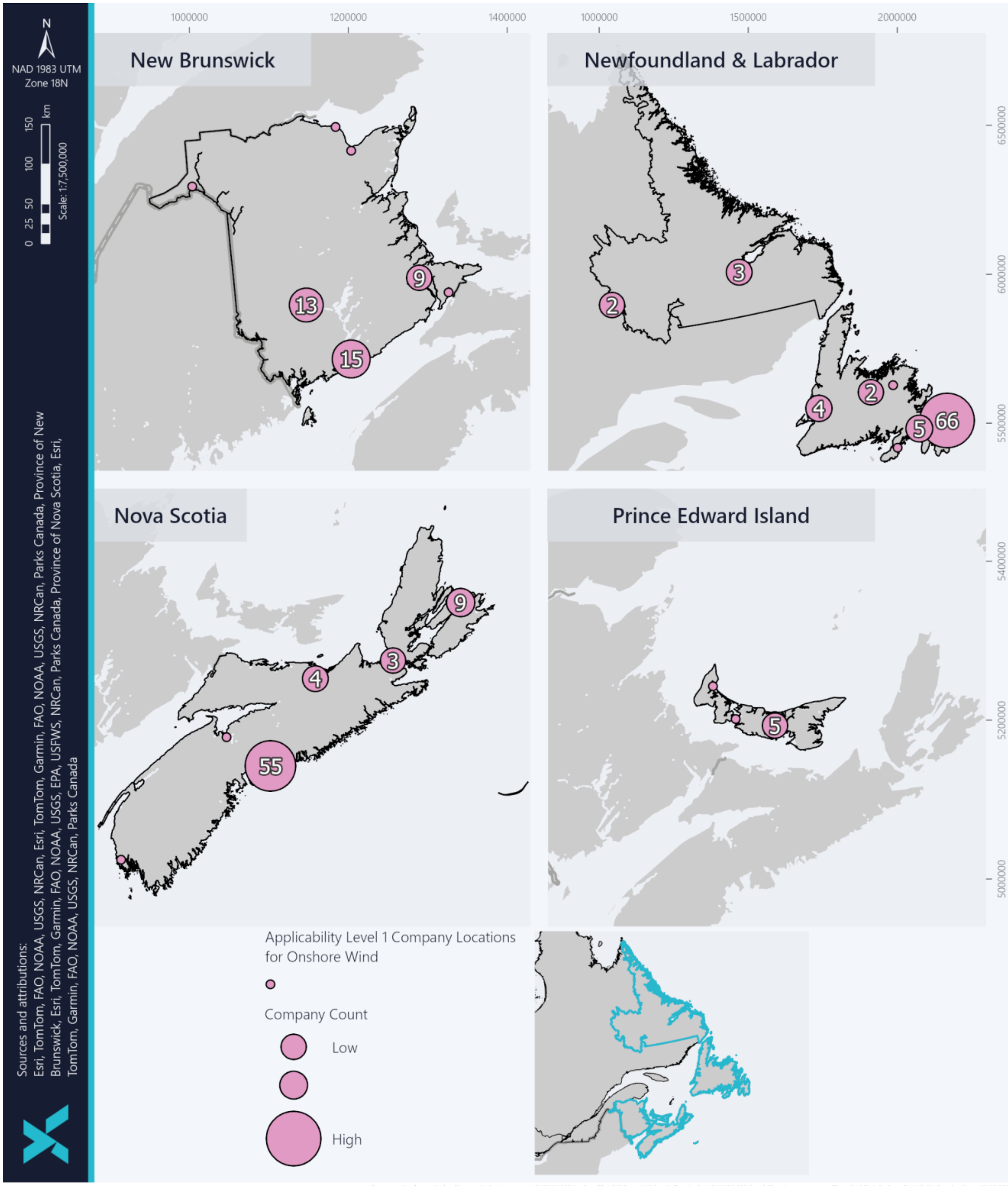


Figure 8-10 - Provincial Distribution of High Applicability Onshore Wind Supply Chain Companies

8.3.1 Results by Province

The results of the onshore wind supply chain analysis, categorized by province, are illustrated in Figure 8-10. Most of these companies are situated in major urban centers: Dartmouth and Halifax in NS; St. John's and Mount Pearl in NL; Saint John and Fredericton in NB; and Charlottetown in PEI. Out of all companies evaluated, approximately 22% were classified as having high-applicability. Nevertheless, the onshore wind sector offers opportunities in specialty areas such as environmental management, civil and site construction, and heavy machinery operations, which are well-established in Atlantic Canada and can be readily adapted for the onshore wind industry.

Nova Scotia

Of the companies evaluated for onshore wind in NS, 73 were categorized as having high-applicability, accounting for approximately 25%. This number represents a slightly greater share of the total number of companies compared to NL, despite the latter having a greater number of companies relevant to onshore wind overall. This is attributable to the increased track record of onshore wind projects in NS compared to NL, while NL has many companies engaged in O&G and mining operations with high potential to enter the onshore wind supply chain. .

In general, NS exhibits a relative distribution of strengths in Manufacturing and Component Supply (particularly electrical and steel supply), followed by Project Development and CTI&C industry, with Dartmouth demonstrating a notable concentration of companies (~32%) followed by Halifax (~27%). This distribution positions the province favorably to facilitate projects across the proposed future development zones as these cities are centrally located geographically within the province.

Newfoundland and Labrador

Among the companies evaluated for onshore wind in NL, 85 were categorized as having high-applicability, representing approximately 19%, while 186 were classified with moderate-applicability (around 42%). The key strengths of these companies lie in Project Development, including project management, engineering and design, and component supply with a focus on secondary steel and ancillary equipment. Other areas of strength include onshore construction, and O&M.

A significant concentration of these companies are in the St. John's Metropolitan Area, which includes St. John's, along with Mount Pearl and Conception Bay South. This concentration is notably greater than in other provinces, where companies are more evenly distributed. A concentration of resources is present in the capital due to many of the reasons discussed in the OSW assessment results, in addition to availability of essential infrastructure and a skilled workforce; however, this could result in operational difficulties in remote areas where onshore wind energy is more likely to be harnessed. This situation could be alleviated through a strategic redistribution of capabilities away from the capital, expansion of services to other regions within NL, and forming strategic partnerships between urban and rural-based NL companies.

New Brunswick

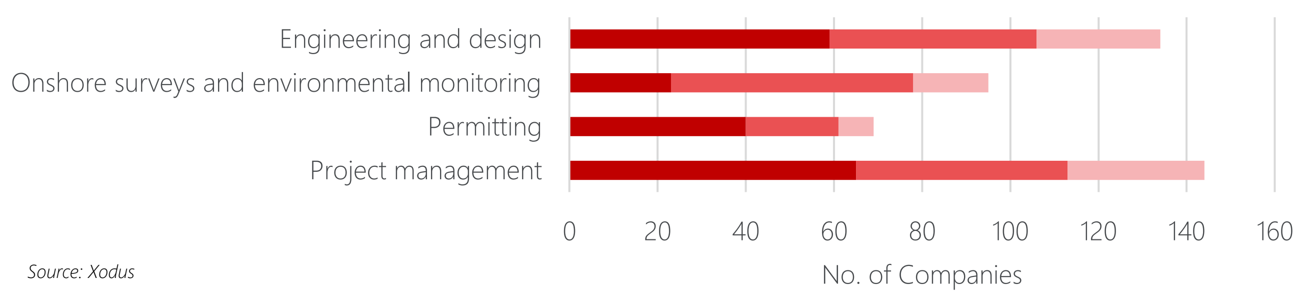
Among the companies evaluated for onshore wind in NB, 41 (~30%) were classified as having high-applicability, with most of these companies situated in Saint John and Fredericton. The relatively high percentage of high-applicability companies in NB results from the province having the greatest amount of installed onshore wind capacity of all Atlantic Canadian provinces at 1.4 GW. In contrast to NL and NS, which exhibit a strong presence in the Project Development supply chain, NB's predominant strength, relatively speaking, is in the high number of Manufacturing and Component Supply sector companies, with strong offerings in ancillary equipment supply of onshore construction and welding equipment.

Prince Edward Island

Among the companies evaluated for onshore wind in PEI, 7 were categorized as having high-applicability, representing approximately 21%, mainly located in Charlottetown. Relative strengths in PEI include project management, as well as electrical/grid connection and commissioning, with some major industries players present despite the relatively small size of the province and its population. These relative strengths are expected given PEI has established a notable history in the development of onshore wind projects, which is poised for further growth.

8.3.2 Project Development

Project development plays a critical role in achieving project goals by maintaining scope, ensuring regulatory compliance, and managing risks. It encompasses planning, design, and operational activities that support efficient material and product flow from suppliers to customers. Effective project development enhances decision-making and optimizes the overall supply chain. Figure 8-11 presents the results of the supply chain assessment of existing project development companies.



Source: Xodus

Figure 8-11 - Project Development - Supply Chain Assessment Results, Onshore Wind

The results of the RAG assessment for Project Development are given in Table 8-10 and are described below.

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Project Development	4	3	4	1	4

Table 8-10 – Project Development RAG Assessment Results, Onshore Wind

Strength of Existing Capabilities

Approximately 75 independent companies were identified as high applicability in both project management, and engineering and design, and 56 independent companies were identified as high applicability in both permitting and project management. One-third of these companies are in NL, and the remaining primarily split between NS and NB. Many of these companies are major international engineering consultancies and dedicated project management companies or developers, that operate in Atlantic Canada to support regional O&G projects.

Most survey and environmental monitoring firms provide project management and engineering and design services, maintaining an even distribution among NL, NS, and NB. Approximately 100 companies fall under low to moderate applicability and have the potential to enhance their services to meet the requirements of the onshore wind industry.

Demand Case

The global Project Development supply chain for onshore wind is well developed, making it easy for suppliers to meet needs, however the scale of new onshore wind planned in Atlantic Canada presents increased overall demand. In Atlantic Canada, a well-established Project Development sector presents significant opportunities for local onshore wind projects, especially as North America prioritizes onshore wind over offshore alternatives. This has also heightened competition among existing firms.

Given that a significant percentage of new onshore wind projects are for green hydrogen or green fuel development, Project Development services for these types of projects will be in demand, though they are likely to be met by external entities, at least initially. Services like project management, permitting, and surveying benefit from a local presence, as regional expertise provides advantages in navigating the local environment, wildlife, and regulations. In contrast, services such as engineering and design can be performed remotely, meaning proximity does not necessarily reduce competition.

Investment Case

Given Atlantic Canada's existing strengths in Project Development, the region is well-positioned to become a key supplier with minimal additional investment. Project management, permitting, and engineering and design services generally require less capital investment compared to manufacturing or installation activities. Survey activities need specialized equipment, but overall, the costs are relatively low. Federal and provincial economic development agencies support local businesses to become more competitive and innovative. Supporting agencies like this can further enhance the region's capabilities in providing these services.

Opportunity for Export Supply

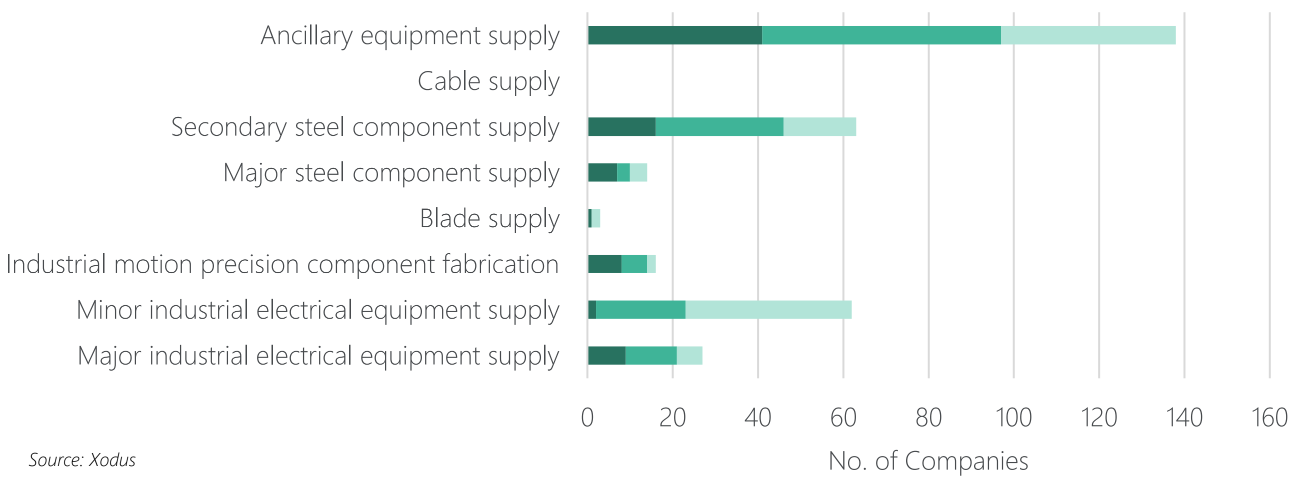
The presence of established competition adversely affects further export prospects in Project Development as onshore wind is a mature industry. Skills in this package have already been shown to have transferred effectively between Atlantic Canadian provinces and beyond in areas where local companies operate, like the Caribbean, suggesting that the export market for onshore Project Development is likely saturated. The additional expertise that may result from the integration of hydrogen and/or green fuel production resulting from onshore wind may produce high-demand exportable skills if developed early enough to beat out competition.

Potential for Partnerships/Collaboration

Most of the companies assigned high applicability in this package were established prior to provincial net-zero emissions targets having been established, which is now prompting them to transition their focus towards greener energy sources. As a result, collaborations and partnerships have been formed and are expected to grow further as companies seek to decarbonize. Given the substantial regional focus on green hydrogen development and green fuels, major players in this space will need local partnerships, both to benefit from local knowledge in Project Development activities, but also to build social license to operate.

8.3.3 Manufacturing and Component Supply

The results of the supply chain assessment of existing Manufacturing and Component Supply companies are provided in Figure 8-12. The regional strengths within the Manufacturing and Component Supply package include ancillary equipment, secondary steel components, and both minor and major industrial electrical equipment. While Atlantic Canada is not strong in major component manufacturing, companies that provide secondary steel fabrication could potentially scale up. Given the extensive pipeline of onshore wind projects planned for the region, exploring options to capture the revenue associated with this high-spend package merits further investigation.



Source: Xodus

Figure 8-12 – Manufacturing and Component Supply – Supply Chain Assessment Results, Onshore Wind

The results of the RAG assessment for Manufacturing and Component Supply are given in Table 8-11 and are described below.

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Manufacturing and Component Supply	2	3	2	4	3

Table 8-11 – Manufacturing and Component Supply – RAG Assessment Results, Onshore Wind

Strength of Existing Capabilities

Currently, Atlantic Canada does not produce components for the onshore wind sector; however, the region offers considerable fabrication capabilities. Each province has at least one company capable of manufacturing large steel components. There are approximately 23 independent companies identified as suppliers of major industrial electrical equipment (such as control systems, transformers, switchgear, etc.), along with smaller industrial electrical equipment providers. Additionally, eight independent companies are recognized for their expertise in industrial motion fabrication and control systems, while nearly 50 independent firms are noted for their relevance in supplying secondary steel and ancillary equipment. The availability of manufacturing for blades, and cable supplies is notably limited, with some companies capable of providing required painting or coating services.

Demand Case

As the onshore wind industry continues to grow, there will be an increased demand for blades, steel, electrical components, and cable supplies. Although there is significant demand for WTG and BOP components, cost pressures for long travel distances given vessel day rates and fuel prices must be considered. Major components for onshore wind are transported globally, as currently manufacturing operations are primarily based in Europe and Asia. incurring substantial shipping costs. The project pipeline in Atlantic Canada's onshore wind sector is sufficient to attract interest from major manufacturers to invest in the region, however they would need certainty in timelines and capacity buildouts, as well as in the economics of the business case to manufacture major components in the region.

Investment Case

Given the high expenses in initiating manufacturing operations and procuring materials for onshore wind components, it is essential that the investment to support supply is underpinned by confidence in the long-term wind market. There is sufficient demand in the onshore wind project pipeline to justify investment, providing investors have confidence in current timelines and capacities. Furthermore, establishment of such large-scale manufacturing facilities presents a considerable opportunity for job creation and the growth of related industries tied to onshore wind. Companies will aim to recoup their investment within a reasonable timeframe and will need financing to sustain their operations.

Opportunity for Export Supply

The robust global demand projections for onshore wind growth, coupled with the global nature of the market, presents significant opportunities for the export of major components related to WTG and BOP manufacturing and component supply. There are already bottlenecks noted for transmission components such as transformers and cables.

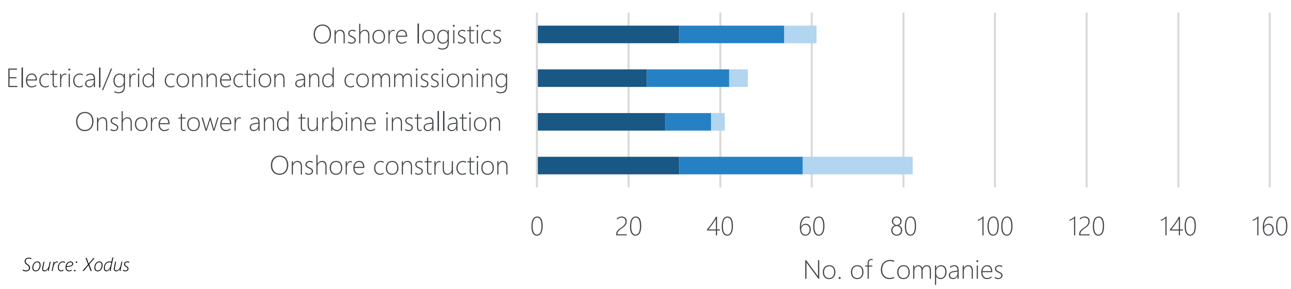
Potential for Partnerships/Collaboration

There are significant opportunities for partnerships and collaborations in this package, and building strong relationships with local businesses and stakeholders will be key to leveraging the full potential of the success of these initiatives. OEMs have strict privacy protocols for their intellectual property and may require a partnership agreement to permit even subcomponent manufacturing. Given the complex design criteria and high costs to establish major component manufacturing, partnership formation may be a way to lower costs, de-risk investments and ensure that best practices are employed.

8.3.4 Construction, Transportation, Installation and Commissioning

The CTI&C of onshore wind projects require specialized equipment and expertise, covering civil sitework, erosion control, and electrical system installation. The commissioning phase is crucial, ensuring all systems meet performance standards through rigorous testing and quality assessments. Commissioning generally focuses on the smooth integration of new energy developments, like wind farms, into the existing power grid. Conversely, responsible decommissioning; including, land restoration and waste disposal, must prioritize environmental sustainability and active community engagement.

The results of the supply chain assessment for existing CTI&C companies are presented in Figure 8-13.



Source: Xodus

Figure 8-13 – Construction, Transportation, Installation and Commissioning – Supply Chain Assessment Results, Onshore Wind

The results of the RAG assessment for CTI&C are given in Table 8-12 and are described below.

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Construction, Transportation Installation and Commissioning	4	3	3	2	3

Table 8-12 - Construction, Transportation, Installation and Commissioning – RAG Assessment Results, Onshore Wind

Strength of Existing Capabilities

There are considerable capabilities available in this supply sector resulting from a strong track record in onshore wind installations across the region. As seen in Figure 8-13, while the overall number of companies in categories associated with CTI&C is not remarkable, but the strong proportion of companies ranked high or moderate applicability is high demonstrates industry experience. Approximately 41 independent firms are identified for their high applicability in both onshore construction and installation activities, which are distributed across the region. The requirements for electrical/grid connections and commissioning demand greater industrial strength, as companies in this domain may also engage in other sectors, such as offshore or renewable energy. Consequently, it is feasible to establish cross-functional industries, albeit with the need for supplementary expertise.

Demand Case

Compared to OSW, onshore wind projects are more easily accessible, reducing logistical challenges by relying on established road and rail systems for transporting turbine components. However, larger, higher-rated turbines can still pose challenges, necessitating infrastructure upgrades like reinforced bridges and roads, and specialized transport vehicles. While not as critical as for offshore projects, ports are still important for onshore wind initiatives, particularly for importing turbine components, and must be equipped to handle large, heavy items. Upgrades necessary to accompany the build out of onshore wind create significant demand in CTI&C services. These services will see logistical benefits from local supply, representing a significant opportunity to leverage these strengths. As the industry grows, the supply of CTI&C services will become strained as the industry potentially faces bottlenecks for key installation equipment, like cranes, and workforce shortages.

Investment Case

Significant investment in this supply sector, encompassing the development of infrastructure such as ports and roads, the acquisition of advanced construction and installation equipment like cranes, workforce training, and R&D aimed at enhancing installation techniques and minimizing costs, must be considered. Establishing a robust local reputation in wind energy projects can enable Atlantic Canada to emerge as a dependable provider of construction and installation services. Capital investment in the CTI&C package for onshore wind is substantial and is impacted by government policies and incentives, market demand, and technological progress. Given local experience in this area, and the benefits to local supply, the investment case here is strong.

Opportunity for Export Supply

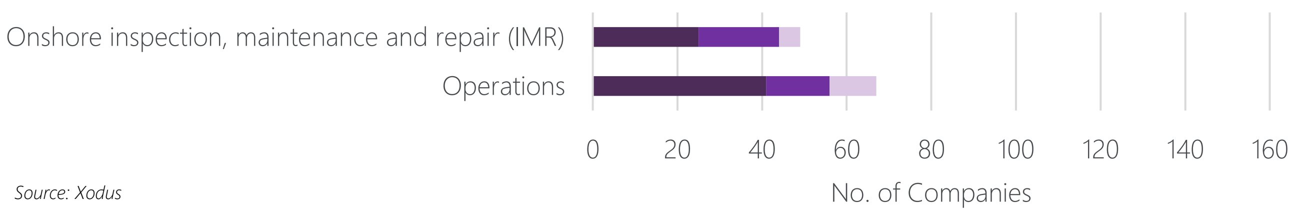
While Atlantic Canada possesses the potential to leverage its capabilities in this sector it is difficult to expand these offerings to an external market given their site-specific nature. Challenges to export include a preference for local supply, market saturation, intense competition, and regulatory hurdles restrict export possibilities for this supply area. By capitalizing on its strengths in the CTI&C sectors, Atlantic Canada can develop a robust local reputation, which can be leveraged regionally across the Atlantic provinces.

Potential for Partnerships/Collaboration

There is already a history in the Atlantic onshore wind industry of companies building track record in CTI&C by leveraging the capabilities of a partner company. Firms with expertise in construction and electrical grid solutions will gain from their experience in designing projects that can withstand severe weather conditions and adhere to stringent safety regulations. This expertise will appeal to more established onshore wind companies looking to set up local development offices in Atlantic Canada.

8.3.5 Operations and Maintenance

O&M is essential for the sustainable and cost-effective operation of onshore wind energy projects. It helps in maximizing energy production, ensuring safety, and managing costs effectively. These include facilities management and monitoring, HSE inspections, weather forecasting, communications, replacement and electrical support. O&M activities also ensure compliance with regulatory requirements and help in accurate reporting of energy production and financial performance. The results of the supply chain assessment of existing O&M companies are provided in Figure 8-14.



Source: Xodus

Figure 8-14 – Operations and Maintenance – Supply Chain Assessment Results, Onshore Wind

The results of the RAG assessment for O&M companies are given in Table 8-13 and are described below.

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Operations and Maintenance	3	3	2	2	4

Table 8-13 – Operations and Maintenance – RAG Assessment Results, Onshore Wind

Strength of Existing Capabilities

In Atlantic Canada, there are numerous developers recognized for their considerable expertise in onshore wind who are equipped to handle both operational and IMR management. There is also a strong O&M support ecosystem with companies that are experienced in IMR activities in onshore wind and adjacent industries. A notable challenge in this package is industry specific training for maintenance activities, and the reported shortage of wind turbine technicians to perform the work. This will only be exacerbated as the industry accelerates in the coming years. While there is a strong baseline of existing capabilities in the region, minor skills and/or certification gaps will likely need to be met through upskilling.

Predictive maintenance planning and leveraging digital solutions like AI and machine learning to streamline operations are available and experiencing ongoing development in Atlantic Canada, further strengthening local capabilities in the long-run and offering an investment opportunity.

Demand Case

The expansion of onshore wind capacity in the Atlantic region fosters a strong O&M opportunity for local companies and workforce. Inspections, regular and unplanned maintenance, and component replacements, along with specialized equipment and skilled personnel, are required through the entire project lifetime. Key challenges, such as severe weather conditions and access to remote sites, can affect maintenance schedules and turbine efficiency, often leading to a preference for local service providers. This approach can also enhance economic viability, which may be influenced by local market dynamics, the availability of subsidies, and competition from alternative energy sources.

Investment Case

Establishing O&M services in less capital intensive than establishing major manufacturing, but till requires the acquisition of specialized equipment, personnel training, as well as ongoing operational costs, like maintenance of an O&M office and associated port facilities. Investors and project proponents will often invest in an O&M base in a region for a single project due to the efficiencies created by being in close proximity to the project site.

Opportunity for Export Supply

Numerous companies in the onshore O&M sector operate on a global scale, particularly at the tope tiers of the supply chain where developers are managing operations, and OEMs are managing the integrity of their assets, generally required through warranty periods. While local suppliers are often favored due to concerns around minimizing downtime, cost reduction, and logistical difficulties, there are still options transfer monitoring and communication tools, skilled personnel, and expertise across borders. Likewise, developers and OEMs may bring external personnel into the region initially to train local personnel and companies to continue with O&M activities in the longer term.

Potential for Partnerships/Collaboration

Beyond simply satisfying local content requirements, the formation of partnerships between OEMs and local O&M service providers will undoubtedly result in advantageous partnerships and collaborative prospects by sharing experience and track record. It is common for OEMs to hire or subcontract maintenance teams during the warranty period for their WTGs, which can last five or more years, after which the developer may take control of maintenance, and may even continue to employ the OEM's maintenance team. It is a cost advantage to the developer/OEM for the maintenance team to be local and is often considered to be the "low-hanging fruit" with regard to creation of local content.

8.3.6 Decommissioning

Decommissioning services ensure that onshore wind projects remain sustainable and reduce long-term environmental impacts resulting from their operation. This process encompasses several essential steps, such as dismantling of the rotor, nacelle, and tower sections, removing foundations, recycling of metals, disposing non-recyclable materials, and restoring the land to its original state, or repurposing for other use. As the onshore wind industry is still relatively young in Atlantic Canada only a handful of projects have reached the decommissioning stage to date. While there are few companies regionally that prominently promote or have experience in decommissioning services, the majority of companies offering these services will seek to develop them when there is greater demand as more wind farms reach the end of their lifetimes. While it is likely that many firms involved in commissioning also have the capability to perform recovery operations, only those that explicitly highlight their decommissioning expertise have been included in the supply chain assessment of companies. The results of the supply chain assessment of existing Decommissioning companies are provided in Figure 8-15.

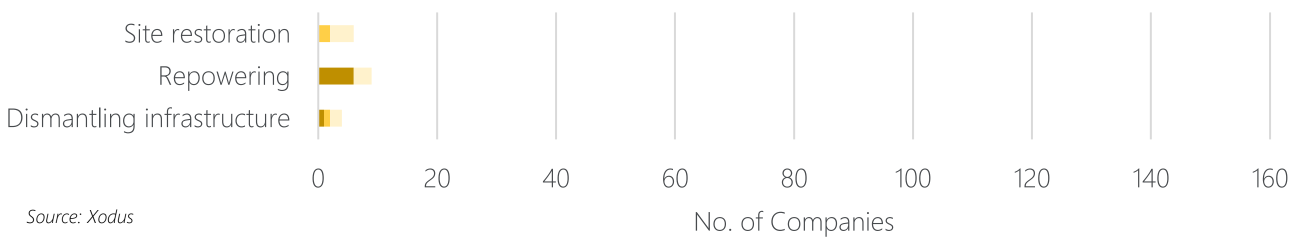


Figure 8-15 – Decommissioning – Supply Chain Assessment Results, Onshore Wind

The results of the RAG assessment for Decommissioning companies are given in Table 8-14 and are described below.

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Decommissioning	2	3	3	2	3

Table 8-14 – Decommissioning – RAG Assessment Results, Onshore Wind

Strength of Existing Capabilities

Atlantic Canada currently lacks companies with stated capabilities to dismantle onshore wind infrastructure and repower aging onshore wind infrastructure. More companies are capable of site restoration, overlapping with those companies rated for strengths in site preparation in the CTI&C package. The project team is confident that there are strengths present in the region in Decommissioning that were not evident during this supply chain assessment, and that as the industry and its projects age, more companies will advertise these capabilities to capitalize on the opportunity.

Demand Case

Currently, there is a restricted demand for decommissioning services on a global scale; however, as the global onshore wind sector expands, the need for decommissioning services, which encompass site restoration and repowering, is expected to rise, thereby exerting pressure on current supply chains. Similarly, there may be a growing demand for expertise in dismantling infrastructure in regions with less experience in this area.

Investment Case

Considering that Atlantic Canada already has a significant number of operational onshore wind turbines the need for decommissioning activities will become increasingly important. This is also an area where there is a major preference for local suppliers. Proactively investing in decommissioning services can assist Atlantic Canada in effectively managing future expenses and logistical challenges related to the retirement of aging wind farms. Investment in decommissioning services also signals good environmental stewardship to local communities and will increase their confidence in project development and execution, limiting push-back and NIMBYism.

Opportunity for Export Supply

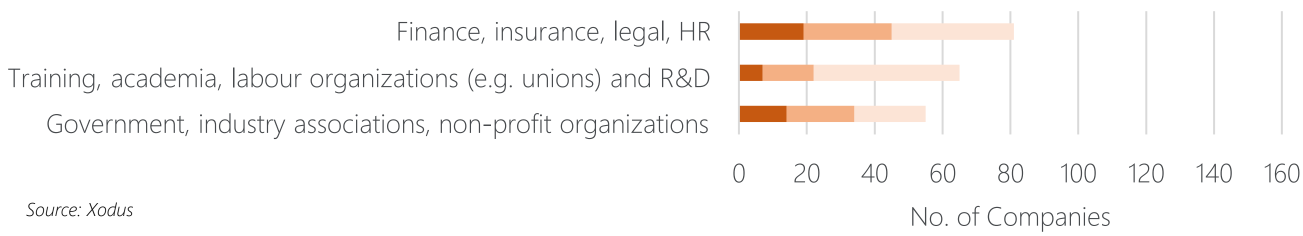
Similar to the OSW sector, while there is potential for significant capabilities to be developed in Atlantic Canada that could be exported, it would require companies and personnel to travel to non-local decommissioning sites, limiting local benefits within Atlantic Canada. Decommissioning activities have a major preference for local suppliers given the cost savings. Exceptions could include repowering operations which may benefit from track record and could be marketed as an exportable skill if developed in a timely manner.

Potential for Partnerships/Collaboration

As decommissioning efforts are not anticipated to be urgently needed for another decade, companies will have the opportunity to gain experience in managing onshore wind components, thereby becoming more appealing partners. The apparent scarcity of specialized decommissioning firms presents a significant opportunity for growth within this sector. As the wind energy industry progresses, there is guaranteed heightened demand, which could attract additional companies to the region. Collaborating with industry leaders and regulatory bodies, investing in innovative solutions and specialized tools, and ensuring transparent engagement with community will allow for effective partnership in this package.

8.3.7 Sector Support

It is crucial to have financial, legal, HR, and insurance firms that possess a comprehensive understanding of onshore wind economics, regulations, and training, as projects cannot advance without these essential support services. To ensure clarity in the very broad sector support analysis of companies, only those with connections to wind energy or related industries were included, based on their experience or stated capabilities. The assessment indicates a robust presence of supporting companies, organizations, and entities within the Atlantic Canadian region. The results of the supply chain assessment of existing Sector Support companies are provided in Figure 8-16.



Source: Xodus

Figure 8-16 – Sector Support Supply Chain Assessment Results, Onshore Wind

The results of the RAG assessment for Sector Support companies are given in Table 8-15.

	Strength of Existing Capabilities	Demand Case	Investment Case	Opportunity for Export Supply	Potential for Partnerships/ Collaboration
Sector Support	4	3	4	1	2

Table 8-15 – Sector Support RAG Assessment, Onshore Wind

Strength of Existing Capabilities

There are substantial and well-established capabilities within Sector Support. There is strength in government departments and agencies supporting industry growth, and a robust network of industry and economic development organizations that are effectively driving industry development in the region. The education, training, and labour ecosystem in Atlantic Canada is quite well-established and has already made strides to provide the skills needed in this growing sector.

Diverse financial, insurance, and legal services are broadly distributed across the region. This includes a range of organizations from small businesses to corporate banking, which are assessed and ranked based on their expertise and focus. Sector Support also presents a significant opportunity for rural companies to engage in the onshore wind supply chain. Various government programs, research institutions, community partnerships, private sector collaborations, and port infrastructure developments represent just a portion of the extensive industry support available.

Demand Case

The demand for sector support services will grow as the substantial pipeline of onshore wind projects is realized. These accelerated development timelines may create bottlenecks, as firms with existing industry-specific experience in financial, insurance, and legal services struggle to meet demand. There is also an onus on the education and training institutes to ensure that an adequate workforce is developed to meet industry demands, as they will need to plan for new programs and marketing campaigns effectively.

Investment Case

Atlantic Canada's sector supply is strong, investment in scaling capacity to meet the needs of the robust onshore wind development pipeline in Atlantic Canada is likely required. Federal and provincial economic development entities are well positioned to offer businesses and organizations in the Sector Support space this type of assistance. Additional investment opportunities exist in the areas of innovation and technology, workforce development, sustainability initiatives, and infrastructure upgrades. Investigating new markets and export possibilities in onshore wind can contribute to diversifying and fortifying the economic foundation of the sector.

Opportunity for Export Supply

The sector supply area has proven to be formidable in creating a tough environment for non-local suppliers. These suppliers are likely to face considerable logistical obstacles due to their distance, the established relationships of local suppliers, and a superior understanding of local market dynamics. Such factors can hinder non-local suppliers' ability to compete effectively and may restrict their opportunities for export. For example, Atlantic Canada has distinct regulations and compliance requirements that differ from those in the rest of Canada and neighbouring countries, which can complicate the navigation of these regulations, further impeding their competitiveness in the export market. Established local suppliers in legal and finances may benefit from advantageous economic policies, subsidies, or other forms of support that are may not be available to non-local suppliers. While training and R&D activities can occur across distances, labour organizations, including Indigenous groups, have very little opportunity to export these services as they are typically locally focused.

Potential for Partnerships & Collaboration

The ability to form international Sector Support in Atlantic Canada is constrained by varying regional legislative requirements and processes that are better met by local entities. Notably, the advancement of onshore wind in Atlantic Canada is primarily guided by local and provincial policies and regulations. The economic and logistical considerations associated with onshore wind project development also tend to be more localized. There are opportunities for local Sector Support companies in financial, insurance, or legal services to collaborate with entities, even foreign entities of their own firms, to benefit from best practices and lessons learned in this industry.

A major opportunity for collaboration in terms of streamlining industry development and efficiently using resources and infrastructure would be through regional collaboration across the Atlantic Canadian provinces. Government collaboration in particular would greatly advance the ability of the region to assist in smoothing scheduling to avoid peaks and valleys, and would demonstrate a greater overall opportunity for investors that view the regional, versus provincial, opportunity.

8.4 Supply Chain Diversity Assessment – Results and Observations

Supplier diversity in the offshore and onshore wind sectors in Atlantic Canada is a vital pathway to equitable economic growth and community inclusion. Supplier diversity is a proactive strategy that ensures businesses owned by underrepresented groups—including women, Indigenous peoples, visible minorities, 2SLGBTQ+ individuals, and persons with disabilities—have equitable access to procurement opportunities. By fostering opportunities for these groups, the wind energy industry can drive innovation, resilience, and trust.

Atlantic Canada's wind energy sector—both offshore and onshore—has the potential to set a new standard for supply chain diversity, driving economic growth while advancing social inclusion and equity. Achieving this will require a coordinated, multifaceted strategy that empowers diverse suppliers to compete effectively while transforming traditional procurement practices to be more inclusive. This includes targeted initiatives, capacity-building programs, monitoring mechanisms, and policy reforms to address systemic barriers. Raising awareness among stakeholders about the benefits of inclusive procurement will be key to fostering a resilient, innovative, and equitable supply chain that delivers lasting value for all.

State of Supplier Diversity in Atlantic Canada

In December 2024, the Atlantic Economic Council released the *Atlantic Diversity Review*, highlighting both progress and ongoing challenges in DEI across the region. The findings from the study on diverse business ownership provide valuable insights into fostering opportunities for underrepresented groups, including Indigenous Peoples, women, racialized communities, persons with disabilities, and the 2SLGBTQ+ community. Below is a snapshot of the region's diverse-owned enterprises:

- Women-owned businesses account for 20% of Atlantic Canadian companies as of 2020.
- Indigenous-owned businesses represent under 3% of businesses but contribute $680 million in revenues, demonstrating significant economic impact.
- Immigrant-owned businesses have tripled since 2005, now exceeding their population representation at 9%.
- Black-owned businesses comprise 0.6% of businesses and face barriers to financing and scaling operations.
- Businesses owned by persons with disabilities account for 2%, showing notable underrepresentation relative to population.
- 2SLGBTQ+ businesses represent under 2% of businesses.

This study's stakeholder interviews, desktop research, and supply chain assessments identified key challenges and best practices for supporting diverse-owned businesses in the region's wind industries. The lack of a centralized registry for diverse-owned businesses made identification and engagement difficult during this study. Associations that support a specific group often open membership to all businesses, making it challenging to determine if a business was actually diverse owned. Diverse-owned companies tend to be SMEs and small businesses in the region tend to lack dedicated websites, complicating identification and analysis efforts. Additionally, because there are no requirements to track diverse supplier participation across the region, it was challenging to track supply chain diversity. Adding to this issue is the overall reluctance of companies to self-identify. For instance, stakeholders reported that, 2SLGBTQ+ and disabled business owners often fear discrimination, limiting self-identification in supply chain databases.

Stakeholder interviews revealed widespread acceptance of DEI, with most organizations stating that their corporate cultures embrace diversity. For instance, some developers noted that DEI could support social license to operate efforts and also set them apart as an employer and corporate citizen. Because onshore wind developments are rural-based, an inclusive culture will foster long-term workforce sustainability. Inclusive practices enhance trust and strengthen community relationships, supporting project approvals and long-term success.

Diverse-Owned Company Assessment Results

About 15% of the total companies assessed in this study were identified as diverse or Indigenous-owned enterprises. Of these, 7.3% were diverse-owned, while 7.7% were Indigenous-owned. Table 8-16 outlines the approximate percentage of diverse-owned companies by province.

PROVINCE	NL	NS	NB	PEI
Indigenous-Owned	58 (11%)	17 (4%)	10 (7%)	4 (10%)
Diverse-Owned (excludes Indigenous)	52 (10%)	21 (5%)	10 (7%)	2 (5%)
Provincial Total: Under-Represented Groups	20%	9%	14%	14%

Table 8-16 - Diverse- and Indigenous-Owned Supply Chain Company Statistics

On balance, diverse-owned companies in Atlantic Canada demonstrate a stronger alignment with onshore wind developments than offshore. OSW requires specialized expertise in areas such as marine operations, foundation and substructure work, and subsea cable installation—areas where diverse-owned providers appear to be underrepresented.

Diverse-owned companies show strength in workforce development and Sector Support services, particularly in HR consulting, training, and capacity building. Some diverse-owned companies also offer expertise in environmental services, permitting, project management, and management support services, all of which are applicable to both onshore and OSW.

Most diverse-owned businesses in the dataset are SMEs and micro-businesses, which will likely be challenged when competing for wind energy contracts. These companies typically do not have robust business development processes and management systems. Many wind energy developers require ISO or other industry-recognized certifications, which can be costly for SMEs. Developers and OEMs often prefer to bundle contracts into large-scale packages, making it difficult for smaller firms to compete. Most small businesses lack dedicated procurement teams or the capacity to navigate complex bidding processes.

A small number of larger, more mature companies offer significant experience and are well-positioned for both onshore and OSW developments. For instance, there are companies that provide medical and occupational health services, supply base services, as well as engineering, electrical services, logistics, and technology services.

The data collected indicates that the province of NL has a more diverse potential onshore/offshore wind supply chain companies compared to other Atlantic provinces. While this may be the result of data availability, this may be attributable to its government policies, and proactive inclusion efforts in the provinces long-standing major resource projects. For 20+ years, the province's offshore regulator has mandated DEI monitoring and investment through legislated Benefits Plans for offshore O&G under the Atlantic Accords Act. The Government of NL has also required

GEIDPs as part of negotiated Benefits Agreements with natural resource developers. Similar requirements are now being extended to onshore wind developments awarded under the Crown Land Call for Bids for Wind Energy Projects process.

Benefits Plans are required under Bill C-49 for both NS and NL and must outline how offshore renewable energy projects will provide economic and social benefits to local communities, including how a project will promote diversity, equity, and inclusion within the workforce and in the development of the project. This includes fair hiring practices and creating opportunities for underrepresented groups. These requirements have fostered the growth of diverse-owned companies by increasing awareness and support for DEI activities and programs, and also have led to more available data on company ownership status for reporting purposes.

In NS, the Women in Business Initiative supports women entrepreneurs through funding, training, and networking opportunities to help women-owned businesses. The Black Business Initiative (BBI) is dedicated to fostering the growth of Black-owned businesses, offering a range of programs, including mentorship, business consulting, and financial support, to help Black entrepreneurs succeed.

NB's Supplier Diversity Action Plan aims to boost the participation of underrepresented businesses in government procurement. By enhancing access to government contracts, the plan helps diverse businesses navigate the procurement process and compete more effectively. This experience can prepare these businesses to establish a foothold in the energy sector.

An area of strength in Atlantic Canada is the presence of industry associations, energy networks, and ocean technology clusters, which are currently being led by diverse executives. These organizations play a critical role in advocacy, networking, and capacity building for smaller businesses. In jurisdictions like Denmark and the Netherlands, industry associations have been instrumental in coordinating diverse supply chain participation, hosting industry matchmaking events, and facilitating partnerships between SMEs and major OSW developers. Atlantic Canada could benefit from similar strategies to ensure that diverse-owned businesses are integrated into upcoming projects.

Best practices from other jurisdictions include:

- **Supplier Diversity Offices:** Massachusetts and New York provide models for certification, tracking, and support.
- **Structured Data Collection:** Self-identification or certification processes in procurement databases and mandated tracking improve inclusion.
- **Inclusive Procurement Policies:** Encouraging or mandating diverse supplier participation fosters growth.
- **Supplier Development Programs:** Training, access to capital, and matchmaking programs enhance opportunities.

8.5 Indigenous Participation in the Wind Supply Chain

In the future, industrial benefits agreements for large offshore and onshore projects may include Indigenous capacity in civil works, security, heavy equipment operators, etc., such as with marshalling yards and port developments that the OSW sector will be building on. Federal government programs and institutions like the Canadian Infrastructure Bank (CIB) are required to provide capital for such infrastructure, and the significant role they play in financing Indigenous Peoples and their Organizations for onshore wind today shows that they could be an important tool in the future. It is noted that such arrangements may require private sector participation before becoming eligible for Indigenous Organization support.

Early industry engagement with the Indigenous Organizations identified in Appendix B.2 of this report is a key foundation to understanding how each project may benefit local and regional Indigenous Groups. It is noted that this practice is already being implemented and supported by developers, Indigenous Organizations, and Governments.

Shortly after Confederation all Indigenous nations fell under the "care" of the new federal government under the Indian Act, established in 1876. The Act set the rules in which the federal government would essentially govern all aspects of Indigenous life. Among other things, the Act states that no property within the First Nation can be transferred to any non-Indigenous entity. This restriction continues to have impacts today including a lack of collateral, personal or business credit, and access to all types of reasonable and low-risk financial credit.

However, Supreme Court of Canada decisions and federal government policies eventually opened new avenues for Indigenous People to participate, particularly in the resource sectors. In 1997, the Delgamuukw v. British Columbia concerned the definition, the content and the extent of Aboriginal title (i.e., ownership of traditional lands). The Supreme Court of Canada observed that Aboriginal title constituted an ancestral right protected by section 35(1) of the Constitution Act, 1982. The ruling led to Indigenous communities challenging resource-based projects that they felt could potentially damage the environment. In Atlantic Canada the first challenge was to the Maritimes Northeast Pipeline (MNEP) Project which was to be built to carry natural gas from the Sable Offshore Energy Project. The challenge was settled when the pipeline company agreed to pay benefits to the 13 bands in NS.

Following the success with MNEP, the bands and the Native Council (an off-reserve Band) reached a benefits settlement with PanCanadian for their pipeline that connected with the Deep Panuke Offshore Natural Gas Project. It also led to the alignment of the *Nova Scotia Renewable Energy Strategy*, and one developed by the First Nations Bands. These strategies led to the first wind investments by Indigenous peoples in the Atlantic region under the NS COMFIT Program.

In NB, a similar program was established by NB Power called the LORESS program. It was established to procure renewable energy projects from Indigenous communities and local entities throughout the province through a competitive bidding process. Another program used by Indigenous Organizations was called Embedded Generation Program for small community owned generators. These programs led to Indigenous Organization investments in the Wisokolamson Energy Project, the Wocawson Energy project and a second phase called the Neweg Energy Project, and the Oinpegitjoig Wind Project.

More recently, the Government of Canada has acted to address the credit limitations under the federal Indian Act by providing its own financing through grants and loans. These programs include:

- The Federal Indigenous Loan Guarantee Program. Initially announced in the Budget 2024-25 with a commitment for $5 billion in loan guarantees to help Indigenous groups access more favourable borrowing rates and the capital required for major economic investments in the natural resources and energy sectors.
- The Canadian Infrastructure Bank's (CIB) Indigenous Equity Financing Program. The Program supports the purchase of equity stakes for First Nation, Metis and Inuit communities on whose traditional territory the project is situated when the CIB is already considering an investment.

Project Equity Participation

Wskijinu'k Mtmo'taqnuow Agency Ltd. (WMA), owned by all 13 bands in NS, and the North Shore Mi'kmaq Tribal Council (NSMTC) are very active investors in onshore wind projects, with applications and approvals supported by these and other federal programs. Details of onshore wind projects in Atlantic Canada with Indigenous ownership/investment are found in Appendix B.2.

CIB financing has been used by many recent Indigenous Organization onshore wind projects in Atlantic Canada, including:

- NS's new Transmission Utility – the (Wasoqonatl) Reliability Intertie which runs 162 km through NS to the NB border., where the CIB has made an equity investment of $217 million and is working with WMA for a similar equity injection into a partnership entity that includes 50% ownership with NSP.
- NS's Energy Storage Project where the CIB committed $138.2 million to the NSP-led project with $18 million going to the WMA. The loan to the WMA was the CIB's first equity loan under the Indigenous Equity Initiative (IEI).
- NS's Benjamin Mill wind project, majority owned by the WMA and Natural Forces. The WMA received a $45.8 million loan from the CIB.
- NS's Port Hawkesbury Paper's wind project is receiving $224.2 million from the CIB to finance the project and to enable a 10% equity investment by the WMA.
- NS's Higgins Mountain Wind Project received a $100 million loan from the CIB to help finance the project and its owners Elemental Energy, Stevens Wind, and the Sipekne'katik First Nation.
- EverWind Fuels has established equity partnerships with three Mi'kmaq First Nations in NS: Membertou, Paqtnkek, and Potlotek for their onshore development in NS. These collaborations are a key part of EverWind's green energy projects. They are designed to ensure Indigenous communities benefit directly from sustainable business growth, employment, and training opportunities. This arrangement has been supported through federal funding support.

Within this framework of strengthened legal obligations and active experience in financing, owning and operating partnerships, Atlantic Canada Indigenous Organizations are setting the stage for increased participation in future renewable energy developments on two fronts:

1) Project Equity Participation, and
2) Supply Chain Participation through Benefits Agreements

The range of federal funding supports for renewable energy development includes community-level up to large scale industrial. As OSW projects emerge these federal programs will become critical for providing credit to projects for Indigenous People's Organizations – particularly given the continued limitations of the Indian Act.

Benefits Agreements

IBAs with Indigenous communities are commonly established across Canada's energy sector. For OSW projects in NS and NL, a Benefits Plan will likely be required under the new Offshore Energy Regulator's framework.

In NL, the provincial government mandates Benefits Plans for onshore wind projects, including a requirement for GEIDPs, as previously mentioned, as well as Indigenous engagement and opportunities. In Labrador, IBAs in place for mining developments have fostered the growth of Indigenous-owned companies, which is evident by the number of Indigenous-owned companies in the province.

While direct Benefits Agreements with Indigenous organizations are not required for wind developments in NS, some wind developers in NL have signed MOUs with Indigenous groups, and IBAs may become part of longer-term local benefits strategies. These agreements often support the development of renewable energy supply chains, education and training, both within and beyond the energy sector, as well as leading to broader community benefits. Ultimately, the goal is to enhance Indigenous participation and engagement in Atlantic Canada's renewable and clean energy sector.

Leveraging Benefits and Offsets for Energy Projects

One of the major challenges for Indigenous Peoples, like other local businesses, in participating in large-scale energy projects is the extensive documented experience and expertise required by global corporations. These requirements can be daunting and difficult to navigate at best, and, at worst, serve as impenetrable barriers to entry.

In 2020, LearnSphere, CAPP, and ABS/Sayle developed a week-long program to introduce potential O&G opportunities to Atlantic First Nations. The initiative included sessions that facilitated discussions between Indigenous businesses, major offshore companies, and mainstream NL supply chain stakeholders to explore potential next steps.

In 2024, CAPP (and ABS/Sayle) convened a forum between NL Indigenous businesses and the offshore sector to restart discussions on viable strategies for future collaboration. Based on these discussions, ABS and Sayle recommended developing a virtual initiative to overcome geographic constraints and support continued engagement.

The proposed **Virtual Nation (VN)** platform would be a web-based portal designed to facilitate four key services:

1) **Opportunity Matching:** VN would search, vet, and distribute all relevant contract opportunities to Indigenous businesses.
2) **Business-to-Business (B2B) Matching:** VN would maintain a vetted list of Indigenous businesses, enabling joint ventures (JVs) and partnerships with mainstream Atlantic companies.

3) **Training and Mentorship:** VN would offer foundational training and business guidance to Indigenous enterprises to strengthen their capacity.
4) **Indigenous Opportunities:** VN would provide ongoing updates and support for users interested in opportunities through the KMKNO and other First Nations with existing benefits agreements.

Building Strategically

Indigenous renewable investments in Atlantic Canada are now branching out from investments in resource development into sector supporting and supply chain projects. For example, NL-based, Indigenous maritime services company, Miawpukek Horizon Maritime Services (Miawpukek Horizon) and green energy developer, EverWind Fuels (EverWind) have signed an MOU to collaborate on the development of a green fuel transshipment corridor between EverWind's clean hydrogen and ammonia project proposed for the Burin Peninsula of NL and it's Point Tupper transshipment facility in Cape Breton, NS.

In another strategic partnership, Membertou First Nation, Qalipu First Nation, and Horizon Naval Engineering have acquired the St. John's Shipyard (New Dock) in NL. The acquisition is expected to pay immediate returns to the Membertou and Qalipu First Nations communities for social and cultural programming. The focus on gaining revenues for Indigenous Organizations to invest in their communities has been typical of their investments in the region, but the partnership also sees the purchase as an opportunity to provide training and employment opportunities for young people.

Through the course of this study, the project team has gained insight into pending expansions of supply chain investments in preparation for large scale wind developments. These investments will strengthen the benefits for Indigenous communities and create a more competitive environment for the supply of goods and services in the sector.

Supporting Development

The Atlantic region hosts several Indigenous businesses with diverse capabilities. For instance, consulting organizations offer Indigenous cultural awareness training programs. Their expertise in facilitating effective engagement between Indigenous communities and external organizations is crucial for the successful implementation of wind energy projects.

Indigenous businesses in Labrador's mining sector provide significant industrial capacity by leveraging local expertise, deep regional knowledge, and established supply chain networks. These businesses, formed through partnerships, are integral to mining operations, offering services such as construction, logistics, heavy equipment operation, environmental monitoring, and workforce training. By integrating Indigenous enterprises into mining projects, companies have benefited from skilled labour, reliable service providers, and strengthened relationships with local communities, contributing to long-term project success.

In particular, Indigenous companies can bring unique strengths to wind energy projects:

- **Land Stewardship:** With traditional knowledge and rights to significant land areas, Indigenous communities can identify optimal sites for wind energy development that align with environmental and cultural considerations.
- **Community Engagement:** Their deep-rooted presence in local communities facilitates effective stakeholder engagement, ensuring that projects receive broad support and deliver tangible benefits to local populations.
- **Sustainable Practices:** A cultural emphasis on environmental stewardship ensures that projects are developed with a focus on sustainability and respect for natural ecosystems.

Circumstances dictate opportunities and growth. For example, industrial mining projects in Labrador have helped to create supply chain companies in that part of the region, while government policies and new financing initiatives have helped secure ownership stakes in most new renewable energy projects in the Maritimes. The next stage developments in the renewable energy sector are seeing and will likely continue to see supply chain developments across the region, including greater ownership of supply chain component businesses to enable these projects.

The move into ownership of supply chain components appears to be driven by a desire to provide employment where suitable and possible for Indigenous youth. In other cases, the investments further down the chain may be more driven by the potential for increased returns. In either case, the emergence of industrial scale onshore wind to support hydrogen, and the potential for large-scale OSW, could bring a new focus to Benefit Agreements in these sectors. The renewable energy sector is ideally positioned to foster Indigenous participation in construction, fabrication, training and services of all kinds. Investments and job creation in these areas would likely serve the communities for growth and prosperity in many areas beyond renewables.

9 OPPORTUNITY ASSESSMENT

9.1 SWOT Analysis

The Strength, Weaknesses, Opportunities and Threats (SWOT) analysis was developed using the findings and perspectives captured through research and stakeholder engagement, complemented with the outputs and considerations from the offshore and onshore demand scenario outputs, and the results of supply chain assessment of companies.

The outcomes of the SWOT analysis are presented in Table 9-1, followed by discussion of individual elements. The subsequent risk analysis, provided in Section 9.2 takes a deeper dive into the identified weaknesses and threats, scoring for likelihood and impact to evaluate likely severity. Mitigative actions will feed into the recommendations on pathways to supply chain development in Section 10, complemented with the perspectives and points raised during a recommendations workshop with the wider stakeholder community.

STRENGTHS	OPPORTUNITIES
• **World-class wind speeds**, both offshore and onshore, have already attracted significant developer attention. • **Growing track record of experience** leveraging port infrastructure for storage, laydown, assembly, and maintenance of OSW projects. • **Transferable skills from adjacent industries**, including offshore O&G, shipbuilding, civil construction, manufacturing, and structural handling. • Strong network of **existing workforce development institutions** with potential to develop offshore and onshore wind training programs. • Established pathways for **Indigenous economic opportunities** on renewable energy and infrastructure projects. • **Positive market signals** from OSW objectives in NS and early leadership from industry organizations like MRC and Energy NL.	• Potential for **local partnerships with global suppliers** to build capacity and enable diversity initiatives. • **Retired/underused O&G infrastructure** can be repurposed for wind development. • Opportunity for **university infrastructure and R&D clusters** to drive innovation in offshore and onshore wind technology research areas. • **Adjacent industry workforce** that is familiar with offshore marine industrial operations. • Ecosystem of **technology-focused innovation** is autonomous systems, advanced 3D printing, digital twins, etc. • Opportunity for **regional collaboration around best practices** in permitting processes, diverse workforce engagement, and local supply chain incentives.

WEAKNESSES	THREATS
• Port and transportation **infrastructure (e.g. bridges) upgrades needed** to handle shipments of onshore and OSW components. • **Complex and onerous procurement systems** and certification processes discourage local suppliers from participating.	• Economic uncertainties, **lack of consistent project pipeline**, and lack of clear regulatory frameworks impacting investments in wind energy sectors. • Resistance from communities due to **'Not In My Backyard' (NIMBY) attitudes** and environmental concerns, including within fishery (re: OSW) and regarding recyclability of components (blades).

WEAKNESSES	THREATS
• **Difficult to identify diverse-owned companies** due to lack of reporting; difficult to confirm diverse-ownership without certification. • **Labour shortages** in key roles like technicians, electricians, and grid engineers. Aging local populations impacting workforce availability. **Issues with existing apprenticeship systems.** • **Stakeholder scepticism** and resistance to wind developments due to rapid rollout without adequate communication. **Local benefits are unclear.** • **Limited access to knowledge and awareness** of available opportunities among potential suppliers, and particularly in underrepresented groups. • **Regional competition among Atlantic provinces** creating inefficiencies and missed collaboration opportunities. Regional disparities in labor market and infrastructure readiness between provinces. • **Inter-provincial trade barriers** limit the ability of provinces to provide mutual supply chain and workforce support.	• **Global bottlenecks in workforce and equipment availability** across multiple concurrent projects, especially for essential infrastructure like transmission and distribution components (e.g. transformers, cables); **no local major component manufacturing**. • Current onshore wind development timeline highly ambitious - **industry sceptical on ability to meet planned CODs**. • High federal duty on temporary imported vessels impacting project economics. **High cost of doing business in Canada**, in general. • **Global competition** from regions with established OSW supply chains and stricter local content policies. • **Uncertainty around access to federal tax incentives** for business and infrastructure development in renewable energy. • **Nascent green hydrogen industry** has inherent risk due to supply chains that are not fully developed and increased scrutiny of export opportunities. • Pathways to market are not obvious – transmission systems and electricity export opportunities are currently limited.

Table 9-1 - Summary of SWOT Analysis Outputs for Offshore and Onshore Wind Supply Chain Development

9.1.1 Strengths & Opportunities

Besides the overall strength of the wind resource in Atlantic Canada and the attention that wind energy potential has attracted to the region, Atlantic Canada's strengths and opportunities, summarized inTable 9-1, are detailed and categorized in-line the following focus areas: Supply Chain, Workforce, Policy, Leadership and Communication, and Innovation.

Supply Chain

- **Growing track record of experience:** Port infrastructure in the region has already supported offshore and onshore wind projects, including marshalling component for OSW projects in the US, providing valuable track record and insight into project execution practices. The region boasts legacy O&G industry assets, and capabilities across storage, marshalling, and installation support for OSW. The growing project pipeline has also encouraged suppliers and OEMs to establish or expand local facilities, such as Vestas' maintenance operations base for immediate service needs and spare part access in NS.
- **Transferable experience from adjacent industries:** Onshore wind projects have benefitted from strengths in the civil construction and manufacturing sectors, with close links to grid and transmission infrastructure deployment and upgrades. Experience and track record can be drawn and transferred from adjacent sectors such as O&G, shipbuilding, advanced manufacturing for defence and aerospace, as well as general civil

construction capabilities for onshore wind and transmission related requirements. Additionally, the Atlantic Accords Acts have set a precedent for local content creation in a fair and equitable way that minimizes project cost impacts and maintains quality which may inform OSW in the region as it develops.

- **Local partnerships with global suppliers:** Local supply chain experience gained from energy and infrastructure developments, such as wider diversity initiatives in the O&G sector, can be adjusted for OSW particularly where global suppliers or OEMs may be looking to partner with the local supply chain. Regional strengths in O&G and mining operations, for example, were achieved through local and international partnerships, meaning local businesses are familiar with this as a means of developing local track record.

Workforce

- **Adjacent industry workforce:** Workers from the offshore O&G, mining, and major civil infrastructure projects are familiar with the scale, complexity, and harsh conditions that are faced in the region, both on and offshore. Many workers are familiar with an offshore rotational lifestyle, strict safety practices and standards, and remote work, which eases workforce transition into the wind industry.
- **Existing workforce development institutions:** The strong existing network of training and educational institutions already provide onshore wind related training and certifications, as well as apprenticeships throughout the project lifecycle. They are poised to continue to support the industry's needs, and to develop programs in support of OSW as the need develops. Facilities recognize that labour shortages are a threat, and are committed to work with industry proponents to mitigate this risk, as they have done in the past as new industries have developed.
- **Indigenous and rural economic opportunities:** Atlantic Canada's provinces are already witnessing examples of growing partnerships within Indigenous communities and suppliers to support renewable energy and infrastructure projects, including a growing focus on Indigenous equity ownerships. As detailed in Section 8.5 there are ideas being discussed, such as the development of accessible online platforms, to promote these opportunities and help Indigenous and rural communities participate in the offshore and onshore wind sectors, particularly given logistical barriers due to lack of proximity to development sites.

Innovation

- **University infrastructure and R&D clusters:** Existing university infrastructure and a robust R&D ecosystem have positioned the region as leaders in engineering and innovation, particularly for harsh-climate and marine technology. This existing experience positions Atlantic Canada to continue to innovate in onshore and OSW technology research areas. Universities and research centres within NB and PEI offer potential to be part of this network and effort, such as through the Wind Energy Institute Canada.
- **Technology-focused innovation:** Atlantic Canada has a number of highly successful, technology-based start-ups that are now serving global markets. There is strong ecosystem support for technology-based innovations such as autonomous underwater vehicles and monitoring, digital twins for asset integrity monitoring, weather forecasting and sensing technology, and advanced 3D printing. Local companies are already supporting offshore O&G by producing hard-to-source parts on demand.

Policy, Leadership, and Communication

- **Sending positive market signals:** NS has announced key policies and objectives to develop OSW resources, sending positive market signals to developers, suppliers, and OEMs in the global market. While NB and PEI have expressed no immediate plans for OSW development, there is a wider industry effort to provide early leadership and promote sector development from organizations like MRC and Energy NL. NL's substantial pipeline of onshore wind projects, representing in excess of 28 GW, has the potential to attract substantial attention to the region.
- **Regional collaboration around best practices:** The Atlantic Canadian provinces are well-positioned to collaboratively establish best practices in the region's offshore and onshore wind sectors, particularly around developing and refining structures for permitting processes, diverse workforce engagement, and local supply chain incentives. For example, other provinces could model NL's Benefits Agreements and GEIDPs to incentivise developers to engage diverse workforces across all projects in the region.

9.1.2 Weaknesses & Threats

While the greatest threat to both offshore and onshore wind is uncertainty around pathways for offtake, other weaknesses and threats introduced in Table 9-1, are detailed and categorized below in-line the following focus areas: Supply Chain, Workforce, Policy, Leadership and Communication, and Innovation.

Supply Chain

- **Strain on limited existing supply chain:** Increased demand for component storage, marshalling, and installation services may constrain wind industry development due to limited existing port and transportation infrastructure capacity and potential shortages in suitable crane and lifting equipment. The accelerated development of the onshore wind industry out to 2040 will be particularly resource intensive with potential impacts on project scheduling.
- **Dependence on global supply chain:** Atlantic Canada currently does not have major component manufacturing facilities, resulting in a reliance on overseas supply. Global bottlenecks in component, equipment, and vessel availability across concurrent project pipelines for both offshore and onshore wind value chains may pose a risk overall to project development in Atlantic Canada, where local supply chain and workforce capabilities are unable to fill these gaps effectively. Simultaneously, global suppliers pose a potential competitive threat due to specialised value chains and capabilities, and potentially increased focus on their own local content.
- **High cost of business:** The high cost of doing business in Atlantic Canada also poses a threat to initial investments in capital intensive activities, like manufacturing, from overseas suppliers. Likewise, a high federal duty on temporary imported vessels may impact project economics around component supply, storage, and installation, particularly for components delivered from overseas facilities. Provinces such as NB have already cited cost differentiation to onshore wind and high costs of deployment as a reason for not pursing OSW in the immediate future.
- **Uncertain electricity and green hydrogen export opportunities:** The scale and likelihood of electricity export opportunities to the US Northeast and wider Canada remain poorly defined and at further risk due to the new US administration's 'America first' approach. The instability in US demand for OSW energy is likely to

have knock-on effects on continuing to develop Atlantic Canada's track record in staging and installation scopes for OSW projects on the US East Coast. There are also questions around the availability of electrolyser supply for green hydrogen production given that supply chains are not fully mature and will be challenged to keep up with rapidly increasing global demands. While appetite from the Netherlands and Germany has been driving wind energy development in Atlantic Canada, there are still uncertainties with regards to costs and timelines.

Workforce

- **Labour shortages:** Labour shortages and regional disparities between workforce capability and associated mobility is a potential weakness, particularly within the growing onshore wind sector and for specialised requirements in the OSW industry. An aging population and a decreased interest in the construction and building trades has led to shortage of experienced trades workers. The complicated requalification process for foreign workers may also constrain opportunities for experienced personnel to provide on-the-job training for the local workforce in critical roles like wind turbine technicians. This issue is exacerbated by uncertainty in project timelines. While there is a strong adjacent industry workforce, it is unlikely the wind industries will be able to match wages in the O&G sector, making it more challenging to attract these workers to the field.
- **Apprenticeship program improvements needed:** Apprenticeship programs have received criticism as they have low completion rates resulting from requirements for 1:1 ratios on the job, antiquated EI program causing financial hardship during training periods, and finding themselves less hirable once journeyperson status is obtained due to higher costs to employers.
- **Complex and onerous procurement processes:** Lengthy onboarding timelines, complex and expensive procurement processes, and uncertainty around industry requirements may discourage local suppliers from engaging with the wind energy supply chain. In particular, this poses barriers to SMEs, rural, diverse-, and Indigenous-owned companies. Furthermore, the lack of industry supplier databases featuring verified, diverse-owned businesses across the region poses a threat to their involvement, with a risk of missing out on crucial early engagement opportunities with developers.

Policy, Leadership, and Communication

- **Lack of clarity on project pipeline:** The lack of clarity around project pipelines poses a threat to offshore and onshore wind development. Only one province has established a clear capacity target for OSW, while another province has approved ambitious development plans for onshore wind for green hydrogen development while some scepticism exists around the near-term demand for hydrogen due to the industry's nascency. The pressure to ensure connectivity and routes to market for planned projects is heightened by the ongoing development of regulatory frameworks, including the accessibility of federal tax incentives and infrastructure funding for sector development. Developers need certainty on project costs to obtain project financing. Without certainty on development timelines, it may not be possible for developers to get their projects financed.
- **Regional competition:** Trade barriers and supply chain disparities across the provinces may limit the ability of provinces to promote mutual supply chain and workforce initiatives and establish effective solutions to address labour shortages and enable workforce mobility.

- **Community opposition:** Resistance from communities owing to 'Not In My Backyard' (NIMBY) attitudes, environmental concerns, fisheries and ocean co-use issues, and weaknesses in the current community inclusion and engagement processes pose threats to the permitting viability and efficient execution of projects or targets within proposed timelines. Misinformation regarding wind energy technology which overstates the rate of failure, exaggerates environmental impacts, and claims oil leakage from turbines is a concern also impacts community opposition, as does the legitimate argument that blades are not recyclable and that there are environmental costs associated with the production of wind energy infrastructure due to large quantities of steel and concrete being used.

9.2 Risk Assessment

The purpose of the risk assessment is to identify, assess, and mitigate weaknesses and threats that could negatively impact offshore or onshore wind industry development, based on the SWOT assessment carried out in Section 9.1. Again, risks are categorized by Supply Chain, Workforce, Policy, Leadership and Communications, and Innovation. Mitigating measures are represented in the Recommendations, presented in Section 10, and mapped to individual risks in Table 9-2. These risks have been derived from the SWOT analysis and discussions with stakeholders and rights holders. Not all risks impact every province or all aspects of wind energy supply chain development equally.

The likelihood and impact of the identified risks were ranked using a Probability vs. Severity matrix, as shown in Figure 8-1. This matrix considers two key dimensions: the probability of the risk occurring, and the severity of consequences should the risk materialize. The assessment is organized into a 4 x 4 grid, with each cell corresponding to a unique combination of likelihood and impact values.

In evaluating the **likelihood** (probability) of risks associated with a wind project, scores are categorized from highly likely to highly unlikely, as follows:

- **Score 4**: Risks classified as highly likely are nearly guaranteed to take place.
- **Score 3**: Risks in this category require ongoing monitoring, as they are expected to recur.
- **Score 2**: Risks deemed possible may occur closely to fifty percent of the time.
- **Score 1**: Risks categorized as comparatively low probability of occurrence.

Similarly, when assessing the **impact** (severity) of a wind project, scores range from catastrophic consequences to minor potential effects:

- **Score 4**: Risk has the potential to stop industry development entirely.
- **Score 3**: Risk may lead to serious problems in industry development.
- **Score 2**: Risks may create problems, although their effects would not be severe.
- **Score 1**: Risk impact is minimal or negligible.

As a result of this process, risks are plotted on the matrix in a corresponding cell, falling into one of the four risk categories:

- **Low (1 – 2)** risk is deemed manageable. The project may continue, with risk mitigation being a secondary concern.

- **Moderate (3 – 4)** risk can proceed with the project but strive to minimize the risk where feasible.
- **High (6 – 9)** risk requires strategies to diminish either the probability of the risk manifesting or the potential consequences should the risk materialize.
- **Extreme (>12)** risk requires methods to be identified to eliminate the risk entirely (mandatory). This could involve adopting an alternative strategy, refraining from certain actions, or utilizing different tools and equipment.

		Likelihood			
		1 Unlikely	2 Possible	3 Likely	4 Almost Certain
Impact	4 Catastrophic	4	8	12	16
	3 Major	3	6	9	12
	2 Moderate	2	4	6	8
	1 Minor	1	2	3	4

Figure 9-1 – Risk Assessment Matrix

CATEGORIES	RISKS	RATING IMPACT	LIKELIHOOD	RISK	MITIGATING RECOMMED-ATION
Supply Chain	Renewables demand is outpacing supply for essential infrastructure like transmission and distribution components.	2	3	High	2, 17, 19
	Port infrastructure improvements required to handle larger or more frequent/simultaneous shipments of onshore and OSW components.	2	2	Moderate	1, 20
	Current grid capacity is insufficient for the scale of energy production planned.	3	3	High	15
	High federal duty on temporary imported vessels impacting project economics. High cost of doing business in Canada, in general.	3	3	High	19
	Reliance on increasingly strained global supply chain; bottlenecks impacts project development timelines	4	3	Extreme	2, 25
Supply Chain (Diversity)	Lack of formal local content mandates, resulting in potential lack of clarity and visibility of benefits.	3	3	High	3, 17, 21
	Complex and onerous procurement systems may discourage SMEs and underrepresented groups from participating.	2	3	High	3, 4, 8, 9
	Underrepresentation of women and racialized groups compared to broader labor market demographics.	2	2	Moderate	5, 6, 7, 8
	Difficult to identify diverse-owned companies due to lack of reporting; difficult to confirm diverse-ownership without certification.	3	3	High	5, 6
Workforce	Potential labour shortages and requirement for high levels of workforce mobility.	2	2	Moderate	4, 10, 11, 12, 14
	Limitations and issues with existing apprenticeship programs.	2	3	High	13
	Misalignment between provincial training requirements to address any gaps in regional onshore/OSW sectors.	2	2	Moderate	10
	Provincial bottlenecks in workforce and equipment availability across multiple concurrent projects.	3	4	Extreme	2, 11, 16, 22

CATEGORIES	RISKS	RATING IMPACT	LIKELIHOOD	RISK	MITIGATING RECOMMED-ATION
Policy, Leadership & Communication	Resistance from communities due to 'Not In My Backyard' (NIMBY) attitudes and environmental concerns.	2	3	High	16, 21, 24
	Industry uncertain about ability to meet planned CODs, undermining potential investment in additional workforce or supply chain capacity.	2	2	Moderate	16, 22
	Offtake uncertainty/lack of pathways for generated electricity and grid constraints limiting development.	4	3	Extreme	15, 16
	Potential policy changes in the U.S. re: renewable energy priorities. Less opportunity for collaboration with America-first approach.	2	3	High	2, 3, 15
	Complicated and expensive for companies to invest and set up operations in the region.	3	3	High	2, 18, 19
	Global competition from regions with established wind supply chains and stricter local content policies.	2	4	High	2, 18, 19
	Regional disparities in labor market and infrastructure readiness between provinces. Regional competition among Atlantic provinces creating inefficiencies and missed collaboration opportunities	2	2	Moderate	10, 22
	Inter-provincial trade barriers limit the ability of provinces to provide mutual supply chain and workforce support.	3	4	Extreme	10, 22
	Delays in regulatory approvals/offtake agreements and government policy adaptation to support large-scale wind energy projects.	2	3	High	17
	Federal tax incentives and infrastructure funding promised but uncertainty around how to access it.	2	3	High	3, 21, 22
Innovation	Current cost and inflationary pressures may limit investment options within innovation or R&D space.	4	4	Extreme	16, 18

Table 9-2 - Risk Assessment for Offshore/Onshore Wind Supply Chain Development

10 RECOMMENDATIONS FOR SUPPLY CHAIN DEVELOPMENT

The pathways to supply chain and workforce development for offshore and onshore wind in Atlantic Canada are focused on addressing current structural and policy related barriers and subsequently establishing core actions that will ensure the enabled opportunities are accessible to local and Indigenous suppliers, leveraging each of the province's strengths and capabilities to the greatest extent possible. By implementing these actions, Atlantic Canada's wind sector can foster an inclusive, equitable, and sustainable supply chain that benefits all stakeholders. A summary of all recommended actions, along with their relevance to offshore and/or onshore wind, their suggested implementation timeline, and the actions owner is given in Figure 10-1.

	Offshore	Onshore	Timeline			Owner
Supply Chain			S	M	L	
Leverage Existing Supply Chain Strengths						
Long-Term Value Creation in Supply Chain Investments	x	x		M		Government/Utilities/Regulators, Developers and/or Tier 1s, Ports
Explore Manufacturing Interest to Encourage Supply Chain Clustering	x	x			L	Government/Utilities/Regulators, Developers and/or Tier 1s, Ports
Strengthen Wind Industry Ecosystem Support						
Streamlined Supply Chain Development Program	x	x	S			Economic Development/Industry Organizations
Promote and Assist Rural Businesses		x		M		Government/Utilities/Regulators, Economic Development/Industry Organizations
Encourage Supply Chain Diversity						
Establish and Communicate Industry Diversity Expectations	x	x	S			Government/Utilities/Regulators, Economic Development/Industry Organizations
Establish Provincial or Regional Diversity Entities/Entity	x	x		M		Government/Utilities/Regulators, Economic Development/Industry Organizations
Diversity Plans For Large-Scale Projects (>500 MW)	x	x			L	Government/Utilities/Regulators
Facilitate Indigenous Involvement in Offshore and Onshore Wind Industry						
Educate Developers on Indigenous Equity Options	x	x	S			Government/Utilities/Regulators, Economic Development/Industry Organizations, Developers and Tier 1s
Create an Indigenous Supply Chain Hub	x	x		M		Government, Economic Development/Industry Organizations, Developers and Tier 1s
Workforce						
Strengthen Workforce Support Structures						
Commitment to Coordination Between Training Entities	x	x	S			Training/Academia
Industry-Funded Training Initiatives	x	x		M		Training/Academia, Developers/Tier 1s
Improve Access to Training and Workforce Development						
Community Career Opportunity Outreach	x	x	S	M		Training/Academia, Economic Development/Industry Organizations
Strengthen Apprenticeship Initiatives	x	x			L	Government/Utilities/Regulators, Training/Academia
Connect Workers with Jobs in Wind Industry						
Adjacent Industry Workforce Attraction	x	x		M		Government/Utilities/Regulators, Training/Academia, Economic Development/Industry Organizations

	Policy						
	Send Positive Market Signals for Regional Wind Energy Development						
15	Explore Electricity Export Opportunities	x		S	M	L	Government/Utilities/Regulators
16	Set Capacity Targets for Wind Energy Development	x	x		M		Government/Utilities/Regulators
17	Establish Transparent and Predictable Permitting and Offtake Processes	x		S	M	L	Government/Utilities/Regulators, Developers and Tier 1s, Economic Development/Industry Organizations
18	Establish Investable Value of Offshore Wind	x		S	M	L	Government/Utilities/Regulators
19	Explore Reductions in Cost of Doing Business in Atlantic Canada	x				L	Government/Utilities/Regulators
	Policy Support for Local Economic Benefits						
20	Direct Licensing Funds to Build Needed Infrastructure	x				L	Government/Utilities/Regulators
	Leadership and Communication						
	Build Industry Awareness and Support						
21	Public Wind Industry Educational Campaign	x	x	S			Economic Development/Industry Organizations
	Create Supply Chain Development Momentum						
22	Interprovincial Collaboration on Wind	x	x		M		Government/Utilities/Regulators, Economic Development/Industry Organizations
	Innovation						
23	Innovation for Next Generation Wind Technology	x	x	S			Training/Academia, Developers and Tier 1s
24	Carbon Footprint Management in Wind Energy Supply Chain	x	x	S			Training/Academia, Developers and Tier 1s
25	Develop 3D Printing to Support Wind Industry Activities	x	x		M		Training/Academia, Developers and Tier 1s

Figure 10-1 - Summary of Recommended Actions for Wind Industry Supply Chain Development

10.1 Supply Chain

Atlantic Canada has a strong potential OSW supply chain and a relatively well-developed onshore wind supply chain. Both supply chains are primarily service driven, with applicable experience in Project Development, CTI&C, O&M, and well-developed Sector Support services. Capability gaps exist in the manufacturing of major components, which is where the vast majority of project spend takes place, presenting the greatest growth opportunity for localized economic benefits.

Regardless of the success in creating the conditions for manufacturing, there are many opportunities in other parts of the project lifecycles. While there is a great opportunity for local companies to benefit from growth in offshore and onshore wind, many companies lack awareness of these opportunities and the associated requirements. While several companies have participated in onshore wind development, there are projects currently under development that will greatly exceed the scale of any projects built to-date, posing new challenges.

OSW is still in its infancy, although similar in many ways to the offshore O&G industry that Atlantic Canadian companies are familiar with. Many local companies are currently unaware of how and where they fit into these new potential supply chains, and what products and services they can provide. As it stands, companies are clustered in urban centers, while most of the work will be performed away from population centers, necessitating logistical considerations for companies and their employees.

Challenges regarding equitable access to opportunity have been observed in Atlantic Canada's traditional industries, and can be improved upon for offshore and onshore wind while progressing through major growth phases in the region. To ensure that this opportunity is maximized, a focus should be placed on improving supply chain diversity through access to SMEs, rural businesses, and companies with diverse-ownership.

Ensuring Indigenous participation in the wind energy supply chain will support these communities in remaining informed, engaged, and as recipients of a fair share of the economic benefits flowing from this new industry. It is important from a legal perspective, but also in terms of reconciliation and sustainable industry development, that Indigenous communities are supported in their own growth efforts to access the supply chains of these industries.

Leverage Existing Supply Chain Strengths

Atlantic Canada is home to several major quayside fabrication operations and has carried out several large-scale infrastructure projects, resulting in an experienced workforce with strong infrastructure project management capabilities. Leveraging these existing strengths is the first step in building a sustainable and inclusive supply chain.

2. **Long-Term Value Creation in Supply Chain Investments:** Focus early investment in building long-term services that leverage existing experience and can support sustainable industry growth but have lower entry costs. Examples include legal, financial, environmental, engineering, and other professional services that require deep knowledge of industry specifics. These are early industry services without which projects will not be able to get off the ground, therefore this provides initial inertia for industry development while at the same time ensuring long-term value creation.

   In addition to developing services, prioritize timely infrastructure improvements such as in marshaling and O&M ports to support the growth of OSW projects, and the ability to import onshore wind components, in the region. For example, equip ports with cranes and lifting equipment, or provide ample land area for storage and assembly. These efforts will serve the developing wind industries but will also provide lasting benefits and expanded opportunities to ports. Coordination between developers and ports is essential to ensure investments are not wasted by duplication of efforts. Improve transportation infrastructure, including bridges, that will allow for onshore wind industry growth, but will have broader benefits beyond this industry.

   Applicability: Offshore, Onshore

   Timeline: Medium-term (2026-2030)

   Actioned Party: Government/Utilities/Regulators, Developers and/or Tier 1s, Ports

   Next Step: Identify funding opportunities that will allow service-based companies to upskill and/or scale to be able to address the needs of the wind industries. Municipalities, provinces, ports, etc. can partner with federal initiatives like the CIB to build out the types of infrastructure needed to boost development of the local wind energy supply chain. While there is still some uncertainty on the buildout trajectory of both offshore and onshore wind with respect to scale and timeline, it is recommended that actioned parties take stock of where initial developments are most likely to take place to ensure the most long-term value creation possible without duplicating efforts or creating redundancy.

3. **Explore Manufacturing Interest to Encourage Supply Chain Clustering:** While providing service-based support to wind energy projects is crucial in enabling a local supply chain, establishing manufacturing operations in Atlantic Canada, while capital intensive initially, could position the region to capture a greater percentage of total industry revenue. Primary manufacturing facilities have been shown to lead to the creation of supply chain hubs, or clusters, as companies locate in the area to support manufacturing operations and build on efficiencies and costs savings resulting from co-location of supply chain activity. Ideally this would be decentralized from population centers and nearer to project installation sites.

   It must be noted that substantial project pipeline and robust investor confidence is needed before any major component manufacturing can be established. Building on opportunity findings from this study, it is recommended that the region develop a realistic and properly timed strategy to determine what type of manufacturing could be best suited to the region and attract these activities to the region if a sufficient project pipeline is established. This study identified several areas where supply chain bottlenecks have occurred or are likely to occur as the global wind industry expands that could be met by local supply and export. There are already significant lead times for transmission equipment such as transformers, cables, etc. There are several satellite offices of companies that manufacture these components located in Atlantic Canada, as noted in Section 8.2.3 that could be encouraged to establish local operations. Regional experience in constructing major steel and concrete structures could be leveraged to establish serial production of gravity-based foundations, jackets, monopiles, or transition pieces for fixed OSW, various types of substructures for floating OSW, tower sections for onshore wind, and topsides and foundation structures for offshore substations.

   It is generally more expensive to manufacture major electrical and steel components in North America compared to many other jurisdictions, however given the global nature of the wind energy supply chain, it may be possible given the right market conditions to establish such operations in Atlantic Canada. Investors will require a full economic analysis with acceptable returns on investment. Due to the many factors that would need to be considered in building a strategic business plan for attracting manufacturing, the timeline for this recommendation is long-term.

   Applicability: Offshore, Onshore

   Timeline: Long-term (+2030)

   Actioned Party: Government/Utilities/Regulators, Developers and/or Tier 1s, Ports

   Next Step: Entities interested in investing in or developing manufacturing operations in Atlantic Canada will need to carry out additional research to ascertain what type of manufacturing makes the most sense from a global demand perspective and determine whether a sufficient return on investment is possible. This is determined by the project pipeline regionally and globally, as well as global commodity prices. Federal government programs that enable the building of clean energy infrastructure may be able improve the economics of new manufacturing, as was the case with the Inflation Reduction Act in the US.

Strengthen Wind Industry Ecosystem Support

While the existing supply chain has substantial potential, companies need support to become aware of opportunities, understand their role in supply chains, determine what certifications they may need, and know who the major industry players are to capitalize on wind industry growth. Facilitating connections between developers/OEMs/Tier 1 companies and the local business ecosystem is essential in maximizing local supply chain integration.

4. **Streamlined Supply Chain Development Program**: At a minimum, developers/OEMs/Tier 1 companies need to be able to search for companies that meet certain criteria if they hope to create local content in OSW. As higher-capacity onshore wind projects are developed, a similar representation of onshore wind companies will need to be available to source local companies. Businesses will also need other support to expand into these new and growing industries in order to understand where they fit in the supply chain and understand who the industry players are.

   The goal of this program is to assist in local content creation on wind energy projects, operating across all projects that could benefit, to facilitate identification of local companies and mitigate barriers to allowing companies to enter the supply chain. This program would consist of an ongoing series of efforts by an Economic Development/ Industry Organization, or a coalition of provincial organizations, whereby collaboration with developers and Tier 1 and 2 suppliers leads to contracts for local companies.

   The hosting entity will keep a curated list of local companies and their capabilities (i.e. a searchable supply chain database), where companies are vetted for their stated capabilities and any diverse or Indigenous ownership status. Developers and Tier 1 or 2 suppliers looking to subcontract scopes can communicate their needs to the program and receive varying levels of support, including the following:
   - Provide curated lists of companies matching desired criteria and track record
   - Meet-the-Buyer Events with local companies
   - Alerts when RFPs are released, or local opportunities are available
   - Partner identification services to help SMEs form partnerships to access larger work scopes
   - Support programs to help local suppliers meet procurement and certification requirements, including funding opportunities
   - Promote best practices for supply chain building
   - Connecting companies with funding opportunities for scaling operations or retooling
   - Facilitating partnership/JV facilitation between external and local companies

   Applicability: Offshore, Onshore (for large projects)

   Timeline: Short-term (2025)

   Actioned Party: Economic Development/Industry Organizations

   Next Step: MRC already hosts a well-developed, searchable supply chain database of OSW companies across Canada, which is free to access. This database provides the services and relevant markets of all companies, as well as contact and website information. It is recommended that this database be expanded to include additional competencies, expertise and experience as well as begin to track diverse-ownership status of companies. In the medium-term it must be decided if MRC will be the Program host, or if another entity, or group of entities, would be best suited.

As MRC focuses primarily on marine renewable energy, a different entity will need to develop and host an onshore wind database for onshore wind companies, and subsequently develop the other activities recommended for this Program. A critical element of this project would be to secure funding to keep the information up to date.

While these types of programs can have substantial benefits in building out supply chains, they require substantial time and funding to be effective. The host organization will need to build its network and ensure sufficient funding to offer these services. Developers may contribute funds to establish this type of program, along with contributions from government entities or programs. The hosting entity will need to establish a strategic plan for developing and maintaining these services.

5. **Promote and Assist Rural Businesses:** The primary goal of this initiative is to increase awareness of opportunities and understanding of supply chain requirements for local companies. Coordination between industry organizations and rural municipalities, EDOs, and/or Chambers of Commerce should occur to familiarize them with project development timelines of onshore wind projects happening in their region, and to introduce major project proponents to allow for collaboration. Industry organizations will provide information and best practices to rural EDOs/Chambers of Commerce to improve coordination of localized efforts. It is important to communicate the advantages of being able to build economic prosperity by locating work away from major population centers due to the rural nature of onshore wind developments. Establishing virtual engagement tools to overcome geographical barriers and allow entry of rural companies into the supply chain may also be required. Collaboration and buy ins for leadership between Chambers of Commerce/EDOs/municipalities/Indigenous communities in rural areas/areas where projects are being built will ensure equitable distribution of benefits and sufficient resources for projects.

   Applicability: Onshore

   Timeline: Medium-term (2026-2030)

   Actioned Party: Government/Utilities/Regulators, Economic Development/Industry Organizations

   Next Step: As a start, this will consist of information sharing and education on the onshore wind industry's supply chain needs. Community information sessions and business assistance programming should be developed in collaboration with local entities and implemented to ensure rural companies are able to access the same types of support services as companies located in cities to ensure equitable access and shared benefits across the full region. This will also create efficiencies where companies that are nearer to projects are able to be part of that project's supply chain.

Encourage Supply Chain Diversity

While Atlantic Canada has a robust potential offshore/onshore wind supply chain, the makeup of that supply chain does not represent that of the region with respect to diversity. Striving towards both diverse-owned companies and a diverse workforce in the wind energy supply chain will help to ensure equitable benefits distribution, in turn garnering broader industry support.

26. **Establish and Communicate Industry Diversity Expectations:** As processes and protocols for the development and expansion of Atlantic Canada's offshore and onshore wind energy industries are established, government, regulators and policy makers must develop benchmarks and measurable goals for supplier diversity initiatives. These need not be binding but should set a target for developers and their subcontractors to meet. Advocacy for government incentives, such as grants and subsidies, to support diverse-owned businesses in scaling, retooling and upskilling should be made available to encourage development and inclusion. Ahead of an official Diversity Entity/Entities being established (see next recommendation), workshops and roundtables should be held to inform and foster continuous engagement with diverse companies, stakeholders and rightsholders should be held to communicate expectations and best practices.

    Applicability: Offshore, Onshore

    Timeline: Short-term (2025)

    Actioned Party: Government/Utilities/Regulators, Economic Development/Industry Organizations

    Next Step: Following best practices from existing industries in Atlantic Canada, like the offshore O&G industry, government will organize to establish a set of best practices and measurable goals, drawing on the results of studies such as this one for targeted actions.

27. **Establish Provincial or Regional Diversity Entities/Entity:** Establish provincial or regional supplier diversity organizations to guide supplier diversity policies, establish a certification process for diverse-owned companies, monitor progress, and provide resources. This organization should keep a searchable database of certified diverse businesses, with a detailed description of the products/services each company provides, across multiple industries as well as offshore and onshore wind. This information can then be shared with the entity/entities owning the Streamlined Supply Chain Development Program.

    The Diversity Entity will also provide certification of diverse-owned businesses including racialized persons, persons with disabilities, women, and members of the 2SLGBTQIA+ community such that independent verification of company credentials is not required by developers or Tier 1 suppliers when hiring. Certification will require regular renewal or re-verification to ensure accuracy. This entity will also facilitate networking and matchmaking events to connect developers with diverse suppliers and advocacy groups and may even be tasked with reviewing supplier diversity policies for companies.

    Applicability: Offshore, Onshore

Timeline: Medium-term (2026-2030)

Actioned Party: Government/Utilities/Regulators, Economic Development/Industry Organizations

Next Step: Designate responsible party to lead the development of the supplier diversity entity in each province, or a regional entity representing all of Atlantic Canada. Conduct research to establish best practices from similar organizations that exist, such as the Supplier Diversity Office in Massachusetts or in New York. Funding will then need to be secured from government to support such an entity.

28. **Diversity Plans for Large-Scale Projects (>500 MW):** For projects exceeding 500 MW, require developers to include supplier diversity plans in procurement processes (either during licensing or in offtake agreements), with specific actions to engage diverse suppliers during early project phases. These will ensure there is early engagement with underrepresented groups in project frameworks and will establish mandatory tracking, reporting, and publishing of supplier diversity metrics to measure progress, identify gaps, and ensure transparency and accountability.

    Applicability: Offshore, Onshore

    Timeline: Medium-term (2026-2030)

    Actioned Party: Government/Utilities/Regulators

    Next Step: Conduct research into requirements for supplier diversity plan content that has been used in other jurisdictions to begin establishing best practices for the Atlantic Canada region and context.

Support Indigenous Involvement in Offshore and Onshore Wind Industry

While supply chain diversity includes the inclusion of Indigenous communities in the development process and supply chain, it is important for these rights holders to be given additional consideration to ensure inclusivity, equal access to opportunity, and a fair share of economic benefits flowing from the wind energy industries.

29. **Educate Developers on Indigenous Equity Options:** Drawing from existing projects, both in the renewable energy industry and otherwise, where Indigenous entities have part or full ownership of projects and/or infrastructure. Identify best practices and educate developers and Tier 1 companies on how equity options would work, why they are beneficial, and ensure good cultural alignment regarding Indigenous engagement and business practices. Indigenous governments and/or economic development organizations must have a leadership role within this process and be supported by the broader industry. This should be integrated into the Best Practices guides for Consultation.

    Applicability: Offshore, Onshore

    Timeline: Short-term (2025)

Actioned Party: Government/Utilities/Regulators, Economic Development/Industry Organizations, Developers and Tier 1s

Next Step: Engage with Indigenous Governments and Organizations to perform research and gather a collection of successful case studies whereby Indigenous ownership and equity partnerships have been established in energy and infrastructure projects.

30. **Create an Indigenous Supply Chain Hub:** Explore a model for Indigenous communities with little experience in OSW and onshore wind where they can partner/learn from a hub of experts. Services provided would include supplying an intermediary between a Tier 1 or 2 supplier to assist with paperwork and certifications during project proposal and contract signing phases. The hub would assist with partnership building for smaller or less experienced Indigenous supply chain companies by building a consortium with industry players and across Indigenous groups. It would also act as a single point of contact for project developers, limiting the burden of engagement with multiple entities by Indigenous communities, and provide research and advise in areas where companies lack experience. The Virtual Nation initiative described in Section 8.5 provides an excellent example of this recommendation.

    Ideally this entity would also host an Indigenous company database, like the Supply Chain database hosted by MRC, that lists companies by their capabilities, location, size, experience, etc. to make it easier for wind project proponents to seek contract opportunities within these communities.

    Applicability: Offshore, Onshore

    Timeline: Medium-term (2026-2030)

    Actioned Party: Government/Utilities/Regulators, Economic Development/Industry Organizations, Developers and Tier 1s

    Next Step: Engage with Indigenous Governments and Organizations to determine the responsible entity, or consortium of entities, that will launch the hub and determine priorities for initial industry support. Seek funding to support the initiative and begin promotional efforts to build participation across supply chain companies and Developers/Tier 1s.

10.2 Workforce

Atlantic Canada has a very capable workforce given the track record of onshore wind projects and experience in adjacent industries such as offshore O&G and major electrical infrastructure projects. Given the planned acceleration of buildout of the onshore wind industry and based on the outcomes of the Development Scenarios presented in Section 7, it is necessary to grow the available workforce, or timelines may be limited by worker availability.

Atlantic Canada has a robust network of educational and training facilities, and many already provide or are developing necessary wind industry specific training. Currently, there is uncertainty regarding project timelines, capacities, locations, and offtake pathways, posing challenges for training institutions as worker readiness must align with opportunity timelines. In early industry development for OSW, this consideration is particularly pertinent given the 10+ year development timeline for OSW projects. To obtain the most comprehensive understanding and consensus on offshore and onshore wind workforce requirements, it is important to ensure regular communication exists between training entities and ensure that adequate workforce support structures are in place.

Communicating the opportunity and ensuring that prospective workers have access to the required training and upskilling programs is important, particularly in removing barriers traditionally faced by underrepresented groups. Ultimately, it is important to ensure that it is easy for developers and Tier 1 and 2 suppliers to hire local workers. They must be able to communicate directly to workforce organizations, and promote the wind industry to ensure maximum employability, not stealing jobs from other industries.

Strengthen Workforce Support Structures

Access to information regarding training requirements is a major challenge for the development of training programs in support of wind energy projects. Developers and OEMs often hold access to this information; therefore, partnerships and knowledge sharing are important to properly meet the demand.

31. **Commitment to Coordination Between Training Entities**: The purpose of this commitment is to streamline the region's wind energy training programs and ensure that they are fully aligned with industry requirements, expectations, and timelines. Compiling this information, engaging with developers and government, and with each other, will help Atlantic Canadian training entities to build confidence in the industry and its ability to create local jobs. To maximize efficiency, the programs need to complement each other, not compete, and awareness of operations across institutions is essential to achieve this. A regional approach to training will ensure that training is accessible to those that need it.

    Applicability: Offshore, Onshore

    Timeline: Short-term (2025)

    Actioned Party: Training/Academia

    Next Step: Secure funding for the region's training colleges under Canada's Sustainable Jobs Plan to allow for coordinated, collaborative development of new programs. Committed training entities could gain publicity by signing an MOU to signify their commitment to offshore and onshore wind workforce development. An example of this is the Connect4Wind initiative that was established in Southern Massachusetts to support workforce training in the region.

32. **Industry-Funded Training Initiatives:** It is in the interest of Developers, OEMs and Tier 1 and 2 suppliers to have ready access to a trained local workforce. Often training for certain activities is model-specific or provided

exclusively by developers or their affiliates to protect trade secrets. This means that training institutions must partner with OEMs or developers to offer the appropriate training. Global Wind Organization certification, which is mandatory in the OSW sector, is costly and time consuming and may pose a challenge for smaller colleges or training entities without additional external financial support. Formalizing partnerships between developers/OEMs and training institutions serves to provide funding, guidance, and curriculum for industry-focused training programs. An example of this is the $2 million (USD) Windward Workforce program sponsored by Vineyard Wind, and the $160,000 investment made by World Energy GH2 in NL's College of the North Atlantic Wind Turbine Technician program.

Applicability: Offshore, Onshore

Timeline: Medium-term (2026-2030)

Actioned Party: Training/Academia, Developers/Tier 1s

Next Step: Training institutions looking to provide wind industry specific training must establish relationships with project developers to jointly design the training initiatives to supplement their government funding in a way that best suits industry needs and timelines.

Improve Access to Training and Workforce Development

Even when training programs are established there is often a wide cross section of the potential worker landscape that is unable to access the training due to barriers such as a lack of awareness, systemic biases, financial constraints, travel distance, etc. Improving access and removing barriers can help drive workforce growth to help avoid shortages and share the benefits of these industries more equitably.

33. **Community Career Opportunity Outreach:** Organize outreach initiatives to highlight career paths in the wind energy field, focusing on communities that are often overlooked or would not otherwise receive this information (i.e. disadvantaged communities, adjacent industry personnel, rural workers). Inform Atlantic Canadian workforce of the opportunity and requirements in offshore and onshore wind to increase awareness of timeline and job activities required to allow them to identify where their skills may be best placed. This outreach should target K-12 schools through to the trades and higher education institutions, as well as union halls and the general public.

    Applicability: Offshore, Onshore

    Timeline: Short-term (2025 – Onshore); Medium-term (2026-2030 – Offshore)

    Actioned Party: Training/Academia, Economic Development/Industry Organizations

    Next Step: Develop standard educational/workshop materials for different age groups and types of training. Workshops for younger groups would be more general and interactive, while workshops for trades or industry professionals would be more specific and technical. General ad campaigns to raise awareness of training opportunities on social media, TV, and for posting in union halls/training facilities. Funding is likely available for such initiatives through industry or government.

34. **Strengthen Apprenticeship Initiatives:** Apprentices form an essential part of the wind energy workforce; however, the current apprenticeship processes can provide challenges for workers. While this is not unique to the wind energy industry, many apprenticeship programs have a low completion rate, put apprentices in financial difficulty due to employment insurance inefficiencies, are limited by 1:1 ratio requirements, and produce individuals found to be less hireable once they obtain journeyperson certification. Given the current and anticipated future trades worker shortages, it is recommended that government and training institutions focus on increasing and improving apprenticeship opportunities, ensuring apprentices can transition into long-term employment following journeyperson designation. As this will require substantial collaboration between training facilities, industry and government, it has been assigned long-term timeline even though there is an existing need.

    Applicability: Offshore, Onshore

    Timeline: Long-term (2030+)

    Actioned Party: Government/Utilities/Regulators, Training/Academia

    Next Step: Significant strategic planning and collaboration will be required to make improvement to apprenticeship programs in Atlantic Canada, including a full assessment of current issues and mitigative actions. Best practices from jurisdictions with successful apprenticeship development programs, such as Switzerland and Germany, should be gathered and used as models. Training entities should work with government on this as it may be impacted by existing legislation. These changes should be aligned, and applied across the provinces to enable workforce mobility.

Connect Workers with Jobs in Wind Industry

While access to training is essential in workforce development, ensuring that people can find well-paying, sustainable jobs following training is the true measure of success. Developers, OEMs and Tier 1 and 2 suppliers need to have confidence that they are hiring competent personnel, that understand the challenges of working in this industry, such as the strict safety culture.

35. **Adjacent Industry Workforce Attraction:** Many workers in Atlantic Canada have experience in adjacent industries, where skills and activities greatly resemble those needed in offshore and onshore wind. Additionally, there are seasonal workers, and those who's employment is linked to industry cycles and may be seeking to increase their overall employability. Creating upskilling initiatives to allow workers to transition from offshore O&G, onshore construction, mining, and other relevant sectors can meet workforce bottleneck challenges while creating supplementary opportunities for the region's existing workforce. It may even be of interest for companies spanning both wind and adjacent industries to provide the necessary upskilling to their workers to capture greater market share.

Applicability: Offshore, Onshore

Timeline: Medium-term (2026-2030)

Actioned Party: Government/Utilities/Regulators, Training/Academia, Economic Development/Industry Organizations

Next Step: Conduct a multi-sector workforce study to identify workforce demand patterns between adjacent industries and skills needed in competing industries. Determine if efficiencies exist with timing for things like downtime, weather, etc. for roles with transferable skills from adjacent industries. This will give a fuller picture of workforce constraints and need for additional training/worker attraction. This study could be used to inform the other Workforce-related recommendations presented in this report.

10.3 Policy

At the early stages of industry development, policy can have major lasting impacts on supply chain development. The structure of licensing rounds, the regulatory processes that are undertaken and the content of PPA's and other types of offtake agreements can be instrumental in growing a local wind energy supply chain, or not. In Atlantic Canada, there are still many aspects of policy yet to be worked out with regards to the OSW industry. With regards to onshore wind, the region is moving into uncharted territory with projects of a much greater scale than have been built before, introducing additional opportunities to enact supply chain and workforce building policies.

Policy can also provide markets with the confidence needed to make long-term investments, establish local offices and facilities, and build projects in newer, and hence riskier, industries like OSW and green hydrogen. Currently there are gaps in policy which have created significant risks for the growth of both offshore and onshore wind. While policies can be difficult to change or enact, recommendations provided in this section attempt to shape a policy landscape that will accelerate supply chain development and the flow of local benefits to Atlantic Canada.

Send Positive Market Signals for Regional Wind Energy Development

36. **Explore Electricity Export Opportunities:** The incredible wind resource that is possessed by Atlantic Canada will not be developed unless there are adequate end uses and pathways for offtake. While green hydrogen presents an enormous opportunity, this industry is also early in its development and has not reached scale, resulting in some uncertainty regarding the ability to meet stated development capacities, timelines, or cost estimates. It is essential that additional end uses and export markets are considered to fully capitalize on the wind energy opportunity.

    While construction will continue on some projects, the Northeast US states have strong renewable energy targets and have just had their OSW industries paused indefinitely. There has been great interest in creating greater opportunity to export clean energy from Atlantic Canada to this region, where large scale hydro is no longer always considered "clean". It is necessary to quantify this potential market and establish a timeline for development, as is the goal of the New England – Maritimes Offshore Energy Corridor (NEMOEC) initiative.

Exploring options to export wind energy elsewhere in Canada could also create demand, such as a revised and revived Atlantic Loop project. Atlantic Loop could support OSW development by integrating more RE into the grid overall. Given the increased focus on removing barriers to internal trade and increasing self-sufficiency, some version on increased interties and the building of a national east-west grid may become an important priority. There is also the opportunity to explore corporate PPAs to fund the energy transformation. Like the sustainable aviation fuel project proposed by Simply Blue Group in Goldsboro, NS, there are many creative ways to utilize renewable energy without putting it on the grid. Using wind energy for energy-intensive datacenters/server farms is another opportunity that can be considered and promoted to further develop a market for Atlantic Canada's renewable electricity.

Applicability: Offshore

Timeline: Short-term (2025 – NS), Medium-term (2026-2030 – NL), Long-term (+2030 – NB and PEI)

Actioned Party: Government/Utilities/Regulators

Next Step: Provincial and federal governments, utilities, and regulators must collaborate on developing a strategy to develop offtake options in order to capital on this opportunity. Any new transmission will take significant time and resources to build and thus it is critical to prioritize these strategies in the short-term so that they can be executed on in the medium and long term. This will give investors' confidence and provide them with clarity on their options.

37. **Set Capacity Targets for Wind Energy Development:** Currently only NS has established a target capacity for OSW. While NL has completed an RA and signed an MOU with the federal government for development of provincial bays, it has not provided the market with timelines for OSW development or set any capacity targets. Neither NB or PEI have expressed any direct aspirations for the development of OSW.

    Onshore wind information timelines and capacity targets for provincial use (i.e. grid integration) are difficult to determine, with conflicting information referencing different timelines in industry literature. The volume of onshore wind planned for green hydrogen development in NL, while ambitious, has led some to question whether the industry will be able to build projects of such high capacities within the timelines that projects have communicated.

    Investors and project developers require a strong, consistent development pipeline to guarantee them return on investment and to allow them to secure project financing. Provincial onshore wind procurement targets and timelines should be established and clearly communicated to industry (i.e. utility will issue procurement for 600 MW in 2029) as a way of driving supply chain planning and growth. OSW targets should be established for NL, and longer-term targets should be established for NS to signal to the market that there is a sufficient pipeline of activity to merit locating an office in the region, investing in local businesses/partnerships, exploring development options, etc. As NS has committed to holding its first competitive solicitation for seabed licensing in 2025, it will need to communicate how much capacity is currently available for development, what the requirements will be for the solicitation, what the process for obtaining offtake will be (i.e. a competitive bidding process amongst license holders, versus non-competitive negotiations directly with NSP, for instance). Creating regional or provincial wind development roadmaps like in NS would be beneficial.

Applicability: Offshore, Onshore

Timeline: Medium-term (2026-2030)

Actioned Party: Government/Utilities/Regulators

Next Step: Provinces must determine what capacity levels and timelines they are confident in being able to achieve and begin promoting these values publicly. The 5 GW by 2030 in NS is clear, concise and easy to remember. By establishing similar targets in NL, and clarifying development targets and timelines for onshore wind, provinces will be de-risking their industries and encouraging local investment.

38. **Establish Transparent and Predictable Licensing, Permitting and Offtake Processes:** Like setting clear capacity and timeline targets, having a transparent and predictable permitting and approval process is essential for attracting developers to the region. While the CNSOER and the CNLOPB (soon to be renamed CNLOER) will be responsible for regulatory oversight of the OSW industry, processes for permitting and offtake are still being developed. Policy should be established to ensure environmental approval processes are harmonized with any licencing requirements, and are aligned with federal and provincial clean energy goals and industry standards. Developers will need to understand the licensing process: whether it will be competitive, if specific project commitments (i.e. cost, local content, etc.) are required at this stage. Timelines for permitting and approval processes should be agreed upon and communicated as soon as possible, and efforts should be made to minimize timelines wherever possible to keep project costs low.

    While there will likely be different offtake options for OSW developers in Atlantic Canada, understanding the requirements of the region's utilities with respect to PPAs, and understanding regulations around corporate PPAs and other offtake mechanisms should be readily available and clearly communicated. These processes often include commitments on supplier diversity, local spend, and local supply chain activity—all of which also have the potential to impact project costs—therefore the sooner project developers understand these processes the better able they will be to make these considerations on their projects.

    Applicability: Offshore

    Timeline: Short-term (2025 – NS), Medium-term (2026-2030 – NL), Long-term (+2030 – NB and PEI)

    Actioned Party: Government/Utilities/Regulators, Developers and Tier 1s, Economic Development/Industry Organizations

    Next Step: Collaboration between governing agencies, government and industry organizations is crucial to build a body of best practices around permitting, licensing, and offtake to determine what processes will work best in the

Atlantic Canada context. A draft of the licensing requirements should be released as soon as possible in NS to enable industry and public input. Where possible, these efforts should be streamlined across provinces to simplify industry development and allow for developers to achieve efficiencies in project development processes.

39. **Establish Investable Value of Offshore Wind:** One of the greatest strengths of the Atlantic Canadian region with regards to wind energy is the world class wind speeds both offshore and onshore. Despite this, a full resource assessment has yet to be carried out to determine the full value of the developable offshore areas. It is recommended that a publicly funded, high-quality assessment of wind resources for OSW is initiated, with priority for the NS offshore area in the near-term, to establish the value of OSW for investors and utilities. Development of a high-quality wind resource data on a broad scope for the region would be of great interest to project developers and utilities. A critical element of the detailed data modelling would be to establish where OSW developments can fill in for onshore wind production.

    Applicability: Offshore

    Timeline: Short-term (2025 – NS), Medium-term (2026-2030 – NL), Long-term (+2030 – NB and PEI)

    Actioned Party: Government/Utilities/Regulators

    Next Step: Implement existing NRCan proposal to collect high-quality OSW data as soon as possible and fund new research programs to support efforts to collect, model and manage site-specific data collection.

40. **Explore Reductions in Cost of Doing Business in Atlantic Canada:** Canada is known as having a high cost of doing business due to high wages, a strong currency, a demanding tax regime, protectionist trade practices—including between provinces—and a difficult to navigate regulatory environment. To unlock economies of scale, workforce opportunities, and interprovincial supply chain development, it is recommended that the various governments seek to remove inter-provincial trade barriers to allow for a freer flow of goods, services, and workers across provinces. Revisiting the Federal Duty on Temporary Imported Vessels could have major impacts on OSW project economics given the extent to which vessels are required during complex installation campaigns. Finalizing policy around Federal tax incentives for renewable energy development would also create additional interest for businesses seeking to establish themselves in the Atlantic Canadian wind energy industry.

    Applicability: Offshore

    Timeline: Long-term (2030+)

    Actioned Party: Government/Utilities/Regulators

    Next Step: Government must conduct market research to determine which policies are currently having the greatest negative impact on the development of the offshore and onshore wind industries relating to business attraction to the region. Legislation should then be prioritized that would streamline processes and remove barriers. This will require significant strategic planning, hence will be enacted on a long-term basis.

Policy Support for Local Economic Benefits

41. **Direct Licensing Funds for Industry Development:** Policymakers are urged to explore creative solutions, such as using revenues from seabed licensing auctions, to fund various industry building activities. This could include transmission and other needed infrastructure, like bridges, ports, roads, etc., provide workforce upskilling, or fund other high priority/high impact recommendations given in this report. With sufficient revenue this approach could also be targeted to large-scale infrastructure projects, such as interconnectors that would facilitate the export of electricity to other regions, such as the northeastern US.

    Applicability: Offshore

    Timeline: Long-term (2030+)

    Actioned Party: Government/Utilities/Regulators

    Next Step: As processes are being developed for licensing, permitting and offtake, this revenue utilization model should be considered for feasibility in greater detail.

10.4 Leadership and Communication

Build Industry Awareness and Support

A major risk that was identified during this scope is the resistance to offshore and onshore wind development that is already observable in the region. Much of this results from a lack of transparency around development processes, additional earlier government engagement requirement, scales and timelines, insufficient communication, and a lack of understanding of local benefits. Misinformation around project outcomes can easily be believed in the absence of effective engagement.

42. **Public Wind Industry Educational Campaign:** There needs to be more transparency in the planning/community consultation process to better manage expectations regarding offshore and onshore wind development. Government should engage as early as possible to communicate their development strategy and obtain community input. Regional energy literacy initiatives should be launched, either by government or industry organizations, designed to inform, educate, engage, and involve communities, Indigenous communities and businesses about what wind energy entails, about the real impacts of its operations, and the benefits that will flow to communities. It is critical for communities to be fully informed and able to make decisions. Understanding the region’s renewable energy plans is a precursor to building local acceptance and support for major energy projects. Government and Industry Organizations must organize around, and promote, the economic opportunity for Atlantic Canada from wind energy as part of the region's position as an energy sector leader.

Applicability: Offshore, Onshore

Timeline: Short-term (2025)

Actioned Party: Government/Utilities/Regulators, Economic Development/Industry Organizations

Next Step: Establish unified and cohesive messaging around wind energy technology, planned developments, associated technologies, environmental impacts, and community benefits.

Create Supply Chain Development Momentum

43. **Interprovincial Collaboration on Wind:** The four Atlantic Provinces would benefit from collaborative marketing, investment attraction, and supply chain development with a unified approach in the furtherance of the offshore and onshore wind industries. By presenting the region as a cohesive unit it strengthens the value proposition of the region compared to any individual province. While each province has its own strengths, together the offering to support wind energy development is much stronger. This would require collaboration between governments and Economic Development/Industry Organizations on messaging and promotion, but could be achieved through jointly attending conferences and trade shows, travelling together as a delegation to meet with industry players or view existing operations, and presenting a united front in the media, offering a positive message about wind energy being of mutual benefit to the full region. This approach would also allow for sharing of resources and improved communication between provinces.

    Applicability: Offshore, Onshore

    Timeline: Medium-term (2026-2030)

    Actioned Party: Government/Utilities/Regulators, Economic Development/Industry Organizations

    Next Step: As this is a complex undertaking, provinces must first align on desired outcomes and prepare a multi-year work plan.

10.5 Innovation

Atlantic Canada has a global reputation for being a centre of excellence in marine engineering and nautical science. The many research institutions that exist across the region have proven track records in technology development for icy and harsh weather conditions, autonomous and remote sensing, robotics, etc. that can be leveraged to support the growing wind industry, while also growing the regions reputation to include wind energy expertise and specialization.

44. **Innovation for Next Generation Wind Technology**: Leverage the existing R&D ecosystem to foster innovation and sector leadership by establishing R&D projects in partnership with universities, public, and private sector entities to address technological challenges in wind energy. Focus on areas such as energy storage, hydrogen production, wind turbine efficiency, harsh weather design, ice resistant turbines, foundations for rocky conditions,

floating OSW technology, decarbonization of offshore O&G production activities, etc. to build intellectual property and technical leadership in the region. Leverage strong position in remote sensing, monitoring, and robotics to explore ways projects can be assessed, built and operated at a lower cost. Cross-sector collaborations between defense and commercial industries highlight dual-use technology applications, such as advanced robotics, automation, etc. which can enhance efficiency in both sectors.

Applicability: Offshore, Onshore

Timeline: Short-term (2025)

Actioned Party: Training/Academia, Developers and Tier 1s

Next Step: Institutions with an R&D focus should be encouraged through private or public funding to undertake research in any of the areas mentioned above. Students of all ages should be encouraged to undertake research and design projects with offshore/onshore wind as a focus. Companies specializing in structural design R&D may be able to obtain funding to develop new technology.

45. **Carbon Footprint Management in Wind Energy Supply Chain:** While it is challenging to correct misinformation regarding wind energy technology, the industry would benefit from community support for R&D efforts to reduce the carbon footprint of the wind energy supply chain by optimizing processes and using sustainable materials. For example, using recycled carbon fiber to make turbine blades lighter and durable, bio-based resins for blade manufacturing, recycled steel and aluminum for tower construction, natural fiber composites and advanced coatings/paints to protect corrosion and extending lifespan. One current area of particular interest is alternate uses for retired turbine blades, which are notoriously difficult to recycle. A significant opportunity also exists in transitioning to alternative fuels to support and service wind farms sustainably, aligning with global decarbonization goals.

    Applicability: Offshore, Onshore

    Timeline: Short-term (2025)

    Actioned Party: Training/Academia, Developers and Tier 1s

    Next Step: Institutions with an R&D focus should be encouraged, through private or public funding, to undertake research in any of the areas mentioned above. Companies specializing in materials or process R&D may be able to obtain funding to develop new technology.

46. **Develop 3D Printing to Support Wind Industry Activities:** All provinces in Atlantic Canada posses existing capabilities for advanced 3D printing of custom parts using various materials. These companies are on the cutting-edge of technological development, serving multiple industries. The offshore O&G industry already benefits from

these services to source hard-to-procure replacement parts. This model could be expanded to onshore and offshore wind, reducing reliance on imports, and providing reprieve when obsolete parts need to be replaced.

Applicability: Offshore, Onshore

Timeline: Medium-term (2026-2030)

Actioned Party: Training/Academia, Developers and Tier 1s

Next Step: Suppliers, R&D entities and industry will need to align on the path forward that will provide greatest value, and develop processes and products together that will assist in driving the wind industry forward. There will likely be a need for partnership agreements with OEMs to manage intellectual property requirements.

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APPENDIX A STAKEHOLDER ENGAGEMENT FRAMEWORK

A.1 Stakeholder Engagement

This Stakeholder Engagement Framework outlines the types of stakeholders, overarching approach and considerations, as well as the associated communication plan applied in this project. This includes the timing of engagement, methods of communication, and targeted outputs delivered. The project team was committed to transparency, information sharing, and meaningful engagement. By fostering an open dialogue, the collective insight and experience of stakeholders were sought to develop effective solutions and foster successful collaboration. The Stakeholder Engagement Framework follows three steps, as shown below:

Stakeholder Mapping	Stakeholder Engagement	Strategy Customization
• Identification • Analysis (Influence & Interest Matrix, Regional Impact, etc.) • Steering, Focus Groups	• Outreach Strategy • Targeted emails, calls, meetings • Workshops & Facilitation	• Feedback & Listening • Customized Adjustments • Expectation Management

Stakeholder Mapping

The first phase of stakeholder engagement required the team to identify all relevant stakeholders within the scope of work. This was done based on the project team's in-depth knowledge of the Atlantic Canadian stakeholder landscape, with outputs captured in an Excel spreadsheet titled 'Stakeholder Outreach'. Stakeholders were mapped according to the following categories:

- Academia/Innovation
- Advocacy
- Economic Development
- Government
- Industry Organization
- Port
- Project Developer
- Stakeholder
- Supply Chain
- Indigenous Development
- Utility
- Training/Labour
- Other

In addition to categorizing stakeholder groups, key contacts were captured and provincial affiliations assigned. Outreach and engagement activities were tracked in this spreadsheet, which was kept in a shared folder accessible to the full project team. The goal of this exercise was to identify and incorporate a diverse range of voices, perspectives, and levels of involvement, thereby facilitating constructive dialogue and collaboration. The Stakeholder Outreach spreadsheet was shared with MRC and the PSC to ensure completeness. By acknowledging the diversity of perspectives and interests surrounding these studies, the project team sought to forge a collaborative path forward that ensures the responsible development of offshore and onshore wind, hydrogen, and energy transmission systems.

Engagement, Screening, and Analysis

Following the identification of the various stakeholders, the project team began creating a shortlist of stakeholders through targeted prioritization and screening. As the majority of engagement with supply chain companies was targeted to occur following the supply chain assessment, supply chain companies were excluded from this exercise for the most part. This exercise ranked each stakeholder by Influence/Power and Interest in the subject at hand, specifically the offshore/onshore wind supply chain. Each stakeholder was ranked on a scale of 1 to 5 on Influence/Power and Interest by project team leads, then averages were calculated and plotted.

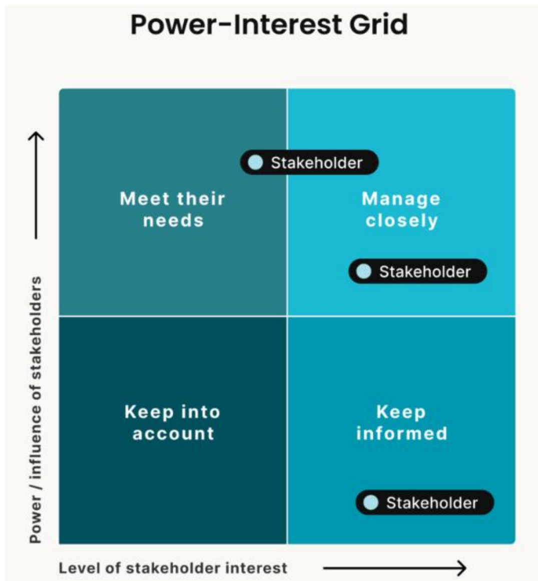
Interest refers to the degree to which a stakeholder is affected by or interested in the outcome of a project/decision/industry. Stakeholders were ranked on Interest according to the following scale:

1. Low interest. Casual interest or curiosity, with either indirect impact or no discernible effect.
2. High interest. Have a direct stake in the project, decision, or industry and are likely to be materially affected by its success or failure.
3. Moderate to low interest. Casual interest or curiosity with minor direct impact.
4. Moderate interest. Interested and engaged in learning about project/decision/industry. Impacted in some way.
5. Moderate to high interest. Direct or indirect stake in the project/decision/industry or minor direct stake. The possibility of being materially affected by its success/failure.

Influence/Power refers to the ability of a stakeholder to influence the outcome of a project/decision/industry. Stakeholders were ranked on Power/Influence according to the following scale:

1. Low power/influence. Limited to no influence; further removed from industry and related decision-making processes.
2. Moderate to low power/influence. Some influence but no decision-making authority. May have a public platform but unlikely to influence public sentiment.
3. Moderate power/influence. Has some authority/capacity to make decisions, allocate resources, and/or shape industry direction in some way. Some ability to influence public sentiment.
4. Moderate to high power/influence. Has authority/capacity to make decisions, allocate resources, and/or shape industry direction in some way. Has access/ability to influence public sentiment in some way.
5. High power/influence. Have ultimate authority/capacity to make decisions, allocate resources, and/or shape industry direction. High level of access/ability to influence public sentiment.

Engagement approaches were then determined using the categories outlined in the figure below. Most stakeholders ranked through this exercise fell under the "Manage closely" category, where their input was considered important to the scope, and they would also be interested in the outcomes. The majority of stakeholders in this category were government, developers, industry associations, regulatory bodies, and Indigenous groups.



Stakeholders in the "Keep into account" quadrant needed to be considered through the project, but engagement was not deemed critical from a supply chain perspective. These stakeholders primarily represented academia, innovation, and industry associations not directly affiliated with offshore renewables. Stakeholders in the "Keep informed" quadrant were considered not critical for engagement, but would benefit from the results of the study. This included ports, regional and municipal development organizations, some key major fabrication companies, and more industry associations. There were not many stakeholders in the "Meet their needs" category; these would be important from a regulatory or social license perspective with regards to the power they hold to influence industry developments.

In addition to influence and interest, in determining a short list of stakeholders to prioritize for engagement other considerations included: known industry participation, history of engagement (i.e. network of project team members), geography, demographic aspects, preferences of MRC and PSC, and level of industry knowledge (attained or required). While supply chain companies were not the primary focus of engagement in this exercise, a number of known, high-potential supply chain companies, primarily those with physical infrastructure or existing industry experience, were included.

Customization and Feedback

The project team provided stakeholders or stakeholder groups with the option to engage in follow-up conversations, where appropriate, to elaborate on or clarify any points. Meeting minutes were recorded and analysed for each session. The responses within the meeting minutes were reviewed and grouped where applicable, giving an organised overview of the outputs of meetings and feedback.

Additionally, the project team invited key stakeholders—identified through insights gained from the initial engagement and based on input from MRC and the PSC—to participate in a workshop prior to submitting the Final Report. This workshop presented recommended actions for supply chain development resulting from the study, and invited participants to make their own recommendations. These were ranked according to an Impact vs. Difficulty/Cost matrix to assign priority.

A.2 Communications Plan

Following the prioritization of stakeholders for outreach, a "Communications Plan" was implemented. This plan detailed the strategy for outreach while clearly articulating the project and engagement purpose, ensuring that these were aligned to serve each other. It outlined the methodology that outreach would follow to ensure consistency and quality outcomes, and detailed how these outcomes would be reported to synthesize insights from multiple stakeholder engagements into a cohesive body of useful information.

Initial Outreach

Based on the stakeholder mapping and prioritization carried out by the project team, stakeholders targeted for outreach were sought to be approved by MRC and the PSC. Outreach to various entities within stakeholder organizations was conducted by both MRC and the project team via email, introducing the project, stating its purpose, and requesting a future interview. If the stakeholder was amenable, a project interview was scheduled at a mutually convenient time either via Microsoft Teams (virtually) or in-person.

Project Purpose

It was important to communicate the project's purpose to the stakeholder at the start of the discussion, including in the initial outreach email, and then again at the start of the interview. The objectives of this study were communicated as follows:

- Providing an overview of offshore and onshore wind supply chains
- Establishing an understanding of the current status and capabilities of the Atlantic Canadian wind supply chain
- Providing an analysis of industry requirements for offshore and onshore wind supply chain needs
- Delivering an assessment of offshore and onshore wind supply chain opportunities in Atlantic Canada to inform an action plan for supply chain development
- Develop recommendations and strategies to address supply chain gaps and challenges, support existing Atlantic Canadian companies that may form part of the supply chain, and develop a strategy for partnership building between companies and the workforce.

The suggested dialogue to communicate the project scope was provided as follows:

"We have been awarded the project "Atlantic Wind Energy Supply Chain Assessment & Pathways for Supply Chain Development" by Marine Renewables Canada, supported by funding from the Atlantic Canada Opportunities Agency (ACOA), Nova Scotia Department of Natural Resources and Renewables, and Prince Edward Island Energy Corporation.

The aim of this study is to identify pathways for developing a Canadian offshore wind supply chain and furthering growth in onshore wind supply chain capabilities. This project will help industry, suppliers, governments, and other stakeholders to understand the existing and potential supply chain opportunities. Your insights, paired with the results of an Atlantic Canada supply chain assessment, will be synthesized into actionable recommendations that will establish sustainable industries, maximize local benefits and content, de-risk future projects, and identify strategic investment opportunities.

All interviewees will remain anonymous unless requested otherwise."

Interview Methodology and Guidance

The basic guidelines that were used for the stakeholder interview are presented below:

- 30 minutes to 1 hour duration to ask questions and inform the study based on their area of knowledge, expertise, or relevance.
- Engagement centered on industry interviews to understand the current offshore/onshore wind capabilities (i.e, trends, leading industries, workforce strengths, regional economic considerations, etc.).
- MRC will approve all outreach conducted through this project scope before it occurs.
- While the conversation should seem natural, ensure all standard questions are asked, and ask follow-up questions as required.
- Team members with knowledge/experience in the interview area should be present (i.e. those with knowledge of NB policy landscape should participate in interviews with NB policy makers).
- Be respectful and remain primarily in listening mode. Keep opinions neutral to avoid influencing the conversation outcomes.
- Following the interview, be sure to thank the interviewee for their time, offer the opportunity to reach out for a follow-up interview (if necessary and appropriate), and specify when the study results will be made available. Ask if the interviewee would like to be acknowledged in the report.

Reporting

In order to be able to accurately and reliably refer back to interview content, the following practices were followed:

- Interviewees remained anonymous. No direct quotes are to be used, and nothing is to be attributed to a specific interviewee unless they request otherwise. Observations and statements may be broadly attributed to a stakeholder group - e.g., "A developer interviewed for this scope stated…"
- Questions may be provided in advance if requested.
- Two team members (minimum) are required to attend each interview, with the aim of having one team member ask questions and another take notes. Notes should be detailed enough to use as a reference when writing the report.
- Minutes should be formatted according to the project template and stored in Word and PDF format in the appropriate project folder.

APPENDIX B INDIGENOUS ORGANIZATIONS AND PROJECTS

B.1 Consultation and Engagement

Crown Consultation and Proponent-led Engagement

The Provincial and Federal Government have a duty to consult Aboriginal peoples in Canada when contemplating decisions that have the potential to impact established or asserted Aboriginal or Treaty rights adversely. While industry proponents do not have a legal duty to consult, they are encouraged to engage with Indigenous groups before the initiation of formal consultation by Government, during formal consultation, and after the formal consultation process, throughout the life-cycle of their project.

During the consultation process, the Government may formally delegate procedural aspects of consultation to proponents. Proponents possess in-depth technical knowledge regarding their project, which makes them best suited to address questions and concerns identified by Indigenous groups during the project's development. Engagement activities undertaken by a proponent, along with any accommodation measures informed by these activities, may be relied upon by the Government to assist it in discharging its duty to consult.

Where and when the Consultation process is triggered may vary depending upon circumstances, including previous consultation processes and agreements in each province. For more details on Consultation for each Province, see:

Nova Scotia: https://novascotia.ca/abor/office/what-we-do/consultation/
New Brunswick: https://www2.gnb.ca/content/gnb/en/corporate/promo/duty-to-consult-portal.html
Prince Edward Island: https://www.princeedwardisland.ca/en/information/executive-council-office/understanding-indigenous-matters
Newfoundland and Labrador: https://www.gov.nl.ca/exec/iar/files/aboriginal_consultation.pdf

B.2 Indigenous Organizations and Partnerships Supporting Energy Sector Participation

For many onshore-renewable energy projects in the region, Indigenous Bands are participating individually and directly as owners. They have partnered with developers in response to provincial government and utility programs, bringing equity capital to the projects with returns to the band and its members. Several organizations in the region are now leading on project investments, leading to the growth of the wind energy supply. Here, a non-exhaustive list of such organizations and partnerships are detailed, provided as an example:

Wskijinu'k Mtmo'taqnuow Agency (WMA)

- **Indigenous Reach:** WMA is an economic development partnership owned by the 13 Mi'kmaw First Nations communities. Created by the 13 NS Chiefs in 2019, WMA explores opportunities to participate in economic activities that benefit the nation. Their participation typically takes the form of joint ventures and equity investments. WMA develops partnerships with industry leaders to participate in opportunities happening in the province..

- **Key Role:** The WMA has been a lead investor in clean energy projects such as the NSP Battery Storage Project and the Province's 2022 rate-based procurement call for more wind, which included the 150 MW Benjamins Mill Wind near Falmouth in Hants County, developed by Natural Forces Development and WMA.

North Shore Tribal Council (NSTC)

- **Indigenous Reach:** NSTC represents seven Mi'kmaq Nations in NB, including Red Bank, Eel River Bar, Pabineau, Eel Ground, Indian Island, Buctouche, and Fort Folly.
- **Key Role:** NSTC has a well-staffed energy division dedicated to capacity-building for members seeking employment in the energy sector. It also provides Indigenous supply chain support and authored a supply chain readiness report for the nuclear industry in NB.

Confederacy of Mainland Mi'kmaq (CMM)

- **Indigenous Reach:** CMM represents all eight mainland NS First Nations: Acadia, Glooscap, Bear River, Annapolis Valley, Millbrook, Sipe'kne'katik, Pictou Landing, and Paqtn'kek.
- **Key Role:** CMM delivers a broad range of support services to its member communities, including health, employment, procurement, environmental, and emergency services. Recently, it expanded into the energy sector, focusing on renewable energy. CMM provides direct procurement support to its members for contracts and tenders and has extensive experience in training initiatives.

Qalipu First Nation

- **Project:** Partnering with World Energy GH2 on *Project Nujio'qonik*.
- **Scope:** Developing 4 GW of renewable electricity through wind projects on Newfoundland's west coast, along with a hydrogen and ammonia production facility in Stephenville for domestic and international markets.
- **Role:** The Qalipu Development Corporation plays a central role in project execution and benefits realization.

Miawpukek First Nation

- **Project:** Partnering with ABO Energy and Copenhagen Infrastructure Partners on the *Toqlukuti'k Wind and Hydrogen Project*.
- **Scope:** Located near the Isthmus of Avalon, this project will generate green hydrogen and ammonia using Newfoundland's world-class wind resources.
- **Cultural Significance:** The project's name, *Toqlukuti'k*—meaning "working together" in Mi'kmaq—reflects the spirit of collaboration.

Exploits Valley Renewable Energy Corporation (EVREC) & Qalipu First Nation

- **Project:** A large-scale green energy development in central Newfoundland.
- **Scope:** Generating over 3 GW of onshore wind energy for green hydrogen and ammonia production.
- **Impact:** The partnership emphasizes community engagement, economic benefits, job creation, and infrastructure development.

APPENDIX C ADDITIONAL SUPPLY CHAIN REQUIREMENTS

C.1 Project Cost Breakdown

Approximate, overall costs per MW installed for fixed, floating, and onshore wind are provided in Figure C-1. Please note that costs are highly variable based on project parameters, and this comparison is provided for comparative purposes only. Floating OSW is approximately forty percent as expensive as fixed OSW and about four times as expensive as onshore wind.

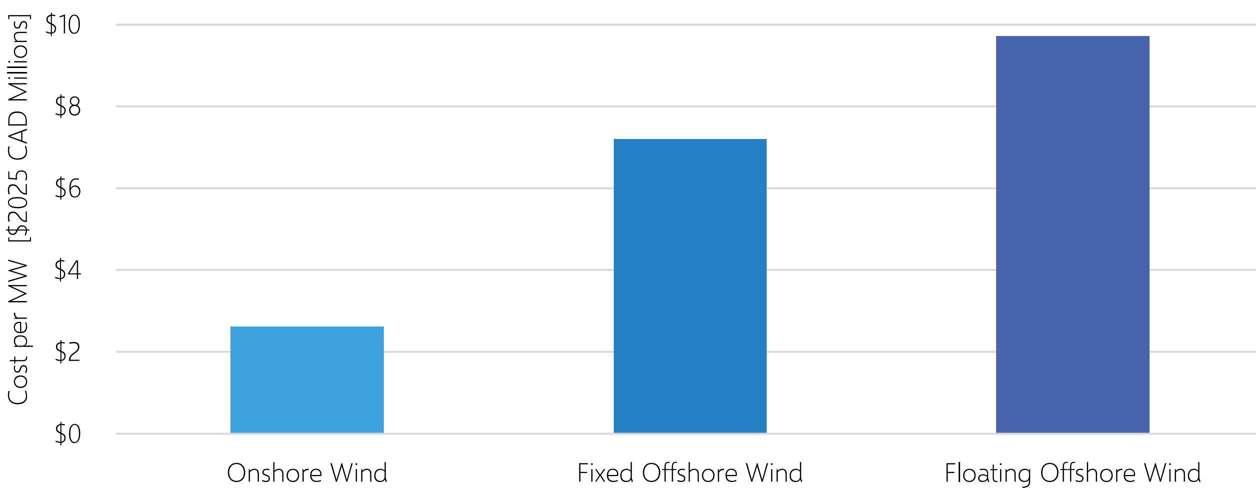


Figure C-1 - Approximate Cost per MW by Wind Energy Technology [63]

This section will discuss the cost breakdown by project spend category for fixed, floating, and onshore wind as illustrated in Figure C-2. Development expenditure (DEVEX) refers to the cost of project development activities, including engineering, survey work, project management tasks, permitting, and conducting Environmental Assessments (EAs) and Environmental Impact Assessments (EIAAs). Capital expenditure (CAPEX) funds are used to acquire, upgrade, and install physical assets. Wind energy projects have a large capital expenditure (CAPEX) due to the extensive physical infrastructure required and the significant amount of steel employed. Fluctuations in commodity prices and global supply chain disruptions significantly impact these costs. Operating expenditure (OPEX) refers to the costs incurred by a company through its day-to-day operations, including maintenance activities and overheads such as insurance, office space, and storage space. Decommissioning expenditure (DECEX) refers to the cost incurred for the removal and disposal of infrastructure when it has reached the end of its useful life.

The cost breakdowns defined here are given as a percentage of total spend and are highly subjective to varying project, environmental, and financial conditions. The purpose of this section is to provide a breakdown of spending to allow for comparison across technologies and supply chain packages. Please note that all costs presented are approximate estimates, and individual project costs depend on numerous factors, including scale, region, technology, and other relevant factors.

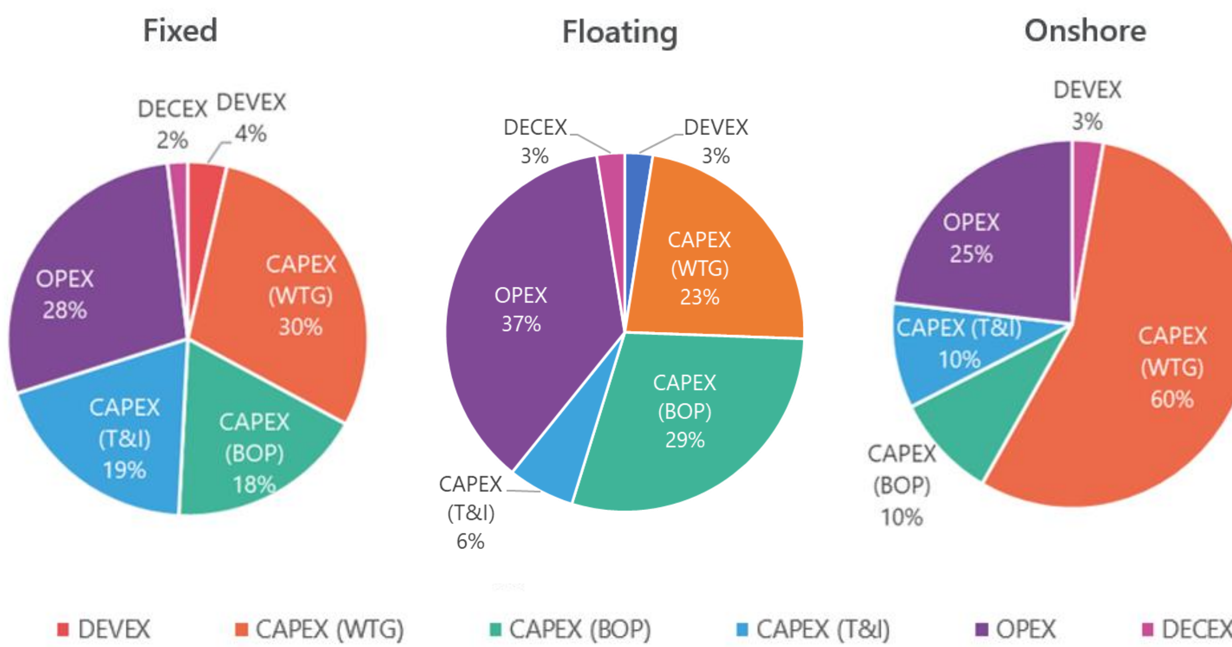


Figure C-2 - Cost Breakdown by Project Phase for Fixed, Floating, and Onshore Wind [63] [64] [65]

Fixed OSW

The fixed OSW market has established itself over the course of more than 30 years since the first fixed turbine was installed, allowing the market to mature and reduce overall costs. More recently, the global pandemic and wars in Europe and the Middle East have disrupted supply chains, causing increases in commodity pricing and reversing some of the cost improvements that had been observed.

In 2019, the total estimated cost for a fixed OSW project was approximately $4.8 million/MW CAD [64]. CAPEX is by far the most expensive phase of fixed OSW projects, with CTI&C accounting for the majority of the cost. This is attributed to the high costs associated with the vessels, which are very expensive to build and lease. Additionally, turbine components are manufactured worldwide, and the cost of transporting each component to the project site significantly adds to project costs. Fixed OSW is a more established market than floating, and serial production has been achieved for the majority of components, resulting in lower overall CAPEX for component foundations compared to floating, due to economies of scale and lower manufacturing complexity between monopiles and assembled floating foundations.

DECEX costs are relatively higher for fixed than for floating or onshore wind due to the complicated process of removing foundations embedded in the seafloor and the need for high-cost vessels to transport components back to shore.

Floating OSW

Floating OSW is still in its nascency as an industry, with the first floating turbine installed less than 20 years ago and the largest installed floating OSW farm to date having a capacity of only 88 MW. There is no dominant floating substructure technology, meaning serial production has yet to ramp up, and economies of scale have not yet been realized. The floating structure is also more complex and dynamic than that of a fixed turbine. These factors mean that a floating OSW project currently experiences higher costs than either fixed or onshore wind projects. The total estimated cost for a floating OSW project is $8 million/MW [64]. Given the high costs of the substructure, CAPEX (BOP) is the most expensive package, with the floating substructure accounting for 22% of the total project cost.

As the WTG is integrated with the substructure at quayside, transportation and installation costs are proportionally less than for a fixed OSW project. During the O&M phase of a floating OSW farm, major interventions will typically require the WTG and floating substructure to be towed back to quayside, which limits spending on activities like major component replacement, which is pricier when carried out at sea, as is the case for fixed OSW. Likewise, DECEX is reduced as decommissioning this type of project is much more straightforward than removing a fixed OSW turbine that is embedded in the seafloor.

Onshore Wind

The most established market of the three wind energy technologies being discussed in this report is onshore wind. The wind turbines are smaller than those used offshore, allowing for transportation via road and rail. As the installation process takes place on land, significant vessel expenses are avoided, as are the more expensive subsea cables and the need for an offshore substation. The total estimated cost for a typical onshore wind farm is $3 million/MW CAD [66].

The most expensive component of an onshore wind project is the WTG itself, accounting for approximately 45% of the total project cost. Decommissioning costs are highly dependent on factors such as terrain, location, and foundation type for an onshore wind farm. Hence, a consistent percentage of the total cost was not available at the time of writing and has been excluded from this study.

C.2 Supply Chain Requirements

To prepare for the supply chain assessment and adequately describe Atlantic Canadian companies in the context of offshore and onshore wind, it is necessary to define major components and key services with respect to the associated industrial capabilities required to fulfill supply.

In this section, subcomponents, materials, and services are defined by major component/service as outlined in Table 4-1. Requirements for each supply element are given in Table C-1 to Table C-11. Note that these definitions are intended to be inclusive of fixed, floating, and onshore wind, although not all requirements apply to all wind energy technologies.

Nacelle

A wind turbine nacelle, situated at the top of the tower, houses the complex electromechanical systems necessary to generate electricity. This system is comprised of the main shaft and bearing, gearbox, and generator, and pitch and yaw systems. The rotor, including the blades, connects to the nacelle and is often referred to as the "nacelle-rotor assembly." Many nacelle components require high precision and low tolerances; hence, suppliers are firmly vetted by OEMs, who often ensure a backup supply for these operations-critical components.

The nacelle assembly process involves bringing together these subcomponents and subassemblies and conducting pre-commission testing and verification. Steps include checking and cleaning parts upon arrival at a quayside assembly facility, then lifting, assembling, and tensioning the subcomponents and subassemblies, followed by cleaning and painting the finished product. The assembly process requires a skilled workforce operating within a large, covered facility equipped with an overhead crane and/or a rolling assembly frame, which moves the assembly from station to station.

Three global OEMs dominate the Western OSW market: Vestas, GE Vernova, and Siemens Gamesa. They primarily assemble their nacelles in Denmark, the United Kingdom (UK), and other European countries, although there have been significant efforts to localize nacelle assembly in the US. Regarding onshore wind, major OEMs include the OSW OEMs, as well as Nordex SE, Enercon, and Suzlon. Key Chinese OEMs, such as Mingyang Smart Energy Group, Goldwind, Shanghai Electric, and Envision, among others, are gaining increasing popularity, particularly in South America, due to their lower costs.

Table C-1 - Key Subcomponents, Materials, and/or Services required for Nacelle Assembly

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY APPLICATION
Auxiliary electrical systems	Industrial electrical equipment Other goods supply
Bedplate	Metal castings and forgings
Coatings	Coatings and marine corrosion protection supply
Cover	Glass fiber supply Metal castings and forgings
Gearbox	Precision component fabrication Metal castings and forgings
Generator	Industrial electrical equipment supply
Hub casting	Metal castings and forgings
Main shaft and bearing	Metal castings and forgings Precision component fabrication
Pitch and yaw systems	Precision component fabrication

Blade

Each wind turbine has three blades, connected to the nacelle through the rotor. The blades must be strong enough to withstand high wind loads and vibrations while remaining flexible, so they require specialized materials and manufacturing processes to ensure their low weight, strength, and durability. During manufacturing, shell molds are prepared by first applying an epoxy-based gel coat, followed by the addition of structural layers, including glass fibers, within the mold. Prefabricated root elements, including steel inserts and foam cores, as well as the metal tip element, which provides lightning protection, are also added to the mold. The main structural element, the spar cap, which consists of prefabricated carbon fiber composite material, is laid. The blade is then sealed, and resin is infused and cured under a vacuum to remove air voids. At this stage, the two blade halves are assembled with webs at the center that transfer the shear load, bonded, and trimmed of excess bonding material before being finished and inspected. This process involves both automated and manual components, as well as strict quality assurance procedures. Blades must be transported in their fully assembled form and cannot be partially assembled at the installation site like some other major components.

Table C-2 - Key Subcomponents, Materials, and/or Services required for Blade Manufacturing

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY APPLICATION
Adhesives	Resin and adhesive supply
Auxiliary electrical equipment	Electrical accessory supply
Carbon fibers	Carbon fiber supply
Coatings	Coatings and marine corrosion protection supply
Core material	Polymer and polymer foam supply
Glass fibers	Carbon fiber supply
Resins	Glass fiber supply

Tower

Towers are tubular steel members that support the nacelle-rotor-assembly. Steel plates are rolled into sections, which are then blasted and coated before being welded together to form tower sections. OSW turbine towers typically consist of several steel sections, which are either welded and assembled at the manufacturing facility or transported to the port and assembled, depending on the scale of the WTG. In fixed OSW, the tower connects to the transition piece, typically using a bolted connection. In onshore wind, the tower sections are often transported in sections and then lifted and welded together on-site.

There are additional components to be fixed inside the tower, including ladders, elevators, internal lighting, safety systems, and platforms, referred to as “tower internals.” These components are typically manufactured independently from the tower manufacturing facility by smaller steel fabricators.

Table C-3 - Key Subcomponents, Materials, and/or Services required for Tower Manufacturing

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY APPLICATION
Auxiliary electrical equipment	Industrial electrical equipment supply
Auxiliary structural equipment	Fabricated metal equipment supply
Coatings	Secondary steel/aluminum fixture fabrication
Fasteners	Coatings and marine corrosion protection supply
Flanges	Precision component fabrication
Steel plates	Major steel structure fabrication

Cables

All wind farms require sufficient cabling. While static and dynamic subsea cables (those used in fixed/onshore and floating OSW, respectively) have differing characteristics and sizes, they follow similar manufacturing processes. Cables consist of either one or three cable cores, depending on whether the current is direct or alternating. The cores consist of stranded conductors, like copper or aluminum, surrounded by semi-conducting tape, cross-linked polyethylene insulation, and a protective lead sheath. A fiber optic cable is included alongside the conductive cable core. The cable core and fiberoptic cable are surrounded by armoring layers, such as polypropylene and bitumen, to protect against corrosion and provide additional adhesion.

The manufacturing process is highly technical, involving the assembly of various materials supplied by a limited number of specialized global suppliers. The equipment required for manufacturing is specialized and has limited suppliers. Machines extrude the various raw materials and combine them in a single production line.

Suppliers such as Prysmian Group, JDR Cable Systems, and Hellenic Cables have manufactured array and export cables for US OSW projects. Nexans was the cable supplier for the Straight of Belle Isle Marine Crossing, representing 30 km of the of the 1,100 km Labrador Island Link, and the two 170 km submarine cables for the Maritime Link project connecting NL and NS. Global manufacturers of HVAC and HVDC electrical equipment for OSW projects include ABB, GE, Hitachi, Mitsubishi, and Siemens. Although these suppliers operate globally, their manufacturing capabilities are localized across Asia and Europe, where there is significant investment in high voltage infrastructure projects. Lead time for cables is usually at least two years.

Table C-4 - Key Subcomponents, Materials, and/or Services required for Array and Export Cable Manufacturing

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY
Cable accessories	Secondary steel/aluminum fixture fabrication
Cable sheath and armor	Steel supply

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY
Conductor core	Copper/Aluminum supply
Core insulation	Cross-linked polythylene supply
Core protection	Polymer and polymer foam supply
Fiberoptic cable	Polymer supply

Substations

As wind energy projects typically connect to a utility power grid, substations are required to match the electrical characteristics necessary for grid transmission. OSW farm construction involves the procurement of both onshore and offshore substations, whereas onshore wind farms typically require only an onshore substation. The offshore substation, or substations, depending on the scale of the project, steps up the power to a higher voltage to reduce transmission losses during transport to the onshore substation and consist of the topside and the foundation. The topside houses the electrical systems that collect power from individual turbines, increase the voltage, and, in some cases, convert alternating current to direct current using equipment such as high-voltage switchgear, transformers, converters, and reactive power compensation. The foundation, similar to that of a turbine, supports the offshore substation and is typically a jacket.

The onshore substation converts the power received from the export cable to the electrical grid voltage, in some cases converting direct current to alternating current. The onshore substation requires an electrical system of high voltage switchgears, transformers, converters, and other transmission equipment. Onshore substations are sometimes contracted to the same EPCI as the offshore substation, which is likely to sub-contract a local transmission system supplier or civil engineering contractor.

Table C-5 - Key Subcomponents, Materials, and/or Services required for Substation Manufacturing

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY
Auxiliary structural equipment	Secondary steel/aluminum fixture fabrication
Auxiliary support equipment	Industrial electrical equipment supply
Electrical equipment	Industrial electrical equipment supply
Topside structure	Industrial electrical equipment and steel supply

Onshore Foundations

Onshore turbine foundations are typically constructed using concrete, rebar/reinforcement materials, and/or piles. Typically categorized into two types, spread foundations distribute the weight of the turbine across a wide area, while piled foundations transfer the load of the turbine to lower-lying compact soil or are anchored to bedrock. Subtypes of spread foundations include shallow and gravity-based, while subtypes of piled foundations include rock anchors, piled rafts, and driven piles. Turbine foundations are civil works that are completed before turbine installation and require the fabrication of various steel components depending on sub-type, as well as several other support services.

Table C-6 - Key Subcomponents, Materials, and/or Services required for Supporting Manufactured Components

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY
Coatings	Coatings and corrosion protection supply
Fasteners	Precision component fabrication
Flanges	Metal castings and forgings
Grout	Other goods supply
Steel plates	Steel supply
Steel rods/anchors	Secondary steel/aluminium fixture fabrication
Foundation concrete	Concrete/high-strength concrete supply
Rebar/reinforcement materials	Rebar/reinforcement materials manufacturing
Formwork	Formwork fabrication
Boreholes	Drilling services
Pile installation	Pile driving, testing, and integrity verification services

The remaining components that are described in this section are only relevant for OSW installations.

Transition Piece

In fixed OSW, the transition piece connects the base of the WTG tower to the foundation. The transition piece consists of a rolled and welded steel plate fitted with joints at the top and base. The flange at the top of the transition piece mates to the flange at the base of the tower, while the bolted or grouted joint at the base secures the transition piece to the monopile. The secondary steelwork is attached by welded or bolted joints, and the transition piece is finished with protective coatings and painted yellow for visibility. The transition piece also acts as a boat landing platform and is generally equipped with a davit crane. Transition pieces are often manufactured by the same companies that manufacture towers, such as Smulders and Marmen Welcon.

Table C-7 - Key Subcomponents, Materials, and/or Services required for Transition Piece Manufacturing

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY
Anode	Secondary steel/aluminum fixture fabrication
Boat landing	Secondary steel/aluminum fixture fabrication
Coatings	Coatings and marine corrosion protection supply
Davit crane	Secondary steel/aluminum fixture fabrication
Flange	Major steel structure fabrication
Steel plates	Steel supply
Work platforms	Secondary steel/aluminum fixture fabrication

Monopiles

Monopiles are currently the most common type of fixed OSW foundation. Monopile manufacturing occurs at large quayside facilities that require sufficient laydown space and load-bearing capacity for manipulation and storage. These facilities receive steel plates, transport them through the facility using cranes, and then mill, weld, and roll them into cones and cans before loading them onto self-propelled modular transporters (SPMTs). The process utilizes highly automated large steel rolling and welding machinery.

Global steel fabricators contracted to supply monopiles and transition pieces for US OSW projects include EEW Group, CS Wind Offshore, Steelwind Nordenham, and Windar Renovables. These components have been manufactured in European countries, including Denmark, Germany, and Spain.

Table C-8 - Key Subcomponents, Materials, and/or services required for Monopile Manufacturing

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY A
Anodes	Secondary steel/aluminum fixture fabrication
Coatings	Coatings and marine corrosion protection supply
Fasteners	Precision component fabrication
Flanges	Metal castings and forgings
Grout	Other goods supply
Scour protection	Riprap supply/filter stone
Steel plates	Steel supply

Jacket

Jacket foundations, used for WTGs and offshore substations in OSW, are made of welded structural steel members, typically in a lattice-truss type arrangement with four or more legs, and attached to the seabed using pin piles or suction buckets. Jackets have traditionally been manufactured at large fabrication yards that possess the necessary equipment, labor, and volumetric capacity. They may serve other industries as well, such as the offshore O&G industry. Jacket structures typically feature an integrated transition piece, which often includes boat landing platforms and a davit crane.

Table C-9 - Key Subcomponents, Materials, and/or Services required for Jacket Manufacturing

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY
Anode	Secondary steel/aluminum fixture fabrication
Boat landing	Secondary steel/aluminum fixture fabrication
Coatings	Coatings and marine corrosion protection supply
Davit crane	Secondary steel/aluminum fixture fabrication
Flange	Major steel structure fabrication
Scour protection	Riprap supply
Steel plates	Steel supply
Work platforms	Secondary steel/aluminum fixture fabrication

Floating Substructure

The floating foundation, or substructure, of an OSW turbine directly supports the tower structure of the WTG without the need for a transition piece. As described in Section 3.1, there is still no consensus on a standard type of floating substructure, but all require structural steel and/or welded steel plates, concrete, ballast, and a mooring and anchoring system. The mooring system consists of chain or synthetic rope. These connect to subsea anchors that are embedded in the seabed.

Table C-10 - Key Subcomponents, Materials, and/or Services required for Floating Substructure Manufacturing

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY
Anchors	Primary steel
Anodes	Secondary steel/aluminium fixture fabrication
Boat landing	Secondary steel/aluminium fixture fabrication
Coatings	Coatings and marine corrosion protection supply
Columns	Primary steel/concrete
Davit crane	Secondary steel/aluminium fixture fabrication
Pontoons	Primary steel/concrete

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY
Trusses	Primary steel
Transition piece	Primary steel
Mooring lines	Steel chains or synthetic fibre production

Other Supporting Manufactured Components

A variety of equipment is required to support the manufacturing and transportation of wind components. Manufacturing facilities require large handling equipment, including heavy-lift cranes and SPMTs, to move components around the facility and equipment for activities such as plate cutting, welding, and shot blasting. Much of the equipment required for the transportation and installation of components, such as sea fastenings, lifting aids, blade racks, monopile cradles, tower grillages, and subsea cable spools, is designed, engineered, and manufactured specifically for individual projects by either an EPCI contractor or on a package-by-package basis by the developer. Additionally, monopile grippers, spreader bars, lifting and flange tools, and upending hinges are rented or fabricated for use in lifting and maneuvering major components. Other equipment, including tracked cable tensioners and cable hold-back winches, maintain controlled tension during subsea cable installation. The reliability of this equipment is crucial, and therefore, the manufactured components must withstand strict inspection.

Table C-11 - Key Subcomponents, Materials, and/or Services required for Supporting Manufactured Components

SUBCOMPONENT, MATERIAL, OR SERVICE	INDUSTRIAL CAPABILITY
Personnel access equipment	Secondary steel/aluminum fixture fabrication
Port equipment	Specialized equipment manufacturing
Sea fastening equipment	Specialized equipment manufacturing

APPENDIX D ATLANTIC CANADA ONSHORE WIND PROJECTS

D.1 Nova Scotia

PROJECT NAME	POTENTIAL CAPACITY [MW]	DEVELOPER	GREEN H2? (Y/N?)	COD
Pubnico Point (Phase 1, 2)	30.6	Atlantic Wind Power Corporation	N	2005
Small projects (<10MW)	177	Owned by municipalities, Indigenous communities, co-ops, universities, and non-profits	N	2015
Dalhousie Mountain Project	51	RMS Energy Ltd. and Firelight Infrastructure Partners LP	N	2009
Digby Neck Wind Farm	30	Nova Scotia Power	N	2010
Nuttby Mountain Wind Farm	50.6	Nova Scotia Power	N	2010
Point Tupper Wind Farm (Phase 1, 2)	22.8	Renewable Energy Services Limited	N	2010
Glen Dhu	62.1	Capstone Infrastructure	N	2011
Lingan (I, II)	18.4	SP Development Limited Partnership	N	2012
Amherst I Wind Farm	31.5	Capstone Infrastructure, Firelight Infrastructure Partners	N	2012
Chebucto Pockwock Community Wind	10	Chebucto Pockwock Lake Wind Field Limited and juwi Wind Canada Ltd.	N	2014
Sable Wind Farm	13.8	The Municipality of the District of Guysborough and Nova Scotia Power Inc.	N	2015
South Canoe Wind Farm	102	Oxford Frozen Foods, Minas Basin Pulp and Power, and Nova Scotia Power	N	2015
Ellershouse Wind Farm (I, II & III)	23.3	Bullfrog Power, Minas Energy, Towns of Antigonish, Berwick and Mahone Bay	N	2017
Benjamins Mill Wind Project (Phase 1, 2)	34	Natural Forces and Wskijnu'k Mtmo'taqnuow Agency Ltd	N	2025
Ellershouse 3 Wind Project (Phase 1, 2)	66	Annapolis Valley First Nation and Potential Renewables Canada Holdings	N	2025

PROJECT NAME	POTENTIAL CAPACITY [MW]	DEVELOPER	GREEN H2? (Y/N?)	COD
Wedgeport Wind Farm Project	81	Elemental Energy Renewables Inc., Stevens Wind Ltd., and Sipekne'katik First Nation	N	2026
Weavers Mountain Wind Energy Project	94.4	Glooscap Energy #2 Limited Partnership and SWEB Development Limited Partnership	N	2026
Higgens Mountain Wind Farm	100	Sipekne'katik First Nation, Elemental Energy, and Stevens Wind	N	2026
Windy Ridge Wind Power Project	340	EverWind Fuels, Bayside Development Corporation, and Potlotek Development Corporation	Y	2026
Kmtnuk Wind Power Project	98	Kmtnuk Wind Ltd. (Wind Strength, a Membertou company and EverWind Fuels Company)	Y	2026
Goose Harbour Lake Wind Farm	168	Wskijinu'k Mtmo'taqnuow Agency Ltd. (WMA) (10% stake), Port Hawkesbury Paper Wind Ltd.	N	2026
Mersey River Wind Project	148.5	Mersey River Wind Inc., Roswall Development Inc. Construction under, financing in place	N	2026
Upper Afton Wind Farm	120	EverWind	Y	2027
Webster's Corner Wind Farm (Bear Head 1)	500	Bear Head Energy	Y	2028
Blueberry Acres	61.2	SWEB, Glooscap First Nation, Green Choice Program	N	2028
Eigg Mountain	150	Renewable Energy Systms Canada, Paq'tnkek and Pictou Landing First Nations; Green Choice Program	N	2028
Melvin Lake	115.5	ABO Energy Canada, Eskasoni, Potlotek, We'koqma'q L'nue'kati, Wagmatook First Nation; Green Choice Program	N	2028
Rhodena	42	ABO Energy Canada in partnership with Eskasoni, Potlotek, We'koqma'q L'nue'kati	N	2028

PROJECT NAME	POTENTIAL CAPACITY [MW]	DEVELOPER	GREEN H2? (Y/N?)	COD
		and Wagmatook First Nations; Green Choice Program		
Sugar Maple	112	SWEB, Glooscap First Nation; Green Choice Program	N	2028
Yellow Birch	149.6	SWEB, Glooscap First Nation; Green Choice Program	N	2028
Bear Lake Wind Power Project	89	Bear Lake Wind Ltd. (Wind Strength, a Membertou company and EverWind Fuels Company)	Y	2030
Goldboro Wind Farm (Simply Blue)	800	Simply Blue; Assumes 100, 5 MW turbines - for Sustainable Aviation Fuel	Y	2030
EverWind Future Project	2000	EverWind	Y	2035
Forest Hill Wind Park (Bear Head 2)	500	Bear Head Energy	Y	2035
	623	**Current (installed before 2025)**		
	5,669	**Under Development**		
	6,292	**Total**		

D.2 Newfoundland and Labrador

PROJECT NAME	POTENTIAL CAPACITY [MW]	DEVELOPER	GREEN H2? (Y/N)	COD	REVISED COD
St. Lawrence Wind	27	Elemental Energy	N	2008	2008
Fermeuse Wind	27	Elemental Energy	N	2009	2009
Ramea Wind-Hydrogen Diesel Project (Phase 1, 2)	0.69	Frontier Power Systems	N	2010	2010
Project Nujio'qonik (Phase 1)	1000	World Energy GH2	Y	2025	2025
Toqlukuti'k Wind and Hydrogen (Phase 1)	700	CIP/ABO Energy	Y	2027	2027
Project Nujio'qonik (Phase 2)	1000	World Energy GH2	Y	2028	2028
Argentia Renewables	300	Pattern Energy	Y	2028	2028
Toqlukuti'k Wind and Hydrogen (Phase 2)	1000	ABO Energy	Y	2028	2029
Burin Peninsula Green Fuels Project (Phase 1)	3000	EverWind Fuels	Y	2028	2031
Exploits Valley Renewable Energy Corporation	3000	Exploits Valley Renewable Energy Corporation	Y	2029	2032
NL Hydro procurement target by 2030 - reference case	500	NL Hydro	N	2030	2032
Project Nujio'qonik (Phase 3)	1000	World Energy GH2	Y	2031	2033
Toqlukuti'k Wind and Hydrogen (Phase 3)	3300	ABO Energy	Y	2032	2035

PROJECT NAME	POTENTIAL CAPACITY [MW]	DEVELOPER	GREEN H2? (Y/N)	COD	REVISED COD
Burin Peninsula Green Fuels Project (Phase 2)	5000	EverWind Fuels	Y	2032	2037
Project Nujio'qonik (Phase 4)	1000	World Energy GH2	Y	2034	2036
Burin Peninsula Green Fuels Project (Phase 3)	2000	EverWind Fuels	Y	2035	2038
North Atlantic Refining Limited	1100	North Atlantic Refining Limited	Y	2035	2038
Project Gwinya	5000	CWP Global	Y	2035	2043
	55	**Current**			
	28,900	**Under Development**			
	28,955	**Total**			

** Revised CODs assume that a maximum of 2 GW of onshore wind can be developed per year.*

D.3 New Brunswick

PROJECT NAME	POTENTIAL CAPACITY [MW]	DEVELOPER	GREEN H2? (Y/N)	COD
Caribou Wind Park	99	ENGIE	N	2009
Lamèque Wind Farm	45	ACCIONA Energy	N	2011
Kent Hills Wind Farm I, II, III	167	TransAlta and Natural Forces	N	2018
Cap-Pelé Wind	2	WKB Community Wind	N	2018
Wisokolamson Energy Project	18	Woodstock First Nation and SWEB Development	N	2019
Wocawson Energy Project	20	Tobique First Nation and Natural Forces	N	2020
Oinpegitjoig (Richibucto) Wind Project	3.8	Pabineau First Nation and Natural Forces	N	2020
Burchill Wind Farm	42	Neqotkuk Maliseet Nation and Natural Forces	N	2023
Neweg Energy Project	25	Natural Forces and Mi'gmaq United Investment Network; (first project announced under the 2023 NB Power REOI for up to 220 MW). 500-600 MW in additional project announcements anticipated	N	2025
Belledune Green Energy Hub	700	Cross River Infrastructure Partners and NextEra; 700-1000 MW (years 1-5); Belledune website says H2 production may start by 2027	Y	2027

PROJECT NAME	POTENTIAL CAPACITY [MW]	DEVELOPER	GREEN H2? (Y/N)	COD
Juniper Wind Farm (Phases 1) - Brighton Mountain	200	J.D. Irving Limited	N	2027
Juniper Wind Farm (Phases 2)	150	J.D. Irving Limited	N	2030
Belledune Green Energy Hub	1000	Cross River Infrastructure Partners and NextEra; 1,000 – 1,500 MW (years 5 -10)	Y	2032
GNB 2023 energy vision	1400		N	2035
	397	Current		
	3475	Under Development		
	3872	Total		

D.4 Prince Edward Island

PROJECT NAME	POTENTIAL CAPACITY [MW]	DEVELOPER	GREEN H2 ? (Y/N)	COD
North Cape Wind Farm (Phase 1, 2)	10.56	PEI Energy Corporation	N	2001, 2004
Aeolus Wind	3	PEI Energy Corporation	N	2002
Eastern Kings Wind Farm	30	PEI Energy Corporation	N	2007
Norway Wind Park	9	ENGIE	N	2007
West Cape Wind Farm (Phase 1, 2)	99	ENGIE	N	2007, 2009
Summerside Wind Farm	12	City of Summerside, Summerside Electric	N	2009
WEICan Wind R&D Park	10	WEICan	N	2013
Hermanville/Clear Springs Wind Farm	30	PEI Energy Corporation	N	2014
Skinners Pond Wind Energy Center	99	Invenergy	N	2025
Eastern Kings Wind Farm Expansion Project	30	PEI Energy Corporation	N	2025
Wejipek Wind Project	18	Lennox Island First Nation and Natural Forces Developments	N	2027
PEI growth forecast	162		N	2032
	204	Current		
	309	Under Development		
	513	Total		

APPENDIX E GLOBAL INDUSTRY OVERVIEW – OFFSHORE WIND

E.1 Europe

United Kingdom

The UK's OSW capacity outlook is strong through to 2040. Currently, the UK has an installed OSW capacity of over 14 GW, with a target of 50 GW by 2030. The country is responsible for some industry-leading initiatives that have stimulated OSW development and provided interesting models for leasing and innovation processes. While the majority of installed capacity is fixed, Scotland is home to the world's first floating wind farm: Equinor's Hywind Scotland (30 MW).

In 2021, Crown Estate Scotland launched the ScotWind leasing round, which resulted in 20 projects with a generating capacity of nearly 30 GW. In this leasing round, 14 projects are anticipated to utilize floating technology. The Innovation and Targeted Oil and Gas (INTOG) leasing round was a Scottish initiative, separate from ScotWind. It focused on the low-carbon electrification of oil and gas (O&G) installations. Additionally, it supported smaller-scale innovation projects, including five pre-commercial projects of up to 100 MW each, and explored alternative outputs such as hydrogen. Five Innovation leases and eight Targeted O&G leases were awarded, totalling 5.5 GW.

The UK has a relatively well-established supply chain, benefiting from its history in offshore O&G and early adoption of large-scale OSW farms. Key component suppliers active within its border include Vestas' blade factory on the Isle of Wight[5], Siemens Gamesa's blade factory in Hull, and JDR Cables in Hartlepool. As the UK OSW market expands, further investment in the SeAH Wind XXXL monopile facility in Teesside and a new factory for Vestas blades at the Port of Leith in Scotland demonstrates a growing supply chain.

Germany

Germany currently has 8.3 GW of installed fixed-bottom OSW capacity. The German government has set forth a goal of 30 GW by 2030, 40 GW by 2035, and 70 GW by 2045. The German Climate Action Law calls for net-zero emissions by 2045. The majority of Germany's OSW is in the North Sea, while some is in the Baltic Sea, and all potential capacity is expected to be fixed.

A robust local supply chain for key components supports the strong development of OSW. Siemens Gamesa's Cuxhaven location manufactures nacelles for OSW turbines. Earlier in 2024, Titan Group reached a Final Investment Decision (FID) to construct an XXXL monopile facility in Cuxhaven.

Denmark

Denmark is the location of the first OSW farm, installed in 1991. It currently has 2.7 GW of installed fixed OSW capacity and is exploring the development of floating OSW. The Thor OSW project, currently under construction, is expected to

[5] *This factory will soon be transitioned to manufacture blades for onshore wind turbines. Source: [Vestas to repurpose Isle of Wight factory, UK, to manufacture onshore blades]*

add 1 GW of capacity by 2027. The Danish government has a goal of 12.9 GW of OSW capacity by 2030 and 35 GW by 2050. The Danish government utilizes the CfD scheme.

Denmark is a pivotal player in the OSW market. As a result of its robust infrastructure and strategic location, Denmark has not only grown its OSW capacity but has also greatly supported OSW farms globally. As the headquarters of one of the major turbine OEMs, Vestas, Denmark provides necessary components to wind farms around the world. While Vestas has production facilities worldwide, Denmark hosts key locations for blade, nacelle, and spare parts manufacturing. It is also home to a major global wind developer, Ørsted.

Further growth in the supply chain is evident with Baltic Structures Company's announcement to build an XXL monopile factory in Denmark. Denmark also hosts key ports that have supported the majority of European OSW installations. The Port of Esbjerg has supported the installation of over 80% of the OSW capacity within Europe and is home to over 200 companies that work within various segments of the OSW market [67]. Additional key ports include the Port of Aalborg and the Port of Odense, which support OSW development via storage, assembly, and decommissioning.

While market signals demonstrate OSW growth in Denmark, the government has announced a three-year delay to its North Sea Energy Island project due to increasing costs, with a likely completion date of 2036. A recently held auction for up to 3 GW of capacity in the Danish North Sea resulted in no bids, attributed to a rigid bid structure with no subsidies or revenue stabilisation mechanisms and high grid connection costs.

France

Currently, France has approximately 1.5 GW of fixed-bottom OSW, as well as a 2 MW demonstration floating OSW project called Floatgen. France aims to deploy 45 GW of both fixed and floating OSW capacity by 2050. Surrounded by deep-water areas, France is on track to become Europe's floating leader.

France possesses multiple factories that support the OSW supply chain. Siemens Gamesa has a factory for blades and nacelles in Le Havre. General Electric has an OSW blade factory in Cherbourg, as well as a nacelle and electrical substation factory in Saint-Nazaire. These factories will become increasingly relevant as further development occurs and France strives to reach its ambitious targets.

Norway

Given its offshore conditions, Norway is best suited for floating OSW. Currently, Norway has one floating OSW farm: the Hywind Tampen project (88 MW) is the world's largest floating OSW farm and the first built to power offshore O&G operations. The Norwegian government has set forth the goal to generate 30 GW of OSW by 2040. Norway is a world leader in floating OSW, with the majority of existing floating OSW capacity having been installed by the majority state-owned developer, Equinor.

Furthermore, Norway's deep-water ports are well-suited for floating OSW construction and installation. Norway has demonstrated its commitment to offshore development with the signing of its first commercial OSW farm, the 1.5 GW Sørlige Nordsjø II, in April 2024.

Despite having limited deployment of OSW, Norway possesses the marine industrial capabilities to develop a strong supply chain. Companies such as Aker Solutions, Implenia, WindWorks Jelsa, Amon, and Nymo have committed to establishing facilities to supply foundation structures to the OSW market. Norway also has substation EPC and EPCI capabilities and experience, with companies like Inocean, Aibel, ABB, and Aker Solutions. However, the Norwegian experience to date has been limited to HVDC platforms only.

E.2 Asia-Pacific

China

China leads the world in installed OSW capacity with approximately 38 GW. In 2022, President Xi Jinping announced plans to develop 1,200 GW of wind and solar power by 2030, aiming for 25% of primary energy to come from non-fossil fuels. It is estimated that China will have nearly 130 GW of installed OSW capacity by 2030. The provinces of Fujian, Shandong, Zhejiang, and Jiangsu are key OSW bases, with over three-quarters of OSW production concentrated in Jiangsu, Guangdong, and Fujian, where regional supply chains have been developed. The rapid development is driven by government policies that incentivize the supply chain and necessary infrastructure development.

China has a robust local supply chain for most major OSW components, with major turbine manufacturers like Goldwind, MingYang, and Shanghai Electric being the largest. China's highly competitive supply chain for OSW turbines has generally supported domestic projects. However, a significant proportion of subcomponents and raw materials for global OSW projects come from China, including particularly rare earth elements, which are crucial for turbine generators. There is intense competition within the Chinese supply chain, however, few major components are exported. Beyond the supply constraints posed by ambitious internal OSW development, there are some security concerns that limit the uptake of Chinese-made wind turbines, particularly in Europe and the US.

Taiwan

Currently, Taiwan has 2.2 GW of fixed OSW, aiming to achieve 5.6 GW of installed OSW capacity by 2025. The government plans to allocate 1.5 GW of capacity each year from 2026 to 2035, totalling 15 GW, which brings the overall target to 20.6 GW by 2035. The Taiwanese Ministry of Economic Affairs established feed-in tariffs (FiTs) for OSW projects that signed 20-year PPAs in 2021.

Policies set forth by the Taiwanese government mandate that at least 60% of the components for OSW projects must be locally sourced; however, in November 2024, the EU and Taiwan announced they had settled a World Trade Organization dispute over local content requirements [68]. It was reported that Taiwan has committed to no longer including localisation requirements in allocation rounds, either as eligibility conditions or as award criteria.

Siemens Gamesa opened a factory in Taichung in 2022, marking their first nacelle assembly factory outside Europe. Expanding supply chain capabilities will become increasingly important, as evidenced by Taiwan's Ministry of Economic Affairs awarding five projects with a total capacity of 2.7 GW in August 2024.

Japan

Japan has an installed capacity of only 294 MW of OSW to date, with 5 MW of that being floating OSW. It aims to install 10 GW of OSW capacity by 2030 and up to 45 GW, including floating OSW, by 2040. Strengthening the transmission system is crucial for integrating large amounts of renewable energy in the country. While Japan has ambitious OSW targets, its supply chain is still relatively immature.

Historically, Japan has relied heavily on importing wind turbines; however, efforts are underway to expand local capabilities. Toshiba's partnership with GE Renewables aims to enhance nacelle production, with initiatives underway to grow component suppliers in Chiba and Akita. In April 2024, JFE Engineering opened a factory to produce monopiles and transition pieces, marking a significant step toward expanding the local supply chain.

South Korea

South Korea currently possesses 128 MW of fixed-bottom OSW. The South Korean government has set an ambitious target to develop 12 GW of OSW by 2030, encompassing both fixed and floating installations. Grid connection has been a significant hurdle for developers; however, a policy aimed at expediting construction and prioritizing grid connections for large-scale OSW farms has been passed by the government.

Despite being a relatively small market, South Korea possesses a capable supply chain. It is estimated that domestic firms made up 77% of the supply chain used in developing the country's existing OSW capacity, primarily in construction stages. While South Korea has capable ports, investment in deep-water ports will likely be needed to support floating OSW expansion. Increasing floating capabilities will be increasingly important, as this year, three floating OSW projects—Gray Whale, Haeworrid, and Bandibuli—were granted grid connections.

Australia

Australia currently has no operational OSW projects, but there are nearly 40 GW of proposed projects, including 10.8 GW of floating OSW projects in New South Wales. While the country has not announced a formal target, the state of Victoria, having exhausted its land for onshore wind near Melbourne, has set ambitious goals to develop 2 GW by 2032, 4 GW by 2035, and 9 GW by 2040. Historically, the sector has been industry-led, with a previous lack of federal policy and legislation posing barriers to investment from both state governments and private equity. The Australian OSW supply chain is immature, requiring significant infrastructure upgrades and partnerships to establish local operations. Major components will likely be imported unless the Australian government pushes for a local build-out.

APPENDIX F GLOBAL INDUSTRY OVERVIEW – ONSHORE WIND

F.1 Europe

Germany

Germany has been a leader in onshore wind energy in Europe, with approximately 29,000 turbines representing 61 GW of installed capacity at the end of 2023 [69]. Germany experienced its most successful year in 2023 for new installations since 2018, contributing 2.5 GW of onshore wind capacity and adding an additional 1 GW to the grid, attributed to an increased bid price ceiling and the implementation of streamlined permitting processes by the EU. The government has set an ambitious target to achieve a total installed capacity of 115 GW by the year 2030. To meet this objective, Germany will need to significantly accelerate its annual expansion rates to nearly 13 GW in the coming years, which is more than quadruple the figures recorded in 2023.

The industry faces challenges such as regulatory hurdles, limited construction space, and the need for faster licensing procedures [70]. Recent reforms are expected to help overcome these obstacles and accelerate the expansion [71]. German companies, Siemens Gamesa, Enercon, Nordex, are integral to the supply chain, from manufacturing turbines to providing maintenance and operational support. They also play a crucial role in the ongoing expansion and technological advancements within the German industry.

Spain

As of 2023, Spain's onshore wind energy capacity is approximately 31 gigawatts (GW). The Spanish National Energy and Climate Plan (NECP) outlines an ambitious objective to achieve 62 GW of wind power capacity by 2030, encompassing both onshore and offshore projects. Additionally, the country is prioritizing hybrid initiatives that integrate wind and solar photovoltaic (PV) systems to enhance efficiency and energy output.

Spain boasts a robust manufacturing sector for wind turbine components, including blades, towers, and nacelles, with companies such as Siemens Gamesa and Acciona playing pivotal roles in both domestic and global markets. The nation's ports and shipyards are crucial to the wind energy supply chain, providing vital infrastructure for the transportation and assembly of wind turbines. Ports such as Bilbao and Ferrol serve as significant logistics hubs.

United Kingdom

The United Kingdom has successfully installed more than 15.4 GW of onshore wind capacity to date, which is enough to power approximately 10.9 million homes. The UK Government is committed to doubling this capacity to 30 GW, aiming to achieve the complete decarbonization of electricity by 2030.

Its government recently lifted the de facto ban on onshore wind in England, which had been in place for nearly a decade [72]. This move is expected to rejuvenate the onshore wind sector and encourage new projects. The UK’s onshore wind project pipeline has grown by 4.2 GW over the past year, reaching a total of 42.7 GW. This increase is substantial compared to the previous year’s growth of 1.5 GW.

Other countries

To reduce the EU's reliance on Russian fossil fuels and achieve climate objectives, the current rate of annual wind power auctions in Europe is insufficient, necessitating an acceleration in their frequency [73]. France and Italy have installed onshore wind power capacities of 22.2 GW and 11.5 GW, with 2030 installed capacity targets of 33.2 GW and 19.3 GW, respectively.

As of 2023, Denmark's onshore wind energy capacity has attained around 4.8 GW, supported by a total of 6,326 onshore wind turbines across the country. In 2022, wind power accounted for more than 53% of Denmark's overall electricity consumption.

As of 2023, Norway's total installed capacity for onshore wind energy stands at around 5 GW. This figure has shown a consistent upward trend over the years, highlighted by the addition of 374 MW of new capacity in 2022. Fosen Vind, located in Central Norway, is recognized as the largest onshore wind power initiative in Europe, boasting a combined capacity of 1 GW. It is anticipated that this project will produce 3.4 TWh of renewable energy annually, sufficient to supply power to approximately 170,000 households in Norway.

F.2 Asia Pacific

China

China built its first onshore wind farm in 1986 in Rongcheng, Shandong Province. Since then, China has rapidly expanded its wind energy capacity and now leads the world in installed onshore wind capacity. China has achieved a cumulative installed onshore wind power capacity of over 404 GW, representing 43% of the total global onshore wind installations. Wind power supplied 466.5 TWh of electricity for the country, equivalent to 6.1% of national electricity production [74]. Such rapid growth in wind power is expected to continue expanding in the context of the carbon neutrality goal. To achieve such a goal, China will need to aim for a cumulative installed wind power capacity of at least 2,500 GW by 2060 [75]. China is currently concentrating on the construction of large-scale onshore wind projects in its northern provinces. The Gansu Wind Farm in China stands as the largest onshore wind farm in the world, featuring approximately 7,000 wind turbines with a planned capacity of 20 GW.

The future outlook for onshore wind in China is anticipated to maintain a trajectory of rapid growth. The Chinese government has established ambitious goals and is providing robust policy support, which includes incentives for renewable energy projects and initiatives aimed at expediting the approval process for new installations [76]. By 2025, it is projected that China may install more capacity annually than the total installed by the rest of the world combined [77].

China stands out as a leader in advanced manufacturing with an onshore wind supply chain that is well developed, offering an extensive and established supplier network and enabling supply of a diverse array of products at competitive prices. They currently produce high-capacity wind turbine components, such as blades, gearboxes, generators, towers, and advanced control systems. Geopolitical issues and ongoing tensions, such as the US-China trade conflict and intellectual property rights, have the potential to disrupt supply chains [78]. Countries may be hesitant to purchase critical onshore wind components from China due to national and energy security concerns. China-based Goldwind is one of the largest wind turbine manufacturers in China and globally. Other significant competitors in the industry include Envision Group, Migyang, Shanghai Electric, and Dongfang Electric, all recognized for their cutting-edge wind turbine technology, manufacturing capabilities, and extensive service offerings in the marketplace.

India

India ranks fourth in the world for total installed onshore wind capacity with 46 GW, and an ambitious target of reaching 110 GW by 2030. The rising demand for wind energy is anticipated to drive the expansion of onshore wind projects, establishing India as a key export center for other APAC regions and bolstering its manufacturing capabilities.

To address grid integration challenges, India is investing in modernizing its grid infrastructure to handle the variability of wind power, including expanding transmission capacity and enhancing grid flexibility. In terms of regulatory reforms, India is introducing policies to support the integration of renewable energy, including flexible PPAs and market-based mechanisms to enhance grid stability.

Australia

Australia has successfully installed 11 GW of onshore capacity, with an anticipated addition of nearly 86 GW of new onshore wind energy expected to be commissioned by 2030 [79]. Several states have enacted policies to streamline the lengthy permitting processes for renewable projects, with more regulatory changes in the past 15 months than in the previous decade.

Other notable strengths of the supply chain include continuous advancements in wind turbine technology and government support. Nevertheless, several challenges must be addressed, particularly the expansion of the transmission network to connect with inland renewable energy initiatives. The current grid is mainly structured to accommodate traditional baseload power sources, which frequently do not correspond effectively with the sites of optimal wind resources [80]. One of the additional challenges involves streamlining the approval process for wind projects and ensuring the acquisition of financing for large-scale projects with extended timelines [80] [79].

Other Countries

As of 2023, Southeast Asia has approximately 6.8 GW of installed utility-scale solar and wind capacity, representing a 20% increase over the past year. The Association of Southeast Asian Nations (ASEAN) aims to increase the share of renewables in the energy mix to 35% by 2025. However, wind energy development in Southeast Asia faces challenges, including regulatory hurdles, financing issues, and the need for improved grid infrastructure.

Japan has an installed onshore wind capacity of 5 GW and aims to increase this to 16 GW by 2030. High installation costs and lengthy environmental impact assessments (EIA) are among the challenges Japan faces. To address these issues, the government is working on policies to streamline these processes and reduce costs.

New Zealand has an installed wind capacity of 1.2 GW spread across 21 fully operational wind farms, which collectively can power over 553,000 households annually. New Zealand's wind farms also boast a high-capacity factor, often around 40% and, in some cases, up to 50%, which is higher than in many other regions.

F.3 Middle East and Africa

Middle East

Saudi Arabia, the world's second-largest oil producer, aims to achieve an installed capacity of 3.2 GW within three years, following the establishment of its first 400 MW utility-scale project Dumat Al Jandal wind farm, the largest in the region. Under the National Renewable Energy Program (NREP), Saudi Arabia aims to install 16 GW of wind capacity by 2030. The Saudi government has introduced various policies to support renewable energy projects, including competitive bidding processes to ensure cost-effective development.

Turkey is another key player, with projected onshore wind capacity expected to exceed 4 GW by 2030. As of 2024, Turkey has an installed capacity of 12 GW of onshore wind energy. This capacity is spread across approximately 300 wind farms, which feature around 4,000 wind turbines. The largest wind farms include the Soma Wind Farm and the Karaburun Wind Farm. Turkey has been actively expanding its renewable energy sector, supported by favorable policies and investments. The wind energy sector is supported by a strong domestic supply chain, with many local and international companies involved in manufacturing and development.

Slow regulatory hurdles, large-scale infrastructure development, and high market competition can delay project implementation in the Middle East. However, the Middle East's proximity to Europe and Asia provides strategic advantages for energy export. Certain regions with high winds, particularly those in coastal and desert areas, are well-suited for wind energy generation.

Africa

Africa currently has 83 operational wind farms, collectively generating a capacity of 9 GW. North Africa stands out with the highest total installed capacity among Africa's five sub-regions, largely due to the early implementation of renewable energy initiatives in Egypt and Morocco. Southern Africa follows, with significant contributions from wind farms in South Africa, primarily developed under the initiative program known as the 'Renewable Energy Independent Power Producer Procurement Programme (REIPPPP)' scheme. Eastern Africa ranks third, featuring several active wind farms in Ethiopia and Kenya.

Several key factors, including abundant wind resources, increasing economic development, and high unemployment rates, drive the growth of the onshore wind sector in Africa. Additionally, supportive policies, such as feed-in tariffs and tax incentives, along with efforts to establish regional power pools and interconnected grids, play a significant role in integrating this industry into the broader energy framework. Numerous challenges must be addressed, including inadequate grid infrastructure and transmission networks, inconsistent policies that affect investors and developers, and difficulties in accessing financing due to macroeconomic conditions and perceived risks.

Certain challenges in the MEA must be addressed, including the necessity for economic and political stability, the development of infrastructure to accommodate such an extensive wind farm, and the establishment of a conducive regulatory and policy environment.

F.4 Latin America and Caribbean

Brazil

South America's total onshore wind capacity is expected to reach 79 GW within the next decade, with Brazil making a significant contribution to this growth. Brazil is projected to add 21.5 GW of new capacity by 2033. LATAM experienced an unprecedented year for new power installations in 2023, attributed mainly to Brazil's addition of 3.6 GW, which contributed to the previous total of 24 GW.

In 2024, Brazil approved the Energy Acceleration Program Energy Transition (PATEN) to provide funds from taxes and establish a new legal framework for low-carbon hydrogen. The U.S. Customs and Border Protection (CBP) and Brazil's Customs Authority also entered a Mutual Recognition Arrangement (MRA) to strengthen collaboration and enhance trade security.

Others

As of March 2024, Chile's installed onshore wind power capacity stands at approximately 4.5 GW, with an ambitious plan to expand this capacity to over 20 GW in various stages of planning and construction. Chile is set to construct its longest power transmission line, capable of transmitting up to 3,000 MW of electricity. Horizonte, located in Chile, is the largest onshore wind project in LATAM, with a total capacity of 778 MW, which powers 700,000 homes annually [81].

One of the primary challenges of the supply chain in most LATAM and Caribbean countries is the inadequate transmission network. The existing grid infrastructure struggles to keep up with the rapid expansion of wind projects, leading to increased curtailment of variable renewable energy sources [82]. Additionally, opposition from local and Indigenous communities has led to the rejection of several projects and delays in the commissioning of existing ones (Pan American, 2023). Another challenge is stiff competition from solar photovoltaic (PV) projects. Solar PV benefits from more dispersed locations, which helps overcome some of the grid upgrade challenges that wind projects face.

F.5 North America

United States

At the end of 2023, the US had approximately 150.5 GW of installed onshore wind capacity, aiming for wind energy to supply 20% of the nation's electricity by 2030. The DOE forecasts a near 60% increase in land-based wind capacity by 2026, reaching around 180 GW. Texas leads in onshore wind development, generating over 32% of the nation's wind energy with more than 19,000 turbines, followed by Iowa, Oklahoma, and Kansas. The Alta Wind Energy Center in California's Tehachapi Pass is the largest onshore wind farm, with a capacity of 1.5 GW.

The U.S. has a well-established onshore wind supply chain, supported by over 500 manufacturing plants, including eight blade facilities, nine tower facilities, and four nacelle assembly facilities. Efforts to improve the recyclability of turbine components are underway, with over 90% of wind turbine materials now recyclable [83]. Key players in U.S. wind development include NextEra Energy Resources (27.7 GW), Invenergy (19 GW), APEX Clean Energy (16.1 GW), Avangrid Renewables (14 GW), and EDF Renewable Energy (12.3 GW).

The sector has faced supply chain challenges due to COVID-19, geopolitical tensions, and rising material costs, including a 86% increase in steel prices in 2022. Warranty claims and technological limitations have further strained OEMs. Despite these issues, strong federal and state policies, including the IRA and renewable energy standards, have created over 125,000 jobs and driven improvements in turbine efficiency.

The U.S. market offers substantial opportunities in onshore wind, driven by capacity expansions, declining generation costs, policy support, and technological advancements. Innovations like larger and more efficient turbines, spiral welding, 3D printing, climbing cranes, and wake steering enhance reliability and performance. Further investment in logistics, infrastructure, workforce development, recycling initiatives, and alternatives to rare earth magnets could strengthen the supply chain and support ongoing sector growth.

Mexico

As of 2023, Mexico has an installed wind power capacity of approximately 8.1 GW and has set an ambitious target to reach around 19 GW of wind power capacity by 2030. The largest wind farm currently in operation is the Amistad Wind Farm, boasting a capacity of 871 MW. Meanwhile, the largest project on the horizon is the Sureste Wind Farm, which is set to have a planned capacity of 1.5 GW. While Mexico relies on international manufacturers for advanced turbine technology, there is an increasing movement towards the local assembly and production of specific components, including towers and electrical parts [84]. This helps reduce costs and lead times associated with importing fully assembled turbines.