FINAL REPORT

INITIAL SOCIO-ECONOMIC IMPACT ANALYSIS OF OFFSHORE WIND DEVELOPMENT IN NOVA SCOTIA

COMMITTEE FOR THE REGIONAL ASSESSMENT OF OFFSHORE WIND DEVELOPMENT IN NOVA SCOTIA

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Contents

List of Tables

List of Figures

SUPPLY CHAIN DEVELOPMENT ROADMAP FOR NOVA SCOTIA

SHORT-TERM SUPPLY CHAIN DEVELOPMENT ACTIONS

- Convene working groups with industry, government and post-secondary partners
- Identify locations to build supply chain assets
- Create predictable timelines & policies for procurement
- Establish incentive mechanisms and programs
- Work with industry & post-secondary partners to establish training programs
- Foster an Innovation Ecosystem
- Increase awareness among existing suppliers of OSW opportunities

Development & Project Planning

2024-2026

SUPPLY CHAIN REQUIREMENTS

- **Site selection & Feasibility Studies**
- **Environmental Impact Assessments**
- **Securing Permits & Licenses**
- **Financial Planning & Securing Investments**

Design & Engineering

2026-2028

- **Turbine Design & Engineering**
- **Foundation & Substructure Design**
- **Electrical Infrastructure Design**

MEDIUM-TERM SUPPLY CHAIN DEVELOPMENT ACTIONS

- Construction of new and upgraded supply chain facilities
- Launch predictable timeline for lease sales up to 2040-2050
- Develop best practices for supply chain activities
- Evolve supply chain to address regulatory and social considerations
- Train a sufficient manufacturing workforce
- Evaluate procedural and impact metrics and incorporate best practices into continued supply chain development

Manufacturing Acquisition & Assembly

2028-2029

- **Turbine components**
- **Foundations**
- **Electrical components**
- **Other Components**
- **Onshore Assembly**

Transportation & Logistics

2029-2031

- **Transporting components to staging areas**
- **Specialized vessels for transporting large components**
- **Logistics & Coordination**

Construction & Installation

2029-2031

- **Site & Seabed Preparation**
- **Foundation/Substructure Installation**
- **Turbine & Nacelle Installation**
- **Electrical Infrastructure Installation**
- **Use of Specialized Vessels**

LONG-TERM SUPPLY CHAIN DEVELOPMENT ACTIONS

- Maintain and upgrade key supply chain infrastructure
- Advocate for federal support for expansion of supply chain infrastructure
- Fill manufacturing gaps
- Continue to expand the offshore wind energy pipeline.

Commissioning

2031-2032

- **Testing & Commissioning of Turbines and Systems**
- **Integration with the Grid**
- **Final Inspections and Certifications**

Operations & Maintenance

2032-2052

- **Regular Maintenance of Turbines and Electrical Systems**
- **Monitoring and Diagnostics**
- **Repairs and Replacements as Needed**
- **Use of Service Vessels and Remote Monitoring Systems**

Decommissioning & Next Stage Developments

2052+

- **Planning**
- **Dismantling and removal of components**
- **Site Restoration and Environmental Remediation**
- **Concurrent commissioning of new equipment and farms**

Executive Summary

Introduction

Nova Scotia is now being recognized as among the best globally in terms of its offshore wind resource[1]. The province has significant advantages for developing offshore wind including 'hard' factors like geography, favourable wind speeds, deep water ports, the province's adjacency to the continental shelf, immediate access to the global shipping lanes between North America and Europe, the Mediterranean and other regions, and our academic and ocean related institutions. That value proposition is also amplified by 'softer' factors that are notable. These include Nova Scotia’s transferrable experience from offshore oil and gas, history and culture arising from ship building, the province’s early prowess in north/south ocean trade, its centuries-old diverse fisheries, and being the home base of generations of seafarers.

These advantages, paired with burgeoning industry interest in using offshore wind energy to power potential investments in emerging fuel sources such as green hydrogen, ammonia, and sustainable aviation fuels (SAF), offer a compelling value proposition for Nova Scotia to enhance critical mass and become Canada’s leading jurisdiction in harnessing wind energy.

The province is aiming to issue five gigawatts (GW) of licenses for offshore wind by 2030, with leasing set to start in 2025[2]. These provincial offshore wind development goals align with Canada's larger environmental objectives, including the transition to clean energy and reaching net-zero emissions by 2050. They also align with Nova Scotia’s ambitious provincial target of an 80% renewable energy mix by 2030 and a net-zero emissions economy by 2050.

The scope of this study includes an assessment of supply chain limitations and opportunities, identification of potential areas of leakage, assessment of labour availability and requirements (including Indigenous labour and those drawn from equity deserving groups), while also identifying other associated consequences for the economy and provincial infrastructure. Policy implications and recommendations are also explored in this report.

While offshore wind is well established in Europe and elsewhere, lessons learned to date from these developments underscore a few key considerations for any jurisdiction considering embarking on such a venture, particularly from a single province perspective:

- The complexity and evolving technologies associated with these developments.
- The global supply/demand context impacting planning, time scale and, ultimately cost.
- The innovation intensity and the diversified value proposition these undertakings offer from construction through to research and development, a factor that allows for differentiation and specialization.
- The scale of these developments and the importance of jurisdictional collaboration from many perspectives – investment intensity, supply chain development, labour supply, port development, socio-economic impact, risk mitigation, among others, and
- What can be learned from those who have gone before along with pitfalls to avoid.

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[1] Province Sets Offshore Wind Target | Government of Nova Scotia News Releases

[2] Nova Scotia Offshore Wind Roadmap

Key Findings

Supply Chain Analysis

Existing capacity in Nova Scotia includes areas such as:

- Demonstrated capability in monopile marshalling at two ports
- Seabed characterization capabilities
- Environmental monitoring capabilities
- Limited professional and manufacturing services

However, there are significant gaps between Nova Scotia's current supply chain capacity and what would be required to develop and service 5GW of offshore wind operations – particularly among what is referred to as "Tier 1" suppliers – which manufacture essential components such as blades, towers, monopiles, etc.

Based on the findings of this study, to build capacity most effectively and rapidly in Tier 1 capabilities by 2030 will require either partnering with other jurisdictions that have these capabilities or building domestic capacity in strategic areas that are aligned with Nova Scotia's existing strengths.

There is less risk involved for companies looking to invest in developing offshore wind operations in a new market if the industry is more established. Therefore, when supply chain components are not available in a jurisdiction pursuing offshore wind, the literature suggests effective policy is needed to "jump-start" the sector to attract developers and manufacturers. However, in efforts to jump-start the sector through policy, it is emphasized in the literature to avoid "top-down" approaches, and to ensure supply chain growth is demand driven.

Labour Analysis

We assessed employment through two approaches – through case study research, benchmarking impacts against US studies, as well as through an IO simulation, using CAPEX and OPEX estimates for various development scenarios in NS' offshore.

Based on the literature reviewed for this study, there are five key categories of workforce demands for building offshore wind:

1. Development
2. Manufacturing and Supply Chain
3. Ports and Staging
4. Maritime construction
5. Operations and Maintenance[3].

For the period of 2025-2032, based on benchmarked labour force estimates calculated for 30 GW in the US[4], five GW in Nova Scotia would result an estimated average of 5,227 workers employed per year in offshore wind between 2025-2032 for construction period installation and supply chain jobs. By 2032, operations and maintenance jobs would employ 2,238 persons per year. While useful as a benchmarked case study example, these estimates are not aligned with the updated results generated through the current modelling work.

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[3] Stefek et al., "U.S. Offshore Wind Workforce Assessment."

[4] Effross, "Offshore Wind Development and Supply Chain Overview."

NS-specific cost analysis projects lower labour estimates for offshore wind CAPEX than those based on the US calculations.

- For port construction alone, over 4-5 year period with $1 billion in investment, construction would result in total employment in full time equivalents (FTEs) of 8,662 jobs with an average total direct employment of between 1,300-1,600 FTEs per year. This would generate a total labour income of just under $580 million over the full duration construction phase of the ports.
- For offshore wind development, labour estimates resulting from CAPEX estimates were explored for five different scenarios. Labour estimates range from total employment of 576 to 4003 jobs on average per year depending on the scenario.
- For offshore wind development operations, labour estimates resulting from OPEX estimates were also explored for each scenario. The average annual employment for offshore windfarm operations includes up to 1,349 positions, at full production capacity, depending on the scenario.

Economic Impacts

The study found that floating offshore wind development would have greater economic benefits for the local economy, than fixed. Floating would also have a lower cost of operations, with the total OPEX per GW estimated at $87 million per year for floating systems and $108 per GW for fixed.

This is due the anticipation that the requirement for monopolies for fixed structures would require relatively more importing of structural elements and professional services, at least in the short-term, while Nova Scotia currently has the fabrication capabilities to manufacture floating structures locally, owing to a well-established boat building industry. Within fixed structures, GBS systems would also tend to have a greater local impact relative to systems anchored to the seafloor, due to the requirement to fabricate the GBS structures near shore. However, key informants engaged for this study shared that the cost difference between the two structures does not suggest fixed structures should be ruled out in Nova Scotia.

In addition to nearly $1 billion in CAPEX for port development, to be invested over 4 to 5 years, the wind CAPEX will cost between $4.2 and up to $69.1 billion under the high-cost estimate, depending on the scenario, based on an average cost of $7B per GW in a NS context.

Scenario:	Stage A1	Stage A2	Stage B1	Stage B2	Scenario C Stage 3
TOTAL CAPEX	**$4,200,000,000**	**$44,914,991,222**	**$4,708,048,078**	**$40,079,639,357**	**$69,070,817,969**
NS CAPEX	**$336,000,000**	**$2,520,000,000**	**$336,000,000**	**$2,800,000,000**	**$5,600,000,000**
Years in Construction	5	15	5	10	12
Project Megawatts	600	4,500	600	5,000	10,000

Summary of Impacts

Leveraging the province of Nova Scotia Input Output (NSIO) model, the following impact estimates emerge for Port Impacts (Total over 4 to 5 years):

- **Port Impacts:**

- **Capital Investment**: $1 billion in port infrastructure construction and upgrades, accruing over a 4-to-5-year period).
- **Annual Average Economic Impact (Construction)**
    - Direct GDP: $120 million/year.
    - Total GDP: $168.45 million/year.
    - Employment: 1,305 direct FTEs (1,732 total FTEs).
    - Labour Income: $91.61 million direct, $115.89 million total.
    - Provincial Revenue: $11.72 million direct, $14.82 million total.
- **Operation and Maintenance (O&M) Impact**:
    - Annual GDP: $7.91 million direct, $13.4 million total.
    - Employment: 70 direct FTEs (124 total FTEs).
    - Labour Income: $4.63 million direct, $7.53 million total.
    - Provincial Revenue: $0.59 million direct, $0.96 million total.

The NSIO results for the wind developments, averaged across all scenarios, are presented below and include:

- Floating Wind Elements (turbines, development and project management, floating structures, electrical infrastructure, and assembly and installation),
- Fixed Wind Elements (turbine, development and project management, substructure and foundation, electrical infrastructure, and assembly and installation),
- Cable (off shore to on shore), including purchase of materials, labour, and installation,
- Onshore substation, including purchase of material, labour, and installation
- Grid infrastructure, including land acquisition, transmission and substation material, and installation.

- **Offshore Wind Development Impacts:**
    - **Total Capital Expenditure (CAPEX)**: Ranges from $4.2 billion to $70 billion.
        - Nova Scotia's share: $0.33 billion to $5.6 billion (under assumptions around NS current supply chain capabilities).
    - **Annual Average Economic Impact (Construction)** – See Table 7:
        - Direct GDP: $34 million to $237 million.
        - Total (Direct and Spinoff) GDP: $58 million to $402 million.
        - Employment: 347 to 2,417 direct FTEs (576 to 4,003 total FTEs).
        - Labour Income: $24 million to $167 million direct, $37 million to $258 million total.
        - Provincial Revenue: $3 million to $21 million direct, $6 million to $42 million total.
    - **Operation and Maintenance (O&M) Impact** – See Table 13:

    - Annual GDP: $5.4 million to $104.6 million.
    - Employment: 44 to 848 direct FTEs (69 to 1,349 total FTEs).
    - Labour Income: $2.7 million to $53.2 million direct, 4.2 million to $81.6 million total.
    - Provincial Revenue: $.34 million to $6.7 million direct, $.54 million to $10.4 million total.

- **Combined Overview (Port Development and Offshore Wind Development):**

Note: Port development spending is phased over five years, while offshore wind construction timelines and associated capital outlays vary by scenario.

- **Construction Phase (Total)**:
    - GDP impact: $770 million to $3,449 million direct, $1,131 million to $5,661 million total (port and offshore wind combined).
    - Employment: 8,261 to 35,536 direct FTEs, up to 56,707 total FTEs.
    - Provincial Revenue: $74 million to $307 million direct, up to $578 million total.
- **Operation Phase (Annual)**:
    - GDP impact: $13.29 million to $112.51 million direct, $21.48 million to $170.28 million total.
    - Employment: 114to 918 direct FTEs, up to 1,473 total FTEs.
    - Provincial Revenue: $1 million to $7 million direct, up to $11 million total.

Offshore wind development presents significant economic opportunities for Nova Scotia, however, without addressing the gap between current labour supply and future demand, the province could face challenges that could impede project timelines and affect the overall economic impact of the investments. Proactive workforce development, on a regional, national, or even international scale, and careful labour market planning will be crucial in leveraging these opportunities among other elements of a comprehensive economic development and implementation strategy.

Gaps and Opportunities

Based on the findings of this study, the following key challenges and opportunities have been identified to address gaps facing Nova Scotia's capacity to effectively develop an offshore wind industry:

- **Manufacturing Capacity:** While Nova Scotia has some manufacturing capacity for offshore wind, such as large-scale steel fabrication, it is limited and not currently sufficient to supply the component requirements for 5GW locally. Further, there are significant gaps related to access to significant amount of steel and cement required for manufacturing offshore wind components. Building domestic manufacturing capacity to reduce the risk associated with cost of importing components from international markets such as Europe and Asia, and addressing the vagaries of availability will be critical to offering a cost-competitive option for offshore wind developers. Further, building the case to address domestic manufacturing gaps is the high demand for offshore wind components within the countries exporting them. It is anticipated there will be a shortage of supplies, equipment and finished goods as Europe and China hasten to deploy newer, larger models of offshore wind power turbines within their own jurisdictions[5]. Building local manufacturing capacity for offshore wind will be a long process. To retain benefits for Nova Scotia, it is recommended that the province target efforts to attract investment in offshore wind manufacturing capacity that aligns with its existing strengths and assets in the early stages (e.g., fabrication of large steel structures) while building to the point of critical mass.

- **Port Capacity:** While outside the scope of this study, the literature shows there is a gap between Nova Scotia's current port capacity and what would be required to support 5GW of offshore wind. While Nova Scotia has some ports currently servicing the US offshore wind sector with marshalling capabilities, servicing 5GW of offshore wind would require investments in upgrading or building new ports capable of withstanding the weight and size of offshore wind components. A companion report completed for the committee provides more details on port requirements to service offshore wind in Nova Scotia.
- **Grid Capacity:** Grid capacity is also outside the scope of this study but an important economic consideration in planning for offshore wind. According to an expert advisor, there is some capacity in the existing grid to accommodate power from another source, such as offshore wind, but it is limited. Wherever and whenever generation from offshore wind is proposed, system integration studies will be required. However, accommodating any substantial offshore wind generation within the grid would require the development of new markets or the instigation of the Atlantic Loop.[6] There is a very limited domestic provincial market.
- **Labour Supply and Training:** There is a currently a gap in Nova Scotia's workforce related to the highly specialized skills and trades required for offshore wind. Additionally, case study research based on US examples suggest that 5GW of offshore wind operations could require more than 5,227 positions filled per year leading up to 2032, based on US requirements for 30GW, with lower projections based on our Nova Scotia-specific cost-analysis. Nova Scotia currently does not have the workforce to fill these positions and sectors that have relevant labour that could transfer to offshore wind with training, such as construction, are currently facing labour shortages throughout the province. There are many opportunities for bolstering the workforce's capacity for servicing the offshore wind sector including:
  - Attraction of foreign specialists
  - Development of upskilling and micro-credential programs for relevant trades
  - Working with post-secondary institutions and industry to support development of new training programs
  - Supporting non-profit workforce development coalitions in partnership with industry and the post-secondary sector.
  - Engaging with Indigenous and other equity deserving groups in workforce development
- **Research and Development:** While Nova Scotia currently has strong ocean-focused R&D institutional capacity, a focus on offshore wind in the province's innovation ecosystem is currently a gap. In other jurisdictions, nationally focused consortiums have been established as independent, not-for-profit organizations that manage industry-focused research and development for offshore wind to maximize economic benefits. Government

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[5] Effross.

[6] The Atlantic Loop was envisioned as a series of transmission expansion projects that would have increased transfer capabilities between Hydro Quebec and New Brunswick and between New Brunswick and Nova Scotia.

grants provide the consortiums with funding to support efforts to address barriers to offshore wind and to reduce the *levelized cost of electricity* (LCoE), including issuing of competitive solicitations for offshore wind technology projects. There is a strong case for a similar, federally focused consortium to be developed in Nova Scotia, given its existing strengths in ocean-based innovation and R&D through established institutions such as the Centre of Ocean Ventures and Entrepreneurship (COVE) in Dartmouth, which focuses on marine innovation, the Oceans Innovation Hub on the Strait of Canso which focuses on marine-based training, and the Pier in Halifax, which focuses on innovation in ports, supply chain, logistics, and maritime policy. Early efforts to fill this gap are underway in Nova Scotia, including the concept of an Offshore Wind Innovation Hub that is currently being explored in the Strait of Canso region.

- **Cross-Border Collaboration:** As the US supply chain is also facing supply chain gaps while working towards its 2030 goal of 30 GW and faces many of the same risks as Nova Scotia related to importing from Europe and Asia amid international shortages for offshore wind components, Nova Scotia and Atlantic Canada as a region could become an important partner to developments along the US' east coast as it builds its offshore wind capacity. Working with the US and Canadian federal governments to identify where Nova Scotia and the Atlantic Region could fill American supply chain gaps could have mutually beneficial effects. It would increase the business case for investing in new manufacturing capabilities for offshore wind in Nova Scotia, and consequently, boost supply chain capacity for Nova Scotia and nearby regions.

Policy and Planning Considerations:

- **A Bottom-up Approach with Government Support to "Jump Start" the sector:** In other jurisdictions, it has been made clear that a bottom-up approach to supply chain development driven by demand rather than a top-down approach is preferred. Top-down approaches with high local content requirements have led to slower, more expensive development processes and in some experiences, demanding these requirements have resulted in legal action due to violation of World Trade Organization (WTO) commitments. Facilitating a bottom-up approach is therefore recommended. However, this does not suggest the sector will be successful without government support. The literature shows effective government policies and investments are recommended in jurisdictions entering offshore wind for the first time in order to "jump start" the sector and make it an attractive location for investors. The literature shows effective government policies and investments are a powerful tool to help "jump-start" offshore wind in new locations[7]. Some mechanisms the government could leverage to support the sector in the early stages of development include:
    - Tax Incentives
    - Legislation
    - Financial support (subsidies, grants, support for access to capital)
- **A Collaborative Approach:** Successful models for building supply chain and workforce capacity for offshore wind include taking a regional or multi-nation approach to build on multiple jurisdiction's existing strengths and assets. Europe offers some interesting case studies and analogues in collaborative initiatives involving multiple countries while accommodating specialization. While the province can accrue significant local benefits with targeted investments and policies to build the supply chain benefits in Nova Scotia

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[7] Effross, "Offshore Wind Development and Supply Chain Overview."

communities, it is unlikely all requirements can be met within its provincial borders by 2030. However, exploring partnership options with the other Atlantic Canadian provinces and provinces such as Ontario that produce the majority of the nation's raw steel and cement products could be explored while the province builds its critical mass. There could be a case for positioning offshore wind in Nova Scotia as a nation-building project for Canada. International collaboration, including with the US, could also be explored as an opportunity to fill gaps. Acting in the early stages of offshore wind planning to develop collaborative relationships with other jurisdictions and to provide government support to incentivize investment attraction for supply chain gaps and to support workforce development, research and innovation would help to launch the sector in a successful direction. Effectively, offshore wind presents enormous opportunities for Nova Scotia, however grasping these opportunities will require a coordinated and collaborative approach with other jurisdictions.

1 Introduction

1.1 Purpose of this Study

21FSP was engaged by the Committee for the Regional Assessment of Offshore Wind Development in Nova Scotia to undertake a first-stage socio-economic assessment of offshore wind development in Nova Scotia aligned with three proposed scenarios for how the sector could develop. The three proposed scenarios were prepared by committee members, and are provided in Appendix A.

This project was coordinated with two adjoining projects that are underway:

- An assessment of the existing electricity grid in Nova Scotia relative to specific development scenarios for 5GW of offshore leases by 2030.
- An examination of selected ports, and related infrastructure, to accommodate both fixed (i.e., monopile/gravity based) and floating offshore wind development in the province, initially for up to 5GW of power. This examination will include an assessment of the investments required, as well as the benefits that will accrue from their role in staging and servicing offshore wind development.

The scope of this study includes an assessment of supply chain limitations and opportunities, identification of potential areas of leakage, assessment of labour availability and requirements (including Indigenous labour and those drawn from equity deserving groups), while also identifying other associated consequences for the economy and provincial infrastructure.

1.2 Report Methodology

Methodology for this report included:

- Secondary research on other jurisdictions' experiences with offshore wind to draw best practices and lessons from which Nova Scotia can learn. This has included referencing benchmarked industry and trade journal reports, and grey literature with particular reference to international experience, notably European sources, wherein the development of offshore wind and associated supply chain development has a much longer history.
- Engagement with expert advisors in energy developments and port infrastructure to gather perspectives on potential socio-economic impacts and approach to methodology.
- Economic Impact analysis was completed using a combination of desktop research and the Province of Nova Scotia's Input/Output model, which is maintained by the Economic and Finance Division of the Department of Finance. The resulting analysis is described in **Section 5**.

2 Background and Project Context

2.1 The Offshore Wind Sector and the Opportunity for Nova Scotia

Offshore wind energy is a well-established and growing global energy source that offers significant opportunities for Nova Scotia. The underlying technology has significantly matured over the past three decades amid growing demand for renewable, clean energy globally.

Presently, offshore wind powers millions of homes and businesses around the world with total capacity having increased ten-fold between 2010 and 2020, a trend that is expected to continue.

Comparatively speaking, offshore wind energy is a relatively recent development. The first commercial offshore windfarm was built in 1991, in Denmark[8]. The first project in North America was at Block Island, Rhode Island, in 2016[9].

Nova Scotia is now being recognized as among the best globally in terms of its offshore wind resource[10]. The province has significant advantages for developing offshore wind including 'hard' factors like geography, favourable wind speeds, deep water ports, the province's adjacency to the continental shelf, immediate access to the global shipping lanes between North America and Europe, the Mediterranean and other regions, and our academic and ocean related institutions. That value proposition is also amplified by 'softer' factors that are notable. These include Nova Scotia’s transferrable experience from offshore oil and gas, history and culture arising from ship building, the province’s early prowess in north/south ocean trade, its centuries-old diverse fisheries, and being the home base of generations of seafarers.

These advantages, paired with burgeoning industry interest in using offshore wind energy to power potential investments in emerging fuel sources such as green hydrogen, ammonia, and sustainable aviation fuels (SAF), offer a compelling value proposition for Nova Scotia to enhance critical mass and become Canada’s leading jurisdiction in harnessing wind energy.

There are also new and emerging challenges to be solved within the sector – some of which Nova Scotia has the marine innovation ecosystem to explore either directly or in partnership with industry and associated institutions over time. Wind turbines themselves continue to evolve. Developments like 'smart blades' and advances in sensor technology are driving new innovations. While the capacity of today’s devices is 17 times that of the initial machines installed in Denmark, these evolutions are continuing apace.

Figure 1: Hywind Scotland Project – Floating Wind Farm

There is also extensive research into floating technology underway as the relative benefits, flexibility and potential cost advantages of this technology continues to evolve. Initial trialed models are being scaled in real world circumstances and this is an area of growing focus internationally. The Hywind Scotland Project (2017), pictured to the right, was the first floating wind farm to

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[8] Offshore Wind – A Brief History (marinetechnologynews.com)
[9] Ørsted, “The Starting Five: Stories from America’s First Offshore Wind Farm.”
[10] Province Sets Offshore Wind Target | Government of Nova Scotia News Releases

generate meaningful amounts of electricity in a real-world environment[11].

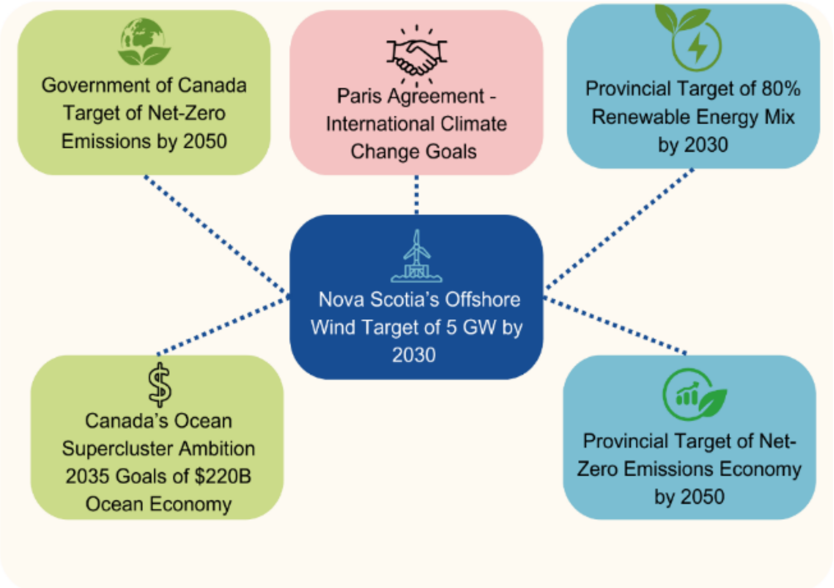
The evolving nature of floating technology means a variety of different construction styles are still being investigated. Industry projections suggest that improved storage technology and floating offshore wind farms are key developments likely to advance the sector in the coming decade, as floating offers more flexibility in site location and access to higher wind speeds. There may be niche areas within these developments, such as new technologies to perfect ballast management in floating platforms, in which Nova Scotia's strong ocean technology and innovation sector could play an important role.

2.2 Current State of Offshore Wind in Nova Scotia

Considering its world-class wind speeds and as a jurisdiction that has already proven its ability in advancing clean energy development, Nova Scotia is exceptionally well-positioned to lead and drive growth in this sector.

The province is aiming to issue five gigawatts (GW) of licenses for offshore wind by 2030, with leasing set to start in 2025[12]. These provincial offshore wind development goals align with Canada's larger environmental objectives, including the transition to clean energy and reaching net-zero emissions by 2050. They also align with Nova Scotia's ambitious provincial target of an 80% renewable energy mix by 2030 and a net-zero emissions economy by 2050.

Figure 2: Strategic Alignment of Nova Scotia's Offshore Wind Target with Provincial, Federal and International Goals.



As explored above, there is growing recognition of offshore wind's potential to generate renewable electricity for green hydrogen production, both for local use and export. The innovation potential and intensity in these developments is significant. In Nova Scotia, industry and government have been advancing towards green hydrogen production, with EverWind Fuels having approval for three onshore wind farms in Nova Scotia (Windy Ridge, Kmtnuk and Bear Lake) to fuel its green hydrogen and ammonia production facility in Point Tupper[13]. The Point Tupper project received the first environmental assessment approval for green hydrogen production in North America and is on track to be the province's first green hydrogen production facility. As of July 2024, the renewable energy company is on track to have its onshore wind farms

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[11] The future of wind energy is floating turbines on the ocean | Climate Central

[12] Nova Scotia Offshore Wind Roadmap

[13] Grant, "Nova Scotia Approves Another Wind Farm to Power Green Hydrogen Plant."

online by 2026[14] and aims to have offshore wind contributing to green hydrogen production by 2030[15]. There are also multiple agreements that have established demand for Nova Scotia-produced green hydrogen internationally, including an MOU between Canada and Germany for the development of a transatlantic hydrogen trade corridor and a recent $300m federal funding commitment to support green hydrogen trade with Germany[16].

Strategically, offshore wind also complements Nova Scotia's leadership in other developmental aspects of optimizing a blue economy strategy. This includes the innovation ecosystem that is growing and scaling around developments such as the Centre for Ocean Ventures and Entrepreneurship (COVE), Net Zero, Canada's Ocean Supercluster, and the work of the Nova Scotia Community College (NSCC) Ocean Technology group, as well as the collaborations and support to be leveraged with the Nova Scotia's post-secondary institutions and economic development agencies, among others.

Overall, Nova Scotia is well positioned to benefit from developing this sector.

3 Lessons Learned – Jurisdictional Review and Implications for Nova Scotia

With any new venture, it is important to understand both critical success factors and potential pitfalls to avoid. To identify these factors for offshore wind in Nova Scotia, a high-level jurisdictional review was undertaken with a focus on lessons learned from the European and American experiences. More specific case studies of success stories in leveraging offshore wind to the benefit of local communities and ports are also provided in this chapter.

3.1 Europe

A Regional Approach to Offshore Wind with Lessons for Nova Scotia

Europe[17] has experienced significant success in developing the offshore wind sector using a regional approach, featuring multijurisdictional collaboration. There are now 189 GW of wind energy in Europe, making up 14% of its power demand. 18.5 GW of this is in Europe's offshore fleet, which has 105 wind farms and 4,500 turbines, and provides 40,000 jobs[18]. These numbers are anticipated to grow, as Europe continues to build its offshore wind capacity.

In addition to contributing a significant source of clean energy and jobs, the offshore wind sector in Europe has had positive economic effects on revitalizing the economy of former industrial towns – an important consideration for Nova Scotia which has similar post-industrial port towns in need of economic revitalization due to a number of demographic and industrial shifts.

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[14] Grant.

[15] Everwind Fuels, "Point Tupper Project."

[16] Natural Resources Canada, "Government of Canada Announces $300 Million in Port Hawkesbury on Canada-Germany Hydrogen Alliance."

[17] Note: references to Europe in this study include both the European Union (EU) and the United Kingdom (UK)

[18] Wind Europe, "European Offshore Wind: The Story Behind the Success."

As an example, for Green Port in Hull, UK, offshore wind has brought €400m in investment and directly created 1,000 new jobs while providing a wide range of social initiatives to the local community[19]. Seaside towns such as Grimsby, Aberdeen and Great Yarmouth in the UK have all experienced economic recovery in recent years due to their status as staging and servicing hubs for offshore wind farms, which has resulted in hundreds of skilled job opportunities, as noted in the adjacent text box[20]. Some of these experiences and others are explored in further detail in case studies provided in Section 3.3.

> *"With this growth comes huge infrastructure investments that are transforming UK's coastal towns from empty ports to bustling industry hubs and with that, thousands of skilled jobs."*
>
> McGuire, 2019.

Overall, Europe offers some of the world's best success stories in offshore wind. The literature highlights the following as critical factors for Europe's success in building the offshore wind sector:

- Regional Cooperation
- Building local manufacturing capacity for supply chain with a bottom-up approach
- Cooperation with other ocean users
- Fostering an innovation ecosystem
- Leveraging lessons learned through offshore oil and gas

These success factors are explored in more detail below.

Regional Cooperation

WindEurope CEO, Giles Dickson recently gave a conference presentation on factors enabling Europe's success in offshore wind. In the presentation, Dickson stressed the importance of regional cooperation to enable rapid growth. He pointed to the example of the *North Seas Energy Cooperation*. This initiative aims to establish an offshore grid linking the ten countries in the North Seas region (Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway, Sweden and the United Kingdom). The North Seas Energy Cooperation is facilitating the cost-effective deployment of offshore wind while promoting interconnection between the countries in the region. The initiative was established through a joint political declaration between the involved countries that established political intent for nation-level collaboration[21].

In this context, considering the capital intensity, potential scale and nation-building dimension of these developments, there is a case for strong collaboration and cooperative development of this renewable energy source in Atlantic Canada.

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[19] Wind Europe.
[20] McGuire, "Offshore Wind Is Transforming The UK's Coastal Towns."
[21] CIRCABC, "Political Declaration of Energy Cooperation Between the North Seas Countries 2016."

> "*Meeting future workforce demand efficiently is best served by a coordinated, regional approach. This approach will enable stakeholders to build consensus around off-shore wind-energy-specific role requirements, collaborate on new and existing programs to provide comparable off-shore-wind focused training and education, and coordinate the mobilization of workforce in related fields to support industry needs.*"
>
> Stefek et al., 2022.

Nova Scotia's proximity and existing relationship with the other Atlantic provinces could be leveraged into a cost-effective development of offshore wind grids and supply chains in a manner that benefits the whole region while boosting Nova Scotia's access to required goods and services for the sector. The literature on offshore wind development generally also points to the benefits of regional cooperation in relation to workforce development for offshore wind, as noted in the adjacent text box.

Building local manufacturing capacity for supply chain with a bottom-up approach

Europe's experience has included manufacturing of offshore wind supplies and materials close to market. In Europe, this included a degree of specialization (e.g., in Europe, Poland makes most of the foundations and cranes even though they don't have any offshore wind farms yet, while Spain specializes in tower manufacturing). As will be explored in more detail in Section 4, Nova Scotia currently lacks many of the specialized manufacturing capabilities required for offshore wind parts and equipment, with some exceptions such as Dartmouth-based Cherubini's capacity for custom steel work including experience developing large scale open hydro turbine gravity bases.

Over time, as the industry evolves, a regional approach similar to Europe's could dilute the pressure on Nova Scotia alone to make and attract investments in new manufacturing capabilities for offshore wind parts, while still allowing developers to acquire required materials nearby and therefore, in a cost-effective manner (as opposed to importing materials made in Europe or Asia at a higher cost). However, a key point in the literature on Europe's success is that its level of localization and specialization in manufacturing capacity has developed from the bottom up – driven by market forces. According to Dickson, only one country in the EU country attempted to impose local content from the top-down – France. A key lesson learned from France's top-down approach is that as of 2019, they had the highest costs for offshore wind development and no operating wind farms. Since 2019, they've only had two operating farms developed – a small amount compared to other EU countries with similar offshore wind goals[22]. As Dickson noted in his conference presentation, "*We know the politics around jobs and the temptation to impose local content. But the European experience shows that if you want both local jobs and low costs, it's best to let the market work*[23]*.*"

In addition to being an expensive country in which to build a wind farm, reportedly, France's top-down approach has also resulted in lengthy timelines for development. France has since pivoted its approach and recently announced "simplification measures" to reduce the current 10-12 years required to build an offshore wind farm in France: "*This (timeline) currently threatens the economic viability of offshore wind farms and put's France's energy targets at risk*"[24]. The simplification measures aim to cut the average offshore wind farm development time in half to six years, and includes accelerating grid connections, increasing the efficiency of auctions by reducing duration

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[22] Wind Europe, "European Offshore Wind: The Story Behind the Success."
[23] Wind Europe.
[24] Wind Europe, "France Commits to Big Offshore Wind Volumes."

of the auction period, adjusting procurement policies to allow using prequalification in procurement and adding non-price criteria[25].

Cooperation with other ocean industries

Another critical success factor for Europe has been attention paid to the importance of a "happy coexistence" between offshore wind and other users of the ocean[26]. Ensuring site locations and regulations related to offshore wind avoid conflicts with other marine-based industries will be critical for the sector in Nova Scotia, which has fishing, shipping, military and biodiversity interests at play.

> *"Offshore wind only works if there's happy coexistence with fishing, shipping, military interests and biodiversity interests."*
>
> WindEurope CEO Giles Dickson

Fostering Successful Innovation Systems in Offshore Wind with Economic Benefits

The literature also highlights another success factor for Europe: its focus on increasing efficiency and lowering the cost of offshore wind operations through investments in innovation.

For example, there have been major advances in Europe towards making floating wind farms more feasible and cost-effective, which opens more areas to offshore wind development. Fixed offshore wind requires specific seabed conditions and limited depths, while floating farms also can be deployed in deeper areas and have environmental advantages, such as a small footprint on the seabed. Floating farms are also less expensive to maintain, as repairs can be completed by hauling turbines to a port, rather than transporting large cranes and other large equipment to sea on a ship.

Figure 3: WindFloat Atlantic Semi-Submersible Floating Offshore Wind Farm, Portugal.

In Portugal, the Windfloat Atlantic project resulted in the world's first semi-submersible floating offshore wind farm that recently finished its third year of operation with an electricity production of 80GWh. The innovative development has overcome challenges of floating wind farms in harsh conditions, with designs withstanding waves of 20 metres and wind gusts of up to 139 kilometres per hour, reaching a new level of readiness for floating technology in extreme offshore conditions[27]. The company also launched an R&D project called ATLANTIS which included integration of robotics in operations to decrease the levelized cost of energy (LCOE) by minimizing reliance on support vessels for inspection and maintenance.

France has also advanced the case for floating wind farms through its recent installation of three floating innovative wind farm turbines using taut anchor lines at the Provence Grand Large floating offshore wind pilot project, 17km off the coast of Port-Saint-Louis-du-Rhône[28]. Taut anchor lines

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[25] Wind Europe.

[26] Wind Europe, "European Offshore Wind: The Story Behind the Success."

[27] Windfloat Atlantic, "World's First Semi-Submersible Floating Offshore Wind Farm."

[28] Provence Grand Large, "The Three Floating Wind Turbines of Provence Grand Large Have Been Successfully Installed At Sea."

are more cost effective than alternatives and give more load sharing between the mooring lines. This installation was the first time this technology of floats with taut anchor lines was used in the offshore wind sector[29].

> *"To increase the success chances of offshore wind technology, both in terms of the share in the future energy system and the economic benefits for businesses, it is necessary to study the innovation system for offshore wind energy, evaluate how the system functions and identify the problems that need to be addressed by policy."*
>
> - Luo et al. 2012

A report from the European Commissions' Joint Research Commission emphasized that investments in technology and innovation are always fraught with uncertainty on whether it will result in economic success. However, based on experiences in the Netherlands, Denmark, Germany and the UK, there is a better chance of success when a focus is placed on developing innovation systems: "…*a conscious and intelligent management of innovation processes strongly increases the success chances of innovation*"[30].

The importance of fostering and evaluating innovation systems to identify solutions for barriers to success is a key lesson learned from the European experience in offshore wind.

Leveraging Experience with Offshore Oil and Gas

Europe's experience with offshore oil and gas is another success factor for its offshore wind industry. The Government of Scotland, for example, highlights its established experience in offshore oil and gas as a competitive advantage for its offshore wind industry. Experience in offshore oil and gas means the offshore wind industry can benefit from existing capabilities in a region's offshore operations, skilled labour, and offshore assets and capabilities such as subsea monitoring capabilities.

While there are specialized skillsets for offshore wind not required in the offshore oil and gas sector, some skills are directly transferrable while others can be transferrable with a focus on upskilling or micro-credentialling. In Scotland's experience, offshore oil and gas workers have transitioned to offshore wind and the majority of the 120,000 offshore oil and gas workers in the UK have expressed an interest in transitioning to the sector. A recent survey conducted by Campaigners Platform, Friends of Earth Scotland and Greenpeace UK found that four out of five offshore oil and gas workers in the UK want to transition from the oil and gas industry and 53% expressed an interest in joining offshore wind in 2020[31].

Challenges Facing Europe's Offshore Wind Industry and Lessons Learned

Despite the success story in Europe, its offshore wind industry (along with the industry elsewhere), is facing significant challenges in the current macroeconomic environment. Some stakeholders have begun to question the financial viability of offshore wind after the cancellation of several projects due to rising raw commodity prices, interest rate hikes, and supply chain bottlenecks – with some projects experiencing cost increases of between 40% and 60%[32] [33] [34]. In response to

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[29] Provence Grand Large.

[30] Luo et al., "A Systemic Assessment of the European Offshore Wind Innovation: Insights from the Netherlands, Denmark, Germany and the United Kingdom."

[31] Airswift, "How Can Offshore Wind Benefit from Transferable Skills within Oil and Gas?"

[32] Offshore Magazine, "Report: Three Offshore Wind Projects Cancelled off New York."

[33] McKinsey & Company, "Offshore Wind: Strategies for Uncertain Times."

[34] Bindman, "Analysis: Cancellations Threaten Biden's 2030 Offshore Wind Target."

these concerns, a recent report by McKinsey & Company addresses how developers can take steps to navigate this changing economic landscape to ensure continued growth.

The report identifies five key drivers impacting the future of the offshore wind industry, including:

- **The position on the cost curve** – meaning how much costs are affecting profitability.
- **The regulatory landscape** – including factors such as the cost of participating in auction processes and subsequent effects on the attractiveness of projects.
- **The market pull** – meaning the demand for green energy from offshore wind.
- **Supply chain capacity** – including factors such as sufficient investment in supply chain capacity to meet government targets.
- **Developer behaviour** – such as developers exiting the market due to reduced internal rates of return. [35]

Each of these drivers are described in Figure 4 below which shows three scenarios ranging from on a scale of "in favour of headwind aggravation" and "in favour of rapid recovery."

Figure 4: Five drivers impacting the future of the offshore wind industry. Source: McKinsey & Company, 2024.

Drivers	Solution space of profitability drivers (through the cycle 2023–33) *In favor of headwind aggravation*		*In favor of rapid recovery*
Position on cost curve	**Diminishing cost position** of OSW[1] vs alternative renewable technologies	**Slow convergence** in cost position toward alternative renewable technologies	**Rapid decrease in LCOE,[2]** putting OSW in line with alternatives such as solar PV and onshore wind
Regulatory landscape	**Reaching government targets is not a priority,** driven by, eg, a difficult macroeconomic environment	**Budget constraints limit** development and value creation	**Commitment to reaching OSW** government targets
Market pull	**Fading momentum in climate policies,** offtakers deprioritizing energy transition to remain competitive	**Market pull expectations down from 2018–22,** but still see high demand for clean energy	**Significant market pull** with advanced commitment in decarbonization targets
Supply chain	**Continued supply bottlenecks,** with limited room for cost improvements	**Situation slowly normalizing–** but disproportionate value capture by suppliers	**Wave of supply chain investments** (eg, support regimes, acceptability of new entrants)
Developer behavior	**Continuing high competitiveness** and limited consolidation	Developers **more selective in market presence** and **some consolidation happening**	**Sufficient consolidation** and reset of strategic behavior

McKinsey & Company expects the offshore wind industry is in a scenario where the industry will continue to grow, despite the challenging cost position developers are facing[36]. The report's proposed solutions for thriving in this scenario include:

- **Taking smart and controlled market bets**, while investing in seed operations to provide further opportunities in case of an upswing.
- **Actively considering consolidation**, including careful assessment of potential inorganic opportunities and the feasibility of anticyclical investments to rebalance growth.
- **Maximizing efficiency,** including exploration of new organizational structures to quickly adapt to shifting circumstances of the offshore wind market and consideration of opportunities to increase performance across development expenses (DEVEX), operational expenses (OPEX) and capital expenses (CAPEX). Collaborating strategically with suppliers to thrive in volatile times.

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[35] McKinsey & Company, "Offshore Wind: Strategies for Uncertain Times."

[36] McKinsey & Company.

- **Establishing strategic supply chain collaborations** to create transparency and predictability. Collaborations could include vertical integration of strategic suppliers and direct sourcing from Tier 2 and Tier 3 suppliers[37].

A recent report from the World Bank on challenges facing offshore wind in Brazil also highlighted methods to overcome the difficult macroeconomic environment for jurisdictions entering offshore wind for the first time. In the World Bank's report, a focus on developing a clear strategic plan for growing the sector, collaboration, and targeted investments were highlighted as critical to overcoming the financial obstacles facing the sector[38].

While the industry's future profitability remains uncertain, the literature indicates there are early signs of improvement relative to inflation and cost of development and operations, and optimism about the potential of offshore wind as a clean, renewable energy source in the region remains strong. By taking strategic approaches to overcome the challenging macroeconomic environment for offshore wind, the literature from McKinsey & Company and the World Bank suggests obstacles to development can be overcome.

3.2 The United States

Background on the Offshore Wind Industry in the United States

Offshore wind in the United States (US) is a much younger sector than Europe's, with the first development occurring in Rhode Island in 2016[39]. The sector has recently seen a surge of development, investment and planning following an announcement from the Biden administration in March 2021 setting a national target of reaching 30 GW of offshore wind capacity by 2030[40]. US offshore wind is currently projected to create 56,000 new jobs and to attract $65 billion in industry investments by 2030[41].

While the American offshore wind industry is less mature than Europe's, its geographical proximity to Nova Scotia and comparability in terms of supply chain and development costs makes the US experience an analogue with important lessons learned for Nova Scotia. The US is also much further ahead than Nova Scotia in its analysis and strategies surrounding supply chain development, with several studies that provide applicable insights into local supply chain development and potential challenges in a North American context.

Also relevant is the not yet fully developed opportunity for Nova Scotia and Atlantic Canada to potentially serve as a staging base for aspects of the US' offshore wind development journey. This could potentially serve as a synergistic opportunity, while adding to the province's, and the Atlantic Region's, development of critical mass in the offshore wind sector.

A Focus on Building Local Capacity for the Supply Chain

At a Leadership 100 event in 2019, offshore wind energy developers and manufacturers in the US identified the need for a clear pathway to developing a domestic supply chain as a top priority for the industry[42]. Building up local manufacturing capabilities was highlighted as critical as it could energize local industries and de-risk projects by reducing reliance on imported resources from

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[37] McKinsey & Company.
[38] World Bank, "Scenarios for Offshore Wind Development in Brazil."
[39] Ørsted, "The Starting Five: Stories from America's First Offshore Wind Farm."
[40] Shields et al., "The Demand for Offshore Wind Energy Supply Chain."
[41] American Clean Power, "Offshore Wind Market Report | 2024."
[42] Shields et al., "The Demand for Offshore Wind Energy Supply Chain."

European or Asian markets. Currently, as detailed in Section 4, Nova Scotia is in a similar situation, with most of the equipment and parts required for offshore wind developments not available domestically.

In response to the prioritization of capacity for localized manufacturing for offshore wind, the National Renewable Energy Laboratory investigated challenges and opportunities related to establishing a domestic supply chain in 2022. The study found that the US' national offshore wind energy target of 30 GW by 2030 would likely require substantial advances in the US supply chain along with development of complementary sectors, such as offshore permitting and grid transmission[43].

Major investments in facilities, ports, vessels, and workforce training initiatives were highlighted as critical to "jump-start" the domestic offshore wind supply chain and to design it in a way that would be flexible enough to adapt as new technologies and larger wind turbines emerge on the market[44].

Significant research has been undertaken in the US to inform supply chain development, including development of a "Road Map" detailing short-term, medium-term, and long-term actions leading up to the US target of 30GW in 2030 and additional activities for continued success of the sector after the target is reached[45].

Short-term actions were focused on developing a strong foundation for the supply chain with preliminary actions such as convening working groups, setting up a favorable regulatory environment, identifying incentives for investment in local supply chain development, engaging with existing suppliers to advertise opportunities associated with offshore wind, and setting up new training programs in partnership with industry and post-secondary institutions to begin specialized workforce development. Short-term actions were suggested to take place in the first year of acting towards offshore wind development in a region.

Medium-term actions were focused on gaining critical momentum within the supply chain through the construction of major supply chain facilities needed to meet pipeline demand, creating predictable timelines for lease area sales over a span of twenty years to allow for long-term planning, leveraging working groups to develop best practices for supply chain activities, and training a sufficient workforce. Medium term actions were suggested to take place in the five years leading up to a government-set target for offshore wind (in the US case: 30 GW).

Long-term actions identified for the US to build its offshore wind supply chain are more focused on maintaining a sustainable industry, including maintaining, upgrading and expanding supply chain infrastructure, continued efforts to fill manufacturing gaps with domestic production, and continued expansion the offshore supply chain to increase domestic capacity. Long-term actions are ongoing actions suggested after the government-set target has been met[46].

These suggested actions for supply chain development have been adapted to a Nova Scotia context in Section 4.1

Insights on challenges facing development of the US offshore wind industry

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[43] Shields et al.

[44] Shields et al.

[45] Shields et al., "A Supply Chain Roadmap for Offshore Wind Energy in the United States."

[46] Shields et al.

The US experience provides insights on potential negative impacts of offshore wind on both the economy and environment. A study that examined economic and ecological effects of producing 8 GW of offshore wind energy in North Carolina by 2040 found that doing so would result in:

- An increase of electricity rates by 28%, or an average cost increase of $330 to $425 per year per customer.
- A loss of 45,000 to 67,000 jobs from electricity price hikes downstream effects on the economy.
- Potential negative impacts on property values and coastal tourism due to effects of offshore wind on “viewshed disruption.”
- Potential negative effects of offshore wind energy on commercial fishing sites, biodiversity, marine habitats and oceanography.
- Potential negative effects on sensitive marine life present in North Carolina’s offshore waters.
- Potential disruptions to marine vessel and military radars due to electromagnetic reflectivity of large metallic structures such as wind turbines[47].

Other concerns raised in North Carolina included the effect of hurricanes on turbine blades, resulting cost of replacements and the issue of “forever waste” from retired or damaged turbines[48].

A recent blade failure at the first major offshore wind farm in Massachusetts, Vineyard Wind, has amplified these concerns. When one of the wind farm’s blades washed upon a beach, it resulted in halted operations and concerns among residents about safety and waste[49].

While these challenges are local to the US regions in which they were highlighted, they raise potential concerns and issues that Nova Scotia may encounter as the industry moves towards development given geographic similarities between the two regions and existing tensions related to power rates in a Nova Scotia context.

This experience and these observations bring into focus the importance of securing *social license* for offshore wind developments. Proactive steps such as studies and strategies such as early engagement with the commercial fishing industry and planned subsidies and other financial mechanisms to avoid rate payers absorbing the high cost of offshore wind development could mitigate many of the issues raised in US.

3.3 Case Studies

To provide more specific details about how offshore wind has transformed towns and ports in positive ways, an examination of three case studies is provided:

- Scotland – Inverness and Aberdeen
- Germany – Emden, Rockstock and Bremerhaven
- England - Grimsby

3.3.1 Scotland

Scotland shares many of the geographic and historical economic features and traits of Nova Scotia. Geographically, both have direct ocean access and extensive coastlines, strong wind

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[47] Sanders, “Big Blow: Offshore Wind’s Devastating Costs and Impacts on North Carolina.”

[48] Sanders.

[49] Groom and Bose, “Faulty Manufacturing Blamed for VIneyard Wind Offshore Blade Failure.”

readings, and experience temperate maritime climates. Historically, both have had economies characterized by maritime traditions, such as fishing and ship building, and other industrial activities such as steel manufacturing and heavy engineering. These similarities, along with Scotland's success in building an offshore wind industry with benefits to the local economy and ports, make the country a strong analogue from which Nova Scotia could emulate best practices and lessons learned.

A brief history of Scotland's development of offshore wind

Scotland's offshore wind development has seen significant growth and innovation over the past few decades. The first major offshore wind projects in Scotland, such as the Robin Rigg Wind Farm in Solway Firth, began development in the Mid 2000s. The Government of Scotland supported the industry in reaching the development stage through supportive policies and subsidies for offshore wind. These supports increased in the period between 2010-2015 to encourage further growth of the industry, guided by the government's "Scottish Energy Strategy." The department responsible for Crown lands began leasing Crown-owned seabed for offshore wind farm development, which attracted significant investment from developers. Over the next five years, Scotland's offshore wind developments benefitted from innovations in turbine technology and installation techniques, which reduced costs and improved efficiency of operations.

Hywind Scotland was the world's first floating offshore wind farm. Over the past four years, Scotland has continued to expand its offshore wind capacity, with projects like the Moray East and Seagreen Wind Farms. In 2021, the government opened a significant amount of Crown seabed for offshore wind leases, which attracted over £700 million in investment commitments.

Leading in Development of Innovative Floating Structures

Hywind Scotland has been a global benchmark for the potential of floating wind farms. It has the highest average capacity factor of any wind farm in the UK[50]. During its first two years of operation, the wind farm achieved an average capacity factor of 54% compared to an offshore wind average in the UK of around 40%[51]. The capacity factor is the ratio of actual energy output over a given period of time to the maximum possible output, meaning lower intermittency and higher value. These results have helped grow confidence in floating offshore wind farms globally.

The soon-to-be world's largest floating offshore windfarm is also under development in Scotland. The Kincardine Offshore Windfarm will feature the most powerful (9.5 MW) turbines ever installed on a floating platform, further establishing Scotland as a global leader in floating offshore wind[52].

Scotland's experience in using floating structures has allowed access to deeper waters and therefore higher and more consistent wind speeds. It also has contributed to jobs and value creation for the local economy, which is explored in more detail below.

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[50] equinor, "Hywind Scotland Remain's the UK's Best Performing Offshore Wind Farm."
[51] equinor.
[52] Principle Power, "Kincardine Offshore Wind Farm."

Local Economic Benefits for Scotland's Port Towns

Offshore wind in Scotland has had positive economic impacts for port towns that are now revitalized hubs of economic activity servicing the industry.

For example, the energy facilities company, Haventus, has injected millions of pounds into rejuvenating the Ardersier Port near Inverness, Scotland. Once completed, the 450-acre site pictured in Figure 5 will provide direct services for companies deploying and servicing offshore wind installations in the North Sea.

The injection of funds into revitalizing the port has been lauded as "*one of the most significant industrial revitalization efforts in the Scottish Highlands in recent years, the project is anticipated to generate hundreds of jobs and substantially augment Scotland's capacity for offshore wind port operations*[53]."

Figure 5: Rendering of Ardersier Port Offshore Wind Hub near Inverness, Scotland

Port developers cited the success in achieving hundreds of millions in financing for port redevelopment to government partnerships and support[54].

Another example of positive local benefits from offshore wind is found in the small Scottish city of Aberdeen. Aberdeen experienced economic decline with the downturn of its traditional industries such as fishing and shipbuilding in recent decades[55]. Aberdeen found success in servicing the offshore oil and gas industry and has now pivoted to a focus on establishing its status as a hub for offshore wind developers amid the declining demand for oil and gas.

A €40 million investment from the European Union supported by Aberdeen Renewable Energy Group in 2018 resulted in the Aberdeen Offshore Wind Farm and European Offshore Wind Deployment Centre, which includes a wind farm and associated facilities for research, testing and training, with its operations and maintenance team stationed at Aberdeen Harbour[56]. The wind farm generates 70% of Aberdeen's household energy demands while offsetting 132,977ft of CO2 from the atmosphere[57]. The Deployment Centre also includes opportunities for oil and gas workers to enhance their careers with new skills for offshore wind and has resulted in fresh energy jobs within the local economy[58].

More recently, the Scottish National Investment Bank provided £30m in funding in addition to funds provided by European Investment Bank, Scottish Enterprise and Aberdeen City to expand Aberdeen Harbour's port infrastructure to allow greater land and water access for servicing the offshore wind sites. The expansions will be able to accommodate larger, wider, and deeper vessels, while providing new land-side facilities.

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[53] Saghir, "Haventus Obtains £100 Million for Ardersier Port's Offshore Wind Hub Transformation."
[54] Saghir.
[55] McGuire, "Offshore Wind Is Transforming The UK's Coastal Towns."
[56] McGuire.
[57] Power Technology, "European Offshore Wind Deployment Centre, Aberdeen."
[58] McGuire, "Offshore Wind Is Transforming The UK's Coastal Towns."

Key Takeaways

Key takeaways from the Scotland Case Study include:

- Strong government support and subsidies in the early stages of developing the offshore wind industry in Scotland supported rapid growth.
- A focus on technological innovations has increased efficiency and value of offshore wind farms and decreased the cost of operations.
- Government supported investments in port infrastructure have helped grow capacity to service offshore wind in port towns previously experiencing economic decline due to downturns in sectors the ports previously served. The towns are now thriving with offshore wind companies and port services providing hundreds of new skilled jobs and economic benefits in these coastal towns.
- Transitioning offshore oil and gas hubs into offshore wind servicing centers have included investments in education and research centers that have supported upskilling of offshore oil and gas workers to grow the offshore wind workforce.

3.3.2 Germany

A brief history of offshore wind in Germany

Germany first entered offshore wind in 2009 with the Alpha Ventus offshore wind farm located in the North Sea. Following Alpha Ventus' success, several additional offshore wind farms were developed between 2010-2020, a decade that saw rapid expansion of the sector with significant investments from government and the private sector. By 2015, Germany had become one of the world's leaders in offshore wind energy with a mature industry and substantial installed capacity in addition to ongoing construction of new sites. Germany reached a significant milestone with over 7.7 GW of installed offshore wind capacity in 2020, and has set targets for 20 GW by 2030, and 40 GW by 2040. By the end of 2022, the offshore wind sector in Germany included 1,539 installed turbines, 8.1 GW, 5% share in net power production and employed 21,400 people[59].

Benefits for Ports and Communities

Germany has successfully leveraged opportunities in offshore wind to the benefit of its ports and surrounding communities. The literature points to at least four of Germany's North Sea and Baltic Sea ports that have been transformed into the country's main wind industry logistical centres, equipment manufacturing, and supply bases[60].

Emden is the main export harbour for Enercon wind turbines, a market leading concrete tower manufacturing plant that was attracted to the town due to its port capabilities and proximity to offshore operations. Several supply chain vendors for offshore wind have also set up operations in Emden as it has grown into a service hub for the industry in Germany.

BARD Engineering chose Emden as its turbine assembly and rotor blade manufacturing location to allow for low-cost transportation from the manufacturing site to the offshore wind farms. Additionally, both BARD and Enercon have built foundries in the area that provide part of their demand for heavy cast components. Overall, Emden port's status as a launching point for servicing the offshore wind industry in Germany has resulted in multiple, large-scale businesses opening in the town with significant economic effects including new skilled jobs and tax revenues.

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[59] Wehrmann, "German Offshore Wind Power - Output, Business and Perspectives."

[60] Renewable Energy World, "Boomtown Bremerhaven: The Offshore Wind Industry Success Story."

In addition to Emden's success at attracting suppliers, the port of Rockstock in eastern Germany has attracted the main wind turbine assembly and rotor blade manufacturing base for wind turbine supplier, Nordex.

The port town of Bremerhaven, Germany has also attracted significant investment from suppliers to offshore wind, including six wind industry hardware suppliers and two wind industry R&D organizations. Bremerhaven has a deep-water port that can accommodate the large, sea-going vessels required to transport offshore wind parts to farm sites – which has been cited as a crucial pre-condition for attracting the suppliers and R&D institutions.

Key Takeaways from the German Case Study

- Regions with ports capable of servicing the offshore wind industry have successfully attracted private-sector investments that have grown domestic manufacturing capacity for the supply chain.
- Ports with nearby manufacturing operations result in local economic benefits for the community, including skilled jobs, business investments and additions to the tax base.
- A snowball effect can occur in port towns with the capacity for offshore wind equipment where clusters of specific suppliers invest in the same location, such as Bremerhaven's experience with wind industry hardware suppliers.

3.3.3 England

As noted in the jurisdictional scan of Europe, the UK is a large global player in the offshore wind industry. Coastal towns in England have experienced economic revitalization after decades of decline due to downturns in traditional marine-based industries. Ports that were once barely operating at half capacity are now thriving hubs servicing the offshore wind industry throughout England.

Benefits for Ports and Communities

Grimsby, a coastal seaport community in England, has been transformed by the presence of nearby offshore wind farms. Historically, Grimsby was an important fishing port and played a major role in the development of the UK's fishing industry. However, the fishing industry in the region has declined amid overfishing, changes in fishing technology and competition from other countries. The arrival of offshore wind investments to Grimsby transformed the post-industrial town into a thriving hub for renewable energy companies and suppliers. Grimsby was identified as a location for offshore wind investment due to its coastal location and proximity to areas identified as "high potential for wind energy production" as well as its existing infrastructure and expertise in marine industries.

The town is now home to the Grimsby Renewable Energy Village – a cluster of businesses that service the offshore wind industry as well as the Grimsby Institute of Further and Higher Education, which offers courses in renewable energy and engineering – providing a direct talent pipeline for offshore wind companies in the area.

European offshore wind giant, Ørsted, opened its offices in Grimsby in 2014 and has since invested over £14 million to create the company's "East Coast Hub" for offshore wind in the town[61]. The company currently employs over 600 people working in long-term, high-skilled jobs out of Grimsby and that number is anticipated to grow[62]. Beyond the investment in the hub, Ørsted has

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[61] Ørsted, "Transforming Coastal Communities."

[62] Ørsted.

also invested more than £45 million directly into the local community, education, and skills development, including a £1 million donation to Grimsby's Horizon Youth Zone, a dedicated facility for youth that offers long-term opportunities to learn and develop skills[63].

The company also partnered with a local trade college in Grimsby to offer a wind turbine technician apprenticeship program that since 2017 has had a 100% retention rate with all who have completed the program becoming full-time Ørsted employees.

In addition to Ørsted, offshore wind companies Innogy, Equinor, Siemens Gamsa, J Murphy & Sons, and RWE operate and support wind farms nearby which has brought investment and job opportunities to the town as well. The influx of renewable energy companies to the town has revitalized the economy. In total, almost 2,000 people are currently employment in the renewable energy industry in Grimsby[64].

The Grimsby case highlights the potential economic and social benefits that can emerge in coastal port towns that attract investment from private industry. The benefits range from direct economic benefits arising from jobs and business presence to social benefits from educational and training opportunities for local youth.

Further, the influx of wind energy related companies to the town has created a range of business opportunities for entrepreneurs, particularly in supply chain services, maintenance and repair, and installation and construction. Entrepreneurs in Grimsby are supported by the Humber Local Enterprise Partnership, a public-private partnership that has established an innovation hub that provides supports, advice, business incubators and co-working spaces for start-ups and entrepreneurs in the offshore wind space.

Key Takeaways from the England Case Study

Some key takeaways from the England case study include:

- Port towns capable of supporting the offshore wind energy receive both economic and social benefits when major developers invest in setting up operations. Economic benefits include jobs and investment from new business presence, social benefits include companies investing in community benefits such as training and youth programs.
- Partnerships between offshore wind companies and local trades colleges can lead to youth retention in port towns, with "on-the-job" training opportunities and full-time employment resulting from the partnership.
- Having a direct talent pipeline in areas attractive for offshore wind development makes a compelling case for a town to receive investment from offshore wind companies seeking a location to set up onshore operations.

3.4 Summary of Key Lessons Learned from Other Jurisdictions and Implications for Nova Scotia

- **Regional cooperation and national support** in building an offshore wind industry has proven benefits, as demonstrated in the examination of Europe. Strategizing grid integration, supply chain development and workforce development with other provinces could result in a more cost and time-effective sector advancement than working to attract and invest in the range of suppliers and specialized workers required for offshore wind as

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[63] Ørsted.

[64] Kasbah, "Open for Green Energy."

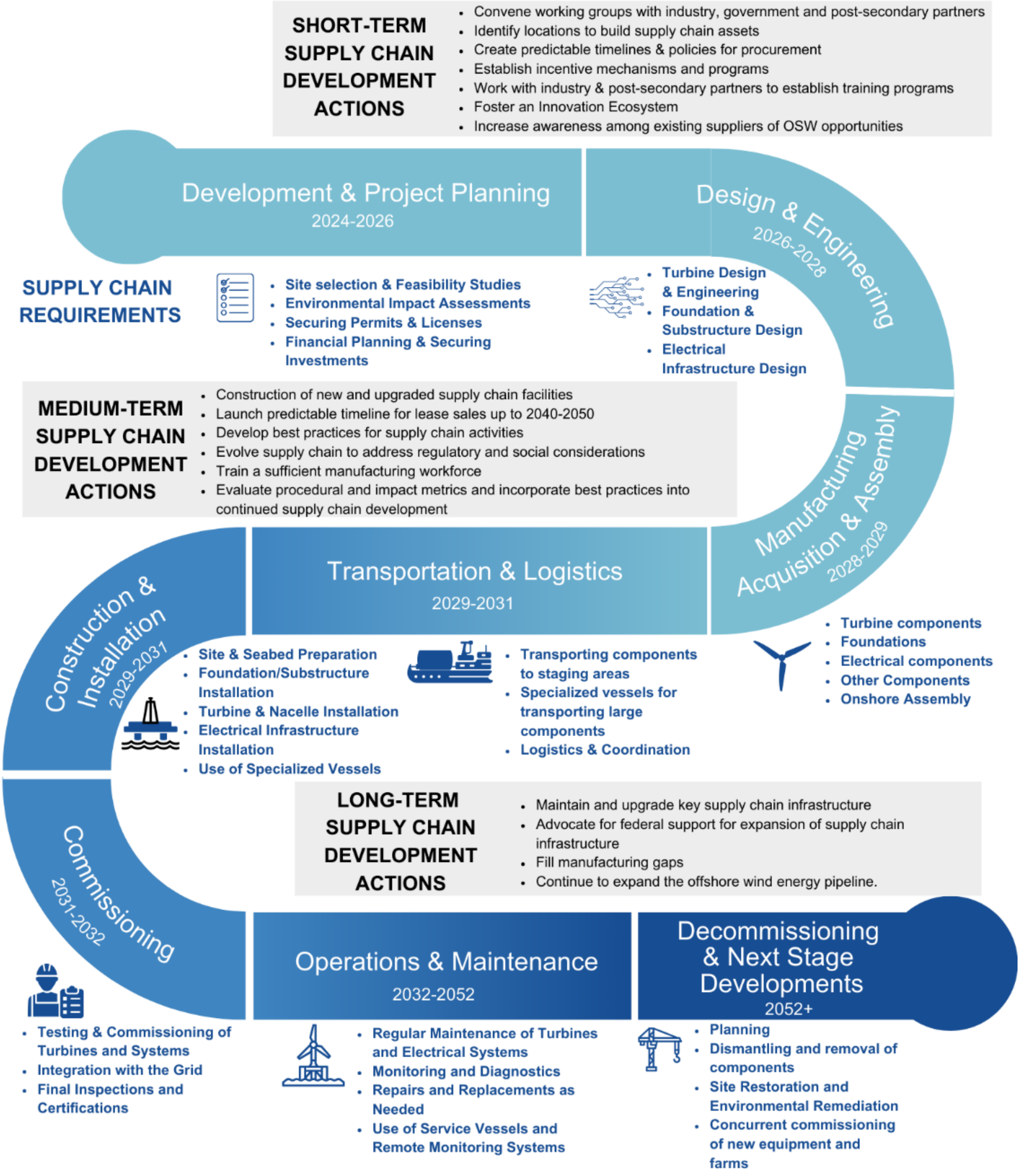
a single entity. In the jurisdictions reviewed, cooperation was achieved on a nation-to-nation level, indicating that Nova Scotia could take this approach as well by encouraging partnerships between Canada and the U.S., for example, to encourage a coordinated approach to supply chain development to the benefit of both countries.

- **Supportive government policies and investments** have been critical to the success of offshore wind in Europe. Successful jurisdictions cite early government support and planning as critical to sector growth. Subsidies, other incentive programs and creation of favourable regulatory environments were crucial to attracting offshore wind developers in the regions examined. In Nova Scotia's case, government support in developing foreign direct investment tools, for example, would be important for growing supply chain capacity.
- **Building local capacity for the supply chain** based on demand rather than a top-down approach has had better results in Europe. A top-down approach has proven to result in slower and more expensive development. A demand-driven approach in Nova Scotia would be recommended based on the findings from the jurisdictional scan.
- **Investing in port infrastructure** to support offshore wind servicing has economic benefits for the communities surrounding the ports. The case studies of port towns in Scotland, England, and Germany show that having port infrastructure capable of supporting offshore wind servicing has tangible economic benefits, including attraction of offshore wind equipment manufacturers and becoming homebases for operation and maintenance supports, leading to the creation of hundreds of local high-skilled jobs in coastal port towns with other social benefits such as local training and entrepreneurship opportunities. There are several port towns in Nova Scotia that are in similar situations to the ones now thriving in Scotland, England and Germany before offshore wind entered the regional economy. While port requirements are outside of the scope of this report, our findings suggest investing in either upgrading existing ports or in constructing new ports in rural areas that are capable of handling the large pieces of equipment and deep-sea vessels required for offshore wind would have tangible economic benefits for port towns in Nova Scotia, particularly in rural areas that have experienced economic decline due to industry and demographic shifts.
- **Social benefits for communities** are another key outcome in jurisdictions that attract major offshore wind companies. As demonstrated in the Grimsby case, major private offshore wind companies can have significant impacts on the general well-being of community members through investments such as youth training and skills development and providing demand for the establishment of new training institutions and apprenticeship opportunities in rural areas. Partnerships between industry and post-secondary institutions also have social benefits for residents, such as guaranteed jobs in their home communities.
- **Focusing on innovation and entrepreneurs** is another key success factor for communities that service the offshore wind industry. R&D institutes, business incubators and other supports for innovators and entrepreneurs are typically present in areas that have attracted investment from major offshore wind companies. At the regional and national level, as the offshore wind sector evolves, fostering innovation systems will be critical to finding solutions to lower the cost of installation and operations as well as solving other industry challenges such as safety, maintenance challenges and others.
- **Building opportunities into and with existing industrial assets,** such as Nova Scotia's strengths in post-secondary education and training, presents an opportunity to make advances in building the talent pipeline for offshore wind. Engaging with existing industrial assets and companies to understand capacity to support the offshore wind supply chain will also be important to optimize local benefits.

4 What We Did - Socio-Economic Impact Analysis

4.1 Supply Chain Analysis

Figure 6: Supply Chain Requirements by Development Phase



SHORT-TERM SUPPLY CHAIN DEVELOPMENT ACTIONS

- Convene working groups with industry, government and post-secondary partners
- Identify locations to build supply chain assets
- Create predictable timelines & policies for procurement
- Establish incentive mechanisms and programs
- Work with industry & post-secondary partners to establish training programs
- Foster an Innovation Ecosystem
- Increase awareness among existing suppliers of OSW opportunities

Development & Project Planning
2024-2026

SUPPLY CHAIN REQUIREMENTS

- Site selection & Feasibility Studies
- Environmental Impact Assessments
- Securing Permits & Licenses
- Financial Planning & Securing Investments

Design & Engineering
2026-2028

- Turbine Design & Engineering
- Foundation & Substructure Design
- Electrical Infrastructure Design

MEDIUM-TERM SUPPLY CHAIN DEVELOPMENT ACTIONS

- Construction of new and upgraded supply chain facilities
- Launch predictable timeline for lease sales up to 2040-2050
- Develop best practices for supply chain activities
- Evolve supply chain to address regulatory and social considerations
- Train a sufficient manufacturing workforce
- Evaluate procedural and impact metrics and incorporate best practices into continued supply chain development

Manufacturing Acquisition & Assembly
2028-2029

- Turbine components
- Foundations
- Electrical components
- Other Components
- Onshore Assembly

Transportation & Logistics
2029-2031

- Transporting components to staging areas
- Specialized vessels for transporting large components
- Logistics & Coordination

Construction & Installation
2029-2031

- Site & Seabed Preparation
- Foundation/Substructure Installation
- Turbine & Nacelle Installation
- Electrical Infrastructure Installation
- Use of Specialized Vessels

LONG-TERM SUPPLY CHAIN DEVELOPMENT ACTIONS

- Maintain and upgrade key supply chain infrastructure
- Advocate for federal support for expansion of supply chain infrastructure
- Fill manufacturing gaps
- Continue to expand the offshore wind energy pipeline.

Commissioning
2031-2032

- Testing & Commissioning of Turbines and Systems
- Integration with the Grid
- Final Inspections and Certifications

Operations & Maintenance
2032-2052

- Regular Maintenance of Turbines and Electrical Systems
- Monitoring and Diagnostics
- Repairs and Replacements as Needed
- Use of Service Vessels and Remote Monitoring Systems

Decommissioning & Next Stage Developments
2052+

- Planning
- Dismantling and removal of components
- Site Restoration and Environmental Remediation
- Concurrent commissioning of new equipment and farms

4.1.1 Supply Chain Requirements for Offshore Wind

Figure 6 provides a high-level overview of a generalized supply chain for offshore wind development, prepared by 21FSP based on an amalgam of sources. This is intended to be illustrative of a prototypical supply chain pathway and not necessarily a precise representation of what may happen in Nova Scotia's case. Indeed, the current scenarios of offshore development are rather high-level at this stage and would require more advancement to help inform a more probable supply chain map.

In general, however, the supply chain for offshore wind includes the skills, services, supplies, technologies and infrastructure required to support the entire lifecycle of an offshore wind project through the following phases:

1. Development and Project Planning
2. Design and Engineering
3. Manufacturing/Acquisition/Assembly
4. Transportation and Logistics
5. Construction and Installation
6. Commissioning
7. Operations and Maintenance
8. Decommissioning and Next Phase Development

Supply chain requirements identified by the Energy Futures Initiative[65] for 30 GW of offshore wind in the US over a period of seven years, scaled to 5GW requirements in Nova Scotia over the same length of time[66] are provided in the table below:

Table 1: Estimated Supply Chain Requirements for 5GW over seven years based on US industry analysis

Supply Chain Component and Commodities Required	5 GW Requirements 2024-2031
Wind Turbines	352
Blades	1,057
Towers	352
Nacelles	352
Total Cabling (km)	2483
Steel (1,000 tons)	1,184
Permanent magnet (1,000 tons)	14

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[65] Effross, "Offshore Wind Development and Supply Chain Overview."

[66] A scaling factor of 0.167 was used to estimate the requirements for 5GW using supply chain estimates for 30GW in the US over a seven-year period and does not account for supply chain elements that may not scale linearly (e.g., economies of scale, logistical constraints, etc.). Calculations for USD have been converted to CAD for this report. Calculations for miles in the US scenario have been converted to kilometres for this report.

Based on the US estimates for 30GW, these supply chain requirements for 5GW will require about 24.7 billion CDN in expenditures. The $24.7 billion includes development expenditures (DEVEX) and operational expenditures (OPEX). About $22.6 billion of the costs, however, are capital expenditures (CAPEX) over a seven-year period[67]. These costs do not include the cost of shipbuilding for specialized wind turbine installation vessels (WTIV), feeder vessels, barges and other vessels that transport supplies to WTIVs. It also does not include the costs of modification or construction of specialized pier facilities that can withstand the weight and size of offshore wind components.

Effross notes that the above components and commodities required for offshore wind are networked, interdependent, and their success depends upon each other:

"Moving first or early, enduring uncertainty without regard to others' entry, without supportive policy, means taking on risk[68]."

Effross suggests that there is less risk involved for companies looking to invest in developing operations in a new market if the industry is more established. Therefore, Effross recommends that when supply chain components are not available in a jurisdiction pursuing offshore wind, that effective policy is needed to "jump-start" the sector[69]:

"Effectively, this means crafting federal and (provincial) industrial and energy policies, temporarily, into a demand-driven marketplace. Although such actions may draw objections from market-driven pursuits, it would be wise to remember the problems these policies are meant to address, including global climate change, local air quality degradation, and the creation of domestic jobs as well as their location, exist largely outside of market mechanisms as undervalued to unvalued externalities. The hidden hand does not grasp that which has no explicit price or cost[70]."

Sheilds et al developed a supply chain development roadmap for the US industry with actions categorized as short-, medium- and long-term time frames for developing a "*robust, resilient and sustainable supply chain*[71]." Notably, Shields et al's analysis concluded that if individual states (or in Canada, provinces or territories) leverage their existing manufacturing capabilities to contribute to the offshore wind energy sector, it would generate significant economic benefits throughout the country, not only in coastal locations in close proximity to offshore wind sites and programs[72].

To apply Shields et al's findings to a Nova Scotia context, we have adapted the roadmap recognizing different requirements for a province in a Canadian context, than the US as a country. Table 2 on the proceeding page provides an adapted supply chain development roadmap for Nova Scotia.

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[67] Cost of supply chain requirements for 5GW of offshore wind in NS has been scaled using estimates for 30 GW of offshore wind for the US in Effross 2022. It does not account for initial investments that do not scale linearly, and therefore the cost of 5GW per GW could be much higher than the cost per GW in calculations for 30 GW.

[68] Effross, "Offshore Wind Development and Supply Chain Overview."

[69] Effross.

[70] Effross.

[71] Shields et al., "A Supply Chain Roadmap for Offshore Wind Energy in the United States."

[72] Shields et al.

Table 2: Summary of Potential Short-, Medium-, and Long-Term Actions to Develop a Domestic Offshore Wind Energy Supply Chain (Adapted from Shields et al, 2023 for a Nova Scotia context)

Action	Outcome
Short-Term Actions: Organizing a Strong Foundation (2024-2026)	
Work with partners in other jurisdictions to convene working groups focused on regional and holistic supply chain development	The formation of actively funded groups with decision-making authority, diverse membership, established communication practices, and clear visions for supply chain development
Identify locations to build the next wave of supply chain development equitably and efficiently	Announcements and initial permitting applications for a sufficient number of facilities (e.g., factories, ports, vessels) to meet the demand of the domestic pipeline
Continue to expand the offshore wind energy pipeline	Develop a predictable timeline for lease area sales and provincial procurement solicitations that extends to (at least) 2036
Assess the need for and impact of incentive mechanisms beyond existing programs	Develop a predicable approach for incentive programs to construct new supply chain assets (e.g., factories, ports, vessels) and produce Tier 1, 2 or 3 components that are not covered through existing programs
Establish strategies and incentive mechanisms targeted at floating wind infrastructure *(*dependent on interest in and feasibility of floating wind farms in a Nova Scotia context)*	Develop a clear and consistent vision that outlines the infrastructure needs to deploy commercial scale floating wind, including preferred port locations, newly built vessels, and industrialization requirements for floating platforms.
Work with industry and post-secondary/other training partners to establish curriculum and funding streams for workforce training centers	Develop curriculum for offshore wind energy workers that is acceptable to all major offshore wind manufacturers; commit funds sufficient to open training centers and train an initial cohort.
Conduct outreach and education activities with existing suppliers to increase awareness of the offshore wind energy opportunities	Increase engagement and contracting between existing major manufacturers and domestic business.
Foster an innovation ecosystem	Leverage existing ocean-based innovation hubs and partnerships between industry and post-secondary to support the development of an innovation ecosystem with robust supports for R&D around offshore wind.
Medium-Term Actions: Gaining Critical Momentum (2026-2031)	

Action	Outcome
Provide government support for the construction of the major supply chain facilities needed to meet the demand pipeline	Support development of a network of domestic manufacturing facilities and ports that can support the demand from all offshore wind energy projects
Continue to expand the offshore wind energy pipeline	Develop a predictable timeline for lease area sales and provincial procurement solicitations that extends to (at least) 2040 and potentially as far as 2050 to allow for sector planning.
Leverage national, regional, and industry working groups to share and develop best practices for supply chain activities.	Develop a standardized approach to community engagement, permitting, developing supporting supply chains, and adapting to evolving technologies throughout different states and supply chain sectors.
Incorporate learning from early-stage commercial-scale projects into ongoing operations and decision-making.	An evolved supply chain that develops in parallel with technologies and processes that are customized for the social and regulatory considerations within the Canadian market (e.g., foundational technologies to minimize pile-driving noise, refined feeder barge strategies to reduce at-sea risk, improved communication and community outreach.)
Train a sufficient offshore wind workforce	Support post-secondary and industry in ongoing development of workforce training centers and apprenticeship programs to produce sufficient throughput of trained workers to fill domestic offshore wind jobs.
Evaluate procedural and impact equity metrics for early-stage commercial-scale projects and incorporate best practices into ongoing supply chain development activities.	Practice commonly used best practices that incorporate community feedback throughout the decision-making process for supply chain investment that apply frameworks that have been refined using lessons learned from early-stage projects.
Long-Term Actions: Maintaining a Sustainable Industry (Beyond 2031).	
Maintain and upgrade key supply chain infrastructure to adapt to evolving technologies	Existing resources developed in the 2020s (e.g., manufacturing facilities, ports, vessels, workforce training centers) remain active and capable of producing new components (e.g., larger wind turbine components, floating wind components), possibly with the inclusion of new innovations or automation; floating wind infrastructure continues to expand to support increasing levels of deployment

Action	Outcome
Advocate for federal support of expansion of supply chain infrastructure to new regions using lessons learned from early build-out	Offshore wind energy supply chain hubs that are present throughout the country with capabilities and are customized for the specific technology, regulatory and community needs of each region.
Advocate for federal support of filling manufacturing gaps in supporting supply chains with domestic production throughout Canada while contributing at the provincial level.	Critical subcomponents and subassemblies are primarily manufactured domestically to decrease reliance on global supply chains.
Continue to expand the offshore wind energy pipeline	A predictable timeline for lease area sales and provincial procurement solutions that extend through 2050.

The actions in the table above were designed by Shields et al using a national, multi-jurisdictional approach with the intention to overcome key barriers to supply chain development collaboratively, through:

- Effective communication between different stakeholder groups
- Strategic planning of large investments in an uncertain environment
- Understanding the cost/benefit trade-offs between domestically produced and imported components[73].

4.1.2 *Nova Scotia's Current Capacity, Gaps and Areas of Potential Leakage*

The province has defined three tiers of supply chain categories along with an assessment of its current capacity in each tier. The tiers include:

- **Tier 1 suppliers**: Companies contracted as primary suppliers for offshore wind projects by the developer, covering items such as wind turbines, foundations, towers, offshore substations, cables, transmission, environmental services, data collection, monitoring, engagement with interested parties, and operations and maintenance.
- **Tier 2 suppliers**: Principal suppliers to Tier 1 suppliers, offering services such as crane operations, civil engineering for onshore electricity infrastructure, subsea cable protection, electrical components, tower manufacturing, yaw and pitch motors, barges, tugboats and fall-arrest systems.
- **Tier 3 suppliers**: Providers of specialized services and products to Tier 2 suppliers, including secondary steel fabrication for foundations or towers, specialized tools, fuel services, dive and survey operations, rubber, concrete, railing and ladders, castings, and hydraulics.

The Nova Scotia Offshore Wind Roadmap Module 2 states that Nova Scotia's experience in marine industries has fostered "a network of strong Tier 2 and Tier 3 suppliers[74]". However, the province's capabilities in Tier 1 – a critical supply chain category – are currently lacking due to this being a new sector for the province with specialized manufacturing requirements.

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[73] Shields et al.

[74] Province of Nova Scotia, "Nova Scotia's Offshore Wind Roadmap: Module 2 - Supply Chain and Infrastructure."

> *"The offshore wind market is experiencing rapid growth through the world with over 380 GW of new offshore wind capacity forecasted to be added over the next decade. This pace of growth and high demand for supplies and services is resulting in global supply chain shortages. Building Nova Scotia's offshore wind supply chain is therefore not only an economic opportunity, it is a necessity to avoid supply chain bottlenecks and ensure growth."*
>
> Nova Scotia's Offshore Wind Roadmap Module 2

The province has identified three goals for supply chain development in support of offshore wind:

1. Ensure initial goal of 5GW of offshore wind development is successful and sustainable by establishing a strategy that optimizes local participation in the supply chain, including diversification opportunities for existing ocean users, while recognizing the need to ensure timely and economically viable project development.
2. Optimize opportunities for Nova Scotia businesses and communities to benefit from offshore wind development, creating a supply chain that is "best in class" which can leverage and enable global participation in the sector for decades to come.
3. Establish an offshore wind supply chain that is inclusive, diverse and equitable creating opportunities for Mi'kmaw, African Nova Scotian, and African Descent communities as well as other underrepresented and underserved groups[75].

It is important to recognize that achieving these supply chain goals with low capacity in the Tier 1 category mentioned above, and establishing the required supply chain for offshore wind in Nova Scotia will be a significant lift.

While other jurisdictions have been developing their manufacturing capabilities to support offshore wind for decades, this is an entirely new sector for the province that requires specialized equipment and material, much of which Nova Scotia does not currently produce – or have the specialized skillsets and knowledge among its workforce to produce.

With only six years between the time of writing and the province's self-imposed deadline to release leases for five GW of offshore wind energy, the runway to establish this supply chain is short. Therefore, it is important to understand what Nova Scotia already has in terms of supply chain capacity, what the province can realistically achieve in terms of new supply chain capacity within this timeframe, and what needs to be done first.

Based on the findings of this study, to build capacity in Tier 1 capabilities by 2030 will require either partnering with

Figure 7: US-bound offshore wind components marshalled at Woodside Port in Halifax, NS in 2023. Source: 21FSP Advisory Inc.

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[75] Province of Nova Scotia.

other jurisdictions that have these capabilities, or building domestic capacity in strategic areas that are aligned with Nova Scotia's existing strengths.

It's also important to understand where it makes sense to import until domestic capacity is improved.

To begin to answer these questions, understanding the current state is an important first step.

Nova Scotia's Current Assets and Strengths for Offshore Wind Supply Chain

According to Nova Scotia Offshore Wind Road Map Module 2, strategically located ports and businesses in Nova Scotia have already achieved the following:

- **Demonstrated capability in monopile marshalling at ports**, including a private pier in Sydney Harbour, Atlantic Canada Bulk Terminal, which offers services for marshalling steel parts required for offshore wind turbines destined for the U.S. (See Figure 9).
- **Seabed characterization capabilities,** bolstered by a strong ocean technology ecosystem in Nova Scotia with companies such as Seaforth Geosurveys, Kraken Robotics' innovative subsea surveying capabilities, and several other Nova Scotian companies leading the sector in seabed characterization.
- **Environmental monitoring capabilities,** also supported by Nova Scotia's strong ocean technology ecosystem with 17 companies specializing in this capability according to Ocean Technology Council of Nova Scotia.
- **Professional and manufacturing services** in support planned offshore wind capacity on the eastern coast of the US[76].

Figure 8: Wind Turbine Part Marshalling at Atlantic Canada Bulk Terminal in Sydney, NS. Source: Ayers 2024

Steel is one of the most critical and intensively used raw materials in offshore wind development with the towers, transition pieces, offshore substations, and foundations (monopiles) all built from steel plates[77]. As noted in Table 1, it is estimated that the offshore wind industry in Nova Scotia will require about 1.2 million tons of steel over a seven-year period of developing the sector.

While Nova Scotia has capabilities in large steel fabrication, it does not produce the raw steel required for manufacturing offshore wind components. According to Natural Resources Canada, steel is produced at 13 plants in five provinces (Alberta, Saskatchewan, Manitoba, Ontario and Quebec[78]). The industry is concentrated in Ontario, with six of the plants operating there. Canada

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[76] Province of Nova Scotia.

[77] Effross, "Offshore Wind Development and Supply Chain Overview."

[78] Natural Resources Canada, "Government of Canada Announces $300 Million in Port Hawkesbury on Canada-Germany Hydrogen Alliance."

also imports a significant amount of steel each year – 6.8 million metric tons of steel in 2019[79]. Without the raw materials produced in Nova Scotia, establishing partnerships between steel fabricators and suppliers in other provinces will be key to achieving a cost-effective supply chain.

Cement is another critical material for manufacturing offshore wind parts. According to Natural Resources Canada, cement, like steel, is primarily produced in central Canada with Ontario producing 50% and Quebec producing 17% of the national capacity. Nova Scotia does have some cement producing capacity. IBISWorld reports Nova Scotia has two cement producers as of June 2024[80]. One of the producers is the Lafarge Brookfield Cement Plant, which employs 70 people in Brookfield and produces reduced carbon Portland limestone cement – branded as OneCem. It's not clear how much concrete is produced in Nova Scotia relative to the supply chain requirements of offshore wind due to the secondary-level research limits of this study, however given the large amount concrete-based components required as detailed in Table 1, it is anticipated that cement will need to be brought into the province if manufacturing of cement-based products for offshore wind proceeds. Based on 2022 data, Canada also imports cement primarily from the US ($121M) Turkey ($48.4M), Chinese Taipei ($9.64M) and Ireland ($5.57M)[81].

Given that two of the most critical raw materials required for manufacturing offshore wind components are primarily produced outside of Nova Scotia, a nation-building approach to building the offshore wind supply chain in strategic locations across Canada while Nova Scotia builds its critical mass, would be prudent. To build capacity within Nova Scotia for producing offshore wind components, partnerships with the other provinces and territories, particularly Ontario, would support effectively meeting supply chain requirements and the five GW goal by 2030.

An assessment of what Nova Scotia currently has against what is required for the development of offshore wind by development phase is provided in **Appendix C.**

Based on our assessment, we anticipate that Nova Scotia will be importing the majority of the technology and applied knowledge in the "Development and Project Planning Phase," which will include higher proportions of offshore talent relative to what Nova Scotia may be able to supply in this phase. Conversely, we expect that activities like 'onshore assembly of turbines on floating platforms or near-shore assembly' will include a relatively high share of Nova Scotia-based labour due to the place-based nature of this activity.

Although our assessment in Appendix C highlights project activities where Nova Scotia is likely able to participate more fully, it does not address Nova Scotia's capacity to participate in these areas. For example, with an active shipbuilding sector, NS would likely have the *industrial machine* to be able to build floating barges, but this does not mean that NS has capacity in the industry to add production slots to actually build floating barges in the timeframes that may be required. The scale of the pending, assessed later in this report, provides more context around Nova Scotia's capacity in these areas.

Overall, as a new industry to Nova Scotia, **there are significant supply chain gaps for offshore wind in the province and indeed in Atlantic Canada**. The scope of these limitations can be illustrated by considering offshore wind capacity in other North American jurisdictions and comparing their economies and sector specializations to Nova Scotia itself.

As noted above, the United States has established a goal of 30GW by 2030, and in recent years several Economic Impact Studies (EIS) have been commissioned to assess the feasibility and

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[79] International Trade Administration, "Steel Imports Report: Canada."
[80] IBISWorld, "Cement Manufacturing in Nova Scotia - Current Trends and Industry Outlook (2019-2029)."
[81] OEC, "Cement in Canada."

likely impact of offshore wind developments in several key coastal markets, such as Virginia, North Carolina, California, Maine, and New York.

The economies of these states are enormous. The GDP (2023) of the state of Virginia alone is $719 billion (over 30% of the GDP of Canada), with the manufacturing and construction sectors contributing $52 billion and $35 billion in real GDP or 7.2% and 4.9% of the total, respectively.

North Carolina is larger still, with a real GDP (2023) of $788 billion and manufacturing and construction sector contributions of approximately $105 billion (13.3%) and $38 billion (4.8%).[82]

In the same year (2023), the total GDP of Nova Scotia in real dollars was $43.8 billion. Manufacturing contributed $3.06 billion (7%) to this figure – over $30 million less than in 2019 – while construction contributed $2.8 billion (6.4%). Put another way, the manufacturing industries of both US states alone exceed the size of the entire Nova Scotian economy.

Yet, studies of offshore wind in Virginia and North Carolina project a total local content of only 10-12%. Given the large disparity in economic size and complexity, it is difficult to imagine an offshore wind development in Nova Scotia allocating more than 5% of total spending to local suppliers and contractors, at least in the economy's current configuration and without significant investment and industry development.

This does not mean that offshore wind should no longer be understood as a significant opportunity. Nova Scotia is indeed strategically positioned to host significant offshore wind infrastructure and farms, and like other large and multi-year industrial development projects, capacity, supply chains, and industrial clusters can be built around them.

Rather, it means that a strategic and staged approach to building the domestic supply chain is needed to leverage Nova Scotia's existing assets as well as the supply chain strengths and manufacturing capabilities in other regions of Canada. As will be reiterated and clarified below, it also means that **a coordinated, regional, national, or even cross-boarder approach to meeting the supply chain needs of the offshore wind industry must be considered to realize Nova Scotia's ambitious offshore wind and green energy targets.**

4.2 Labour Analysis

4.2.1 Labour Requirement

There are five key categories of workforce demands for building offshore wind:

1. Development
2. Manufacturing and Supply Chain
3. Ports and Staging
4. Maritime construction
5. Operations and Maintenance[83].

For the period of 2025-2032, using labour force estimates calculated for 30 GW in the US[84], five GW in Nova Scotia would result in an estimated average of 5,227 workers employed per year

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[82] State-level GDP figures and industry GDP contributions are released quarterly by the US Bureau of Economic Analysis.

[83] Stefek et al., "U.S. Offshore Wind Workforce Assessment."

[84] Effross, "Offshore Wind Development and Supply Chain Overview."

between 2025-2032 for construction period installation and supply chain jobs. By 2032, operations and maintenance jobs would employ 2,238 persons.

Between 2043-2052, construction and supply chain jobs would employ 6,813 per year on average and by 2052, operations and maintenance activities would employ 6,012 workers. Labour requirements calculated in a cost-analysis for Nova Scotia show lower projections, including up to 848 direct FTEs per year once wind farms are operational (See Section 5).

Wages for offshore wind jobs conservatively average $81,000 CDN (for construction and $75,000 CDN for operations and maintenance, with a range of $72,000 CDN to $180,000 CDN across all job categories (based on 2022 dollar value).

4.2.2 Labour Availability and Training Capacity

Offshore wind development in Nova Scotia faces several labour force challenges that could impact the sector's growth and sustainability without strategic and coordinated workforce development planning.

The sector requires a highly specialized workforce, including engineers, technicians, and project managers with expertise in offshore wind technologies. It is anticipated that Nova Scotia will face a shortage of Canadian workers with these specific skills, as the industry is new in not only the province, but throughout country. To build capacity in these specialized areas, it is anticipated that skilled labour will need to be imported through targeted economic immigration programs and strategic recruitment of specialists from international jurisdictions to lead curriculum development and offshore wind focused training programs as the province's post-secondary and training institutions build offshore wind into its offerings.

At a roundtable held in Halifax in January 2024 with 14 industry leaders in the province's clean energy sector, it was noted that Nova Scotia already possesses many of the foundational skills needed for offshore wind and hydrogen production due to its established industries in offshore oil and gas, tidal energy and the naval sector. These industries have labourers that have transferrable skills to offshore wind, however, upskilling or "Work-Integrated Learning" was noted as required in order to bring labourers across to the offshore wind sector, as it requires specific training and skillsets[85]. Developing micro-credentialing opportunities at Nova Scotia's training and post-secondary institutions would support bringing labourers with transferrable skills into the offshore wind sector.

Despite recent population growth, the province's labour market still faces a declining and aging workforce due to low birth rates, age distributions, and outmigration of young workers. The provincial labour market is currently in decline, including a reduction in 1,700 jobs in June 2024 alone, primarily in full-time employment[86]. The unemployment rate has been gradually rising since May 2024, reaching 6.6% in June 2024[87]. There are regional disparities when it comes to employment, with Halifax witnessing robust job growth, while more rural areas such as the North Shore are experiencing declines in labour force participation[88].

The scope of the challenge may be further illustrated by comparing labour requirements, expressed in Full Time Equivalents (FTEs), to the most recent labour force data for Nova Scotia. As clarified in the comparative offshore wind study, in Appendix B, the total labour inputs

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[85] ICTC, "Strengthening Nova Scotia's Clean Energy Economy."
[86] Department of Labour, Skills and Immigration, "Labour Market Information News: Labour Force Survey."
[87] Department of Labour, Skills and Immigration.
[88] Department of Labour, Skills and Immigration.

necessary for one GW of offshore wind energy range from 8000-9000 FTEs, or 16 – 18 million hours of total labour time. The bulk of these labour inputs (5600 – 6500 FTEs) are required for the construction and installation phase of the project.

The construction sector in Nova Scotia currently employs a total of 37,500 FTEs, approximately, 19,700 of whom are employed in non-residential construction sector (or slightly less than 16,000 FTEs if factoring out transportation engineering). As of 2023, the slack in the construction labour force – which has dropped by almost half from 2020 figures – is approximately 2700 FTEs or 5,404,000 work hours that could be allocated to new or upcoming projects.[89]

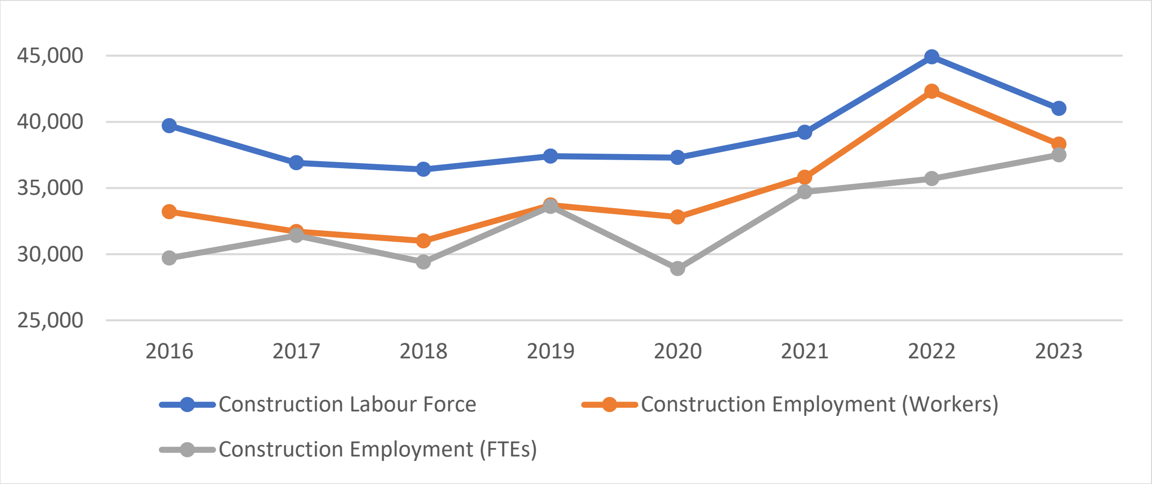

Figure 9: Construction Labour Force and Employment in Nova Scotia: 2019-2023

Therefore, total labour inputs required for the construction and installation phase for just one GW of offshore wind energy would likely comprise up to a quarter of the total non-residential construction workforce, even when accounting for the labour force slack (and given that tasks for the construction and installation phase will be shared by the manufacturing workforce). This is a significant given the other major non-residential construction projects impending in Nova Scotia that will already stretch available labour resources and personnel, including in onshore wind energy projects (i.e., EverWind), healthcare infrastructure (i.e., the QE2 expansion), renewable fuels (i.e., Simply Blue energy hub), and others.

Additionally, the existing slack within the construction sector likely does not represent seasoned workers who may be utilized or allocated immediately to new projects. In a high-demand labour market (represented in Figure 9), unemployed workers in the construction workforce are likely very new to the industry (and could be swiftly integrated into new and existing projects) or are not members of a primary project team but nonetheless affiliated with an existing operator or contractor.

Given the challenges related to specialized skills and labour availability, investments in clean energy training and workforce development initiatives would be required in order to meet the labour market challenges that are currently constraining Nova Scotia's potential in staffing offshore wind development, operations and maintenance. Continued investments from the

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[89] As Figure 9 illustrates (i.e., in the narrowing gap between the number of workers and the total FTEs) the number of part time construction workers, who could otherwise have been brought on to full time work to meet rising demand in the sector, has also declined significantly. This is another indication that labour force slack is tightening.

province to create more training seats in high-demand trade programs was recommended by the roundtable[90].

Planning is already underway among Nova Scotia's post-secondary and training institutions, with Nova Scotia Community College (NSCC) reportedly preparing new programs to meet future workforce demands in offshore wind.

NSCC recently announced it is modernizing its Electrical Technician Program to focus on large-scale wind energy with a focus on preparing students to be employable in the province's forthcoming offshore wind sector[91].

4.2.3 Labour Opportunities and Impacts for Indigenous and Other Equity Deserving Groups

The offshore wind industry in Nova Scotia would benefit from a concerted effort to engage the Mi'kmaw population to fill skilled labour gaps for the sector. Renewable energy companies in Nova Scotia have been proactive in partnering with various Mi'kmaw Communities to support capacity building, which opens the door for early community engagement and programs for labour opportunities that will emerge with the beginning of offshore wind developments in the province.

According to Statistics Canada, the Indigenous population is one of the fastest-growing segments of young people in Canada. The Indigenous population is experienced population growth of 42.5% between 2006 and 2016, compared to 11.6% for the non-Indigenous population.

As Canada and Nova Scotia grapples with a skilled workforce shortage, young, Mi'kmaw students could be engaged early ahead of forthcoming developments leading into 2030 and encouraged to choose careers in offshore wind. Support programs such as grants or tuition waivers for Indigenous students at Nova Scotian institutions offering programs in skilled trades relevant to offshore wind could be a proactive step in encouraging Indigenous labour participation in the province's offshore wind sector.

Engaging other equity deserving groups, such as African Nova Scotians and people living with disabilities, in workforce planning for the offshore wind industry would also help expand the labour pool while building a pool of labour reflective of the diverse range of Nova Scotians. Including equity-deserving groups in workforce planning also results in the following benefits:

- **Reduction in socio-economic disparities**: By including equity-deserving groups in workforce planning, the province can help reduce historical and systemic economic disparities and create better economic outcomes for these groups, contributing to the overall well-being of their communities.
- **Social license**: When equity-deserving communities see that an industry is committed to equity and inclusion, it can support building of trust and social license for the sector. This can lead to strong community support for offshore wind projects, which is crucial for its long-term success.
- **Alignment with provincial and federal goals:** Nova Scotia, like the rest of Canada, is committed to equity and inclusion in the workforce. By actively including equity-deserving groups in the offshore wind industry, the province aligns with broader governmental goals and regulations.

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[90] ICLeveraTC, "Strengthening Nova Scotia's Clean Energy Economy."

[91] NSCC, "RBC Funding Powers up Wind Energy Education at NSCC."

- **Building a resilient workforce:** A diverse and inclusive workforce is a sustainable one that is less vulnerable to demographic and economic shifts.

A recent report completed by the Canadian Research Institute for the Advancement of Women provides strategies for including women in offshore wind development in Nova Scotia along with specific engagement strategies for this group[92]. The report highlights that there are several provincial organizations in Nova Scotia already engaging and collecting data with these groups that the province can draw upon when developing an inclusive offshore wind sector.

While engaging equity deserving groups will have benefits for the offshore wind industry and these communities, it is worth noting that it is not enough to fill the labour gap that the province is facing for the offshore wind sector's labour requirements. With deaths outpacing births in Nova Scotia, the need for targeted skills-based immigration for the offshore wind sector will be critical to ensuring labour supply meets the demands of construction, operations and maintenance of the developments in the coming years.

5 Economic Impact Analysis

In this section of the study, we estimate the direct, indirect, and induced project impacts that will accrue to Nova Scotia as a result of the offshore wind development scenarios developed by the committee (See **Appendix A** for the scenarios).

As the project evolves, and project scopes, temporal dimensions, and cost estimates continue to be refined, the nature of the economic interactions assumed herein will change and, necessarily, so will the assessment of indirect and spinoff economic impacts.

A challenge for estimating the economic impact associated with this project is the newness of offshore wind technology to Nova Scotia. Existing *Supply and Use Tables* for Nova Scotia, which map industry inter-relations of how things are produced and used in the province and form the basis of the Nova Scotia Input Output (NSIO) model, are not precisely reflective of this particular form of energy production, since offshore wind production does not yet exist in the province.

Onshore wind energy generation, in contrast, has an established track record in Nova Scotia, and our collective experience as a province in this space has informed the data underpinning existing *Supply and Use Tables.*

In terms of industrial processes, and from the perspective of the supply / use tables, we've made assumptions about what industry are likely to be impacted.

In addressing the requirements of this study, 21FSP was provided with capital and operational expenditures related to various scenarios of potential offshore development scenarios and the significant level of financial investment the project entails.

This was provided for **shore-side development** – the marine facilities and ports that would need to be developed to accommodate the construction, servicing, and land-based connections to the grid; and the **offshore development** – the design, acquisition and installation of the supporting structures (fixed and floating systems), towers, turbines, and subsea cabling.

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[92] Fusco et al., "Gender-Based Analysis plus in Offshore Wind Development: Data and Community Engagement Strategies for Amore Equitable Future for Nova Scotians."

The details within the production scenarios included financial projections related to expenditures only. We made further assumptions around sourcing capital and labour for both construction and operations of the offshore wind developments.

As noted above, estimates for the wind energy portion of the development were derived from benchmarking recent wind development projects internationally (with currency conversion and CPI adjustments as necessary). We estimated Nova Scotia's overall benefits capture rate at an average of 8% for CAPEX and 20% for OPEX in NS.

Further adjustments were made to all expenditures (CAPEX and OPEX) for each scenario to estimate the spending activity that is likely to accrue to Nova Scotia.

Existing secondary information was secured and referenced to complement this primary research. This included an examination of Supply and Use Tables, as well, supplemental primary sources included interviews with the technical advisors to the committee.

5.1 Shore-Side Development – CAPEX and OPEX

21FSP was provided a summary of capital costs for port development to accommodate the offshore wind development – both during construction as well as operation. The candidate facilities that had been identified for investment included:

- Atlantic Canada Bulk Terminal - $38 million
- Novaporte Terminal $266 million
- A new Terminal in the Strait of Canso $266 million
- Sheet Harbour $166 million
- Woodside $58 million
- Shelburne $90 million

With the inclusion of projects are several other smaller ports and the associated CAPEX, the total province wide investment in ports and harbours was estimated to be on the order of $1 billion. This would be spent over a 5-year period on a combination of new construction and updates to existing marine facilities to accommodate what would be required at full build out of the offshore wind developments (see **Appendix A**).

Because these are large civil projects, and because Nova Scotia has a long and established track record in building ports and harbours, a significant share of the professional services and labour requirements could be supplied by Nova Scotia. In addition, the heavy equipment would also be sourced in the province, even if it is not produced in the province. The materials will have a high local component as well, with the exception of steel and timbers that may be required, depending on the ultimate design.

Operationally, there is more uncertainty in terms of the costs to manage and run these facilities, with this depending on the level of use, requirements for shore-side workers, wear and tear, security requirements, among other unknows. To address this, we have assumed that O&M would cost the equivalent of a straight-line depreciation of the total value of the construction cost – approximately $17 million per year, expended on port and harbor operations (NAICS 48831).

The following section presents the results of the IO run as it pertains to the shoreside infrastructure development and operations.

5.1.1 Port CAPEX Results

Table 3 presents the economic Impact of harbor construction and upgrades.

Table 3: Impact of harbour construction and upgrade at $1 billion investment (Total CAPEX), 2023 dollars and impact of harbour construction and upgrade on average per year, 2023 dollars (per year of construction)

Impact of Harbour Construction and Upgrade at $1 billion investment, 2023 dollars				
	Direct	**Indirect**	**Induced**	**Total**
Nominal GDP ($ millions)	$600.02	$103.99	$138.23	$842.24
Labour Income ($ millions)	$458.03	$65.10	$56.32	$579.46
Employment (FTEs)	6,524	1,011	1,127	8,662
Prov Revenue ($ millions)	$58.6	$8.3	$7.2	$74.1

Impact of Harbour Construction and Upgrade on Average Per Year				
Nominal GDP ($ millions)	$120.00	$20.80	$27.65	$168.45
Labour Income ($ millions)	$91.61	$13.02	$11.26	$115.89
Employment (FTEs)	1,305	202	225	1,732
Prov Revenue ($ millions)	$11.72	$1.66	$1.44	$14.82

Over the 4-to-5-year period of construction, the $1 billion investment (2023 dollars) would have the following impacts:

- A contribution to GDP of $842 million, including $600 million in direct impacts, $104 million in indirect impacts, and just under $138 million in induced impacts,
- Total labour income of just under $580 million, comprised of $458 million in direct impacts, $65 million in indirect impacts, and $56 million in induced impacts,
- Total employment in full time equivalents (FTEs) of 8,662 jobs, including 6,524 in direct employment, 1,011 in indirect employment, and 1,127 in induced employment, and
- $74 million in total provincial revenues through $59 million in direct revenues, $8 in indirect revenues, and $7 million in induced provincial tax revenues.

The CAPEX investment is a one-time-only impact that occurs during the period of construction and ends with the completion of the construction phase.

Averaged over the construction period of between 4 to 5 years, the total direct employment would equate to between 1,300 and 1,600 FTEs per year.

5.1.2 Port OPEX Results

Table 4 presents the economic Impact of the operations of the harbour, following the assumptions noted above.

Table 4: Impact of harbour Operations and Maintenance in one year, 2023 dollars

	Direct	Indirect	Induced	Total
Nominal GDP ($ millions)	$7.91	$3.33	$2.16	$13.40
Labour Income ($ millions)	$4.63	$2.02	$0.88	$7.53
Employment (FTEs)	70	37	18	124
Prov Revenue ($ millions)	$0.59	$0.26	$0.11	$0.96

During each year of operations, the estimated $17 million spent in OPEX (2023 dollars) would have the following impacts:

- A contribution to GDP of $13 million, including $8 in direct impacts, $3 million in indirect impacts, and $2 million in induced impacts,
- Total labour income of $7.5 million, comprised of $5 million in direct impacts, $2 million in indirect impacts, and just under $1 million in induced impacts,
- Total employment in full time equivalents (FTEs) of 124 jobs, including 70 jobs direct employment, 37 jobs in indirect employment, and 18 in induced employment, and
- $0.96 million in total provincial revenues through $0.59 million in direct revenues, $0.26 in indirect revenues, and $0.11 million in induced provincial tax revenues.

These impacts are reoccurring, throughout every year of the operation phases of the project, and inflation to the business of running and maintaining these facilities.

5.2 Offshore Wind Development – CAPEX and OPEX

5.2.1 *Wind CAPEX*

Table 5 provides a summary of the total CAPEX by the scenario evaluated through the NSIO model, allocated to the input-output accounts applied in this analysis.

This distilled version of the expenditures reflects five scenarios that have been considered, from a $4.2 billion, 0.6GW project to a $69 billion 10GW phase. These include CAPEX estimates for the following project elements:

- Floating Wind Elements (turbines, development and project management, floating structures, electrical infrastructure, and assembly and installation),
- Fixed Wind Elements (turbine, development and project management, substructure and foundation, electrical infrastructure, and assembly and installation),
- Cable (off shore to on shore), including purchase of materials, labour, and installation,
- Onshore substation, including purchase of material, labour, and installation

- Grid infrastructure, including land acquisition, transmission and substation material, and installation.

The methodology used to derive the CAPEX was to apply per GW unit costs derived from other benchmark studies, most notable Kitty Hawk, using a per GW cost, adjusted for a 2024 and Atlantic Canadian Context, including currency conversion and CPI adjustments.

Table 5: CAPEX by Scenario

	Stage A1	Stage A2	Stage B1	Stage B2	Scenario C Stage 3
	Turbines (86 - 7MW)	Turbines (100 - 15MW)	Turbines (86 - 7MW)	2.5 GW in service 2040 at Middle Bank and Sable Bank in support of H2 production, related products and their export	15 MW Turbines
CAPEX ($ millions)	**$4,200.00**	**$44,915.00**	**$4,708.00**	**$40,080.00**	**$69,070.00**
CAPEX Duration in Years	**5.00**	**15.00**	**5.00**	**10.00**	**12.00**
CAPEX By Categories ($ millions)					
Subtotal Floating	$3,607.28	$14,696.26	$3,607.28	$0.00	$22,332.61
Subtotal Fixed	$0.00	$25,576.08	$0.00	$35,542.73	$38,700.31
Subtotal Cable	$254.02	$1,130.10	$297.39	$997.51	$1,239.14
Subtotal Substation	$169.35	$1,198.66	$179.68	$1,201.97	$2,263.50
Subtotal Grid	$169.35	$2,313.89	$623.70	$2,337.43	$4,535.26
TOTAL ($ millions)	**$4,200.00**	**$44,915.00**	**$4,708.00**	**$40,080.00**	**$69,070.00**

The costs are not discounted and reflective of current dollars.

Table 6 provides a summary of the CAPEX allocated to the IO model vectors used in the impact simulation, adjusted for the activity expected to be able to be accommodated by existing NS-based supply chains.

Table 6: Offshore Wind Scenarios CAPEX Modeled, scaled for NS

	Stage A1	Stage A2	Stage B1	Stage B2	Scenario C Stage 3
TOTAL CAPEX ($ millions)	**$4,200.00**	**$44,915.00**	**$4,708.00**	**$40,080.00**	**$69,070.00**
NS CAPEX ($ millions), total	**$336.0**	**$3,593.00**	**$377.00**	**$3206.00**	**$5,525.00**
Years in Construction	5.00	15.00	5.00	10.00	12.00
NS CAPEX ($millions), average per year	$67.2	$168.0	$67.2	$280.0	$466.7
Project Megawatts	**600**	**4,500**	**600**	**5,000**	**10,000**
Average % NS	8%	8%	8%	8%	8%
Assumed IO Accounts					
Subtotal Floating ($ millions)	$288.58	$1,175.70	$288.58	$0.00	$1,786.61
NAICS 237 - Heavy and Civil Engineering Construction	$86.57	$352.71	$86.57	$0.00	$535.98
NAICS 335 - Electrical Equipment Manufacturing	$86.57	$352.71	$86.57	$0.00	$535.98
NAICS 2211 - Electric Power Generation	$43.29	$176.36	$43.29	$0.00	$267.99
NAICS 3366 - Ship and Boat Building	$57.72	$235.14	$57.72	$0.00	$357.32

NAICS 4883 - Support Activities for Water Transportation	$14.43	$58.79	$14.43	$0.00	$89.33
Subtotal Fixed ($ millions)	$0.00	$2,046.09	$0.00	$2,843.42	$3,096.02
NAICS 237 - Heavy and Civil Engineering Construction	$0.00	$716.13	$0.00	$995.20	$1,083.61
NAICS 335 - Electrical Equipment Manufacturing	$0.00	$511.52	$0.00	$710.85	$774.01
NAICS 2211 - Electric Power Generation	$0.00	$306.91	$0.00	$426.51	$464.40
NAICS 3366 - Ship and Boat Building	$0.00	$306.91	$0.00	$426.51	$464.40
NAICS 4883 - Support Activities for Water Transportation	$0.00	$204.61	$0.00	$284.34	$309.60
Subtotal Cable ($ millions)	$20.32	$90.41	$23.79	$79.80	$99.13
NAICS 237 - Heavy and Civil Engineering Construction	$5.08	$22.60	$5.95	$19.95	$24.78
NAICS 335 - Electrical Equipment Manufacturing	$3.05	$13.56	$3.57	$11.97	$14.87
NAICS 2211 - Electric Power Generation	$2.03	$9.04	$2.38	$7.98	$9.91
NAICS 3366 - Ship and Boat Building	$1.02	$4.52	$1.19	$3.99	$4.96
NAICS 4883 - Support Activities for Water Transportation	$9.14	$40.68	$10.71	$35.91	$44.61
Subtotal Substation ($ millions)	$13.55	$95.89	$14.37	$96.16	$181.08
NAICS 237 - Heavy and Civil Engineering Construction	$2.71	$19.18	$2.87	$19.23	$36.22
NAICS 335 - Electrical Equipment Manufacturing	$5.42	$38.36	$5.75	$38.46	$72.43
NAICS 2211 - Electric Power Generation	$2.03	$14.38	$2.16	$14.42	$27.16
NAICS 3366 - Ship and Boat Building	$0.00	$0.00	$0.00	$0.00	$0.00
NAICS 4883 - Support Activities for Water Transportation	$3.39	$23.97	$3.59	$24.04	$45.27
Subtotal Grid ($ millions)	$13.55	$185.11	$49.90	$186.99	$362.82
NAICS 237 - Heavy and Civil Engineering Construction	$2.03	$27.77	$7.48	$28.05	$54.42
NAICS 335 - Electrical Equipment Manufacturing	$5.42	$74.04	$19.96	$74.80	$145.13
NAICS 2211 - Electric Power Generation	$3.39	$46.28	$12.47	$46.75	$90.71
NAICS 3366 - Ship and Boat Building	$0.00	$0.00	$0.00	$0.00	$0.00
NAICS 4883 - Support Activities for Water Transportation	$2.71	$37.02	$9.98	$37.40	$72.56
Total NS CAPEX ($ millions)	**$336.00**	**$3,593.00**	**$377.00**	**$3,206.00**	**$5,525.00**

The five scenarios shown in the table, and described more fully in **Appendix A**, include:

- Stage A1: a 600 MW phase, to be developed and in service for 2032 at Sydney Bight. The 5-year construction phase will cost an estimated $4.2 billion (current dollars),

- Stage A2: will see a 4.5 GW expansion and take 15 years to construct, with a total cost estimated at $44.9 billion (current dollars),

- Stage B1: a 600 MW phase, with an in-service date of 2032, located on Eastern Shore and Canso Bank. The five-year construction project will cost an estimated $4.7 billion
- Stage B2: will see a 5GW development including a 2.5 GW phase with an in-service date of 2035 located at Middle Bank and Sable Bank and another 2.5 GW phase with an in-service data of 2040 at Middle Bank and Sable Bank. The project will take a combined 10 years to complete and cost a combined $40.1 billion, and
- Stage C3: a 10 GW phase with an in-service date of 2050, with turbines located at Middle Bank, Sable Bank and Emerald Bank. The 12-year project will cost an estimated $69.1 billion.

Estimates of the economic impact of CAPEX in each scenario are presented in the following table as annual averages during construction, that is the impacts show what would happen on average in each year of construction.

Table 7: Impact of offshore windfarm capital expenditure on average per year, 2023 dollars

	Direct	Indirect	Induced	Total
Stage A1				
Nominal GDP ($ millions)	$34.14	$7.27	$16.38	$57.80
Labour Income ($ millions)	$24.04	$4.72	$8.44	$37.20
Employment (FTEs)	347	77	151	576
Prov Revenue ($ millions)	$2.99	$2.56	$0.52	$6.06
Stage A2				
Nominal GDP ($ millions)	$123.62	$26.46	$59.00	$209.08
Labour Income ($ millions)	$86.73	$17.14	$30.39	$134.25
Employment (FTEs)	1,257	280	545	2,083
Prov Revenue ($ millions)	$10.77	$9.25	$1.86	$21.88
StageB1				
Nominal GDP ($ millions)	$38.15	$8.21	$18.45	$64.82
Labour Income ($ millions)	$26.75	$5.33	$9.50	$41.58
Employment (FTEs)	388	87	170	647
Prov Revenue ($ millions)	$3.32	$2.85	$0.58	$6.75
Stage B2				
Nominal GDP ($ millions)	$166.84	$36.10	$79.70	$282.65
Labour Income ($ millions)	$116.65	$23.31	$41.07	$181.02
Employment (FTEs)	1,697	381	737	2,816
Prov Revenue ($ millions)	$14.48	$12.44	$2.49	$29.41
Scenario C Stage 3				
Nominal GDP ($ millions)	$237.41	$50.79	$113.37	$401.57

Labour Income ($ millions)	$166.54	$32.89	$58.39	$257.82
Employment (FTEs)	2,417	538	1,048	4,003
Prov Revenue ($ millions)	$20.68	$17.78	$3.58	$42.03

Table 7 shows that the capital investment on offshore projects varies by scenario and could result in direct nominal GDP of between $34 million and $237 million per year, including direct labour income of between $24 million and $166.5 million, and up to 2,417 direct FTEs and 4,003 total FTEs on average per year of construction.

To place the full CAPEX in perspective, the total impact on nominal GDP of offshore windfarm construction ranges from $289 million to $4,819 million, including $186 million to $3,094 million in labour income (**Table 8**). **Total (direct and spinoff) employment over the construction periods ranges from 2,881 FTEs to 48,045 FTEs, depending on the scenario.**

Table 8: Total impact of offshore windfarm construction, 2023 dollars

	Direct	Indirect	Induced	Total
Stage A1				
Nominal GDP ($ millions)	$170.71	$36.37	$81.92	$289.00
Labour Income ($ millions)	$120.21	$23.62	$42.18	$186.02
Employment (FTEs)	1,737	386	758	2,881
Prov Revenue ($ millions)	$14.95	$12.77	$2.60	$30.32
Stage A2				
Nominal GDP ($ millions)	$1,854.28	$396.90	$884.96	$3,136.15
Labour Income ($ millions)	$1,300.90	$257.00	$455.87	$2,013.77
Employment (FTEs)	18,868	4,204	8,182	31,253
Prov Revenue ($ millions)	$161.54	$138.72	$27.89	$328.15
Stage B1				
Nominal GDP ($ millions)	$190.76	$41.07	$92.24	$324.07
Labour Income ($ millions)	$133.78	$26.64	$47.50	$207.92
Employment (FTEs)	1,944	437	854	3,235
Prov Revenue ($ millions)	$16.60	$14.24	$2.92	$33.75
Stage B2				
Nominal GDP ($ millions)	$1,668.46	$360.99	$797.05	$2,826.50
Labour Income ($ millions)	$1,166.49	$233.04	$410.71	$1,810.24
Employment (FTEs)	16,971	3,819	7,373	28,163
Prov Revenue ($ millions)	$144.74	$124.45	$24.87	$294.06
Scenario C Stage 3				
Nominal GDP ($ millions)	$2,848.94	$609.44	$1,360.46	$4,818.84
Labour Income ($ millions)	$1,998.52	$394.68	$700.69	$3,093.89
Employment (FTEs)	29,012	6,456	12,577	48,045
Prov Revenue ($ millions)	$248.16	$213.30	$42.92	$504.38

Even at a fraction of these estimates, the total CAPEX impacts are considerable and, in our view, exceeds the current labour market capacity today in the sectors impacted by these potential investments, particularly in the context of concurrent and competing projects. If the project is unable to hire new employees, it will need to take labour from existing firms and projects. This would diminish the economic impact of the project on the Nova Scotia economy.

Table 9 outlines the requirements of labour for construction based on the existing employment in the industries. Heavy and civil engineering construction as well as electrical equipment manufacturing require the largest number of workers. Current numbers of FTEs that were reported in 2023 in the select industries is less than the required amount for the project for nearly half of the scenarios.

Table 9: Direct FTEs required for CAPEX by industry vs. FTEs currently employed in 2023

Scenarios	**A1**	**A2**	**B1**	**B2**	**C3**	**FTEs 2023**
NAICS 2371 - Utility System Construction BS23C3	205	2,236	244	2,004	3,477	547
NAICS 237 - Heavy and Civil Engineering Construction BS23C5	681	8,041	727	7,504	12,255	1,780
NAICS 3353 - Electrical Equipment Manufacturing	556	5,478	641	4,625	8,533	40
NAICS 3366 - Ship and Boat Building	174	1,620	175	1,276	2,450	2,597
NAICS 4883 - Support Activities for Water Transportation	121	1,494	159	2,297	2,297	3,451

Part of the labour requirement would need to be allocated to the operating expenditures. The calculation of labour required for OPEX is independent of CAPEX, although these are more manageable than construction needs based on current labour force supply. Table 10 outlines the requirements of labour for operations based on the existing employment in the industries.

Table 10: Direct FTEs required on average per year for OPEX when operating at full capacity by industry vs. FTEs currently employed in 2023

Scenarios	**A1**	**A2**	**B1**	**B2**	**C3**	**FTEs 2023**
NAICS 2371 - Utility System Construction BS23C3	32	278	32	328	617	547
NAICS 237 - Heavy and Civil Engineering Construction BS23C5	2	19	2	23	43	1,780
NAICS 3353 - Electrical Equipment Manufacturing	2	15	2	18	34	40
NAICS 3366 - Ship and Boat Building	1	5	1	6	12	2,597
NAICS 4883 - Support Activities for Water Transportation	7	64	7	75	142	3,451

5.2.2 Wind OPEX

The project years vary based on scenarios and are estimated to take on average between 12-26 years in operation. An average Nova Scotia share of the operating expenditures would be 20% of the total.

Operational impacts were estimated based on the following assumptions.

Table 11: Fixed Bottom and Floating OPEX Estimates (2022)

	Fixed Bottom Installed Value $/MW-yr	Floating Value Installed $/MW-yr
Maintenance		
Labour (Technicians)	4000	4000
Materials	2000	3000
Equipment (vessels)	85,000	49,000
Operations		
Management Administration	2000	2000
Port Fees	1000	14,000
Insurance	15,000	15,000
Total OPEX	**108,000**	87,000
For a 1GW site per year	**$108,000,000**	**$87,000,000**

The total operating costs per GW was $87 million per GW of capacity for floating systems and $108 per GW of capacity for fixed systems.

Table 12 provides a summary of OPEX scenarios at full capacity, outlining both the total OPEX per year and the NS OPEX (20%) per year. It is worth noting that Stage A1 and Stage B1 have the same impacts because they have the same operational cost requirements (per year once at full capacity), and the difference would be in the years when those costs occur.

Table 12: Summary of OPEX scenarios at full capacity, 2023 dollars

Scenario:	**Stage A1**	**Stage A2**	**Stage B1**	**Stage B2**	**Scenario C Stage 3**
NS OPEX 20% ($ millions) per year	$10.5	$91.5	$10.5	$108.2	$203.5
Occurs at year	6	7	8	14	26
Total OPEX ($ millions) per year	$52.37	$457.65	$52.37	$541.08	$1,017.54

Table 13 shows the annual operation and maintenance impact of the facility operating at full capacity.

Table 13: Impacts of offshore windfarm operating expenditures on average per year at full capacity, 2023 dollars

	Direct	Indirect	Induced	Total
Stage A1				
Nominal GDP ($ thousands)	$5,384	$1,407	$1,283	$8,075
Labour Income ($ thousands)	$2,737	$941	$523	$4,201
Employment (FTEs)	44	15	10	69
Prov Revenue ($ thousands)	$348	$120	$67	$535
Stage A2				
Nominal GDP ($ thousands)	$47,046	$12,299	$11,211	$70,556
Labour Income ($ thousands)	$23,914	$8,224	$4,568	$36,706
Employment (FTEs)	381	134	91	607
Prov Revenue ($ thousands)	$3,044	$1,047	$583	$4,674
Stage B1				
Nominal GDP ($ thousands)	$5,384	$1,407	$1,283	$8,075
Labour Income ($ thousands)	$2,737	$941	$523	$4,201
Employment (FTEs)	44	15	10	69
Prov Revenue ($ thousands)	$348	$120	$67	$535
Stage B2				
Nominal GDP ($ thousands)	$55,623	$14,541	$13,255	$83,419
Labour Income ($ thousands)	$28,274	$9,723	$5,401	$43,398
Employment (FTEs)	451	158	108	717
Prov Revenue ($ thousands)	$3,599	$1,238	$689	$5,526
Scenario C Stage 3				
Nominal GDP ($ thousands)	$104,602	$27,345	$24,927	$156,875
Labour Income ($ thousands)	$53,171	$18,285	$10,157	$81,613
Employment (FTEs)	848	298	203	1,349
Prov Revenue ($ thousands)	$6,769	$2,328	$1,296	$10,393

As shown in the table, the annual average for OPEX could result in direct nominal GDP between $5,384 thousand and $104,602 thousand including direct labour income of between $2,737 thousand and $53,171 thousand, and up to 848 FTEs on average per year at full operations.

6 Other Impacts

6.1.1 Potential Impacts on the Fishing Sector

The commercial fishing sector in Nova Scotia is an important and valued contributor to the provincial and national economy with an estimated value of $2.8 billion as of 2022. As noted in the jurisdictional review, ensuring "happy coexistence" between the fishing sector and offshore wind is critical to the latter's success[93]. Nova Scotia has already begun best practices for engaging with commercial fisheries by facilitating an early working session with the fishing industry. According to the literature, early communication with commercial fishers and achieving agreement on "exclusion zones" for offshore wind that protect established fishing grounds is one important step to ensuring coexistence can be achieved. According to Aegir's report on potential site locations for offshore wind in Nova Scotia, the most desirable locations for offshore wind in Nova Scotia are unlikely to interfere with commercial fishing[94]. However, awareness of potential environmental, economic and cultural impacts on fishing communities is important to understand to mitigate negative effects through strategic planning for offshore wind developments.

According to the ICES, existing knowledge on the impact of offshore wind on fisheries is focused mainly on ecological impacts, while assessments of socio-cultural effects are lacking and there is no common, consistent and accepted framework for defining and quantifying socio-economic impacts on fisheries[95]. A workshop hosted by ICES focused on defining socio-economic implications off offshore wind on fishing behaviour, fishing communities, and coastal communities.

Themes arising from the workshop included:

- **Environmental impacts:** Potential environmental impacts raised included physical presence of wind turbines leading to varying degrees of displacement of fishers due to safety issues, insurance questions, or legislative exclusion. Presence of turbines also could change local abundance and distribution of fish, potentially altering target species availability. Potential biological effects raised included habitat alteration, productivity changes and larval considerations. Non-biological effects raised included impacts on bathymetry, turbidity, sedimentation, and cool pools. Spatial and temporal effects on fishing activity raised included impacts on catch per unit effort (CPUE), the types of vessels and gears fishers could not use near offshore wind, effects on transit times to fishing grounds and loss of fishing grounds.
- **Economic Impacts:** Potential economic impacts focused on risk of financial losses for fishers, fishing sectors, and the wider value chain. Observations on the potential impacts on access to fishing grounds, potential displacement, and how these link to catch efficiency, cost, business risk and uncertainty, adaptability and government frameworks were discussed. Effects of offshore wind on fishers' ability to use their existing gear was raised as a potential economic impact, as changing gear requirements due to impacts on species or ability to use mobile gear would have capital expenses related to acquiring new gear and permits. It was also raised that CPUE could also decrease during construction phase but increase during operations and maintenance phases. It was also raised that economic impacts on fisheries would differ depending on if the fisheries were coastal or

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[93] Wind Europe, "European Offshore Wind: The Story Behind the Success."

[94] AEGIR, "Value Mapping Nova Scotia's Offshore Wind Resources."

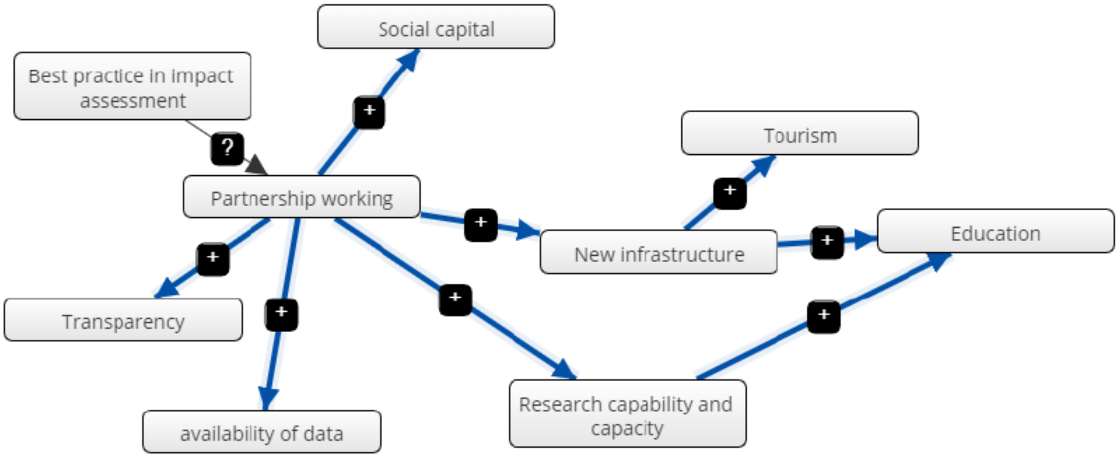
[95] ICES Scientific Reports, "Workshop on Socio-Economic Implications of Offshore Wind on Fishing Communities (WKSEIOWFC)."

offshore, in Europe or North America, and if the offshore wind turbines were fixed or floating. There are many variables to be considered.

- **Cultural Impacts:** Discussions on cultural impacts were focused on management, governance, distribution of power and how this links to social capital through the organization of industry and community networks. Effects on a fisheries' connections to a "working waterfront," tourism, safety, identity, and social cohesion were raised as potential cultural impacts. The severity of effects would depend on a community's reliance on the fishery and socio-economic well-being of fishing community members.

To circumvent negative socio-economic effects of offshore wind on fishing communities, offshore wind company Ørsted's approach with fishers in Bridlington, UK offers a best practice example. Ørsted partnered with the community in a way that led to positive outcomes in a number of areas including social capital, increased research capability and the provision of new infrastructure, which attracts tourism to the community[96].

Figure 9: Cause and Effect Map on Cultural Benefits from Partnership between Orsted and crab/lobster fishers in Bridlington, UK. Source: ICES, 2021



Positive impacts for the fishing industry from offshore wind have been highlighted in a recent report from KPMG. The report states that offshore wind farms can have a positive impact on fish stocks: "*Ocean warming has reduced the yield of fisheries around the globe, with some regions experiencing up to 35% declines in maximum sustainable yields. But OSW areas can provide a refuge for juvenile fish, giving fish stocks the potential to replenish*"[97] Research has shown that offshore wind structures can act as "artificial reefs" that provide protective habitats for a range of fish and marine life species, providing a long-term positive for fishing communities[98].

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[96] ICES Scientific Reports.
[97] KPMG, "Factoring Social and Community Impacts into the Offshore Wind Business Case."
[98] KPMG.

The literature emphasizes that strategic site selection for leases in partnership with the fishing industry is an important factor in achieving these beneficial impacts of offshore wind and ensuring that both industry and biodiversity can flourish[99].

Additionally, the province has highlighted opportunities for the fishing sector to benefit directly from contracts and employment within the offshore wind sector, including use of fishing vessels during off-seasons for surveys, scientific data collection, and as scout vessels to prevent conflict between offshore wind activities and vessel traffic or encounters with fishing gear[100].

6.1.2 Urban/Rural Impacts

As noted in the jurisdictional scan, rural coastal communities have significant opportunities to capture social and economic benefits of offshore wind development in Nova Scotia.

Aegir identified several ports in Nova Scotia as promising for offshore wind development that are accepted as either construction or operations and maintenance ports in its model for calculating the LCoE (See Figure 9). Urban ports such as Halifax and Sydney already play an important role in offshore wind project development in the US as marshalling stations, however there are opportunities for rural port towns close to the proposed offshore wind sites for Nova Scotia such as Sheet Harbour, Goldboro, Brooklyn, and Port Hawkesbury to benefit as well. Another opportunity is for Pictou County, where there was wind turbine manufacturing in the past, industrial sites capable of managing large steel manufacturing, access to rail and a private port.

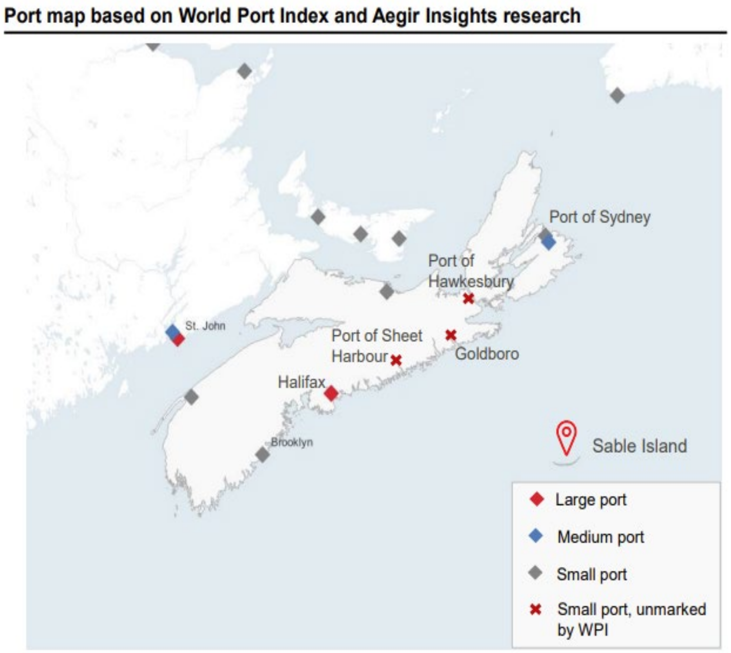

Figure 10: Port map for Offshore Wind in Nova Scotia based on World Port Index and Aegir Insights Research. Source: Aegir 2023

Depending on where the supply chain and wind farms develop, there are significant opportunities for rural, coastal port towns in Nova Scotia to accrue economic and social benefits from offshore wind in a similar way that those in Europe have experienced over the past decade.

7 Findings and Implications

This section disseminates the findings of this study through a summary of key gaps and opportunities for Nova Scotia to successfully grow the offshore wind sector to the benefit of Nova Scotia's economy and communities. This section is focused on identifying strategies for

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[99] KPMG.

[100] Province of Nova Scotia, "Nova Scotia's Offshore Wind Roadmap: Module 2 - Supply Chain and Infrastructure."

overcoming gaps and challenges facing the developing of offshore wind in Nova Scotia with a focus on how benefits can be retained within the province over the lifecycle of offshore wind.

7.1 Gap Analysis and Opportunity Assessment

Based on the findings of this study, the following key gaps and opportunities have been identified to address gaps facing Nova Scotia's capacity to effectively develop an offshore wind industry:

- Manufacturing Capacity
- Capacity of Ports for Offshore Wind
- Capacity of the Grid for Offshore Wind
- Labour Supply and Training
- Research and Development
- Collaboration with Other Jurisdictions

7.1.1 Manufacturing Capacity

As noted throughout this study, Nova Scotia currently has assets related to marshalling capabilities, ocean technology to support subsea surveys and environmental monitoring, and some relevant manufacturing capabilities.

However, there are significant gaps related to access to significant amount of steel and cement required for manufacturing offshore wind components, and currently the capacity to manufacture offshore wind components is low relative to the demand for five GW.

Building domestic manufacturing capacity to reduce the risk associated with costs and availability of importing components from international markets such as Europe and Asia will be critical to offering a cost-competitive option for offshore wind developers.

Further building the case to address domestic manufacturing gaps is the high demand for offshore wind components within the countries exporting them. It is anticipated there will be a shortage of supplies, equipment and finished goods as Europe and China hasten to deploy newer, larger models of offshore wind power turbines within their own jurisdictions[101].

Building local manufacturing capacity for offshore wind will be a long process. To retain benefits for Nova Scotia, it is recommended that the province target efforts to attract investment in offshore wind manufacturing that align with its existing strengths and assets in the early stages (e.g., fabrication of large steel structures) while building to the point of critical mass.

7.1.2 Capacity of Ports for Offshore Wind

While outside the scope of this study, the literature shows there is a gap between Nova Scotia's current port capacity to support 5GW of offshore wind and what would be required. While Nova Scotia has some ports currently servicing the US offshore wind sector with marshalling capabilities, servicing 5GW of offshore wind would require investments in upgrading or building new ports capable of withstanding the weight and size of offshore wind components. A companion report completed for the committee provides more details on port requirements to service offshore wind in Nova Scotia.

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[101] Effross, "Offshore Wind Development and Supply Chain Overview."

7.1.3 Capacity of the Grid for Offshore Wind

Grid capacity is also outside the scope of this study but an important economic consideration in planning for offshore wind. According to an expert advisor to the committee, there is some capacity in the existing grid to accommodate power from another source, such as offshore wind, but it is limited. Wherever and whenever generation from offshore wind is proposed, system integration studies will be required. However, accommodating any substantial offshore wind generation within the grid would require the development of new markets or the instigation of the Atlantic Loop[102]. There is a very limited domestic provincial market.

7.1.4 Labour Supply and Training

As noted in Section 4.2, there is a currently a gap in Nova Scotia's workforce related to the highly specialized skills and trades required for offshore wind. There are many opportunities for bolstering the workforce's capacity for servicing the offshore wind sector including:

- **Attraction of foreign specialists** in offshore wind through targeted immigration and recruitment programs to fill gaps in the workforce and to act as advisors for the development of training curriculum and programs, and instructors in newly established offshore wind education and training programs.
- **Development of upskilling and micro-credential programs** to transition offshore oil/gas and relevant naval careers into the offshore wind sector coupled with engagement with transferrable workers to increase awareness of transition opportunities.
- **Working with post-secondary institutions and industry to support development of new training programs** focused on building the offshore wind workforce is an important consideration for the province. Both NSCC and post-secondary engineering schools could add new programs and seats with government support.
- **Developing non-profit workforce development coalitions** focused on building the labour supply for offshore wind. In the US, several states have developed workforce development programs for offshore wind including Rhode Island, New York and Massachusetts. A common trend among state workforce development programs is collaboration between post-secondary institutions, and industry to design and launch workforce development programming with financial support from the state government[103]. For example, the New York Offshore Wind Training Institute was established at a cost of $20 million through the State University of New York. The institute is developing a plan for deploying public funds and have issued the first solicitation for $3 million in public funds to support organizations focused on early training and skills development in disadvantaged communities and priority populations[104]. In New Jersey, a similar institution was established – the Wind Innovation and New Development Institute (WIND) – following an executive order from the state's governor. The institute will be established as an independent non-profit with an advisory board representative of all key stakeholder groups to guide its activities. This approach includes a mandate for the non-profit to coordinate and galvanize cross-

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[102] The Atlantic Loop was envisioned as a series of transmission expansion projects that would have increased transfer capabilities between Hydro Quebec and New Brunswick and between New Brunswick and Nova Scotia.
[103] Effross.
[104] Effross.

organizational efforts for offshore wind workforce development. The province could be the catalyst for launching a similar workforce development coalition in Nova Scotia.

- **Engaging with Indigenous and other equity deserving groups in workforce development:** As explored in section 4.2, there are opportunities to bolster the offshore wind labour force with targeted training and engagement with Indigenous and other equity deserving groups. There are a range of benefits explored in 4.2 related to engaging with equity deserving populations, however, it has been noted that this alone will not fill the labour gap.

7.1.5 Research and Development

While Nova Scotia currently has strong ocean-focused R&D institutes, a focus on offshore wind in the province's innovation ecosystem is currently a gap.

In New York, the Department of Energy created the National Offshore Wind Research and Development Consortium, which is a nationally focused, independent, not-for-profit organization dedicated to managing industry-focused research and development of offshore wind to maximize economic benefits for the U.S. State and federal grants provide the consortium with $41 million to support efforts to address barriers to offshore wind development and to reduce the levelized cost of energy. The consortium issues competitive solicitations for offshore wind technology projects.

There is a strong case for a similar, federally focused consortium to be developed in Nova Scotia, given its existing strengths in ocean-based innovation and R&D through established institutions such as the Centre of Ocean Ventures and Entrepreneurship in Dartmouth, which focuses on marine innovation, the Oceans Innovation Hub on the Strait of Canso which focuses on marine-based training, and the Pier in Halifax, which focuses on innovation in ports, supply chain, logistics, and maritime policy. Early efforts to fill this gap are underway in Nova Scotia, including the concept of an Offshore Wind Innovation Hub that is currently being explored in the Strait of Canso region.

7.1.6 Collaboration with Other Jurisdictions

The US supply chain is also facing supply chain gaps while working towards its 2030 goal of 30 GW and faces the same risks as Nova Scotia related to importing from Europe and Asia amid international shortages for offshore wind parts. Nova Scotia and Atlantic Canada as a region could therefore become an important partner to developments along the US' east coast as it builds its offshore wind capacity. Working with the US and Canadian federal governments to identify where Nova Scotia and the Atlantic Region could fill American supply chain gaps could have mutually beneficial effects. It would increase the business case for investing in new manufacturing capabilities for offshore wind in Nova Scotia, and consequently, boost supply chain capacity for Nova Scotia and nearby regions.

In addition to collaborating with the US to boost manufacturing demand, Nova Scotia could also pursue collaboration with the other Atlantic Provinces to strategize on decisions related to supply chain focus. For example, Nova Scotia has experience with port marshalling, ocean monitoring and manufacturing large steel structures and therefore it would be beneficial to build on this existing capacity when targeting investments in building the local manufacturing capacity for offshore wind components.

Other provinces may have strengths in other complementary areas that would allow Nova Scotia quicker access to critical equipment and materials than building new capacity from the ground up.

Establishing a working group with the other Atlantic provinces on collaborative supply chain planning could be an opportunity to collectively identify existing strengths that could be bolstered, allowing for a collective effort to build the supply chain for the region and reduction of pressure on Nova Scotia.

While this approach would mean some benefits would accrue outside of Nova Scotia, it would allow the province to more rapidly build access to near-by finished goods, which would lower risks associated with cost and availability compared to imported goods. This would build the business case for investors seeking a comprehensive supply chain capacity in order to set up operations in Nova Scotia. Long-term, working collaboratively to build supply chain capacity to attract investment with other provinces would create ongoing local benefits for Nova Scotians as the sector evolves.

Ultimately, and considering the supply chain limitations discussed above, it is unlikely Nova Scotia will reach its ambitious goal of 5GW offshore wind capacity (within an acceptable timeframe) **without** engaging in robust cross-border collaboration, up to and including formalizing a trade agreement with the United States. After all, the province's economy is less than half of 1% of the US economy, with 0.3% of the labour force and 0.2% of the current energy production capacity. **Yet, Nova Scotia's offshore wind target is almost 17% of the United States' 30GW-by-2030 objective**.

In other words, the province intends to generate almost a fifth of the offshore wind energy output of the United States over the same timeframe, despite hosting less than one one-hundredth of the capacity to do so. Nova Scotia cannot successfully undertake such a task on its own.

7.2 Policy and Planning Considerations

Several planning priorities and policy considerations for Nova Scotia have been identified based on the findings of this study:

7.2.1 Bottom-up Approach with Government Support to Jump Start the Sector

In other jurisdictions, it has been made clear that a bottom-up approach to supply chain development driven by demand rather than a top-down approach is preferred. Top-down approaches with high local content requirements have led to slower, more expensive development processes and in some experiences, demanding these requirements have resulted in legal action due to violation of World Trade Organization commitments. Allowing a bottom-up approach is therefore recommended. However, this does not suggest the sector will be successful without government support. The literature shows effective government policies and investments are recommended in jurisdictions entering offshore wind for the first time in order to "jump start" the sector and make it an attractive location for investors. The literature shows effective government policies and investments are a powerful tool to help "jump-start" offshore wind in new locations[105]. Some mechanisms the government could leverage to support the sector in the early stages of development include:

- **Tax Incentives:** Tax credits for projects that would build the province's supply chain capacity has proven to be a successful approach for attracting investment in in other

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[105] Effross.

jurisdictions[106]. Tax incentives could be explored in Nova Scotia as an incentive tool for attracting foreign direct investment and expansion of domestic capacity.

- **Legislation:** In the US, legislation has an been proposed called the *Offshore Wind American Manufacturing Act,* which would be a mechanism to boost domestic manufacturing for offshore wind. The legislation would create an investment tax credit and a production tax credit for qualified offshore wind components and vessels. The outcomes of the legislation would include:
    - A 30% investment tax credit for qualified facilities that manufacture offshore wind components and subcomponents
    - A new production tax credit that ranges from $0.02 to $0.05 per watt multiplied by the total rated capacity of a turbine. The tax varies by components (e.g., blades, towers, nacelles, etc.).
    - Prioritization of domestic workers and requirement of prevailing wages for labourers involved in the construction and expansion of qualified manufacturing facilities or in the manufacture of qualified offshore wind products.

  Legislative mechanisms to incentivize domestic production of offshore wind parts and prioritization of domestic workers could be explored in Nova Scotia as a way to build the domestic supply chain and local workforce.
- **Financial support (subsidies, grants, support for access to capital):** Providing financial supports for industry was raised in the jurisdictional review as a key success factor in areas that are leading in offshore wind. Infusion of subsidies and funds in the early stages could support capacity building in manufacturing and workforce development. Developing programs to support access to capital for new developments could also incentivize entrepreneurs interested in offshore wind to enter the province. Subsidies and grants for offshore wind development can accelerate timelines to reaching operation and maintenance phases, while lowering the LCoE, managing effects of costly offshore wind development on power rates for Nova Scotia customers.

7.2.2 Regional / Provincial Considerations

Successful models for building supply chain and workforce capacity for offshore wind include taking a regional or multi-nation approach to build on multiple jurisdiction's existing strengths and assets. While the province can accrue significant local benefits with targeted investments and policies to build the supply chain benefits in Nova Scotia communities, it is unlikely all requirements can be met within its provincial borders by 2030. However, exploring partnership options with the other Atlantic Canadian provinces and provinces such as Ontario that produce the majority of the nation's raw steel and cement products could be explored while the province builds its critical mass. There could be a case for positioning offshore wind in Nova Scotia as a nation-building project for Canada.

International collaboration could also be explored as an opportunity to fill gaps. International partnerships are highlighted by the Global Wind Energy Council as critical for overcoming the risks associated with global competition. For example, McKinsey & Company highlight that joint ventures with internationally based companies experienced in offshore wind could accelerate technology transfer and skill development within the province[107].

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[106] Effross.

[107] McKinsey & Company, "How to Succeed in the Expanding Global Offshore Wind Market."

Acting in the early stages of offshore wind planning to develop collaborative relationships with other jurisdictions and to provide government support to incentivize investment attraction for supply chain gaps and to support workforce development, research and innovation would help to launch the sector in a successful direction.

7.3 Risks

Based on the findings of this study, the following risks have been identified for developing offshore wind in Nova Scotia:

- Global competition and sanctions
- Financial viability of projects
- Long-term supply chain gaps
- Insufficient labour supply and access to talent

Recommendations for mitigating each identified risk are provided in the subsections below.

7.3.1 Global Competition and Sanctions

The global offshore wind industry is increasingly competitive, with more countries and companies vying for limited resources, such as seabed leases, specialized vessels, and critical minerals like rare earth elements. This competition drives up costs and puts pressure on supply chains, which are already strained. For instance, supply chain bottlenecks are expected to become more severe by 2026, particularly outside of China, unless there is substantial investment and cooperation among global stakeholders[108] A report for the Global Wind Energy Council suggests global cooperation and further investment will be required to overcome supply chain bottlenecks resulting from increased competition for resources to grow offshore wind sectors in various countries.

Further, the current geopolitical environment, including potential sanctions for failing to meet climate change targets, could impact access to investors, materials and supplies. This could include restrictions on the export of crucial materials needed for renewable energy projects, such as the rare earth elements dominated by China and Russia. China's control over these resources gives it significant leverage, and there is a real risk that geopolitical tensions could lead to restrictions on access, further complicating the supply chain for offshore wind.

These factors combined mean that Nova Scotia's offshore wind initiatives could face delays, higher costs, and increased uncertainty, which could undermine the economic viability of these projects and make them more challenging to implement successfully.

To overcome these challenges, acting on the opportunities outlined in 5.1 related to building the domestic supply chain will be critical. Investments in local manufacturing capabilities can reduce dependence on global supply chains and shield the domestic industry from globally influenced disruptions.

Other risks mitigation strategies for overcoming challenges related to global competition include leveraging policy and financial instruments as noted in Section 5.2, such as tax breaks, subsidies for projects, and grants for infrastructure development to make offshore wind projects in Nova Scotia more financially viable. Investments in R&D as suggested in Section 5.1 can also help mitigate risks associated with global competition, particularly in alternative materials for offshore

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[108] Global Wind Energy Council, “Global Offshore Wind Report 2023.”

wind technology could reduce reliance on critical minerals sourced from countries that could be sanctioned in the future. Strengthening international alliances and partnerships through engagement in multilateral forums focused on international trade and renewable energy could also help mitigate these risks by providing avenues for influence on global policies in ways that benefit Canada and consequently, Nova Scotia[109]. Global partnerships can also secure access to critical resources and technologies that are lacking domestically.

Developing a comprehensive risk management strategy that includes scenario planning for various geopolitical and economic outcomes would also support risk mitigation. The strategy should contain contingency plans for supply chain disruptions, changes in global market dynamics, and the imposition of sanctions against countries that feed the global supply chain for critical offshore wind components.

7.3.2 Financial Viability of Projects

The costs associated with developing offshore wind infrastructure in Nova Scotia compared to regions that have established supply chains with low reliance on imports may make the province less appealing to investors in a competitive market. Without substantial government subsidies and other financial tools such as tax breaks, there is a risk that projects may not be financially viable. Federal and provincial financial incentives for investors and developers such as subsidies, tax incentives and grants could help reduce this risk[110].

Advocating for federal loan guarantees to reduce financial risks for investors and developers would also support mitigating this risk. Loan guarantees ensure financing is available on more favourable terms, which is critical for large-scale infrastructure projects like offshore wind[111].

7.3.3 Long-term Supply Chain Gaps / Access to Required Components and Equipment

As noted in Section 4.1, lack of existing supply chain capacity threatens the success of offshore wind in Nova Scotia. By employing the supply chain building approaches identified in 4.1 (e.g., development of financial mechanisms to incentivize investment in local manufacturing of offshore wind parts to jump start the industry), leveraging Nova Scotia's existing strengths, and by working with partners in other jurisdictions while Nova Scotia builds its capacity could help mitigate supply chain risks.

7.3.4 Insufficient Labour Supply and Access to Talent

A labour shortage of the skilled trades and professions required to service the offshore wind industry is also a risk facing offshore wind in Nova Scotia. The strategies to build a skilled workforce for offshore wind in Nova Scotia detailed in section 5.1, such as development of offshore wind workforce development consortiums, partnerships with post-secondary and industry, government funding for new training programs, and targeted recruitment of internationally based specialists with expertise in offshore wind to support workforce development and to fill labour gaps could help mitigate the risks associated with insufficient labour supply.

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[109] Global Wind Energy Council.

[110] Global Wind Energy Council.

[111] McKinsey & Company, "How to Succeed in the Expanding Global Offshore Wind Market."

However, there are also risks associated with relying on immigration. The current political environment in Canada is focused on challenges associated with population growth including a housing crisis. Limiting immigration has been raised in political narratives as a method for addressing the housing crisis in Canada and has manifested in new restrictions on the number of international students that can be accepted into post-secondary institutions.

The province's roadmap also highlights Nova Scotia's existing talent pool in related industries that could be transferred to offshore wind to support labour requirements, however, the specialized set of skills required for offshore wind will require upskilling and micro-credentialling, as well as targeted recruitment efforts to transfer workers from other sectors.

Further compounding challenges related to transferring labour is the high demand for jobs within relevant sectors. For example, the construction sector in Nova Scotia has high demand for labour as new housing builds and large capital projects are outpacing construction and other trades' workforce development efforts.

Overall, all proposed solutions for filling the talent gap for offshore wind in Nova Scotia have associated challenges in labour attraction. This underscores the need for a workforce development strategy that will attract talent from diverse sources – domestic and international – to mitigate risks associate with insufficient labour supply to construct, operate and maintain offshore wind farms in Nova Scotia.

8 Future Considerations

Offshore wind development represents a significant opportunity for Nova Scotia, but achieving its potential will require targeted investments in supply chain, port infrastructure, and workforce development along with a collaborative approach to working in a coordinated manner with other regions and potentially countries. Government support is necessary to "jump-start" the offshore wind sector and will need to include regional cooperation with other provinces and in so doing, Atlantic Canada could reduce development costs and increase opportunities for supply chain development.

Beyond the scope of this report but a key recommendation arising from it is the need for the province to disseminate the findings of this report, along with reports related to port and grid capacity, into a comprehensive risk management framework including a robust decision-making process that will allow to province to nimbly address challenges as they arise. This process should include a clear hierarchy of responsibility, criteria for escalating issues, and a framework for decisions in response to risks as they emerge.

Scenario planning is also recommended as a future consideration to reduce risks associated with offshore wind development. Developing contingency plans for various scenarios (e.g., changes in international trade policies) is recommended.

Establishing an evaluation process for the province's policies related to offshore wind is also recommended. Establishing mechanisms for regular reviews and updates of policies to ensure they remain relevant in the face of changing global conditions and industry advancements will support the competitiveness of Nova Scotia's industry. The evaluation process should result in feedback loops in which lessons learned from ongoing and completed projects can inform policy adjustments and strategic decisions to continually improve the province's approach to supporting development of an offshore wind sector and benefits for Nova Scotians.

Bibliography

AEGIR. “Value Mapping Nova Scotia’s Offshore Wind Resources.” Net Zero Atlantic, April 20, 2023. https://netzeroatlantic.ca/sites/default/files/2023-04/Value%20Mapping%20Nova%20Scotia%20Offshore%20Wind%20Resources.pdf.

Airswift. “How Can Offshore Wind Benefit from Transferable Skills within Oil and Gas?,” December 10, 2020. https://www.airswift.com/blog/transferable-skills-oil-gas-offshore-wind.

American Clean Power. “Offshore Wind Market Report | 2024,” 2024. https://cleanpower.org/resources/offshore-wind-market-report-2024/.

Bindman, Polly. “Analysis: Cancellations Threaten Biden’s 2030 Offshore Wind Target.” *Energy Monitor*, February 14, 2024. https://www.energymonitor.ai/tech/renewables/analysis-cancellations-threaten-bidens-2030-offshore-wind-target/.

CIRCABC. “Political Declaration of Energy Cooperation Between the North Seas Countries 2016,” 2016. https://circabc.europa.eu/ui/group/9198696f-e42c-4a88-b4f1-7a1788eb9b7c/library/f9baf2e3-832b-4db2-a627-36950a243f69/details.

Department of Labour, Skills and Immigration. “Labour Market Information News: Labour Force Survey,” July 2024. https://lmi.novascotia.ca/sites/default/files/2024-07/20240717%20Labour%20Market%20Information%20News%20-%20LFS%20June%202024.pdf.

Effross, D. “Offshore Wind Development and Supply Chain Overview.” Labour Energy Partnership, June 2022. https://energyfuturesinitiative.org/wp-content/uploads/sites/2/2022/06/OffshoreWindDevelopmentAndSupplyChainOverview_WhitePaper.pdf.

equinor. “Hywind Scotland Remain’s the UK’s Best Performing Offshore Wind Farm,” March 23, 2021. https://www.equinor.com/news/archive/20210323-hywind-scotland-uk-best-performing-offshore-wind-farm.

Everwind Fuels. “Point Tupper Project.” Accessed August 1, 2024. https://everwindfuels.com/projects/point_tupper.

Fusco, Leah, Jane Stinson, Leah Levac, and Deborah Stienstra. “Gender-Based Analysis plus in Offshore Wind Development: Data and Community Engagement Strategies for Amore Equitable Future for Nova Scotians.” Canadian Research Institute for the Advancement of Women, August 30, 2024.

Global Wind Energy Council. “Global Offshore Wind Report 2023,” 2023. https://gwec.net/gwecs-global-offshore-wind-report-2023/.

Grant, Taryn. “Nova Scotia Approves Another Wind Farm to Power Green Hydrogen Plant.” *CBC News*, July 30, 2024. https://www.cbc.ca/news/canada/nova-scotia/nova-scotia-approves-another-wind-farm-to-power-green-hydrogen-plant-1.7279135.

Groom, Nichola, and Sourasis Bose. “Faulty Manufacturing Blamed for VIneyard Wind Offshore Blade Failure.” *Reuters* (blog), July 24, 2024. https://www.reuters.com/business/energy/ge-vernova-says-manufacturing-issue-led-vineyard-turbine-blade-failure-2024-07-24/.

IBISWorld. “Cement Manufacturing in Nova Scotia - Current Trends and Industry Outlook (2019-2029),” June 2024. https://www.ibisworld.com/ca/industry/nova-scotia/cement-manufacturing/16317/.

ICES Scientific Reports. “Workshop on Socio-Economic Implications of Offshore Wind on Fishing Communities (WKSEIOWFC).” ICEF Scientific Reports. International Council for the Exploration of the Sea, 2021.

ICTC. “Strengthening Nova Scotia’s Clean Energy Economy,” May 22, 2024. https://ictc-ctic.ca/reports/strengthening-nova-scotias-clean-energy-economy.

International Trade Administration. “Steel Imports Report: Canada,” May 2020. https://legacy.trade.gov/steel/countries/pdfs/imports-Canada.pdf.

Kasbah. “Open for Green Energy,” 2024. https://thekasbah.co.uk/green-energy/.

KPMG. “Factoring Social and Community Impacts into the Offshore Wind Business Case,” December 14, 2023. https://kpmg.com/uk/en/blogs/home/posts/2023/12/factoring-social-and-community-impacts-into-the-offshore-wind-business-case.html.

Luo, Lin, Roberto Lacal-Arantegui, Anna J. Wieczorek, Simona O. Negro, Robert Harmsen, Gaston J. Heimeriks, and Marko P. Hekkert. “A Systemic Assessment of the European Offshore Wind Innovation: Insights from the Netherlands, Denmark, Germany and the United Kingdom.” JRC Scientific and Policy Reports. JRC - Institute for Energy and Transport and Copernicus In, 2012.

McGuire, Lauren. “Offshore Wind Is Transforming The UK’s Coastal Towns.” *NES Fircroft*, July 10, 2019. https://www.nesfircroft.com/resources/blog/offshore-wind-is-transforming-the-uk-s-coastal-towns/.

McKinsey & Company. “How to Succeed in the Expanding Global Offshore Wind Market,” April 20, 2022. https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/how-to-succeed-in-the-expanding-global-offshore-wind-market.

———. “Offshore Wind: Strategies for Uncertain Times,” July 12, 2024. https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/offshore-wind-strategies-for-uncertain-times.

Natural Resources Canada. “Government of Canada Announces $300 Million in Port Hawkesbury on Canada-Germany Hydrogen Alliance,” July 31, 2024. https://www.canada.ca/en/natural-resources-canada/news/2024/07/government-of-canada-announces-300-million-in-port-hawkesbury-on-canada---germany-hydrogen-alliance.html.

NSCC. “RBC Funding Powers up Wind Energy Education at NSCC,” 2024. https://www.nscc.ca/foundation/news-and-stories/impact-stories/stories/rbc-wind-energy-funding.asp.

OEC. “Cement in Canada,” n.d. https://oec.world/en/profile/bilateral-product/cement/reporter/can.

Offshore Magazine. “Report: Three Offshore Wind Projects Cancelled off New York,” April 22, 2024. https://www.offshore-mag.com/renewable-energy/article/55019982/report-three-offshore-wind-projects-cancelled-off-new-york.

Ørsted. “The Starting Five: Stories from America’s First Offshore Wind Farm.” Accessed August 11, 2024. https://us.orsted.com/renewable-energy-solutions/offshore-wind/block-island-wind-farm.

———. “Transforming Coastal Communities.” Accessed August 2, 2024. https://orsted.co.uk/energy-solutions/offshore-wind/transforming-communities.

Power Technology. “European Offshore Wind Deployment Centre, Aberdeen,” October 5, 2018. https://www.power-technology.com/projects/european-offshore-wind-deployment-centre-aberdeen/?cf-view.

Principle Power. “Kincardine Offshore Wind Farm,” 2024. https://www.principlepower.com/projects/kincardine-offshore-wind-farm.

Provence Grand Large. “The Three Floating Wind Turbines of Provence Grand Large Have Been Successfully Installed At Sea,” October 11, 2023. https://provencegrandlarge.fr/2023/10/11/les-trois-eoliennes-flottantes-de-provence-grand-large-ont-ete-installees-en-mer-avec-succes/.

Province of Nova Scotia. “Nova Scotia’s Offshore Wind Roadmap: Module 2 - Supply Chain and Infrastructure,” n.d. https://novascotia.ca/offshore-wind/docs/offshore-wind-roadmap-module-2.pdf.

Renewable Energy World. “Boomtown Bremerhaven: The Offshore Wind Industry Success Story,” March 13, 2009. https://www.renewableenergyworld.com/wind-power/boomtown-bremerhaven-the-offshore-wind-industry-success-story/.

Saghir, Hammaad. “Haventus Obtains £100 Million for Ardersier Port’s Offshore Wind Hub Transformation.” *Sustainable Times* (blog), May 14, 2024. https://www.sustainabletimes.co.uk/post/haventus-obtains-100-million-for-ardersier-port-s-offshore-wind-hub-transformation.

Sanders, Jon. “Big Blow: Offshore Wind’s Devastating Costs and Impacts on North Carolina.” The John Locke Foundation, June 1, 2022. https://www.johnlocke.org/research/big-blow-offshore-wind-powers-devastating-costs-and-impacts-on-north-carolina/.

Shields, Matt, Ruth Marsh, Jeremy Stefek, Frank Oteri, Ross Gould, Noe Rouzel, Katherine Diaz, et al. “The Demand for Offshore Wind Energy Supply Chain.” National Renewable Energy Labratory, June 2022. https://www.nrel.gov/docs/fy22osti/81602.pdf.

Shields, Matt, Jeremy Stefek, Frank Oteri, Sabina Maniak, Matlida Kreider, Elizabeth Gill, Ross Gould, Courtney Malvik, Sam Tirone, and Eric Hines. “A Supply Chain Roadmap for Offshore Wind Energy in the United States.” Golden, CO: National Renewable Energy Labratory, 2023. https://www.nrel.gov/docs/fy23osti/84710.pdf.

Stefek, Jeremy, Chloe Constant, Heidi Tinnesand, Corrie Christol, and Ruth Baranowski. “U.S. Offshore Wind Workforce Assessment.” National Renewable Energy Labratory, October 2022. https://www.nrel.gov/docs/fy23osti/81798.pdf.

Wehrmann, Benjamin. “German Offshore Wind Power - Output, Business and Perspectives.” Clean Energy Wire, January 27, 2023. https://www.cleanenergywire.org/factsheets/german-offshore-wind-power-output-business-and-perspectives.

Wind Europe. “European Offshore Wind: The Story Behind the Success,” April 9, 2019. https://windeurope.org/newsroom/news/european-offshore-wind-the-story-behind-the-success/.

———. “France Commits to Big Offshore Wind Volumes,” May 22, 2024. https://windeurope.org/newsroom/news/france-commits-to-big-offshore-wind-volumes/.

Windfloat Atlantic. “World’s First Semi-Submersible Floating Offshore Wind Farm,” n.d. https://www.windfloat-atlantic.com/.

World Bank. “Scenarios for Offshore Wind Development in Brazil.” Washington, D.C., July 2024. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099071824152541731/p1790301a6fb9702119dfe173210dbb9b56.

Appendix A: Scenarios for Offshore Wind Development in Nova Scotia.

- **Stage A1:** A 600 MW phase, to be developed and in service for 2032 at Sydney Bight. In this scenario, there would be a 5-year construction phase.

- **Stage A2**: A 4.5 GW expansion and take 15 years to construct.

- **Stage B1:** a 600 MW phase, with an in-service date of 2032, located on Eastern Shore and Canso Bank. In this scenario, there would be a 5-year construction phase.

- **Stage B2:** A 5GW development including a 2.5 GW phase with an in-service date of 2035 located at Middle Bank and Sable Bank and another 2.5 GW phase with an in-service data of 2040 at Middle Bank and Sable Bank. The project will take a combined 10 years.

- **Stage C3:** A 10 GW phase with an in-service date of 2050, with turbines located at Middle Bank, Sable Bank and Emerald Bank. This scenario would be a 12-year project.

Appendix B: Comparative Summary of Offshore Wind Projects

Purpose

The following presents a comparative summary of costs related to Offshore Wind (OSW) projects in North America and Europe. Its purpose is to collate benchmark data for corroborating or “ground truthing” an assessment of costs and economic impacts related to OSW in the province of Nova Scotia.

Methodology and Limitations

Publicly accessible and recent reports (1-4 years) on the economic impact of OSW were sourced online and interrogated for the following key data points:

- Cost per GW
- Jobs per GW
- Household income per GW
- GDP per GW
- Taxes per GW

It quickly became apparent that distilling clear and comprehensive data related to these fields across multiple projects would be difficult, because there is little consistency or consensus among economic impact analysts on necessary outcomes for an economic impact study and indeed what is meant by the term “economic impact,” at all.

Some researchers prioritize total costs (e.g., total CAPEX in dollars/kWh) while ignoring local content and the percentage of spending in a local economy. Others go too far the other way, exploring regional growth while neglecting total costs.

For this reason, two of the most comprehensive reports were reviewed and used to populate the summary tables below. More specific data related to discrete themes was mined from the remaining studies and factored into the summary section, which provides a bulleted review of OSW costs, inputs, and impacts. This study ends by considering the implications of this comparative analysis for the development of OSW in Nova Scotia.

Kitty Hawk Wind Projects

Kitty Hawk (2024)[112]	Impacts	Direct (total)	Direct (Local Content)	Local Content (%)
DEVEX	Cost per GW	$310.62	$109.7	35%
	Jobs per GW	128	59	35%
	Household income per GW			
	GDP per GW			
	Taxes per GW		$2.306	
CAPEX	Cost per GW	$2,988.6	$330.2	11%
	Jobs per GW	5,625	1,190	11%
	Household income per GW[113]			
	GDP per GW			
	Taxes per GW		$20.83	
OPEX (25 years)	Cost per GW	$1,870.9 - $1,583.5	$1,029.3	55%-65%
	Jobs per GW	2,756.3 - 2,337.9	1,519.65	55%-65%
	Household income per GW			
	GDP per GW			
	Taxes per GW		$402.868	

Table 14: Kitty Hawk Wind Projects summary: USD/millions

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[112] As will be clarified below, data for this study was sourced from two reports: “Kitty Hawk Wind Projects in Virginia: Economic & Fiscal Impact,” prepared by Chmura for Avangrid Renewables in March 2024, and “Kitty Hawk Offshore: Economic Impact of Kitty Hawk Offshore Wind,” by the Public Strategy Group, released in 2020.

[113] It was noted that Virginia would see a total net increase in household earnings of $400 million, or an average salary of **$64,778 USD** for all direct and indirect workers on the project.

Assumptions and Limitations of the Kitty Hawk Study

Figures for Table 1 are based on a synthesis of two Economic Impact Studies on the Kitty Hawk wind projects. These studies were authored by separate firms and diverge marginally but consequentially on the scope and emphasis of their research.

The first study, "Economic Impact of Kitty Hawk Offshore Wind," prepared by the Public Strategy Group in 2020, assesses the aggregate economic benefits the project will deliver for the state of Virginia, supplying figures for total employment generated during each phase of the project, net spending in Virginia during the construction phase, revenue generated from income, sales and property tax, and the aggregate rise in household earnings Virginians can expect between 2020 and 2030.[114]

On the one hand, the study is useful because it clarifies the percentage of total construction costs that will be spent in Virginia (even supplying the substitution rate) and disaggregates those costs based on development spending (surveys, lands costs, etc.) and construction spending (e.g., onshore substation) This allows us to calculate total DEVEX and CAPEX for the project.

On the other hand, because the study is focused on the aggregate economic impact, it does not provide insight on direct labour requirements – the FTE figures listed in the report instead represent direct *and* indirect labour inputs without differentiating between them. This emphasis on aggregation also detracts from the value of the household earning figures, which in the report total $400 million during the construction (2020 – 2030) and $327 million during the initial operations phase (2026-2030). This is simply the value of the total earnings of all direct and indirect employees during these periods and can therefore only provide a rough estimation of household incomes if we assume that no two employees will be living together.[115]

In this case, the average yearly salary, calculated as the total projected earnings ($725,000,000) divided by the total direct and indirect FTE count (11,191), is $64,778USD.

Finally, the study is limited because it offers only a partial assessment of operational costs for the Kitty Hawk projects, providing salaries and total earnings for employees but ignoring the local content and cost of materials during the O&M phase.

Some of these gaps were filled by a second study on the Kitty Hawk projects, released in 2024 by Chmura Analytics. This study is useful because it breaks down employment into direct, indirect, and induced categories, allowing us to estimate total and local labour requirements using the local content figures gleaned from the PSG study. It also provides estimates for tax revenues during each phase – including the operations phase (which is absent in PSG strategy).

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[114] The Public Strategy Group (PSG) brand is not present in the report, but in December 2020, Avangrid Renewables noted in a press release that an EIS had been completed by the PSG. The findings referenced in the press release match those of the report used here.

[115] The report makes no reference to induced impact or employment, and it is not clear that the document's reference to "indirect" impact includes the former category. For example, it defines "indirect earnings" as "those earning generated by Avangrid Renewables spending that go to individuals not employed by Avangrid Renewables. For example, some of the indirect household earnings from construction spending will go to manufacturing workers who increase their hours in order to meet Avangrid Renewables demand for turbine foundations." In this respect, the total impacts outlined in the report are less comparable to total impacts of another scenario that includes all three effects.

However, there are two limitations to the Chmura report. First, the employment counts are not full-time equivalents (FTEs), but job totals (i.e., a part-time job for one year is also counted as 1.0) Therefore, the jobs per GW tabulation is likely high, depending on the (unclarified) number of part-time jobs factored into the analysis. Second, while the report outlines direct O&M in Virginia, it does not provide any local content figures, making it impossible to determine total operational costs. A relatively high range of 55-65% was designated as an estimate for this short comparative study, because of the well-developed training ecosystem emerging in Virginia for wind turbine technicians (e.g. at Centura College).

Conversion Assumptions: 2.5GW to 1GW

- **Costs:** Cost were designated as fixed or variable, with the latter scaled by 0.4 (e.g. “surveys” was designated as a fixed cost and left unchanged, while foundations and “other components” were designated as variable costs and scaled).
- **Labour:** The following ratios were applied to each of the development, construction, and operational phases:
    - **Development:** 60% fixed and 40% variable
    - **Construction:** 15% fixed and 85% variable
    - **Operational:** 25% fixed and 75% variable
- **Taxes:** The following ratios were applied to the tax categories below:
    - **BPOL:** 30% fixed and 70% variable
    - **Individual Income:** 10% fixed and 90% variable
    - **Corporate Income:** 20% fixed and 80% variable
    - **Sales:** 10% fixed and 90% variable
    - **Property:** 80% fixed and 20% variable

Offshore Wind in Denmark

Denmark Model (2020)[116]	Impacts	Direct (total)[117]	Direct (Local Content)	Local Content (%)
DEVEX	Cost per GW	$165.3	$88.65	54%
	Jobs per GW (FTE)	574	314	55%
	Household income per GW			
	GDP[118] per GW		$104.4	
	Taxes per GW			
CAPEX[119]	Cost per GW	$2,852	$1,328	47%
	Jobs per GW (FTE)	6,256	3,000	48%
	Household income per GW[120]			
	GDP per GW		$1,493	
	Taxes per GW			
OPEX (25 years)	Cost per GW	$1,354	$898.05	66%
	Jobs per GW	1,907	1,287	67%
	Household income per GW			

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[116] The data in this table is based on the model results conducted for Denmark, rather than on the application of that model for specific and in-development wind farms, such as the Thor Wind Farm. The results for the model (i.e. prior to their application) were more detailed and broken down into Development as well as Construction and Operation phases. Costs used were "average," rather than the minimum or maximum values. The report itself it entitled "Socio-economic impact study of offshore wind," by Thomas Sylvest. The report was released in July 2020.

[117] Costs and labour inputs outlined in this column represent total project costs and inputs, not only total supplier contract costs, which are marginally lower (e.g. total DEVEX costs related to supplier contracts is listed in the report as $154.3 million USD). The percentage of local content listed in the right-most column represents the Danish market share of the total cost, not of total supplier contracts.

[118] Figures for GDP were converted to USD from DKK based on a 2020 exchange rate (the year of the report).

[119] CAPEX in the report (excluding Development, which is designated as DEVEX) is split into three phases: 2A Production Wind Turbines, 2B Production Balance of Plant, and 3 Installation & Grid Connection.

[120] Much like the Kitty Hawk study, the report on OSW in Denmark offers aggregate figures for salaries earned by Danish employees during the lifespan of the project. However, the Denmark model includes induced as well as direct and indirect workers. In the Danish case, the average annual salary is **$85,171 USD**.

	GDP per GW		$1,189	
	Taxes per GW			
DEPEX (6-36 months)	Cost per GW	$446.88	$197.4	44%
	Jobs per GW	713	321	45%
	Household income per GW			
	GDP per GW		$263.25	
	Taxes per GW			

Table 15: Summary of socioeconomic impacts of offshore wind in Denmark: USD/millions

Assumptions and Limitations of the Denmark Study

There is much less to say regarding assumptions and limitations of the Danish example. The report used to populate Table 2 was the most comprehensive of the studies consulted, incorporating data on total costs, labour inputs, local content, GDP, and employee salaries in one document. Unlike the Kitty Hawk example, there was no need to synthesize or patch together multiple sources to generate a picture of the whole.

Further, and similarly unlike the Kitty Hawk example, the Danish model yielded data and projections for a 1GW wind farm, so there was no need to convert the figures to accommodate the 1GW benchmark.

The obvious limitation with the study is its age. Written over four years ago, the costs outlined in the report now likely underestimate total capital expenditures required for a 1GW wind farm. Further, the national focus of the report detracts from its value as a comparative piece. That is, because the emphasis of the research is the national economy of Denmark (almost 6 million residents and a GDP of over $400 billion) the projected share of local contracts will be much higher than that of a more regional study (e.g. of Nova Scotia).[121]

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[121] However, given that the GDP of Denmark is smaller than many US states, including Virginia, an almost 50% share of local contracts for construction is ambitious.

Summary by Theme

The following conclusions can be distilled from secondary reporting on OSW, despite variations in research emphasis:

- **Cost:** Total capital expenditures (DEVEX and CAPEX) for a 1GW wind farm range from $3 billion USD to almost $5 billion USD, with more capital required for an offshore floating farm than a fixed bottom farm. Total OPEX ranges from $1.5 billion USD to $1.8 billion USD, bringing total costs to a range of $4.8 billion USD and $6.3 billion USD, as Table 3 illustrates, based on the above data and projections made for four US regions by analysts at Wood Mackenzie.

Table 3: Costs per GW for select OSW projects (USD)

Cost	**New York Bight**	**Carolinas**	**Gulf of Maine**	**California**	**Kitty Hawk**	**Denmark**
CAPEX	$4.0 billion	$4.0 billion	$4.8 billion	$4.8 billion	$4.36 billion	$3.02 billion
OPEX	$1.7 billion	$1.7 billion	$1.5 billion[122]	$1.5 billion	$1.029 billion	$1.8 billion
Total	$5.7 billion	$5.7 billion	$6.3 billion	$6.3 billion	$5.389 billion	$4.82 billion

- **Local Content:** For studies of local economic development (e.g. EIS for OSW at the state level, rather than the national level), the share of projected local construction contracts ranges from 10% (North Carolina) to 12% (Virginia). In Maine, the projected share of contracts related to turbines, balance of system, and electrical infrastructure is also 10%, but estimations related to ports, staging, vessels, and labor are as high as 30%.
- **Labour:** Direct labour requirements for a 1GW OSW farm range from 7500-9000 FTEs for the total life of the project, with the construction phase comprising the largest labour needs.
- **Taxes:** Tax revenue per GW naturally varies considerably according to local tax and regulatory regimes. In the US example, these range from an average of $10.6 million per year in state and local taxes (in the Virginia example, for the forty-year duration of the project), to approximately $50 million per year in state and local taxes (in the California example, as determined by a 2021 report released by California Polytechnic University).

There was regrettably insufficient data in the reports to comment seriously on household income and GDP per GW.

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[122] The Wood Mackenzie study gives $60/kW as an annual O&M cost for the Gulf of Maine and California. The annual cost for New York and the Carolinas is $68/kW. The figures represented here represent the total cost of a 25-year project.

Implications for OSW in Nova Scotia

What does this mean for the development of OSW in Nova Scotia? How should we think about the feasibility of the province's ambitious 5GW OSW target? A useful starting point for addressing these questions is to consider the local content percentages identified in studies of regional-level OSW projects, because this attests to the capacity or readiness of local economies to host such projects and to the scope of materials and labour that will need to be sourced externally.

We saw that estimates for local content shares in the states of Virginia, North Carolina and Maine ranged from 10-12% (and as high as 30% for some components, such as vessels). Each of these states feature large, diverse economies with a rich history of manufacturing and marine-related sector growth. The GDP of Virginia alone is over $700 billion, and manufacturing and construction (as of 2023) are the fourth and third fastest growing industries in the state, respectively.

With a GDP of approximately $45.6 billion (2024), **Nova Scotia would struggle to similarly accommodate a local content share of 10-12%,** not only because of the disparity in GDP size but considering the labour force challenges affecting the construction sector in the province. According to a 2024 report by BuildForce Canada, and as reported by the Construction Association of Nova Scotia, as many as 8,200 workers – over 20% of the current construction labour force – are expected to retire from the NS construction industry by 2033. **The sector will need to recruit some 10,600 workers by this date just to meet anticipated employer demands for the industry as a whole.**

Comparing Nova Scotia's energy targets to national-level figures adds another useful perspective. The regional US projects alluded to above (Virginia, Maine, California, New York, etc.) are part of a wider plan to generate 30GW in OSW power across the United States. This goal factors in a national GDP of $26.7 trillion (2023), a labor force of 166 million (2024), export revenues of $2.1 trillion (2023) and a total energy production capacity of 1,189GW per year.

Nova Scotia's ambitious 5GW OSW target is approximately 17% of the US target. **Yet, the province's economy (GDP to GDP) is less than half of 1% of the US economy (0.171%).** With a labour force of 515,200 (2024), export revenues of $7 billion (2023), and a current energy production capacity of 2.5GW (0.2% of the US total), Nova Scotia cannot undertake an OSW project of this magnitude on its own. It is unlikely even the combined resources of Atlantic Canada will be sufficient.

Rather, leveraging this opportunity will require a national-level consolidation of resources and industry development strategy, as well as an innovative international trade agreement on OSW with the United States to facilitate resource sharing along the east cost of North America, from the Chesapeake up through the Gulf of Maine and the Atlantic shores of Nova Scotia.

Appendix C: Assessment of Supply Chain Capacity

The table below is intended to show the relative Nova Scotia-based labour and capital intensity across various phases of the project, based on what we understand of the current commercial and industrial makeup of Nova Scotia's economy.

Table 16: Supply Chain Requirements by Development Phase

Phase	NS Labour Intensity	Non-NS Labour Intensity	NS Capital Intensity	Non-NS Capital Intensity
1. Development and Project Planning:				
• Site selection and feasibility studies	Low	LowHigh	Low	Low
• Environmental impact assessments	Low	HighLow	Low	Low
• Securing permits and licenses	Low	HighLow	Low	Low
• Financial planning and securing investments	Low	HighLow	Low	Low
2. Design and Engineering:				
• Turbine design and engineering	Low	High	Low	Low
• Foundation and substructure design (fixed-bottom types include monopiles, jackets, gravity bases)	Low	High	Low	Low
• Electrical infrastructure design (cabling, substations)	Low	High	Low	Low
3. Manufacturing/Acquisition/Assembly:				
• Turbines: blades, nacelles, towers	Low	High	Low	High
• Foundations: monopiles, jackets, gravity-based structures	Moderate to High depending on GBS vs Mono	Low	Moderate to High depending on GBS vs Mono	High
• Electrical components: cables, transformers, substations	Low	High	Moderate	High

Phase	NS Labour Intensity	Non-NS Labour Intensity	NS Capital Intensity	Non-NS Capital Intensity
• Other components: boat landings, access platforms	Low	High	Moderate to High depending on GBS vs Mono	High
• Onshore assembly of turbines on floating platforms or near-shore assembly	Moderate to High depending on GBS vs Mono	Low	Moderate to High depending on GBS vs Mono	Low
4. Transportation and Logistics:				
• Transportation of components from manufacturing sites to staging areas	Low	High	Moderate to High depending on GBS vs Mono	High
• Specialized vessels for transporting large components	Low	High	Moderate to High depending on GBS vs Mono	High
• Coordination of logistics for timely delivery	Low	High	Low	Low
5. Construction and Installation:				
• Site preparation and seabed preparation	Low to Moderate depending on GBS vs Mono	Low	Moderate to High depending on GBS vs Mono	Moderate to High depending on GBS vs Mono
• Installation of foundations and substructures	Low to Moderate depending on GBS vs Mono	Low	Moderate to High depending on GBS vs Mono	Moderate to High depending on GBS vs Mono
• Installation of turbines and nacelles	Low to Moderate depending on GBS vs Mono	Low	Moderate to High depending on GBS vs Mono	Moderate to High depending on GBS vs Mono

Phase	NS Labour Intensity	Non-NS Labour Intensity	NS Capital Intensity	Non-NS Capital Intensity
• Electrical infrastructure installation (cables, substations)	Low to Moderate depending on GBS vs Mono	Low	Moderate to High depending on GBS vs Mono	Moderate to High depending on GBS vs Mono
• Use of specialized vessels such as jack-up rigs, heavy-lift ships, and cable-laying vessels	Low to Moderate depending on GBS vs Mono	Low	Moderate to High depending on GBS vs Mono	Moderate to High depending on GBS vs Mono
6. Commissioning:				
• Testing and commissioning of turbines and electrical systems	Low	High	Moderate	Low
• Integration with the grid	High	Low	High	Low
• Final inspections and certifications	Low	Low	Low	Low
7. Operations and Maintenance:				
• Regular maintenance of turbines and infrastructure	Moderate, depending on scale	High	Low	High
• Monitoring and diagnostics	Moderate, depending on scale	High	Low	High
• Repairs and replacements as needed	Moderate, depending on scale	High	Low	High
• Use of service vessels and remote monitoring systems	Moderate, depending on scale	Moderate, depending on scale	Moderate, depending on sourcing	Moderate, depending on sourcing
8. Decommissioning:				

Phase	NS Labour Intensity	Non-NS Labour Intensity	NS Capital Intensity	Non-NS Capital Intensity
• Planning for end-of-life decommissioning	High	Low	Moderate to High depending on GBS vs Mono	Moderate to High depending on GBS vs Mono
• Dismantling and removal of turbines, foundations, and electrical components	High	Low	Moderate to High depending on GBS vs Mono	Moderate to High depending on GBS vs Mono
• Site restoration and environmental remediation	High	Low	Moderate to High depending on GBS vs Mono	Moderate to High depending on GBS vs Mono