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A Regional Approach to Offshore Wind Energy Manufacturing in the Central Atlantic: Supply Chain

Paula Pérez, George Hagerman, Gianna White, Bailey Pons, Jeremy Stefek, Brinn McDowell, and Matthew Shields

National Renewable Energy Laboratory

Produced under direction of National Offshore Wind Research and Development Consortium by NREL under Interagency Agreement FIA-22-23288.

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Office of Energy Efficiency & Renewable Energy
Operated under Contract No. DE-AC36-08GO28308

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Strategic Partnership Project Report
NREL/TP-5000-92432
September 2025

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Suggested Citation
Pérez, Paula, George Hagerman, Gianna White, Bailey Pons, Jeremy Stefek, Brinn McDowell, and Matthew Shields. 2025. *A Regional Approach to Offshore Wind Energy Manufacturing in the Central Atlantic: Supply Chain*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-92432. https://www.nrel.gov/docs/fy25osti/92432.pdf.

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Strategic Partnership Project Report
NREL/TP-5000-92432
September 2025

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Acknowledgments

This study was funded by the National Offshore Wind Research and Development Consortium (NOWRDC) with additional funds provided by the Maryland Energy Administration and the North Carolina Department of Commerce. The authors would like to thank the external stakeholders that contributed to the scope and content of this report, including Christine Sloan (NOWRDC), Kori Groenwald (NOWRDC), Jennifer Mundt (North Carolina Department of Commerce), John Hardin (North Carolina Department of Commerce), Joshua Levy (North Carolina Department of Commerce), Emma Stoney (Maryland Energy Administration), Samuel Beirne (Maryland Energy Administration), Ken Jurman (Virginia Department of Energy), Thomas Noyes (Delaware Department of Natural Resources and Environmental Control), Tim Mack (US Wind), and Garry Harris (Center for Sustainable Communities). Peer reviewers include:

- Ross Gould (Oceantic Network)
- Sam Tirone (Oceantic Network)
- John Larson (Dominion Energy)
- Garry Harris (Center for Sustainable Communities)
- Samuel Herbert (U.S. Department of Energy)
- Isaac Ward-Fineman (U.S. Department of Energy)
- Brett Anders (U.S. Department of Energy)
- Claire Richer (American Clean Power Association)
- Anne Reynolds (American Clean Power Association)
- Ian Gansler (American Association of Port Authorities)
- Kirby Rootes-Murdy (Bureau of Ocean Energy Management)
- Philip Temnaes (Danish Energy Agency)
- William Lim (Danish Energy Agency)
- Mads-Peter Hansen (Danish Energy Agency)
- Emma Stoney (Maryland Energy Agency)
- Jennifer Mundt (North Carolina Chamber of Commerce)
- Joshua Levy (North Carolina Chamber of Commerce)

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List of Acronyms

AMPTC	advanced manufacturing production tax credit
BOEM	Bureau of Ocean Energy Management
CBA	Community Benefit Agreement
COD	commercial operation date
CVOW	Coastal Virginia Offshore Wind
EPA	Environmental Protection Agency
FFIV	floating foundation installation vessel
GBF	gravity base foundation
NREL	National Renewable Energy Laboratory
QOZ	Qualified Opportunity Zone
RAP	registered apprenticeship program
SBJ	suction bucket jacket
SCC	Supply Chain Connect
S_{SCC}	Supply Chain Connect score
SGRE	Siemens Gamesa Renewable Energy
SMART-POWER	Southeast and Mid-Atlantic Regional Transformative Partnership for Offshore Wind Resources
WTIV	wind turbine installation vessel

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Executive Summary

Growth of the offshore wind industry in the United States is likely to require growth in the nation's manufacturing capacity and additional resources and investments to meet energy project demands. Such growth has the potential to provide positive economic impacts for local communities, workers, and entire states.

To realize the benefits of developing a domestic offshore wind supply chain, the states of Maryland, North Carolina and Virginia are working together under the Southeast and Mid-Atlantic Regional Transformative Partnership for Offshore Wind Resources (SMART-POWER) regional collaboration to advance the industry, with Delaware as a supporting state. This report is part of the SMART-POWER Workforce and Supply Chain Analysis study, funded by the National Offshore Wind Research and Development Consortium. The study assesses challenges and opportunities for the four Central Atlantic states to understand key regional strengths and identify supply chain investments that could effectively leverage their resources and provide benefits to both the member states and the offshore wind sector as a whole.

This report represents one of two parts of the study, which focuses on the business opportunities and barriers for investment in major offshore wind turbine component facilities and the related implications for nearby communities, workforce readiness, small and medium-sized businesses, and overall deployment of offshore wind energy in the region and along the East Coast. The second part of the study can be found in a companion report published in parallel, *A Regional Approach to Offshore Wind Energy Manufacturing in the Central Atlantic: Workforce* (Pons et al. 2025), which evaluates in more detail the workforce readiness of the region, states, and communities to meet the needs of major component manufacturing and evaluates relevant training programs across the region.

Industry Needs and Regional Strengths

The SMART-POWER region's historical manufacturing and maritime industry expertise is evidenced through its competitive ports, existing skilled manufacturing-related workforce, support of educational and workforce training programs, and Tier 2 and Tier 3 businesses in the region relevant for Tier 1 manufacturing.[1] We identify three focus areas centered around Tier 1 manufacturing for the SMART-POWER region to meet key industry needs that can leverage the region's own strengths and resources:

- **Blade manufacturing**. This is the European supply chain's most constrained Tier 1 component and will experience significant shortages beginning in 2025. There are no presently announced U.S. facilities, although the Portsmouth Marine Terminal in Virginia was previously considered by Siemens Gamesa Renewable Energy for a blade facility.[2]

[1] Tier 1 components are the large, finished components typically staged at a fabrication port, such as blades, towers, nacelles or foundations. Tier 2 refers to subassemblies or integrated subcomponents that have a specific function for a Tier 1 component, such as a pitch system for blades or a service lift for towers. Tier 3 refers to subcomponents which are generally commonly available items integrated into Tier 2 subassemblies.

[2] The Siemens Gamesa Renewable Energy blade facility at Portsmouth Marine Terminal in Virginia was announced in late 2021 (Radowitz and Ferris 2021) and canceled in November 2023 (Lee 2023).

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- **Tower manufacturing**. Towers are another significantly constrained component in the European supply chain. There are three announced U.S. facilities (US Wind/Haizea facility in Sparrows Point, Maryland, Marmen Welcon[3] in Albany, New York, and a US Forged Rings facility at an undisclosed East Coast location), none of which are operational or in active development.
- **Monopile manufacturing**. Monopiles have similar upcoming bottlenecks in the European supply chain, but there is only one operational facility in the United States (EEW in Paulsboro, New Jersey), and one announced (US Wind/Haizea in Maryland).

We present three different East Coast project deployment scenarios based on announced offshore wind projects as of **November 30, 2024**. The baseline deployment scenario is based on project development data, including project development schedules, state procurement targets, available lease areas, macroeconomic factors, and potential infrastructure or supply chain constraints, resulting in 17.2 GW of installed capacity by 2030 and 81.4 GW by 2040, with an erratic boom/bust pattern of low and high deployment due to competing factors like state targets. The low deployment scenario modifies the baseline scenario through macroeconomic and supply chain limitations, resulting in 13.5 GW installed by 2030 and 51.4 GW by 2040, while the high deployment scenario models favorable macroeconomic and supply chain factors, resulting in 17.2 GW installed by 2030 and 112.8 GW by 2040.

Key Takeaways

After assessing potential business, workforce, and community impact considerations for Tier 1 investments, we outline six key takeaways:

1. **The existing and announced manufacturing facilities in the United States likely do not have sufficient production capacity to support the demand for towers, blades, and monopiles from offshore wind projects in the SMART-POWER region (nor for the whole East Coast pipeline, as estimated by our deployment scenarios).** Additionally, there are significant bottlenecks expected in the global supply for these components beginning in 2025–2028 and lasting at least until 2030.
2. **We estimate that expanding the East Coast supply chain to include two full blade manufacturing facilities and one new tower facility could potentially reduce the risk of undersupply from 2027 to 2040 across deployment scenarios. The monopile demand in these scenarios can likely be met by the two facilities that have already been announced.** These estimates are based on our assessment of supply and demand across the East Coast. There is continuing uncertainty about the presently announced facilities, which pose additional challenges for developers as they work to secure components but which may lead to opportunities for additional facilities if any of the current announcements are delayed or canceled.
3. **The component demand from the deployment scenarios in the SMART-POWER region would likely be sufficient to cover the supply of components from the two**

[3] While we include the previously proposed Marmen Welcon tower facility in our analysis, the Port of Albany is no longer pursuing this development as of early 2025. Beacon Island in the Port of Albany is considering investments for other maritime industries, although it is still permitted for manufacturing and staging for offshore wind (Ferris 2025; Rulison 2025).

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blade facilities and one tower facility, although new facilities will likely need additional funding to make projects financially viable. Across the deployment scenarios, the SMART-POWER states account for 24%–37% of East Coast deployment by 2040. The resulting market is likely sufficient to cover most orders needed by new blade and tower facilities, in addition to announced facilities. We calculate potentially favorable business cases for new facilities (Figure ES-1) with tax credit or funding support,[4] while facilities modeled without funding support likely have less favorable business cases (Figure ES-2).

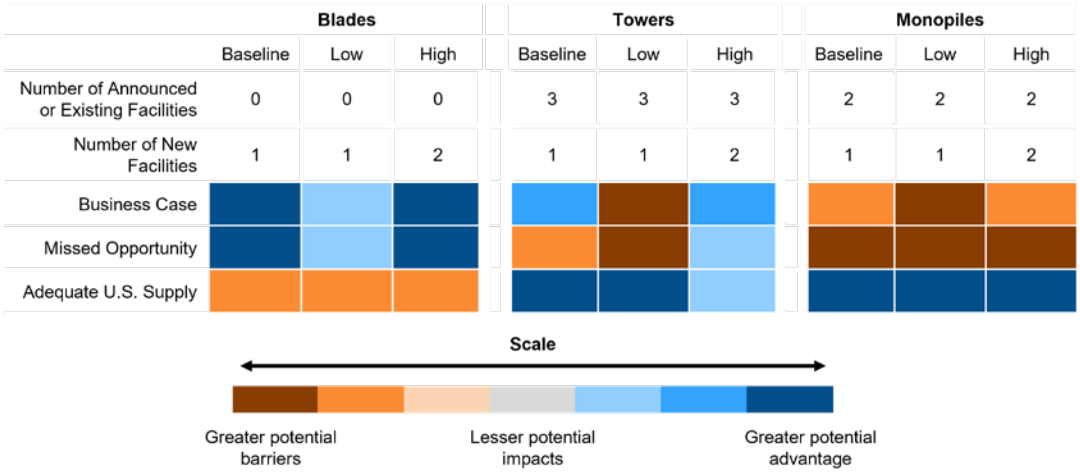

Figure ES-1. Opportunities or barriers for new Tier 1 facilities deployment scenarios.

The business case metric describes the attractiveness of an investment for a manufacturer, missed opportunity describes the resilience of the business case when faced with competition, and the adequacy of U.S. supply describes whether project developers will be able to secure domestic components based on available supply.

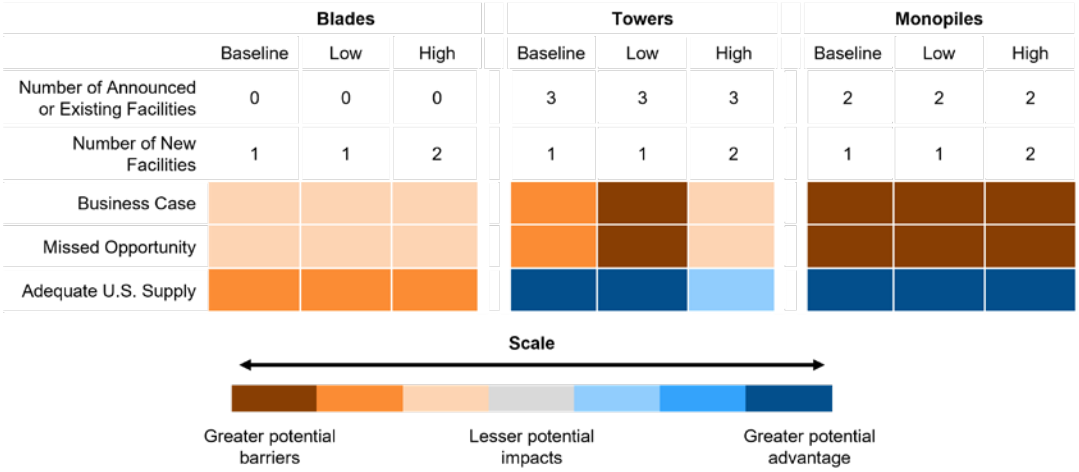

Figure ES-2. Opportunities or barriers for new Tier 1 facilities with reduced funding support.

[4] Our main analyses and results in Figure ES-1 assume that new manufacturing facilities would be able to claim the advanced manufacturing production tax credit as outlined in the 2022 Inflation Reduction Act. With the passing of the One Big Beautiful Bill Act on July 4, 2025, which modifies tax credit guidance for components sold after 2027, we expect business cases for new facilities to be less favorable (Figure ES-2).

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4. **The SMART-POWER states are likely well suited to host new Tier 1 facilities because they have at least six potential ports capable of hosting manufacturing facilities (one or two per state), with a highly capable regional workforce and supporting business network.** There is high workforce readiness (Figure ES-3) at Port of Wilmington in Delaware, Sparrows Point in Maryland, the Hampton Roads area in Virginia (including Fairwinds Landing and Portsmouth Marine Terminal), and Port of Wilmington in North Carolina. Portsmouth Marine Terminal and Port of Morehead City could increase workforce readiness with improvements to commuting access and regional connectivity between jobs, workers, and training or educational programs. There is also a strong network of Tier 2 and Tier 3 suppliers in the region, including established or announced secondary steel and cable manufacturers. Technical port upgrade assessments were beyond the scope of this study.

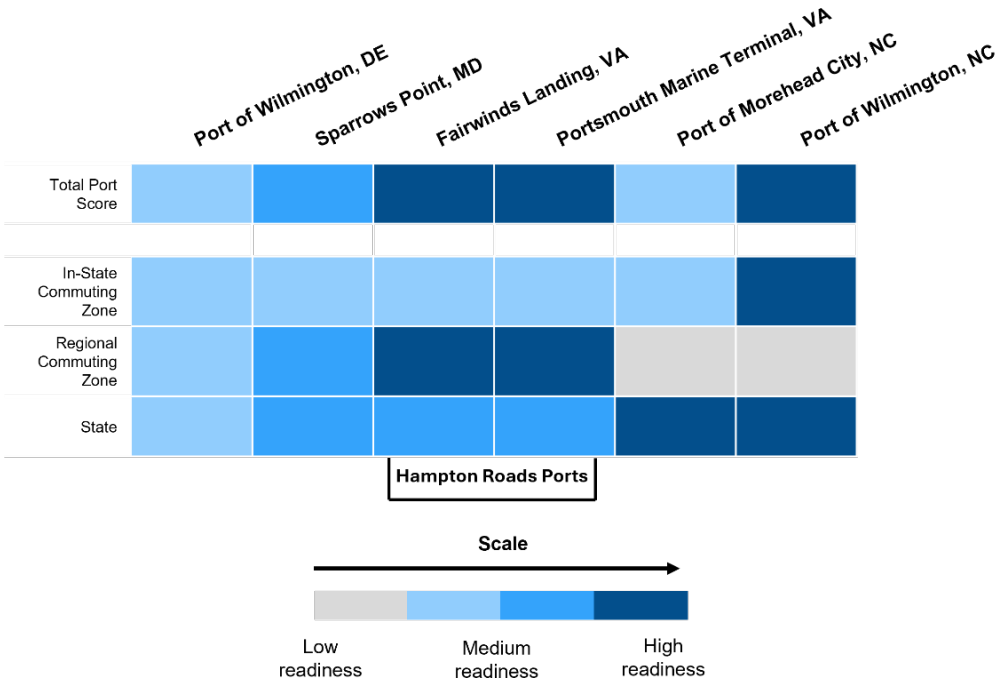

Figure ES-3. Workforce readiness evaluation by port, aggregated for all three focus areas (blade, tower, and monopile fabrication), and their respective local, regional, and state scores.

The total score is an aggregate of a port's local, regional, and state score, capturing the availability of skilled relevant labor and the opportunity to develop/maintain a skilled labor force with existing training and educational programs.

5. **Port communities around at least four ports have a high potential for positive investment impact, which could be enhanced with targeted engagement between industry and community members to improve the potential for positive outcomes.** Supply chain investments could potentially bring benefits to port communities such as local investments in education, training, or infrastructure, as well as mitigation of negative port activity impacts. Although potential negative impacts of port activity such as localized air pollution or noise could coincide with existing environmental vulnerabilities and barriers to economic mobility in SMART-POWER port communities (Figure ES-4), targeted community engagement and benefits could potentially alleviate some of these concerns while distributing more broadly the benefits of new investments. Port communities with high historic underinvestment or unemployment are likely to

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benefit the most. Key socioeconomic issues across SMART-POWER ports include high percentages of low-income households and higher poverty rates than average (disproportionately impacting people of color) and adverse health outcomes like high adult asthma rates. Community members and organizations are generally eager for and receptive to industry engagement that is more representative of different groups, includes different voices in decision-making processes, and is more impactful with tangible benefits and protections.

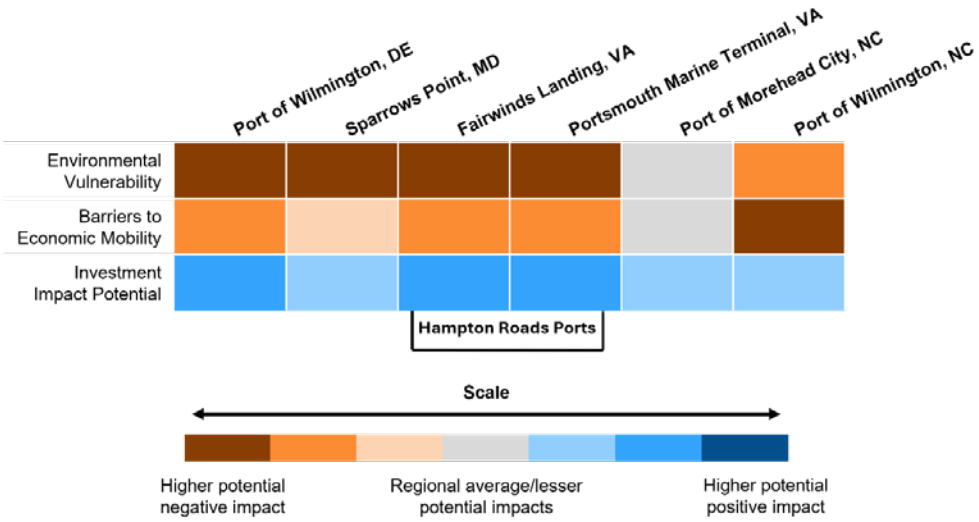

Figure ES-4. Community impact evaluation by port community (defined as the 5-mile port radius).

Environmental vulnerability and barriers to economic mobility describe the existing public health and socioeconomic concerns in a port community, respectively, that could benefit from targeted community benefits. The investment impact potential describes the extent to which new investment could address historic underinvestment.

6. **Interstate collaboration could help develop a regional supply chain that could meet the component demand from SMART-POWER projects, fill gaps in the overall East Coast pipeline, and contribute to a stable order book and greater workforce readiness for new supply chain facilities.** Publicly announced commercial operation dates of projects in the East Coast pipeline indicate a potential for boom/bust cycles in deployment timelines. This erratic schedule may create challenges for new supply chain facilities in securing stable component orders. Ongoing communication between SMART-POWER states and project developers in the region could help identify actions to mitigate these risks. Earlier supply chain investments may reduce risk of component procurement bottlenecks when the global supply chain is most stressed beginning in 2025.

Although there is uncertainty in the market and other challenges with developing manufacturing resources, there is an opportunity for the Central Atlantic states of Delaware, Maryland, Virginia, and North Carolina, building off the existing SMART-POWER framework, to establish a strategic vision and act on it to help meet renewable energy targets. Developing tower, blade, or monopile manufacturing resources could help projects in the region avoid delays attributed to anticipated global supply chain bottlenecks with the added benefit of creating jobs and economic growth. Regional communication and coordination between the states could help to achieve these benefits by establishing strategic plans for building supply chain assets, training the workforce, and advancing offshore wind project development.

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1 Introduction

Growth of the offshore wind industry in the United States is likely to require expansion of the nation's manufacturing and maritime capacity and the addition of thousands of jobs. This growth may potentially help address historic underinvestment in and around port communities while contributing to the nation's electricity grid. As the first commercial-scale offshore wind projects are being built and put into operation along the East Coast, the industry has faced challenges in getting projects started and securing supporting investment (McCoy et al. 2024). Challenges range from macroeconomic shocks such as surging inflation and high interest rates to supply chain, vessel, and port infrastructure constraints. There is general consensus in the industry regarding the need to develop a domestic supply chain that meets energy project demands and promotes economic development and job creation (Shields et al. 2023) while reducing barriers and uncertainty for all domestic projects and stakeholders.

Many states along the East Coast have begun procurement of offshore wind projects and have identified investments at the local and state levels in ports, manufacturing, workforce, and related infrastructure to potentially support the development of a domestic supply chain (McCoy et al. 2024). In addition to individual state initiatives, there are efforts underway for East Coast states to share information and collaborate or coordinate to support the development of a domestic supply chain. One example is a Memorandum of Understanding signed in 2022 between key federal and state agencies to explore regional collaboration opportunities in supply chain development (U.S. Department of Energy et al. 2023). Another regional collaboration effort is the Southeast and Mid-Atlantic Regional Transformative Partnership for Offshore Wind Resources, or SMART-POWER, between Maryland, Virginia, and North Carolina, with participation from Delaware, focused on strengthening the offshore wind industry with emphasis on supply chain development in the Central Atlantic region (Porter 2020).

This report is part of the SMART-POWER Workforce and Supply Chain Analysis project, which assesses the challenges and opportunities for Maryland, Virginia, North Carolina, and Delaware to collaborate regionally to develop a domestic supply chain for the U.S. offshore wind industry and capture the potential benefits. Funded by the National Offshore Wind Research and Development Consortium and led by the National Renewable Energy Laboratory (NREL), the study aims to understand key regional strengths and identify supply chain investments that can potentially leverage these resources, as well as provide benefits to both the member states and the offshore wind sector as a whole.

This report represents one of two parts of the study; it focuses on the business opportunities and barriers for investment in major component facilities and the related implications for nearby communities, workforce readiness, small and medium-sized businesses, and overall deployment of offshore wind energy in the region and along the East Coast. The second part of the study is published in a companion report, *A Regional Approach to Offshore Wind Energy Manufacturing in the Central Atlantic: Workforce* (Pons et al. 2025), which evaluates in more detail the workforce readiness of the region, states, and communities to meet the needs for major component manufacturing and evaluates relevant training programs across the region.

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1.1 Recent Supply Chain Developments

Since the publication of NREL's national offshore supply chain road map study (Shields et al. 2023), the domestic offshore wind supply chain has experienced growth while dealing with numerous challenges. As of November 2024, facility, port, and vessel investment announcements exceeded $7.1 billion across the country (U.S. Department of Energy 2024), filling in some of the initial needs to meet project deployment. These investments begin to address some of the seven key national-scale obstacles identified in the road map: (1) investment risk, (2) siting and technology challenges, (3) limited supplier networks, (4) insufficient port and vessel infrastructure, (5) limited domestic workforce, (6) cost competitiveness, and (7) ensuring shared socioeconomic opportunity and environmental benefits.

However, additional critical barriers in the past 3 years also include macroeconomic shocks from elevated inflation, supply chain bottlenecks since the 2020 COVID-19 pandemic, and project cancellations and delays tied to important facility orders and investments (McCoy et al. 2024).

Within the SMART-POWER region, the continued development and marshaling of the Coastal Virginia Offshore Wind (CVOW) project and the announcement of a new cable manufacturing facility by LS GreenLink in Chesapeake, Virginia (LS GreenLink 2024) may signal continued investment in the offshore wind industry amid recent challenges. We have developed the supply chain assessment framework for this report with an understanding of these key drivers and barriers in order to remain aligned with the identified needs of East Coast states, manufacturers, developers, and other involved stakeholders.

1.2 Supply Chain Assessment Framework

The following assessment was structured to capture numerous supply chain considerations. As illustrated in Figure 1, the assessment framework starts from a broad scale of analysis at the global and national levels, then narrows down to regional and community-scale evaluations, then further down to the individual facility scale. **Section 2. The Big Picture** is intended to provide industry context for developing a domestic supply chain and for how various industry gaps align with SMART-POWER state strengths and interests. Set into this context, the three Tier 1 components[5] we evaluate for manufacturing in the region are blades, towers, and monopiles (the justification for focusing on these components is described in Section 2.2).

Sections 3–5 evaluate different opportunities, challenges and potential impacts of supply chain investments, measured and contrasted with quantitative metrics unique to each section:

- **Section 3. Port Locations and Port Communities** examines indicative ports for manufacturing across the SMART-POWER region, followed by community impact considerations, such as potential health and economic vulnerabilities and opportunities for the surrounding communities. The three community impact evaluation metrics are "location-specific" (making comparisons between port locations) but "component-agnostic" (not influenced by the selection of Tier 1 component for a given facility).

[5] Tier 1 components are large, finished components such as blades, towers or foundations. Other tiers referenced in this study include Tier 2 (subassemblies) and Tier 3 (subcomponents integrated into Tier 2 subassemblies).

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- **Section 4. Community Capacities** assesses the workforce readiness surrounding each port to meet the workforce needs and skill sets for major component manufacturing; it also evaluates the existing Tier 2 and Tier 3 businesses that could benefit from and be leveraged to support supply chain investments. The workforce readiness and business availability evaluation metrics are both "location-specific" and "component-specific."
- **Section 5. Individual Facility Evaluation** focuses on the potential business opportunities and barriers for investment in one or more major component facilities and considers the implications of individual investment decisions for manufacturers, state leadership, and project developers. The three facility evaluation metrics are "location-agnostic," as they are independent of the port location, but are highly "component-specific" to evaluate how facility investments may differ by Tier 1 component.

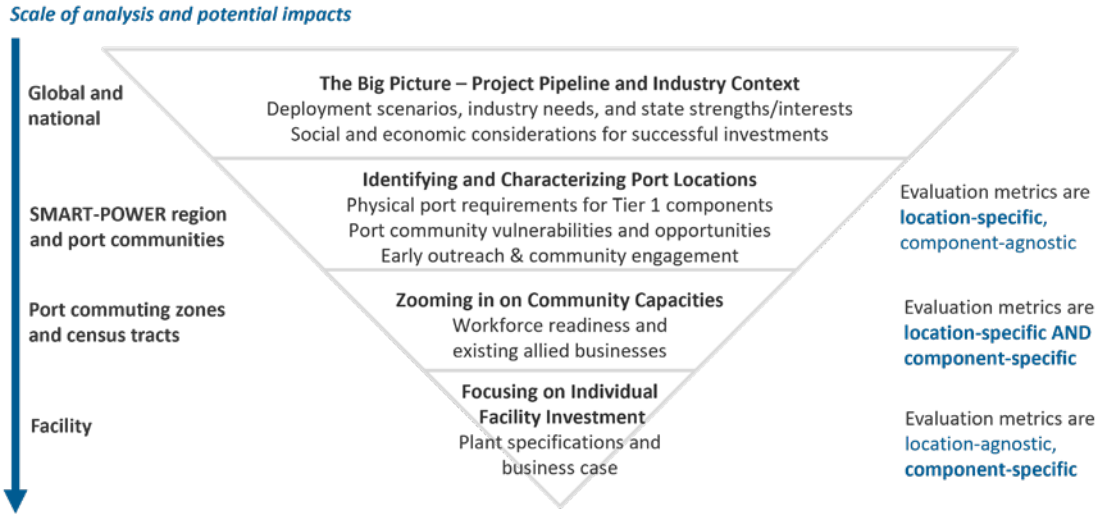

Figure 1. The assessment framework covers supply chain considerations from a broad, global scale down to the individual facility scale

Each section will use the calculated metric results with additional context from each state, the Central Atlantic region, and the entire East Coast to identify the main opportunities and challenges related to supply chain development. All metrics have been customized for this study and combine a number of factors and datasets in different ways (described in detail in Appendix B). The final results are presented in summarizing matrices with results from each metric compared across focus areas, port locations, and deployment scenarios. The metrics and all other results and conclusions are meant to provide information to the SMART-POWER states and other key stakeholders; this is not a decision-making study.

In addition to the main sections covered by this framework, **Section 6. Additional Opportunities for the SMART-POWER Region** addresses three crosscutting topics at a high level that represent additional challenges and opportunities for the region and the industry; these topics may warrant a more in-depth evaluation outside of this publication:

- Usage of SMART-POWER ports as marshaling ports
- Longer-term storage of Tier 1 components at SMART-POWER ports
- Fabrication of alternative wind turbine foundations.

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2 The Big Picture

The potential challenges and opportunities for supply chain investment in the SMART-POWER region are set within the broader global and national context. There is a significant opportunity for SMART-POWER states to realize the benefits of developing an offshore wind supply chain by leveraging their regional and individual state strengths and interests to add to the growth of offshore wind in their own states while contributing to the overall industry's success.

The following subsections detail the broad offshore wind deployment and supply chain challenges faced globally and nationally and summarize the relevant SMART-POWER state resources, which result in three supply chain focus areas in this assessment to meet industry needs with state strengths.

Additionally, we present three East Coast deployment scenarios that frame our evaluation of supply chain challenges and opportunities, and we discuss guiding social and economic considerations. In this assessment, we do not consider West Coast industry needs or resources as a factor in the development of the offshore wind supply chain on the East Coast.

For the data presented in this assessment, we used a cutoff date of **November 30, 2024**. As such, public data on project development, lease areas, state targets, supply chain facility announcements, and other related deployment and supply chain information is current only as of the cutoff date.

2.1 Supply Chain Challenges and Industry Needs

The offshore wind industry is growing globally and in the United States, encouraged by efforts to expand energy generation to meet demand growth, government buy-in and incentives for renewable energy, and grid diversification for reliability, among other factors.

In 2023, the Global Wind Energy Council forecast more than 2 TW of wind energy capacity installed by 2030 under contemporary policies across the world, with up to 1.5 TW more in overall wind energy capacity needed to support various climate targets, of which 494 GW correspond to offshore wind energy (Global Wind Energy Council 2023). Domestically, NREL's *Offshore Wind Market Report: 2024 Edition* (McCoy et al. 2024) identified offshore wind procurement mandates from eight states totaling 45.7 GW by 2040 as of May 31, 2024, while the project development and operational pipeline for offshore wind represented a generating capacity of 80.5 GW.

While deployment goals may bolster offshore wind energy build-out, global supply chains are not currently capable of supplying the necessary components, vessels, and port infrastructure in a timely and cost-effective manner. Some key supply chain challenges and bottlenecks include:

- Mining for central raw materials (such as zinc, copper, iron, and rare earth metals) concentrated in very few countries, primarily China, as well as production of gearboxes, converters, castings and generators. Disruptions in imports result in significant bottlenecks for key offshore wind components relying on these materials and subcomponents.

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- Tier 1 component manufacturing for the United States primarily comes from the European supply chain, which is also dependent on imports and is currently insufficient to meet European offshore wind goals, let alone deployment abroad.
- Thin component manufacturing margins, project pipeline uncertainty, and conflicts between varying component lead times and timeline uncertainty slow down manufacturing capacity expansions.

For project installation, the top five supply chain bottlenecks identified (Global Wind Energy Council 2023; Wood Mackenzie 2023) are:

- **Wind turbine installation vessels (WTIVs):** While WTIVs are less likely to experience bottlenecks in Europe until 2028, the Jones Act limits foreign-flagged WTIV use in the United States, regardless of availability, making it an existing bottleneck domestically.
- **Blades:** European bottlenecks are expected to begin in 2025; blades represent the greatest investment deficit to meet global 2030 targets.
- **Towers:** European bottlenecks are expected to begin in 2026.
- **Fixed-bottom foundations (primarily monopiles):** European bottlenecks are expected to begin in 2026.
- **Nacelles:** European bottlenecks are expected to begin in 2026; nacelles represent the smallest (but still significant) investment deficit to meet global 2030 targets, compared to the previously listed components.

European component undersupply identified to begin in 2025–2026 is estimated to last (and in most cases worsen) at least until 2030 (Global Wind Energy Council 2023; Wood Mackenzie 2023).

Developing a domestic supply chain for offshore wind could potentially support project installations starting in the late 2020s and help meet domestic energy and emission reduction targets (Shields et al. 2023). Prioritizing the listed components with critical bottlenecks can likely de-risk projects and the overall industry. Notwithstanding, addressing these multiple challenges may require a significant level of investment, complicated by the uncertainty in project rollout, evolving technologies such as alternative foundations and increasing turbine sizes, and uncertainty in the time frames and coordination across all the different necessary investments.

2.2 Focus Areas Based on SMART-POWER Strengths

To address industry challenges and needs, this assessment focuses at each stage on the strengths and resources that exist within the SMART-POWER region. After an initial review of the region's ports, we identified six ports that likely meet the physical requirements for Tier 1 manufacturing, with minimum to moderate investment required for component handling (detailed in Section 3.1), supported by the region's dynamic maritime industry. In addition, there are programs, initiatives, or organizations that may increase socioeconomic benefits for port communities or that have the potential to do so (Sections 3.3 to 3.5).

Additionally, the region's historical manufacturing experience, particularly in the steel industry, is evidenced through its existing skilled manufacturing-related workforce, supporting educational

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and workforce training programs, and Tier 2 and Tier 3 businesses in the region relevant for Tier 1 manufacturing (Sections 4.1 and 4.2).

As a result, the three selected focus areas are intended to capture the region's industry strengths and existing resources, which can be leveraged with strategic investments to support supply chain development. The three selected focus areas encompass:

- **Full blade manufacturing**, considering this is Europe's most constrained Tier 1 component, has no presently announced U.S. facility, and the Portsmouth Marine Terminal in Virginia was considered by Siemens Gamesa Renewable Energy (SGRE) as a location for a blade finishing facility.[6]
- **Tower manufacturing**, as there are three announced U.S. facilities (US Wind/Haizea facility in Sparrows Point, Maryland; Marmen Welcon[7] in Albany, New York; US Forged Rings facility at an undisclosed East Coast location), but none are currently operational.
- **Monopile manufacturing**, with only one operational facility (EEW in Paulsboro, New Jersey), and one announced (US Wind/Haizea in Maryland).

While there are other industry needs and state strengths, the following assessment is framed around these three focus areas as some of the highest priorities for the regional supply chain development. Section 6 addresses some additional opportunities based on identified state and regional strengths; to leverage the existing port infrastructure, maritime experience and waterways, marshaling ports, and storage ports are explored as sidebar studies, as is alternative foundation fabrication that can use the steel manufacturing expertise of the region.

2.3 Project Deployment Scenarios

We present three different East Coast project deployment scenarios to characterize supply chain opportunities and challenges under a variety of conditions. The scenarios are based on announced offshore wind projects on the East Coast as of **November 30, 2024**, their expected development schedules, and other deployment drivers such as state procurement targets, available lease areas, expected technology trends, various macroeconomic factors, and potential infrastructure or supply chain constraints. Scenario data sources and assumptions are detailed in Appendix A.

The following scenarios are not future projections; they have been developed from 2024 to 2040 for analytical purposes to capture potential deployment trends and challenges based on a variety of macroeconomic factors and extended to 2042 to capture component demand in 2040 (assuming Tier 1 procurement happens 2 years before a project's commercial operation date (COD)). More information on the methodology behind the scenarios can be found in Appendix A. The scenarios only include deployment on the East Coast (from Maine to South Carolina) and

[6] The SGRE blade facility at Portsmouth Marine Terminal, Virginia, was announced in late 2021 (Radowitz and Ferris 2021) but canceled in November 2023 (Lee 2023).
[7] While we include the previously proposed Marmen Welcon tower facility in our analysis, the Port of Albany is no longer pursuing this development as of early 2025. Beacon Island in the Port of Albany is considering investments for other maritime industries, although it is still permitted for manufacturing and staging for offshore wind (Ferris 2025; Rulison 2025).

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have been summarized in Table 1. All canceled or terminated projects are assumed to reenter the pipeline after some delay, which is also detailed in Appendix A. The SMART-POWER region accounts for 24%–37% (12.3–39.0 GW) of overall East Coast deployment by 2040 across the scenarios (illustrated in additional figures for the SMART-POWER region in Appendix A).

Table 1. Deployment Scenario Summary

Deployment Scenario	Installed Capacity by 2030 (GW)	Installed Capacity by 2040 (GW)	Average Installed Capacity 2030–2040 (GW/year)	Installed Capacity by 2040 in the SMART-POWER Region (GW)
Baseline	17.2	81.4	6.4	26.3
Low	13.5	51.4	3.8	12.3
High	17.2	112.8	9.6	39.0

The **baseline deployment scenario** (Figure 2) describes East Coast deployment based on project development information, state targets, and known lease areas as of November 30, 2024. State targets for the East Coast are summarized on the OpenEI platform maintained by NREL (NREL 2024). The higher annual deployment levels are likely to be enabled by mixed macroeconomic factors, potentially including low interest and/or inflation rates and periods of higher government support for offshore wind. However, this scenario is tempered by individual state and developer interests guiding project CODs, indicating a low level of regional coordination. While this results in most states meeting their targets, it also leads to an erratic deployment trend following a recurring boom/bust pattern of 2–3 years of low deployment, followed by 2–3 years of high deployment.

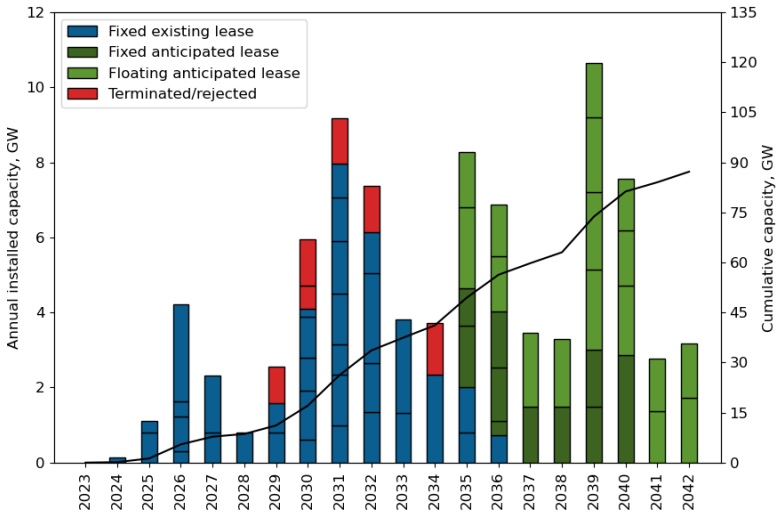

Figure 2. Baseline deployment scenario for the East Coast

The **low deployment scenario** (Figure 3) describes East Coast deployment limited by a combination of unfavorable macroeconomic factors (high interest and/or inflation rates, low government support for the industry, more severe and prolonged supply chain bottlenecks) as well as severe infrastructure or supply chain constraints. This scenario takes the baseline scenario

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as the starting point, then limits the number of projects installed per year. Projects at more advanced development stages are prioritized and delayed less (as described in detail in Appendix A).

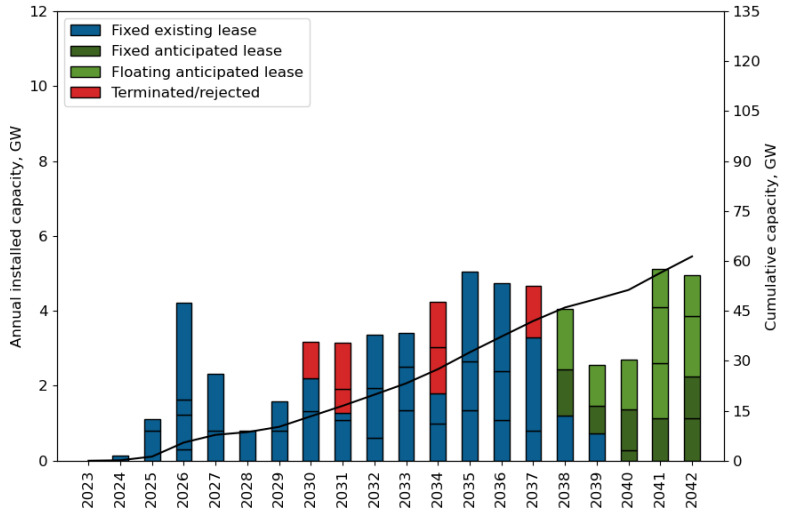

Figure 3. Low deployment scenario for the East Coast

The **high deployment scenario** (Figure 4) takes the opposite approach to describe accelerated East Coast deployment resulting from a combination of highly favorable macroeconomic factors (low interest and/or inflation rates, high government support, reduced supply chain bottlenecks) as well as regional coordination and higher levels of infrastructure investment. This scenario also takes the baseline scenario as the starting point, then accelerates the deployment pipeline after 2031 (assuming earlier projects cannot be accelerated) to consistent levels of high deployment.

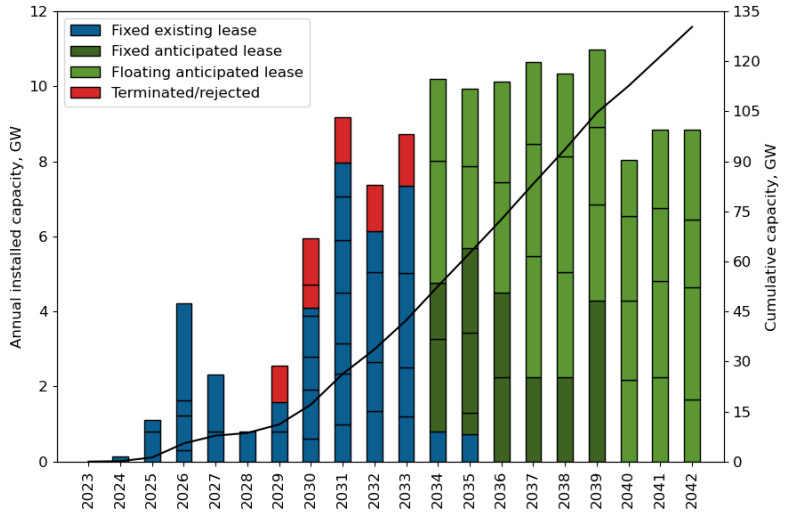

Figure 4. High deployment scenario for the East Coast

2.4 Social and Economic Considerations

The following sections of this report evaluate social and economic considerations with the same detail as market and business considerations, rooted in an understanding of the importance of all

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these different dimensions in successful supply chain investments. Proactive engagement with different groups from port communities, the workforce, and small and medium businesses can potentially improve trust and buy-in for major projects like the construction and operation of Tier 1 manufacturing facilities as well as the broader offshore wind energy industry. Additional benefits may include more efficient regulatory processes at local, state, and national levels and minimizing potential negative impacts such as community opposition, negative press, and litigation (EPA 2020).

While potential environmental impacts from Tier 1 manufacturing at ports are not explored in depth in this report, they are an additional dimension of importance to supply chain development so that environmental benefits may be achieved with minimum negative impacts across supplier and manufacturer locations and to promote healthy port communities. A discussion of recent efforts related to environmental and community impacts can be found in NREL's national supply chain road map (Shields et al. 2023).

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3 Port Locations and Port Communities

Due to the large dimensions of offshore wind components, Tier 1 manufacturing facilities generally require massive, specialized equipment, infrastructure and vessels for fabrication, storage, and transportation via waterways. Across the SMART-POWER region, we identified six different ports that may be suitable for blade, tower, or monopile manufacturing based on their physical characteristics and capabilities, with little to moderate additional investment likely needed. Technical port upgrade assessments were beyond the scope of this study. There may be other port locations, not identified in this study, also suitable for component manufacturing.

Additionally, port communities, defined herein as the immediate 5-mile radius surrounding a port, were identified and analyzed for each of the indicative port locations within the SMART-POWER region. While the 5-mile radius may not entirely capture areas in a city or town involved or affected by offshore wind supply chain development, it is consistent with previous NREL research (Shields et al. 2023) focused on households more directly and regularly impacted by port activity. We evaluate the existing public health and socioeconomic vulnerabilities in port communities to provide an understanding of issues that may coincide or be exacerbated by additional port activity, but that could also be improved upon through targeted community investments. We also present opportunities and tools for community engagement and involvement in the supply chain investment process. As the United States ramps up its offshore wind supply chain, it is valuable for manufacturers and developers to be aware of the disproportionate impacts from their projects that communities may experience, as well as how those effects may be exacerbated if port communities are not afforded the same advantages from port operations as other communities in the area, such as jobs and economic growth (EPA 2020).

> **Collaboration Resources**
>
> The U.S. Environmental Protection Agency's Community-Port Collaboration Toolkit (https://www.epa.gov/community-port-collaboration/community-port-collaboration-toolkit) has resources for enhancing collaboration skills between communities and ports like the Ports Primer for Communities and Community Action Roadmap. The toolkit was developed in collaboration with port operators, port communities, and community organizations.

3.1 Indicative Ports for Tier 1 Manufacturing

The ports selected in this assessment (listed below and shown in Figure 5) were compared against generic facility specifications for Tier 1 component manufacturing (see reference and port-specific specifications in Appendix E) to determine their suitability. While Port of Wilmington in Delaware does not meet the laydown area requirements,[8] it was included in this assessment due to the possibility to expand into adjacent developable land and to consider some of the state's related capabilities beyond Tier 1 manufacturing. One to two ports per state were identified in the SMART-POWER region as potentially capable of Tier 1 manufacturing.

[8] Laydown area is the available space at a port needed to store and handle cargo, or in the case of offshore wind manufacturing, Tier 1 components such as blades, towers, and monopiles.

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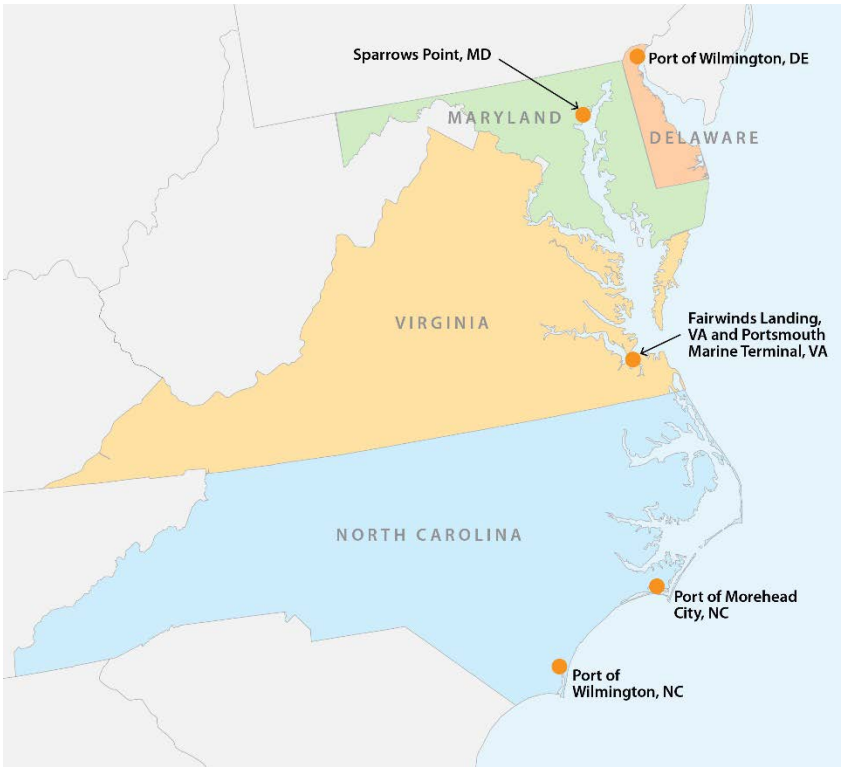

Figure 5. Indicative port locations for Tier 1 manufacturing in the SMART-POWER region

1. **Port of Wilmington, Delaware,** is a port located at the confluence of the Delaware and Christina Rivers in Wilmington, Delaware, with experience handling containers and various project cargos, especially fruit and automobiles. The port has also handled wind turbine blades and has a 60-acre development site for wind turbine component manufacturing, assembly, and staging (Port Wilmington n.d.).
2. **Sparrows Point, Maryland,** is at the location of a former iron and steel facility, known today as Tradepoint Atlantic, that is under redevelopment as a container terminal and the announced site for Sparrows Point Steel (Sparrows Point Container Terminal n.d.). The facility is expected to become a long-term tower and monopile production and marshaling facility, established by Baltimore-based US Wind (US Wind n.d.), and was awarded a $47 million federal grant in 2023 through the Maritime Administration's competitive Port Infrastructure Development Program (US Wind 2023).
3. **Fairwinds Landing, Virginia,** is a maritime operations and logistics site located in Norfolk, Virginia, in the Hampton Roads region. This site is primarily intended to support Hampton Roads' offshore wind, defense, and transportation industries. The Fairwinds Landing Monitoring and Coordination Center will be used to monitor offshore wind farm asset performance and perform operations and maintenance (Hampton Roads Alliance 2023). Fairwinds Landing was awarded a Port Infrastructure Development Program federal grant for $39 million in 2023 to make improvements to support heavy lift equipment and a floating pier (Office of Senator Mark R. Warner 2023).
4. **Portsmouth Marine Terminal, Virginia,** is in Portsmouth, Virginia, across from Fairwinds Landing in the Hampton Roads region. It is one of the largest facilities in the Port of Virginia and sits on the west bank of the Elizabeth River. Portsmouth has growing

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contributions to the maritime, transportation, and logistics industries, unmanned systems, advanced manufacturing, and offshore wind energy, demonstrating the area's traditional and emerging industry involvement. Portsmouth Marine Terminal has received numerous upgrades, including reinforcing pavement in the cargo yard, rebuilding the berth, and reworking its vessel mooring to serve as the staging port for CVOW (Port of Virginia 2023).

5. **Port of Morehead City, North Carolina,** is centrally located along the state's coastline. In 2024, North Carolina's Ports Authority announced a proposed project to construct the Radio Island Multi-Use Terminal to support new industries in the area, including the offshore wind industry (North Carolina State Ports Authority 2024). Radio Island is a sparsely populated island between Morehead City and Beaufort. The 5-mile radius for this port was based around Radio Island (Figure 5) to consider more direct and regular impacts on surrounding populations.
6. **Port of Wilmington, North Carolina,** is in the southern corner of the North Carolina coastline. The port is approximately 26 miles from the ocean on the Cape Fear River with a 42-foot navigation channel (North Carolina Ports n.d.).

3.2 Overarching Community Vulnerabilities and Opportunities

The communities immediately surrounding the indicative ports are expected to be the most impacted by the development of offshore wind manufacturing facilities. For an initial understanding of the vulnerabilities and opportunities in port communities, environmental and socioeconomic implications at each community were evaluated with three different community impact metrics (Table 2), intended to capture the extent to which a supply chain investment could have an additional positive or negative impact. All metrics are based on data from the first version of the Climate and Economic Justice Screening Tool (Council on Environmental Quality 2022).

Table 2. Community Impact Metric Descriptions

Community Impact Metric	Definition	Implications
Environmental vulnerability	To what extent are environmental burdens experienced by port communities?	What are the existing environmental burdens experienced, and how could supply chain investments mitigate or exacerbate existing negative impacts?
Barriers to economic mobility	To what extent are there barriers present to accessing jobs in a port community?	What are the specific educational and workforce barriers present, and how can they be anticipated or addressed?
Investment impact potential	To what extent could an investment have a positive economic impact in a port community?	How can port development address past and present gaps in a community's economic opportunities? This metric is tempered by barriers to economic mobility.

The metric results are presented in Figure 6 on a scale ranging from "higher potential negative impact" (indicating the extent of existing negative factors that could potentially be exacerbated by additional port activity), to "higher potential positive impact" (which could potentially be

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leveraged by supply chain investments to provide economic opportunities). The qualitative scale is intended to enable easy comparison across the metrics while conveying that they are aggregated and estimated impacts that may not reflect communities' lived experiences with high accuracy. Appendix B.1 provides more detail on the methodology for each metric and a breakdown of all factors.

Except for Port of Morehead City, North Carolina, all ports currently experience moderate to high levels of environmental vulnerability related to past and present port activity, primarily due to elevated adult asthma rates, exposure to wastewater discharge, and proximity to Superfund sites.[9] Additional port operations from offshore wind manufacturing may contribute to these issues but may also be mitigated with appropriate tools and engagement. Port of Morehead City exhibits low levels of environmental vulnerability, which may be due to its low surrounding population density, but environmental impacts may still be considered related to offshore wind energy port and supply chain development, such as the Final Environmental Impacts Statement signed on January 2024 (North Carolina State Ports Authority 2024).

Barriers to economic mobility present similar moderate to high potential negative impacts, primarily due to low household incomes and high poverty rates. While barriers to economic mobility generally affect smaller areas in port communities, they usually overlap with environmental vulnerabilities, contributing to compounding negative impacts for households. This suggests that community engagement may need to address various levels of negative impacts within the same port community.

Mirroring the negative metrics, the positive metric for investment impact potential is generally higher for high population density ports. Additionally, investment impact potential in each port community is more widespread than the two previous metrics, indicating the potential for extensive sharing of benefits.

[9] Superfund sites are contaminated sites with hazardous waste that has been dumped or improperly managed from manufacturing facilities, processing plants, landfills, and mining sites, managed under the EPA's Superfund program (EPA 2024).

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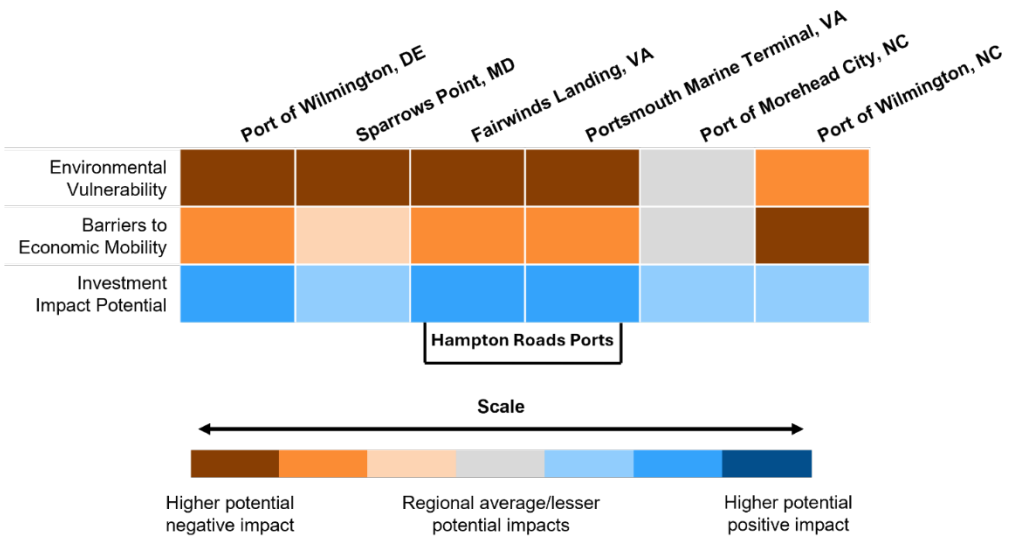

Figure 6. Community impact metric evaluation by port.

Existing vulnerabilities and barriers are highest in ports with greater positive investment impact potential, suggesting opportunities for targeted community engagement to avoid exacerbating negative impacts while distributing benefits.

3.3 Port Community Profiles

To complement the community impact metrics, various data sources were used to characterize each port community (Tables 3 to 7). All findings are data driven, using federal and state data sources, and do not impact previous metric results. A description of methodology and data sources can be found in Appendix B.2, and additional demographics and results can be found in Appendix C. While each port community has a unique history and present lived experiences, the following challenges were identified for the collective SMART-POWER port communities:

- Income and poverty: Each of the port communities had higher rates of poverty and lower median household incomes compared to their respective state averages.
- Socioeconomic factors: More densely populated port communities are more likely to have significant racial disparities, with higher percentages of people of color correlating with higher poverty rates and lower income, while higher percentages of white residents correlated with higher income and lower poverty rates.
- Health outcomes: Lower median household income and poverty rates are strongly correlated with several adverse health outcomes like adult asthma and diabetes.
- Ports identified as “high-density” are immediately surrounded by more densely populated neighborhoods and tend to experience greater community impacts, positive or negative, including Port of Wilmington, Delaware, Hampton Roads ports in Virginia, and Port of Wilmington, North Carolina. Ports labeled “low density” have a lower population density immediately around them, either because they are in less residential or urbanized areas or because they are surrounded by more water than land.

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Table 3. Community Profile for Port of Wilmington, Delaware

Category	Port Community Profile
Population Density and Distribution	• High-density port • Estimated population of 166,246
Public Health and Environmental Considerations	• Low-income areas tend to have higher levels of environmental risks, such as particulate matter (PM2.5) and hazardous waste
Socioeconomic Factors	• Consistent with the findings for the wider SMART-POWER region
Assets and Port Activity	• Could meet spatial requirements for Tier 1 components with additional development of adjacent undeveloped land • Potential for the port to engage with Tier 2 and Tier 3 component manufacturing from small and medium businesses either in the immediate surrounding communities or across the state and SMART-POWER region

Table 4. Community Profile for Sparrows Point, Maryland

Category	Port Community Profile
Population Density and Distribution	• Low-density port • Estimated population of 79,419
Public Health and Environmental Considerations	• Only indicative port with significant nearby wastewater discharge; this is caused by the Bear Creek Superfund site located adjacent to Sparrows Point • A significant contributor to the environmental vulnerability of the region is wastewater degradation
Socioeconomic Considerations	• Consistent with the findings for the wider SMART-POWER region
Assets and Port Activity	• In addition to having a lower population to impact, Sparrows Point has the benefit of being close to an active urban center and the Port of Baltimore

Given that 90% of the land acreage in the Virginia port communities is shared in the Hampton Roads region, the analysis for Fairwinds Landing and Portsmouth Marine Terminal is grouped together (Table 5). Additional research and interviews were done on Portsmouth Marine Terminal to better understand how different community stakeholder have felt about offshore wind manufacturing given its rapid development and the magnitude of its impact, presented in the "Community Insights" callout following the table.

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Table 5. Community Profile for Fairwinds Landing and Portsmouth Marine Terminal, Virginia

Category	Port Community Profile
Population Density and Distribution	• High-density ports. Of the indicative port locations, the Virginia ports have the largest populations and greatest scale of impact on neighboring communities. • The 5-mile radiuses around Fairwinds Landing and Portsmouth Marine Terminal have an estimated population of 233,468 and 245,813, respectively. • If both locations became more active manufacturing sites, there is potential for residents to face compounding impacts brought on by dual manufacturing sites in such proximity.
Public Health and Environmental Considerations	• The region has historically faced higher rates of air pollution likely in relation to nearby energy generation facilities, such as the Lambert Point coal terminal, one of the largest in the Northern Hemisphere, which exposed the local population to particulate matter by transporting coal in uncovered railcars (Cox 2020). • Air pollution challenges have contributed to higher-than-average rates of asthma for the region, with adult asthma being particularly acute among the community's Black population. Portsmouth and Norfolk residents suffer from disproportionately higher mortality and morbidity rates compared to their neighboring cities in the region (Portsmouth Health District and Virginia Department of Health 2018). • The Virginia location contains the highest proximity of Superfund sites out of all the indicative port locations.
Socioeconomic Considerations	• Of the indicative ports, the Virginia ports have the most significant difference in regional and state poverty rates (Appendix C).
Assets and Port Activity	• The proximity of the two ports makes the Hampton Roads area a very active port and maritime center with the possibility to share or complement capabilities. • The broader Port of Virginia encompassing Portsmouth Marine Terminal and other terminals is the first U.S. port to be entirely powered by 100% renewable electricity (Port of Virginia 2024).

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Community Insights: Portsmouth Marine Terminal

Refer to Appendix C.3 for more information on the qualitative research supporting the following community insights.

Since Portsmouth Marine Terminal and its port community have overlapping socioeconomic and environmental considerations, lessons learned from this region could inform the potential risks and benefits of offshore wind manufacturing, not only for the SMART-POWER region but across other American ports. Per the 2017 Portsmouth Community Health survey (Portsmouth Health District and Virginia Department of Health 2018) and additional interviews carried out by NREL with community groups, different Portsmouth residents state they would like for any new developments to take a community-centric approach. They have identified several community concerns, such as:

- High asthma rates, pollution, environmental impacts, and public health issues, including hypertension and cancer mortality
- Dominion Energy supply chain activities for the CVOW project engaging more with Portsmouth businesses
- Economic challenges that hinder economic mobility, such as housing affordability, sustainable wage jobs, energy burdens, and health disparities
- Ensuring that investments in energy and infrastructure projects provide tangible benefits to local communities, especially historically underinvested-in areas.

Engaging Port Communities in Decision-Making

Developers and community residents generally agree that developments in the port region should aim to minimize negative impacts on residents and the environment, but there are often hurdles during the process. One such hurdle is the level of community engagement during the decision-making process. Residents of port communities share that they feel frustrated with the existing meeting and engagement processes, which they think require little meaningful community input to "check a box" for developers.

There is strong evidence that the public's involvement in the decision-making process can contribute valuable local knowledge, inform policy or other solutions, and improve the perception of decision outcomes among residents (Carley and Konisky 2020). To ensure fairness in decision-making, it is critical that these processes be as receptive and welcoming to community input as possible, especially given the vulnerabilities of port communities (EPA 2020). Beyond community input, community buy-in is needed for success, according to Portsmouth resident and Director of the Center for Sustainable Communities, Garry Harris: "We really need the communities to take ownership of this … not just informing them, not just consulting them, not just telling [them] about the project, but there needs to be some ownership here."

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Addressing Disproportionate Burden

Decades' worth of accumulating negative environmental and economic impacts is another source of discontent for port communities. Portsmouth experiences high air pollution, which contributes to public health problems like high rates of asthma, hypertension, and cancer mortality (Portsmouth Health District and Virginia Department of Health 2018).

Health disparities in the region are not shared equally; Black residents experience poverty and asthma at disproportionate rates. Nationally, Black Americans have the highest mortality rates from air pollution when compared to other racial groups (Geldsetzer et al. 2024). Low-income and racial minority residents are most vulnerable to pollution impacts compounded by other social determinants of health, leading to significant disparities in health outcomes (Geldsetzer et al. 2024). Additionally, these communities have historically held less political influence and power to combat polluting industries within their communities.

Portsmouth residents are no strangers to the impact of port pollutants; even small levels of pollutants may have generational impacts on residents (Partnership for Working Families and Community Benefits Law Center 2016). Residents have worked for decades to minimize the resulting environmental disparities. While it can be important that the harms associated with port development are appropriately addressed, it may also benefit residents to be aware of how different energy technologies could benefit port communities and reduce health disparities, especially in communities located near industrial sites, like Portsmouth (Carley and Konisky 2020; Geldsetzer et al. 2024).

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Table 6. Community Profile for Port of Morehead City, North Carolina

Category	Port Community Profile
Population Density and Distribution	• Low-density port • Based on the 5-mile radius around Radio Island within the Port of Morehead City, this is the smallest population of the indicative port locations, with an estimated population of 17,383.
Public Health and Environmental Considerations	• There are very few environmental vulnerabilities for this port community. • Port of Morehead City is the only indicative port location without a Superfund site close to the port community. • Environmental vulnerabilities are spread evenly across the port community, reducing disproportionate impacts.
Socioeconomic Considerations	• Port of Morehead City is the only location that does not show strong correlations between any particular socioeconomic and environmental factors. • Supply chain investment impacts are likely to be felt evenly across socioeconomic backgrounds.
Assets and Port Activity	• This port was identified by an NC study as one of two deep-water port facilities in the state, important for offshore wind manufacturing (BVG Associates et al. 2021), along with Port of Wilmington, NC.

Table 7. Community Profile for Port of Wilmington, North Carolina

Category	Port Community Profile
Population Density and Distribution	• Port of Wilmington is one of the high-density ports of the indicative ports for the SMART-POWER region, with an estimated population of 106,279.
Public Health and Environmental Considerations	• A significant contributor to the environmental vulnerability of the region is the proximity of Superfund sites. • For the port community, lower-income residents are more likely to live in proximity to Superfund sites.
Socioeconomic Considerations	• Consistent with the findings for the wider SMART-POWER region.
Assets and Port Activity	• Identified as one of two deep-water port facilities in the state, important for offshore wind manufacturing (BVG Associates et al. 2021).

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3.4 Environmental and Public Health Considerations

Day-to-day port operations can cause environmental impacts such as air, water, and land pollution that negatively affect the health of nearby residents, although this varies by type of operation. The cumulative impact of constant exposure to pollutants can span multiple generations (EPA 2020). Due to their proximity to port activities, port communities are disproportionately burdened by pollutants from industrial manufacturing. Developers and decision makers should be aware that small environmental impacts can have greater effects in areas dealing with decades of cumulative impacts than when evaluated in isolation. It is important to work directly with impacted populations—engaging local communities in planning and decision-making through processes such as participatory planning, community advisory committees, and forums/workshops—to better understand their issues and identify feasible solutions that will provide environmental and health protections (EPA 2020).

Energy or manufacturing infrastructure developments may produce pollutants and other negative impacts such as construction noise disruptions, unpleasant smells, or increased traffic, which may be disproportionately borne by the surrounding communities (Carley and Konisky 2020; Getor et al. 2022). While these drawbacks of new energy technologies for local communities are important to those experiencing them, they should be weighed against the broader health and environmental impacts or benefits of implementing new energy technologies, especially when there is an opportunity to offset disproportionate impacts on low-income or minority communities (Carley and Konisky 2020; Qiu et al. 2022). By prioritizing local health considerations for immediately impacted communities and taking steps to offset energy burdens and negative impacts, energy innovations can not only address historic disparities but set a precedent of fair distribution of benefits for future energy initiatives.

3.5 Potential Intervention Tools

Positive community engagement can potentially result in improved community/government relations, increased community decision-making capacity, and reduced long-term negative impacts. A successful collaborative decision-making process may involve appropriate stakeholders from port communities and can be addressed with different tools, mechanisms, or best practices. This section breaks down key information about some commonly considered tools, with greatest detail provided for Community Benefit Agreements (CBAs). Additional challenges, best practices, and examples specific to offshore wind supply chain development are discussed by Shields et al. (2023). Tools can be adopted and adapted based on each location's unique set of needs and concerns (EPA 2020).

Resulting community benefits may also take many different forms. Benefits may include prioritization of contracts for small businesses, income and tax diversification, education and workforce development investments, community infrastructure investments (such as school campus investments, broadband improvements or public park investments), lower energy bills for impacted community members, or other forms of benefits (Gill et al. 2023; Shields et al. 2023).

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Community Engagement Guide

Policy Link's "Community Engagement Guide for Sustainable Communities" (https://www.policylink.org/sites/default/files/COMMUNITYENGAGEMENTGUIDE_LY_FINAL%20(1).pdf) is a guide intended to help local and regional planning organizations build new partnerships and relationships with communities to develop a shared vision. The guide includes resources on meaningful community engagement and strategies for overcoming common hurdles.

3.5.1 Community Benefit Agreements

CBAs are formal agreements between developers and local communities to ensure that new developments bring tangible benefits to communities they may impact (NREL 2023; PolicyLink n.d.) These agreements outline benefits that the developer will commit to providing, such as job creation, community infrastructure improvements, and/or environmental protections. The main purpose of a CBA is to address community concerns and mitigate the potential negative impacts of development projects by ensuring the residents share in the economic and social gains.

Wind Energy Community Benefits Database

Example CBAs, community benefit funds, donations, and other kinds of benefits from land-based and offshore wind energy initiatives in the United States from 2022 to 2024 can be found in the Wind Energy Community Benefits Database (https://windexchange.energy.gov/projects/community-benefit-agreements), a searchable database produced by NREL.

Benefits of CBAs

Effective CBAs result in measurable improvements for affected communities, particularly vulnerable residents, such as creating good jobs, affordable housing, and neighborhood services. When CBAs function effectively, impacted communities can receive tangible economic and social advantages from this transparent procedure and dependable legal framework (Partnership for Working Families and Community Benefits Law Center 2016).

- Mitigating negative impacts: CBAs can be used to mitigate potential negative impacts of nearby developments. This can include environmental safeguards, noise and pollution control, and strategies to minimize displacing residents.
- Accountability mechanisms: Community organizations can enforce the conditions of the CBA directly against the developers, which provides a degree of assurance that is often not included through typical planning procedures (PolicyLink n.d.).
- Economic benefits and local hiring: CBAs have the potential to create a large positive impact with respect to job creation and boosting the local economy. Ensuring that jobs at various skill and education levels are easily accessible is essential to developing a well-rounded local economy.

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Risks and Challenges of CBAs

CBAs can be an effective tool for granting local communities protections, yet they also have the potential to be misappropriated. Weak CBAs can allow for co-option, and in some cases, developers and elected officials have misused them to help projects get approved (Partnership for Working Families and Community Benefits Law Center 2016).

- Community representation: When the community representatives participating in CBA negotiations do not adequately represent the variety of community interests impacted by the development, it can undermine the potential positive impacts. This can happen as a result of developers (both intentionally and unintentionally) excluding groups/residents who are most vulnerable or highly critical of the development's impacts (PolicyLink n.d.).
- Reaching consensus: A CBA is not a perfect solution; it is used to mitigate—not solve for—harms caused by developers and existing community vulnerabilities. Discussions between community representatives and developers may become tense; thus, it is imperative that CBA negotiations neither overpromise nor allow feasible improvements to go excluded.
- Legal fees and enforcement: Community coalitions will often require legal representation; in the event they cannot secure free legal counsel, the community will have to pay out of pocket. Should terms of the CBA ever need to be enforced, the associated legal fees may be substantial (PolicyLink n.d.).

> **CBA Guidance**
>
> The Partnership for Working Families and Community Benefits Law Center's "Common Challenges in Negotiating Community Benefits Agreements—and How to Avoid Them" (https://citizensplanninginstitute.org/wp-content/uploads/2022/06/Effective-CBAs.pdf) offers guidelines for successful CBAs, signs of weak CBAs, case examples of detrimental and ineffective CBAs, and an analysis of the components of strong and weak CBAs.

3.5.2 Impact Assessments

Impact assessment tools evaluate the potential social and environmental impacts of projects or policies, guiding decision-making processes to ensure informed, robust outcomes. These tools consider various factors such as environmental, social, economic, and health impacts (EPA 2020). A range of assessment tools are available, each designed to focus on specific aspects of community and environmental well-being.

Benefits of Impact Assessments

- Informed decision-making: Tools like Environmental Impact Assessments and Health Impact Assessments help identify potential risks and benefits before projects are initiated (EPA 2020).

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- Risk mitigation: Human Health Risk Assessments can help predict and mitigate potential health hazards posed by pollutants and protect local public health.

Risks and Challenges of Impact Assessments

- Community engagement challenges: While tools like Social Impact Assessments promote community involvement, engaging stakeholders authentically can be challenging and may lead to conflicts if not handled properly.

3.5.3 Qualified Opportunity Zones

Qualified Opportunity Zones (QOZs) were established under the 2017 Tax Cuts and Jobs Act with the goal of promoting economic development and creating jobs in impoverished neighborhoods. Eligible taxpayers may contribute to a Qualified Opportunity Fund, which must invest 90% of its assets in QOZ property, with capital gain taxes postponed for reinvested investments, and all capital gains exempted for 10-year retention (Department of Housing and Urban Development n.d.[b]). All six port locations in this assessment have a QOZ within their 5-mile radius (Department of Housing and Urban Development n.d.[c]).

Benefits of QOZs

- Economic growth in impoverished areas: QOZs aim to stimulate investment and job creation in economically distressed neighborhoods, driving local development and revitalization by attracting investments.

Risks and Challenges of QOZs

- Potential for gentrification: Without adequate planning, QOZ investments could lead to rising property values and rents, potentially displacing low-income residents.

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4 Community Capacities

To support the build-out of a domestic supply chain for offshore wind energy, a well-trained and readily available workforce will likely be necessary for Tier 1 facility investments as well as for engaging Tier 2 and Tier 3 businesses. Both aspects are evaluated in the following subsections at the state level and for in-state and regional commuting zones.

While the SMART-POWER region presents numerous workforce and business strengths for the offshore wind industry, supporting a skilled workforce and engaged business network will likely require additional resources from states and other stakeholders. Two crosscutting needs underlie the workforce and business engagement assessments:

1. **Improving regional connectivity may depend on information sharing and collaboration** between potential workers or businesses and any supporting programs locally or regionally to ensure more individuals and communities can tap into the potential opportunities presented by the supply chain, which they may otherwise be unaware of.
2. **Reaching historically underinvested-in populations may be possible with targeted efforts** to increase workforce readiness and business engagement, both in and near port communities. Such populations may include low-income households or racial minorities as identified in Section 3, as well as women- or veteran-owned small businesses. Thoughtful, strategic outreach and support programs may be able to tap into the potential presented by such groups while ensuring benefits and opportunities are distributed in the region.

An in-depth workforce readiness evaluation, expanding on Section 4.1, is available in the companion Workforce report (Pons et al. 2025).

4.1 Workforce Readiness

The relevant workforce for Tier 1 manufacturing in the SMART-POWER region is assessed herein with a workforce readiness metric, which evaluates economic and training indicators specific to the SMART-POWER states on an occupational and geographical scale. The metric was built to compare specific ports in the SMART-POWER states based on the selected Tier 1 components of the assessment; for this reason, the metric is not applicable for comparison across the United States. The framework of the metric, shown in Figure 7, is made up of three parts: the in-state commuting score, the regional score, and the state score.

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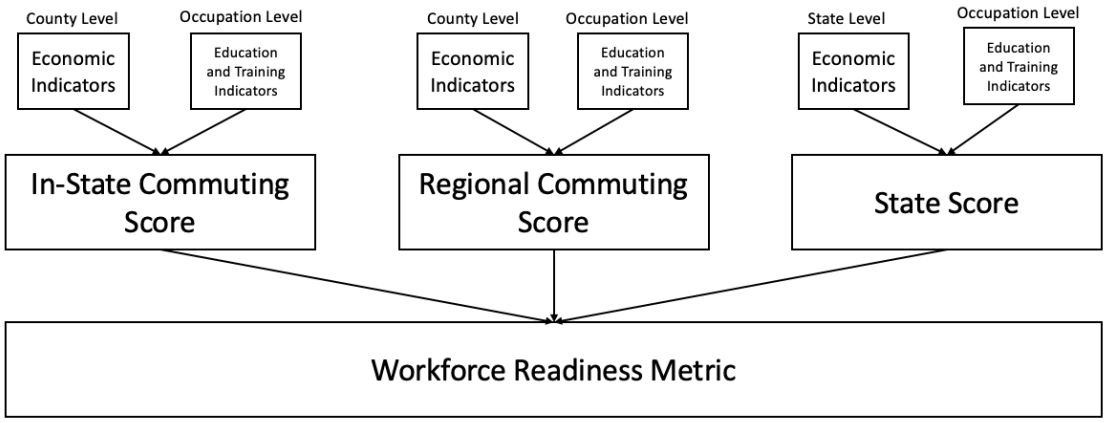

Figure 7. Workforce readiness metric framework

While the state score is based on state-level data, the in-state commute and regional score are calculated with county-level data. The in-state commute score pulls from the counties where workers commute to the county of the relevant port from within the state, whereas the regional score draws from the out-of-state counties that were identified to commute to the same port (filtered to only include commuting counties within the SMART-POWER states). More information on the multiple indicators included in each score and how the final metric is calculated can be found in Appendix B.3.

The workforce readiness results for each port in this assessment, shown in Figure 8, provide a snapshot of an area's relative ability to support the workforce needs for a blade, tower, or monopile facility at the time of this publication. As such, the metric represents current workforce development and is not meant to provide foresight into the future workforce development ability of an area. Due to their proximity, Fairwinds Landing and Portsmouth Marine Terminal in the Hampton Roads area were evaluated together and have the same metric results.

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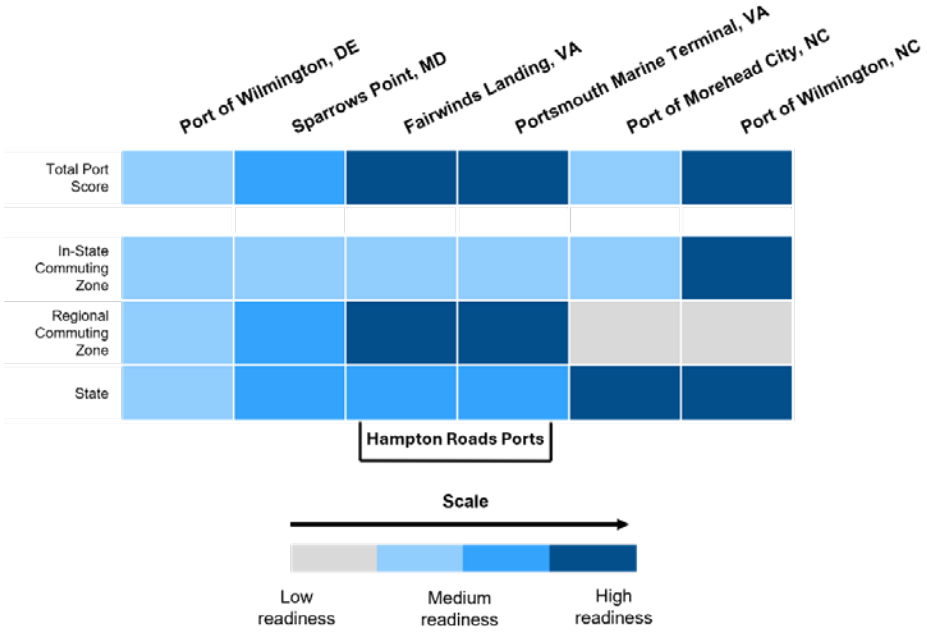

Figure 8. Workforce readiness metric evaluation by port, aggregated for all three focus areas (blade, tower, and monopile facilities), and their respective in-state commute, regional, and state scores.

While the metric was evaluated for each focus area separately (workforce readiness for blades, towers, and monopiles), the results did not have significant differences between each of the components. Tasks and experience for certain manufacturing processes vary by Tier 1 component, but most occupations included in the metric calculation contain broader skill sets and do not capture these skill nuances between components. Additionally, the occupations with distinct job titles and roles are a minority out of all the occupations and other indicators captured by the metric, resulting in a minimal impact on the results.

The workforce readiness metric is not intended to be used as a singular indicator for informing decisions on where to place a manufacturing facility; it is one of many metrics that could be leveraged to evaluate potential supply chain decisions and analyze the existing workforce. While the rest of this subsection provides workforce readiness descriptions by state and port, the following key takeaways summarize regional trends:

- The results of the assessment of workforce readiness generally indicate strengths across the SMART-POWER region due to historic and current expertise in manufacturing (particularly in the steel industry), existing education and training programs for relevant occupations, and worker availability near most evaluated ports.
- The gaps in workforce readiness vary by port but could likely be reduced with increased regional connectivity and strategic investment in additional workforce programs. There is a lack of offshore-wind-specific programs at the state level (except within Maryland) that address workforce gaps.
- Ports more central in the region (i.e., Virginia and Maryland) have a greater opportunity to leverage regional connectivity with other SMART-POWER states, yet transportation

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barriers are important to understand and address, as they may limit commuting and connectivity to and from port locations.

- Of the evaluated ports in the region, four have a relatively high workforce readiness (the two Hampton Roads ports (Virginia), Port of Wilmington (North Carolina), and Sparrows Point (Maryland)). They all have varying contributions of workforce availability, existing skill sets, and training and educational programs across the in-state commute, regional, and state levels, indicating there are numerous avenues to increase workforce readiness.
- Though North Carolina has a relatively higher workforce readiness at the state level, primarily due to a significant past and present manufacturing industry, Maryland, Delaware, and Virginia demonstrate strong workforce readiness across most of their ports at the in-state commute and regional levels.

4.1.1 Delaware

While Delaware is not known for having a large industrial presence—it has one of the lowest levels of manufacturing employment in the United States (U.S. Bureau of Labor Statistics 2024)—its manufacturing sector is growing, representing a workforce growth opportunity. Because of its current low level of manufacturing employment and its limited capacity in manufacturing-related training programs, Delaware ranked relatively low overall in workforce readiness to produce blades, towers, or monopiles compared to other SMART-POWER states.

However, Delaware has a higher unemployment rate that points to an available workforce to recruit, train, and hire for production facilities, as well as an increase in manufacturing employment (based on a 1-year percentage change), representing a growing state manufacturing industry. These factors indicate that Delaware has a growing manufacturing sector with a population that could enter training programs to learn skills for manufacturing-related jobs, but the state would need to expand or develop programs to train the necessary skills or leverage regional training opportunities. In addition to the state-level assessment, in-state and regional commuting zones were evaluated for Port of Wilmington on the Delaware River to understand the workforce readiness for nearby communities to support blade, tower, or monopile manufacturing.

Port of Wilmington, Delaware

Much of the port workforce comes from local labor unions such as the International Longshoremen's Union Local 1694, which supplies around 400–500 workers to unload ships or upward of 1,000 workers during busy periods. Additional workers from other labor unions work in warehouse storage (Barrish 2024). While the state of Delaware currently has a lower readiness level for meeting the workforce demands required by a blade, tower, or monopile manufacturing facility, the in-state and regional commuting zones surrounding Port of Wilmington offer available workers and existing education and training programs.

Local workforce readiness for this port is driven by a higher number of available workers for new manufacturing roles, as demonstrated by a higher unemployment rate and the number of related industry closures. With respect to training, the local area has an average number of existing registered apprenticeship programs (RAPs) to train the types of occupations needed, compared to other SMART-POWER ports, but a lower capacity of relevant two-year and four-year degree programs. For such occupations, the broader regional area (defined as out-of-state

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counties within commuting distance) has a higher number of programs compared to other ports but a lower readiness for RAPs. The regional area includes Maryland, which has a higher number of university programs to recruit engineering and management roles.

Workforce readiness for Port of Wilmington is also higher because of programmatic support at the in-state commute and regional levels. The local workforce development boards for Delaware counties near Port of Wilmington all have either a manufacturing or offshore wind development program. The Delaware Pathways Program, which gives high school students specialized instruction and career pathways to in-demand jobs, is an example of this type of local program support. The Delaware Pathways Program includes a manufacturing career cluster that has a partnership with Delaware Technical Community College for careers in manufacturing engineering technology, manufacturing logistics, manufacturing production, and industrial maintenance (Delaware Pathways 2024). Due to the relatively lower existing manufacturing employment in the in-state and regional commuting zones, programs like this are critical to ensure people who are looking for work in Delaware can participate in offshore wind manufacturing.

Wilmington overall has a relatively average workforce readiness. Port of Wilmington's regional commuting zone opens access to out-of-state training program opportunities for people in the nearby port communities who are seeking employment. There is potential for Port of Wilmington to focus on using existing local programs to expand and develop RAPs and support factory-level workers for Tier 1 manufacturing.

4.1.2 Maryland

Through workforce investments and partnerships, Maryland is a rising leader in offshore wind workforce development, providing residents access to training and employment opportunities. Maryland ranks third out of the four SMART-POWER states in workforce readiness to support occupations for the production of blades, towers, and monopiles, based on a snapshot of state economic and workforce data. Compared to the other SMART-POWER states, Maryland has a lower unemployment rate and lower manufacturing specialty, which decreases the state's workforce readiness because it could be more challenging to recruit workers with related skills into manufacturing careers. However, Maryland Works for Wind—a regional consortium managing a $23 million investment—factors strongly in the state's potential to support offshore wind manufacturing because of its potential to increase the workforce readiness for the state through program support. Maryland Works for Wind provides grants across the state to develop occupational training, fund supportive services to increase access for job training, and facilitates job placement into sectors such as offshore wind fabrication (Maryland Department of Labor n.d.). This program's support supplements a state training landscape that has a high number of two-year and four-year degree programs that are typically used to train management and engineering roles. To better support component manufacturing, Maryland may consider continuing to develop the skilled trades through investments in RAPs and two-year degree programs.

In addition to a state-level assessment, communities near Sparrows Point in Maryland were evaluated to understand how in-state and regional commuting zones affect the workforce readiness at a community level near a potential manufacturing facility.

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Sparrows Point, Maryland

Sparrows Point, Maryland, is a potential hub for Tier 1 component manufacturing with the announced US Wind and Haizea tower and monopile facility (Buljan 2023; McCoy et al. 2024). Additionally, it is connected to Baltimore to the northwest by Highway 695 and to communities in Anne Arundel and Howard counties to the west on Highway 695. The economic factors across these counties and the nearby training programs factor into the workforce evaluation because many workers can easily commute to Sparrows Point from surrounding areas like Washington, D.C., Baltimore, and Delaware.

Sparrows Point has a relatively average workforce readiness level. Across the in-state and regional commuting zones, a low unemployment rate could cause a strain on filling job openings, indicating a lower workforce availability compared to other port locations in the SMART-POWER region. Within the in-state commuting zone, there is a lack of existing workers with the skills needed for offshore wind component manufacturing based on its relatively lower manufacturing employment specialty. However, the regional level has a higher available workforce and access to training programs, so prioritizing regional connection could lead to an increased workforce readiness level.

Additionally, closures of facilities in related industries—like the 2012 closure of one of the largest iron and steel making facilities, Bethlehem Steel at Sparrows Point (US Wind 2023)—are a relative strength in the in-state commuting zone for the Sparrows Point workforce readiness level. Displaced workers from related industry closures may have transferable skills to support offshore wind component manufacturing facilities. Furthermore, due to the area's historical manufacturing involvement, nearby training programs may be able to train new workers or upskill a transitioning workforce for the offshore wind industry. US Wind has stated its commitment to partnering with United Steelworkers and other major regional labor organizations (US Wind 2023).

Using regional training programs in Delaware and Virginia is a key factor in higher workforce readiness for Sparrows Point. There are more two-year and four-year degree programs in communities near Sparrows Point than in other SMART-POWER port locations at both the in-state commute and regional levels for the occupational needs for offshore wind component manufacturing. There is potential for manufacturers to leverage these programs and the high number of RAPs across the region to increase workforce readiness.

With facility investments in Sparrows Point, the port can supply workforce needs for Tier 1 manufacturing, especially for monopile and tower production. The key to increasing workforce readiness will likely be engaging with workers and RAPs in the regional communing zone around Sparrows Point. Workforce readiness could potentially also increase if more workers from nearby communities become available. Focusing awareness strategies on historically underinvested-in populations and communities, which represent most census tracts surrounding the city of Baltimore, could provide an opportunity to recruit additional workers.

4.1.3 Virginia

Virginia offers a strong foundation for offshore wind blade, tower, and monopile manufacturing from a workforce perspective, because of the state's historic involvement in manufacturing and

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the robust education and training system. When compared to the other SMART-POWER states, Virginia ranked second for workforce readiness for blade, tower, or monopile manufacturing. The state has two-year and four-year programs as well as RAPs and an available workforce with transferable skills.

While having a strong foundation at the state level is important, many of the workforce development activities happen within communities. The Hampton Roads area in the southeast part of the state was evaluated based on in-state commute and regional workforce readiness levels to support a blade, tower, or monopile manufacturing facility.

Hampton Roads, Virginia

The ports in the Hampton Roads area— Portsmouth Marine Terminal and Fairwinds Landing— were found to have a relatively high workforce readiness because of the available workforce with the skill sets required to support a blade, tower, or monopile manufacturing facility at the in-state and regional commuting zones.

The area has current and historic involvement in manufacturing and a relatively high unemployment rate compared to other assessed port locations. The high number of applicable two-year and four-year degree programs and RAPs have the potential to be leveraged with minimal modifications to train an offshore wind manufacturing workforce in the area. The in-state commute level has more applicable RAPs, and the regional level has more two-year and four-year degree programs in addition to more policy and training support; therefore, regional connectivity could unlock complementary training expertise to ensure that a facility's occupational needs are met.

Although workforce readiness for the Hampton Roads area is higher than for the other ports, there are additional opportunities to strengthen its readiness. Recruiting unemployed workers (especially those in historically underinvested-in communities) and leveraging existing training programs has the potential to support a facility in Hampton Roads and bring economic and workforce development to numerous areas.

The Portsmouth@Work program is a notable policy initiative that offers accessible training pathways for Hampton Roads residents near Portsmouth. This program offers job readiness resources, skill building, and college or vocational certification for Portsmouth residents. Courses applicable to offshore wind energy include marine coating, pipefitting, welding, global wind certification, and a maritime institute bootcamp.

4.1.4 North Carolina

The past and present manufacturing industry in North Carolina is advantageous for workforce development for offshore wind manufacturing. In comparison to the other SMART-POWER states, North Carolina ranked relatively high for workforce readiness for a manufacturing facility.

The state's higher average population percentage working in manufacturing, workforce specialization in the manufacturing industry, two-year and four-year education and training programs, and RAPs all support North Carolina's readiness. At the state level, a relative

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weakness for North Carolina was workforce availability. The workforce was deemed less available compared to the other states due to a low unemployment rate; however, a relative strength is the greater number of transferable skills among workers and workforce development programs than other SMART-POWER states. This indicates that the existing workforce may require limited additional training or can attend training programs in the state related to occupations in the offshore wind manufacturing industry. The Port of Morehead City and the Port of Wilmington were evaluated based on their in-state commute and regional workforce readiness levels to support a blade, tower, or monopile manufacturing facility.

Port of Morehead City, North Carolina

At the in-state commuting level, the Port of Morehead City has a relatively lower level of workforce availability when compared to the other evaluated ports. However, because of the presence of other manufacturing in the in-state commuting zone, much of the workforce may already have skill sets that are transferable to offshore wind Tier 1 manufacturing with limited on-the-job training or upskilling. At the regional level, while the workforce was determined to have transferable skills to the offshore wind industry, there is a less available workforce due to a relatively lower unemployment rate compared to the other port locations in the SMART-POWER region. Based on the location of Port of Morehead City within the SMART-POWER states, a potential manufacturing facility would rely on the in-state commuting area for its workforce.

There is a lower number of RAPs and a relatively average number of two-year and four-year programs in the in-state commuting zone compared to the other SMART-POWER port locations. In the regional area, there is a lower number of RAPs and two-year and four-year programs. If a facility were located at the Port of Morehead City, specialized training programs for offshore wind manufacturing could be developed in the area. Nonetheless, there is a relatively greater transferability of skills from related industries to offshore wind manufacturing at the in-state commute and regional levels, indicating there may be limited need for additional training for manufacturing occupations.

Considering these factors, Port of Morehead City was determined to have a relatively lower workforce readiness as compared to other ports. Nonetheless, the Port of Morehead City has other advantages such as wider state support and state specialization in manufacturing, as well as available space and resources at the port.

Port of Wilmington, North Carolina

The Port of Wilmington has relatively higher in-state commuting and regional workforce readiness levels, indicating a significant potential for the area's workforce to support a Tier 1 manufacturing facility. The high workforce readiness levels are a result of average workforce availability combined with high specialization in manufacturing, indicating that there is potential to recruit jobseekers with an already transferable skill set into a Tier 1 manufacturing facility.

Locally and regionally, there is low to average workforce development program support around Port of Wilmington, but a higher number of two-year and four-year educational programs as well as RAPs relevant for offshore wind manufacturing.

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Through state support, greater specialization in manufacturing, and a moderate level of available workforce, Port of Wilmington was identified to have a relatively higher workforce readiness level at the in-state commuting and regional levels compared to other SMART-POWER ports. If a facility were to be placed at the Port of Wilmington, there is potential for the current workforce to be able to support Tier 1 manufacturing, although continued support for education and training is likely necessary to maintain or further improve workforce readiness.

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4.2 Allied Tier 2 and Tier 3 Businesses

In addition to workforce readiness, engagement of Tier 2 and Tier 3 businesses, referred to here as "allied businesses," in the supply chain allows for small and medium businesses in the region to benefit from the growing offshore wind industry while reducing costs and uncertainty for Tier 1 manufacturers. In alignment with common terminology, we define the four different tiers in the offshore wind supply chain:

1. **Tier 1: Finished components.** Finished components are the large components typically staged at a fabrication port adjacent to the manufacturing or fabrication plant, or a project's marshaling port, ready to be transported and installed offshore. The supply of Tier 1 components is typically divided into major work packages contracted directly between the project developer and the Tier 1 supplier. These include the wind turbine kits (individual rotor blades, nacelle with rotor-hub, and tower), the foundation elements (typically a monopile and transition piece), and grid interconnection components (subsea array cables, offshore substation, and subsea export cable). Grid interconnection facilities onshore include directionally drilled shore-crossings, underground cable vault, onshore substation, and underground or overhead power lines.
2. **Tier 2: Subassemblies.** Subassemblies are systems of integrated subcomponents that have a specific function for a Tier 1 component, such as a pitch system for blades, a service lift for towers, or interior deck and ladder assemblies for transition pieces. Tier 1 manufacturers may have multiple Tier 2 suppliers who are prequalified to produce a specific subassembly and typically enter long-lead contracts to purchase these for a manufacturing run.
3. **Tier 3: Subcomponents.** Subcomponents are commonly available items that are integrated into Tier 2 subassemblies, such as motors, gears, casings or housings, switch plates, and fasteners. Tier 3 suppliers are typically vendors who routinely stock these items, offering them for sale on the open market rather than entering one-on-one contracts.
4. **Tier 4: Raw materials.** Raw materials, such as steel, copper, rare earth metals, glass fiber, carbon fiber, resins, adhesives, or concrete, are directly processed into Tier 3 subcomponents or Tier 2 subassemblies.

The availability of allied businesses within the SMART-POWER region was evaluated for four Tier 1 components: blades, towers, monopiles, and transition pieces. Appendix D contains supply chain hierarchy maps for each component that outline subassemblies and subcomponents. Although NREL did not undertake a detailed assessment of transition piece manufacturing, transition pieces are included in this section because they illustrate how they are different from monopiles with respect to their required number and diversity of Tier 2 and Tier 3 suppliers. Since transition pieces and monopiles are generally coupled foundation components, this affects the number of allied businesses in a state or region that can potentially support their fabrication.

Additionally, allied business availability for the SMART-POWER region was compared with the overall allied business availability of the East Coast (geographically from Maine to North Carolina) to understand relative strengths and gaps.

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Allied business availability is measured with data obtained from the Oceantic Network's Supply Chain Connect (SCC) database, resulting in an aggregate score called Supply Chain Connect score (S_{SCC}).[10] Details on the methodology can be found in Appendix B.4. These data were current as of year-end 2022; therefore, they may not reflect more recent supply chain developments.

The S_{SCC} weights the capabilities of individual businesses in a state with the ability to manufacture a subassembly or subcomponent for a given Tier 1 component (Figure 9) for East Coast states from Maine to North Carolina. The state scores were then summed for the SMART-POWER region and for the East Coast as a whole (Figure 10). Scores have not been weighted by state or regional population; therefore, larger states tend to have higher allied business availability and higher corresponding S_{SCC}.

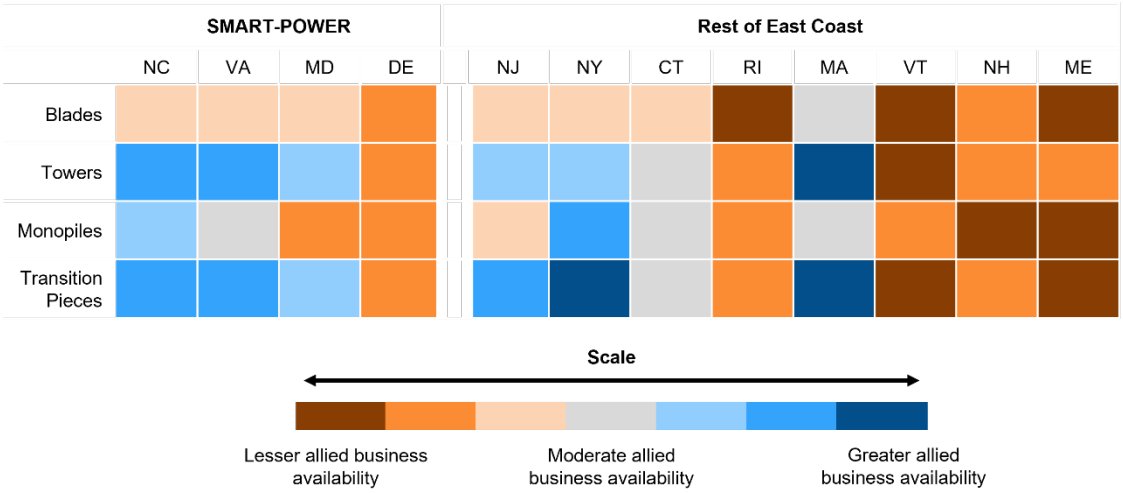

Figure 9. East Coast state Supply Chain Connect scores.

State scores are presented left to right in alignment with their geographic position from southwest to northeast.

[10] The Oceantic Network (previously known as the Business Network for Offshore Wind) prepared the score from its Supply Chain Connect database in support of the NREL offshore wind supply chain roadmap (Shields et al. 2023).

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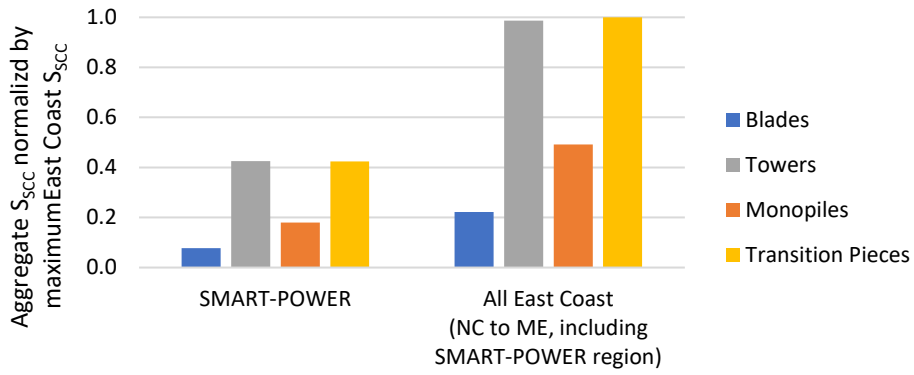

Figure 10. East Coast regional Supply Chain Connect scores

There are four key takeaways from the state and regional assessment:

1. **Towers and transition pieces:** The SMART-POWER region likely has significant allied business availability for towers and transition pieces, accounting in our results for more than 40% of the total East Coast availability. This includes supply for tower subcomponents and subassemblies related to personnel access and equipment, such as doors, work platforms, ladders, and other secondary steel components for towers. The case is similar for transition pieces because of a comparable supply chain hierarchy.
2. **Monopiles:** While overall monopile allied business availability is lower across the East Coast than for towers and transition pieces, potential allied business availability in the SMART-POWER region represents 36% of the total. However, fewer and less component-diverse allied businesses are needed for monopile fabrication than for towers or transition pieces (as can be seen by comparing the supply chain hierarchy maps in Appendix D). Therefore, there are inherently fewer allied businesses self-reporting their capabilities to support a monopile facility than to support fabrication of towers or transition pieces.
3. **Blades:** Potential allied business support for blade fabrication is quite low compared to the other Tier 1 components along the East Coast, with approximately one allied business reported for every five tower or transition piece businesses. Additionally, the SMART-POWER allied business availability is 16% of total East Coast availability. Considering the maritime expertise and number of inland waterways in the SMART-POWER region, there may be an opportunity to engage fiberglass boat builders in the offshore wind supply chain if their capabilities are transferable to blade subcomponent and material supply.
4. **Regional collaboration:** No one state has seemingly sufficient allied business support for all major components to be manufactured, yet the strengths of individual states can likely be leveraged in combination and with coordination to meet Tier 1, 2, and 3 supply needs.

The SCC data used for the S_{SCC} entails each participating business self-reporting information in multiple categories. It is possible that other existing allied businesses are not currently captured in the results but may already be engaged or could engage in the future. Additionally, self-reported product categories may be incomplete or misinterpreted by participating businesses.

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As such, we present the S_{SCC} as a snapshot of potential business availability but identify opportunities for more state and industry engagement with Tier 2 and Tier 3 businesses, as well as transparency by Tier 1 manufacturers in reporting their engaged suppliers.

Numerous small businesses may also have little understanding or information on the offshore wind industry, including how to participate and how broader risks (like project pipeline or facility investment uncertainty) may impact them. Visibility into these risks and proactive risk mitigation can potentially be supported by the states and industry.

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5 Individual Facility Evaluation

As illustrated in our baseline, low, and high deployment scenarios (Section 2.3), offshore wind deployment on the East Coast between 2024 and 2040 may vary significantly depending on different macroeconomic and industry factors. Across any scenario, our results show that investment in individual Tier 1 facilities is likely necessary to support the growing demand for components amidst constrained global supply chains. At the same time, facilities' success will depend on securing sufficient up-front funding and component orders year after year.

Based on announced and existing facilities, we model the opportunity for new facilities in the SMART-POWER region for blades, towers, and monopiles. The following subsections describe the modeled supply and demand for blades, towers, and monopiles on the East Coast, including these new facilities, as well as the potential supply chain opportunities and challenges for investing in each facility type.

5.1 Domestic Tier 1 Component Supply and Demand

New blade, tower, and monopile facility competitiveness is influenced by existing domestic facilities. Critically, no full blade manufacturing or blade finishing facilities are currently announced in the United States—despite blades being a significantly constrained component in the global supply chain—after the cancellation of the Siemens Gamesa finishing facility in Virginia and the presumed cancellation of the General Electric/LM Wind Power facility in New York (McCoy et al. 2024).

By the assessment's data cutoff of **November 30, 2024**, four manufacturing facilities (within the three focus areas of blades, towers, and monopiles) had been announced on the East Coast:

- **Monopile** facility by EEW in Paulsboro, New Jersey—the only tower or monopile facility that has begun production
- **Monopile and tower** facility by US Wind and Haizea in Sparrows Point, Maryland
- **Tower** facility by Marmen Welcon in Albany, New York[11]
- **Tower** facility by US Forged Rings at an undisclosed location on the East Coast.

More information on data sources and facility assumptions can be found in Appendix B.5.

In addition to existing facilities, we have modeled East Coast supply and demand (Figure 11) with new illustrative Tier 1 manufacturing facilities that could be constructed in the SMART-POWER region. For blades, we model a full manufacturing facility as opposed to a blade finishing facility. Component supply and demand is assumed to happen 2 years before a project's COD and does not consider projects or component supply outside of the East Coast. We assume one additional facility of each component type is constructed in the baseline and low deployment scenarios, and two additional facilities to meet elevated demand in the high deployment scenario

[11] While we include the previously proposed Marmen Welcon tower facility in our analysis, the Port of Albany is no longer pursuing this development as of early 2025. Beacon Island in the Port of Albany is considering investments for other maritime industries, although it is still permitted for manufacturing and staging for offshore wind (Ferris 2025; Rulison 2025).

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(see Appendix B.5 for a comparison of supply and demand before and after adding new facilities).

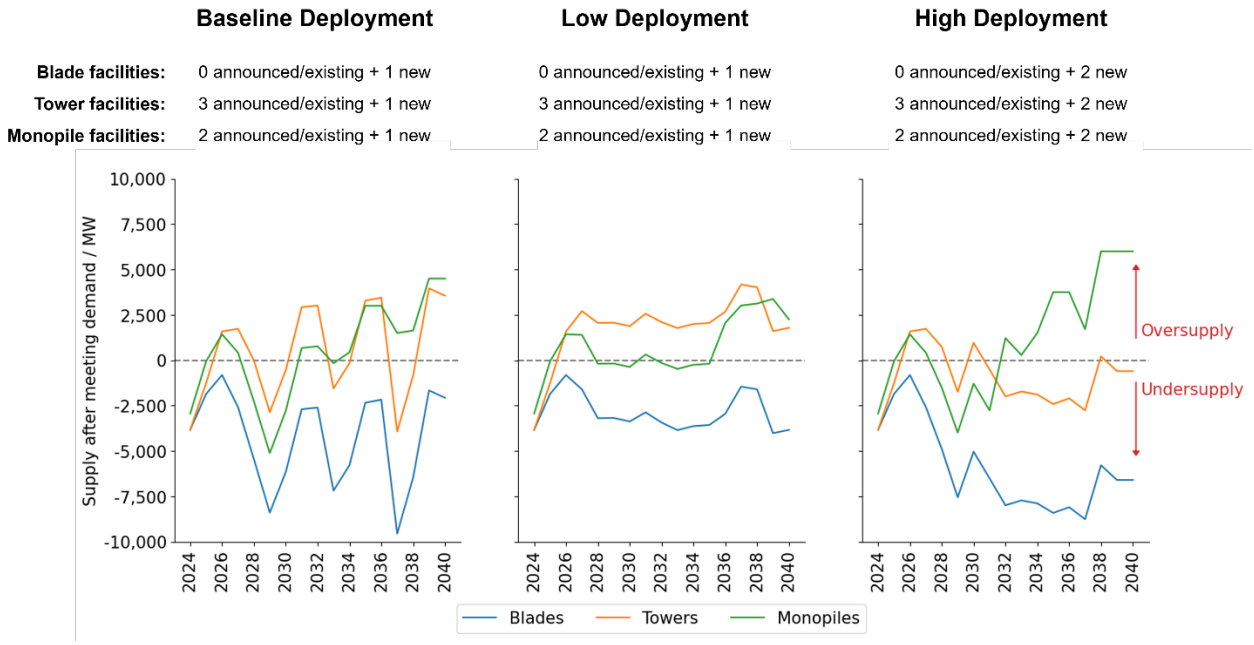

Figure 11. Remaining supply after meeting demand (shown here in megawatts) of Tier 1 components on the East Coast, with new, illustrative facilities in the SMART-POWER region.

New facilities in the baseline and high deployment scenarios begin operations in 2028, whereas new facilities in the low deployment scenario begin operations in 2031 due to assumed delays or challenges in opening new facilities. Zero megawatts of supply after meeting demand suggests perfect domestic market equilibrium.

Each scenario displays a combination of potential oversupply and undersupply risks, influenced by project deployment and facility additions. While the modeled supply and demand should not be interpreted as accurate market projections, we find that the erratic boom/bust pattern of project development in the baseline deployment scenario may cause uncertainty for manufacturers and project developers in the form of cycles of sharp oversupply and undersupply.

Nonetheless, each component may face different challenges. Blades are likely to be consistently undersupplied across scenarios and thus may represent the largest supply chain bottleneck for project development. The addition of one or two blade manufacturing facilities may alleviate but not entirely correct undersupply in any scenario.

Conversely, tower supply and demand are more balanced across scenarios, but there is a likely risk of either undersupply or oversupply depending on the level of deployment. The potential benefit and market opportunity of additional tower facilities is highly dependent on future deployment levels. Similarly, monopile supply and demand will likely be generally balanced up until the mid-2030s, but then there may be a greater risk of oversupply for manufacturers due to the expectation of more projects installing floating foundations and fewer monopiles. The addition of new monopile facilities may correct undersupply up to the mid-2030s and thereafter likely exacerbates oversupply in all scenarios.

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5.2 Supply Chain Build-Out Opportunities and Challenges

Based on the modeled component supply and demand, we identified several opportunities and challenges for new Tier 1 manufacturing facilities in the SMART-POWER region. Taking a comparative approach, each Tier 1 component was evaluated across the three deployment scenarios (baseline, low, and high) by the three metrics described in Table 8. The metrics communicate the barriers or advantages for various stakeholders in pursuing a particular component facility investment and how they may vary with different deployment levels.

Section 5.2 presents the three metric results for general supply chain build-out opportunities and challenges, based on the three deployment scenarios and industry conditions as of **November 30, 2024**. To reflect additional perspectives and potential industry impacts, we also present three different sensitivity analyses: reduced facility availability in light of potential delays or cancellations for announced facilities (Section 5.3), regional collaboration among states for facilities and projects exclusively in SMART-POWER states (Section 5.4), and additional opportunities and challenges if facilities do not receive additional government funding support such as the advanced manufacturing production tax credit (AMPTC; Section 5.5).

Table 8. Supply Chain Metric Descriptions

Supply Chain Metric	Stakeholder Most Impacted	Implications
Business case	Manufacturers	Are **manufacturers** likely to find this investment an attractive opportunity, influenced by the domestic demand and tax credits they can capture?[12]
Missed opportunity	State leadership and agencies	How might the business case decrease from losing a "first-mover advantage" if **states** do not encourage and secure investments early?
Adequate U.S. supply	Developers	Are **developers** able to meet their component needs with domestic supply or will they need to source them from the global market, potentially facing supply chain bottlenecks?

Each metric is summarized in Figure 12 on a scale ranging from *greater potential barriers* to *greater potential advantages*. We selected a qualitative scale for ease of interpretation and to convey that these are potential impacts rather than accurate projections. Appendix B.5 details the methodology behind each metric and a breakdown of the factors that influence each result. Across all components and scenarios, we found three overarching patterns:

[12] Our main results and regional analyses in Sections 5.2 through 5.4 assume that new manufacturing facilities would be able to claim the AMPTC as outlined in the 2022 Inflation Reduction Act. The *Reduced Government Funding Support* sensitivity analysis in Section 5.5 assumes no AMPTC for any new facility. With the passing of the One Big Beautiful Bill Act on July 4, 2025, which modifies AMPTC guidance for wind turbine components sold after 2027, we expect the business case for new facilities to be less favorable and more aligned with this sensitivity analysis.

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1. **Deployment consistency may reduce risk for developers and manufacturers:** The erratic boom/bust pattern in the baseline scenario results in cycles of oversupply and undersupply, as described in Section 5.1, that may negatively impact a facility's overall business case. However, blades are currently so undersupplied that a new facility would be minimally impacted by this erratic deployment pattern.
2. **Global bottlenecks line up with peak domestic deployment:** The first bottleneck in global supply across all components is expected to take place in 2025–2026 (Global Wind Energy Council 2023; Wood Mackenzie 2023), and last at least through 2030; therefore, developers with earlier supply contracts may experience an advantage in a crunched global supply chain.
3. **Funding support or incentives could potentially improve a facility's business case:** Our results indicate that facilities that receive incentives, such as the AMPTC, may see an improvement in their business case, particularly for tower and monopile facilities when they experience lower orders.

Figure 12. Supply chain metric evaluation by Tier 1 component

In line with previous observations on component supply and demand, each component faces unique opportunities and challenges:

Blades: Without other announced domestic facilities, blades are likely to be the most undersupplied component. With the expected global bottlenecks, there is likely substantial blade demand (and lacking supply) to justify at least two facilities across all deployment pipeline scenarios, but there still will likely be severe blade shortages/bottlenecks for developers, even in the low deployment scenario. Unlike most other Tier 1 components, the blades market faces the additional challenge of being fragmented by original equipment manufacturer, since blade molds represent important intellectual property for each produced blade length. Investments in new molds often represent some of the highest costs for blade manufacturing facilities as well, particularly when serving a market with a range of blade lengths.

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Towers: These are the Tier 1 components with most announced supply; therefore, a new facility in a low deployment scenario will likely face significant competition and may have a low business case. Higher deployment may be more conducive of a positive business case for one additional facility (baseline deployment scenario) or two facilities (high deployment scenario). New tower facilities are also at risk of experiencing a significant missed opportunity if another tower facility is built elsewhere and may experience competition for contracts during low demand periods in an erratic scenario.

Monopiles: While there is currently less competition for monopiles than towers, monopile facilities have a lower business case across scenarios because more alternative and floating foundation projects are expected to be installed in the early 2030s (BOEM 2024a; McCoy et al. 2024). However, the majority of fixed-bottom projects on the East Coast are expected to install monopiles (McCoy et al. 2024), so developers may still face some shortages in the late 2020s and early 2030s. However, there is a higher risk of oversupply for manufacturers, potentially discouraging new investments. Strategies encouraging manufacturing and installation of alternative foundations may be one pathway to mitigate this risk.

5.3 Reduced Facility Availability

Considering the challenges with inflation, rising costs, permitting, and uncertain market signals that announced Tier 1 facilities have faced, it is possible that existing announcements are considerably delayed or withdrawn, as in the case of the SGRE blades finishing facility that was announced and later canceled at Portsmouth Marine Terminal. We present an alternative market scenario in which not all of the announced monopile or tower facilities are actually built. While the EEW monopile facility has been constructed and was previously in production, we do not make a distinction from the announced US Wind monopile facility in the subsequent analysis considering potential pauses or challenges with additional manufacturing. The market scenario for blades remains the same as presented above, as there are already no announced blade facilities on the East Coast.

Shown in Figure 13, we include one announced tower facility out of the previous three, assuming two announcements do not come online, and delay expected operational dates for this facility by 2 years to 2028. We also include one of the two announced monopile facilities, considering either challenges in continuing production at the constructed EEW facility or the US Wind announcement not coming online; this announced facility is modeled with an expected operational date of 2025. We include potential additional facilities with the same assumptions as above to understand the opportunity for the same new facility investments in the SMART-POWER region.

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Figure 13. Remaining supply after meeting demand (shown here in megawatts) of Tier 1 components on the East Coast, with reduced announced facilities plus additional facilities in the SMART-POWER region.

New facilities in the baseline and high deployment scenarios begin operations in 2028, and new facilities in the low deployment scenario begin operations in 2031 due to assumed delays or challenges in opening new facilities. Zero megawatts of supply after meeting demand suggests perfect domestic market equilibrium.

In this analysis, the balance of supply versus demand changes drastically to signal an undersupply of towers almost equivalent to that of blades across all three scenarios. Similarly, monopiles appear undersupplied up until the mid-2030s, although they still face potentially low demand (and consequently oversupply) closer to 2040 in the baseline and high scenarios.

The resulting business case and missed opportunity metrics are more favorable for a new tower or monopile facility investment (Figure 14). There is a more favorable business case for a new tower facility across all scenarios due to the reduced competition, with a limited negative impact if it were to lose its first-mover advantage (reducing the missed opportunity metric result), although it may result in insufficient U.S. supply for domestic projects. A new monopile facility still represents a considerably low business case for the low scenario, but a more favorable business case with higher deployment. However, a new monopile facility would be at greater risk from losing its first-mover advantage.

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Figure 14. Supply chain metric evaluation by Tier 1 component, with reduced announced facilities

5.4 Regional Collaboration for Facility Investments

An assessment of the supply chain across the East Coast presents high levels of uncertainty due to the complexity of many projects, state deployment targets, procurement schedules, port development, workforce needs, and many more factors. While these issues still exist at a regional level, regional collaboration between states, such as the SMART-POWER states, could potentially address some of the challenges more successfully.

Single states likely will not have a large enough pipeline of projects to fully support a new supply chain facility, but a regional pipeline could potentially have sufficient buying power to fill the order books of new factories robustly. In this section, we consider the size of the supply chain that would be required to meet component demand exclusively in the SMART-POWER region. In this sensitivity study, we remove existing and announced factories from other regions (i.e., the EEW monopile factory in New Jersey and the Marmen Welcon tower facility in New York) and add new manufacturing resources that could potentially be developed to support projects in SMART-POWER lease areas. We retain the announced US Wind facility that is expected to produce towers and monopiles at Sparrows Point, Maryland. As a result, supply and demand become more balanced as the market is less prone to oversupply and undersupply.

The localized pipeline of projects (illustrated in Appendix A for the SMART-POWER region) is mostly met in our analysis by the supply modeled in the region for all components (Figure 15). The boom/bust cycle of projects is still present in the baseline deployment scenario, also driven by the lack of projects installed in some years in the region, but the impact of oversupply and undersupply is reduced. Moderate oversupply for facilities may be more easily addressed by supplying components to East Coast projects outside the SMART-POWER region, and similarly, moderate undersupply for projects may be more readily addressed by sourcing components from other East Coast or foreign facilities.

Nonetheless, there could likely be an increase in oversupply and undersupply risk in a high deployment scenario, where the increased production capacity of all three components is not

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adequately met in years without project installations, and greater capacity installed from new projects or increased capacity density is not met as closely by the region's supply on peak deployment years. This scenario highlights the potential for greater regional collaboration across the East Coast to reduce these risks.

Figure 15. Remaining supply after meeting demand (shown here in megawatts) of Tier 1 components exclusively in the SMART-POWER region.

New facilities in the baseline and high deployment scenarios begin operations in 2028, and new facilities in the low deployment scenario begin operations in 2031 due to assumed delays or challenges in opening new facilities. Zero megawatts of supply after meeting demand suggests perfect domestic market equilibrium.

There is substantial opportunity for additional facilities in the SMART-POWER region to potentially fill the majority of their order book with component orders from the same region. The business case for a blade facility is likely once again the strongest due to the lack of competition, or even two blade facilities in a high deployment scenario. An additional tower or monopile facility may find it more important to complement their order book with component orders outside the SMART-POWER region if they must compete with the announced US Wind facility, although it may reduce uncertainty for the region's project to procure towers or monopiles.

5.5 Reduced Government Funding Support

All supply chain analyses above assume new facilities would be eligible to receive the AMPTC per the existing guidance as of the data cutoff date of November 30, 2024. Across all previous analyses and deployment scenarios, we identify the AMPTC as a substantial positive impact on a facility's business case. For facilities modeled to start production later (2031 as opposed to 2028), the impact is less significant as they receive fewer tax credits before the AMPTC phaseout period per the 2022 Inflation Reduction Act. To evaluate the impact of additional

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facility funding and tax credits, such as the AMPTC, we present supply chain metric results without any tax credits to any new facility[13] (Figure 16).

The metric results demonstrate a likely decline in the business case for all scenarios and components. This is caused by the reduced available funding through tax credits and highlights a potential funding gap that manufacturers face to establish any new facility.

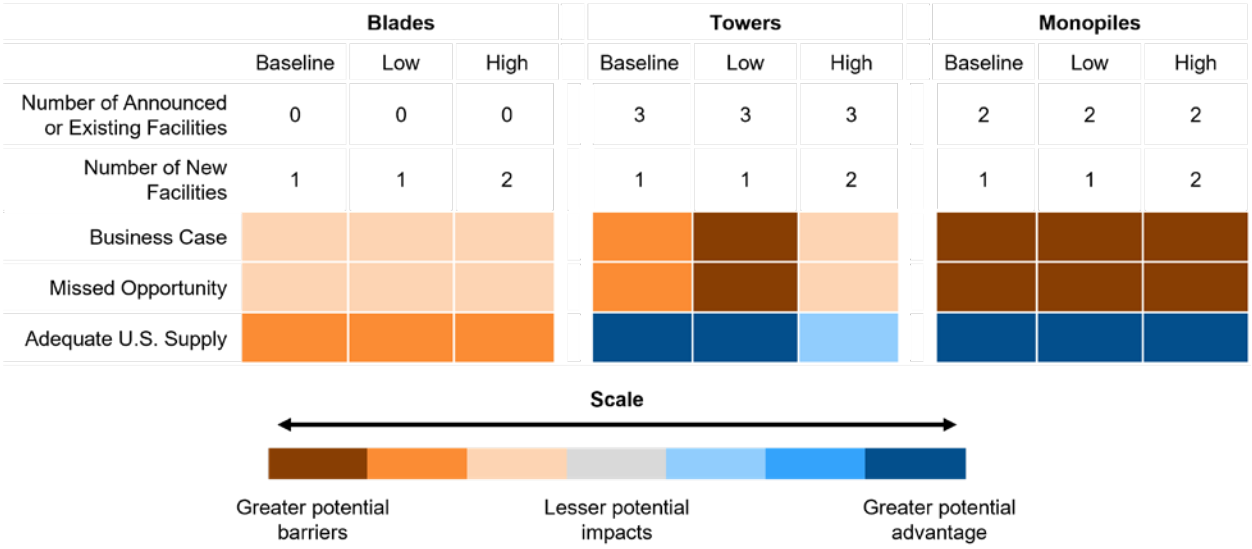

Figure 16. Supply chain metric evaluation by Tier 1 component, with reduced announced facilities

The business case for a new blade manufacturing facility may experience the greatest decline when compared to results with the AMPTC (Figure 12 in Section 5.2); despite significant demand from projects, blade facilities may experience substantial barriers in profitability. The business case for a new tower facility also will likely decline from a positive to a negative business case in a baseline or high deployment scenario and remains negative in a low deployment scenario. A new monopile facility will likely continue to experience a negative business case across scenarios.

The missed opportunity across components and scenarios mirrors their business case, indicating that increased competition is likely not as significant a factor when funding support is reduced. Adequate U.S. supply results are the same for facilities modeled with funding support (Figure 12) but would likely decline if the proposed facilities did not come online and supply decreased.

[13] With the passing of the One Big Beautiful Bill Act on July 4, 2025, which modifies AMPTC guidance such that wind turbine components sold after 2027 are no longer eligible for the tax credit, we expect the business case for new facilities to be less favorable and more aligned with this sensitivity analysis.

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5.6 Implications for the SMART-POWER States

The opportunities for new facility investments in the SMART-POWER region will likely require involvement from all participating states to realize their full benefits and reduce uncertainty for manufacturers and developers. We outline below four main implications for the SMART-POWER states:

1. Additional manufacturing capacity is likely needed for the offshore wind sector as a whole and for the SMART-POWER states to meet target deployment goals. With global supply chain constraints, domestic manufacturing for blades, towers, and monopiles is likely insufficient for projects to be constructed in the 2020s and early 2030s. The assessment's results indicate potential opportunity for at least one or two blade facilities and one tower facility, assuming all currently announced facilities come online as expected. Additional investment opportunities may exist for any of the three components if announced facilities are canceled or delayed.
2. Collaborative strategies from the SMART-POWER states could potentially de-risk manufacturing investments by enabling or encouraging a more consistent pipeline and robust order books for manufacturers within the SMART-POWER region. This would likely provide additional stability to the region's projects by potentially getting priority access to components. Additional collaboration with other East Coast states may be beneficial to address potential periods of oversupply and undersupply.
3. There is a funding gap for new facilities that could potentially be bridged with tax credits, state incentives or other mechanisms, as evidenced by the impact of modeled tax credits such as the AMPTC. Earlier supply chain investments may also reduce risk of component procurement bottlenecks when the global supply chain is most stressed. New facilities for towers or monopiles face increased competition from announced facilities and thus may also benefit from a first-mover advantage.
4. Grants and incentives are not necessarily the only way to attract investments; the SMART-POWER states have demonstrated through recent legislation, targets, and policies that they are "open for business" and that their positive business proposition can be competitive with other East Coast states. Under CNBC's 2024 annual state competitiveness for business rankings, Virginia and North Carolina were ranked as first and second for highest overall competitiveness (CNBC 2024). Reducing risk for facilities, mentioned above, may also attract manufacturers to their region.

As detailed in previous sections, there are several SMART-POWER ports with the physical requirements and workforce readiness for Tier 1 manufacturing, as well as supporting businesses across the entire region. While regional collaboration is likely essential to realize the benefits offered by a U.S. offshore wind industry, each state has different strengths to leverage the business opportunities and overcome the challenges discussed.

Delaware, while likely not pursuing a Tier 1 facility, has demonstrated support for the offshore wind industry, most recently with the passing of the Delaware Energy Solutions Act to allow up to 1,200 MW of offshore wind procurement (Jeanfreau 2024). Delaware is well placed to complement regional players through its workforce and its lower-tier suppliers as well as tap into its business, research, and development expertise at hubs like the Science, Technology and Advanced Research Campus at the University of Delaware. Its location between Maryland and

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New Jersey may enable Delaware to leverage partnerships and regional benefits both north and south of the state. While Tier 1 investment decisions from other states may influence lower-tier businesses in Delaware, proactive strategies to support small business diversification and adaptability have the potential to reduce dependency on external investment decisions.

Additionally, there is potential for a Delaware port, such as Port of Wilmington, to serve as a marshaling port rather than a manufacturing or staging port (see Sections 6.1 and 6.2 for additional opportunities for marshaling and component storage at SMART-POWER ports).

Maryland has a demonstrated interest and capacity to participate in the offshore wind supply chain through its manufacturing and port facilities at Sparrows Point and through secondary steel production by Crystal Steel Fabricators at Federalsburg, an announced Ørsted operations and maintenance hub in Ocean City and another by US Wind in West Ocean City, and a new Hellenic Cables manufacturing facility in Baltimore. The state can continue to build on these facilities as a hub for offshore wind (McCoy et al. 2024; Hooper 2024). The Hellenic Cables facility is also an example of an offshore wind energy manufacturer receiving a Qualifying Advanced Energy Project (48C) tax credit from the Inflation Reduction Act (Cenergy Holdings 2024). The state's historic resources in the maritime and manufacturing industries can potentially be further revitalized and leveraged for Tier 1 manufacturing and supporting business.

Virginia counts on the experience and expanded capacities at Portsmouth Marine Terminal to support Tier 1 manufacturing, needing little additional investment to accommodate manufacturing of blades, and existing capacity for monopiles. High staging and manufacturing readiness at Portsmouth Marine Terminal are complementary to additional availability at Fairwinds Landing for offshore wind supply chain investments. A new cable manufacturing facility by LS GreenLink was also announced to be built in Chesapeake (Office of the Governor of Virginia 2024). The state's significant shipbuilding, steel rolling, and welding expertise extend opportunities for Virginia beyond Tier 1 manufacturing.

North Carolina has Port of Morehead City and Port of Wilmington as two considerably different but capable ports for Tier 1 manufacturing, with the likely ability to support more than one Tier 1 facility. There are significant manufacturing strengths and legacies statewide, particularly for steel manufacturing, and significant inter/intra-state collaboration working toward renewable energy targets. To prepare for potential in-state manufacturing facility investments, the North Carolina Taskforce for Offshore Wind Economic Resource Strategies, or NC TOWERS, was established in 2021 under Executive Order 218, titled Advancing North Carolina's Economic and Clean Energy Future with Offshore Wind (North Carolina Department of Commerce 2024). The order also established the state's offshore wind targets and created the position for Assistant Secretary of Clean Energy Economic Development in the Department of Commerce to find economic and workforce development opportunities, particularly in the offshore wind industry.

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6 Additional Opportunities for the SMART-POWER Region

The focus areas presented in this study reflect potentially critical needs for the SMART-POWER region's supply chain; however, they are not an exclusive list of investments that could help to facilitate offshore wind deployment in the region and along the Atlantic Coast. In this section, we present some alternative supply chain resources that could leverage existing strengths within the region. We consider these additional resources at a higher, more qualitative level than the blade, monopile, and tower facilities.

6.1 Marshaling Ports

6.1.1 Asset Description and Regional Demand

A marshaling port is a coastal facility where a fixed-bottom offshore wind project stages major components and transports them to an installation vessel (Shields et al. 2023). The capabilities of the port are critical for enabling an efficient installation rate for an offshore wind project. The size and weight of offshore wind components require design characteristics beyond most existing ports in the United States. Particular design drivers include having sufficient laydown area, quayside length, berth depth, channel depth and width, quayside and upland bearing capacity, and air draft (Shields et al. 2022). The design requirements may change based on whether the port will interact with feeder barges or larger WTIVs, which could require deeper drafts and higher air drafts. A basic list of marshaling port requirements is provided in Table 9. See Parkison and Kempton (2022) for a more detailed description of the activities at a marshaling port.

Table 9. Minimum Port Requirements for Fixed-Bottom Marshaling Activities

Reprinted from Shields et al. (2022)

Parameter	Minimum Value
Draft (feeder barge)	6–7 m
Draft (wind turbine installation vessel)	12 m
Air draft	150 m
Laydown area[14]	25 acres
Quayside length	500 m
Bearing capacity[15]	15 t/m^2

[14] Developers prefer at least 50 acres of laydown space but have marshaled out of smaller ports in the northeastern United States, including the New Bedford Marine Commerce Terminal (Massachusetts) and the New London State Pier (Connecticut).

[15] Higher bearing capacities are required at quayside loading areas.

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Shields et al. (2023) evaluated a list of potential marshaling ports and identified eight announced marshaling ports that could contribute to the needs of offshore wind project development if they were fully funded and developed on time (along with a sufficient vessel fleet). This analysis did not capture the latest Central Atlantic lease areas auctioned in 2024 (BOEM 2024b), or the recent macroeconomic disruptions that have led to project rebids, cancellations, and delays (Ury et al. 2024). The baseline deployment scenario used in this study estimates a deployment of around 26 GW in the SMART-POWER region by 2040, corresponding to an average of 1.6 GW per year. European marshaling ports have typically installed around 750 MW per year; using this as a rough estimate, the SMART-POWER region could need two to three marshaling ports to install the projects.

6.1.2 Potential Resources in the Central Atlantic Region

The SMART-POWER region already features two marshaling ports: Portsmouth Marine Terminal in Virginia marshaling the CVOW project, and US Wind has identified Sparrows Point in Maryland as the likely marshaling port for their MarWin and Momentum Wind projects. The region is also close to the New Jersey Wind Port on the Delaware River, although this port will likely be engaged with installing offshore wind projects with offtake agreements in New York and New Jersey.

In addition to the active or announced ports in the region, we also list Port of Morehead City in North Carolina, which has been identified by the North Carolina Ports Authority as a potential site for a multi-use terminal that could serve the offshore wind industry (North Carolina State Ports Authority 2024). The relevant parameters for each port and approximate travel distances to a few representative offshore wind projects along the East Coast, are listed in Table 10.

Table 10. High-Level Port Parameters in the Central Atlantic Region

Port	Staging Area (acres)	Berth Length (m)	Air Draft Restriction (m)	Transport Distance (nautical miles) to:			
				Community Offshore Wind (NY)	Atlantic Shores Offshore Wind (NJ)	Momentum Wind (MD)	Kitty Hawk (NC)
New Jersey Wind Port	70	854	None	141	101	84	199
Sparrows Point (south route)	250	366	56.7	339	314	245	198
Sparrows Point (north route)	250	366	40.5	203	163	146	N/A
Portsmouth Marine Terminal	287	1,079	None	221	196	127	80
Port of Morehead City (Radio Island)	128	1,635	None	487	462	393	65

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6.1.3 Considerations for Investment

A marshaling port could cost on the order of $300–$400 million to construct (Shields et al. 2023), requiring careful consideration of the investment. Committing to such an investment would require a reasonable degree of confidence that the port would have a consistent series of contracts, likely for at least the first 10 years of operation; however, the certainty in this pipeline has been a challenge for the U.S. offshore wind industry in the due to permitting delays and project terminations (Shields et al. 2023). For the Central Atlantic region to invest in a new marshaling port, additional study would be required to understand the degree to which the deployment of the regional pipeline is constrained by existing ports (i.e., Sparrows Point and Portsmouth Marine Terminal). Such a study could potentially consider the anticipated deployment schedule of the projects, proximity of the ports to offshore wind projects, likely vessel spreads for each project, state procurement schedules, and the capabilities of each port.

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6.2 Tier 1 Component Storage at Ports

6.2.1 Asset Description and Regional Demand

The establishment of one or more Tier 1 component storage ports within the SMART-POWER region could potentially enable more continuous production by a new Tier 1 fabrication facility, while still enabling finished Tier 1 components to be readily available for marshaling and deployment. This is particularly important to reduce the risk of oversupply and undersupply of components that may result from a boom/bust demand-supply cycle. As shown in Figure 17 (with blades as an example), Tier 1 component demand in the baseline deployment scenario exhibits significant variation of this sort, driven by multiple projects having a required COD in the same year. This coincidence of CODs is generally driven by the alignment of various state offshore wind procurement targets.

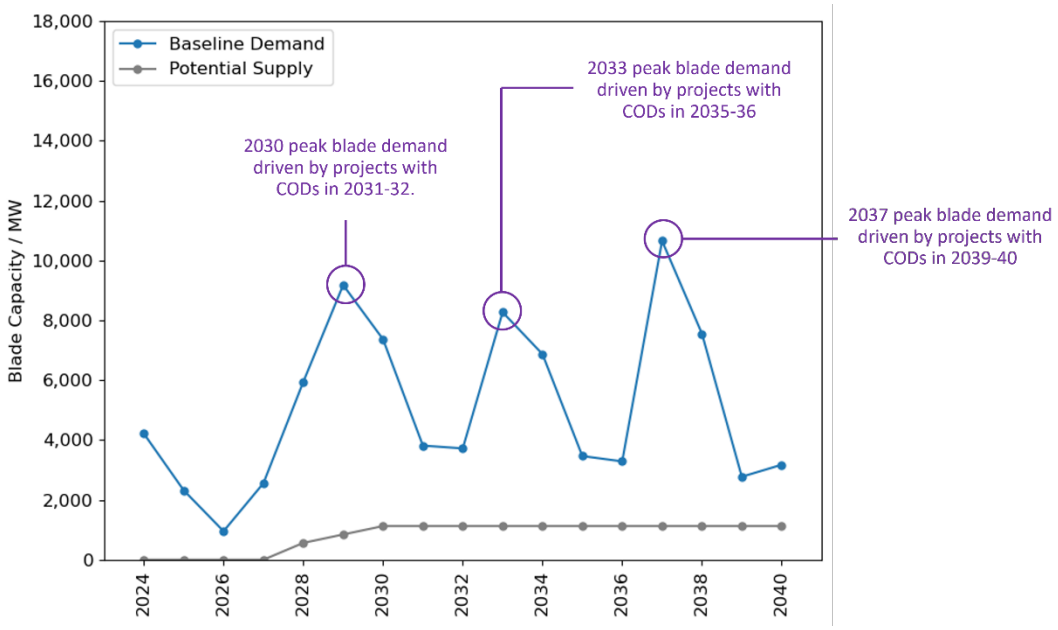

Figure 17. Peaks in blade demand and supply for blades in a baseline deployment scenario.

Blades are assumed to be procured from suppliers 2 years before a project's COD. Each blade plant produces 225 blades/year.

States are likely to have limited or perhaps no flexibility or mechanism to coordinate their offshore wind procurement CODs. Storage ports therefore may provide a practical means to buffer potentially erratic demand for Tier 1 components, enabling Tier 1 fabrication facilities to schedule stable production, year-on-year, while reducing the risk of supply chain bottlenecks for developers.

To better understand factors that may impact a component storage strategy, we conducted a high-level analysis of blade demand variation from 2024 to 2040 by evaluating three interacting input parameters. Storage of other Tier 1 components such as towers or monopiles may differ in storage time requirements, or spatial requirements at ports, but are expected to follow similar patterns. For the analysis, we assume a set number of blades are stored for a given duration before procurement, if the expected demand in a given year surpasses a "triggering threshold," described by three parameters:

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- **Storage duration:** Are blades to be stored for 1 or 2 years before being procured by a developer for project deployment? In other words, is blade demand shifted 1 or 2 years before project demand?
- **Triggering threshold:** What is the forecast demand threshold (in number of blades/year), above which the forecast demand triggers the need for storage? In years where forecast blade demand is less than the threshold, no storage would be needed for that year; when the forecast demand exceeds the threshold, a certain percentage of that year's total demand will be shifted earlier by using storage to reduce the excess peak demand.[16]
- **Percentage shifted:** What percentage of a given year's forecast blade demand requires storage, thereby shifting production to an earlier year?

The resulting metric quantifies variability of annual blade production, as measured by its standard deviation. As a reference point, the standard deviation of the original baseline (no storage), is 538 blades/year. Figure 18 presents the results of the parametric analysis as a heat map, with greener shades indicating that the standard deviation of year-on-year blade production is less than the standard deviation of the baseline scenario (i.e., better matched to consistent production), whereas redder shades indicate that the standard deviation is more than the standard deviation of the baseline scenario (more erratic).

1 year of storage				
Percentage shifted	Threshold (# blades/year)			
	500	800	1200	1500
25%	468	461	455	465
50%	456	510	494	536
75%	504	659	632	709

2 years of storage				
Percentage shifted	Threshold (# blades/year)			
	500	800	1200	1500
25%	382	316	308	374
50%	343	405	384	427
75%	452	694	669	645

Figure 18. Standard deviation of year-on-year blade production for different storage parameters.

The storage case with lowest standard deviation, framed by a black rectangle, corresponds to 2 years of storage with a 1,200 blade/year threshold and 25% shift, detailed in Figure 19.

[16] Our parametric analysis is not iterative; therefore, if blade demand is shifted to prior years to the extent where the earlier year now surpasses the triggering threshold, demand stays fixed at that point rather than being further shifted. This can result in new demand peaks and is one of the main reasons why some storage parameter combinations worsen blade demand variability.

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Note that in all cases, one year of blade storage makes little difference because the peaks in the baseline deployment scenario are generally made up of two consecutive years of high deployment (Figure 2, Section 2.3).

The best-case scenario (Figure 19) triggers storage when forecast blade demand exceeds 1,200 blades/year, and stores 25% of that year's forecast total demand over the prior two years. In this scenario, the blade storage port(s) must have enough total upland area to store at least 400 blades (25% of 1,200).

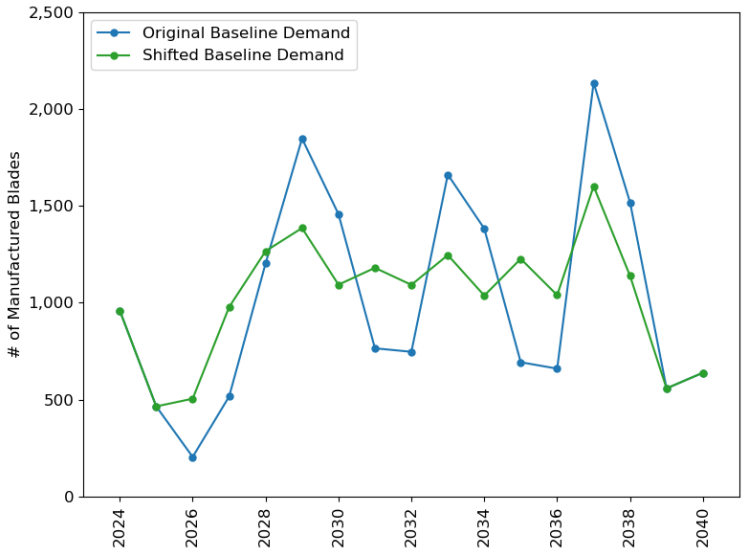

Figure 19. The best-case scenario triggers storage when forecast blade demand exceeds 1,200 blades/year while storing 25% of that year's forecast total demand over the prior 2 years.

Standard deviation of blade demand without storage = 538 blades/year, with storage = 308 blades/year.

6.2.2 Potential Resources in the Central Atlantic Region

The area required to store these quantities of blades can be estimated from recent investments in the Port of Hull, which is located on the north bank of the Humber Estuary on the North Sea coast of England. Hull has the United Kingdom's largest blade fabrication plant to date, developed and owned by turbine original equipment manufacturer SGRE, with its first 75-m-long blades produced in 2016 for its 6-MW and 7-MW offshore wind turbines (Russell 2016). In 2021–2022, the SGRE blade plant in Hull was expanded to produce 108-m blades for its new 14-MW to 15-MW offshore wind turbines, with 60 acres available to maneuver and store blades (Snieckus 2023).

We estimate that at the SGRE facility, a minimum of 2.3 acres are needed immediately adjacent to any one of the fabrication or finishing halls, in order to have the circular space needed to rotate a single blade or blade mold for maneuvering into and out of a building. This would leave 57.7 acres for the reported storage capacity of 240 blades at Alexandra Dock (Maslin 2022). This implies a packing density of 25 blades per 6 acres, or **a packing density of 4.2 blades per acre at a blade storage port**. Based on this packing density, a blade storage port optimized for the best-case demand-shifting scenario described above (400 blades) should have an upland area of at least 95–100 acres. A smaller area, approximately 60 acres (250 blades), would meet less-demanding scenarios for blade storage.

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Since blades are transported horizontally, storage ports can potentially be sited upriver from bridges, power lines, and other river crossings. Due to their upriver location, the real estate for these properties is generally less costly to lease or purchase than for industrial sites that are located closer to open-water shipping lanes and which have no overhead obstructions along their routing to open water.

6.2.3 Considerations for Investment

The cost to develop a waterfront industrial site into a storage port for blades or monopiles is at least an order of magnitude less than the cost to develop a marshaling port as estimated in Section 6.1. The Port of Argentia in Newfoundland, Canada, is a good example of an industrial site that has been developed as a storage port for monopiles and blades for U.S. East Coast offshore wind projects.

In August 2022, the Port of Argentia secured its first monopile storage contract, and a second contract was signed in March 2023. The required infrastructure improvements included widening roads, burying utility lines, and creating 3 acres of new laydown area adjacent to the docking berth, for which the Port of Argentia invested CAD 10 million (USD 7.3 million) over the course of 10 months (Memija 2023), making the site ready to receive its first monopile shipment.

The port has dedicated over 70 hectares (173 acres) of paved runways to create the upland storage yard, which has a total storage capacity of 120 monopiles (The Maritime Executive 2024). This implies a packing density of 0.7 monopiles per acre.

Overall, Tier 1 component storage ports present the following opportunities and challenges:

- Based on ongoing commercial experience, storage ports can potentially be cost-effective over a range of upland areas, ranging from 6 acres (as the SGRE blade storage yard in the Port of Hull) to nearly 180 acres (as at the monopile storage yard at the Port of Argentia).
- Ten acres of industrial waterfront upland area can accommodate approximately seven monopiles or 42 blades. Thus, 30 acres could likely accommodate 14 monopiles and the blade sets for 14 15-MW turbines, corresponding to 210 MW of future offshore wind generation capacity per 30 acres of aggregated storage capacity.
- Based on the Port of Argentia, a storage port investment of USD 10 million could be sufficient to develop 180 acres of upland storage and associated quayside improvements, corresponding to 1,260 MW of future offshore wind generation capacity. This could store approximately 84 monopiles and 252 blades.
- On the urbanized U.S. East Coast, no such single, large property exists that is not already being used as a commercial shipping port or being developed as an offshore wind marshaling port. To realize the same storage potential, multiple sites would likely have to be developed, and this may introduce logistics complexity.

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6.3 Alternative Foundation Fabrication

6.3.1 Asset Description and Regional Demand

All U.S. East Coast offshore wind energy projects under construction or in environmental review as of November 2024 were planning to install extra-extra-large (XXL) monopiles, having a bottom diameter of 8.5–11 m. To build out all active East Coast commercial wind energy leases in this way would likely require an average supply of 210, 300, and 350 monopiles per year in low, baseline, and high deployment scenarios, respectively, from 2024 through 2033. As highlighted in Section 2.1, Europe currently has surplus monopile production capacity that can supplement the U.S. monopile supply, which at present is quite limited (Global Wind Energy Council 2023; Wood Mackenzie 2023). However, Europe's surplus capacity is expected to be fully absorbed by European demand beyond 2026 (Rystad Energy 2023). Additionally, a monopile fabrication facility is estimated to cost $300–$350 million with a lead time of 3 years or longer (Rystad Energy 2023).

By comparison, the U.S. domestic supply chain for monopiles is limited. The monopile finishing plant in Paulsboro, New Jersey, is expected to be able to fully fabricate 100 XXL monopiles per year by 2026, processing 0.15 million metric tons (mt)/year of steel (Magyar 2023). The second announced U.S. monopile fabrication plant at Sparrows Point, Maryland, is expected to have an annual production capacity of ~67 XXL monopiles, processing 0.10 mt/year of steel (US Wind n.d.). As a point of comparison, Dominion's 2.6-GW CVOW project is expected to install 176 XXL monopiles in 2024–2025, having a total weight of 0.27 mt. CVOW's monopiles are imported from Europe, but this reference point suggests that just one future project of this size would consume nearly all the currently announced U.S. monopile production capacity.

Construction of a monopile fabrication plant takes, on average, 3 years of lead time (Rystad Energy 2023), which may be insufficient to establish a new facility in the United States to address a monopile supply shortfall in the late 2020's. However, establishing outdoor fabrication facilities for gravity base foundations (GBFs) or suction bucket jackets (SBJs; see an example SBJ in Figure 20) could be established in 12–18 months.

Producing either or both of these alternative foundation types in the SMART-POWER region could diversify the domestic supply chain for fixed-bottom offshore wind foundations. Moreover, both these alternative foundation types can be designed to have mass and buoyancy distributions that enable them to be self-floating, capable of being deployed by simple harbor tugs.

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Figure 20. Example three-legged suction bucket jacket designed to support a 10-MW reference turbine (178-m rotor diameter) in 30-m depth (adapted from Kempton et al. 2017). The SBJ design has 1,234 t mass, 3 x 12 m diameter suction caissons, and 3.6 m towing draft.

Thus, addressing the monopile supply gap with self-floating alternative foundation types could potentially avoid the need for heavy lift foundation installation vessels. The looming global heavy lift floating foundation installation vessel (FFIV) shortage will likely have a negative impact on nations meeting their offshore wind procurement targets (Spinergie 2024). In terms of total annual vessel-years, the global market demand (excluding China) for FFIVs is 9 years of vessel time as of 2023, which was comfortably met by a supply of 12 vessel-years. By 2029, however, FFIV demand is forecast to be 29 years, but the global FFIV fleet will be able to supply only 15 years.

In addition to overcoming forecast global shortfalls in monopile supply and FFIV availability, self-floating fixed-bottom foundations may avoid the environmental effect of impact pile driving and added cost of noise mitigation, such as bubble curtains. Since monopile driving is an intense sound source, albeit over limited periods of time relative to a project's construction phase, U.S. East Coast pile driving for offshore wind is confined to the 6-month period from May to October, when the endangered North Atlantic right whale is not migrating, and then only during daylight hours, due to the need for visual detection of dolphins, whales, or sea turtles by protected species observers (EDF Energy 2019).

By eliminating impact pile driving, self-floating foundations can potentially be installed year-round, likely improving a project's delivery timeline while being more environmentally benign. As illustrated in Figure 21, this flexibility would more than double the available offshore installation hours within a calendar year. Even during stormier winter months, there can be calm periods of several days to a few weeks, which would likely be sufficient to mobilize readily available harbor tugs to take advantage of even a short weather window to deploy several self-floating foundations offshore before the next storm develops.

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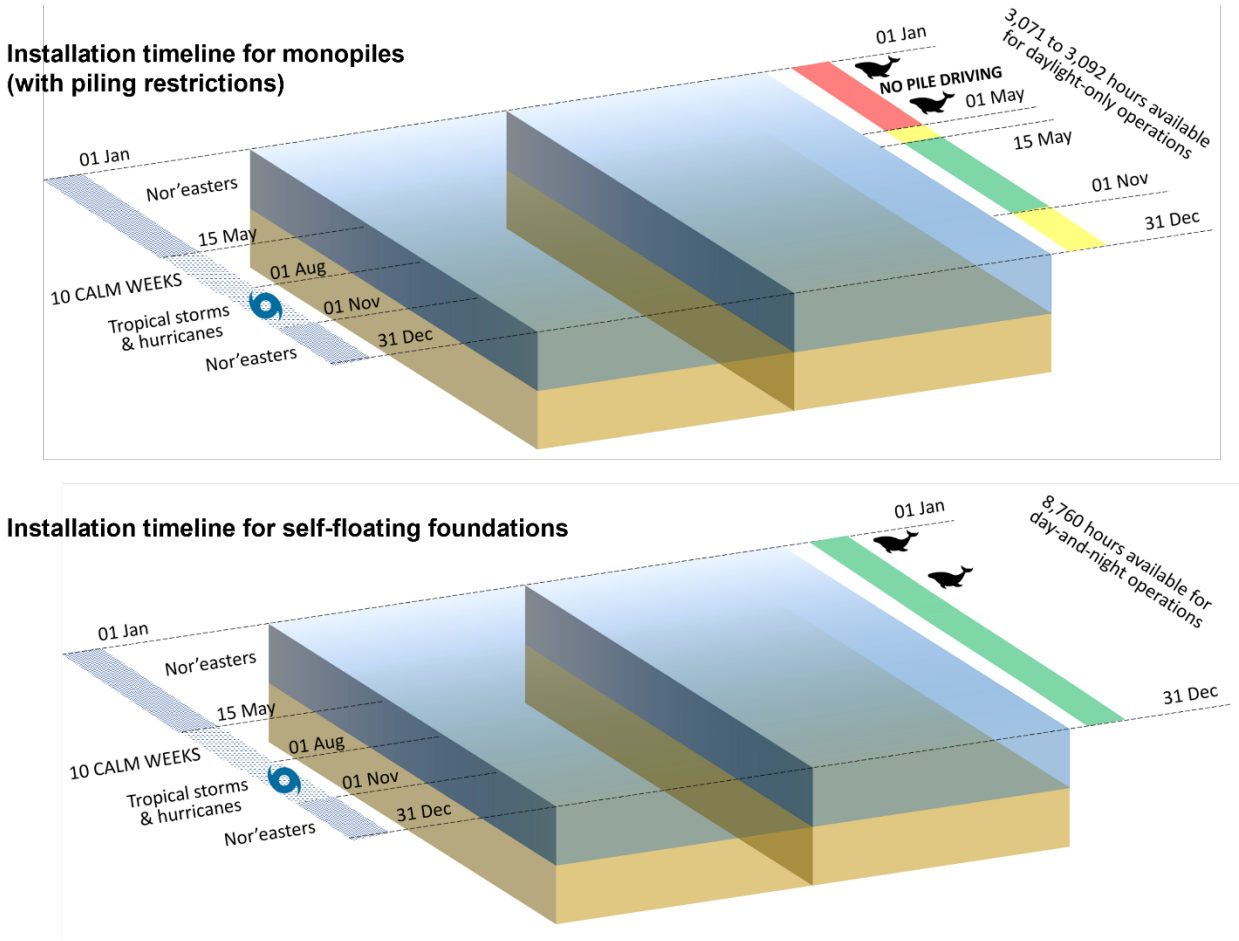

Figure 21. The permissible year-round installation timeline for monopiles (top) and self-floating foundations (bottom) compared with whale migration season restrictions.

Green indicates the routinely permitted installation windows to avoid North Atlantic right whale migration, yellow represents periods where special permission is required to extend the pile driving season, and red indicates no impact pile driving under any circumstances.

6.3.2 Potential Resources in the Central Atlantic Region

GBFs and SBJs have been fabricated in the United Kingdom using floodable graving docks, but this infrastructure is not readily available in the United States, where floating drydocks are more common. Floating drydocks, however, are designed for ships and typically do not have sufficient width for a GBF or SBJ that can support a large offshore wind turbine. A solution could be to identify an ocean deck barge with suitable deck area and strength, which can be temporarily outfitted with proven ballasting boxes to create a semisubmersible work platform. This enables dry fabrication of a gravity base slab and perimeter wall, after which the barge deck is then submerged to float off the base to allow finishing alongside the quay.

SBJs for a given turbine size are significantly lighter than GBFs, and SBJ fabrication can be done on any quay already capable of supporting monopiles because SBJs also typically weigh less than monopiles. Once the SBJ has been fully fabricated, complete with secondary steel, coatings, and sacrificial anode installation, self-propelled mobile transporters can be used to

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move the SBJ onto a semisubmersible barge platform, which is then submerged to float off the finished SBJ for towing offshore.

As determined by prior NREL research, a dedicated facility to fabricate self-floating GBFs or SBJs with a throughput of 50 structures per year would likely need to meet the following requirements:

- A quayside section length of 300 m and a width of 100 m
- The above plan dimensions have a surface area of 30,000 m^2 (or 7.4 acres)
- The quayside area should have an average bearing strength of at least 6 t/m^2
- The quay alongside charted depth, which corresponds to mean lower low water must be greater than 7.8 m, and the access channel to open-water sea routes should be deeper than 10 m at mean lower low water
- No overhead restrictions (e.g., unlimited air draft).

Table 11 lists potential fabrication ports on the U.S. East Coast that meet all the above requirements. The New London State Pier and Portsmouth Marine Terminal are two locations that between them could potentially cover the entire U.S. East Coast at foundation towing speeds of 2 to 4 knots and which have over a kilometer of berthing space, enabling a GBF or SBJ fabrication operation to comfortably coexist with offshore wind project marshaling activities.

Table 11. Key Features of Potential U.S. East Coast Fabrication Sites for GBF or SBJ Foundations

Towing distance based on National Oceanic and Atmospheric Administration Office of Coast Survey estimated sea route distances between ports.

Port Name (listed north to south)	State	Laydown Area (acres)	Quayside Length (m)	Alongside Depth (m)	Towing Distance (nautical miles) to:		
					New England	New Jersey	Kitty Hawk
Port of Bridgeport	CT	18.3	375	9.8	127–182	231	445
New London State Pier	CT	30	1,244	12.2	77–136	185	399
Arthur Kills Terminal	NY	32	411	10.7	191–223	84	298
New Jersey Wind Port	NJ	70	854	11.5	308–340	104	218
Newport News Marine Terminal	VA	165	1,061	12.2	374–406	196	68
Portsmouth Marine Terminal	VA	287	1,079	13.1	390–422	212	84
Port of Morehead City (Radio Island)	NC	128	1,635	11-14	571–603	393	65

6.3.3 Considerations for Investment

While the monopile supply chain has been well-industrialized in Europe, existing and announced European monopile fabrication plants will not be able to meet European offshore wind demand and thus will not have any surplus capacity to supply U.S. projects after 2026 or 2027. At that point, U.S. monopile production capacity will be under 200 XXL monopiles per year,

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insufficient to support more than 3 GW/year of offshore wind capacity. By comparison, as shown in the baseline deployment scenario (Figure 2), the East Coast supply chain may potentially experience annual fixed-bottom offshore wind project deployment ranging from 4 to 8 GW per year from 2030 through 2035.

The lead time and capital investment required for a new monopile plant is substantial (3 years or more), and this barrier is compounded by the relatively short build-out period for fixed-bottom foundations before the U.S. East Coast offshore wind project pipeline is expected to transition to mostly floating wind projects. By comparison, concrete GBF and steel SBJ outdoor fabrication facilities can likely be established within 12–18 months for a much lower capital investment (estimated $25–$30 million) (Rystad Energy 2023). This means that the capital investment can be recovered more quickly and may be a better fit to the relatively short fixed-bottom project build-out from 2030 through 2035.

The greatest barrier to adoption of self-floating alternative foundations may be the lack of any existing U.S. East Coast fabrication facilities, which is perceived as a supply chain risk. For SBJs, there are existing jacket fabrication facilities that supply production platforms to Gulf and Caribbean offshore oil and gas industry, and a lower-risk first step would be for these to fabricate jacket frames, that could be shipped at "flat packs" to SBJ assembly yards on the East Coast. This approach was successfully undertaken by ScottishPower Renewables for the three-legged, pin-pile jackets at its East Anglia One project.

The SMART-POWER region is well positioned with assets that could accommodate the fabrication of alternative foundations to monopiles, including but not limited to concrete GBFs and steel SBJs. This could benefit the U.S. offshore wind industry be alleviating shortfalls in monopile supply from European and domestic monopile fabrication plants as well as a looming global shortage of heavy lift foundation installation vessels. Fabrication facilities of these foundation types can be established with relatively low capital investment ($25 to $30 million) and short lead times of 12 to 18 months. Since offshore oil and gas jacket fabrication yards already exist in the Gulf and Caribbean Sea, they potentially offer a relatively low-risk pathway by which they could ship "flat packs" of jacket frames and other components to assembly ports in the SMART-POWER region.

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7 Conclusions and Future Work

This report has provided an initial analysis of how the SMART-POWER region could leverage existing strengths in manufacturing capabilities, workforce readiness, and port assets to develop a regional offshore wind supply chain. We have introduced a methodology that evaluates supply chain investment based on key metrics for manufacturing investments, workforce, and community impact, and have been able to use this methodology to identify potential opportunities that could benefit both the region and the offshore wind industry. In particular, we find that developing tower, blade, or monopile manufacturing resources could help projects to avoid delays attributed to anticipated global supply chain bottlenecks with the added potential benefit of creating jobs and economic growth. Regional communication and coordination between the Central Atlantic states of Delaware, Maryland, Virginia, and North Carolina, which builds off of the existing SMART-POWER framework, could help achieve these benefits by establishing strategic plans for building supply chain assets, training the workforce, and advancing offshore wind project development.

7.1 Key Takeaways

Takeaway #1: The existing and announced manufacturing facilities in the United States likely do not have sufficient production capacity to support the demand for towers, blades, and monopiles from offshore wind projects in the SMART-POWER region (or for the whole East Coast pipeline, as estimated by our deployment scenarios).

- The list of existing and announced factories includes tower facilities in New York (Marmen Welcon), Maryland (US Wind/Haizea), and an as-yet-undisclosed location (US Forged Rings), and a monopile facility in New Jersey (EEW) as well as monopile manufacturing at the same Maryland facility (US Wind/Haizea).
- Global supply expects to see significant bottlenecks for these components beginning in 2025–2028 and lasting at least until 2030, which corresponds to potential increase in component demand to meet U.S. pipeline needs (starting in the early 2030s).

Takeaway #2: We estimate that expanding the supply chain to include two full blade manufacturing facilities and one new tower facility could potentially reduce the risk of undersupply from 2027 to 2040 for the East Coast deployment scenarios considered in this report. Investing in additional monopile facilities beyond the two that have already been announced would likely require a higher deployment scenario.

- These estimates are based on our assessment of supply and demand across the East Coast, and an evaluation of the business case metrics for each component across the three deployment scenarios.
- The opportunity for new facilities is greatest for full blade manufacturing due to the critically insufficient expected supply, with blades likely in high demand on the East Coast across all deployment scenarios. Our results indicate a potentially high business opportunity for at least one facility in a baseline or low deployment scenario, and at least two facilities in a high deployment scenario.
- Towers also represent a significant opportunity, although likely for just one more facility on the East Coast to avoid redundancy and oversupply under a baseline or high

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deployment scenario; a low deployment scenario results in a lower business case for a new tower facility.
- Monopiles represent a greater risk of insufficient demand to justify an additional facility across scenarios, particularly due to decreased monopile demand after 2030 with an increase in floating wind projects. Nonetheless, projects in the 2020s and early 2030s may face monopile shortages that may prompt other solutions such as facility expansions or greater investment in alternative foundations.
- There is continuing uncertainty and challenges for the presently announced facilities, especially in light of investment cancellations over the past 2 years. While this poses an additional challenge for developers as they work to secure components, it may also lead to opportunities for additional facilities if any of the current announcements are delayed or canceled.

Takeaway #3: The component demand from the pipeline of SMART-POWER projects would likely be sufficient to cover the supply of components from these two blade facilities and one tower facility, although new facilities will likely need additional funding to make projects financially viable.

- Across the three deployment scenarios, the SMART-POWER states account for 24%–37% of overall East Coast deployment by 2040. The resulting market is likely sufficient to cover the majority of orders needed by new blade and tower facilities in the region, in addition to the announced US Wind/Haizea tower and monopile facility.
- Even with sufficient component demand, any new facility is likely to experience funding gaps that may limit their financial viability. Potential approaches to bridge funding gaps may include tax credits like the AMPTC, state incentives, or other mechanisms.
- Collaboration within the SMART-POWER region could potentially provide the region's projects first access to much-needed Tier 1 components, reducing the risk of facing supply chain bottlenecks at a national or global level.
- Collaboration with the broader East Coast supply chain and project pipeline can reduce uncertainty for SMART-POWER projects and manufacturers by matching over or undersupply of components with the broader East Coast demand and supply.

Takeaway #4: The SMART-POWER states are well suited to host new Tier 1 facilities because they have at least six potential ports capable of hosting manufacturing facilities (one to two per state), with a highly capable regional workforce and supporting business network.

- All six identified ports meet the minimum physical characteristics needed for Tier 1 manufacturing or can reach them with additional investment.
- There is high workforce readiness at Port of Wilmington in Delaware, Sparrows Point in Maryland, the Hampton Roads area in Virginia (including Fairwinds Landing and Portsmouth Marine Terminal), and Port of Wilmington in North Carolina. Portsmouth Marine Terminal and Port of Morehead City, North Carolina, could potentially increase workforce readiness with improvements to commuting access and regional connectivity between jobs, workers, and training or educational programs.
- While North Carolina and Maryland have historic manufacturing strengths in the steel industry, their existing skilled manufacturing workers have transferable skills in

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occupations needed for blade manufacturing as well. As such, high workforce readiness for steel manufacturing indicates a similarly elevated workforce readiness level for blade manufacturing.
- There is a strong network of Tier 2 and Tier 3 suppliers in the region, with dozens of businesses indicating an availability and interest to support blade, tower, or monopile manufacturing. This includes key offshore wind manufacturers established in the region such as secondary steel production by Crystal Steel Fabricators at Federalsburg, Maryland, a new Hellenic Cables manufacturing facility in Baltimore, Maryland, and a new cable LS GreenLink manufacturing facility in Chesapeake, Virginia.
- Suppliers in the region that are currently active in other industries, such as fiberglass boat fabrication, may be well suited to engage in component and subcomponent manufacturing. A deeper dive is needed to understand how businesses in the offshore wind industry and adjacent industries could effectively integrate into a robust offshore wind supply chain.

Takeaway #5: Port communities around at least four ports have a high potential for positive investment impact, which could be enhanced with targeted engagement between industry and community members to improve the potential for positive outcomes.

- In addition to job opportunities and business for small and medium enterprises, supply chain investments could potentially bring benefits to port communities such as investments in education, training, or infrastructure, among other forms of benefits, as well as important mitigation of potential negative impacts like noise and pollution from construction or manufacturing activity. Port communities with high historic underinvestment or unemployment are likely to benefit the most from community investments and impact mitigation strategies, including Port of Wilmington, Delaware, Fairwinds Landing and Portsmouth Marine Terminal in Virginia, and Port of Wilmington, North Carolina.
- Radio Island development in the Port of Morehead City would be more distant from densely populated areas, resulting in a lower investment impact potential but also likely minimum negative community impacts.
- Key existing socioeconomic issues across SMART-POWER ports include high percentages of low-income households and higher poverty rates than average (disproportionately impacting people of color), and adverse health outcomes from port activity such as high adult asthma rates. Although potential negative impacts of offshore wind port activity could coincide with existing environmental vulnerabilities and barriers to economic mobility, targeted community engagement and benefits could alleviate some of these concerns, while distributing more broadly the benefits of renewable energy investments.
- There have been challenges with past and current community engagement efforts, but community members and organizations are generally eager for and receptive to community engagement that is more representative of multiple community perspectives, recognizes different voices and includes them in decision-making processes, and is more impactful by leading to tangible community benefits and protections.

Takeaway #6: Interstate collaboration could potentially help develop a regional supply chain that could meet the component demand from SMART-POWER projects, fill gaps in

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the overall East Coast pipeline, and contribute to a stable order book and greater workforce readiness for new supply chain facilities.

- Publicly announced CODs of projects in the East Coast pipeline indicate a potential for boom/bust cycles in deployment timelines. This erratic schedule may create challenges for new supply chain facilities in securing stable order books. Ongoing communication between SMART-POWER states and project developers in the region could help elucidate what actions could mitigate these risks, such as how state procurement schedules could affect CODs or what deployment rates are possible given available local supply chain or port resources.
- Early investments may reduce the risk of component procurement bottlenecks when the global supply chain is most stressed beginning in 2025, impacting the numerous projects with CODs in 2030–2032. Unlike blade facility investments, new tower or monopile facilities will likely face increased competition from announced facilities and thus may also benefit from a first-mover advantage.
- Ports with lower workforce readiness at the local or broader state level could increase their readiness through regional coordination within the SMART-POWER region, by connecting local and regional workers with local port job opportunities and regional programs.
- The focus of this report has been on collaboration within the SMART-POWER states; as a result, Maryland and Virginia show the highest opportunity for regional benefits because they each border two states within the region. North Carolina and Delaware can also benefit from partnerships within the SMART-POWER region but could also explore opportunities with existing supply chains in South Carolina and New Jersey, respectively.

7.2 Future Work

The methodologies and results in this report could be expanded upon to develop a greater understanding of the challenges and opportunities in the SMART-POWER region or elsewhere in the U.S. Potential future studies and activities could include:

- Implementing the methodology from this report in other regions, such as the Northeast, the West Coast, or the Gulf, to help to identify the opportunity space for supply chain development. Ultimately, results could be compared between different regions.
- Expanding and refining the database of existing small- and medium-sized businesses in the SMART-POWER region that could support the offshore wind industry. These findings could then be used to better understand the locations with the strongest supporting network for various Tier 1 components.
- Conducting further analysis to understand how supply chain and deployment activities in neighboring regions (particularly in New York and New Jersey) impact the opportunity space for the SMART-POWER region.
- Complementing the desktop studies and evaluated metrics provided in this report with additional outreach to communities and small businesses in potential supply chain communities.
- Evaluating the financing needs for new supply chain assets and identifying where actions by states could help to de-risk investment.

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- Extending the analysis on additional opportunities for the SMART-POWER region on marshaling ports, component storage and alternative foundation fabrication to characterize the size, benefits and challenges of each opportunity.

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Appendix A. Deployment Scenario Development

The East Coast project deployment scenarios presented in Section 2.3 are detailed in this appendix and are reprinted below for reference in Table A-2 and Figures A-1, A-3, and A-5. All scenarios are intended for analytical use in this assessment; they are not projections nor policy recommendations.

The baseline, low and high deployment scenarios were developed to capture various opportunities and challenges that may arise between 2024 and 2040 from potential combinations of macroeconomic factors (described in Table A-1). All scenarios focus exclusively on East Coast projects (from Maine to South Carolina) and were extended to 2042 to calculate 2040 component demand (assumed to take place 2 years earlier than project COD). While the baseline scenario closely reflects up-to-date project deployment data as of **November 30, 2024**, the low and high deployment scenarios are modified from the baseline deployment scenario.

Table A-1. Macroeconomic Factors Potentially Contributing to Different Deployment Scenarios

Deployment Scenario	Interest Rate / Inflation	Federal Support	Level of Interstate Coordination	Infrastructure Bottlenecks	State Procurement Goals Met?
Baseline	High	High	Low	High	Most
Low	High	Low	High	High	No
High	Low	High	High	Low	Yes

Across the three scenarios, 13.5 to 17.2 GW are installed by 2030, and 51.4 to 112.8 GW by 2040, with average installations 2030–2040 ranging from 3.8 to 9.6 GW/year (Table A-2). The SMART-POWER region accounts for 24%–37% of overall East Coast deployment by 2040 across the scenarios.

Table A-2. Deployment Scenario Summary

Deployment Scenario	Installed Capacity by 2030 (GW)	Installed Capacity by 2040 (GW)	Average Installed Capacity 2030–2040 (GW/year)	Installed Capacity by 2040 in the SMART-POWER Region (GW)
Baseline	17.2	81.4	6.4	26.3
Low	13.5	51.4	3.8	12.3
High	17.2	112.8	9.6	39.0

A.1 Baseline Deployment Scenario

The baseline deployment scenario for the East Coast (Figure A-1) is based on the most up-to-date publicly available data on existing and announced projects, state goals and mandates, and lease areas established by BOEM, with data cutoff as of November 30, 2024. Additional project development assumptions are complemented by internal NREL databases and published

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research, namely, the 2024 Offshore Wind Market Report (McCoy et al. 2024) and the National Supply Chain Roadmap (Shields et al. 2023).

As presented across Figures A-1 to A-6, each scenario comprises projects with existing leases, either with or without offtake contracts (in blue); projects with canceled offtake contracts, rejected renegotiation petitions, or terminated projects (in red); and projects with anticipated leases, which correspond to potential but hypothetical projects, either based on existing wind energy or call areas established by BOEM (with a capacity density of 4 MW/km^2), or on long-term state procurement targets (in green).

While existing lease CODs are primarily based on publicly available information, less developed project CODs and anticipated project CODs attempt to distribute where and when projects are deployed while still meeting most state targets (NREL 2024).

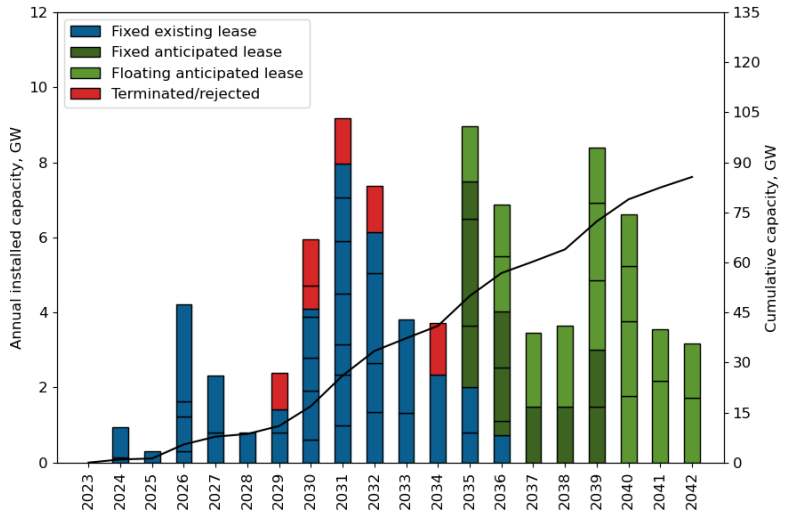

Figure A-1. Baseline deployment scenario for the East Coast

Projects with canceled offtake contracts are modeled to reenter the pipeline after 3 years of delay (assuming 1 year for project design modifications, 1 year for supply chain contract modifications, and 1 year for reestablishing a procurement contract). Terminated projects, defined as projects that developers will not renegotiate or continue developing, reenter the pipeline after 6 years of delay (assuming 3 years of lease transfer, sale or other solution, with three more years to reenter the pipeline as described above). Projects that had previously canceled offtake contracts but have since re-signed a contract have been reintroduced into the pipeline as normal.

- Canceled projects as of November 30, 2024, include New England Wind 2, Empire Wind 2, Skipjack 1 and 2, and Beacon Wind 1 (causing delays for Beacon Wind 2). The 3-year delay is assumed to incorporate 1 year for project design modifications, 1 year to secure a new offtake contract, and 1 year to renegotiate supply chain procurement contracts.
- Terminated projects are Ocean Wind 1 and Ocean Wind 2. The 6-year delay is based on the previous 3-year delay with three additional years for lease sale or transfer of ownership and more involved project redesign.

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- Projects with renegotiated contracts include Sunrise Wind, Empire Wind 1, New England Wind 1, and SouthCoast Wind 1.

This scenario is subject to mixed macroeconomic conditions and competing state targets across the East Coast without interstate coordination. While this results in most states meeting their targets, it also leads to an erratic deployment trend following a recurring boom/bust pattern of 2-3 years of low deployment, followed by 2-3 years of high deployment (Figure A-1).

The projects with offtake contracts in the SMART-POWER region, and other anticipated leases that may seek offtake contracts with SMART-POWER states, are presented in Figure A-2, reaching deployment of 26.3 GW in the region by 2040.

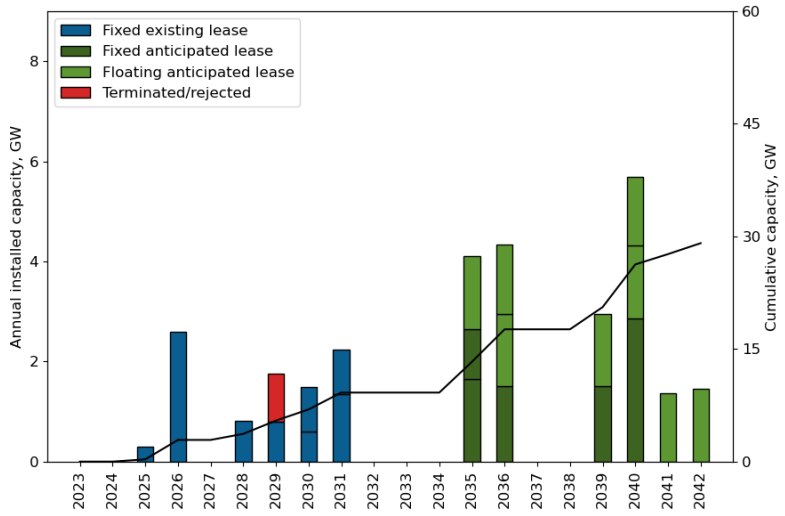

Figure A-2. Baseline deployment scenario for the SMART-POWER region

A.2 Low and High Deployment Scenarios

The low deployment scenario (Figure A-3 for the East Coast and Figure A-4 for solely the SMART-POWER region) describes deployment limited by a combination of unfavorable macroeconomic factors and severe infrastructure or supply chain constraints. This scenario takes the baseline scenario as the starting point, then limits the number of projects installed per year, under the assumption there may be insufficient funding, vessels or port availability for a larger number of projects per year. The limits on deployment are:

- Maximum two projects per year in the 2020s
- Maximum three projects per year in the 2030s
- Maximum four projects per year in the 2040s.

Projects at more advanced development stages are prioritized and delayed less, resulting in the less advanced existing and anticipated leases to be delayed by more years. Projects are prioritized if they meet the following criteria, in order of decreasing importance:

1. An offtake contract is in place
2. The federal permitting process is advanced
3. The lease area has an announced project

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4. There is confidence in the public COD, often from an available construction and operations plan
5. There are no other major projects in the same state, or more broadly the same region, and with the same COD.

The same anticipated leases as the baseline deployment scenario are used, except the capacity density is adjusted to 3 MW/km^2.

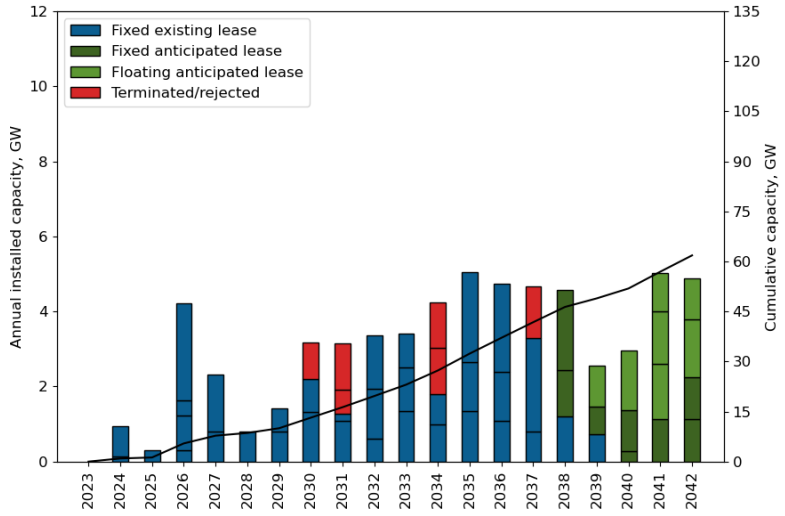

Figure A-3. Low deployment scenario for the East Coast

Projects corresponding solely to the SMART-POWER region are shown in Figure A-4.

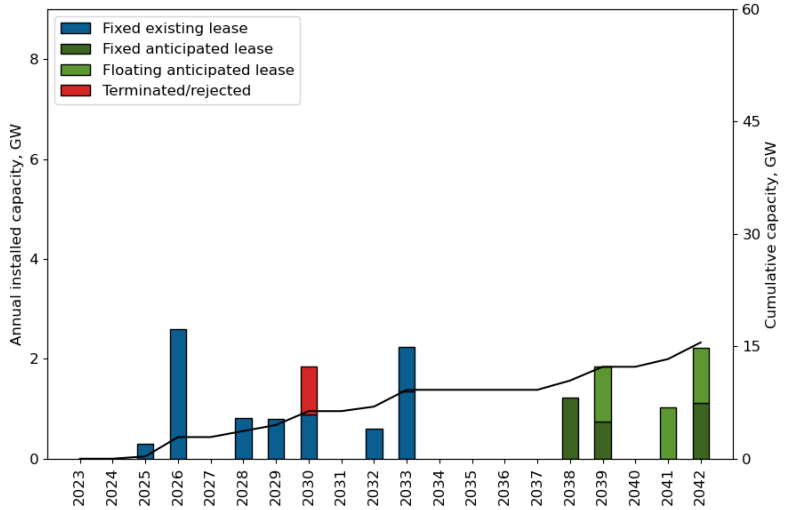

Figure A-4. Low deployment scenario for the SMART-POWER region

The high deployment scenario (Figure A-5) takes the opposite approach to describe accelerated deployment due to highly favorable macroeconomic factors, regional coordination, and higher levels of infrastructure investment. This scenario also takes the baseline scenario as the starting point, then accelerates the deployment pipeline after 2032 (assuming projects in the 2020s cannot

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be accelerated much and their development timelines are less flexible), to consistent levels of high deployment, such that:

- There is a minimum of five projects per year OR 6 GW/year after 2032
- There is a minimum of 8 GW/year after 2035
- There is never more than 12 GW/year.

The anticipated lease capacity density is adjusted from the baseline to 6 MW/km^2, and 10 additional anticipated leases are added between 2040 and 2042 (24.3 GW).

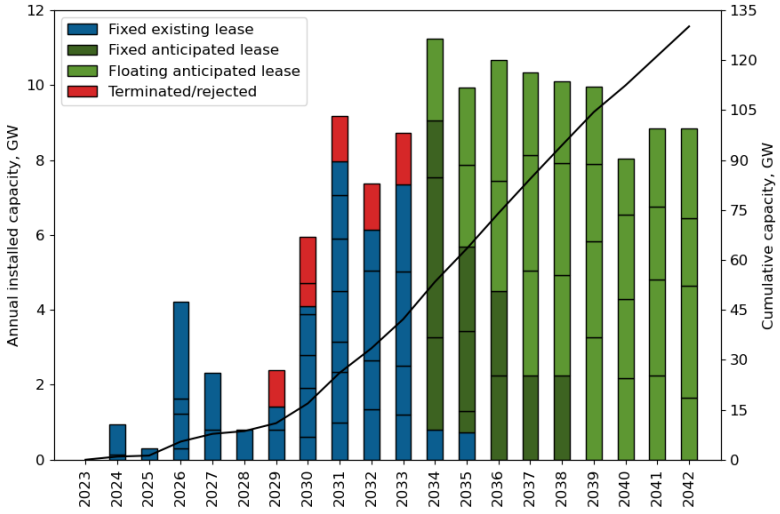

Figure A-5. High deployment scenario for the East Coast

Projects corresponding to the SMART-POWER region are shown in Figure A-6.

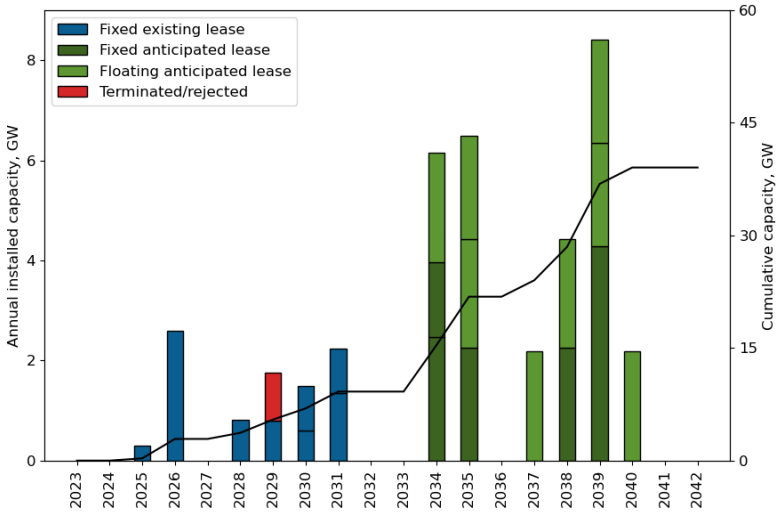

Figure A-6. High deployment scenario for the SMART-POWER region

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Appendix B. Supply Chain Evaluation Methodologies

The methodology for each supply chain evaluation section presented in this assessment is detailed below. Unless specified, all figures, maps, and graphics were developed by the authors. Most analyses used a combination of evaluation metrics in order to provide results that can be compared across ports, deployment scenarios, and components consistently.

B.1 Quantitative Community Impact Analysis

The community impact analysis was composed of two quantitative parts. The first part of the analysis consisted of developing and calculating the three community impact metrics. As presented in Section 3.2, the metrics are defined as:

- Environmental vulnerability: To what extent are environmental challenges experienced by port communities?
- Barriers to economic mobility: To what extent are there barriers present to accessing jobs in a port community?
- Investment impact potential: To what extent could an investment have a positive economic impact in a port community?

The level of vulnerabilities, barriers, or impact potential are not an indication of a better or worse investment opportunity but are socioeconomic cost/benefit trade-offs that can shape the proposal and development of a port facility. All metrics are weighted equally to allow states and other stakeholders to compare against their own priorities. Each metric was calculated by port:

- The census tracts within a 5-mile radius of a port were identified.
- Community vulnerability data were collected from the first version of the U.S. Council on Environmental Quality's Climate and Economic Justice Screening Tool (CEJST, Council on Environmental Quality 2022), for the criteria outlined in B-1.
- A tract was counted as "impacted" if it met the criteria (Table B-1).
- The proportion of "impacted" tracts out of the total port community tracts was converted to a percentage and weighted against the regional average in order to classify it.

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Table B-1. Community Impact Metric Criteria

Community Impact Metric	CEJST criteria
Environmental vulnerability	At or above 90th percentile for: particulate matter 2.5 in the air **OR** Diesel particulate matter exposure **OR** Proximity to National Priorities List (Superfund) sites **OR** Wastewater discharge **OR** Asthma rates among adults **AND** at or above 65th percentile for low income
Barriers to economic mobility	At or above 90th percentile for: Linguistic isolation **OR** Low medium household income **OR** At or below federal poverty level **AND** Low high school attainment
Investment impact potential	Tract has experienced historic underinvestment and remains low income **AND** Unemployment is 5% or higher

The second part of the analysis pulled data from the American Community Survey 5-year estimates from the year 2022 to analyze demographic and socioeconomic data from selected census tracts for each indicative port location. Each census tract was assigned a weight equal to the percentage of the census tract within a 5-mile radius from the respective port. The raw data were processed by applying the weight to each variable from the American Community Survey to accurately reflect the representation for each census tract. Aggregates were calculated for each category and compared across ports.

Additional data analysis was done to create a correlation matrix comparing select socioeconomic, environmental, and public health variables using data from CEJST. Statistically significant correlations supported findings from the initial analysis, highlighting the intricate relationships between socioeconomic factors, environmental conditions, and public health outcomes. All data sources are outlined in Table B-2.

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Table B-2. Quantitative Community Profile Data Sources

Metric	Data Source	Supplemental Data
Demographic Profile	US Census Bureau, American Community Survey, 2022	Total Population, Population Age 0-65+, Race/Ethnicity, Median Household Income, Educational Attainment, Population in Poverty, Population with Limited English Proficiency, Population with Any Disability
Community Factors	Climate and Economic Justice Screening Tool (CEJST), 2022	Legacy pollution, water and wastewater, workforce development
Health Status	Centers for Disease Control and Prevention, Behavioral Risk Factor Surveillance System, 2022	Health Outcomes, Health Risk Behaviors
Health Status	Virginia Department of Health Assessment, Virginia's Plan For Well-Being	Access to Care, Chronic Conditions
Health Status	Portsmouth Community Health Survey	Health Outcomes, Access to Care, Chronic Conditions

B.2 Community Engagement and Qualitative Methods

A literature review was done to analyze the intersections of port communities, environmental impacts, and public health considerations. Community groups from the Portsmouth, Virginia, region were solicited for their insights and perspectives to ensure the community insights were adequately represented and integrated into the analysis.

B.3 Workforce Readiness Metric

The companion Workforce report (Pons et al. 2025) contains a more detailed methodology breakdown for the research and insights in the workforce readiness section (4.1). Multiple indicators are leveraged to inform the three scores in the workforce readiness metric. The indicators, their sources, and their assumptions are provided in Table B-3. Once the indicators were collected, a z-score and associated percentile for each indicator were separately calculated to allow for comparison across locations in the SMART-POWER states. The scores were then averaged to create workforce readiness scores.

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Table B-3. Workforce Readiness Metric Indicators, Data Sources, and Assumptions

Metric	Type of Metric	Data Source	Assumptions
Civilian labor force participation rate	State, Local, Regional	U.S. Census Bureau	If the civilian labor force in the radius is higher than the regional average than we assume it will be more feasible to develop a workforce there.
Offshore wind-focused workforce program or initiatives	State, Local, Regional	State websites	If there are direct funds from the state for offshore wind workforce development programs, then we assume there is more state support, and it will be easier to develop a qualified workforce.
State unemployment rate	State	U.S. Bureau of Labor Statistics	If the unemployment rate is high, then we assume there are more available workers.
One-year percent change in industry employment, seasonally adjusted for manufacturing	State	U.S. Bureau of Labor Statistics	If the percentage of the manufacturing workforce in a state is decreasing, then we assume that there may be a decreasing number of workers with transferable skill sets to offshore wind.
Percent of population working in manufacturing	State	U.S. Bureau of Labor Statistics	If the percentage of the population working in manufacturing is higher than the national average, then we assume that there are more workers with transferable knowledge to offshore-wind-specific manufacturing.
Locational quotient (LQ)	Component-specific, Occupational level	U.S. Bureau of Labor Statistics	If the LQ is higher than the national average, then we assume that there is more specialization of the occupation within that state and therefore could lead to more workers with transferable knowledge to offshore wind manufacturing demands.
Number of registered apprenticeship programs	Component-specific, Occupational level	State websites or U.S. Department of Labor	If there are related programs in the radius it will raise the feasibility to train.
Number of two-year college/university programs	Component-specific, Occupational level	National Center for Education Statistics	If there are related programs in the radius it will raise the feasibility train.
Number of four-year college/university programs	Component-specific, Occupational level	National Center for Education Statistics	If there are related programs in the radius it will raise the feasibility to train.

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B.4 Allied Tier 2 and Tier 3 Business Evaluation

The Supply Chain Connect score, S_{SCC}, was calculated using data from the Oceantic Network, following the same calculation for each state and region:

$$S_{SCC} = \sum \left(n_{facilities} + n_{facilities} \left[0.25 x_{workforce} + 0.35 x_{experience} + 0.40 x_{certification} \right] \right)$$

where:

- $n_{facilities}$ is the number of manufacturing facilities that a given business owns within the state
- $x_{workforce}$ is a discrete score between zero and one that represents the number of employees in the company. $x_{workforce}$ is discretized as follows:
    - $x_{workforce} = 0.33$ if there are less than 50 employees
    - $x_{workforce} = 0.67$ if there are 50–250 employees
    - $x_{workforce} = 1$ if there are more than 250 employees
- $x_{experience}$ is a discrete score between zero and one that represents a business' experience in related industries. $x_{experience}$ is discretized as follows:
    - $x_{experience} = 0$ if the business has no related experience
    - $x_{experience} = 0.33$ if the business has oil and gas experience
    - $x_{experience} = 0.67$ if the business has land-based wind energy experience
    - $x_{experience} = 1$ if the business has offshore wind energy experience
- $x_{certification}$ is a discrete score, either zero or one, that identifies a business's relevant certifications. $x_{certification}$ is discretized as follows:
    - $x_{certification} = 0$ if the business has not identified any relevant certifications
    - $x_{certification} = 1$ if the business has identified one or more relevant certifications
- Each of the above three scores are multiplied by weighting factors of 0.25, 0.35, and 0.4, respectively. This weighting indicates that a business's certifications are most important, followed by its experience in related industries, followed by the size of its workforce.

B.5 Individual Facility Evaluation

The initial Tier 1 component supply and demand estimated were constructed using cost, throughput and construction time estimates (Table B-4), in addition to project deployment estimates from the scenarios (detailed in Appendix A). Announced manufacturing facilities (Table B-5) were modeled using publicly available data.

Unless specified, for all modeled facilities (announced or hypothetical), we assume a production ramp-up period to full capacity of 50% in the first year, 75% in the second year, and 100% from the third year on.

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Table B-4. Average Tier 1 Manufacturing Facility Specifications (adapted from Shields et al. 2023)

Component	Throughput (components/year)	Capital Investment ($ millions)	Permitting and Construction (years)
Blade	225	300	3–5
Tower	100	250	3–5
Monopile	100	400	2

Table B-5. Announced Tier 1 Manufacturing Facilities on the East Coast (McCoy et al. 2024)

Company	Tier 1 Component	Location	Estimated COD	Estimated Annual Production
EEW	Monopiles	Paulsboro, New Jersey	2026	100 monopiles annually after Phase 2 is completed in 2026
US Wind/Haizea	Monopiles & towers	Sparrows Point, Maryland	2025	100 monopiles annually at full capacity (before partnership with Haizea). Tower capacity unclear but assumed to be 100.
Marmen Welcon	Towers	Albany, New York	2026	150 towers annually (or 100 towers and 100 transition pieces)
US Forged Rings	Towers	Undisclosed (East Coast)	2026	100 monopiles annually at full capacity

While Figure 11 in Section 5.1 summarizes supply and demand after including hypothetical facilities, Figures B-1 to B-3 present a breakdown of modeled Tier 1 supply and demand by component, demonstrating the magnitude of the shift in component availability before and after one or two additional (hypothetical) facilities are incorporated into the East Coast supply chain.

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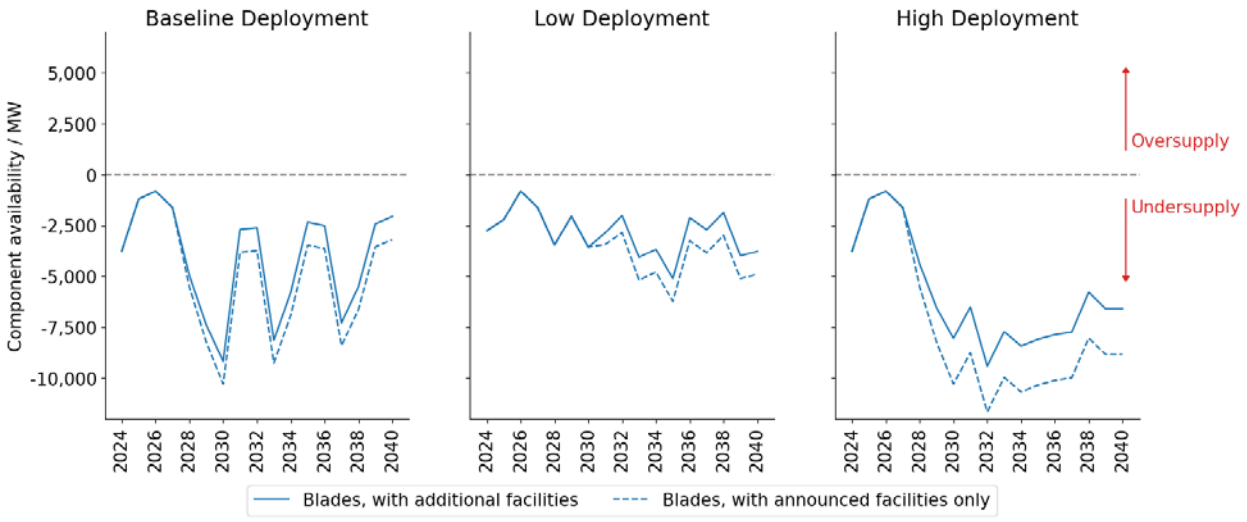

Figure B-1. Modeled East Coast blade supply after meeting demand (supply minus demand) with and without additional facilities in the SMART-POWER region.

We model one additional facility in the baseline and low deployment scenarios and two additional facilities in the high deployment scenario. Zero megawatts of supply after meeting demand suggests perfect domestic market equilibrium.

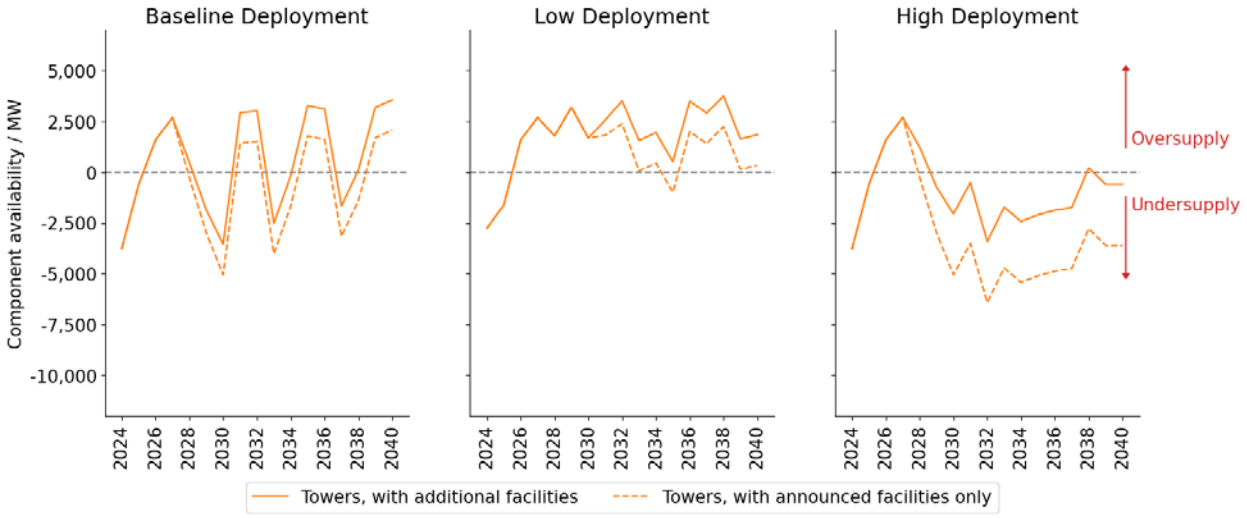

Figure B-2. Modeled East Coast tower supply after meeting demand (supply minus demand) with and without additional facilities in the SMART-POWER region.

We model one additional facility in the baseline and low deployment scenarios and two additional facilities in the high deployment scenario. Zero megawatts of supply after meeting demand suggests perfect domestic market equilibrium.

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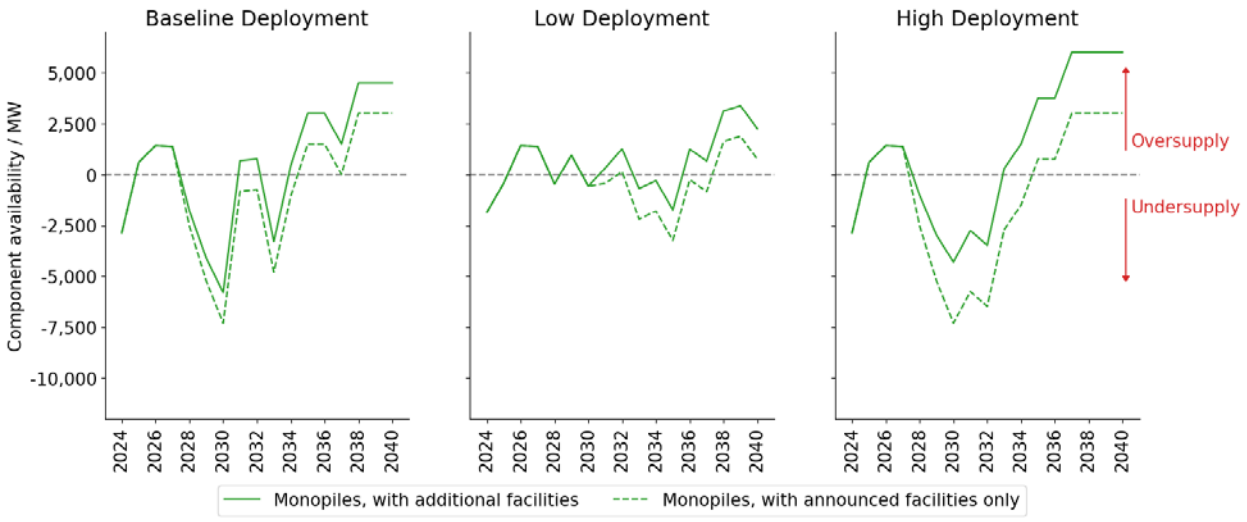

Figure B-3. Modeled East Coast monopile supply after meeting demand (supply minus demand) with and without additional facilities in the SMART-POWER region.

We model one additional facility in the baseline and low deployment scenarios and two additional facilities in the high deployment scenario. Zero megawatts of supply after meeting demand suggests perfect domestic market equilibrium.

To evaluate facility investments, three metrics were developed, building on previous NREL research, defined and calculated as outlined in Table B-6.

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Table B-6. Individual Facility Metric Definition and Methodology

Individual Facility Metric	Definition	Method
Business case	Are **manufacturers** likely to find this investment as an attractive opportunity, influenced by the domestic demand and any incentives they can capture?	A cash flow model was developed for each facility, where the main inputs are the available market, incentives such as the AMPTC and the operational date. The resulting Internal Rate of Return is used to compare across business cases and is indicative but not representative of potential facility cash flows, therefore the numerical values are not reported.
Missed opportunity	How might the business case decrease from losing a first-mover advantage if **states** do not encourage and secure investments early?	Using the same cash flow model as the business case metric, an additional facility is added to the scenario with the same operational date and production rate to simulate increased competition.
Adequate U.S. supply	Are **developers** able to meet their component needs with domestic supply or will they face supply chain bottlenecks?	Calculated as the percentage of total component demand that is met by each scenario's total component supply.

Overall facility investment takeaways and metric interpretation in Section 5.2 are complemented with insights from intermediary metric outputs, such as factory utilization rate, capture of AMPTCs, and potential business case without AMPTCs.

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Appendix C. Supporting Context for Port Community Considerations

In support of Section 3, the following subsections contain additional statistics and information from the community impact metrics and port community research.

C.1 Community Impact Metric Breakdown

The six factors included in the environmental vulnerability metric (Figure 6) present similar trends across ports. Figure C-1 below shows the percentage of the total score each factor contributes to. Across the board, Superfund site proximity and adult asthma incidence appear to be the greatest contributors to environmental vulnerability at port communities, although wastewater discharge is a third major contributor at Port of Wilmington, Delaware, Sparrows Point, Maryland, and Port of Wilmington, North Carolina. The port community within the 5-mile radius of Radio Island at the Port of Morehead City has an environmental vulnerability score of zero due to low incidence of all factors.

The SMART-POWER states as a whole exhibit similar trends, with overall higher relative incidence of adult asthma than Superfund proximity.

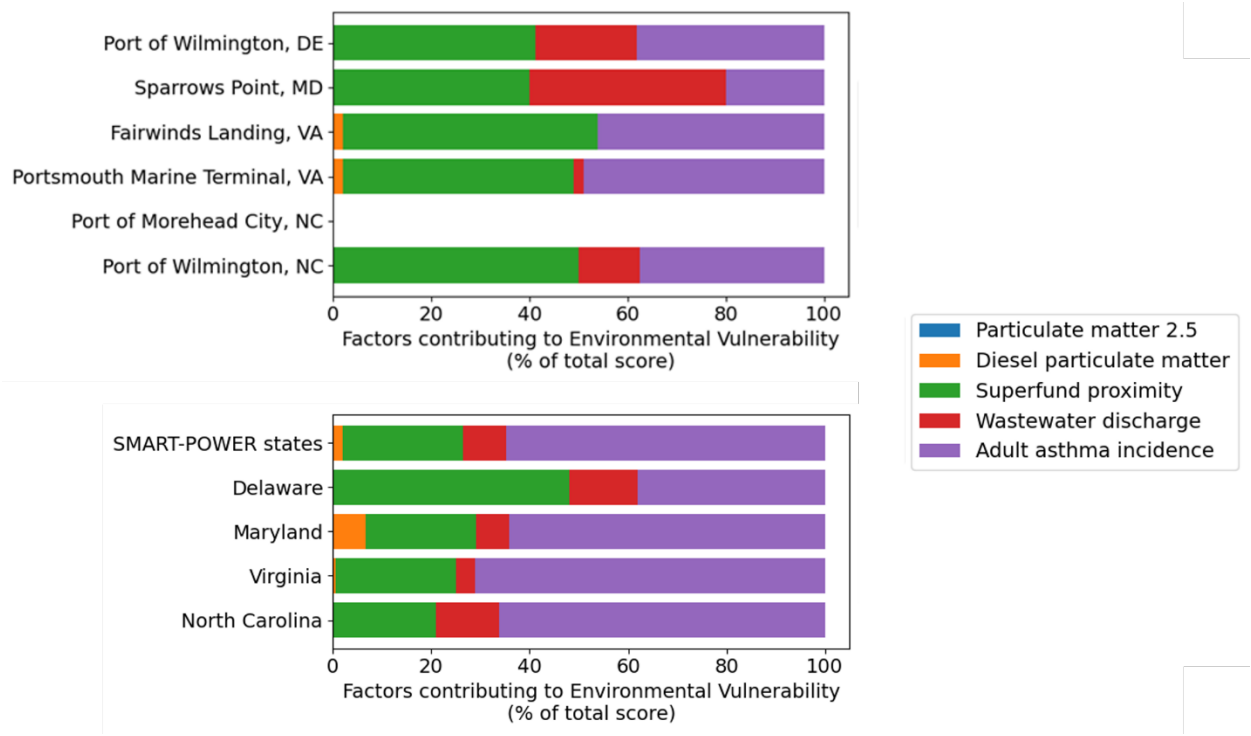

Figure C-1. Breakdown of environmental vulnerability metric into contributors. Top: port breakdown, bottom: comparison by state and for the SMART-POWER region.

Port of Morehead City, North Carolina, has a score of zero, therefore no breakdown is available.

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The three factors that make up the barriers to economic mobility metric scores (Figure 6) vary more across ports; their breakdown is presented in Figure C-2. Port of Wilmington, Delaware, as well as the Hampton Roads area in Virginia (encompassing Fairwinds Landing and Portsmouth Marine Terminal), experience a similar contribution of low median household income and households below the federal poverty level as barriers to economic mobility. Port of Wilmington, Delaware, is also the only port with linguistic isolation contributing as a potential barrier to economic mobility.

By contrast, the barriers to economic mobility score at Sparrows Point is entirely made up of low median household income, which indicates a lower household income relative to each port's respective metropolitan area or non-metropolitan county (Department of Housing and Urban Development n.d.[a]), but not necessarily below the federal poverty level. The barriers to economic mobility at Port of Wilmington, North Carolina, present the opposite trend, with the greatest contribution being household income below the federal poverty level, but not as many households with low median income relative to their broader metropolitan area or non-metropolitan county. The port community around Radio Island at the Port of Morehead City also again presents a score of 0.

At the state and regional level, low median household income and household income below the federal poverty level have similar contributions to the overall score, although linguistic isolation becomes a greater relative barrier.

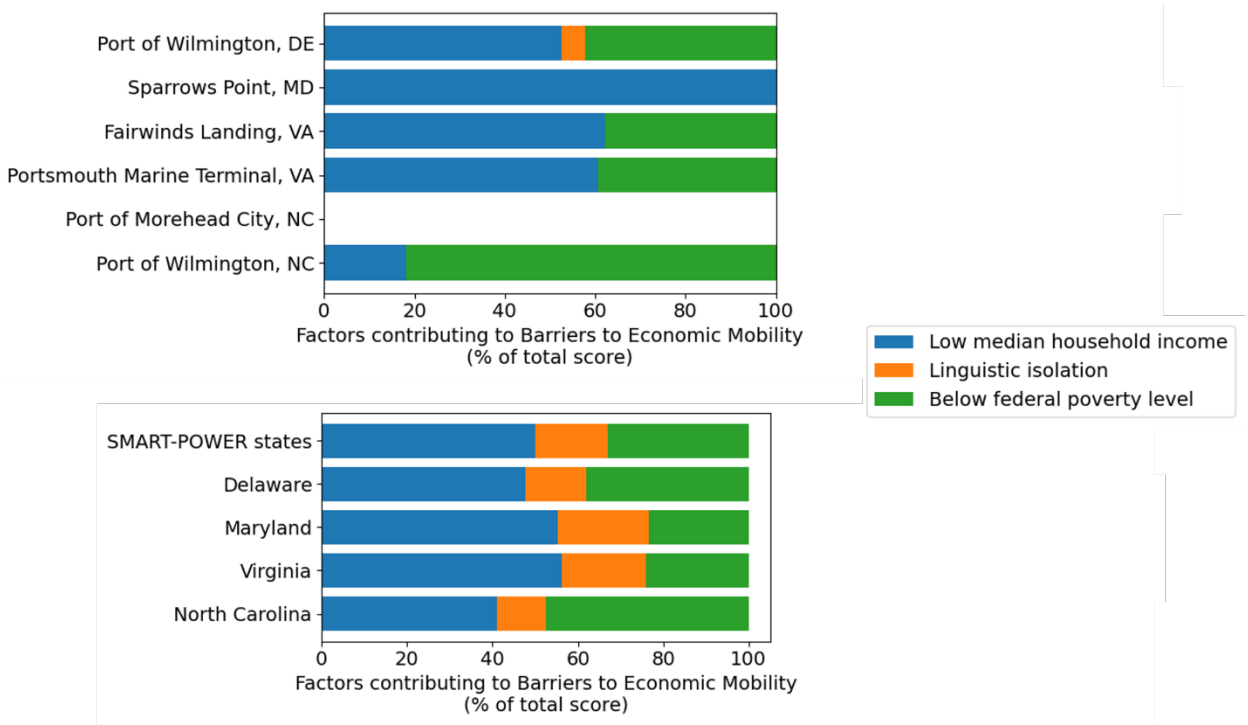

Figure C-2. Breakdown of barriers to mobility metric into contributors. Top: port breakdown, bottom: comparison by state and for the SMART-POWER region.

Port of Morehead City, North Carolina, has a score of zero, therefore no breakdown is available.

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C.2 Statistics Supporting Community Profiles

Figures C-3 to C-7 complement the community profile summaries presented in Section 3.3, detailing the demographic and socioeconomic characteristics of port communities and their comparison to state and national averages.

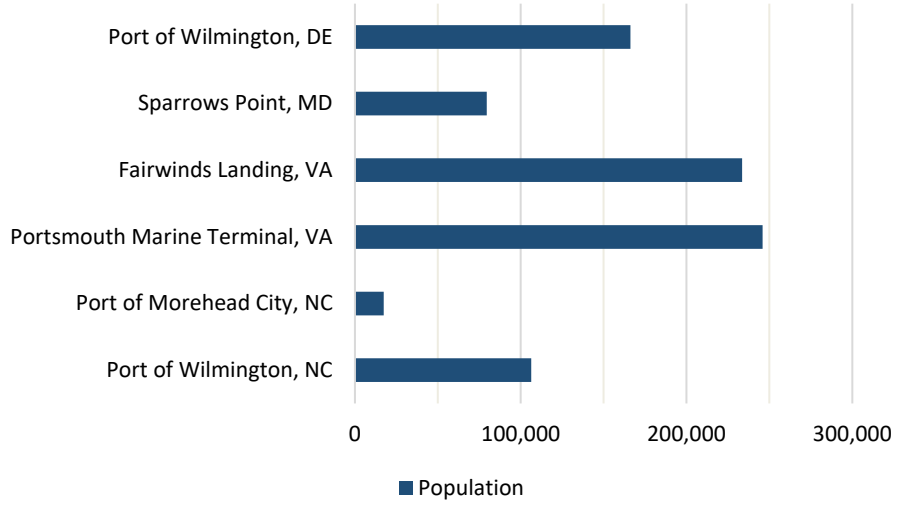

Figure C-3. Port community population estimates

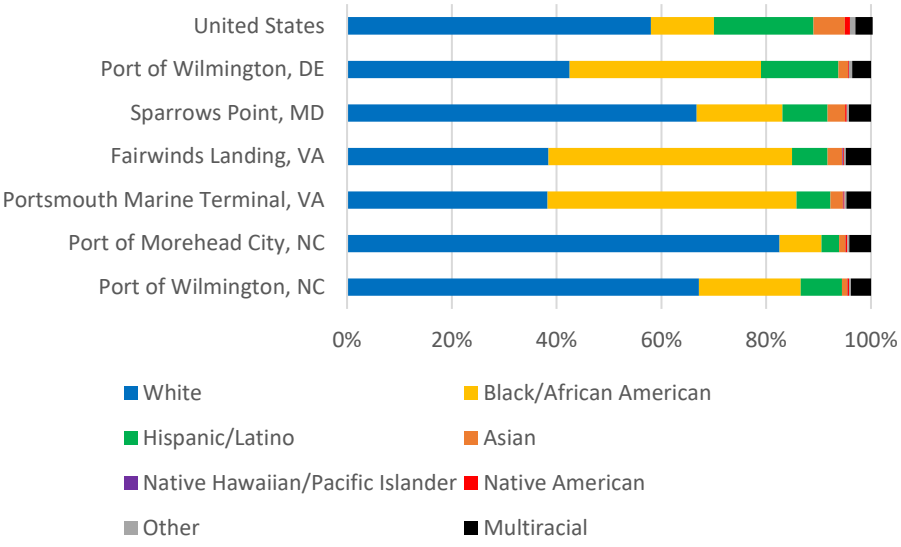

Figure C-4. Race/ethnicity breakdown by port community

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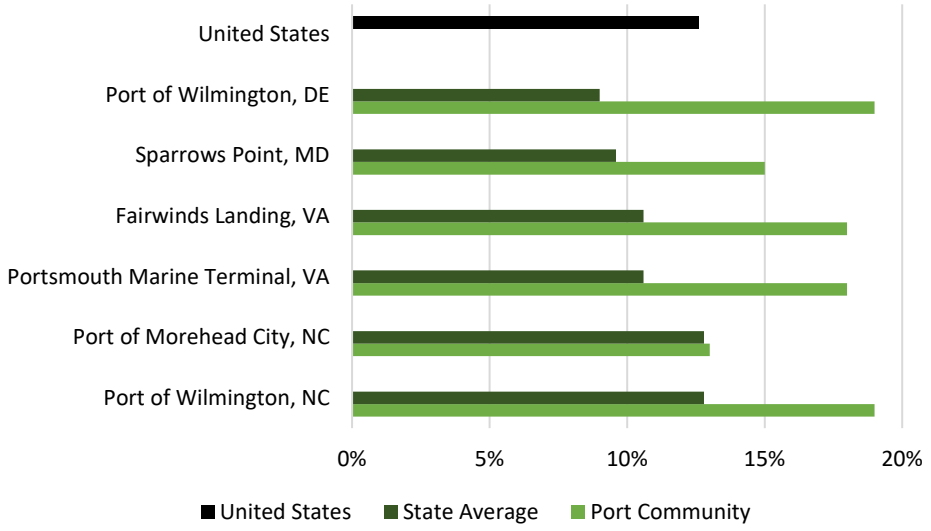

Figure C-5. Percentage of population below federal poverty line by port community

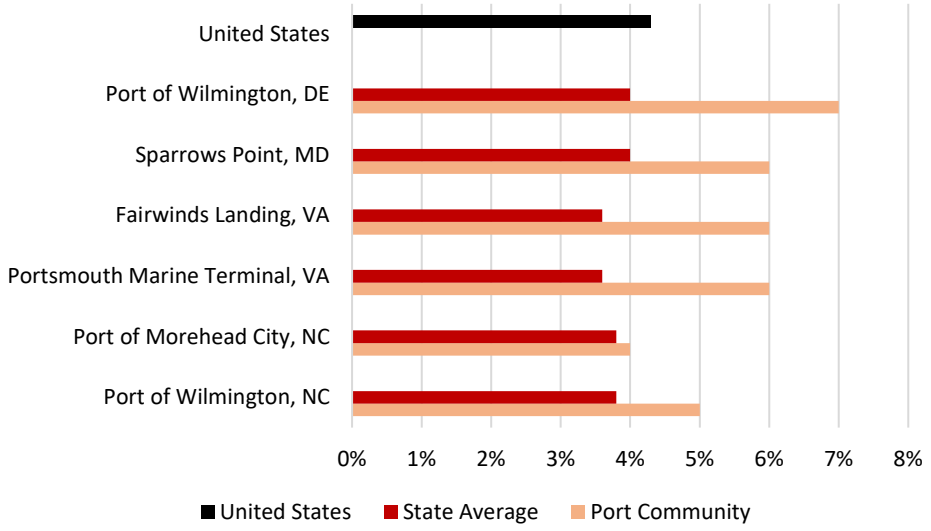

Figure C-6. Percentage of population unemployed (for population 16 years and over) by port community

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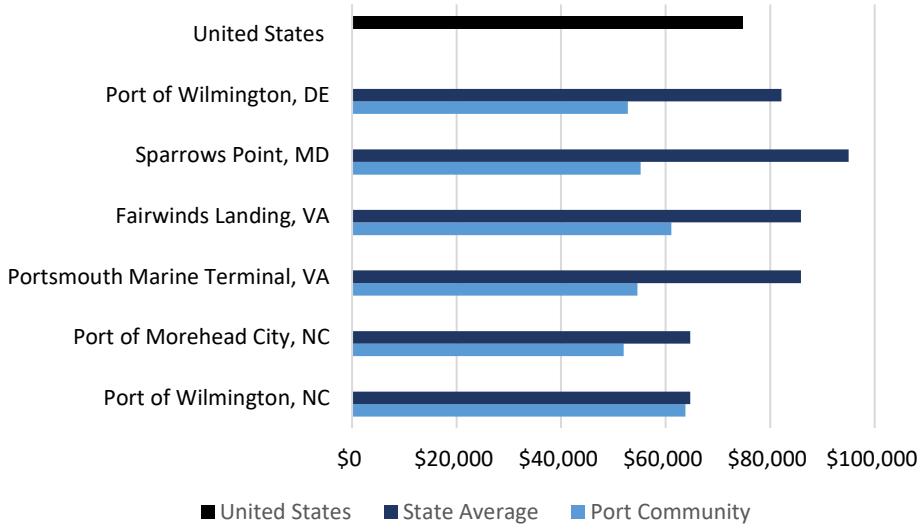

Figure C-7. Median household income in the past 12 months (in 2022 inflation adjusted dollars) by port community

C.3 Community Engagement Interviews

As part of the port community research and the Portsmouth Marine Terminal community insights, we carried out interviews with port community stakeholders. The following points summarize the interview that was the most pertinent to issues relating to community engagement and community impacts or benefits at Portsmouth Marine Terminal; these points are a complement to the information presented in Section 3.3.

Interviewed person and organization: Garry Harris, President, Center for Sustainable Communities

Environmental Vulnerability

- Concern: High asthma rates, pollution, environmental impacts, and public health issues, including hypertension and cancer mortality, are significant problems in Portsmouth.
- Goal to address concern: Mitigate environmental and public health issues through a community benefits agreement and improved environmental practices.
- Current Community Initiatives: A consortium of Hampton Roads groups—including urban leagues, community colleges, unions, military, and renewable energy advocacy groups—is being formed to address these issues and ensure no externalities are associated with the project.
- Exemplary Programs to Possibly Emulate or Adopt: The Regional Energy Democracy Initiative in Texas and Louisiana focuses on energy democracy.

Barriers to Economic Mobility

- Concern: Dominion supply chain engagement for CVOW is not reaching Portsmouth businesses.

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- Goal to address concern: Inform local businesses of Dominion event(s) with enough lead time and preparation that local businesses can meaningfully participate.
- Current community initiatives: Development of a community-based app for renewable energy workforce development, involvement of the University of Michigan and Georgia Tech in project support, and the creation of community benefits plans and advisory boards to guide project integration and impact.
- Concern: Economic challenges include housing affordability, sustainable wage jobs, energy burdens, and health disparities, which hinder economic mobility.
- Goal to address concern: Enhance economic opportunities through job creation, workforce development, and supportive economic policies tailored to the community's needs.
- Current community initiatives: The creation of jobs and small businesses through renewable energy initiatives and workforce development programs; engagement with local institutions like Centura College for training and education.

Investment Impact Potential

- Concern: There is a need to ensure that investments in renewable energy and infrastructure projects provide tangible benefits to local communities, especially historically underinvested-in areas.
- Goal to address concern: Maximize the positive economic impact of investments by ensuring that they contribute to regional prosperity, job creation, and the development of local industries.
- Current community initiatives: Community ownership over projects/project impacts. Pivoting toward a more community-centric approach overall, including tools such as Community Benefits Agreements, an advisory board, outreach efforts, and forums.

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Appendix D. Tier 2 and Tier 3 Supply Chain Hierarchy Maps

The structure and component diversity of Tier 2 and Tier 3 suppliers required for Tier 1 manufacturing can be best understood via supply chain hierarchy maps, generally composed of one finished Tier 1 component, made up of Tier 2 subassemblies, which are themselves made up of Tier 3 subcomponents (as outlined in Figure D-1). We present hierarchy maps for the three focus areas (blades, towers, monopiles) as well as for transition pieces in Figures D-2 to D-5.

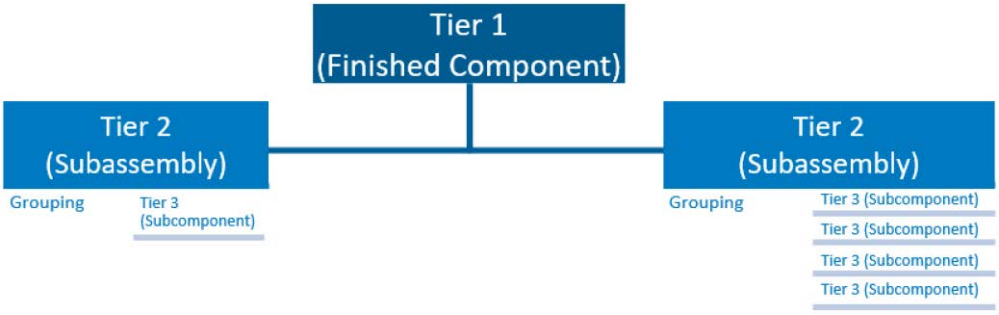

Figure D-1. Key to offshore wind supply chain hierarchy maps that start at the Tier 1 level

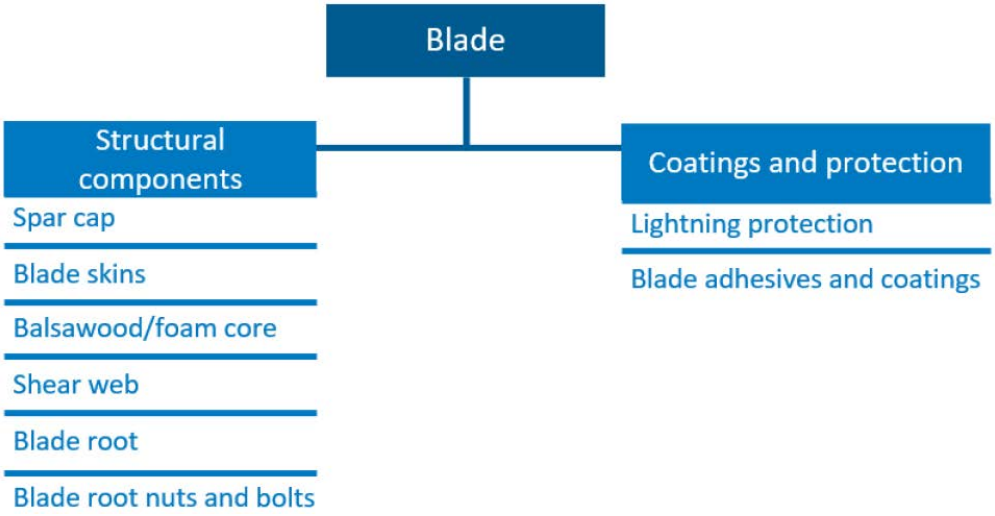

Figure D-2. Blade supply chain hierarchy of Tier 2 subassemblies and Tier 3 subcomponents

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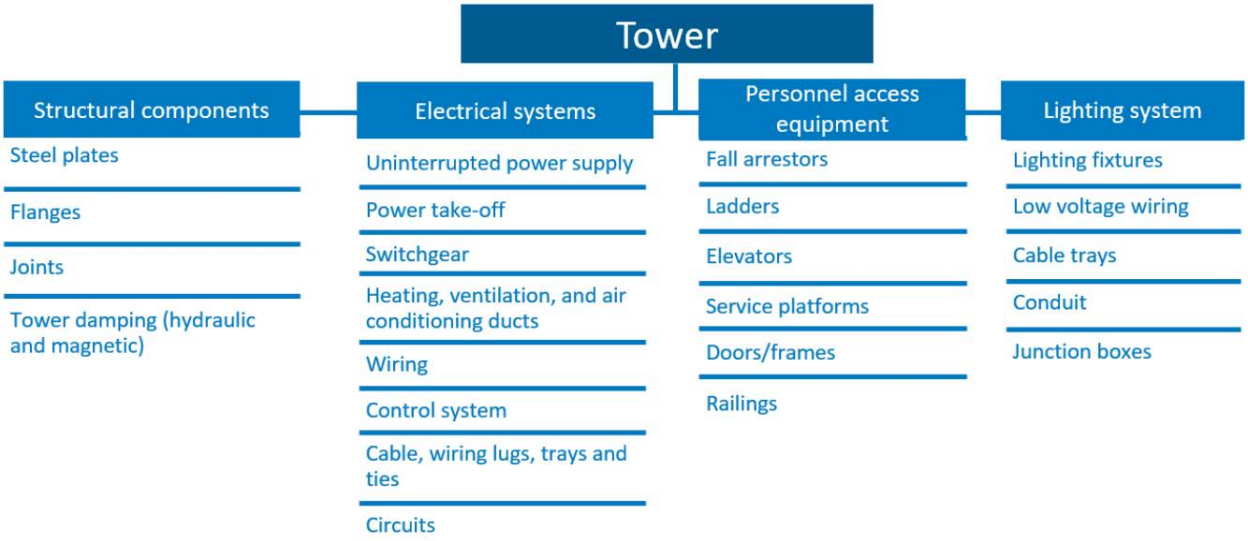

Figure D-3. Tower supply chain hierarchy of Tier 2 subassemblies and Tier 3 subcomponents

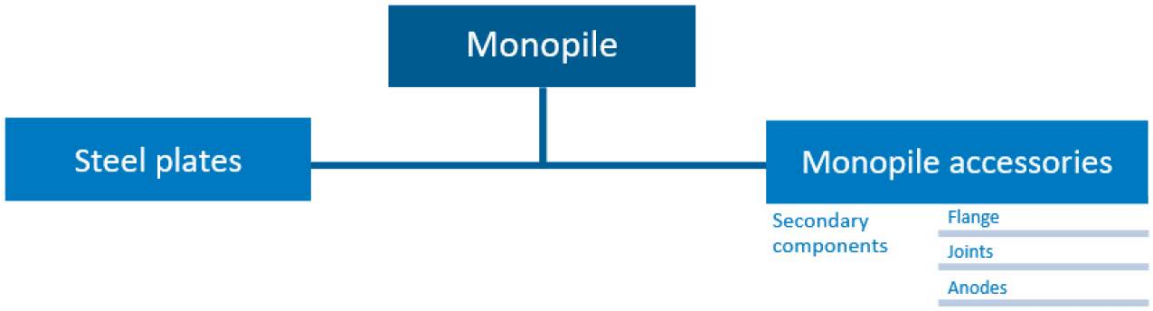

Figure D-4. Monopile supply chain hierarchy of Tier 2 subassemblies and Tier 3 subcomponents

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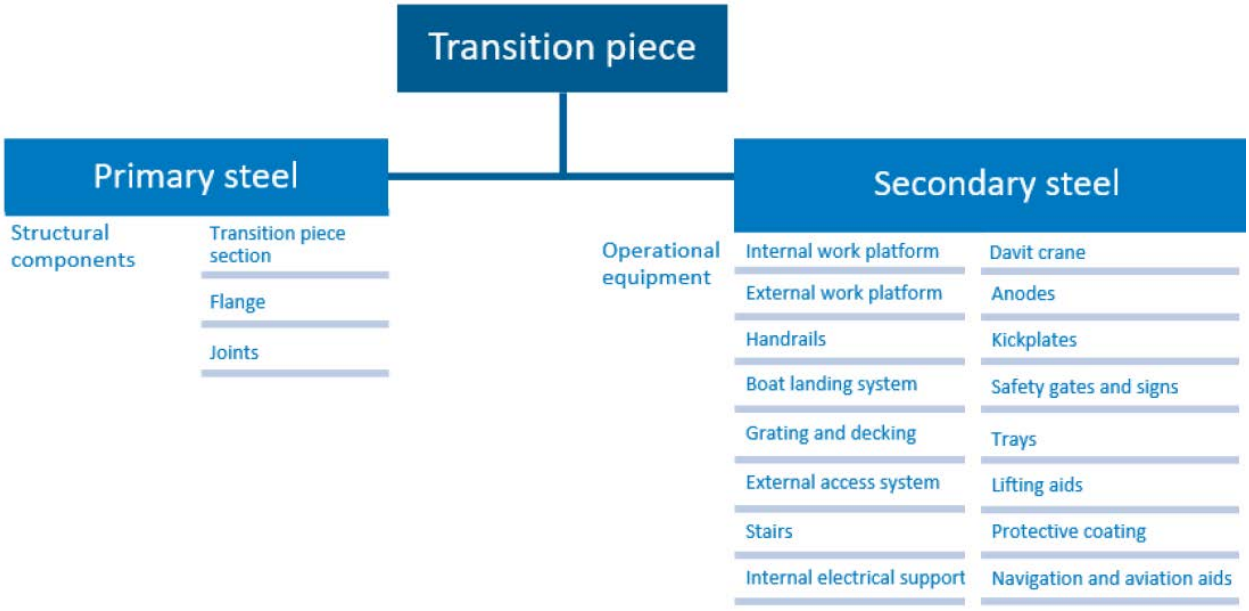

Figure D-5. Transition piece supply chain hierarchy of Tier 2 subassemblies and Tier 3 subcomponents

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Appendix E. Indicative Port Characteristics

The general estimated characteristics for indicative SMART-POWER ports are presented in Table E-1, gathered from each port's publicly available information.

Table E-1. Characteristics of Indicative SMART-POWER Ports for Tier 1 Manufacturing

Port	State	Meets Laydown Area Requirements	Estimated Laydown Area (acres)	Meets Navigation Channel Depth Requirements	Estimated Navigation Channel Depth (m)
Port of Wilmington	Delaware	No	32	Yes	10–14
Sparrows Point	Maryland	Yes	168	Yes	12–14
Fairwinds Landing	Virginia	Yes	111	Yes	10–12
Portsmouth Marine Terminal	Virginia	Yes	120+	Yes	12–15
Port of Morehead City	North Carolina	Yes	139	Yes	12.8
Port of Wilmington	North Carolina	Yes	86	Yes	12.8

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