Addressing U.S. Manufacturing and Service Capacity/Gaps and Technical Standards

LABOR ENERGY PARTNERSHIP

Prepared by
David W. Cash
June 2022

FOREWORD

This paper was prepared by David W. Cash for the Labor Energy Partnership Offshore Wind Workshop and is not intended to reflect the views, opinions or research of the Labor Energy Partnership.

About the Labor Energy Partnership

The Labor Energy Partnership (LEP) is based on a shared commitment of the AFL-CIO and the Energy Futures Initiative (EFI) to promote federal, regional and state energy policies that address the climate crisis while recognizing the imperatives of economic, racial and gender justice through quality jobs and the preservation of workers' rights.

Suggested Citation: Cash, D. W. (2022, June). *Addressing U.S. Manufacturing and Service Capacity/Gaps and Technical Standards*. © 2022 Labor Energy Partnership.

Acknowledgements

The following experts generously donated their time and knowledge through interviews: Jocelyn Brown-Saracino, Bruce Carlisle, Jennifer Cullen, Anna Fendley, David Foster, Hayes Framme, Patrick Gilman, Ross Gould, Dave Hume, Stephen Johnson, Margaret Lemmerman, Brian Lombardozzi, Jesse Mermell, Walter Musial, Riley Ohlson, Dale Reckman, Matt Shields, Paul Spitsen and Grant van Wyngaarden. The views presented in this paper do not necessarily reflect the views of these interviewees.

This paper was supported by funds from the Labor Energy Partnerhip.

EXECUTIVE SUMMARY

This paper attempts to analyze the existing offshore wind (OSW) supply chain and value chain capacity and gaps in U.S. manufacturing, vessels, ports, workforce development and standards. It further identifies opportunities and constraints in meeting goals of equity as the domestic OSW sector develops across all these dimensions. As the Biden administration notes, the development of the OSW sector offers the prospect not only to reduce emissions at scale, but also to seize the opportunity to create jobs along the value chain, create union and high-wage jobs, reduce U.S. sector uncertainties and drive equity, especially in overburdened and vulnerable communities.

This paper frames the above issues with a goal to guide discussion about policy options that can help capture the benefits of a domestic OSW industry (environmental, economic and equity). A complete analysis of policy recommendations is presented in White Paper #3 of this series, *Advancing Policy Measures to Drive Development of the Domestic Offshore Wind Supply Chain*.

Key Findings

- The OSW market is evolving rapidly, as the Biden administration puts in place OSW initiatives and states drive more OSW procurement.
- While there is greater market certainty, there is still enough uncertainties to stunt some investments in critical supply chain components, such as steel and iron castings, where China is a dominant player.
- While there had been concern about boom-and-bust cycles, the pipeline for projects on the East Coast are such that there should be relative steadiness for capital expenditures (CAPEX) on components through at least 2030.
- Across a number of indicators, minority-owned businesses and diversity of leadership in the OSW workforce are areas of needed improvement, although states and developers are including a variety of procurement requirements that advance diversity, equity and inclusion goals, and the Biden administration is launching the Justice40 initiative.
- Developers are investing in manufacturing facilities, ports, training, vessels and other critical parts of the supply chain to ensure sourcing—in essence, verticalizing the supply chain.
- States are aggressively and competitively investing in ports, workforce development and other infrastructure to attract economic development.
- The two previous points expose a dynamic that could lead to relatively quick up-front deployment of OSW assets but is ad hoc and not strategic from a regional economic investment and infrastructure perspective.
- Building a domestic supply chain will require a broad range of technical, managerial, administrative and trades skills. At this point, as in other areas of supply chain development, there is little strategic effort to understand the needs and develop sectorwide training. Unions, community colleges, Maritime Administration (MARAD)–based institutions and others are existing organizations that have already stepped in to begin meeting this growing need.
- It is still unclear how international construction, electrical and maritime standards or European standards used by many of the developers who are active in the United States will synchronize with emerging U.S. standards. Efforts are underway between the U.S. Department of Energy (DOE), the American Clean Power Association, the Business Network for Offshore Wind (BNOW) and other stakeholders to develop and harmonize standards.
- Across all of the above areas, more comprehensive data collection and management must be implemented.

0. Context

On March 29, 2021, the Biden administration announced a national target of deploying 30 gigawatts (GW) of OSW by 2030. In announcing this target, the administration presented a range of benefits, including emissions reductions to mitigate the impacts of climate change, job growth, bringing justice to overburdened communities, supporting an economic transition to clean energy for fossil fuel–dependent and underserved communities and enhancing national security. One focus of the initiative highlighted by the White House is the benefits of building a robust domestic supply chain as the backbone of the growth of the OSW sector and capturing benefits across the entire OSW value chain:

> Massive supply chain benefits of deploying OSW energy at scale: Meeting the 2030 target will catalyze significant supply chain benefits, including new port upgrade investments totaling more than $500 million; one to two new U.S. factories for each major windfarm component, including wind turbine nacelles blades, towers, foundations and subsea cables; additional cumulative demand of more than 7 million tons of steel—equivalent to four years of output for a typical U.S. steel mill; and the construction of four to six specialized turbine installation vessels in U.S. shipyards, each representing an investment between $250 million and $500 million. (White House, 2021a)

The OSW target is one component of the administration's larger goal of addressing the challenges of climate by reaching net-zero greenhouse gas emissions by 2050 (White House, 2021b) and by seizing the economic opportunities of moving rapidly to a clean energy future (White House, 2021c). In addition, the increasing urgency of addressing climate change has been reiterated by recent reports from international scientific and energy organizations that outline the high degree of scientific certainty of large-scale expected negative impacts of climate change in a business-as-usual scenario (Intergovernmental Panel on Climate Change [IPCC], 2021) and the need to rapidly transition away from a fossil fuel–based economy (International Energy Agency [IEA], 2021).

As this international consensus has solidified, so has international pressure for a global compact that is more enforceable and robust than the Paris Agreement. At the United Nations Framework Convention on Climate Change (UNFCCC) 2021 Conference of the Parties (COP), although enforceability was not achieved, countries continued to pledge greater emissions reductions through national actions. For many countries, this will translate into increased expansion of OSW markets, technology development and deployment (UNFCCC COP26, 2021).

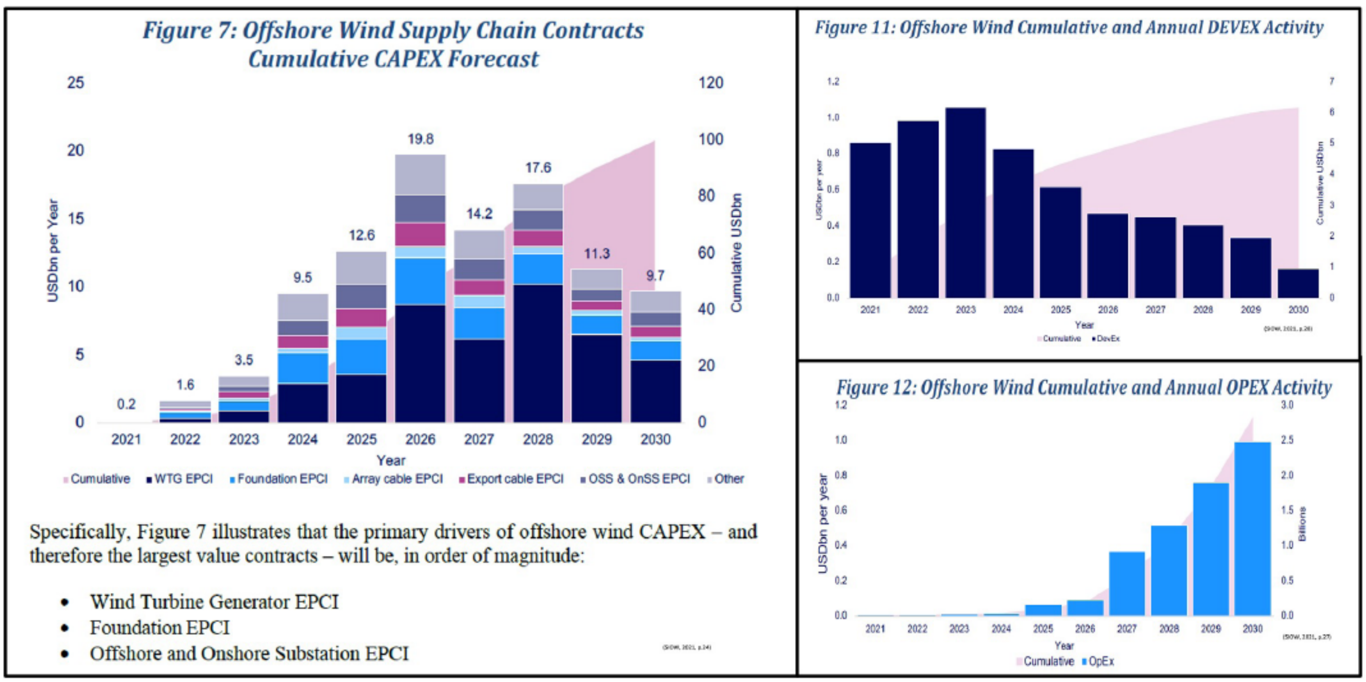
Prior to the Biden administration, OSW was already poised to grow. In 2020, the OSW project pipeline grew by 24%, from 28.5 GW to 35.3 GW, and state policies and procurement plans represented a commitment to almost 40 GW (Musial et al., 2021). This March, the New York Wind Bight aAuction conducted by the Bureau of Ocean Energy Management (BOEM) leased Wind Energy Areas totaling almost a half-million acres of land for OSW projects, bringing in a record-breaking $4.37 billion in winning bids for six parcels. At least in part, that growth was spurred by state incentives and policies designed to capture both the environmental benefits of renewable energy and the economic and job growth benefits of the expansion of a U.S. supply chain.

While activity at the federal, state and international levels and in the private sector signals rapid growth, there are significant questions about the adequacy of the U.S. domestic supply chain, as current U.S. OSW development deeply depends on the global supply chain and markets. In attempting to develop a robust domestic supply chain, the United States is playing catch-up with Asia and Europe, both regions that have relatively mature markets, manufacturing, port and vessel infrastructure, government support and relative investment certainty. "The OSW supply chain remains largely global, with a growing number of U.S. offshore energy and onshore wind suppliers preparing to enter the industry. Many of the supply chain actors, both international and domestic, are grappling with the questions of whether, when, and where to set up manufacturing hubs in the U.S." (McClellan, 2019, p. 28).

1. CAPEX, Development Expenditures (DEVEX) and Operations Expenditures (OPEX)

Recent analyses point to an enormous economic engine if the Biden administration's 30-GW goal is realized. The most recent supply chain report from the University of Delaware's Special Initiative on Offshore Wind (SIOW) "forecasts a nearly $109 billion revenue opportunity for U.S. OSW component suppliers through the end of the coming decade and highlights this sector's critical inflection point" (McClellan, 2019, p. 28). This research updates other recent work that has attempted to identify the largest drivers of CAPEX categories that can help focus investment in and development of U.S. manufacturing facilities. As illustrated in **Figure 1**; (McClellan, 2019, pp. 24, 27, 28), the engineering, procurement, construction and installation (EPCI) of three drivers constitute the majority of CAPEX expenditures: wind turbine generators, foundations, offshore/onshore substations and export and array cables. The total cumulative CAPEX value through 2030 is *approximately* $100 billion, while DEVEX and OPEX are much smaller portions, at approximately $6 billion and $2.5 billion, respectively. OPEX will continue to rise beyond 2030 as additional projects are completed and move to operations.

FIGURE 1



Two additional findings for U.S. supply chain development emerge from this and related research. The first is that the timing of the project pipeline provides a relatively constant and incremental increase in capital construction expenditures (see **Figure 2**; McClellan, 2019, p. 8). As the author of the SIOW report notes, "contrary to some prognostications, we do not predict an extreme boom-and-bust cycle for any of the key components; rather, we predict a steady CAPEX expenditure on these components" (McClellan, 2019, p. 24). "The procurement schedule forecasted here suggests that, when OSW power contracting slows down in one state, the momentum will continue in other states and continue to drive the supply chain potential of this massive and growing industry" (McClellan, 2019, p. 28). One consequence of this relates to manufacturing facilities, for whom there may be greater certainty than earlier predicted (see the next section and the importance of certainty). A second finding is that per-kilowatt CAPEX and OPEX are expected to decline through 2050, driven partly by economies of scale and partly by innovation, both of which interact with domestic and international supply chain dynamics (see **Figure 3**; National Renewable Energy Laboratory [NREL], 2021).

FIGURE 2

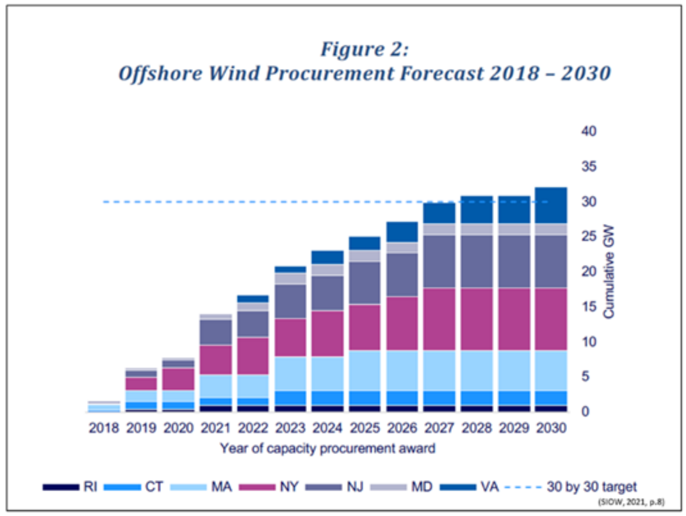
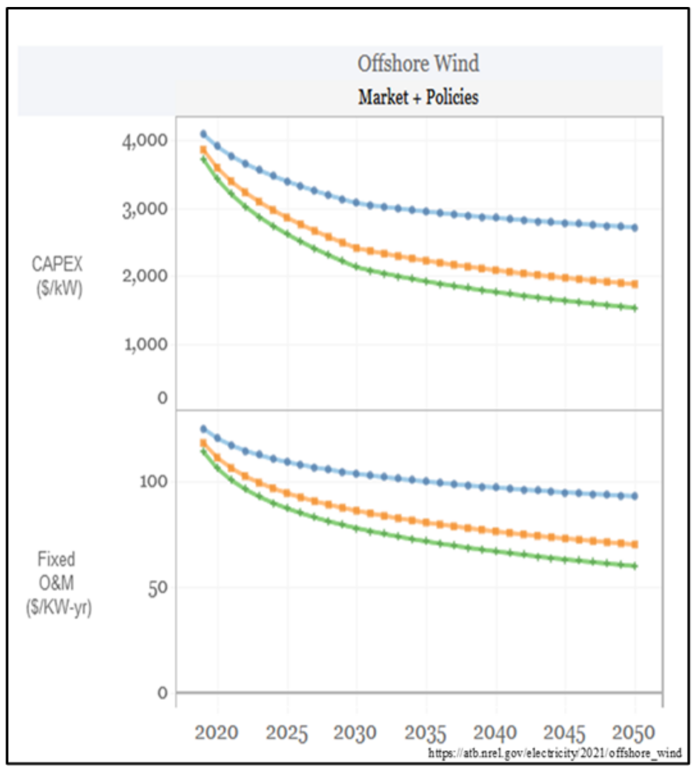


FIGURE 3



1.1. Discussion Questions

1.1.1. What are the implications for supply chain development of incremental (not boom-and-bust) capital investments?

1.1.2. How do U.S. research and development investments interact with supply chain dynamics?

1.1.3. What are the implications of economies of scale on supply chain dynamics?

1.1.4. What are the implications for the supply chain in the face of large and fast CAPEX changes (e.g., large steps in turbine size, commercialization of floating turbines, etc.)?

2. Manufacturing Facilities

The manufactured products required to deploy 30 GW of OSW by 2030 are significant: more than 2,000 towers, nacelles and blade sets; more than 8,000 kilometers of cables; and more than 50 offshore substations and foundations. The development, installation and service equipment required to support this deployment and operations and maintenance (e.g., monitoring, marine surveys, transportation) will be equally substantial.

A recent NREL study, *Power Sector, Supply Chain, Jobs and Emissions Implications of 30 Gigawatts of Offshore Wind Power by 2030*, projected the U.S. Tier 1 manufacturing gaps that will need to be filled by new or expanded facilities (see **Table 1**; Lantz et al., 2021, p. 15).

TABLE 1

Table 4. Production Facilities Required To Meet the 2020-2030 Annual Supply Chain Demand
(Sources include a variety of publicly available press releases and industry characterizations compiled by the authors)

Production Facility	Annual Output	Number Needed To Meet 2030 Target
Steel Mill	1,500,000 tons/yr	1
Monopile Factory	165 units/yr	2
Tower Factory	155 units/yr	2
Nacelle Factory	250 nacelles/yr	2
Blade Factory	600 blades/yr	2
Export Cable Fabrication	121 miles/yr	8

In addition, it is predicted that approximately 46 offshore substations and foundations and 17 onshore substations and foundations will be needed through 2030 (McClellan, 2019, p. 19). While there is uncertainty, "[i]t is worth noting that the number of 'new-build' onshore substations required, or indeed the level of work required to upgrade pre-existing facilities, is a factor of the current specifications of the existing infrastructure in each state; OSW projects are expected to make use of existing facilities where possible" (McClellan, 2019, p. 22).

De-Risking Capital Investment

The fundamental question of whether or not U.S. companies can meet this demand hinges largely on market and policy certainty. Retooling existing facilities or building new facilities requires large up-front investments—in some cases, on the order of more than approximately $200 million. Uncertainty over whether the OSW sector will continue to grow creates risk that will dampen such investments. Clearly, the policy environment will have a large impact on this uncertainty. While the companion Labor Energy Partnership White Paper #3, *Advancing Policy Measures to Drive Development on the Domestic OSW Supply Chain*, goes into depth on policy tools, a portfolio of possible tools that raise the certainty of market growth includes but is not limited to extension of the Production and Investment Tax Credits, adequate loan guarantees, long-term power purchase agreements, renewable and clean energy standards and robust international agreements.

Collaboration/Competition With Europe and China

As the OSW market has launched in the United States, it has depended on, to varying degrees, European manufacturing, technical expertise and materials, especially for products and services that cannot be procured through the already existing U.S. land-based wind supply chain. In addition, all of the major projects in the U.S. pipeline are driven by European firms that bring a greater familiarity of the European supply chain, although several see advantages of broadening the U.S. supply chain. As Ørsted Offshore North America CEO David Hardy testified at an October 2021 hearing of the U.S. House Committee on Energy and Commerce Subcommittee on Energy:

> One of the challenges facing the U.S. OSW industry is the capacity and expertise within the supply chain. Ørsted has a two-pronged approach to help solve this challenge. This includes 1.) building U.S. infrastructure with American companies and 2.) attracting European firms to build U.S. facilities, creating foreign direct investment and American jobs." (U.S. House of Representatives, 2021, p. 2)

Of course, policy can have a significant impact on the pace and depth of these kinds of approaches, and Hardy noted at the end of his testimony that "Europe has had several decades to build the necessary infrastructure to support a mature OSW industry. In order to meet the U.S.'s goal of 30 gigawatts by 2030, we need to continue prioritizing the development of the U.S. supply chain. While it is possible to achieve our shared vision, this hard work requires a continued commitment from public and private partners at the local, state and federal levels to grow the industry in the decades ahead" (U.S. House of Representatives, 2021, p. 5). Also, see the Spotlight on this page.

European firms entering the U.S. market will continually be balancing costs, timing, reliability of product delivery and politics as they navigate and integrate U.S. and European supply chains. Often this navigation will be collaborative, and there are many examples in the United States of the kind of dynamic that Hardy described as the "two-pronged" approach to solving the U.S. supply chain challenge. Examples includes the expansion of onshore wind in the United States and the growth of the oil and gas industry. But supply chain dynamics are also competitive. At this early stage in the U.S. OSW sector, led by European developers, it is not a surprise that at least for the short term, there will be competition between U.S. and European suppliers, although during the past five years, increasing U.S. content has already been evident, a trend predicted to continue over the next decade.

SPOTLIGHT

Ørsted's Two-Pronged Approach to Building a Supply Chain

Ørsted, headquartered in Denmark with a U.S. office in Boston, has been awarded 4,000 megawatts (MW) of development rights in six projects along the East Coast. As the developer of the first U.S. offshore wind farm, Block Island, Ørsted has had more time to solve supply chain challenges than other developers. As noted in the text, the company approaches the supply chain development with a two-pronged approach, illustrated by two examples:

1. **Building U.S. infrastructure with American companies.** Example: It is contracting with Riggs Distler & Company, Inc., a New Jersey general contractor that will manage the 934-MW Sunrise off the coast of New York. Riggs Distler will provide a broad range of onshore heavy civil, mechanical, and electrical services centered around the construction, assembly, inspection, and installation of the Sunrise Wind advanced foundation components. (Riggs Distler, 2021).
2. **Attracting European firms to build U.S. facilities, creating foreign direct investment and American jobs.** Example: Without a U.S. monopile fabricator, Ørsted signed and MOU with German steel fabricator Erndtebrücker Eisenwerk (EEW) for a joint investment in a manufacturing facility in the Paulsboro Marine Terminal in New Jersey (Maritime Executive, 2020). The agreement also includes commitments to union jobs, training and workforce development.

In addition to these two prongs, Ørsted has also invested in a range of community engagement, training, workforce development and the identification and contracting with minority- and women-owned enterprises.

Perhaps the largest competitive concern for U.S. OSW development is with Chinese steel. Chinese excess steel capacity continues to affect global markets and raise uncertainty about the viability and long-term sustainability of U.S. production for the OSW sector (Organisation for Economic Co-operation and Development, 2021). Iron castings represents a particular gap in the supply chain with no major domestic large iron casting manufacturing facility in the United States capable of being competitive at the needed production volumes (Johnson, 2021). A further complication with Chinese steel competing with U.S. steel is its relatively high carbon footprint. Chinese steel production has an energy intensity that is 50% greater than that of steel produced in the United States due to China's heavy reliance on coal-generated electricity and coal-produced coke to power its steel-making furnaces (Hasanbeigi & Springer, 2019). In a recent publication on OSW supply chain development, the U.S. Department of Energy (DOE) suggested that further investment into "green steel" production could further decarbonize steel production domestically and provide further incentive to use domestically sourced steel (DOE, 2022).

The range of collaboration and competition dynamics, as well as the lack of parity between U.S. and Chinese environmental regulations, points toward policy solutions such as domestic content requirements, federal, state and local incentives for siting manufacturing facilities and carbon border adjustment mechanisms.

Vertical Supply Chaining, Siting and Co-Locating

Strategies that are beginning to drive growth of significant U.S. supply chain facilities have often involved partnerships led by developers seeking to build Tier 1 manufacturing facilities that can feed projects a reliable source of component and material inputs. These are also often located at our near ports (see the following section), designed to limit transportation costs and increase manufacturing and assembly synergies. And as with the development of ports, these initiatives are often supported by state or municipal incentives, tax advantages, training programs, long-term power purchase agreements or renewable portfolio standards (see **Table 2** for a list of recent investments in these types of Tier 1 facilities).

TABLE 2. **OSW Manufacturing Investments in the United States**

Product	Contracting Firm	Investment	Location of Manufacturing Facility	Date of Announcement	Source
Steel	Ørsted and U.S. Wind	$76 million	Maryland	2017	(American Wind Energy Association [AWEA], 2021)
Foundations	Ørsted and EEW	$250 million	Paulsboro, New Jersey*	2019	(NREL, 2021)
Foundations	Equinor	Unspecified	Coeymans, New York*	2019	(McCue, 2021)
Cables	Marmon Utility	$4 million	Seymour, Connecticut	2019	(NREL, 2021)
Cables (for export to Scotland)	Nexans	Unspecified	Charleston, South Carolina	2020	(NREL, 2021)
Towers, transition pieces and foundations	Marmen Welcon and Smulders	$350 million	Albany, New York*	2021	(Marmen Welcon, 2021)
Blades	Dominion and Siemens Gamesa	$200 million	Portsmouth Marine Terminal, Virginia*	2021	(Siemens Gamesa, 2021)
Cables	Nexans, Ørsted and Eversource	$220 million	Charleston, South Carolina	2021	(Windpower Engineering & Development [WPED] Staff, 2021a)
Foundations	Ørsted and Eversource	$24 million	Providence, Rhode Island*	2021	(Revolution Wind, 2021)
Foundations	Ørsted, Eversource and Riggs Distler & Company	$86 million	Coeymans, New York*	2021	(Buljan, 2021)
Steel	Ørsted and Crystal Steel Fabricators	$76 million	Federalsburg, Maryland	2021	(Milligan, 2021)

**Indicates at a port.*

One potential advantage of these Tier 1 facilities is their ability to act as “anchor tenants,” attracting Tier 2 and 3 facilities to the same or nearby sites. This is seen in Europe in the OSW ecosystem and in the U.S. and international oil and gas sectors, but also in the United States in how some manufacturing has developed in the land-based wind sector. This has obvious advantages, especially for more complex outputs such as nacelles and substations, which have multiple components and subcomponents for which proximity to their manufacture might be advantageous. It also has advantages for the development and growth of the service and operations and maintenance (O&M) portions of the development cycle, where there may be a greater necessity for co-located portside service providers.

To the extent that new manufacturing facilities are built or old ones are retooled and/or expanded, this aspect of the OSW supply chain provides an opportunity for economic development targeted to create benefits for underserved and vulnerable communities.

While this growth may be internally strategic for developers and advantageous to successful states competing for economic development, there may be foregone opportunities for synergies and efficiencies without a more regional approach. “State competition is helping to quickly develop the market. However, more state coordination and cooperation is needed. As the industry matures, companies cannot build factories and operations in every state and a better understanding of the State’s assets along with specific needs would help the industry grow so there could be a focus for each state” (BNOW, 2019a, p. 5). “It must be done on a national basis to identify where strengths and gaps lie and highlight areas for regional cooperation” (BNOW, 2019a, p. 6). For example, there could be some integration or synergies developed between suppliers along the coastal area with land-locked industrial states to support the OSW industry, especially with the production of Tier 2 or 3 inputs that might not be advantaged by co-location at coastal sites.

2.1. Discussion Questions

- 2.1.1. Are there benefits from pursuing more national or regional approaches to manufacturing versus ad hoc developer–/state-driven investments?
- 2.1.2. How can/should these manufacturing facilities be financed?
- 2.1.3. What information is needed to convert existing versus adding new manufacturing facilities?
- 2.1.4. How are sites chosen?
- 2.1.5. What is the role of municipal, state and federal investment in site selection, etc.?
- 2.1.6. How can women- and minority-owned manufacturing facilities and underserved communities be supported as manufacturing expands?

2.2. Policy/Action Recommendations (Federal, State, Municipal and Private Sector)

- 2.2.1. Loan guarantees
- 2.2.2. Tax incentives
- 2.2.3. Continued vertical supply chaining by developers and partners
- 2.2.4. Procurement rules benefiting women- and minority-owned businesses and underserved communities
- 2.2.5. Border adjustment mechanisms
- 2.2.6. Federal or regional strategic planning

3. Vessels[1]

Working vessels required by the OSW industry are a critical part of the supply chain and exhibit similar challenges as those with manufacturing facilities; however, they also have additional challenges related to the Jones Act. The act requires that cargo that is shipped from one U.S. point to another must be on vessels that are U.S.-built, U.S. citizen–owned and registered in the United States and have an American crew. While Europe and Asia have built out OSW-specific vessels, there are few in the United States. Thus, there is a significant capacity gap in highly specialized vessels, such as wind turbine installation vessels (WTIV). From a global perspective, there is a significant supply-and-demand imbalance, with the projected expansion of OSW in the U.S. market and elsewhere overwhelming the supply of existing specialized capacity. “The lack of supply and overwhelming demand indicates the potential for future market delays and potentially failure that could inhibit the highly anticipated U.S. offshore wind buildout” (Bocklet et al., p. 26).

Like manufacturing facilities, WTIVs are capital-intensive; for example, the Dominion plan to build the WTIV *Charybdis* is projected to cost $500 million (Griset, 2020). The demand for their time is uncertain and variable, following the punctuated timeline of projects. And they have the added complication of needing to comply with Jones Act requirements. The Dominion example is similar to the example of the current path of Tier 1 manufacturing facilities—single developers—partnering with others to make capital investments that are internally strategic but not necessarily strategic for the sector. A recent report by analysts at Tufts University notes, “Developers have multiple pathways to achieve the U.S. build-out, some serving the public interest better than others. Selecting a strategy that involves commissioning a fleet of U.S.-built WTIVs or feeder vessels could lead to a revival of American shipyard jobs” (Bocklet et al., p. 26).

For other less specialized vessels, there is less cause for concern. There are opportunities, for example, in repurposing vessels used in declining or equally variable industries, such as oil and gas and fisheries, and utilizing vessels that provide more generalized service. A December 2020 Government Accountability Office report found that for roles such as survey vessels, foundation installation vessels, cable-laying vessels and O&M vessels, “[p]roject developers and vessel operators we interviewed generally told us that they are confident that they will be able to find vessels to fill these roles, and that in some cases it is likely that new Jones Act–compliant vessels will be built to support the industry” (p. 18).

As with manufacturing, to the extent that new shipbuilding occurs, there is an opportunity for such economic development to provide benefits to underserved and vulnerable communities and act as an economic engine in port cities that are economically stressed.

3.1. Discussion Questions

- 3.1.1. Are there benefits from pursuing more national or regional approaches to vessel building?
- 3.1.2. How can/should vessels be financed?
- 3.1.3. What is the role of developer/federal/state/municipal investments?
- 3.1.4. How can women- and minority-owned businesses and underserved communities related to vessel development, maintenance and crews be supported?
- 3.1.5. How should the inherent variability of OSW projects (boom-and-bust) be addressed in the financing, building and deployment of vessels?
- 3.1.6. How should the specific challenges and opportunities of the Jones Act be addressed?

3.2. Policy/Action Recommendations (Federal, Regional and State)

- 3.2.1. Direct funding and loan guarantees
- 3.2.2. Tax incentives
- 3.2.3. Amendments to the Jones Act
- 3.2.4. Provision of certainty and guaranteed demand
- 3.2.5. Federal or regional strategic planning

1 This paper covers this topic only at a summary level, while White Paper #4 is solely devoted to the issue of vessels.

4. Port Development

> Even if sufficient vessels are available to support the U.S. deployment pipeline, the development and timing of port infrastructure could become a significant bottleneck for the industry. This delay may be especially true as wind turbines and project sizes continue to grow. Larger turbines and bigger projects push the limits of the existing infrastructure in terms of heavy-lift crane weight and height capacities, wharf access for increasingly larger ships, rising height clearances and channel draft requirements, and the growing need to expand physical laydown space. (American Bureau of Shipping [ABS], 2021)
>
> Approximately five staging ports will be required to meet the needs of the first 10 GW of OSW energy projects on the Atlantic Coast alone. (Lefevre-Marton et al., 2019)
>
> Floating wind will face additional challenges, as no U.S. ports currently exist that can support a commercial-scale floating wind project. (Musial et al., 2021, p. 28)

Even more than with manufacturing facilities and vessels, ports are a linchpin in a robust value chain. In its early stages, OSW can be supplied by nondomestic products and served by non-U.S.-flagged ships. However, no project can proceed without access to an adequate U.S. port. Thus, the pace necessary to reach a goal of 30 GW of OSW by 2030 cannot be maintained without suitable port facilities and associated heavy cranes, storage areas, staging areas and adequate draft. In addition, compared with manufacturing and vessels, ports may depend more heavily on state and municipal government for site access and approval, permitting, incentives and infrastructure support.

Precisely because many of the ports that are being redeveloped are in cities that are experiencing economic challenges and whose communities are particularly vulnerable, the investment in port infrastructure, and the attendant Tier 2 and 3 manufacturing, services and O&M that might be inspired to locate nearby can provide a comprehensive opportunity to generate benefits for underserved and vulnerable communities.

Given the threshold importance of ports, it has been strongly in the interest of developers to invest in port infrastructure at this early stage of OSW development in the United States, especially in the absence of large-scale federal or state investment to date. Thus, a "large focus of many U.S. investment announcements has been improvements to port infrastructure, which are needed to ensure ports can serve as staging areas for manufacturing, assembly, and transportation of large OSW components. Companies including Ørsted, Eversource, Vineyard Wind, Equinor and U.S. Wind are planning to establish offshore wind assembly hubs and operations and maintenance hubs across ports from Maryland up to Massachusetts" (AWEA, 2021, p. 5). **Table 3** outlines the recent investments in ports and port infrastructure by developers and those states that support OSW development.

TABLE 3. **OSW-Related Port Investments in the United States**				
Location	**Firms**	**Investment**	**Date**	**Source**
Tradepoint Atlantic, Maryland	U.S. Wind	$26.4 million	2017	(AWEA, 2021)
Port of Providence and Kingston, Rhode Island	Ørsted and Eversource	$40 million	2018	(AWEA, 2021)
Bridgeport, Connecticut	Vineyard Wind	Unspecified	2019	(AWEA, 2021)
Tradepoint Atlantic, Maryland	Ørsted	$13.2 million	2019	(AWEA, 2021)
New Bedford, Massachusetts	Vineyard Wind	$50,000	2019	(AWEA, 2021)
Atlantic City, New Jersey	Ørsted	Unspecified	2019	(Musial et al., 2021)
Port Jefferson, New Jersey	Ørsted and Eversource	Unspecified	2019	(Musial et al., 2021)
Brayton Point, Massachusetts	Anbaric	$650 million	2019	(Musial et al., 2021)
Port of Coeymans, South Brooklyn Marine Terminal, Port of Albany, Port Jefferson Harbor and Montauk Harbor, New York	New York state (New York State Energy Research and Development Authority [NYSERDA]), Equinor, Ørsted and Eversource	$730 million	2019–2021	(Musial et al., 2021)
New London, Connecticut	Ørsted, Eversource and Connecticut Port Authority	$157 million	2020	(AWEA, 2021)
New Bedford, Massachusetts	Massachusetts Clean Energy Center, Avangrid/ Copenhagen Infrastructure Partners, Energias de Portugal Renováveis/Shell	$32.5 million (Vineyard Wind and Mayflower Wind); $113 million in public money	2020	(Musial et al., 2021)
Port of Paulsboro, New Jersey	Ørsted, Public Service Enterprise Group, Inc. (PSEG) and EEW	$250 million	2020	(Musial et al., 2021)
New Jersey Wind Port, New Jersey	State of New Jersey (New Jersey) Economic Development Authority)	$300 million to $400 million	2020	(Musial et al., 2021)
Hampton Roads, Virginia	State of Virginia (GO Virginia)	$500,000	2020	(Musial et al., 2021)
Portsmouth Marine Terminal, Virginia	Ørsted	$13 million to $33 million	2020	(Musial et al., 2021)
Port of Providence, Rhode Island	Ørsted and Eversource	$40 million	2020/2021	(Musial et al., 2021)
Quonset Point, Rhode Island	Ørsted and Eversource	$40 million	2020/2021	(Musial et al., 2021)
Salem, Massachusetts	Vineyard Wind (Avangrid Renewables and Copenhagen Infrastructure Partners)	Unspecified	2021	(WPED Staff, 2021b)

As is happening with manufacturing and vessels, single developers and joint ventures are making capital investments that are internally strategic and, in fact, driving OSW development faster than it otherwise would have gone. Had developers and individual states waited for federal or regional strategic planning and actions, there would be few, if any, projects moving forward now. But this ad hoc approach might leave the sector more constrained and less efficient in the long run than if a more comprehensive and strategic approach were adopted. It also does not consider geography; as individual developers, states and port cities make agreements, it is unclear whether the current and near-term distribution of port assets across the Eastern seaboard is most efficient at delivering the port infrastructure parts of the supply chain that the OSW sector can most effectively utilize.

4.1. Discussion Questions

4.1.1. Are there benefits from pursuing more national or regional approaches to port infrastructure?

4.1.2. How can/should ports be financed?

4.1.3. What is the role of developer/federal/state/municipal investments?

4.1.4. How can women- and minority-owned businesses and underserved communities related to port development and maintenance be supported?

4.1.5. How should the inherent variability of OSW projects (boom-and-bust) be addressed in the development of ports?

4.2. Policy/Action Recommendations (Federal, Regional, State, Municipal and Private Sector)

4.2.1. Direct funding and loan guarantees

4.2.2. Tax incentives

4.2.3. Streamlined permitting

4.2.4. Incentives for co-locating manufacturing service and O&M facilities

4.2.5. Federal or regional strategic planning, perhaps integrated with the infrastructure section of the recently passed infrastructure bill

5. Equity and Women- and Minority-Owned Businesses

The Biden-Harris administration's climate and clean energy goals include a wide array of efforts to improve equity in the distribution of benefits of the expansion of the OSW sector. The broad objective is to ensure that good-paying jobs, supply chain facilities and infrastructure improvements are created in communities that have historically been underserved or disproportionately impacted by environmental harms and/or may experience economic and social dislocation in the transition away from fossil fuels. In releasing Executive Order 14008 on January 27, 2021, *Tackling the Climate Crisis at Home and Abroad*, President Biden launched the Justice40 initiative, which, in part, was tasked with determining "how certain Federal investments might be made toward a goal that 40% of the overall benefits flow to disadvantaged communities (White House, 2021c). The recommendations shall focus on investments in the areas of clean energy and energy efficiency…" (White House, 2021c, pp. 7631–7632).

Part of this effort is to support women- and minority-owned businesses as the U.S. supply chain develops where there are indications that there is significant underrepresentation.

While there is an effort to collect more aggregated national data on diversity, equity and inclusion in the supply chain (see ongoing initiatives through the BNOW's Offshore Wind Supply Chain Connect[2]), some states have started collecting statewide data, which, at least at an exceedingly high level, may be representative of the sector as a whole. For example, although not a scientific study, an examination of the Massachusetts Offshore Wind Supply Chain Directory suggests significant underrepresentation of women- and minority-owned businesses. In the directory of 427 firms, nine are women-owned (~2%), and four are minority-owned (~1%; Massachusetts Clean Energy Center [MassCEC], 2021a).

In an international survey-based study on gender in the wind sector, the International Renewable Energy Agency (IRENA) found that women represent 26% of the wind sector workforce in North America and Europe. And although the study did not explore business ownership, it did find that women hold only 10% of senior management positions in the North American and European wind sectors (IRENA, 2019).

2 BNOW. (n.d.). *Business Network for Offshore Wind's Offshore Wind Supply Chain Connect*. Retrieved from https://www.offshorewindus.org/supplychain/.

In a study that examined diversity in the energy sector as a whole, similar gaps of leadership exist: "About a third (35%) [of White respondents] noted that they are company executives. By comparison, only 17% of Black or African American energy workers reported that they are company executives, and only 19% of Hispanic or Latinx workers reported the same. Similarly, only 22% of Asian energy workers indicated that they are company executives" (National Association of State Energy Officials [NASEO], 2021, p. 6).[3] Although this does not capture the diversity of business ownership, it does suggest a lower proportion of minority leadership relative to the sector workforce.

Aggregated data of employees in the wind sector as a whole (including both land-based and OSW) show the percentage of women in the wind sector (31%) as significantly below the national workforce average (47%). But racial diversity shows greater parity: "Wind EPG [electric power generation] is also more ethnically diverse than the national workforce, with higher levels of Hispanic or Latino and Asian workers" (NASEO & Energy Futures Initiative [EFI], 2021a, p. 61). Asian workers and workers who self-identify as two or more races make up 10% and 11% of the sector but only 6% and 2% of the national workforce, respectively. The exception is Black or African American workers, who make up only 8% of the wind sector workforce but 12% of the national workforce (see **Table 4**; NASEO & EFI, 2021a, p. 62).

TABLE 4

Table 20.
Wind Electric Power Generation - Demographics, Q4 2019

Demographic	Employees	Percent of Sector	National Workforce Averages
Male	78,739	69%	53%
Female	36,035	31%	47%
Hispanic or Latino	22,480	20%	18%
Not Hispanic or Latino	92,294	80%	82%
American Indian or Alaska Native	1,359	1%	>1%
Asian	11,371	10%	6%
Black or African American	9,118	8%	12%
Native Hawaiian or other Pacific Islander	1,470	1%	>1%
White	79,035	69%	78%
Two or more races	12,421	11%	2%
Veterans	10,888	9%	6%
55 and over	16,733	15%	23%
Union	7,243	6%	6%

NASEO and EFI (2021) *2020 U.S. Energy & Employment Report*. National Association of State Energy Officials and Energy Futures Initiative, https://www.usenergyjobs.org/. pp. 62.

The federal government is attempting to launch a more comprehensive way to address equity during the transition to clean energy. As noted above, for example, in Executive Order 14008, the administration launched its Justice40 initiative to ensure benefits of the clean energy transition accrue to vulnerable and underserved communities. In addition, states and developers have worked toward codifying such efforts through a range of legislative changes, procurement rules and philanthropic initiatives funded by developers. One such model includes legislation that adds equity criteria to state-level energy procurement evaluation and thus supply chain decision-making on the part of developers. Most states that are driving OSW development have such criteria, and, in fact, those criteria are becoming increasingly ambitious. One example is in Massachusetts.

3 These percentages do not add up to 100% because the samples were segmented by race and ethnicity. In other words, of all White workers, 35% reported they were in executive positions, and of all Black or African American workers, only 17% reported that they were in executive positions. Recall that Black workers make up a much smaller percentage of the energy workforce than do White workers.

OSW and Equity in Massachusetts and New York

In March 2021, Massachusetts passed "[a]n Act creating a next-generation roadmap for Massachusetts climate policy"(Ch. 8, MA, 2021). In addition to requiring a more rapid emissions reduction target and an additional 2.4-GW procurement of OSW, the act also required a range of new and expanded protections and opportunities for environmental justice communities.

After passage of the act, the Massachusetts Department of Energy Resources (MA DOER) released a Request for Proposals for long-term OSW contracts that contained the following description of what would be evaluated in proposals:

> *Economic Benefits to the Commonwealth and Diversity, Equity and Inclusion (DEI)*
>
> - Demonstrated ability and commitment to create and foster short- and long-term employment and economic development in the Commonwealth, where feasible, and a commitment to diversity, equity and inclusion, including employment and procurement/contracting opportunities, for minority, women, veterans, LGBT and persons with disabilities…
>
> …..
>
> – A diversity, equity and inclusion plan that includes, at a minimum, both a Workforce Diversity Plan and a Supplier Diversity Program Plan described below. The diversity, equity and inclusion plan should describe the proposed strategy to actively promote access to employment and contracting opportunities for, and to actively recruit, diverse workers, vendors, contractors, and investors, and include how the direct, specific and measurable employment and contracting benefits created by the proposed project provides employment and procurement/contracting opportunities for minority, women, veterans, LGBT and persons with disabilities. (MA DOER, 2021, pp. 31–32)

Prior to the bids being submitted, a statewide environmental nongovernmental organization, the Environmental League of Massachusetts, funded an informal workshop that brought together potential bidders with environmental justice (EJ) groups, women and minority business leaders and other actors in the clean energy justice space. The goals were to create a deeper network and connections and expose bidders to interests of EJ groups and firms that could advance the equity goals of the procurement and to expose firms to possible opportunities and enter into the growing supply chain.

It is unclear what the impact of both the procurement requirements and the informal workshop will be (bids were submitted in September 2021, and many sections of the bids are proprietary and not publicly available), but one bidder included in its proposal:

> Mayflower Wind is committing to investing up to $80.9 million over 20 years to grow the local offshore wind workforce, increase the capacity of Massachusetts educational institutions, and drive the local economy in economically distressed areas and the Commonwealth as a whole…. Mayflower Wind's support is centered on partnerships with existing and durable local institutions—providing those partners with substantial resources that amount to transformational investments…Mayflower Wind is working to ensure that DEI is at the core of each partnership, so that these opportunities are widely and equitably available across Massachusetts communities." (Mayflower Wind, 2021, pp. 13-9, 12-19, 13-12–13-13)

New York state took a similar approach with its passage of the Climate Leadership and Community Protection Act of 2019. In addition to setting a statewide goal to deploy 9,000 MW of OSW energy by 2035, the act required that solicitations for OSW projects include the following:

- 40% of the overall benefits from clean energy programs must go to disadvantaged communities for workforce development, low-income energy assistance and housing. Other investments and projects may also qualify;
- community engagement plans that provide opportunities to build community equity;
- prioritization of job creation and other benefits for disadvantaged communities. (Terry, 2021)

With the New York Public Service Commission and NYSERDA administering the new solicitations, outcomes seem to be similar to those in Massachusetts:

> Empire Wind 2 (1,260 MW) and Beacon Wind (1,230 MW) of Equinor Wind US LLC will generate enough clean energy to power 1.3 million homes and will be major economic drivers, supporting:
>
> - More than 5,200 direct jobs;
> - Combined economic activity of $8.9 billion in labor, supplies, development and manufacturing statewide; and
> - $47 million in workforce development and just access funding.

Putting the state's equity goals squarely into action, Empire Wind 2 and Beacon Wind will deliver significant economic benefits to disadvantaged communities and support the responsible retirement of aging fossil fuel plants in Queens and Nassau County.

5.1. Discussion Questions

5.1.1. How can equity be better integrated into the growth of OSW in the United States?

5.1.2. What role can unions play in diversifying the workforce (see Section 6, on workforce)?

5.1.3. How can development of women- and minority-owned businesses be more integrated into supply chain decisions about manufacturing facilities, vessels and port infrastructure?

5.2. Policy/Action Recommendations (Federal, State, Municipal and Private Sector)

5.2.1. DEI procurement requirements/criteria

5.2.2. Domestic content requirements

5.2.3. Project labor agreements

5.2.4. Funds set aside by developers for the support of women- and minority-owned business supply chain development

5.2.5. Community benefits agreements

6. Workforce and Workforce Development

The title of the Biden-Harris administration's announcement of its OSW goals was "Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs." The word *jobs* is used 24 times, and *union* is used eight times in the official press release. The job opportunities in the OSW supply chain in the United States are significant and growing. In addition, the administration is also prioritizing the possible benefits of the clean energy economy in general and the OSW industry in particular as a way to attain more equitable economic development. Executive Order 13990 of January 20, 2021, *Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis*, states as its goal "to prioritize both environmental justice and the creation of the well-paying union jobs necessary to deliver on these goals" (White House, 2021d, p. 7037).

Building a domestic supply chain will require a broad range of technical, managerial, administrative and trades skills. "Developing, building, and operating offshore wind projects offers the promise of job creation and a chance for skilled workers to apply their craft to a new industry. Offshore wind jobs are good, well-paying jobs requiring a diverse technical workforce spanning an estimated 74 occupations" (AWEA, 2021, p. 4). The 30-MW Block Island project:

> ...included the following skilled trades, which essentially are the same as those who will work on any offshore wind project, fixed-bottom or floating:
>
> - Piledrivers and Divers (United Brotherhood of Carpenters)—setting the foundation of the platform, driving the foundation into seabed and cable installation;
> - Millwrights (United Brotherhood of Carpenters)—assembly and installation of nacelle, tower and blades;
> - Plumbers and Pipefitters (UA)—assembly and installation of nacelle, tower and blades;
> - Operating Engineers—crane operators and tugboat crews;
> - IBEW—electrical;
> - Painters—surfacing and painting;
> - Elevator Constructors—installation of tower elevators;
> - Laborers—multiple tasks; and
> - Longshoremen and boat crews—stevedoring and marine services, including during the operations and maintenance phase. (Collier et al., 2019, p. 23)

Unionization

The first goal enumerated in President Biden's announcement of OSW goals was to "Advance ambitious wind energy projects to create good-paying, union jobs" (White House, 2021d).:

How unionization will evolve as OSW develops is uncertain. Part of this uncertainty results from lack of consistent and disaggregated data on unionization.

> Currently, data on unionization [are] collected by several federal agencies, using different metrics, and resulting in a range of unionization rates. Addressing these variations and developing robust and consistent federal data is an important area for improvement, and would assist policymakers, unions, employers, and workers in identifying the benefits, and potential tradeoffs, that unionization can bring in economic recovery, energy labor market changes, workforce development, and economic resilience. (NASEO & EFI, 2021b, p. 2)

TABLE 5

UNIONIZATION

Across sub-technologies, natural gas generation, coal generation, nuclear generation and traditional transmission and distribution had the highest unionization rates.

	Percent Union Membership
Natural Gas Generation	15.1%
Nuclear Generation	19.5%
Coal Generation	14.7%
Other Renewable Generation	8.8%
Solar Generation	9.6%
Wind Generation	9.5%
Oil Generation	6.7%
Petroleum Fuels	5.6%
Coal Fuels	9.8%
Nuclear Fuels	5.5%
Natural Gas Fuels	4.9%
Renewable Fuels	4.1%
Traditional Transmission and Distribution	17.0%
Grid Modernization	9.9%
Storage	9.6%
Advanced Transportation	4.3%

Current but limited data suggest that unionization in the wind sector (on land and offshore combined; disaggregated data are not available) has increased between 2019 and 2020, growing from 6% to 9.5% (NASEO & EFI, 2021a; 2021b). The percentage of 9.5 is higher than the national workforce average of 6% but lower than other energy sectors, such as nuclear generation (19%), natural gas generation (15%) and coal generation (15%; NASEO & EFI, 2022a; see **Table 5**; NASEO & EFI, 2022a, p. xviii).

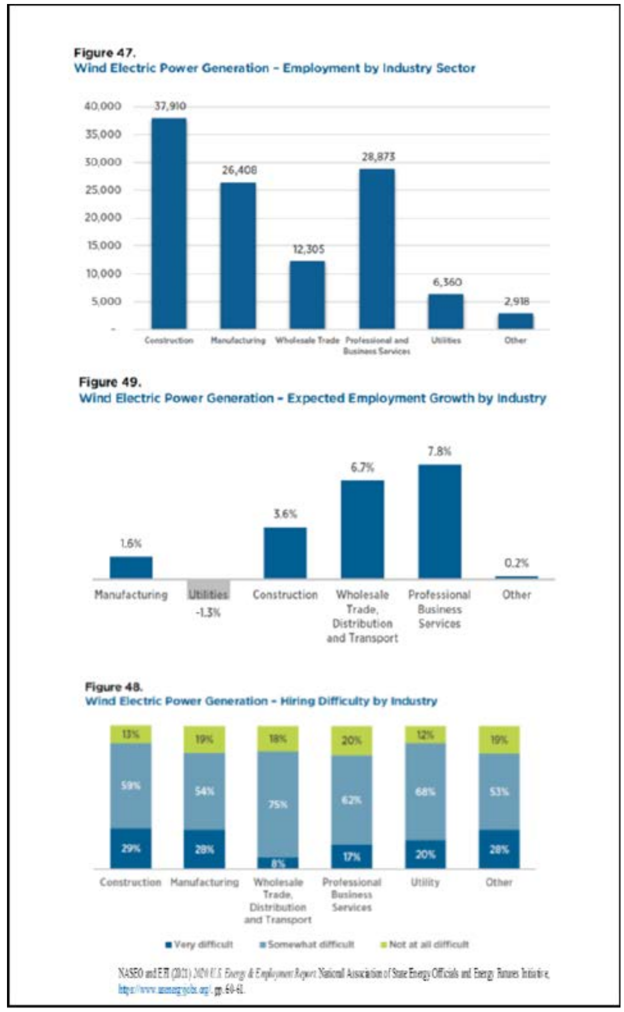
Capacity and Gaps

The recent energy jobs report released by the NASEO and EFI highlights existing jobs, potential gaps of needed worker skills and diversity in the sector. The study analyzed the wind sector as a whole, combining offshore and onshore data.

Three graphs from the report paint a picture of a large and growing sector but one that may have significant challenges in filling needed positions (see **Figure 4**; NASEO & EFI, 2021a, pp. 60–61). The first graph illustrates that the majority of wind sector jobs are in the construction and manufacturing areas, with professional and business services accounting for an additional 25%.

The second graph shows projected job growth by area for 2020. With a pipeline of greater than 30 GW and current installed capacity at only 43 MW, job growth in the offshore sector is predicted to accelerate for the near future. Total job growth only in 2020 was predicted to be about 4% (and this was before the Biden administration announced a national goal of 30 GW).

FIGURE 4



The third graph gives an indication of workforce gaps and difficulty hiring that currently exists and may be exacerbated in the future. Data were collected through surveys of wind sector employers (both offshore and land-based). "In 2019, 87% of construction employers in the wind sector reported that hiring new workers was somewhat difficult or exceedingly difficult (with 29% reporting that hiring was very difficult). The next two largest segments of the wind industry—professional services and manufacturing—reported overall hiring difficulty of 80% and 81%, respectively" (NASEO & EFI, 2021a, p. 60).

There are few comprehensive current U.S. offshore workforce data or wind workforce gap analyses that have an up-to-date review of the current and future demand for workforce requirements across the supply chain. (Analyses are currently being conducted by the NREL and are projected to be completed in the first quarter of 2022.)

While there are no national-level data, several states have undertaken such analyses, the most recent from Massachusetts, supported by the MassCEC. Overall, the analysis illuminates "the gap between the anticipated workforce needed in the near-term to support the first 1,600 MW offshore wind projects and the workforce currently available (as of 2020) to understand the current degree of occupational demand in the OSW supply chain. Across all phases, 37% have sufficient workers to meet the anticipated OSW workforce demand, while 27% have a moderate workforce gap, and 36% of occupations were determined to have a significant in-state workforce gap. The state is most prepared to meet science, engineering, management and maritime needs, while least prepared to meet construction and assembly needs" (MassCEC, 2021, p. iii). See **Table 5** (MassCEC, 2021, p. 22); red represents a significant workforce gap, yellow denotes a moderate workforce gap and green denotes no workforce gap.

The Need for Training

These gaps point toward the need for training, retraining and upskilling. The MassCEC notes that there are three key target audiences for training, each of which requires separate strategies and engagement with educational institutions, unions and firms. These include incumbent workers in the workforce who seek upskilling, those already in the training pipeline and those not employed or in the training or education pipeline.

Focusing on incumbent workers especially could have the benefit of targeting workforce communities that might be negatively impacted by the transition to OSW or are otherwise in sectors that are struggling. These include oil and gas workers, especially in the Gulf Coast; fishing communities in the Northeast; and inland oil, gas and coal workers (e.g., in Appalachia or the Mountain West) who may seek training in OSW manufacturing facilities (especially Tier 2 or 3) that do not need to be located on the coast.

TABLE 6

Table 1. MA workforce gaps for construction & operations of proposed wind farms by occupation[14]

Occupation	Workforce Gap
Construction Laborers	Red
Miscellaneous Plant and System Operators *	Green
Wind Turbine Service Technicians	Yellow
Sailors and Marine Oilers	Yellow
Riggers	Yellow
Captains, Mates, and Pilots of Water Vessels*	Green
Logisticians	Yellow
Heavy and Tractor-Trailer Truck Drivers	Red
Structural Iron and Steel Workers	Yellow
Inspectors, Testers, Sorters, Samplers, and Weighers	Red
Cement Masons and Concrete Finishers	Yellow
Welders, Cutters, Solderers, and Brazers	Yellow
Crane and Tower Operators	Yellow
Maintenance and Repair Workers, General	Red
Helpers--Installation, Maintenance, and Repair Workers	Red
Operating Engineers and Other Construction Equipment Operators	Red
Transportation, Storage, and Distribution Managers*	Green
Elevator and Escalator Installers and Repairers	Yellow
Production Workers, All Other	Red
Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	Yellow
Financial Managers	Red
Electrical Power-Line Installers and Repairers	Red
Hoist and Winch Operators	Yellow
General and Operations Managers*	Green
Industrial Production Managers*	Green
Commercial Pilots	Green
Metal-Refining Furnace Operators and Tenders	Yellow
Ship Engineers	Green

*Denotes occupations for which Massachusetts has a surplus of workers that can be supplied to other states.

MassCEC (2021b) 2021 Offshore Wind Workforce Training & Development in Massachusetts Report. https://files-cdn.masscec.com/reports/MassCEC%20OSW%20Workforce%20Final%20Report_Sept%202021.pdf

A second motivation for training is to seize economic opportunities for "communities experiencing higher rates of unemployment, underemployment and other disadvantages [and] could be targeted for recruitment into offshore wind career pathways" (MassCEC, 2021, p. 16). Many of the states supporting wind development—and, as noted above, the Biden administration—see the economic development of OSW as fundamental to addressing existing and historical economic inequities and correcting past environmental injustices. Intentional and strategic programs for training and retraining can be a mechanism to create job growth and greater economic security.

A third driver of training and one that interacts with the gaps of supply and demand for workers in an expanding sector is the range of certifications required along the supply chain in this new sector. These include but are not limited to general health and safety training, Global Wind Organization (GWO) Basic Safety Training and federally required certification under the Standards of Training Certification and Watchkeeping for Seafarers (Collier et al., 2019). In addition, specialized maritime, construction and operations and maintenance trainings are needed, and Tier 1 suppliers, for example, may have specialized needs for workforce qualifications that are developer-, firm- or technology-specific.

Implementing Training

There is already a foundation of training and workforce development that is union-based and in the network of vocational technical high schools, community colleges, higher education institutions and the U.S. Department of Transportation's MARAD's six maritime academies, the U.S. Merchant Marine Academy and the six state maritime academies (in California, Michigan, Maine, Massachusetts, New York and Texas). Many of the states where OSW is being developed have already begun to develop new curricula, programs, certificates and degrees to meet the current and future demand of trained workforce in the sector.

Union-led training efforts have already taken a number of different forms. One is building on the long tradition of unions themselves offering trainings that advance expertise in new technologies. For clean energy work, this has manifest in new solar, wind and electric vehicle/battery curriculum. For example:

> [U]nion training facilities across the country—jointly funded by the International Brotherhood of Electrical Workers [IBEW] and the National Electrical Contractors Association—have been incorporating green energy into their curriculum….More than 70 training centers across the country offer photovoltaic training and last year, the IBEW launched a 40-hour wind turbine "boot camp" in five states, with the program expected to branch out to other locations soon. (IBEW, 2022)

A second form of union training has been to team with OSW developers. This is seen in the 2020 agreement between Ørsted and North America's Building Trades Union with the goal of training American workers for the impending expansion of offshore jobs (Energy Mix, 2020). This is also seen in project-specific agreements, such as the Atlantic Shores (a joint venture between Shell New Energies U.S. and EDF Renewables U.S.) project in New Jersey creating a training agreement with six New Jersey unions: Eastern Atlantic States Regional Council of Carpenters; Laborers; IBEW Locals 456, 400 and 351; Operating Engineers Local 825; Ironworkers and Eastern Millwright Regional Council. States also join developers in supporting training as in Massachusetts, where the MassCEC invested $2 million, adding to investments by Vineyard Wind and Mayflower Wind for training, some of which goes directly to IBEW Local 223 and the Piledrivers and Divers Local 56. The latter will support the GWO's Basic Safety Training program (NASEO & EFI, 2021b).

In addition, OSW states have developed and/or funded a wide range of training programs that are implemented through the existing educational institutions listed above or, as noted in the previous paragraph, through unions or private training institutions. In the recently released MassCEC workforce development report, a training inventory was developed that identified 45 training programs in the Northeast (New England, New York and New Jersey). While these are forming a backbone of training opportunities, the report notes, "Most training curricula do not yet include specific preparation for the demands of offshore wind energy, though multiple offshore-specific programs are in development" (MassCEC, 2021, p. 11).

Perhaps a model that has been the most effective thus far for workforce development and training are project labor agreements (PLA) associated with individual OSW projects. Whether or not a PLA is required is state-dependent. The following states require some kind of PLA that includes wage standards and training or apprentice requirements: Connecticut, Maryland, Massachusetts, New York and New Jersey. One illustration of the impact of these agreements follows:

> In June 2019, the state Board of Public Utilities awarded a contract to Ørsted for its 1.1 GW Ocean Wind project. According to a governor's office press release about the award, the project will create "an estimated 15,000 jobs over the project life." The statement also said Ørsted won the deal over competing bids from EDF/Shell and Equinor because Ørsted offered greater economic benefits, including development of an in-state supply chain. As part of its application, Ørsted signed a Memorandum of Understanding (MOU) with the South Jersey Building and Construction Trades Council, calling for a PLA for offshore wind construction jobs that pay prevailing wage. It also signed MOUs with three local universities—Rowan, Stockton and Rutgers—to create wind apprenticeship programs and professional/technical development programs with Stockton and Rutgers Universities. (Collier et al., 2019, p. 27)

6.1. Discussion Questions

6.1.1. How can workforce development/training programs be done in time to meet the demand of project supply chain timelines?

6.1.2. How can workforce development/training programs be created to be consistent with the Justice40 goals, benefiting both historically vulnerable/disadvantaged communities and communities displaced by the decline of the fossil fuel sector?

6.1.3. How can training programs be financed?

6.2. Policy/Action Recommendations (Federal, State, Municipal and Private Sector)

6.2.1. Data: Establish protocols and methodologies for gathering more granular, accurate and reliable data on unionization rates in the energy sector (NASEO & EFI, 2021b)

6.2.2. Greater regional coordination of training programs

6.2.3. PLA requirements

6.2.4. Labor standards requirements for Energy Tax Credits

6.2.5. Community benefits agreements

6.2.6. Curricular changes at technical vocational high schools, community colleges, colleges and universities

6.2.7. Greater support for maritime academies (federal and state)

7. Technical Standards

As the U.S. OSW industry expands rapidly, especially led by a range of European developers, there is a risk that lack of harmonization of standards will raise costs, disrupt the supply chain and cause significant safety concerns. “The U.S. offshore wind industry is progressing toward construction and operations sooner than the availability of supporting standards, and guidelines, and regulatory frameworks” (Musial et al., 2020, p. 4). Such a lack of supporting and harmonized standards can stunt development of a robust supply chain.

Currently, a range of international standards are already in place. Many of these are simply carryovers from ocean-based oil and gas development. Others have been developed specifically for OSW. Several examples of standard setting or certification organizations and their focus include: International Organization for Standardization (ISO), covering tens of thousands of technology standards; International Electrotechnical Commission (IEC), which covers electric and electronic technologies, including some wind turbine standards; ABS, which provides guidance for bottom-founded and floating OSW turbines; and DNV, which has a “complete set of standards and recommended practices for wind power plants including turbines, bottom-fixed and floating support structure, cables and offshore substation[s]” (DNV, 2020, p. 8). A schematic of the DNV set of standards and guidelines can be seen in **Figure 5** (DNV, 2020, p. 17).

FIGURE 5

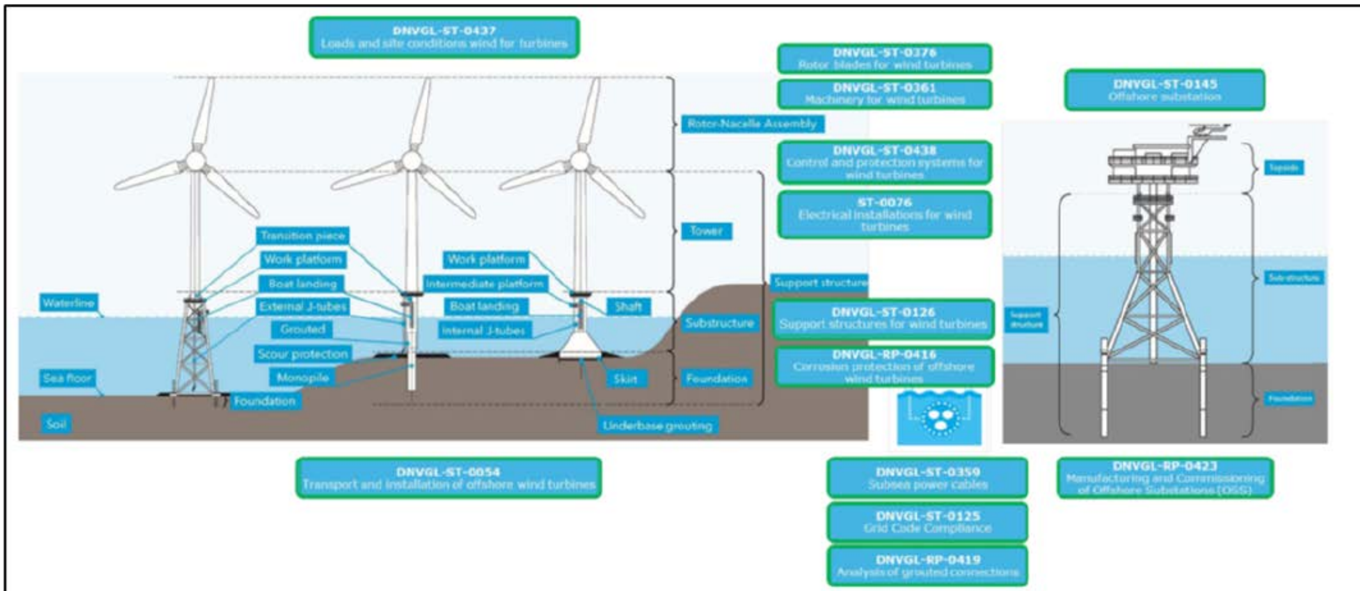


Figure 3-1 Overview of DNV GL standards for the different assets in a wind power plant

At this stage, it is still unclear how these international standards—or European standards used by many of the developers who are active in the United States—synchronize with emerging U.S. standards. However, in 2017, a three-year process was launched to prepare standards that could guide the growing OSW industry: the U.S. Offshore Wind Standards Initiative.

> In preparation for the development of large-scale offshore wind energy projects, the U.S. industry is developing consensus guideline and standards to reduce uncertainty and ensure orderly deployment. Nationally focused standards and guidelines must account for the United States’ unique offshore conditions on the outer continental shelf and state waterways, as well as provide reasonable requirements for commercial offshore development. (DOE, 2017)

The effort was led by a collaboration of the DOE, NREL, BOEM, Bureau of Safety and Environmental Enforcement (BSEE), BNOW and AWEA.[4] The goal was to recommend regulations and American National Standards Institute (ANSI)–approved standards where applicable and recommended practice guidelines. Five working groups framed the scope of work: Offshore Compliance Recommended Practices; U.S. Floating Offshore Wind Systems; U.S. Offshore Wind Metocean Conditions Characterization; U.S. Geotechnical and Geophysical Investigations and Design; and Offshore Wind Submarine Cables (BNOW, 2019b).

Under the leadership of the newly constituted American Clean Power Association (ACP), as the secretariat for ANSI standards in the wind sector, the five working groups have continued their development of standards and guidance and project that the five recommended practice documents will be completed by the summer of 2022. In this effort:

> ACP administers the ANSI standards process through ACP consensus bodies (committees) that develop and maintain voluntary national consensus standards for the renewable energy industry, ensures that the process for revision of standards is timely and in accordance with the ANSI Essential Requirements procedures, and publishes the final product of the consensus process. (ACP, 2021)

The five committees are building on existing international or European standards, and ACP sees part of its mission to synchronize standards and guidelines while accounting for specificities of the U.S. market and geography. "ACP will take a leadership role in the development and industry acceptance of U.S. Wind Energy standards while resolving discrepancies between U.S. Standards and Internationally accepted Standards, seeking to harmonize at the highest possible level" (ACP, 2021).

7.1. Discussion Questions

7.1.1. What processes can quickly and effectively develop technical standards at a speed adequate to reach the goal of 30 GW by 2030?

7.1.2. What is the interaction of technical standards and U.S. regulations?

7.1.3. Where are the biggest disconnects between international or European standards and emerging U.S. standards?

7.2. Policy/Action Recommendations (Federal, International, Private Sector and Unions)

7.2.1. Completion of the U.S. Offshore Wind Standards Initiative and the collaboration of the DOE, NREL, BOEM, BSEE, BNOW and ACP

7.2.2. U.S. Departments of Energy and Commerce, working with the Manufacturing Extension Partnership system to develop standards

7.2.3. Engagement with international standardization bodies (e.g., IEC, ISO and DNV)

4 In 2020, the AWEA merged with several other clean energy organizations to form the ACP.

BIBLIOGRAPHY

American Bureau of Shipping. (2021). *Offshore Wind Report. Positioning for U.S. Expansion: U.S. Ports and Vessels Innovation*. Retrieved from https://ww2.eagle.org/en/Products-and-Services/offshore-energy/offshore-wind.html.

American Clean Power Association. (2021). *Standards Development*. Accessed Nov. 12, 2021. Retrieved from https://cleanpower.org/standards-development.

American Wind Energy Association. (2012). *AWEA Offshore Compliance Recommended Practices: For Design, Deployment and Operation of Offshore Wind Turbines in the United States*. Retrieved from https://cleanpower.org/resources/awea-offshore-compliance-recommended-practices-2012/.

American Wind Energy Association. (2021). *U.S. Offshore Wind Power Economic Impact Assessment*. Retrieved from https://supportoffshorewind.org/wp-content/uploads/sites/6/2020/03/AWEA_Offshore-Wind-Economic-ImpactsV3.pdf.

Business Network for Offshore Wind. (2019a). Leadership 100 Work Plan. Retrieved from https://www.offshorewindus.org/wp-content/uploads/2019/06/L100WhitePaperJun.3.2019.pdf.

Business Network for Offshore Wind. (2019b). *U.S. Offshore Wind Standards Initiative*. International Partnering Forum 2019, New York, April 10, 2019. Retrieved from http://www.offshorewindus.org/2019ipf/pres/offshore.pdf.

Bocklet, C., Herbosa, C., Loweth, G., et al. (2021). *Wind Turbine Installation Vessels: Global Supply Chain Impacts on the U.S. Offshore Wind Market*. OSPRE-2021-02. Tufts University. Retrieved from https://dl.tufts.edu/concern/pdfs/rn301f830.

Buljan, A. (2021, Oct. 11). "New York Company Secures USD 86 Million Offshore Wind Foundation Deal with Ørsted and Eversource." Offshorewind.biz. Retrieved from https://www.offshorewind.biz/2021/10/11/new-york-company-secures-usd-86-million-offshore-wind-foundation-deal-with-orsted-and-eversource/.

BVG Associates, Lloyd's Register, Timmons Group and North Carolina Clean Energy Technology Center. (2021). *Building North Carolina's Offshore Wind Supply Chain: A Roadmap for Leveraging Manufacturing and Infrastructure Advantages*. Retrieved from https://files.nc.gov/nccommerce/documents/Policymaker-Reports/Report_North-Carolina-OSW-Supply-Chain-Assessment_BVGAssociates_asPublished-Mar3-2021.pdf.

Collier, R., Hull, S., Sawyerr, O., et al. (2019, September). *California Offshore Wind: Workforce Impacts and Grid Integration*. Center for Labor Research and Education, University of California, Berkeley. Retrieved from http://laborcenter.berkeley.edu/offshore-wind-workforce-grid.

Commonwealth of Massachusetts. (Ch. 8 MA). (2021). *An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy*. Retrieved from https://malegislature.gov/Laws/SessionLaws/Acts/2021/Chapter8.

Dillinger. (2019). *Steelwind Nordenham: A Passion for Monopiles!* Retrieved from http://www.steelwind-nordenham.de/imperia/md/content/steelwind/swn_imagebrosch%C3%BCre_en_11_2019.pdf.

DNV. (2020). *Overview of Offshore Wind Standards and Regulations in Selected Countries*. Retrieved from https://www.norskindustri.no/siteassets/dokumenter/rapporter-og-brosjyrer/leveransemodeller-havvind/dnv-gl-report_overview-of-offshore-wind-standard-and-certification-requirements_final_11.12.2020_signed.pdf.

Electrical Workers. (2022). *Getting on the Road to a Green Career: A Working Green Factsheet*. Accessed Jan. 13, 2022. Retrieved from http://ibewutilitytraining.org/WorkingGreen/factsheet.htm.

Energy Mix. (2020). "Ørsted, U.S. Building Trades Union Form Training Partnership for Offshore Wind." The Energy Mix, Nov. 22, 2020. Retrieved from https://www.theenergymix.com/2020/11/22/orsted-u-s-building-trades-union-form-training-partnership-for-offshore-wind/.

Froese, M. (2017). "U.S. Launches Initiative for Offshore Wind Standards." Windpower Engineering & Development. Retrieved from http://www.windpowerengineering.com/uncategorized/u-s-launches-initiative-offshore-wind-standards/.

Government Accountability Office. (2020). *Offshore Wind Energy: Planned Projects May Lead to Construction of New Vessels in the U.S., but Industry Has Made Few Decisions Amid Uncertainties*. GAO-21-153. Retrieved from https://www.gao.gov/products/gao-21-153.

Griset, R. (2020). "Dominion Announces Construction Has Begun on Offshore Wind Vessel: Vessel Will Be Used in Construction of Utility's Massive Wind Farm Off Coast of Virginia Beach." Virginia Business. Retrieved from https://www.virginiabusiness.com/article/dominion-announces-construction-has-begun-on-offshore-wind-vessel/.

Hasanbeigi, A., & Springer, C. (2019). *How Clean Is the U.S. Steel Industry? An International Benchmarking of Energy and CO2 Intensities*. Global Efficiency Intelligence. Retrieved from https://www.belfercenter.org/sites/default/files/files/publication/how-clean-is-the-us-steel-industry-nv.pdf.

Intergovernmental Panel on Climate Change. (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report* [Masson-Delmotte, V., Zhai, P., Pirani, A., et al. (eds.)]. Cambridge University Press. In press. Retrieved from https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf.

International Energy Agency. (2021). *Net Zero by 2050*. Retrieved from https://www.iea.org/reports/net-zero-by-2050.

International Renewable Energy Agency. (2018). *Nurturing Offshore Wind Markets: Good Practices for International Standardization*. Retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/May/IRENA_Nurturing_offshore_wind_2018.pdf.

International Renewable Energy Agency. (2019, January). *Renewable Energy: A Gender Perspective*. Retrieved from https://www.irena.org/publications/2020/Jan/Wind-energy-A-gender-perspective.

Johnson, S. (2021). Personal communication.

Keyser, D., & Tegen, S. (2019). *The Wind Energy Workforce in the United States: Training, Hiring and Future Needs*. NREL/TP-6A20-73908. Retrieved from https://www.nrel.gov/docs/fy19osti/73908.pdf.

Lantz, E., Barter, G., Gilman, P., et al. (2021). *Power Sector, Supply Chain, Jobs and Emissions Implications of 30 Gigawatts of Offshore Wind Power by 2030*. NREL/TP-5000-80031. Retrieved from https://www.nrel.gov/docs/fy21osti/80031.pdf.

Lefevre-Marton, N., Saharia, R., Sellschop, R., & Tai, H. (2019). *Scaling the U.S. East Coast Offshore Wind Industry to 20 Gigawatts and Beyond*. McKinsey & Company. Retrieved from https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/scaling-the-us-east-coast-offshore-wind-industry-to-20-gigawatts-and-beyond.

Maritime Executive. (2020, Dec. 23). "Ørsted and EEW Investing in New Jersey Wind Port Project." Retrieved from https://www.maritime-executive.com/article/oersted-and-eew-investing-in-new-jersey-wind-port-project.

Marmen Welcon, LLC. (2021, Aug. 21). "Marmen Welcon and Smulders to Produce Offshore Wind Transition Pieces at the Port of Albany, New York" [Press release]. Retrieved from https://www.prnewswire.com/news-releases/marmen-welcon-and-smulders-to-produce-offshore-wind-transition-pieces-at-the-port-of-albany-new-york-301361910.html.

Massachusetts Clean Energy Center. (2021a). *The Massachusetts Offshore Wind Supply Chain Directory*. Retrieved from https://directory.masscec.com/listing/p:1.

Massachusetts Clean Energy Center. (2021b). *2021 Offshore Wind Workforce Training & Development in Massachusetts Report*. Retrieved from https://files-cdn.masscec.com/reports/MassCEC%20OSW%20Workforce%20Final%20Report_Sept%202021.pdf.

Massachusetts Department of Energy Resources. (2021). *Request for Proposals for Long-Term Contracts for Offshore Wind Energy Projects*. Retrieved from https://macleanenergy.files.wordpress.com/2021/05/83c3-rfp-and-appendices-final.pdf.

Mayflower Wind. (2021). *Section 83C Request for Proposal Application Form, Appendix A*. Retrieved from https://macleanenergy.files.wordpress.com/2021/09/mayflower-83ciii-public-submission.zip.

McClellan, S.A (2019). *Supply Chain Contracting Forecast for U.S. Offshore Wind Power*. Special Initiative on Offshore Wind. Retrieved from https://www.noia.org/wp-content/uploads/2019/05/SIOW-Paper.pdf.

McCrone, B.X (2021, Feb. 23). "Offshore Wind Developer Signs Job Training Agreement With 6 NJ Labor Unions." NBC10 Philadelphia. Retrieved from https://www.nbcphiladelphia.com/news/national-international/changing-climate/offshore-wind-developer-atlantic-shores-signs-job-training-agreement-with-6-nj-labor-unions/2716354/.

McCue, D. (2021, Jan. 15). "Equinor Selected for NY Offshore Wind Project." Renewable Energy Magazine. Retrieved from https://www.renewableenergymagazine.com/wind/equinor-selected-for-ny-offshore-wind-project-20210115.

Milligan, C. (2021, Oct. 14). "Ørsted's Latest Investment Brings Offshore Wind Steel Fabrication to Md.'s Eastern Shore." MarylandINNO. Retrieved from https://www.bizjournals.com/baltimore/inno/stories/news/2021/10/14/orsted-invest-offshore-wind-steel-fabrication-md.html.

Musial, W., Constant, C., Cooperman, A., et al. (2020). *Offshore Wind Electrical Safety Standards Harmonization: Workshop Proceedings*. National Renewable Energy Laboratory. Retrieved from https://www.nrel.gov/docs/fy20osti/76849.pdf.

Musial, W., Spitsen, P., Beiter, P., et al. (2021). *Offshore Wind Market Report: 2021 Edition*. National Renewable Energy Laboratory. Retrieved from https://www.energy.gov/sites/default/files/2021-08/Offshore%20Wind%20Market%20Report%202021%20Edition_Final.pdf.

National Association of State Energy Officials. (2021). *Diversity in the Energy Workforce: Data Findings to Inform State Energy, Climate and Workforce Development Policies and Programs*. Retrieved from https://www.ourenergypolicy.org/resources/diversity-in-the-u-s-energy-workforce-data-findings-to-inform-state-energy-climate-and-workforce-development-policies-and-programs/.

National Association of State Energy Officials, Energy Futures Initiative. (2021a). *2020 U.S. Energy & Employment Report*. Retrieved from https://www.usenergyjobs.org/s/USEER-2020-0615.pdf.

National Association of State Energy Officials, Energy Futures Initiative. (2021b). *2020 Wages, Benefit and Change: A Supplemental Report to the Annual U.S. Energy & Employment Report*. Retrieved from https://www.usenergyjobs.org/s/Wage-Report.pdf.

National Association of State Energy Officials, Energy Futures Initiative. (2022a). *2021 U.S. Energy & Employment Report: Executive Summary*. Retrieved from https://www.energy.gov/sites/default/files/2021-07/USEER%202021%20Executive%20Summary.pdf.

National Association of State Energy Officials, Energy Futures Initiative. (2022b). *2021 U.S. Energy & Employment Report*. Retrieved from https://www.energy.gov/sites/default/files/2021-07/USEER%202021%20Main%20Body.pdf.

National Renewable Energy Laboratory. (2021). *Annual Technology Baseline*. Retrieved from https://atb.nrel.gov/.

New York State Energy Research and Development Authority. (2021, January). *2020 Offshore Wind Solicitation (Closed)*. Retrieved from https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/Offshore-Wind-Solicitations/2020-Solicitation.

OffshoreWIND.biz. (2017). "U.S. Starts Working on Offshore Wind Standards." Retrieved from https://www.offshorewind.biz/2017/09/13/u-s-starts-working-on-offshore-wind-standards/.

Organisation for Economic Co-operation and Development. (2021). *Latest Developments in Steelmaking Capacity*. Retrieved from https://www.oecd.org/industry/ind/latest-developments-in-steelmaking-capacity-2021.pdf.

Revolution Wind. (2021, April 14). "Ørsted and Eversource Establishing Regional Offshore Wind Foundation Component Manufacturing Facility at ProvPort in Rhode Island." Retrieved from https://revolution-wind.com/news/2021/04/14/16/00/regional-offshore-wind-foundation-component-manufacturing-facility-at-provport.

Riggs Distler. (2021, Oct. 9). "Riggs Distler Selected for Offshore Wind Contract." Retrieved from https://riggsdistler.com/riggs-distler-selected-for-offshore-wind-contract/.

Siemens Gamesa. (2021, Oct. 25). "Global Leadership Grows: Siemens Gamesa Solidifies Offshore Presence in U.S. With Virginia Blade Facility." Retrieved from https://www.siemensgamesa.com/en-int/newsroom/2021/10/offshore-blade-facility-virginia-usa.

Terry, G. (2021, March 18). "A Positive Trend: U.S. Offshore Wind Solicitations Address Equity." Windpower Engineering & Development. Retrieved from https://www.windpowerengineering.com/a-positive-trend-u-s-offshore-wind-solicitations-address-equity/.

Tisheva, P. (2015). "Siemens Gets Hull City Consent for UK Wind Turbine Blade Factory." Retrieved from https://renewablesnow.com/news/siemens-gets-hull-city-consent-for-uk-wind-turbine-blade-factory-479133/.

United Nations Framework Convention on Climate Change, Conference of the Parties 26. (2021, Nov. 13). *Glasgow Climate Pact, Advance Version*. Retrieved from https://unfccc.int/sites/default/files/resource/cma2021_L16_adv.pdf.

U.S. Department of Energy. (2012). *U.S. Offshore Wind Manufacturing and Supply Chain Development Report*. Retrieved from https://www.energy.gov/sites/default/files/2013/12/f5/us_offshore_wind_supply_chain_and_manufacturing_development.pdf.

U.S. Department of Energy. (2022). *U.S. Wind Energy Supply Chain Deep Dive Assessment*. Retrieved from https://www.energy.gov/sites/default/files/2022-02/Wind%20Supply%20Chain%20Report%20-%20Final%202.25.22.pdf.

U.S. House of Representatives. (2021). *Committee on Energy and Commerce, Subcommittee on Energy Testimony of David Hardy, CEO of Ørsted Offshore North America, Offshore Wind, Onshore Benefits: Growing the Domestic Wind Energy Industry*. Retrieved from https://energycommerce.house.gov/sites/democrats.energycommerce.house.gov/files/documents/Witness%20Testimony_Hardy_ENG_2021.10.21.pdf.

White House. (2021a). *FACT SHEET: Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs*. Retrieved from https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/.

White House. (2021b). *FACT SHEET: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies*. Retrieved from https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/.

White House. (2021c). Executive Order 14008 of January 27, 2021: Tackling the Climate Crisis at Home and Abroad. *Federal Register*, *86*(19), 7619–7633. Retrieved from https://www.energy.gov/sites/default/files/2021/02/f83/eo-14008-tackling-climate-crisis-home-abroad.pdf.

White House. (2021d). Executive Order 13990 of January 20, 2021: Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis. *Federal Register*, *86*(14), 7037–7043. Retrieved from https://www.energy.gov/sites/default/files/2021/02/f83/eo-13990-protecting-public-health-environment-restoring.pdf.

Windpower Engineering & Development (WPED) Staff. (2021a). "Nexans Subsea Transmission Cable Manufacturing Facility Setting Up in South Carolina for Offshore Wind Market." Windpower Engineering & Development, Nov. 9, 2021. Retrieved from https://www.windpowerengineering.com/nexans-subsea-transmission-cable-manufacturing-facility-setting-up-in-south-carolina-for-offshore-wind-market/.

WPED Staff. (2021b). "Vineyard Wind Proposes Offshore Wind Port Site in Salem, Massachusetts." Windpower Engineering & Development, Sept. 30, 2021. Retrieved from https://www.windpowerengineering.com/vineyard-wind-proposes-offshore-wind-port-site-in-salem-massachusetts/.