County of Humboldt

Redwood Coast Region Offshore Wind Supply Chain Assessment

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XODUS

Boston

99 Summer Street
Suite 1720 . Boston
MA 02110 . USA

T +1 (0)8572 631772
E brooklyn.fox@xodusgroup.com

www.xodusgroup.com

COMPLIANCE AND FUNDING DISCLOSURE

This work was undertaken in compliance with the applicable requirements of the Federal Funding Accountability and Transparency Act, 2 C.F.R. Part 200, 2 C.F.R. Part 2900, and all relevant implementing regulations, policies, procedures, and standards in effect at the time of performance, as amended.

The deliverables and activities described in this report were supported by the Workforce Innovation and Opportunity Act (WIOA), with zero (0) percent financed from non-federal sources. All work was carried out in compliance with the applicable provisions of the Workforce Innovation and Opportunity Act Subgrant Agreement (Subgrant No. AA211007), as amended, between the County and the California Employment Development Department.

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EXECUTIVE SUMMARY

This report assesses and analyses the existing and potential capabilities of the Redwood Coast Region (Redwood Region, comprised of Humboldt, Del Norte, Mendocino and Lake Counties, in support of the floating offshore wind industry in California and abroad. The goal of this study is to evaluate the region's supply chain strengths and gaps to provide an evidence base for regional investment and business attraction opportunities.

Global offshore wind is anticipated to approach 200 GW of installed capacity by the end of this decade, with approximately 14 GW of floating capacity[1]. While the floating offshore wind industry is still immature at time of writing California has set a target of 25 GW by 2045. The Humboldt Bay Harbor District was awarded $426.7 million to build an offshore wind terminal that will be principally engaged in staging and integration (S&I) and operations and maintenance (O&M) of projects that will be developed off the coast of Northern and Central California.

With a deep tribal history, the Redwood Region was built out during the California Gold Rush, and has experienced the growth and decline of a number of industries. Currently the region is seeking to maximize economic benefits resulting from its role in floating offshore wind. A supply chain assessment of existing companies was carried out using standard industry taxonomy. The subsequent opportunity assessment considered two cases: the opportunity for OEMs and Tier 1s to locate in the region, and the ability of the local companies to contribute to the broader floating offshore wind supply chain. The assessments resulted in the following observations and outcomes:

Focus on Local Contribution to Port Development – Early focus on the local opportunity to assist in developing capabilities required to support S&I and O&M port services, including cranes, fuel provision, quayside equipment, logistics management, and more.

Project Development, S&I, and Onshore Construction as Key Opportunities – Demonstrated regional strengths in project development, environmental and land-based surveying, heavy equipment rental, metal fabrication, electrical services, and onshore construction, corresponding to immediate regional opportunities.

Opportunity to Localize Floating-Specific Supply – The greatest opportunity beyond S&I and O&M port operations is likely to be manufacturing floating-specific offshore wind components, such as anchors, or performing assembly activities for floating substructures in the longer-term.

Raise Awareness and Educate Local Businesses – Local companies may increase their opportunity to participate by understanding of the types of products and services required, participating in targeted engagement focused on partnership building, and investment in scaling, retooling and certification.

Engage the Local Community in a Meaningful Way – Consultation with the local community and tribal members must be a priority to ensure that development activities are in line with their desires, values, and concerns. To effectively build an offshore wind supply chain it is crucial to communicate opportunities directly to the community and local companies to ensure they are given the chance to prepare and participate.

[1] NREL Offshore Wind Market Report 2024 Edition

1 INTRODUCTION

Humboldt County is exploring opportunities to support development of the floating offshore wind industry on the US West Coast. Xodus has been contracted by Humboldt County's Office of Economic Development (GoHumCo) to conduct a comprehensive assessment of the local and regional supply chain, workforce, and community related to offshore wind. This assessment covers Humboldt County and the wider Redwood Region, including Mendocino, Del Norte and Lake Counties, as well as Tribal Lands (collectively defined as the 'Redwood Region') with the goal of identifying additional opportunities to support floating offshore wind, including port development activities.

1.1 Project Overview

The scope of work followed in this report was developed in partnership with the County of Humboldt and informed by extensive community engagement. This allowed Xodus to adapt its substantial experience in offshore wind supply chain assessment to address unique community challenges, identify niche opportunities, and address recurring questions and themes raised by community members. The scope of work that this Supply Chain Assessment Report is part of is detailed in Figure 1.1, demonstrating the flow of community engagement work into the supply chain and workforce assessments.

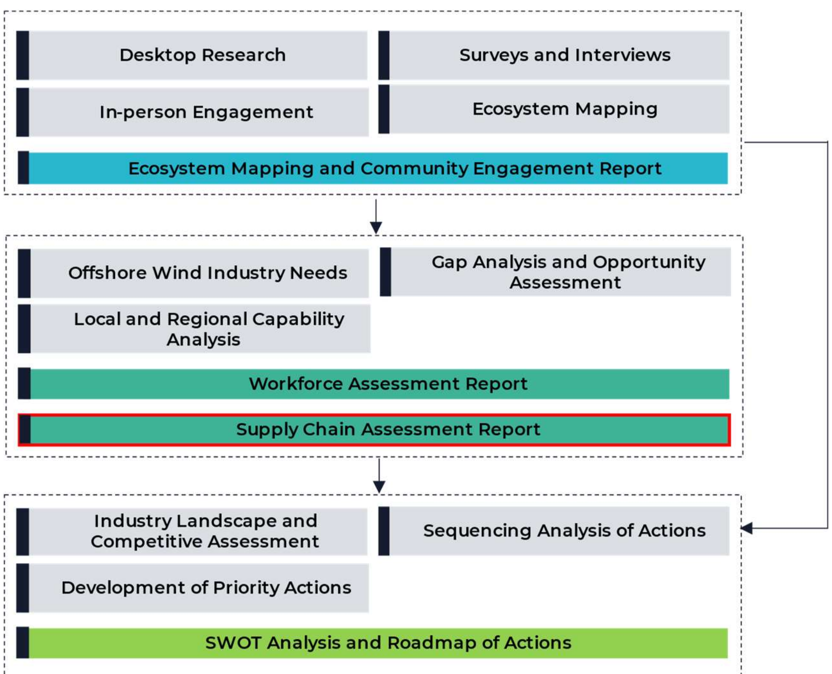


Figure 1.1 - Full Scope of Work Tasks and Deliverables

Following the supply chain assessment, a SWOT analysis will be carried out, identifying and drawing insights from strengths, weaknesses, opportunities, and threats relating to Humboldt County and the Redwood Region as the offshore wind industry is built out in California. The project will culminate in a Roadmap of Actions—a comprehensive report with recommendations to drive sustainable offshore wind development that will maximize economic development and job creation opportunities for the residents of the Redwood Coast.

1.2 Objectives

The goal of this supply chain assessment is to analyze the existing and potential local and regional capabilities that may be leveraged in developing the floating offshore wind industry in California and the broader US. This will provide an overview of the supply chain strengths and gaps in Humboldt County and the wider Redwood Region, which will provide evidence to prioritize regional investment and business attraction opportunities. The outcomes of this report will inform a SWOT analysis to support action planning for the Redwood Region as it works towards its established goals and objectives in support of the floating offshore wind industry.

1.3 Scope of Document

This report is structured as follows:

Section 2: Offshore Wind Industry Landscape – Provides context for the supply chain assessment by discussing the current and future offshore wind development trajectory. This begins with a global perspective and narrows in on the US, followed by California and the Redwood Region – all with a focus on floating offshore wind.

Section 3: Offshore Wind Supply Chain – Gives an overview of the floating offshore wind supply chain, introducing the taxonomy used as a basis for the supply chain assessment, and detailing the requirements for each supply chain area. Descriptions of the state of floating offshore wind supply chain development globally, in the US, and on the West Coast are provided, identifying major players in the industry.

Section 4: Regional Supply Chain Assessment – This section explores the existing dominant historical and contemporary industries of the Redwood Coast alongside the cultural impacts of past industries. Following this, it details the methodology and results of the supply chain assessment of companies in Humboldt County and the Redwood Region based on the taxonomy introduced in Section 3.

Section 5: Opportunity Assessment – Assesses the opportunity for OEMs and Tier 1s to establish operations in the Redwood Region for each supply chain area based on a variety of relevant criteria. This is followed by an assessment of the opportunities available to local businesses in Humboldt County and the Redwood region to enter the floating offshore wind supply chain, again using relevant criteria to assess the strength of the opportunity.

Section 6: Discussion – Provides a summary of the findings and notable observations from this phase of the study, setting up the SWOT analysis that will be performed in the next phase of work.

1.4 Definitions

1.4.1 Glossary of Terms

Developer – An offshore wind developer is the owner and operator of an offshore wind farm. Generally, they are large multi-national energy producers and responsible for the delivery of the project in alignment with the terms agreed with local and/or national regulatory agencies and any agreed power purchase agreement (PPA).

Original Equipment Manufacturer – An original equipment manufacturer (OEM) is the manufacturer of a product that is fully developed by the company. OEMs may still purchase parts from other manufacturers and use them to assemble their finished products.

Tier 1 – Tier 1 companies are suppliers of equipment or services to the project that generally contract directly with the developer. Contracts are typically worth tens or hundreds of millions for the top level (Tier 1) packages such as supply or installation of WTGs or remaining balance of plant. Generally, the Tier 1 contractor will take the risk for schedule and cost overrun and be penalized accordingly should they not comply with agreed delivery dates.

Tier 2/3 – Tier 2 contractors supply products and services directly to the Tier 1 contractors. Tier 1 suppliers will have a small selection of Tier 2 companies from which they exclusively source certain material, equipment, or services (to guarantee quality, price and/or schedule certainty) with other Tier 2 supply opportunities being subject to a competitive tender process to encourage competition in the supply chain. Tier 3 companies supply directly to Tier 2 suppliers.

1.4.2 Acronyms and Abbreviations

Acronym/Abbreviation	Definition
APAC	Asia-Pacific
AUV	Autonomous Underwater Vehicle
BOEM	Bureau of Ocean Energy Management
BoP	Balance of Plant
COD	Commercial Operation Date
CTV	Crew Transfer Vessel
DBE	Disadvantaged Business Enterprise
EPCI	Engineering, Procurement, Construction and Installation
ESP	Electrical Service Platform
GHG	Greenhouse Gas
GW	Gigawatt
GWO	Global Wind Organization
HBE	Humboldt Builders Exchange
HLV	Heavy Lift Vessel
IIJA	Infrastructure Investment and Jobs Act
IRM	Inspection, Repair and Maintenance
IRA	Inflation Reduction Act

Acronym/Abbreviation	Definition
ITC	Investment Tax Credit
MassCEC	Massachusetts Clean Energy Center
MCT	Marine Commerce Terminal
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MW	Megawatt
NAICS	North American Industry Classification System
NDT	Non-Destructive Testing
NYSERDA	New York State Energy Research and Development Authority
O&M	Operations and Maintenance
OCS	Outer Continental Shelf
OEM	Original Equipment Manufacturer
PTC	Production Tax Credit
RCPS	Renewable and Clean Portfolio Standard
ROV	Remotely-Operated Vehicle
SBDC	Small Business Development Council
SBE	Small Business Enterprise
SOC	Standard Occupational Classification
SOV	Service Operation Vessel
S&I	Staging and Installation
SWOT	Strength, Weakness, Opportunity, Threat
TLP	Tension Leg Platform
US	United States
WTG	Wind Turbine Generator
WTIV	Wind Turbine Installation Vessel

2 OFFSHORE WIND INDUSTRY LANDSCAPE

Offshore wind as an industry is very complex, and its development can be impacted by a variety of factors, including the project pipeline and investment appetite, geographic constraints, federal and state policy, and other external market pressures. Floating offshore wind, as a novel technology, and California's North Coast, as a novel geography, both pose unique challenges and opportunities for the market. For supply chain considerations in particular, opportunities for local companies are likely to be influenced by factors such as industry economics and bankability, public perception and appetite, local job markets, education opportunities in a region, adjacent and parallel industries, and more. This section provides context on the industry landscape globally, domestically, regionally, and locally to provide a basis for supply chain assessment and opportunity considerations specific to the Redwood Region.

2.1 Global Industry Landscape

The global offshore wind industry has been steadily growing over many years, becoming well established and maturing in select regions. Denmark and the United Kingdom have developed some of the world's first offshore wind projects, and technological advancements and government support have enabled expansion into new regions. At the end of 2023, the installed offshore wind capacity in the global market was 70 GW; it is forecast to reach nearly 200 GW by the end of the decade (Figure 2.1).

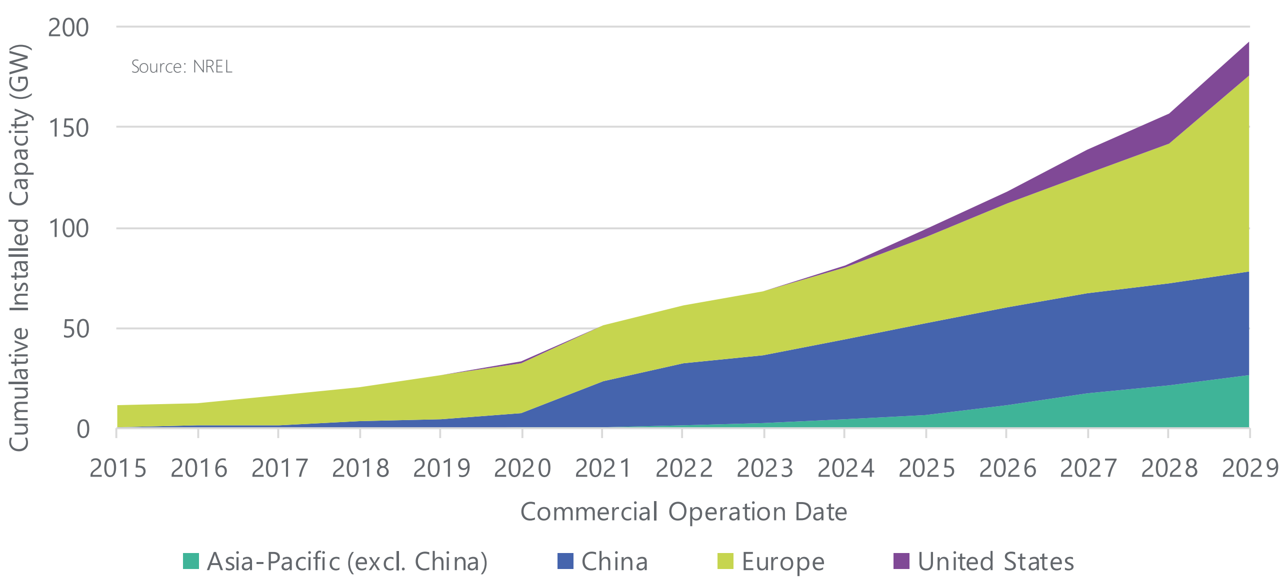


Figure 2.1 - Estimated cumulative offshore wind capacity by region according to developer-announced Commercial Operation Date (COD). Source: NREL Offshore Wind Market Report: 2024 Edition.

Fixed offshore wind is the dominant technology in the global market, over floating offshore wind. Fixed foundations are typically used in water depths of 60 meters or less, depending on sea and seabed conditions. Offshore wind development to date has primarily occurred in shallow waters close to shore due to the lower costs associated with manufacturing, installation, and maintenance of fixed wind compared to floating. Floating offshore wind technology enables development in deeper waters, which allows access to new markets and geographies, providing adjacent communities with the opportunity to leverage this renewable energy source and the benefits of development that come along with it. Development in deeper water also enables expansion of offshore wind development in jurisdictions where fixed development has already occurred, as those wind resources further offshore in deeper water depths can then be accessed. Due to the narrow continental shelf off the US West Coast and the resulting deep waters, California and the broader US West Coast will be developing exclusively floating offshore wind.

While both markets are still gaining traction, the floating offshore wind market is nascent compared to the fixed market. At the end of 2023, the installed capacity of floating offshore wind in the global market was 235 MW out of a total 70 GW. Projections made in 2024 estimate that the global floating offshore wind market will reach approximately 14 GW of installed capacity by 2029 (Figure 2.2). These numbers are likely ambitious given ongoing commercial challenges and a continued focus from developers on project returns, fixed assets, and specific markets.

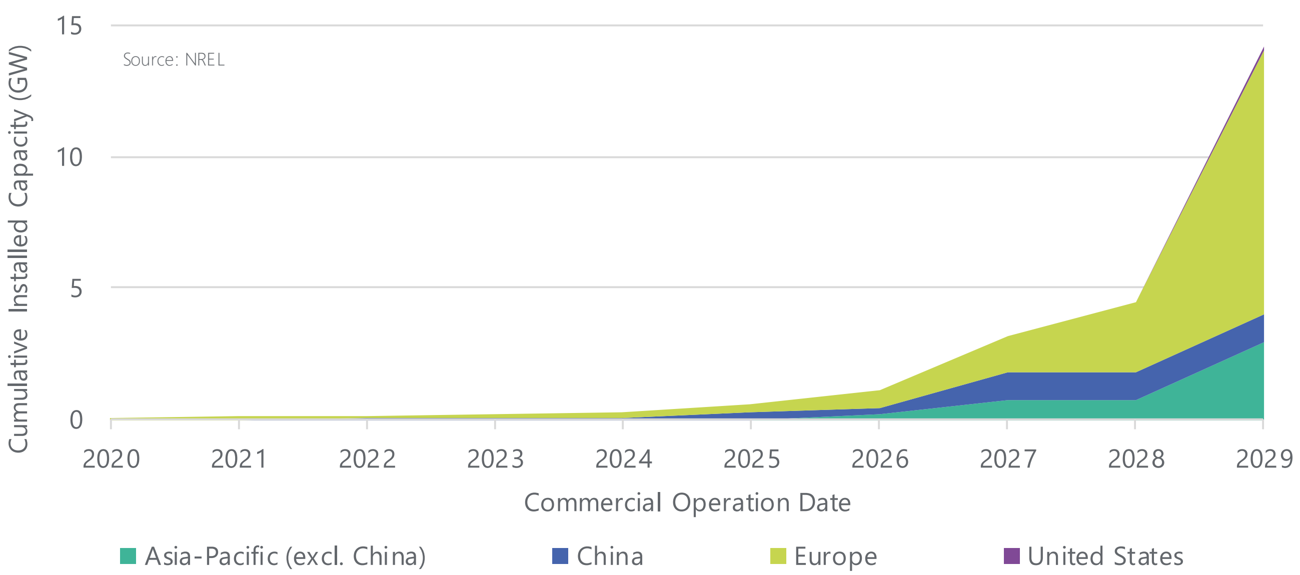


Figure 2.2 - Estimated global cumulative floating offshore wind capacity by region, according to announced COD. Source: NREL Offshore Wind Market Report: 2024 Edition.

Only seven countries had floating offshore wind farms either operating or under construction at the end of 2023. Norway leads installed floating wind capacity and operates the largest floating offshore wind farm in the world, the pilot project Hywind Tampen (88 MW). Other pilot floating offshore wind projects have been installed in the European market in Portugal, France, and Spain, and the Asia-Pacific (APAC) market in Japan and China. These early-mover countries will be responsible for the majority of announced floating offshore wind projects deployed through 2029, and new players Italy and Taiwan are also expected to deploy floating offshore wind projects in this time.

Currently operating floating offshore wind farms are small pilot projects; none are commercial scale. Pilot projects are not profit-driven, but rather they create opportunities to test new technologies, collect data on environmental impacts, and trial installation and maintenance methods at lower cost and risk than at commercial scale. Pilot projects installed so far have featured far fewer and smaller wind turbines, eliminating the need for a costly floating offshore substation. Commercial scale projects intend to deliver electricity to the grid at competitive rates and still provide operators a profit, so they will depend on cost-effective, verified technology that supports larger capacity.

The relatively high costs of floating technology and the nascency of the floating offshore wind market are responsible for the lag in commercial scale floating offshore wind development compared to that of fixed offshore wind. The technology requires complex installation and maintenance methods that are unproven for commercial scale projects. Additionally, floating-specific supply chains are less established, and serialized manufacturing facilities do not yet exist to support mass production of required components. This can be partly attributed to the variety of floating substructures that are under development with none having been established as the dominant technology, despite some frontrunner options. These technological and economic challenges make commercial scale floating offshore wind development an estimated 50% more expensive than fixed offshore wind development. Solving these challenges will be a critical enabler of commercial scale floating offshore wind development anywhere in the world.

The high capital expenditure required by commercial scale floating offshore wind is projected to decrease over time, with NREL forecasting a of 67% reduction from 2021 costs by 2035. Governments are developing financing support mechanisms to enable buildout of infrastructure such as serialized manufacturing facilities and ports specially designed for floating offshore wind. As discussed above, European pilot projects are helping validate technology, installation, and maintenance methods, decreasing risk for developers and project financiers. Learning curves will improve which will increase efficiency and reduce errors in installation and maintenance. These advances will help lower costs of commercial scale floating offshore wind deployment globally.

Some countries, recognizing costs will decrease over time, have already tendered commercial scale floating offshore wind despite existing unsolved challenges in its development. The French government held the world's first commercial scale floating offshore wind tender in 2024 for the 250 MW South Brittany project[2], which saw an unexpectedly low winning bid price. There are likely several reasons for the low bid price, with one of the primary reasons being that developers are not responsible for grid connection costs in France. The French government provides financial security for developers, including indexing the bid price to inflation, and the French government conducts certain surveys and studies before auctions, streamlining the permitting process and lowering risk for developers. This tender represents a significant milestone in the commercialization of floating offshore wind as the winning bidder was the first commercial scale floating offshore wind project to secure a funding mechanism.

The UK also recently made advancements in commercial scale floating offshore wind development. The UK government awarded an offtake contract to Green Volt (400 MW) in 2024. The floating offshore wind industry

[2] *France announces winners of world's first commercial-scale floating offshore wind auction*

considers this project a strong first-mover for commercially viable floating offshore wind in the UK, securing a lower strike price of £139.93/MWh than the ceiling of £176/MWh set by the UK Government for the subsidy.

Europe's fixed offshore wind market has aided the emergence of a small-scale floating market in ways the US cannot currently replicate. Components in the atmospheric zone (i.e., the wind turbine components and substation topside) and many lower tier capabilities and products (e.g., secondary steel fabrication, marine grade coatings, and corrosion protection systems) are relatively similar across fixed and floating applications, so floating offshore wind projects in Europe can leverage existing supply chains established in the region. The workforce can more easily upskill for floating offshore wind manufacturing and installation when already trained for fixed offshore wind. Existing regulatory support and public understanding of offshore wind in general also help clear some of the hurdles of starting a floating offshore wind market.

2.2 US Industry Landscape

In 2021, the US federal government established the goal of deploying 30 GW of offshore wind in the US by 2030, with a target of 15 GW of floating offshore wind capacity by 2035. Many US coastal states have expressed their interest in offshore wind power and have set offshore wind procurement goals either by executive order or through legislation. California's offshore wind procurement goal is the most ambitious target of any US state (Figure 2.3).

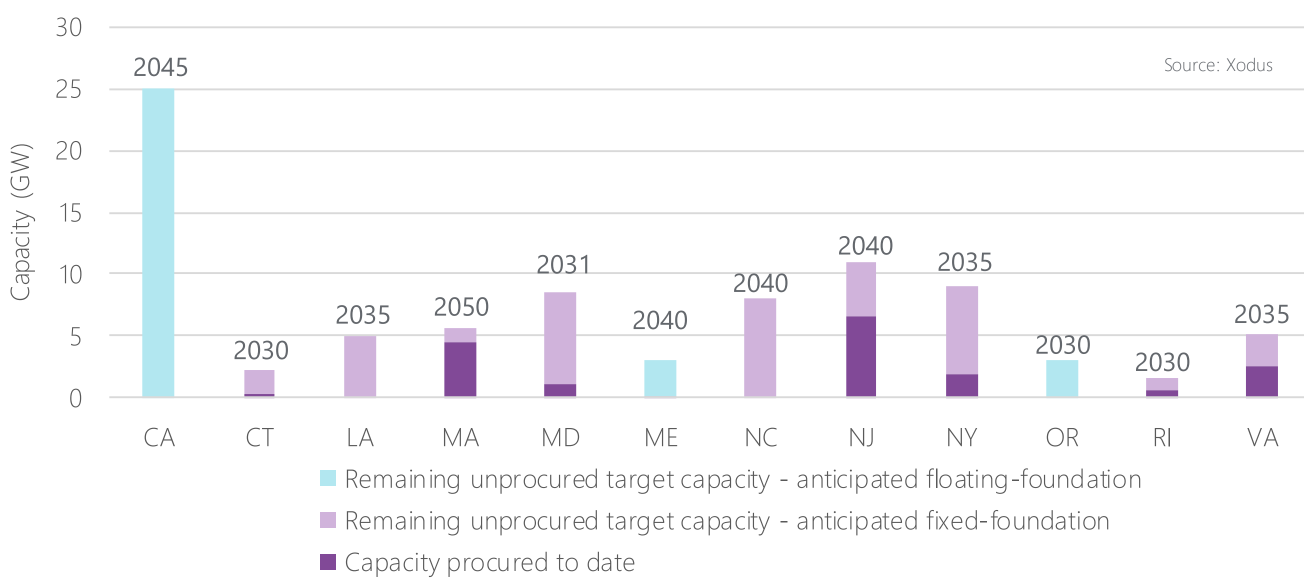


Figure 2.3 – Fixed and floating procurement goals of the US states with target year.

States' offshore wind procurement goals drive project development in the US, shaping the US offshore wind project pipeline and helping developers and investors prepare long-term strategies. While recent political changes have impacted project certainty, the US offshore wind pipeline is forecasted to grow to over 70 GW of installed capacity by 2040, with many states participating in the industry's development (Figure 2.4).

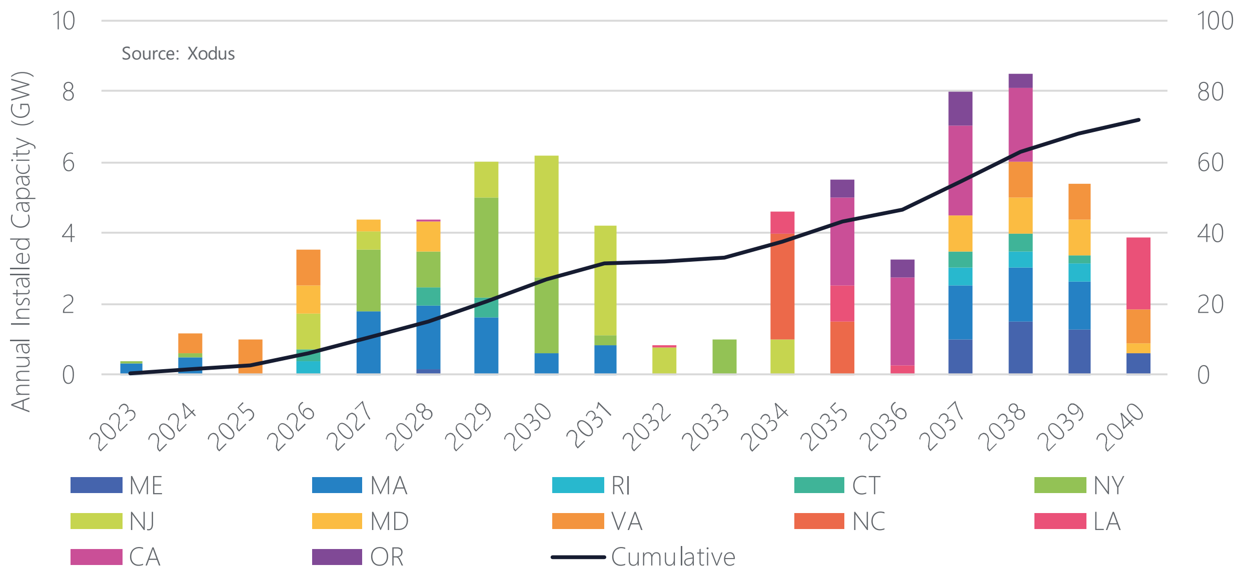


Figure 2.4 - Forecast of installed fixed and floating (combined) offshore wind capacity through 2040.

Some projects with early CODs have struggled to move forward due to increased commodity and manufacturing costs, supply chain disruptions, and bottlenecks. For example, New York State Energy Research & Development Authority (NYSERDA) and respective project developers canceled three offtake contracts in the state, representing 4 GW in capacity, because of changes in the wind turbine supplier's investment plans. Two Massachusetts projects cancelled their offtake contracts because of inflation caused by the COVID-19 pandemic, and two New Jersey projects did the same after a delay in vessel availability was anticipated to impact their installation schedules considerably. The current federal administration has also implemented changes that will impact the buildout of this industry, discussed further in Sections 2.2.1 and 2.2.2. These macroeconomic influences and market changes create uncertainty in the long-term project pipeline.

2.2.1 Floating Offshore Wind as a US Opportunity

Floating offshore wind is an important market opportunity in the US. About two-thirds of the US offshore wind energy potential, or approximately 2,800 GW[3], exists in water depths that require floating offshore wind turbines. Three states with offshore wind procurement goals—California, Oregon, and Maine—can procure only floating offshore wind power

[3] [What Will It Take To Unlock U.S. Floating Offshore Wind Energy?]

due to water depth constraints offshore. Taking advantage of this energy potential and regulatory support in these states could allow the US to be a leader in the floating offshore wind market.

The Bureau of Ocean Energy Management (BOEM) has spent over a decade preparing for floating offshore wind development in the Gulf of Maine and offshore California, Oregon, and Hawaii. BOEM's preparations have included engaging with stakeholders, consulting industry experts, and working with state agencies to determine interest levels and identify lease areas for development. BOEM held the first floating offshore wind auction in California at the end of 2022, with five developers securing lease areas. This lease sale initialized commercial-scale floating offshore wind development in the US after years of preparation.

BOEM had previously planned additional auctions for floating offshore wind lease areas, including a lease auction in the Gulf of Maine this year, however an executive action in January 2025 titled "*Temporary Withdrawal of All Areas on the Outer Continental Shelf from Offshore Wind Leasing and Review of the Federal Government's Leasing and Permitting Practices for Wind Projects*," has stopped leasing activity indefinitely. It is uncertain whether any leasing for offshore wind development will occur during the current administration, however the Californian floating offshore wind industry may be less impacted overall given the timelines for development are further out than on the US East Coast, where the industry is currently more mature. As seen in Figure 2.5, California is not expecting first power from floating offshore wind until 2035, with a current focus on infrastructure development.

The US floating offshore wind project pipeline is years behind the fixed offshore wind pipeline, mirroring trends seen globally; the forecast of installed floating offshore wind capacity in the US market can be seen in Figure 2.5. The long lead time before the commencement of commercial-scale floating offshore wind installation is a result of the technological and economic challenges of floating offshore wind in the global market. The drop in annual installed capacity after 2038 reflects the uncertainty in the market's evolution but could be significantly influenced by the announcement of further leasing rounds and additional state appetites for offshore wind capacity.

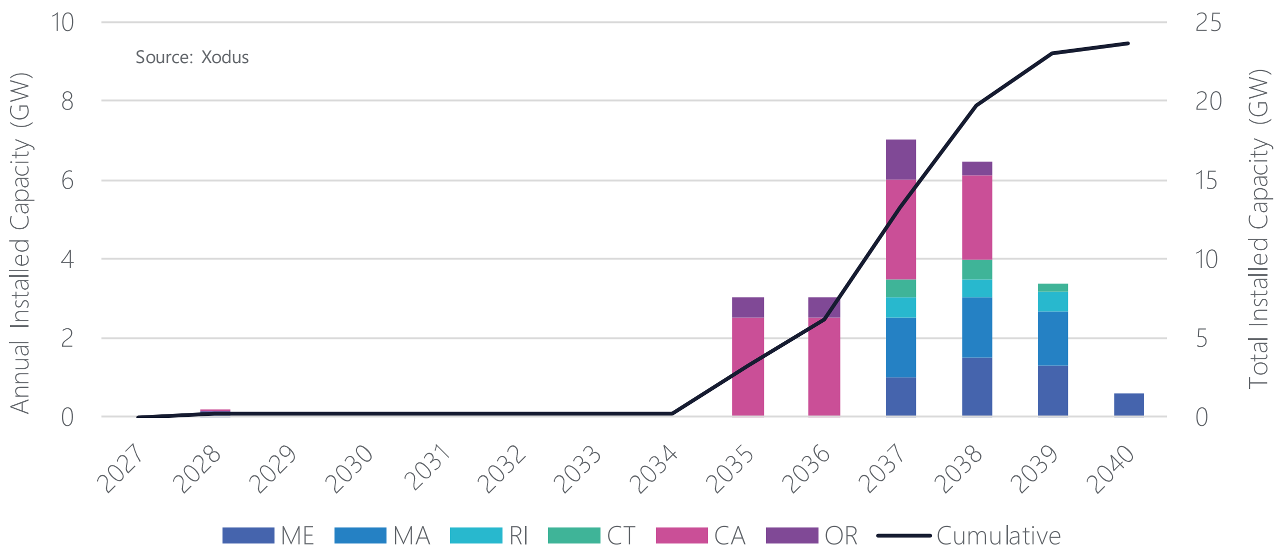


Figure 2.5 - Forecast of installed floating offshore wind capacity through 2040.

The US floating offshore wind market is experiencing global and novel challenges unique to the US. Unproven installation and maintenance methods for commercial-scale projects and nascent supply chains impact all markets, including the US. Without an established fixed offshore wind supply chain to synergize with a new floating offshore wind supply chain, the US is facing additional challenges, and investment must be split between the fixed and floating supply chains, at least until that of the fixed reaches maturity. As an additional hurdle, supply chains on the US East Coast and West Coast are isolated from one another, given the geographic range of the country and the resulting high transportation costs to move goods between the two. Most major components are too large for land transport, meaning it is not feasible to ship them cross-country, and using alternate waterways like the Panama Canal would be cost prohibitive.

To build the supply chain to confront these challenges, a secure and reliable project pipeline is necessary to encourage investment. Project certainty helps suppliers and developers de-risk projects and encourages investment in a nascent industry. Future lease auctions will continue to grow the US offshore wind pipeline and bring down investment risk; as investments are made and supply chains develop, commercial-scale floating offshore wind costs will come down.

2.2.2 US Federal Incentives

The previous federal administration took steps to stabilize and build confidence in the offshore wind industry by establishing the Inflation Reduction Act (IRA), signed into law in 2022. The IRA seeks to provide significant expansions to renewable energy tax credits for developers and manufacturers, however there is uncertainty around its future implementation. As established in Sec. 7 of the January 2025 *"Unleashing American Energy"* executive action, all funds appropriated through the IRA and the Infrastructure and Jobs Act have been paused pending a review by the Office of Management and Budget and the National Economic Council.

Under the IRA, the investment tax credits (ITC) program has partly enabled US offshore wind projects, to date. The clean energy ITC has a base credit of 6% but can reach up to 50% through incremental bonus credits if project developers also fulfill certain workforce and domestic content requirements (Table 2.1). The ITC is planned to be phased out beginning in 2030 and ending in either 2032 or once annual greenhouse gas (GHG) emissions from electricity production in the US have decreased by 75% (from 2022 levels), whichever comes later. It is important to note that some legal firms have suggested that the ITC for offshore wind may have an extended eligibility window until Jan 1st, 2035, but this has not been officially stated by the IRS. This phase-out means that, as currently written, the IRA's ITC would not apply to any California offshore wind projects constructed after 2032, and thus remains unaffected by the aforementioned executive action. However, the ITC program may be redesigned over the coming decade to include offshore wind projects constructed after 2032 if the US has not achieved its clean energy and climate targets, and if future administrations are supportive of such developments.

The IRA's incentive to utilize domestic suppliers had already begun influencing developers' procurement and supplier investment strategies before being paused. Many developers decided to seek procurement in states such as New York and New Jersey, which prioritize local content and have invested in planned domestic manufacturing facilities.

Offshore wind's eligibility for the Energy Community Tax Credit Bonus would provide an opportunity for developers to boost credit for locating project transmission systems in communities that have historically seen disproportionate local siting of fossil-fuel-based industries or where a certain percentage of the tax base is reliant on fossil fuel industries. If implemented, this bonus credit would likely play a role in determining interconnection locations and port utilization for projects looking to capitalize on this opportunity. The requirements that developers must satisfy to achieve a given incremental increase in ITC are described in Table 2.1.

Table 2.1 - Investment Tax Credits relevant to offshore wind projects developed in the U.S. (117th Congress (2021-2022), 2022)

REQUIREMENT	TOTAL INCREMENTAL ITC	DESCRIPTION
Baseline	6%	Construction on the offshore wind project must be between Jan 1st, 2025, and Jan 1st 2032.
+ Prevailing Wages	30%	All laborers and mechanics must be paid prevailing wages as defined by the Department of Labor for a given locality and job type.
+ Apprenticeships		Qualified apprentices in registered apprentice programs must perform 15% of the total labor hours for projects constructed after 2024.

REQUIREMENT	TOTAL INCREMENTAL ITC	DESCRIPTION
+ Domestic Content	40%	Steel, iron, and other manufactured products that comprise the project must be produced in the US.
+ Energy Community	50%	Project's interconnection and power conditioning equipment and/or supervisory control and data acquisition equipment must be located in a federally recognized Energy Community.

In addition to the ITC, the IRA established the Advanced Manufacturing Production Credit, which introduced a federal production tax credit (PTC) for domestic manufacturing of offshore wind components. The value of the PTC depends on the type of component being manufactured and the total wattage of the turbine it will support. For example, a nacelle manufactured in the US is eligible for a PTC of 5 cents per watt of rated turbine capacity. As such, a nacelle for a 12 MW turbine would generate a PTC of $600,000. If implemented, the PTC is set to be phased out between 2030 and 2032, with components sold in 2030 receiving a PTC equal to 75% of the rate, components sold in 2031 receiving a PTC equal to 50% of the rate, and components sold in 2032 receiving a PTC equal to 25% of the rate. Table 2.2 provides the PTC rates for each offshore wind component manufactured in the US. It is important to note that the tax credit for construction-related vessels is based on the vessel's sales price and not on a traditional PTC mechanism.

Table 2.2 - Advanced Manufacturing Production Credits for US-manufactured offshore wind components (117th Congress (2021-2022), 2022)

COMPONENT	PTC
Blade	2¢ per watt of rated turbine capacity
Nacelle	5¢ per watt of rated turbine capacity
Tower	3¢ per watt of rated turbine capacity
Fixed Foundation	2¢ per watt of rated turbine capacity
Floating Foundation and Mooring System	4¢ per watt of rated turbine capacity
Construction Related Vessels	10% of sales price

While these PTCs will likely play a role in the decision-making of OEMs looking to develop manufacturing facilities inside the US, they will likely not be the primary determining factor. Other variables such as proximity to projects, overall demand, demand consistency, state-based incentives, material costs, and existing supplier relationships will also influence where manufacturing facilities are established. PTCs will provide significant value to existing suppliers who are currently working or could work, in the offshore wind industry. This includes manufacturers of vessels (such as Wind Turbine Installation Vessels (WTIVs), Service Operations Vessels (SOVs), and Crew Transfer Vessels (CTVs)), who will be able to get 10% of the sales price credited.

2.3 California Industry Landscape

Global and national trends show that opportunity for supply chains to be developed for the offshore wind market depends on several interrelated factors. Requirements include a secure pipeline of projects to create demand for local suppliers, regional ambitions for economic development, strong policy and public sector financial support, and the presence of a capable or potential to be capable, adjacent supply chain. California, with support from the federal government, is establishing itself as a leader in the floating offshore wind industry with the introduction of policies that send strong market signals and unlock funding to advance the sector.

California is one of the highest energy-demand states and has some of the most ambitious renewable energy targets in the country. In 2018, the state passed Senate Bill 100 (SB 100), which mandates the state's electricity grid must be powered by 100% renewable energy and carbon-neutral sources by 2045. Offshore wind is expected to be a critical resource in achieving this goal, providing large-scale energy generation, especially in the evening hours, complimenting the high capacity of solar power and offering a necessary balance to the grid. In 2022, BOEM held California's first offshore wind auction for five lease areas offshore California, initiating commercial scale floating offshore wind development in the US.

The trajectory of commercializing floating offshore wind in California has been advancing at pace, with strong support from the local and state governments. Figure 2.6 shows a timeline of progress to commercialization of the industry. Shortly after announcing its climate goals in 2018, the state gave a priority focus to supporting the growth of the state offshore wind industry. The state codified this through the passage of Assembly Bill 525, adopting ambitious offshore wind targets, determining a pathway for the centralized procurement of generated power, approving transmission upgrades to enable offshore wind power distribution, and approving a plan to procure 7.6 GW of offshore wind energy.

Figure 2.6 – Key milestones in California policy and port upgrade funding to support offshore wind development.

Despite the current political climate, these strong market signals have provided confidence in the California offshore wind market, unlocking further investment and funding to support the critical infrastructure with the goal of making these projects feasible. This includes the development of ports, transmission networks, workforce training, and the broader supply chain, all of which are essential to advancing California's floating offshore wind industry toward commercialization.

Developing port infrastructure close to the floating offshore wind project sites will be important to enable technical and economic feasibility of project installation. The Port of Humboldt Bay has been identified as a critical port for development in the region. As mentioned, Figure 2.6 highlights strong enthusiasm for offshore wind within the Redwood Coast community, where local funding was provided in 2020 to the Humboldt Bay Harbor District to conduct conceptual studies, years prior to state goals being established or lease areas announced. This local funding was soon followed by additional state and federal funding in the years of 2021-2023 to develop the Port of Humboldt Bay into an offshore wind marine terminal. The Humboldt Bay Harbor District was awarded $426.7 million to construct an offshore wind terminal. These funds were awarded under the Department of Transportation’s Nationally Significant Multimodal Freight & Highway Projects program, funded through the 2021 Bipartisan Infrastructure Law. With this investment, Humboldt Bay will likely be the first staging and integration port on the West Coast.

The development of suitable transmission infrastructure is a critical step in enabling offshore wind development, particularly in the North Coast region. As it stands, Northern California does not have sufficient transmission capacity to accommodate commercial offshore wind generation, and as such the timeline of transmission network upgrades will directly impact the timeline of offshore wind development in the region. While the ability to deliver offshore wind projects in the region will depend on the buildout of port and transmission infrastructure, the development timelines anticipated for this are likely to be of benefit to the California floating offshore wind industry, where increasing technical and commercial maturity will bring down costs with time, and where lead times are required to also address the ongoing technical challenges associated with installation of floating offshore wind at California’s water depths.

Through state-held energy procurement solicitation rounds, there may be expectations placed on offshore wind project developers to ensure suitable domestic supply chain content is achieved, as has been seen on the East Coast. The successful development of the California supply chain will be driven by the presence and scale of political and economic support given to businesses to enable investment. Ongoing maturation of the floating wind industry is also likely to bring clarity to technical requirements; as uncertainties in floater design and deep water deployment methods are resolved, a more targeted and efficient supply chain is likely to emerge.

2.3.1 Redwood Coast

In 2022, BOEM held a lease auction for the seabed rights to develop offshore wind projects off the coast of California. This resulted in the award of two lease areas off the coast of Humboldt County and three off the coast of San Luis Obispo County. The northern California leases were secured by project developers RWE and Vineyard Offshore, while the three leases off the coast of San Luis Obispo County were secured by Equinor, Invenergy, and Golden State Wind. Figure 2.7 shows the location of the five offshore wind sites and their proximity to the Redwood Coast region.

Studies indicate that approximately 70% of the capacity necessary to meet California's goal of 25 GW by 2045 will likely be located in waters off the coast of Northern California[4], emphasizing the region's critical role in meeting the state's offshore wind goals. The Port of Humboldt Bay has been identified as the most suitable port in Northern California to be able to accommodate floating offshore wind project construction and installation. Ports suitable to support offshore wind operations and maintenance (O&M) include those in Humboldt County and at Crescent City Harbor, Del Norte County.

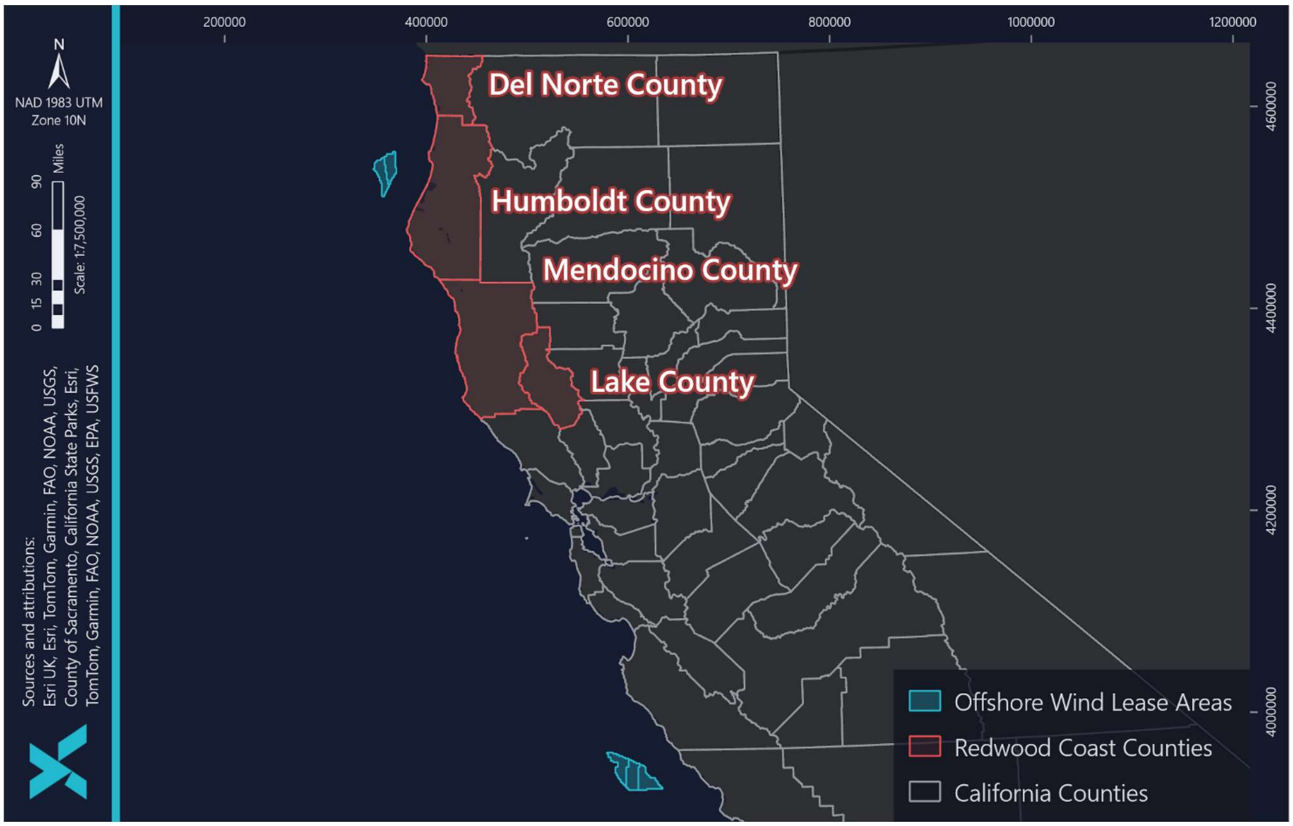


Figure 2.7 - Offshore wind lease areas awarded in the 2022 BOEM California lease auction.

The County and other community leads are eager to examine and prepare for the supply chain opportunities in the region, as evidenced through several initiatives and efforts among different organizations. Humboldt County has hosted an annual offshore wind conference called POWERCA in the region for two consecutive years, building momentum and collaboration within the community. The Schatz Energy Research Center in Humboldt County has conducted several technical studies to support the industry, ranging from studies on environmental impacts to transmission planning; they have also coordinated the Pacific Offshore Wind Consortium, a collaborative effort with the Pacific Marine Energy Center at Oregon State University and the Center for Coastal Marine Sciences at Cal Poly San Luis Obispo. Additionally, the WindLINK initiative was announced as a collaboration between GoHumCo and local and

[4] *FAQs — Offshore Wind California*

regional businesses, and has been established to align the needs of industry with local businesses as development gets underway.

Both RWE and Vineyard Offshore have been active in the region, having a local presence, prioritizing community and tribal engagement, and focusing on early project development activities, including RWE's site surveys for Project Canopy. A Memorandum of Understanding (MOU) was established between Humboldt County and the two developers and states that these three parties will work together to establish a framework for mutual support, collaboration, and coordination in the successful development of the region's offshore wind industry. This MOU is the first of its kind in the US allowing two developers to work together for the betterment of the industry and region.

Community buy-in is critical to advancing the offshore wind industry in a productive and equitable manner, and Humboldt County's local and regional initiatives, combined with an appetite for economic growth, are fostering the conditions necessary for a successful industry build out. As development progresses, it will be crucial to identify what opportunities for the region are realistic and have the potential for long-term positive impacts, given it's history, strengths, adjacent industries, and appetite.

3 OFFSHORE WIND SUPPLY CHAIN

The opportunity for a regional supply chain to benefit from the growth of the offshore wind industry will depend on several factors including the specific supply requirements of projects and the availability, capability, and location of Tier 1 supply. Developers of US floating offshore wind projects do not yet have certainty on the project design to inform supply chain selection. Many component and service requirements for technologies unique to the floating offshore wind industry have also not yet been standardized or commercialized. The impacts of the pause on IRA funding and the current administration's actions limiting offshore wind development are also uncertain. The case for investing in offshore wind supply chain development in Humboldt County and the Redwood Region will be influenced by how these uncertainties are addressed by the industry.

3.1 Floating Offshore Wind Supply Chain Requirements

Offshore wind projects are complex: over a period of approximately 10 years various project development and procurement activities take place, necessitating careful timing so that all parts of the project are ready at the right time for installation and commissioning activities. Following this, the projects are operational for 25+ years, with regular and unplanned maintenance, major component replacements, ongoing monitoring, and finally, decommissioning.

The taxonomy of a typical floating offshore wind project is given in Table 3.1. This taxonomy comprises multiple Supply Elements that describe the broad requirements for products and services that enable the development, construction, and operation of an offshore wind farm.

Supply Elements generally represent Tier 1 and Tier 2 packages where supply is commonly fulfilled by a distinct provider or group of providers. Wind Turbine Supply and Balance of Plant Supply refer to the production of physical infrastructure, while the remaining Supply Chain Areas refer primarily to services. The O&M phase of the project is the longest, covering the project's active life, which is usually assumed to be 25 years. Decommissioning is the final phase of an offshore wind farm's life—given that decommissioning activities will not take place in California for at least 30 years, this is not considered as part of this analysis.

Table 3.1 - Taxonomy for a floating offshore wind project.

Supply Chain Area	Supply Element	Details
Project Development	Development and Permitting	Companies engaged in all or part of permitting and regulatory compliance processes including EIAs.
	Surveys	Wind resources assessments, geotechnical surveys, metocean assessments, protected species observers, etc.
	Engineering and Design	Front-end engineering and design: turbine layout, electrical and civil infrastructure, feasibility analysis, etc.

	Project Management	Developers or those subcontracted to manage packages of a project.
Wind Turbine Supply	Nacelle	Wind turbine generator, transformers, switchgear, control systems, power offtake system, bedplate, housings, gearbox, main shaft, yaw/pitch motors, HVAC, lighting systems, fire alarms, etc.
	Blades	Glass/carbon fiber, polymer foam, balsawood, resin, etc.
	Tower	Steel plate, large gauge welding services, major steel component fabrication facilities, secondary steel, etc.
Balance of Plant Supply	Dynamic Cables	Cable raw material supply (bitumen, lead alloy, copper, aluminum), cable manufacturing facilities, buoyancy modules, cable accessories, etc.
	Static Cables	Cable raw material supply (bitumen, lead alloy, copper, aluminum), cable manufacturing facilities, cable accessories, etc.
	Floating Substructure	Tubular steel, steel plate, large gauge welding services, concrete, major steel component fabrication facilities, etc.
	Mooring and Anchor Systems	Chain, synthetic rope, connectors, anchor manufacturing, etc.
	Offshore Substation	Major steel component supply, major industrial electrical equipment supply, floating substructure, secondary steel, HVAC, lighting systems, fire alarms, etc.
	Secondary Steel	Ladders, handrails, work platforms, boat landings, walk-to-work platforms, davit cranes, structural fasteners (custom and stock), cable terminations, installation aids, seafastening/grillages, etc.
	Onshore Substation	Major steel component supply, major industrial electrical equipment supply, site preparation, access roads, secondary steel, HVAC, lighting systems, fire alarms, etc.
Transportation and Installation	Onshore Construction	Road building, grading, leveling, landscaping, foundation preparation for tower, onshore substation, etc.
	Offshore Substation Installation	Tow out of offshore substation, connecting electrical infrastructure, calibration and testing, commissioning works, etc.
	Offshore Cable Installation	Cable-lay operations, terminating and connecting electrical infrastructure, energizing systems, commissioning works, calibration, testing, etc.

	Anchor and Mooring Installation	Respective vessel activities, site preparation, surveys pre-and post-installation.
	Staging and Integration	Final assembly work, vertical integration of nacelle-rotor assembly, tower, and floating substation.
	Wind Turbine Installation	Tow-out of floating OSW turbines.
	Ports and Logistics	Warranty surveyors, brokerage and customs functions, helicopter services, HSE inspectors, etc.
Operations and Maintenance	Operations	Facilities management and monitoring, HSE inspectors, weather forecasting and metocean data, communications, emergency response systems.
	Turbine Maintenance and Services	Contracting companies representing wind turbine technicians, rope access technicians, offshore scaffolding, engineering services, regulatory services, remotely-operated vehicles (ROVs), autonomous underwater vehicles (AUVs), divers, vessels, turbine service kits, etc.
	Balance of Plant Maintenance and Services	Contracting companies representing wind turbine technicians, rope access technicians, offshore scaffolding, engineering services, regulatory services, ROVs, AUVs, divers, vessels.
	Major Repair or Component Replacement	Major component replacement support, electrical support, maintenance support.
	Offshore Vessels and Logistics	Vessel supply services (CTVs, SOVs, WTIVs, heavy-lift vessels, cable lay vessels, diver boats, pilot/scout boats, barges, etc), ROV's, divers, etc.

Table 3.2 details what products and services are required in each Supply Chain Area, broken out by a standardized Tier 1, Tier 2, and Tier 3 supply. Note that this is a simplified description of tiered supply chain activities that are subject to both the developer procurement strategy as well as the Tier 1 or OEM supplier approach to their wider supply chain.

Table 3.2 - Products and services required by Supply Chain Area.

SUPPLY CHAIN ELEMENT	DESCRIPTION OF PRODUCTS AND SERVICES
Project Development	Tier 1: Services – Engineering and design, permitting, surveying – activities subcontracted directly by project developers. Tier 2: Components – Survey vessels, related sensing and measurement equipment, provision of software tools. Services: Environmental monitoring, data collection.

SUPPLY CHAIN ELEMENT	DESCRIPTION OF PRODUCTS AND SERVICES
Wind Turbine Supply	Tier 1: OEM – Turbine OEMs manufacture blades and nacelles for turbines; Tower OEMs roll and weld steel plates into towers. Tier 2: Components – Generator, bearing, drive shaft, gear box, steel plates, flanges, steel fixtures, coatings. Tier 3: Materials – Fiberglass or carbon fiber, resin, steel, aluminum, iron/cast iron.
Balance of Plant: Substructure and Mooring Supply	Tier 1: OEM – Substructure OEMs roll and weld steel plates into floating substructures. Anchors and mooring OEMs weld steel plates and produce steel chain or synthetic rope. Tier 2: Components – Steel plates, flanges, steel fixtures, coatings, synthetic fibers. Tier 3: Materials – Steel, aluminum, polyester, nylon and High Modulus Polyethylene.
Balance of Plant: Static and Dynamic Cable Supply	Tier 1: OEM – Subsea cable OEMs design and manufacture dynamic subsea cables. Tier 2: Components – Cable core, cable outer, fiber optic cable, cable tray fabricator. Tier 3: Materials – Copper or aluminum, cross-linked polyethylene insulation, bitumen, dyes, adhesives.
Balance of Plant: Electrical Infrastructure Supply	Tier 1: OEM – Electrical infrastructure OEMs manufacture onshore and offshore substations. Tier 2: Components – Switchgear, transformers, converters, reactive power compensation. Tier 3: Materials – Steel, aluminum, copper.
Transportation and Installation	Tier 1: Staging and marshalling, turbine/substructure integration and installation, anchor and mooring line installation, subsea cable installation, offshore substation installation – activities subcontracted directly by project developers, including the required vessels. Tier 2/3: Services – Warehousing and storage, fuel bunkering, logistics management and port services, equipment rental (e.g. cranes).
Operations and Maintenance	Tier 1: Services – Asset management, predictive maintenance, corrective maintenance, major component replacement – activities subcontracted directly by project developers. Tier 2/3: Services/Components - SCADA systems, inspection services, drones, ROVs, non-destructive testing (NDT) technicians, provision replacement components, coatings, corrosion protection, etc.

There are several components in an offshore wind farm that have very similar, if not identical, manufacturing processes regardless of whether they are being used for fixed or floating offshore wind. The wind turbine generators, including the nacelle, hub, and blades, are unchanged, while the tower may require increased wall thickness or slight design changes to accommodate the increased loadings seen with floating wind turbines. Unlike with fixed wind, some floating offshore wind turbines do not require designated transition pieces as this is a function of the substructure. Typical floating substructures are shown in Figure 3.1.

Semisubmersibles are considered as the prevalent foundation technology for this study, and are comprised of steel columns separated by pontoons, secured to the seabed using mooring lines and anchors. Cables, although similar to those in fixed-bottom offshore wind with regards to rated capacity and internal structure, are dynamic instead of static, and are suspended in the water column using buoyancy modules to allow for motion of the floating platform. Offshore substations, though similar to fixed-bottom structures above the waterline, also require floating substructures in deeper water depths as those found offshore California. However, these substructures must be designed differently than the floating substructures supporting wind turbines because of the increased weight and different load distributions of the substations. Floating substation design is proving to be one of the greatest challenges of commercial scale floating offshore wind technology design.

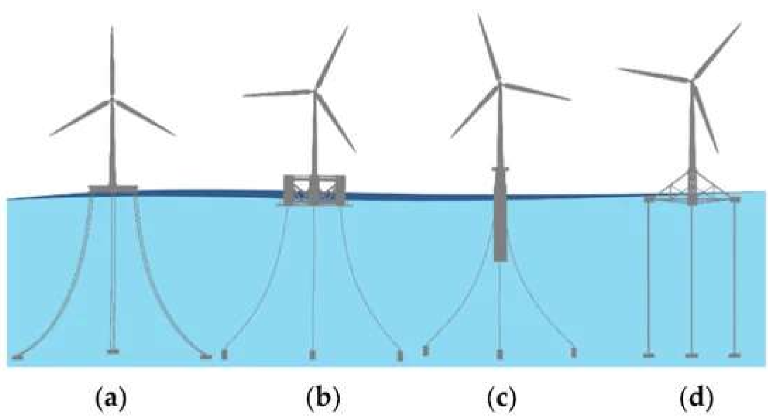


Figure 3.1 - Floating Substructure Types, (a) Barge, (b) Semisubmersible, (c) Spar, (d) Tension Leg Platform (TLP). Source: Journal of Marine Science and Engineering (2022)

3.2 Supply Chain Landscape

The relative maturity of the global and regional US supply chain for key project elements and the main components within is highlighted below (Table 3.3). The expansion of offshore wind supply chain capability in emerging markets relies both on leveraging existing capability in other markets and regions to support delivery of projects as well as the nascent, yet adjacent capability in new, local markets.

Table 3.3 - Summary of offshore wind supply chain capabilities in the global, US, and West Coast regions.

ELEMENT	GLOBAL CAPABILITY	US CAPABILITY	WEST COAST CAPABILITY
Project Development	Established	Established	Emerging
Wind Turbine Supply	Established	Emerging	Not yet emerging

ELEMENT	GLOBAL CAPABILITY	US CAPABILITY	WEST COAST CAPABILITY
Floating Substructure Supply	Emerging	Not yet emerging	Not yet emerging
Dynamic Subsea Cable Supply	Emerging	Not yet emerging	Not yet emerging
Electrical Infrastructure Supply	Established	Emerging	Not yet emerging
Floating Substation Supply	Emerging	Not yet emerging	Not yet emerging
Transportation and Installation	Established	Emerging	Not yet emerging
Operations and Maintenance	Established	Emerging	Not yet emerging

3.2.1 Global Landscape

The development of floating offshore wind supply chain capability has been linked both to adjusting and expanding existing fabrication and shipyard capabilities to respond demand in other markets, as well as the development of local capability where floating offshore wind installations have been planned and are set as a key strategic market priority. China has the largest offshore wind market in the world and a robust, domestic supply chain. Whilst trade restrictions and national security concerns have made developers and other governments hesitant to procure wind turbine components from China, the country has a track record of supplying monopile and jacket foundations, as well as subsea cables and other Tier 2/3 subcomponents to the global offshore wind industry. This includes floating offshore wind. Analysis of the global supply chain landscape and capability gaps therefore consider capability existing in Europe, the APAC, and the US. As the region leading offshore wind development outside China, Europe offers a strong floating offshore wind supply chain capability, and has focused to expand this through additional port and fabrication facility investments.

As noted, the global supply chain landscape for floating offshore wind includes both established and emerging capabilities. Serialized manufacturing facilities for floating offshore wind components do not yet exist, and this gap must be filled to support commercial scale production and deployment anywhere in the world. Floating offshore wind manufacturing clusters are starting to form as manufacturers of fixed offshore wind components explore floating solutions, and other suppliers gain experience from floating offshore wind pilot projects. Examples of potential floating offshore wind manufacturing clusters include the Scottish Cromarty and Moray Firths. Key aspects of global capability are explored in Table 3.4, and additional detail on the capability behind each of the supply chain elements and their status in the global supply chain can be found in Appendix A.

Table 3.4 - Summary of global capability to support floating offshore wind development across supply chain elements.

ELEMENT	GLOBAL CAPABILITY
Project Development	• **Capability is somewhat established in all regions** in the global market; however ongoing learnings and capabilities are still being developed in the engineering space for floating offshore wind ahead of the industry reaching maturity in emerging markets. • Many companies headquartered out of the more mature European market will open divisions in new geographies to access new markets. • Project development services are typically readily available.
Wind Turbine Supply	• Capability is established in Europe and emerging in APAC and the US. • Europe's manufacturing is currently supporting the global market, but **European manufacturing expected to be at capacity** by 2027. Reduced US demand following federal government's pause on offshore wind leasing will free up global capacity. • Several existing manufacturing facilities are planning upgrades to increase output, and new facilities are planned in APAC and the US, although US plans are currently uncertain. • **Supply chains are dependent on China for key subcomponents** including gearboxes, generators, converters, and large castings, as well as carbon fiber and rare earth metals.
Floating Substructure Supply	• Capability is emerging in Europe and APAC. • **Serialized manufacturing for floating substructures does not yet exist globally**. • European manufacturers supplied substructures and mooring lines to floating pilot projects in small scopes. • Scalability of design and manufacturing methods for **floating substructures for offshore substations poses a challenge**, as pilot projects have either not required offshore substations or water depths allowed for jacket foundations. Floating substation substructures are being explored in **South Korea, Japan, and Taiwan**. • Serialized manufacturing gap creates an opportunity for market entry for any country willing to take on the risk of the new industry; however, countries like China, South Korea and Spain with existing manufacturing strengths are likely advantaged due to facilities that are being expanded upon.
Subsea Cable Supply	• **Capability to supply static cables is established** in all regions in the global market. • **Dynamic array cable production has been established** by subsea cable suppliers in Europe, but **product testing is a bottleneck** to enabling commercial scale manufacturing of dynamic cables. • **Dynamic export cables still require testing and certification** before commercial scale production is readily available.

ELEMENT	GLOBAL CAPABILITY
Electrical Infrastructure Supply	• Capability for **construction of onshore and offshore substations is established** in the global market, with supply of electrical components coming primarily from China and South Korea. • Electrical equipment manufactured for commercial scale fixed offshore wind projects can also supply floating projects, so **established players will continue to dominate this supply**. • **New offshore substation solutions are being considered** for commercial scale floating, such as subsea substations, energy islands, and direct connection to onshore grid. Capability gaps may open if a new technology is deemed best to replace floating offshore substations.
Transportation and Installation	• Capability to supply some vessels is established, but **new vessels will need to be built**. • **Local vessels operating in adjacent industries are often contracted as support vessels**, so new markets typically engage local mariners to develop this capability. • **Anchor handing tugs are available in the global market** to support floating offshore wind turbine tow-out and hook-up, but they were originally built for the oil and gas industry, so they are not optimized for floating offshore wind. • A **shortage of dynamic cable laying vessels** and land-based heavy-lift cranes capable of integrating wind turbines at quayside exists in the global market.
Operations and Maintenance	• Capability is established in the global market, but O&M is mostly localized, so **new markets cannot depend on global O&M capability**. • The nascency of the floating offshore wind industry means best O&M methods for commercial scale projects are not yet known. The demand for specific capabilities (e.g., vessels, equipment) and **capability gaps in new markets will become apparent as best practice O&M methods are established**.

3.2.2 US Landscape

The focus on offshore wind component manufacturing in the US has increased in recent years. Domestic manufacturing has been incentivized by the IRA and financing mechanisms offered through procurement contacts. States, developers, and Tier 1 manufacturers have all invested heavily in establishing new Tier 1 manufacturing facilities, and facility development plans for a variety of components in the supply chain have been announced (Table 3.5).

Table 3.5 - Announced Tier 1 U.S. manufacturing facilities to support offshore wind in the US.

COMPONENT	SUPPLIER	FACILITY LOCATION	PUBLICALLY ANNOUNCED INVESTMENT	STATUS
Nacelle	Vestas	Wind Port, NJ	Unknown	Announced
Tower	Marmen Welcon	Port of Albany, NY	$700 million**	Announced

COMPONENT	SUPPLIER	FACILITY LOCATION	PUBLICALLY ANNOUNCED INVESTMENT	STATUS
	US Forged Rings	East Coast	$700 million**	Announced
	Haizea Wind Group	Sparrows Point, MD	$150 million	Announced
Monopile*	EEW	Paulsboro Marine Terminal, NJ	$250 million	Operational
	Haizea Wind Group	Sparrows Point, MD	$150 million	Announced
Transition Piece*	Marmen Welcon	Port of Albany, NY	$700 million**	Announced
Array Cable	Hellenic Cables	Sparrows Point, MD	Unknown	Announced
Export Cable	Nexans	Charleston, SC	$310 million	Operational
	LS Greenlink	Chesapeake, VA	$99 million	Announced
Offshore Substation	Kiewit	Ingleside, TX	Unknown	Operational

*Not used in floating offshore wind.
**Total announced investment covers capability to supply more than one component type

Some manufacturing facility development plans have been linked to the success of specific projects, which has increased risk for the US manufacturing landscape. Several US offshore wind projects have been canceled or postponed, in turn leading to the cancellation or delay of linked manufacturing facility investment plans.

Wind turbine supply capability is emerging through these facility development plans, but the anticipated supply will likely not serve the West Coast. Manufacturing processes for wind turbine components, offshore substation topsides, and export cables are relatively similar between fixed and floating wind and, as such, these facilities could theoretically support the developing floating market. However, the size of the components and the distance of the water transit route between the East Coast and West Coast results in high transport costs, creating a supply chain disconnect. Domestic-manufactured offshore wind components will likely be more expensive than foreign-manufactured ones; without efficiencies from a short transit distance or state local content benefits, procuring components manufactured on the East Coast will not be economically feasible for West Coast developers.

Floating offshore wind manufacturing capability, including floating substructure and dynamic cable manufacturing, has not yet emerged in the US, although such capability could grow in the coming years. The US could manufacture mooring lines, anchors, buoyancy modules[5], and other subcomponents that have analogs in the offshore oil and gas industry.

Subsea cable supply is an emerging capability in the US. The Nexans facility in South Carolina is one of the only operational Tier 1 manufacturing facilities in the US, and it has supplied both US and European projects. The facility could supply static cables for floating offshore wind projects but not West Coast projects, due to geographic constraints

[5] Deep Water Buoyancy Inc. *is a Maine based company that already produces buoyancy modules for offshore energy industries.*

as previously noted. Dynamic cable manufacturing is a current gap in the US market, with demand to be seen primarily on the West Coast.

The supply of electrical infrastructure is an emerging capability in the US. Kiewit has offshore substation manufacturing capabilities in Texas but procures electrical and auxiliary systems from many global suppliers. Some suppliers, such as General Electric, Siemens, Schneider Electric, and ABB, manufacture electrical equipment required in onshore substations in the US. The supply of onshore substations in the US is well established, given their necessity in power grids and transmission networks.

The Jones Act heavily influences the procurement, transport, and installation of offshore wind components. The Act requires that when transporting offshore wind components between two US points, which include US ports and offshore wind farms, work must be conducted by US-flagged vessels that are US-built, US-owned, and US-crewed. This requirement also applies to vessels required to install anchors and mooring lines, and those used to perform floating substructure hook-up. However, Jones Act Requirements do not extend to cable-laying vessels, meaning that vessels from other markets could be utilized for this work.

Pilot projects have opted for different approaches for turbine integration, either using a heavy-lift crane stationed at quayside, a submersible barge, vessel-mounted cranes, or a WTIV. A global bottleneck on supply of both heavy-lift cranes and WTIVs raises questions about how US floating offshore wind projects will handle wind turbine integration. While not the preferred installation option due to day rate impacts on cost, an additional complicating factor is that WTIVs will likely have to be Jones Act-compliant to handle wind turbine integration, limiting this option in the US market. The construction of the Charybdis, the first-ever Jones Act-compliant WTIV, provides an option here, though costs would need to be considered.

The US has a limited supply of anchor handling tugs, so early US floating offshore wind projects may face a bottleneck unless additional capacity can be sourced to meet demand. The US market will also continue to rely on foreign-built and operated vessels and experienced foreign Engineering, Procurement, Construction and Installation (EPCI) companies to conduct transportation and installation campaigns. Jones Act-compliant floating offshore wind installation strategies are still in development.

O&M is an emerging capability in the US. The US's first installed offshore wind projects in the Northeast have reached the O&M phase, and these projects have begun to exercise local O&M skillsets. These projects have also created a concentration of O&M suppliers of technology such as remotely operated vehicles, autonomous underwater vessels, and condition-based monitoring systems. As noted above, O&M in new markets are typically self-reliant, so projects in new regions in the US create opportunities for technological innovation and employment from local communities.

3.2.3 West Coast Supply Chain Landscape

The first round of utility-scale floating offshore wind projects in California is projected to begin procuring major components in the early 2030s to meet state targeted CODs of 2035-2037. Given the 25 GW offshore wind procurement goal set by California, efforts are being made to develop a West Coast manufacturing capability to minimize dependency on imports.

The nascency of the floating offshore wind industry, need for investment in adjacent infrastructure, and the formation of specialist supply chain capability will impact the cost of delivering energy. There is ambition in the state to ensure ratepayers are not adversely impacted by high energy prices, further emphasizing the need for affordable energy solutions. The drive to reduce energy prices will likely result in the industry relying on global suppliers that can offer more competitive pricing. However, certain activities such as staging and integration (S&I) will be preferred to be conducted near project locations. This requires ports with specific characteristics including sufficient water depth, load bearing capacity, height clearances, and proximity to offshore project sites.

There is not yet a best practice established for floating substructure manufacturing. Substructures can either be imported in their final form, whereby components are fabricated and assembled overseas then shipped, or can be fabricated using a modular approach, whereby components are fabricated at the foreign fabrication site and shipped to the S&I site for final assembly. It is likely that West Coast offshore wind projects will import substructures from Asia given the region's lower fabrication costs, established capability, and higher expected production capacity.

A multi-port approach across several states would open opportunities for the states of Washington and Oregon, which have port infrastructure and industrial capabilities that could attract offshore wind activities related to storing components, manufacturing, O&M, and offshore logistics. While California does have an advantage of strong political will and being a first-mover, other regions may offer stronger industrial adjacency and workforce capability that would make the regions more attractive to Tier 1 suppliers. For example, Washington's strong maritime industry and shipbuilding capabilities, and Oregon's industrial capacity and proximity to the Northern California lease areas, could serve as strong incentives for Tier 1 localization.

The following sections highlight the offshore wind landscape across California, Washington, and Oregon, identifying potential port capabilities, existing adjacent supply chains, and regional strengths that could attract supply chain development. Table 3.6 provides a summary of each region's capabilities as they relate to the offshore wind industry. While this is not an extensive supply chain analysis, it offers an overview of each region and provides context and insight into a future SWOT analysis.

While Table 3.6 offers a general overview, it is important to note that none of the listed ports or supply chain capabilities are currently prepared to meet the demands of the offshore wind industry in their current state. All will require significant investment to be fully operational. The potential ports were identified through the AB 525 Port Readiness Plan and through NREL's *"The Demand for a Domestic Offshore Wind Energy Supply Chain"* [6], which assessed West Coast ports' suitability for various activities.

[6] *The Demand for a Domestic Offshore Wind Energy Supply Chain*

Table 3.6 - West Coast floating offshore wind supply chain overview, by region.

STATE	POTENTIAL PORT CAPABILITY	EXISTING SUPPLY CHAIN	STRENGTHS AND OPPORTUNITIES
California	Northern CA (S&I, O&M, Final Assembly, Manufacturing)	S&I port location, limited existing supply chain.	- Proximity to offshore wind projects. - Local content requirement from solicitations (incentivizing in-state content). - Local govt. support and subsidies. - Port development timelines aligned with offshore project timelines. - First mover's advantage. - Ambitious state targets. - OSW and floating foundation technology developers established in the region.
	Bay Area (Manufacturing)	Headquarters for technology developers- Principle Power, Ocergy, some fabrication capabilities.	
	Central Coast (O&M)	Professional industries, scientists and engineers.	
	Southern CA (S&I, O&M, Final Assembly, Manufacturing)	Sourcing of fabrication or final assembly of floating substructures at General Dynamics NASSCO, aerospace industry, S&I Port plans in Long Beach.	
Oregon	Port of Coos Bay (S&I, Manufacturing, Final Assembly) Port of Astoria (S&I, Final Assembly)	Marine operations and logistics, some industrial manufacturing including center and outside columns, tubulars, fabrication of truss and tendons structures for floating foundations, overall anchoring solutions.	- Adjacency to Northern CA and future Oregon lease sales. - Potential anchor supply capabilities. - Lower real-estate prices.
Washington	Port of Seattle/Tacoma (Manufacturing, S&I, Final Assembly) Port of Grays Harbor (Manufacturing, S&I, Final Assembly)	Strong marine manufacturing and shipbuilding industry, including mooring lines and anchoring solutions, piles, tubular fabrication and columns for floating substructures, secondary steel, vessel operations and logistics, large aerospace industry and industrial base.	- Local ambition to participate in supply chain. - Longstanding, existing industrial manufacturing. - Capabilities directly adjacent or within the offshore wind supply chain. - Lower cost comparatively to Southern CA. - Specialized and concentrated workforce.

California

California has the competitive advantage of hosting the first commercial scale floating offshore wind projects in the US. The state is recognized as being a leader in innovation and sustainability, reflected through its ambitious offshore wind targets and political incentives to grow the industry supply chain.

In California, the Port of Humboldt Bay's Heavy Lift Marine Terminal and the Port of Long Beach's Pier Wind Project have developed conceptual plans for S&I, final assembly, and manufacturing activities. Federal and state investments have been targeted at these two ports, as the timeline of commercially viable floating offshore wind project development hinges on the port development for S&I activities. Currently, both ports' upgrades are scheduled to align with the demands of the industry. The Humboldt Bay Harbor District's conceptual plan is shown in Figure 3.2, and Pier Wind's conceptual plan in Figure 3.3.

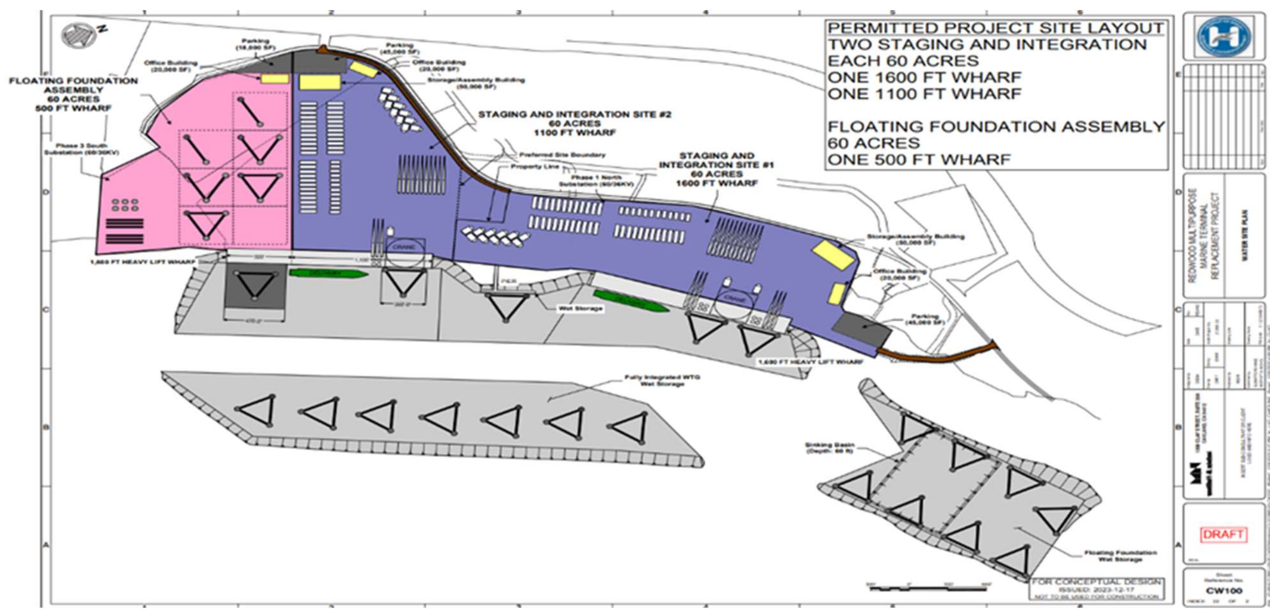


Figure 3.2 - Harbor district conceptual plan for Heavy Lift Marine Terminal[7].

The Humboldt Bay Harbor District has planned a three-phased approach for its buildout. Phase one includes the development of one S&I terminal, phase two includes the development of an additional S&I terminal (both indicated in the purple shading), and phase three (indicated in pink shading) aims to establish local manufacturing and final assembly of floating foundations. It is anticipated that phase one will be completed by the end of 2029[8], however this is contingent on a number of factors and may shift.

[7] CEQA - Project Description - 20240401.pdf
[8] Project Timeline | North Coast Offshore Wind

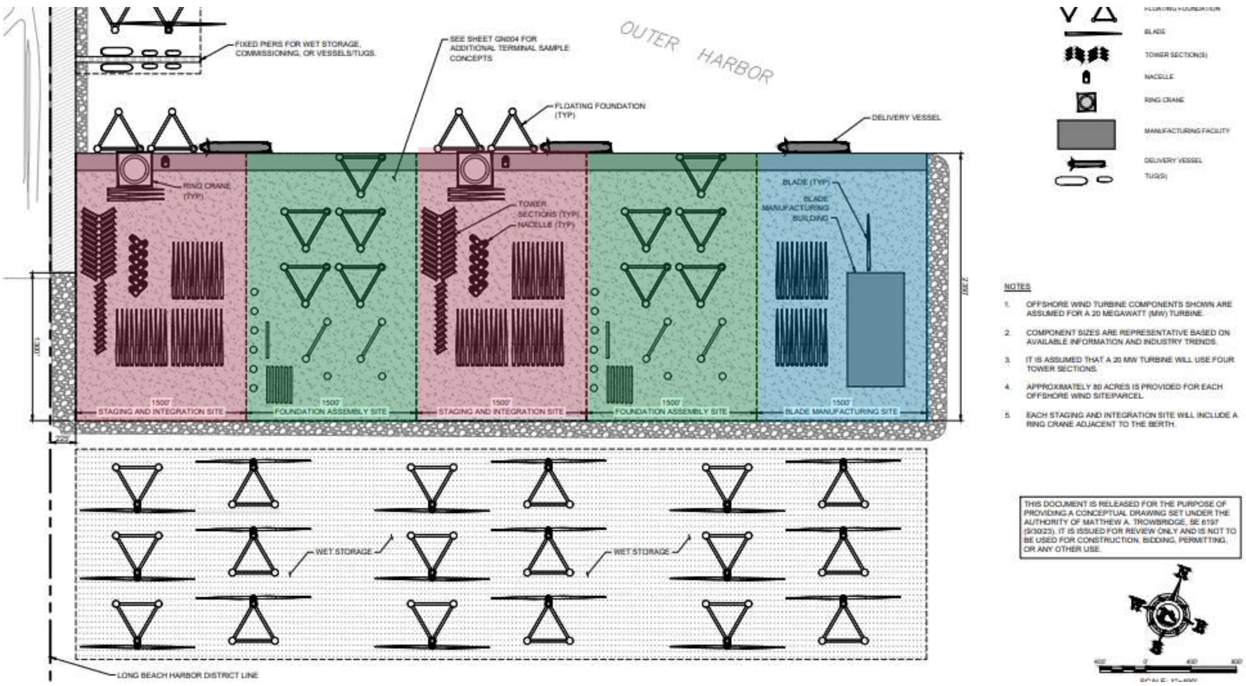


Figure 3.3 - Pier Wind Conceptual Layout Drawing (Moffatt & Nichol adapted from original version 2023[9]).

The Port of Long Beach's Pier Wind project, shown in Figure 3.3 will require extensive land reclamation to build the terminal up from existing waterfront space. The Pier Wind project proposes a five terminal, 400-acre approach, hosting two staging and integration activities, indicated in pink, two foundation assembly areas, indicated in green, and one blade manufacturing facility, indicated in blue. The Port of Long Beach plans to develop the port in two phases, one for the first 200 acres, expected to be complete in 2031, and a second phase for the remaining 200 acres by 2035. However, these dates are subject to change based on when notice to proceed is granted, but a close alignment between port readiness and respective offshore wind activity timing should be ensured. The proximity to a manufacturing workforce and existing supply chain in Southern California makes the possibility of localizing component manufacturing more likely.

If manufacturing were to occur in California, regions with stronger supply chain networks and a more diverse workforce such as the Southern California and the Bay Area would be more likely to attract these facilities. However, the cost of doing business in these regions is notably higher than the national average. Southern California, recognized for its strengths in defense contracting and shipbuilding, such as San Diego's General Dynamics NASSCO, could leverage existing capabilities for fabrication or final assembly of floating foundations. Without local content requirements or other investment attraction to bring costs down, it is unlikely that establishing facilities in these areas would be the preference for suppliers. The Bay Area, known for expertise in technology development and advanced manufacturing

[9] 2023-04-20-Pier-Wind-Concept-Report-FINAL.pdf

related to semiconductors and electronics, aligns well with the demand for complex precision components needed in turbine generators and control systems.

Oregon

An offshore wind lease auction off the coast of Oregon was originally slated for October 2024 but was recently canceled due to a lack of developer interest in the sites at this time. While there are not active leases tied to the state, there are other ways in which state entities could support offshore wind development. Both the Port of Coos Bay and the Port of Astoria may be able to participate in the industry, as they are strategically located to service and supply projects in Northern California. However, they would need to show a strong appetite for involvement, and this has not yet been the case, potentially in part due to the pushback that has been observed in the region due to environmental and tribal concerns regarding offshore wind development.

Current capabilities adjacent to the offshore wind supply chain in the state are in marine-focused manufacturing, including some anchor supply and larger-scale manufacturing yards. Strengths in the marine sector could support offshore wind logistics, installation activities, and O&M activities.

Washington

Washington State is not anticipated to have offshore wind leasing rounds in the near future, but there may be opportunities for assets and organizations in the region to support offshore wind development on the West Coast. Recently, Blue Wind Collaborative, a state initiative to analyze supply chain opportunities in the region, was announced, indicating early appetite for involvement in the broader regional supply chain.

The Port of Seattle and Grays Harbor were highlighted in NREL's The Demand for a Domestic Offshore Wind Energy Supply Chain study as ports capable of supporting manufacturing, S&I, and final assembly, with the Port of Seattle noted as having a higher level of potential readiness. The state has unique strengths and is home to 75 ports, which could potentially lead to expanded opportunities to access supply chain inland through widespread port and waterway access.

Washington is recognized as home to a long-standing shipbuilding industry with major shipbuilders and shipyards such as All American Marine, Vigor, SAFE Boats International and Orion Marine Group. One of the critical global supply chain bottlenecks in the floating offshore wind supply chain is vessel supply, specifically heavy lift vessels, anchor handling tugs, and cable lay vessels. As mentioned, the Jones Act imposes additional restrictions on the availability of vessels for West Coast projects, further necessitating the demand for new vessels. This could present a key supply opportunity in the state.

Washington also has a strong footprint in maritime logistics and port operations, with global operators such as Crowley, Centerline Logistics, and Foss located in the region. Washington's established marine sector make the region capable of supplying floating specific components such as mooring line rope at Samson Rope and Cortland Company, and some anchor supply.

The state is well positioned with established supply chain networks and a highly skilled workforce in directly adjacent industries, and may offer a lower cost of doing business than that of California. However, Washington has not yet seen significant investment or funding to establish the region, and no in-state offshore wind ambitions have been announced. Such ambitions typically bring attention and financial commitment to a region. If the state begins prioritizing offshore wind, it could be a strong contender to support floating-specific components, necessary shipbuilding, and project installation and logistics.

3.3 Typical Local Supply Opportunities

Local supplier contracting has become a priority for US offshore wind projects. This trend has been established by states who make local economic benefit generation an important criterion in scoring offtake solicitation bids. Developers often specify commitments for local content creation in these bids. The degree to which they are bound to these commitments varies by state, with most states requiring regular reporting of local content creation, and others demanding financial penalties if local content commitments are not met.

Establishing Tier 1 manufacturing in new markets can be technically and economically challenging. In many cases OEMs have established their existing production either in lower cost countries in order to secure the most competitive pricing or in markets with strong existing and historic demand, such in Denmark and the UK. Tier 1 suppliers can be apprehensive to disrupt existing optimized supply chains by onboarding new local companies. It is especially difficult for new suppliers to be certified for bespoke components due to complicated and time consuming certification processes. The process to identify, audit and onboard new suppliers can take months to several years. It involves checking the safety record, certifications, sustainability, cost, and quality aspects of the new supplier. These factors have made lower tier manufacturing localization less of a focus in local supply chain engagement planning.

For a nascent industry, local contracts will most likely be placed where there is logic and necessity for the supply to be local and where bespoke components and extensive certification are not required. Examples include project development work which relies on local knowledge and existing stakeholder relationships to streamline permitting and engagement processes, transportation and installation scopes which rely on local ports services, and O&M supply chains where there is technical and economic logic for local supply.

General products and services that are not bespoke to offshore wind and easier to procure will benefit from the development of offshore wind projects as an additional revenue stream. Local opportunities and such as heavy lift equipment, personal protective equipment, ship supplies and services, onshore construction management, sitework, and ports services will be required. Supply chains for these products and services have typically been built up by various common industries, and most coastal mid-size communities have available suppliers. Table 3.7 includes some examples of opportunities for local supply.

Table 3.7 – Typical opportunities for local supply in offshore wind projects

ELEMENT	OPPORTUNITES FOR LOCAL SUPPLY	
Project Development	• Electrical design • Environmental impact assessment • FEED scopes • Financial services • HSEQ services • Installation design	• Legal services • Offshore environmental surveys • Offshore geological and hydrological surveys • Onshore environmental surveys • Permitting services • Socioeconomic surveys
Wind Turbine and Balance of Plant Supply	• Access ladders • Boat fenders and platforms • Cable trays	• Internal and external platforms • Transport services
Transportation and Installation	• Barge ballasting • Boulder clearance • Bunkering • Construction and building contractors • Crawler cranes • Crew transfer vessels • Crewing services • Electrical contractors • Feeder barge • Guard vessels • Land surveys • Marine coordination • Marshalling • Meteorological forecasting	• Offshore support • Onshore construction scopes • Onshore logistics • Port services • Pre-lay grapnel runs • Scour supply, transportation, and installation • Ships supplies (such as fresh food) • Sitework • Stevedoring • Towing tugs • Transport services
Operations and Maintenance	• Blade inspection • Electrical inspection • Equipment inspection • Marine warranty surveying • Mechanical inspection • Meteorological forecasting	• Personal protective equipment • Port services as per installation support scopes • Remotely operated vehicles • Structural inspection • Training

The scale of local supplier contracting on the first US commercial scale offshore wind project, Vineyard Wind 1, shows how developers can effectively create local opportunities in new markets despite constraints on manufacturing supply chain localization. The developer of Vineyard Wind 1 utilized a "look local first" philosophy around local content creation, encouraging their subcontractors to hire locally wherever possible. A breakdown of Massachusetts-based supply contracts by tier is given in Figure 3.4.

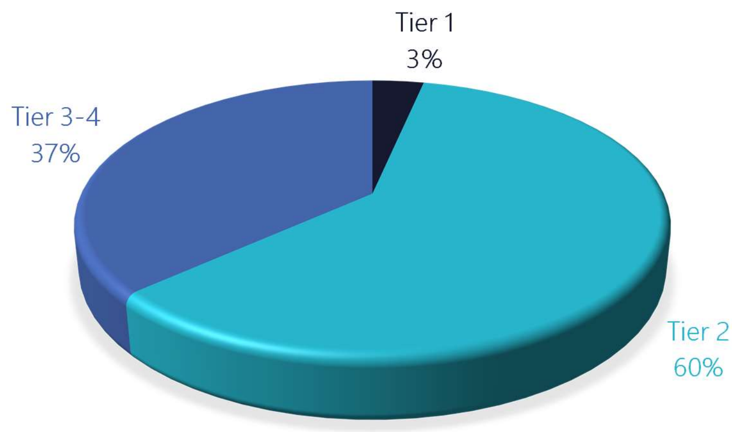


Figure 3.4 – Local supplier breakdown by tier level for Vineyard Wind 1.

Public information provided by the developer revealed that over 30 companies were contracted from Massachusetts or nearby Rhode Island. The one local Tier 1 company was the owner of the installation port, the Massachusetts Clean Energy Center Marine Commerce Terminal. Most lower tier companies provided services in support of site surveying, port logistics, and onshore construction, as well as non-custom products, such as generators, hydraulics systems, fuel provision, and vessel equipment. Labor was another major local content creator, with local stevedores, electricians, and vessel operators on site to support operations. These types of contracts may provide insight into the opportunities for Humboldt County and the Redwood Region.

4 REGIONAL SUPPLY CHAIN ASSESSMENT

The opportunity for suppliers in Humboldt County and the wider Redwood Region to meaningfully participate in the emerging offshore wind industry will depend in part on their capability to provide relevant products and services. A new industry developing in a region can attempt to draw from existing capabilities serving adjacent industries to meet its needs. Tier 1 manufacturers are also more likely to establish in a region with existing Tier 2 capabilities that can lower cost and risk of their supply. Understanding the regional supply chain's capability to meet the requirements for products and services of West Coast offshore wind projects will help inform actions that can be taken to support supply chain development.

4.1 Redwood Region Background

The Redwood Coast has experienced the impacts of several industries having periods of great prosperity or rapid economic growth abruptly followed by periods of economic contraction. The California Gold Rush attracted 300,000 people to the region, forming towns in northern California including Trinidad, Eureka and Arcata. In less than a decade, the decline of gold mining was replaced by the emergence of redwood logging that enabled the advancement of transport infrastructure in the region. The gradual diminishing of the timber industry following the Great Depression eventually led to the final sawmill closing in the region in the 1990s. The collapse of the cannabis industry in 2018 following state regulatory systems going into effect has devastated the local economy and left communities struggling. While Humboldt County has been able to adapt to changing industry landscapes, the local population has expressed skepticism around the purported benefits that further new industries may bring to the region and whether the impacts will be lasting.

The majority of offshore wind project supply chain costs come from manufacture and installation of the offshore generation and transmission infrastructure. However, despite the Redwood Region having hosted a range of historical industries, there has been limited industrial manufacturing in the region to date. Opportunities for existing suppliers in the region will instead need to come from the capabilities they offer to other relevant adjacent industries.

Currently the regional economy benefits from a variety of commercial, construction trade, social, and public service industries, as shown in Table 4.1. These industries vary in relevance and direct applicability to the needs of the offshore wind sector. The prominent construction industry may hold suppliers capable of providing materials, fabricated subcomponents such as secondary steel, or heavy machinery used in onshore construction. Professional, Scientific, and Technical Services may include suppliers capable of supporting the planning and design phases of offshore wind projects, with the necessary project-specific upskilling. The remaining industries are much less likely to represent suppliers that will provide products and services relevant to offshore wind.

Table 4.1 – Top 10 industries in the Redwood Coast by Total Employment and Total Revenue.

TOP 10 INDUSTRIES IN REDWOOD COAST BY TOTAL EMPLOYMENT	TOTAL EMPLOYMENT	TOP 10 INDUSTRIES IN REDWOOD COAST BY REVENUE	TOTAL REVENUE
Administrative Government	23,500	Real Estate	$3,060,000,000
Construction	10,800	Administrative Government	$2,320,000,000
Social Assistance	10,700	Construction	$1,759,000,000
Food Services and Drinking Places	10,200	Wholesale Trade	$1,543,000,000
Professional, Scientific and Technical Services	6,700	Government Enterprises	$1,203,000,000
Administrative and Support Services	6,000	Food Services and Drinking Places	$1,013,000,000
Ambulatory Health Care Services	5,900	Professional, Scientific and Technical Services	$941,000,000
Real Estate	5,300	Hospitals	$903,000,000
Government Enterprises	4,200	Wood Product Manufacturing	$901,000,000
Hospitals	4,000	Utilities	$805,000,000

4.2 Assessment Approach

Companies in Humboldt, Mendocino, Del Norte, and Lake Counties were assessed for their current ability to support offshore wind project development, manufacturing, installation, and operations. Suppliers in the region were categorized according to the fit of their products and services against offshore wind supply chain taxonomy defined in Table 3.1. Data on Redwood Region companies was sourced from:

- California Employment Development Department,
- Data Axle, and
- Econovue.

Companies with no relevancy to the offshore wind industry were filtered out and the remaining suppliers individually assessed to establish an understanding of what strengths and gaps exist in the region. Companies with multiple relevant supply capabilities were assessed against the needs of each corresponding offshore wind industry supply requirement as appropriate. Companies' supply capabilities were assessed on a scale of applicability as follows:

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

4.3 Assessment Results

The supply chain assessment found approximately 100 companies in the Redwood Region with some applicability to the offshore wind sector. Figure 4.2Error! Reference source not found. shows the categorization of regional supply capability. Areas of potential stronger supply capability are in permitting, onshore construction, and ports and logistics services. However, based on this assessment it is unlikely that any of the existing companies in the Redwood Region would be able to support large scale manufacturing of major components or provide Tier 1 products or services without substantial investment.

The geographic distribution of companies assessed, organized by relevant supply chain area, is shown in Figure 4.2. Across all supply chain areas, the greatest concentration of companies is in Humboldt County in the vicinity of Humboldt and Arcata Bays, with the majority of assessed companies (62%) located in Humboldt County. High applicability companies were only seen in the Onshore Construction supply element.

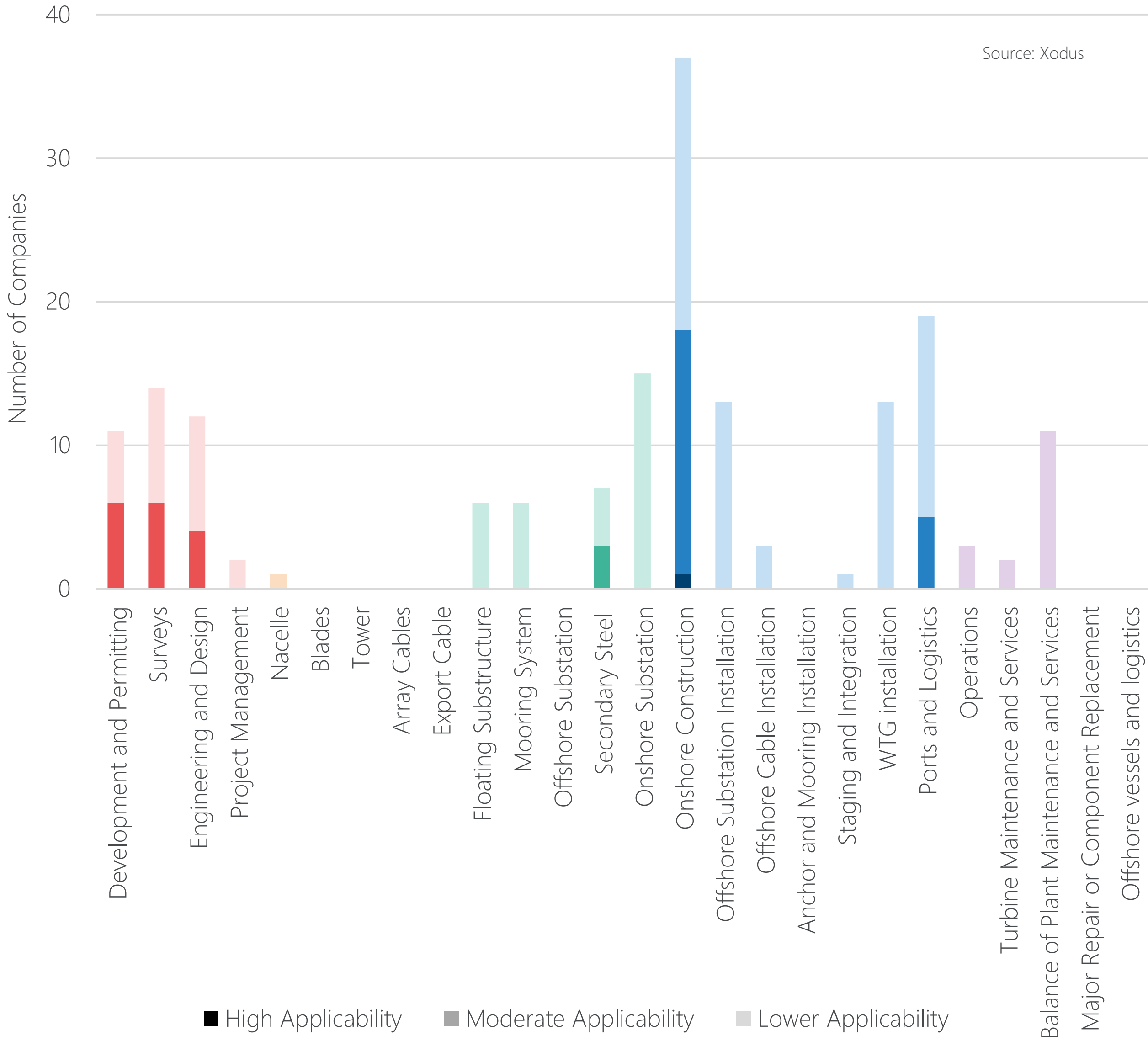
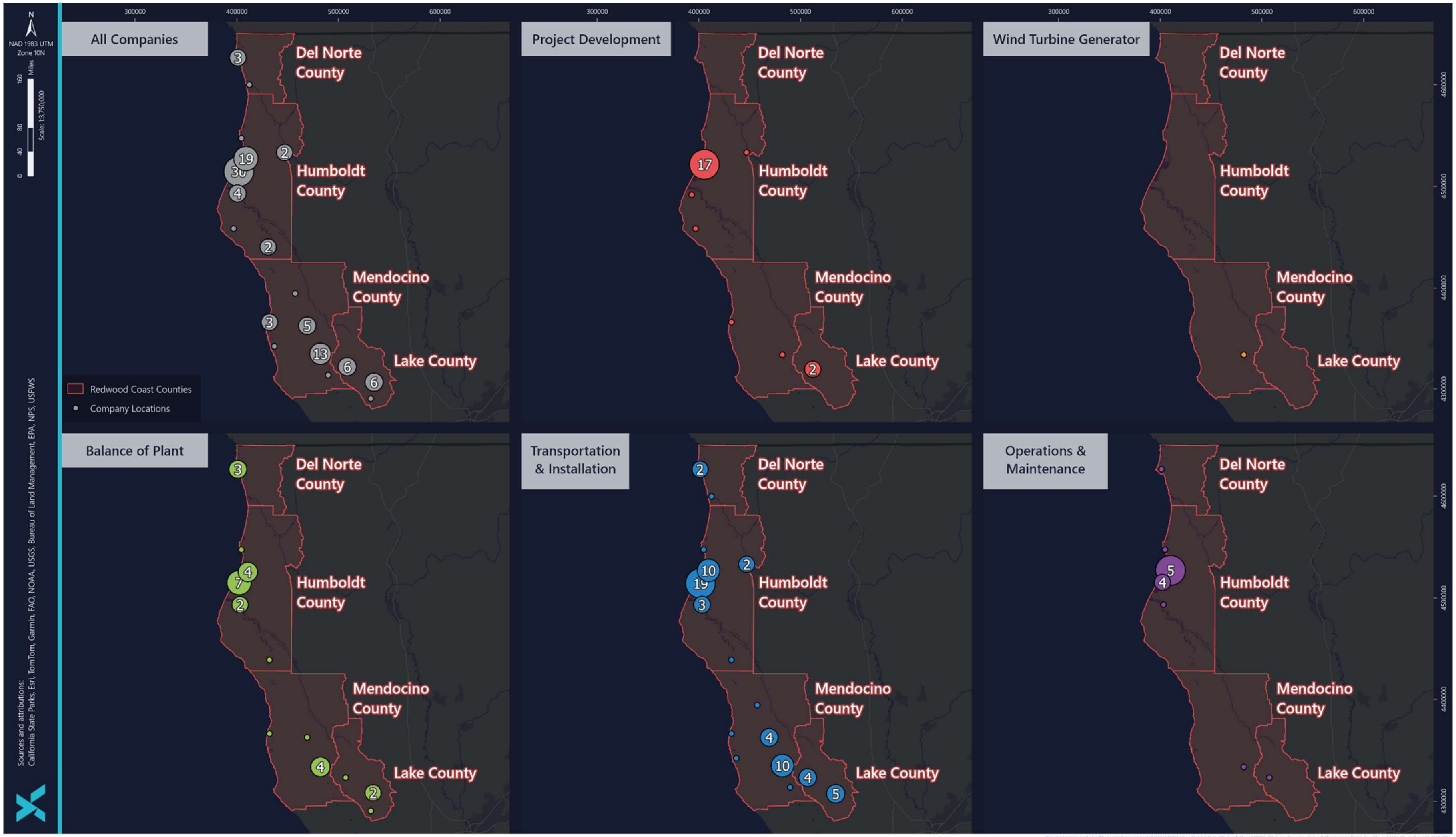


Figure 4.1 – Breakdown of Redwood Region supply chain capability.



Error! Reference source not found.*Figure 4.2 - Geographic distribution of companies by supply chain area.*

4.3.1 Project Development

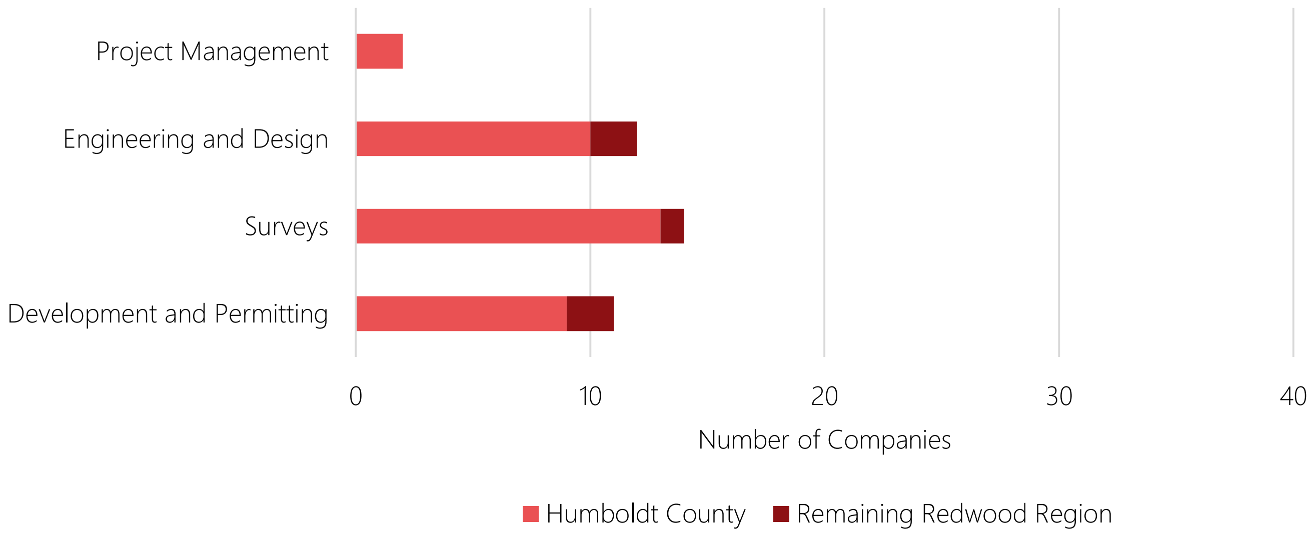


Figure 4.3 - Project Development companies in Humboldt County and the remaining Redwood Region.

Over 25 companies were assigned the Development and Permitting supply element during the supply chain assessment. There are no high applicability companies in this category. An example of a company with adjacent industry capabilities that was assessed to have moderate applicability is SHN Consulting Engineers & Geologists. This company offers civil and geotechnical engineering, environmental, planning and permitting services and states that they plan to serve the renewable energy industry. There are several other companies capable of conducting land-based surveys and carrying out some environmental permitting tasks. The Institute for Wildlife Studies has locations in Arcata, Blue Lake, and Eureka, and is capable of providing baseline data for birds, animals and fish impact studies. There are a number of engineering firms in the region providing civil, mechanical and electrical engineering services, as well as firms offering architectural services. None of the engineering or design firms assessed were found to have direct offshore wind design experience.

4.3.2 Wind Turbine Supply

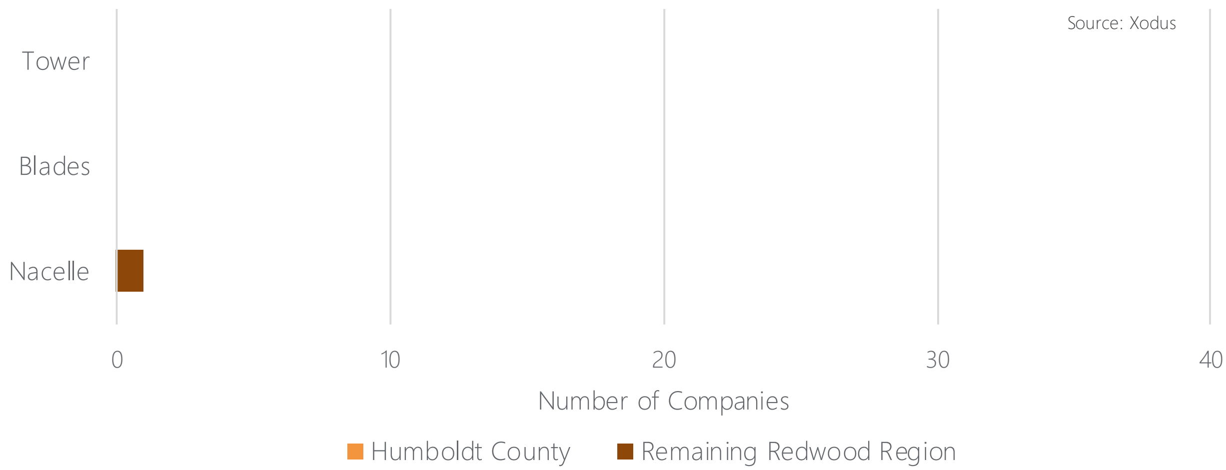


Figure 4.4 – Wind Turbine Supply companies in Humboldt County and the remaining Redwood Region.

Offshore wind turbines are highly complex structures requiring specialized manufacturing processes for nacelle, blades, rotor and tower, and including specialized electricity generation, conversion and offtake equipment. No company appears to have the potential to support major component manufacturing for the wind turbines. One company, Evden Enterprises in Ukiah, is well-suited to perform high precision machining and could potentially be considered as a Tier 2 or 3 supplier with sufficient investment, although the onboarding process for turbine OEMs is arduous and highly competitive.

4.3.3 Balance of Plant Supply

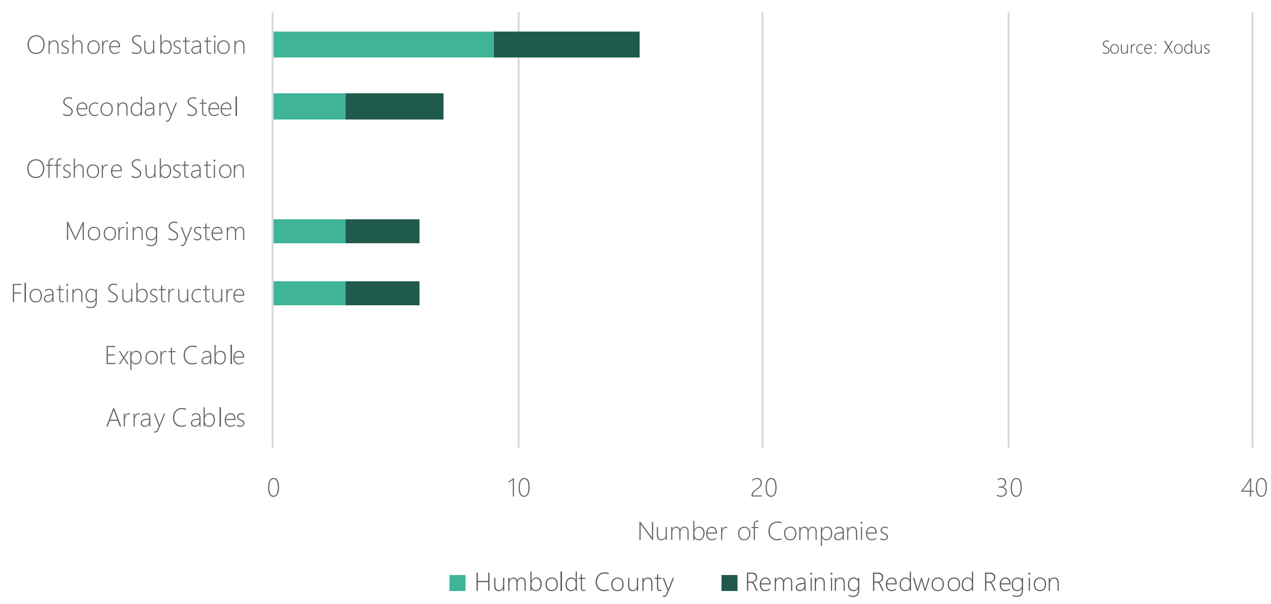


Figure 4.5 – Balance of Plant companies in Humboldt County and the remaining Redwood Region.

Balance of Plant supply is a broad category comprising manufacturing and supply of components for foundations, onshore and offshore substations, moorings and anchors, and both subsea and export cables. While no Tier 1 manufacturing companies presently exist in the region there may be opportunity for small to medium scale component manufacturing and secondary steel component fabrication. North Coast Fabricators has a fabrication facility that may be able to support fabrication of secondary steel structures. Companies such as woman-owned BT Metals, already certified by the California Public Utilities Commission, can supply steel plates, beams, bars, etc. as well as aluminum and stainless steel for various types of construction, potentially including anchor manufacturing, and subcomponents for floating substructures. Similarly, O&M Industries may have experience in industrial fabrication operations and would likely be able to support anchor or substructure manufacturing with adequate scaling.

Several fabrication shops and welding product providers may also be able to benefit should there be local production of anchors, secondary steel, subcomponent fabrication and integration, and other finishing work (e.g. coating application, corrosion protection system installation, NDT and verification, etc.).

4.3.4 Transportation and Installation

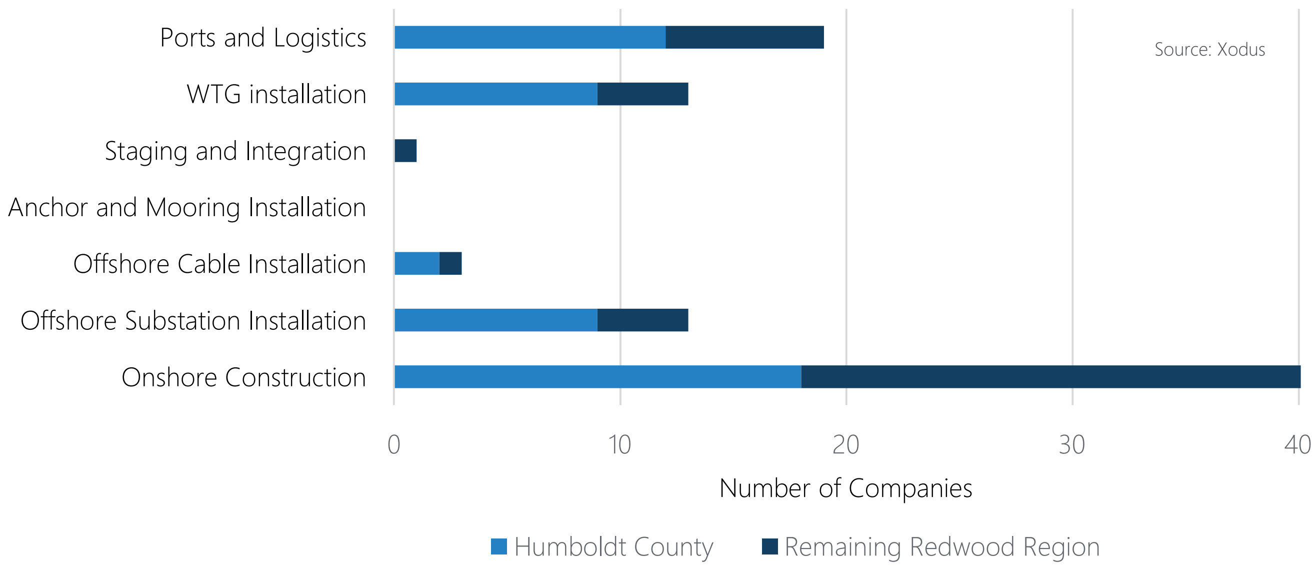


Figure 4.6 – Transportation and Installation companies in Humboldt County and the remaining Redwood Region

The Redwood Region has good capability in onshore construction services to support building onshore infrastructure associated with offshore wind project development. Onshore construction is the only category where high applicability companies were reported. There are many potential Tier 2 and 3 general and commercial contractors capable of site preparation, O&M base construction, building warehousing, industrial buildings, offices, roads, etc. Indigenous owned Yurok Tribe Construction Corporation and woman-owned Bouthilliers Construction Inc. have carried out site preparation and restoration work, and Tidewater Contractors Inc. and R Brown Construction Co. Inc are experienced in civil construction work. There are also local companies providing construction equipment that could be engaged at the Tier 3 level and beyond.

The development scenarios being considered for the Redwood Region include at least one S&I terminal being established in Humboldt County which would bring opportunities to local companies to provide ports and logistics services. This includes warehousing and storage, vessel and installation logistics management, fuel provision, and the equipment needed quayside to move and manipulate components prior to installation.

With regards to installation of the WTG, offshore cables, and the offshore substation, several local electrical contractors have been considered as being able to contribute and overlap within these supply chain categories. Significant upskilling is required for these companies to perform such work. There is precedence in other states for local electricians to perform cable connection and commissioning work for offshore wind, however this has been seen in partnership with training institutions offering industry specific training. There are several suppliers in the region providing industrial equipment and moving and handling services that would be able to provide Tier 2 and Tier 3 support. These companies are concentrated in the Humboldt Bay region, noting that there are very few supporting companies in Del Norte near Crescent City. Employee-owned Acme Rigging & Supply Co., based in Ukiah, supports various heavy industry trades, and provides wire rope, chain, slings, and other hardware items used in lifting operations.

There are a number of industrial electrical contractors that could become engaged in electrical commissioning. Eureka based An Electrician Inc. is an example of a local electrical firm doing residential and commercial work that could potentially upskill to assist in installation and commissioning work of the onshore substation, while significant upskilling would be required for offshore installation and commissioning work.

4.3.5 Operations and Maintenance

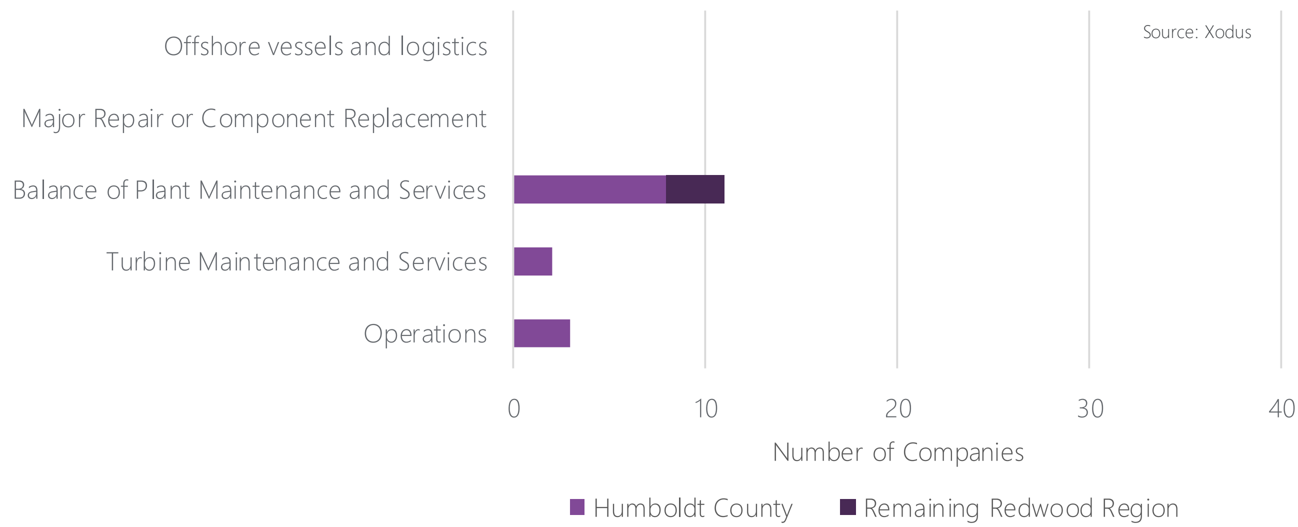


Figure 4.7 – Operations and Maintenance companies in Humboldt County and the remaining Redwood Region

Many of the same port services are needed during the 25+ year operations period for an offshore wind farm as are required during project installation. There are additional supply chain requirements for inspection, repair and maintenance of the offshore generation infrastructure, and the offshore and onshore transmission infrastructure. McKeever Energy & Electric, located in Arcata, are O&M contractors with capability to provide asset support for maritime infrastructure and high voltage, switchgear, and electrical distribution work. Daqota Systems in Arcata provide control systems that may be employed during wind farm operations.

5 OPPORTUNITY ASSESSMENT

When considering the potential for Humboldt County and the Redwood Region to support offshore wind development, opportunities must be assessed both for OEMs and Tier 1 companies that may locate in the region, as well as for existing local companies to become part of a regional floating offshore wind supply chain. This assessment first looks at the opportunity for OEMs/Tier 1s to establish operations in the region, which would bring significant localized investment. The second portion of this assessment investigated the opportunity for local companies to get involved in the broader offshore wind supply chain. This builds on the research presented in Sections 2 and 3, and incorporates the results of the supply chain assessment carried out in Section 4.

5.1 Opportunity for New Supply Chain Attraction

As the floating offshore wind industry develops on the US West Coast, there are several options for where Tier 1 component manufacturing might take place. While early projects are likely to be supplied from overseas, there will be an effort to localize as much manufacturing as possible domestically to maximize retention of economic benefits in the state. It is anticipated that the Port of Humboldt Bay will be a key player to enable floating offshore wind build-out in the region, providing an S&I area for nearby projects. While it would likely take significant incentives and a larger project pipeline, it is also possible that OEMs and Tier 1s could establish local operations. It is important to note that the likelihood of OEM or Tier 1 localization in Humboldt depends significantly on the project pipeline and exportability, as the market size needs to be large enough to warrant an acceptable return on the significant investment that comes with new market entry.

There are many factors contributing to a manufacturing company's decision as to where to establish new operations. Several of these factors are considered in this assessment using the relevant criteria defined below, placed in the specific context of the Redwood Region given available information at this point in time:

- Relative project spend: Proportion of total project spend typically attributable to the supply area. This represents the scale of the risk and revenue potential for an OEM or Tier 1 in setting up operations in the region.
- Investment case: Level of investment, market confidence, and volume of offshore wind projects in the pipeline needed to justify an OEM/Tier 1 company locating in the Redwood Region.
- Opportunity for US market supply: The potential for capable OEM or Tier 1 companies operating out of the Redwood Region to supply projects in the wider US market given technical and economic barriers to accessing demand alongside current and future supply competition, should capability be established.
- Regional familiarity and industrial alignment: Considers the extent to which OEM or Tier 1 operations in the given supply chain area are familiar to local workforce and aligned with the existing and/or historical industrial practices of Humboldt Country and the Redwood Region. A lack of alignment would likely require disruption in the region, such as infrastructure upgrades (e.g. roads, waste systems, energy use, etc.), workforce training/recruitment and environmental impacts.

The scoring system applied to this opportunity assessment is described in Table 5.1.

Table 5.1 - Scoring system for OEM/Tier 1 opportunity assessment.

CRITERION	SCORE 1	SCORE 2	SCORE 3	SCORE 4
Relative project spend	Average spend in supply area is <1% of project lifetime expenditure.	Average spend in supply area is between 1% and 4% of project lifetime expenditure.	Average spend in supply area is between 4% and 7% of project lifetime expenditure.	Average spend in supply area is >7% of project lifetime expenditure.
Investment case	Investment required to supply is significant enough to need public support and requires long-term confidence in multiple offshore wind projects on the West Coast.	Investment required to enable supply triggered by long-term confidence in multiple offshore wind projects on the West Coast.	Investment required to enable supply can be triggered by single offshore wind contract on the West Coast.	Little or no further investment needed to enable supply.
Opportunity for US market supply	Low opportunity to supply from Redwood Region from combination of barriers to access export market and established competition serving demand.	Limited opportunity to supply export markets from Redwood Region from either barriers to access or established competition serving demand.	Limited competition and some access to export market demand means Redwood Region supply to export market could be achievable	Low competition and strong accessible export market demand means Redwood Region supply would be sought
Regional familiarity and industrial alignment	Operations are unfamiliar to local workforce and have low alignment with existing/historical industrial practices.	Some operations resemble those familiar to local workforce and have some alignment with existing/historical industrial practices.	Operations resemble those familiar to workforce and are somewhat aligned with existing/historical industrial practices.	Operations are familiar to workforce and aligned with existing/historical industrial practices.

The results of the opportunity assessment, summarized in Table 5.2 and subsequently explained, considered the opportunity for OEMs and Tier 1s to establish operations in the Redwood Region evaluated by supply area or supply element, as appropriate.

Table 5.2 - Opportunity for new supply chain attraction.

SUPPLY CHAIN ELEMENT	RELATIVE PROJECT SPEND	INVESTMENT CASE	OPPORTUNITY FOR US MARKET SUPPLY	REGIONAL FAMILIARITY AND INDUSTRIAL ALIGNMENT
Project Development	2	3	2	4
Nacelle	4	1	2	1
Blades	3	1	2	1
Tower	2	2	1	2
Cables	3	1	3	1
Floating Substructure	4	1	1	1
Anchor and Mooring System	2	2	3	2
Substations	2	1	2	1
Transportation and Installation	3	2	1	2
Operations and Maintenance	4	2	1	2

5.1.1 Project Development

Summary

RELATIVE PROJECT SPEND	INVESTMENT CASE	OPPORTUNITY FOR US MARKET SUPPLY	REGIONAL FAMILIARITY AND INDUSTRIAL ALIGNMENT
2	3	2	4

Relative Project Spend

Project development is not a capital intensive supply area as it occurs without any major procurement of physical infrastructure. Carrying out environmental, resource and metocean, and geological and hydrographical surveys requires vessels and specialized equipment, while permitting, engineering and project management activities do not require dedicated physical infrastructure beyond office space and potentially proprietary tools like software. The total cost of Project Development represents about 2.5% of total project costs with individual scopes to suppliers typically less than 1% of total project spend[10].

Investment Case

The expertise and equipment required for most project development services are used across several sectors and so little investment is typically required to support the offshore wind sector, however given the majority of surveying and environmental monitoring capabilities in the region are onshore, investment will likely be required for specialized equipment like survey vessels, ROVs, geophysical survey elements, etc. Given the proximity to project sites and the relatively low level of investment required to establish regional operations, there is logic for project developers to set up project development offices in the Redwood Region.

Opportunity for US Market Supply

Given the desk-based nature of most work in this category there are negligible logistical barriers to exporting these services, with the exception of surveying which is often better provided by local companies with knowledge of the local ecosystems. The industry has seen large multi-national survey companies enter the US offshore wind market in the very early stages and dominate the large site investigation scopes. Where local survey firms will see success is in smaller nearshore and environmentally focused scopes.

Regional Familiarity and Industrial Alignment

Project development activities are well aligned with existing businesses in the Redwood Region. Little disruption would be caused by developers or Tier 1 companies' presence in the region in this supply area given the relatively low

[10] *Total project cost assumptions for supply chain categories listed in this section have been taken from the following to align with standard industry assumptions* [Wind farm costs | Guide to a floating offshore wind farm,]

workforce and physical infrastructure requirements. Offshore survey activity may result in additional port traffic, however the existing marine industries would see only minimal impacts as a result of these activities.

5.1.2 Nacelle

Summary

RELATIVE PROJECT SPEND	INVESTMENT CASE	OPPORTUNITY FOR US MARKET SUPPLY	REGIONAL FAMILIARITY AND INDUSTRIAL ALIGNMENT
4	1	2	1

Relative Project Spend

The nacelle is the most complex and expensive component in an offshore wind farm, with strict manufacturing tolerances and quality assurance standards. It makes up about 13% of total project spend.

Investment Case

Nacelle assembly facilities are costly to establish and maintain. A high level of investment and long-term confidence in obtaining suitable market share of the future project pipeline would be required to establish new facilities, particularly where turbine OEM's existing facilities have capacity to meet market demand. Nacelle manufacturers also typically have established networks of thousands of vetted suppliers, including contingency supply. To set up locally they would need to either find new regional suppliers—a complicated, time consuming, and expensive process for suppliers of operationally critical components, such as those in the rotor-nacelle assembly—or adjust logistics such that existing suppliers could ship subcomponents to the newly established assembly facility. Both options would increase operational costs, which would translate to higher prices for projects.

Opportunity for US market supply

There are currently no wind turbine OEMs located on the West Coast where there is not yet an investment case to establish new facilities for a limited project pipeline. Should a wind turbine OEM or their Tier 2 suppliers establish manufacturing operations in the Redwood Region they would supply floating offshore wind projects anywhere on the US West Coast. Challenges in moving large components from the West Coast to the East Coast where there is a larger project pipeline will hinder the opportunity to establish a nacelle assembly facility in the Redwood Region.

Regional Familiarity and Industrial Alignment

Manufacturing of nacelles requires a significant network of subcomponent manufacturers. This would result in a lot of logistical management and importing occurring in the Redwood Region, which could lead to more local disruption than other manufacturing of other component types. The nacelle's manufacturing process can be labor intensive. This type of manufacturing would require substantial personnel which could impact the existing regional workforce and may require additional workers to move to the region.

5.1.3 Blades

Summary

RELATIVE PROJECT SPEND	INVESTMENT CASE	OPPORTUNITY FOR US MARKET SUPPLY	REGIONAL FAMILIARITY AND INDUSTRIAL ALIGNMENT
3	1	2	1

Relative Project Spend

Blade production is the result of tightly controlled manufacturing and quality assurance processes. Together with the hub, it contributes approximately 6.3% to total project spend.

Investment Case

Blade manufacturing processes require expansive production facilities, specialized molds and equipment, specially trained personnel, and strict quality assurance and testing procedures. Blades can be over 100 m long, and can not be transported in multiple sections. For this reason, constructing a facility to manufacture blades requires significant investment in quayside space, bespoke equipment, and personnel. Strong market confidence and a substantial project pipeline would need to be confirmed in order to recoup the high investment costs required.

Opportunity for US market supply

A blade manufacturing facility would serve the whole US West Coast market. Challenges in moving large components from the West Coast to the East Coast where there is a larger project pipeline will hinder the opportunity to establish a blade manufacturing facility in the Redwood Region.

Regional Familiarity and Industrial Alignment

Manufacturing wind turbine blades requires considerable laydown space with specialized storage and lifting frames. Requirements for large quantities of composite material, glass fiber, resin, etc. as well as large-scale manufacturing infrastructure, specialized industrial processes, and unique workforce competencies would be unfamiliar to the region should any blade manufacturing be established.

5.1.4 Tower

Summary

RELATIVE PROJECT SPEND	INVESTMENT CASE	OPPORTUNITY FOR US MARKET SUPPLY	REGIONAL FAMILIARITY AND INDUSTRIAL ALIGNMENT
2	2	1	2

Relative Project Spend

Wind turbine towers are made of large quantities of steel. The resulting capital costs for producing an offshore wind turbine are substantial, making up nearly 4% of total project costs.

Investment Case

Tower manufacturing may be more straightforward than nacelle and blade manufacturing given it is largely thick steel sheet welded longitudinally, however given the substantial size of towers and the thickness of the plate required, investment costs for facilities are significant. A Tier 1 tower manufacturer will also need to assure a supply of steel plate, and specialized welding and NDT technicians available to ensure quality of the finished product. Given the high capital expenditure required to establish tower manufacturing for the wind turbine, a significant project pipeline would be required to justify this kind of investment.

Opportunity for US market supply

A tower manufacturing facility would serve the whole US West Coast market. The possibility of emerging East Coast supplier capability and challenges in moving large components from the West Coast to the East Coast where there is a larger project pipeline will hinder the opportunity to establish a tower manufacturing facility in the Redwood Region.

Regional Familiarity and Industrial Alignment

Manufacturing of tower components also requires considerable laydown space and site load bearing capacity, as well as requirements for large quantities of thick steel plate. Serial manufacturing of large offshore wind towers may require personnel relocating to the region. The scale of this manufacturing operation would be unfamiliar to the region.

5.1.5 Cables

Summary

RELATIVE PROJECT SPEND	INVESTMENT CASE	OPPORTUNITY FOR US MARKET SUPPLY	REGIONAL FAMILIARITY AND INDUSTRIAL ALIGNMENT
3	1	3	1

Relative Project Spend

Cables (array and export together) make up about 5.4% of total project costs.

Investment Case

Cable manufacturing requires significant upfront expenditure in cable winding equipment, direct relationships and logistical connections to raw materials providers, significant quayside space with a dock capable of spooling cables directly onto pipelay vessels (or specialized on-site storage reels), and highly specialized personnel. While there have yet to be any cable manufacturing operations for offshore wind present on the West Coast, there is existing capability on the East Coast with a number of additional facilities proposed.

Transporting cables long distances is standard practice given large amounts of cable can be shipped at once, making it less logistically challenging than components like blades or towers which take up more deck space. This disadvantages OEMs that may wish to establish operations in the Redwood Region as the additional costs incurred to establish manufacturing versus using existing facilities may be difficult to justify. A significant West Coast pipeline may result in an adequate business case.

Opportunity for US market supply

There are currently no subsea cable manufacturing activities on the West Coast to compete with an OEM/Tier 1 company operating out of the Humboldt Region, but only a minor cost and logistics benefit to manufacturing cable in the region given international supply routes are well established and can be lower cost than US-produced cable, even with shorter shipping distances. There is, however, a limited supply of subsea cables globally meaning that bottlenecks will occur once the floating offshore wind industry ramps up. This, plus the potential logistics benefits of domestic, West Coast production may be able to attract a cable OEM to the region, but only if costs can be competitive with overseas supply.

Regional Familiarity and Industrial Alignment

There is currently no large-scale manufacturing taking place in Humboldt County or the wider Redwood Region. Cable manufacturing has no precedent in the region and would require specially trained workforce. It would require significant space for operations and storage, along with the import of large quantities of raw materials that may require infrastructure upgrades such as new roads, quayside upgrades and potentially additional waste treatment facilities.

5.1.6 Floating Substructure

Summary

RELATIVE PROJECT SPEND	INVESTMENT CASE	OPPORTUNITY FOR US MARKET SUPPLY	REGIONAL FAMILIARITY AND INDUSTRIAL ALIGNMENT
4	1	1	1

Relative Project Spend

Floating substructures make up a significant portion of project capital expenditure, representing about 16.6% of total project spend.

Investment Case

Consistent manufacturing requirements for floating substructures are yet to be established, while there is no consensus on any singular floating substructure design. Substructures may also be manufactured and fully assembled before shipping to site, or may be shipped and then assembled at site, impacting manufacturing operations, space requirements, workforce requirements, etc. Given these uncertainties, as well as the high upfront costs to establish these operations, a significant project pipeline with sufficient confidence in substructure preference will likely be required before a fabricator would be able to establish themselves in the Redwood Region. The significant funding awarded to develop the Port of Humboldt Bay as a S&I port will likely enable on-site assembly, and may serve to increase the likelihood of additional investment to create substructure manufacturing at the site.

Opportunity for US market supply

Globally, there is currently no established serial floating substructure manufacturing activities as the market is not yet sufficiently mature to enable investment. Capability to manufacture floating substructures in the region would supply the US West Coast market. Competing fabrication capability in APAC and the inability to transport floating substructures to the East Coast significantly limits the opportunity for wider market supply.

Regional Familiarity and Industrial Alignment

Welding and metal work, required in floating substructure fabrication, has some track record in the Redwood Region, however on a much smaller scale compared to the requirements of floating offshore wind. Substructure manufacturing operations would require significant space for operations and storage, along with the import of large quantities of raw materials and component parts that may require infrastructure upgrades such as new roads or waste treatment facilities. This is also the most labor intensive manufacturing process across the balance of plant components, particularly for semisubmersible foundations.

5.1.7 Anchor and Mooring System

Summary

RELATIVE PROJECT SPEND	INVESTMENT CASE	OPPORTUNITY FOR US MARKET SUPPLY	REGIONAL FAMILIARITY AND INDUSTRIAL ALIGNMENT
2	2	3	2

Relative Project Spend

The mooring system is comprised of either specialized nylon rope or steel chains, not dissimilar to those used in offshore oil and gas operations but larger in scale. There are various types of anchors that can be employed, but they are typically fabricated steel structures. The relative project spend for mooring and anchor systems is less substantial than most other major components about 3.1%.

Investment Case

Mooring line production can be an efficient serial process given long lengths are produced and spooled onto storage reels. While specialized equipment and raw materials are required for both rope and chain manufacturing, an OEM may find a business case for establishing operations in the Redwood Region given a sufficient project pipeline with adequate market confidence. The production of anchors is labor intensive compared to mooring lines. Attracting a Tier 1 to manufacture anchors for floating offshore wind to the region may be justified given the relatively lower capital expenditure to establish operations compared to other major components. A sufficient project pipeline would be required to attract anchor manufacturing to the Redwood Region, or enable local fabricators to scale up to meet this need.

Opportunity for US Market Supply

Lower capital cost components, like mooring and anchor systems, that are specific to floating offshore wind, present the greatest opportunity for the Redwood Region to establish an export market given they are easier and less costly to transport compared to cables, which require specialized vessels, or bulky floating substructures. There is no current manufacturing capability for these components on the West Coast so a mooring line or anchor OEM may consider establishing first mover advantage for these components in the Redwood Region.

Regional Familiarity and Industrial Alignment

Synthetic mooring line, and metal chain manufacturing has little to no precedent in the region and would require specially trained workforce. Anchor manufacturing has some precedent with regards to welding and metal work that exists in the region, but it is likely that a Tier 1 manufacturer for these products would still need to upskill personnel and companies with existing experience for this scale of operation. All manufacturing operations would require significant space for operations and storage, along with the import of large quantities of raw materials and component parts that may require infrastructure upgrades such as new roads or additional waste treatment facilities.

5.1.8 Substations

Summary

RELATIVE PROJECT SPEND	INVESTMENT CASE	OPPORTUNITY FOR US MARKET SUPPLY	REGIONAL FAMILIARITY AND INDUSTRIAL ALIGNMENT
2	1	2	1

Relative Project Spend

The relative project spend for an onshore substation is about 1.4% of total project spend, while an offshore substation is about 2.6%.

Investment Case

Offshore substation manufacturing requires a large fabrication yard. Each substation is designed and built to project specifications and in low quantities where there are no economies of scale while still requiring specialized manufacturing facilities, equipment, and adequate space. Given there is no existing infrastructure in the Redwood Region that could be adapted to serve offshore substation manufacturing, upfront costs to establish operations would be significant and would require a strong project pipeline to justify the expense for limited return. Onshore substation construction is less challenging with regards to construction as there is no need for a foundation. There are companies in Humboldt and the greater Redwood Region that are capable of scaling to provide such services with minimal investment.

Opportunity for US Market Supply

Currently, there is manufacturing capability for offshore substations in the Gulf of Mexico, however the logistics of shipping these to the West Coast is challenging. There are also currently substantial global capabilities to manufacture offshore substations given the structural similarity to topsides structures used in offshore oil and gas operations, therefore significant competition exists, limiting the attractiveness of the opportunity for a substation OEM to locate in the Redwood Region. There will be demand on the West Coast for floating specific components, such as the offshore substation's substructure, as the industry develops. It may be more feasible for the region to produce these as fewer overall components are required, and hence serial manufacturing capabilities are not required. With regards to onshore substations, there is no opportunity for US market supply as these are typically constructed locally.

Regional Familiarity and Industrial Alignment

With regards to onshore substations, there is significant regional familiarity as these onshore substations have essentially the same requirements as a standard onshore electrical substation, like those that already exist in the region. Other than small to medium scale metal fabrication work and some industrial electrical contractors, there are no existing operations that resemble offshore substation fabrication. Like floating substructure manufacturing, establishing this type of operation in the region would require infrastructure upgrades and worker relocation to the region.

5.1.9 Transportation and Installation

Summary

RELATIVE PROJECT SPEND	INVESTMENT CASE	OPPORTUNITY FOR US MARKET SUPPLY	REGIONAL FAMILIARITY AND INDUSTRIAL ALIGNMENT
3	2	1	2

Relative Project Spend

The cost for transportation and installation activities for a floating offshore wind farm range between 1%-3% of total project costs, though this is dependent on the distance from the marshalling and integration sites to the project site, the water depths of the project, and other factors like the amount of time spent waiting on weather.

Investment Case

Given the costs required to upgrade the Port of Humboldt Bay as an S&I port, multiple projects are expected to be installed to justify the upfront spend. The importance of port infrastructure to enabling floating offshore wind project development has led to public sector investment support. Project developers have typically also been willing to provide some investment and share risk in developing installation ports. Significant investment would be required to develop local installation capabilities. In early projects, at a minimum, it is likely that external expertise will be employed to perform installation activities as there is little to no local experience in this space.

Opportunity for US market supply

S&I ports with strong capability can be used to support projects across a wide geographical area, although there will be logistical benefit to local supply where available. The Port of Humboldt Bay may face competition from other West Coast ports in development and will not be used to support project S&I for East Coast projects. With regards to installation activities, the region does not have any particular strengths here that could be exported, such as vessels or experienced workforce.

Regional Familiarity and Industrial Alignment

Humboldt County and the wider Redwood Region have some familiarity with industrial port activities given shipping, fishing and logging industries that take place in the region, though the activities required to marshal and install a floating offshore wind farm out of the port will be of a significantly larger scale. It is already known that significant port infrastructure upgrades are required to support these operations, which will result in a port space that is significantly different to the one that currently exists. The region has no notable experience in offshore installation activities.

5.1.10 Operations and Maintenance

Summary

RELATIVE PROJECT SPEND	INVESTMENT CASE	OPPORTUNITY FOR US MARKET SUPPLY	REGIONAL FAMILIARITY AND INDUSTRIAL ALIGNMENT
4	2	1	2

Relative Project Spend

The O&M phase of a floating offshore wind farm can last in excess of 25 years as electricity production and offtake is closely monitored, and both regular and unplanned maintenance activities are needed. Given this extended lifetime, this supply area represents about 37% of overall costs, distributed across a number of individual contracts.

Investment Case

Additional investment required to develop capability in operations services is relatively low given the existing investment in the Port of Humboldt Bay that will enable component replacement at quayside. Companies investing in their own capability to support O&M activities will take confidence from the long-term opportunity. To fully develop capability in this area the region will need to invest in CTVs and SOVs.

Opportunity for US Market Supply

There is a significant logistics benefit to local supply where mobilization costs can be minimized and the ability to attend to repairs quickly reduces generation downtime. While specialist O&M provision can be mobilized from further afield, given the advantage for most O&M services to be sourced and located near a project it is unlikely the Redwood Region would export this capability to the broader US market.

Regional Familiarity and Industrial Alignment

The majority of standard operational monitoring and offshore inspection, repair and maintenance of a floating offshore wind farm would cause little disruption and would be fairly well aligned with existing activities in the region. Major maintenance campaigns requiring the fully assembled wind turbines to be brought back to port would result in a level of disruption similar to constructing a full S&I operation.

5.2 Opportunity for Existing Supply Chain Development

As the floating offshore wind industry develops on the US West Coast and the Port of Humboldt Bay is built out in support of the industry, opportunities will become available for companies in the Redwood Region to support this development. Companies may be able to serve the industry in their current form, or they may be able to access new opportunities through retooling, scaling, forming partnerships, or shifting their operating strategy. The decision for companies to make inward investment, or their ability to secure external investment, to meet the requirements of the offshore wind industry will be influenced by factors including the scale of the supply opportunity and the ability to lower the risk of market entry through collaboration with established suppliers.

The opportunity for local companies in Humboldt County and the Redwood Region to contribute to the US offshore wind supply chain is assessed here using relevant criteria, defined as:

- Independence from OEM/Tier 1 localization: Considers the extent to which the opportunity for local companies entering the offshore wind supply chain in Humboldt County and the Redwood Region at a Tier 2 or Tier 3 level is dependent on an OEM or Tier 1 establishing operations in the region.
- Relevant industry experience: Considers the ability of companies in Humboldt County and the Redwood Region to provide support for activities under the given supply chain area based on existing experience and expertise, when assessed out to a Tier 3 level of supply.
- Opportunity for export of local capabilities: The degree to which current or future capabilities in the Redwood Region are exportable to the wider US offshore wind industry.
- Potential for partnerships/collaboration: Considers the degree to which local companies in Humboldt County and the Redwood Region are likely to form partnerships and/or collaborate, either with each other or with external companies, to develop a competitive supply chain offering.

The scoring system applied to this opportunity assessment is described in Table 5.3., noting that supply chain elements have been grouped within their main categories and opportunities for individual sub-components may thus vary to the wider category.

Table 5.3 - Scoring system for opportunity assessment.

CRITERION	SCORE 1	SCORE 2	SCORE 3	SCORE 4
Independence from OEM/Tier 1 localization	Opportunity for local companies strongly depends on presence of OEM/Tier 1 operations.	Few opportunities exist for local companies independent of regional OEM/Tier 1 operations.	Some opportunity exists for local companies independent of regional OEM/Tier 1 operations.	Opportunity exists for local companies independent of regional OEM/Tier 1 operations.
Relevant industry experience	No known local companies with relevant experience in offshore wind or an adjacent industry.	Local companies with some relevant experience but are unlikely to offer a competitive solution, even with change in strategy and/or additional investment.	Local companies with some relevant experience are likely to offer a competitive solution with change in strategy and/or additional investment to offer a competitive solution.	Local companies with relevant experience are likely to provide a competitive solution with minimal change in strategy or additional investment.
Opportunity for export of local capabilities	Significant logistics barrier to export and/or established competing supply harms US market supply opportunity from Redwood Region.	Some logistics barrier to export and/or established competing supply may limit US market supply opportunity from Redwood Region.	No particular barriers to export and/or limited established competing supply could justify US market supply opportunity from Redwood Region.	Logistics benefit to export and/or lack of established competing supply could justify US market supply opportunity from Redwood Region.
Potential for partnerships/ collaboration	Difficult to form local partnerships and/or collaborate to be competitive in this supply chain area.	Some opportunity to form local partnerships and/or collaborate to be competitive in this supply chain area.	Opportunity to form local partnerships and/or collaborate to be competitive in this supply chain area exists.	Existing local businesses are proactively seeking to form local partnerships and/or collaborate to be competitive in this supply chain area.

The results of the opportunity assessment, summarized in Table 5.4 and subsequently explained, consider the opportunity for local companies to become part of the floating offshore wind supply chain in the Redwood Region.

Table 5.4 - Opportunity for Developing Existing Supply Chain

SUPPLY CHAIN ELEMENT	INDEPENDENCE FROM OEM/TIER 1 LOCALIZATION	RELEVANT INDUSTRY EXPERIENCE	OPPORTUNITY FOR EXPORT OF LOCAL CAPABILITIES	POTENTIAL FOR PARTNERSHIPS/ COLLABORATION
Project Development	4	3	2	3
Wind Turbine Supply	1	1	2	1
Balance of Plant Supply	2	2	2	2
Transportation and Installation	2	2	2	2
Operations and Maintenance	4	2	1	3

5.2.1 Project Development

Summary

INDEPENDENCE FROM OEM/TIER 1 LOCALIZATION	RELEVANT INDUSTRY EXPERIENCE	OPPORTUNITY FOR EXPORT OF LOCAL CAPABILITIES	POTENTIAL FOR PARTNERSHIPS/ COLLABORATION
4	3	2	3

Independence from OEM/Tier 1 Localization

Local companies would be well placed to support project development tasks in Humboldt County, in particular by providing local support and specialist knowledge to permitting, environmental assessment, and surveying activities. This can represent an opportunity for a developer to meet ambitions for local content of their project whilst also improving the quality of design and permitting activities.

Relevant Industry Experience

There are a number of companies, particularly in Humboldt County, that could be capable of supporting engineering, permitting, or onshore surveying for offshore wind with investment and strategic development. The environmental and survey companies in the region currently lack sufficient offshore experience to provide a broader set of services. There are several engineering and architectural firms, some of which are capable of project management activities, that could potentially assist in wind farm development activities, though none have direct industry experience to date. Local companies would likely be engaged only in supporting roles, performing subtasks for more experienced Tier 1 and Tier 2 suppliers.

Opportunity for Export of Local Capabilities

Given the desk-based nature of most work in this category, there is no particular disadvantage to exporting these services. This is, however, a highly competitive area of offshore wind farm development with ample global and domestic expertise that companies from the Redwood Region would have to compete against. Given California will likely lead the West Coast in floating offshore wind development, some first mover advantages may permit the region to export these services to other western coastal states if capabilities were developed, but due to the competitive nature of project development work, this is unlikely. Surveying activities are often better provided by companies in proximity to project sites with knowledge of the local ecosystems, therefore capabilities established in this supply area are unlikely to be broadly exported.

Potential for Partnerships/Collaboration

Given the general low investment required for companies looking to gain experience in project development, this is a potential opportunity for partnership formation and collaboration between more experienced firms, and those local to Humboldt County and the Redwood Region. For example, non-local companies with experience in marine surveying and sensing could partner with regional firms with local ecosystem knowledge, such as tribal and environmental organizations. This provides an opportunity for knowledge sharing and capacity building in the Redwood Region.

The MOA between RWE, Vineyard Offshore, and Humboldt County Economic Development expresses a commitment to explore pathways for sustainable economic development and workforce planning. Given that project development work is closely managed by developers with much being carried out either in-house or by a trusted network of consultants, there is an opportunity to leverage this MOA to grow partnerships between these developers and local companies.

5.2.2 Wind Turbine Supply

Summary

INDEPENDENCE FROM OEM/TIER 1 LOCALIZATION	RELEVANT INDUSTRY EXPERIENCE	OPPORTUNITY FOR EXPORT OF LOCAL CAPABILITIES	POTENTIAL FOR PARTNERSHIPS/ COLLABORATION
1	1	2	1

Independence from OEM/Tier 1 Localization

There will be significantly limited opportunity to develop Humboldt County and the Redwood Region supply chain in this area. The ability for local companies to secure offshore wind supply chain contracts is highly dependent on an OEM or Tier 1 manufacturer locating in the region with strong capability to disrupt established supply chains.

Relevant Industry Experience

While some local companies are capable of providing standard items used in the final assembly of wind turbine components, there are no known local companies that have relevant experience providing such equipment for an industrial marine environment. Local fabrication shops and trades workers (for example, welders, scaffolders, coatings specialists, etc.) may be considered to have adjacent industry experience that could be employed if an OEM or Tier 1 manufacturer were to establish regional operations, but even in these cases there would likely be expensive upskilling and certification required.

Opportunity for Export of Local Capabilities

If local companies were able to develop capabilities in this supply chain area through fabrication of secondary steel items, or were to develop expertise in specialized coating applications, for example, there is a chance that these products and services might be exportable to the US West Coast. However, this is highly unlikely to occur due to the lack of industry-specific experience in this supply area, paired with the established existing supply chains partners that OEMs possess.

Potential for Partnerships/Collaboration

Local companies lack sufficient experience to benefit from partnership formation as a way to access greater opportunities in this supply area. If an OEM or Tier 1 manufacturer was to establish regional operations, there is an opportunity for local companies with relevant skills but a lack of industry experience to partner with qualified suppliers to supply subcomponents, secondary steel, or provision of various services in order to satisfy local content requirements.

5.2.3 Balance of Plant Supply

Summary

INDEPENDENCE FROM OEM/TIER 1 LOCALIZATION	RELEVANT INDUSTRY EXPERIENCE	OPPORTUNITY FOR EXPORT OF LOCAL CAPABILITIES	POTENTIAL FOR PARTNERSHIPS/ COLLABORATION
2	2	2	2

Independence from OEM/Tier 1 Localization

Humboldt County and the Redwood Region are capable of supplying construction materials and equipment to support some balance of plant manufacturing activities. However, the opportunity for local companies to supply to the offshore wind industry in this supply area is highly dependent on balance of plant OEMs and Tier 1 companies localizing in the region. It is unlikely that local products or services would be sought in this supply area at a Tier 2 or 3 level without focused effort to increase the local content of projects. There are some companies with the potential to scale up to perform anchor manufacturing, but this would need to be deliberate and would likely require outside experience.

Relevant Industry Experience

There are known local companies that have relevant industry experience in this supply area. There are companies in the Redwood Region that could supply standard products and equipment in support of manufacturing operations, but these companies are non-specialized and mostly act as distributors. It is unlikely that these companies have supplied marine industrial operations beyond the fishing and recreational boating industries.

Opportunity for Export of Local Capabilities

Should local companies gain experience or establish consistent supply of standard components used in balance of plant manufacturing operations, they may find export markets across the US West Coast. This is, however, very unlikely given that most suppliers in the region operate on a smaller scale than would be required to supply serial manufacturing operations, and the Redwood Region lacks major transportation infrastructure outside of its ports.

Potential for Partnerships/Collaboration

As a major impediment to local companies being able to supply the offshore wind industry is scale. If capable local firms were able to partner or create joint ventures to increase their output capacity and undertake targeted learning it may be possible for them to establish Tier 2 or 3 supply for some balance of plant manufacturing operations, such as anchor production. Companies with relatively low production volume capacity, or that have complementary skillsets, may consider partnering to increase their supply chain offering.

Given the low level of industry knowledge in the region, these types of partnerships would need to be supported by local economic development groups and industry organizations, and there would be a steep learning curve for any companies that express a desire to enter the industry.

5.2.4 Transportation and Installation

Summary

INDEPENDENCE FROM OEM/TIER 1 LOCALIZATION	RELEVANT INDUSTRY EXPERIENCE	OPPORTUNITY FOR EXPORT OF LOCAL CAPABILITIES	POTENTIAL FOR PARTNERSHIPS/ COLLABORATION
2	2	2	2

Independence from OEM/Tier 1 Localization

A range of services to installation contractors can be sourced locally to the S&I port, thus there will be opportunities for local companies to provide quayside and support services. However, given the lack of experience in the region, it is unlikely that companies in the Redwood Region will be able to support at any tier level unless there is an experienced project developer in the region driving operations.

Relevant Industry Experience

While there are several companies that may be able to supply at a Tier 3 level, providing equipment, fabricating seafastening items, lifting aids, and storage frames, and serving logistical functions such as land-based shipping, no local companies have direct industry or large-scale industrial experience. Given the substantial investment being made in the Port of Humbolt Bay, and the desire for the port to support transportation and installation activities, it is possible that local companies could scale to provide competitive solutions at the Tier 2 or 3 level. There are a number of regional electrical contractors that state they have commercial and industrial experience that may be able to contribute to installation and commissioning activities, however this would require substantial workforce development in addition to scaling.

Opportunity for Export of Local Capabilities

Given the location dependent nature of this work, it is unlikely that local companies in the Redwood Region would be able to export any competencies developed in this supply area to other US West Coast projects. If local electrical firms were able to specialize in installation and commissioning of wind turbines or substations there may be opportunity for this expertise to be exported to other projects across the US, however given the lack of current industry-specific experience in the region, and the fact that this expertise is being established domestically in fixed-bottom projects on the East Coast, it is unlikely to result in a significant local opportunity.

Potential for Partnerships/Collaboration

Existing companies may possess capabilities that alone do not lead to opportunities, but when paired with other companies may present a competitive option at a Tier 2 or 3 level. Onshore construction work is likely to be delivered by local companies working in collaboration. In other jurisdictions, efforts have been made to connect companies with complementary skills such that together they are capable of responding to subcontracting operations where, independently, they did not meet requirements. Industry organizations and economic development organizations can often play a major role in making these connections and making companies aware of opportunities for partnership.

5.2.5 Operations and Maintenance

Summary

INDEPENDENCE FROM OEM/TIER 1 LOCALIZATION	RELEVANT INDUSTRY EXPERIENCE	OPPORTUNITY FOR EXPORT OF LOCAL CAPABILITIES	POTENTIAL FOR PARTNERSHIPS/ COLLABORATION
4	2	1	3

Independence from OEM/Tier 1 Localization

The majority of O&M services are typically procured from close to the project location, where possible, and are independent of the origin of component supply, with the exception of component replacement/warranty elements where technicians and OEM personnel may be sent in.

Relevant Industry Experience

While there are some companies that could offer certain support services during O&M activities, none of the companies assessed have relevant industry experience to enable them to operate above a Tier 3 level of supply. There are some local companies that are capable of providing Tier 3 services, particularly in maintenance activities, but upskilling and scaling would be required alongside expanding current capability to provide services offshore.

Opportunity for Export of Local Capabilities

Given the need for O&M activities to be sourced near the project site, and the fact that Redwood Region companies lack industry-specific experience in this supply area, it is unlikely that any local capabilities will be exported to other US projects. Were local companies able to develop capabilities in this supply area, either through partnership with external entities or expanding their offering through local partnering, it is possible that these competencies could be applied during O&M activities for projects in Oregon, given their proximity to Crescent City.

Potential for Partnerships/Collaboration

As the Port of Humboldt Bay has already secured significant funds that have been earmarked for port development and the establishment of an O&M base, it is likely that local firms will be able to partner with external companies to gain industry experience, support operations, and satisfy local content requirements. Companies would need to be educated on what O&M activities entail, and investment would be required to scale operations and upskill personnel. Existing companies may find that by forming partnerships, they are able to access greater opportunities than they would alone, and could in turn develop local knowledge and expertise, opening additional opportunities as the industry progresses.

Given the S&I facilities planned for development in Humboldt County are likely to serve multiple projects as the floating offshore wind industry develops on the US West Coast, companies that are able to capitalize on early opportunities will be able to leverage that experience on future projects. Industry and economic development organizations should focus on helping to identify such partnerships so that local firms can benefit from this first mover advantage.

6 DISCUSSION

Industry confidence is a key driver of investor appetite and confidence. The commitment to 25 GW of floating offshore wind development in California—a state with strong decarbonization obligations and a friendly approach to renewable energy development—has built a degree of market confidence among developers. The first seabed leasing round off the coast of California was largely well received, and developers RWE and Vineyard Offshore have signaled support for supply chain and workforce development in support of floating offshore wind in Humboldt County. The federal grant of $426.7 million in port development has bolstered confidence for development in this region and provided the certainty needed to initiate studies into pathways for supply chain development in the Redwood Region.

In assessing supply chain opportunities for the Redwood Region, several key themes stood out. These are presented below and provide additional context for how best the region can prioritize efforts and position itself to localize as many benefits as practicable.

Recognize the Nascency of Floating Offshore Wind as an Industry – Given the relative immaturity of the floating wind industry, there is much uncertainty, and thus a lack of confidence, in the project pipeline and its associated timelines. This makes it difficult to reliably predict whether a business case exists for domestic manufacturing and when supply chain development needs to occur. While progress is being made, there is no dominant floating offshore wind substructure technology, and questions remain regarding whether and to what extent the wind turbine components themselves need to be altered to support floating offshore wind. The global supply chain is not well established, therefore uncertainty in sourcing components adds to the risk that developers and investors face. As certainty in the technologies and economies of scale are achieved, pricing should become more predictable, and costs should come down.

Focus on Local Contribution to Port Development – As it stands now, the existing supply chain in the Redwood Region is currently insufficient to support S&I and O&M activities independently. While planned development activities in the region are anticipated to meet some of these gaps, there is a lack of port support services among the companies assessed, including in crane capacity, fuel bunkering, port transportation equipment (such as self-propelled modular transporters, NDT services, etc.). This provides a great opportunity to seek out partnerships with larger, experienced companies focused on port operations and associated logistics. To meet these needs, additional expertise will need to be brought into the region, and investment in local companies to scale, partner, and develop their workforce will be needed. To this end, construction of a floating offshore wind port provides a significant growth opportunity for the local region, and must be carried out in a thoughtful way, with oversight and participation by local industry and economic development groups.

Project Development, S&I, and Onshore Construction as Key Opportunities – In assessing the supply chain potential of Humboldt County and the Redwood Region, plans for the region to develop S&I facilities, as well as an O&M base, were front of mind. As identified in the assessment, there are no major manufacturing or supply chain strengths in the wider Redwood Region, and while a number of utility companies exist, there are no Tier 1 companies that could contribute to a quayside supply chain build out. That being said, the region does possess a number of potential Tier 2 companies operating in onshore construction, environmental and land-based surveying, engineering, heavy equipment rental, small- and medium-scale metal fabrication, and commercial electrical services. When assessing the supply chain at lower tiers, company operations tend to become less industry-specific, but could still be applicable. Such local companies include those providing building materials, non-custom electrical components, and site services including HVAC, fire protection, coating application, etc. These companies should be made aware of opportunities to participate in project build-out as they become available.

Localize Floating-Specific Scopes Where Possible – The opportunity assessment looked at two cases: the opportunity for OEMs and Tier 1s to locate in the region, and the ability of the local supply chain to become part of the broader floating offshore wind supply chain. It should be noted that without the influx of port development investment, it is unlikely that an OEM or Tier 1 would select the Redwood Region for their operations. Port development plans, bolstered by potential IRA benefits to local investments, may be sufficient to attract some manufacturing operations to the region, but the best opportunity for the region beyond planned S&I and O&M activities is likely to be in manufacturing floating-specific offshore wind components like anchors, or performing assembly activities for floating substructures on site.

Raise Awareness and Educate Local Businesses – Humboldt County is home to the greatest volume of companies assessed to have some relevance to offshore wind, while relevant supply chain companies are sparser in the remaining Redwood Region. In the near-term, local businesses will be able to provide support at the periphery of the industry where products and services are less industry-specific. While the local opportunity is very much tied to the Port of Humboldt's development, opportunities for local companies can be maximized through educational campaigns to increase regional understanding of the types of products and services required, targeted engagement focused on partnership building, investment in scaling, retooling and obtention of certifications, and eventually in workforce training initiatives.

Engage the Local Community in a Meaningful Way – While creating a new industry presents an opportunity for much-needed economic growth in a region, it is critically important to consult with the local community and tribal members to ensure that development activities are in line with their desires, values, and concerns. The impetus for offshore wind supply chain development is coming from forces external to the region, and while job creation and economic stimulus are largely viewed as positive, it can have negative impacts on local ecosystems and culture if it is not carried out in a way that is sustainable and with careful planning. Additionally, many of these community organizations are already actively pursuing opportunities in this space, so great value can be gained in working together to help them achieve their goals and realize more realistic opportunities.

The SWOT assessment that follows from this report will take into consideration the community engagement, workforce development requirements, and supply chain gaps that have been discussed here. Ultimately, a successful offshore wind industry in the Redwood Region will take time and significant consideration to build. Recommendations made in following report will focus on identifying actionable items to increase awareness of the Redwood Region's ability to support the growth of this industry, identifying strategic initiatives with a goal of localizing as much benefit as possible.

APPENDIX A DESCRIPTION OF GLOBAL SUPPLY CHAIN

Project Development

Project development services are a firmly established capability in the global market. Such work includes permitting, surveying, and engineering and is similar across fixed and floating offshore wind. As a result, many firms established in the fixed market have pivoted to support the floating market as well. Project development companies are typically most experienced in regions with the greatest offshore wind installed capacity, with several global companies headquartered out of the more mature European market. These established players open divisions in new geographies to access new markets. Some small capability gaps exist in new markets where established players have not yet expanded, but generally these gaps are closed relatively quickly, so overall project development services tend to be readily available.

Wind Turbine Supply

Wind turbine supply is an established capability in the Western market, dominated by three OEMs: Siemens Gamesa, GE Vernova, and Vestas, headquartered in Spain, the US, and Denmark, respectively. European countries have been able to build up manufacturing capacity through regulatory support and a steady pipeline of projects over the past decades. There are five nacelle assembly facilities operating in Europe, and another is expected to open this year in Eastern Europe. The Global Wind Energy Council forecasted in their Global Offshore Wind Report 2023 that Europe's offshore wind turbine nacelle assembly capacity will struggle to supply European projects starting in 2027, meaning that the European supply chain cannot be relied upon to meet global demand as the global project pipeline grows.

Announced nacelle assembly facility development plans in the US and APAC regions are critical to meet demand in these markets. Taiwan, Japan, and South Korea are preparing for a ramp-up of offshore wind installations and prioritizing local content policies, which is attracting major component manufacturer investment. All three OEMs have established themselves in APAC, with four operating nacelle assembly facilities in Taiwan and South Korea, and four additional facilities announced as of February 2023. Blade manufacturing has also been established in Taiwan, and tower manufacturing plans are in development. There are no operating nacelle assembly facilities in North America, and only one with active development plans: the Vestas nacelle assembly facility. It is imperative these announced facilities are constructed to meet demand in these regions, since European production will not be able to meet demand in the 2030s as noted above.

China produces a large quantity of offshore wind turbines, but this production does not currently serve the Western market, although this may change in the future. Goldwind, Envision, and Mingyang are the main OEMs in the Chinese market, hosting 20 nacelle assembly facilities in the country, with 47 more under development as of February 2023. This major production capacity is seen across the entire offshore wind supply chain in China. However, trade restrictions based on national security concerns have prevented any Tier 1 component manufactured in China from being contracted to projects in the US market, so consideration of global market dynamics from the Western perspective exclude supply of Tier 1 components from China.

The wind turbine subcomponent supply chain is particularly globalized, with most markets partially dependent on Chinese manufacturing. OEMs typically subcontract manufacturing of subcomponents, and Chinese suppliers dominate the supply of key components including gearboxes, generators, converters, and large castings. The manufacturing of these subcomponents is unable to match the demand, resulting in a bottleneck for all markets. Chinese suppliers also dominate the supply of rare earth metals and carbon fiber, and their production is also unable to match global demand. Chinese suppliers have announced additional capacity expansion in production of these key subcomponents, and European and North American markets are expected to continue to rely on this production.

Many Tier 2 wind turbine subcomponents are bespoke and manufactured by trusted suppliers at established facilities in lower-cost regions. Tier 2 suppliers typically operate in multiple industries and have a large global footprint, generating hundreds of millions or billions of dollars in annual turnover. Some of this manufacturing is established in Europe and APAC (excluding China). Tier 1 suppliers still have an interest in localizing suppliers in response to the demand for local economic benefit generation and the low-cost domestic manufacturing opportunities offered by the IRA, but new local suppliers would need to compete with these large firms on cost and quality.

Floating Substructure Supply

Supply of floating substructures is an emerging capability in the global market. Design of floating substructures for wind turbines has not been standardized and production of these floating substructures has not been serialized, but floating pilot projects have given large European manufacturers some experience. Aker Solutions manufactured floating concrete substructures at the company's facility in Norway for one European pilot project, and Welcon manufactured the floating substructures at the company's facility in Demark for another. Lankhorst Offshore manufactured mooring lines for three pilot projects at its facility in Portugal. Europe is expected to build on this emerging capability to establish commercial scale production capacity in the region as the floating offshore wind project pipeline develops.

Countries in APAC are also investigating floating foundation production. Japan has announced investigation into floating substructure manufacturing, while South Korean companies in the shipbuilding market, including HSG Sungdong Shipbuilding, recently announced plans to construct a production hub for floating platforms at an old US naval base in the Philippines. Principle Power, headquartered in the San Francisco Bay Area in California, is linking the floating substructure markets in the US and Asia and plans to supply the floating platforms for two projects in South Korea and one in Japan. Principle Power has been discussing a supply chain partnership with HSG Sungdong Shipbuilding, which is a great example of cross-regional collaboration and an early sign of the emerging global capability outside Europe.

Supply of floating substructures for offshore substations has not yet emerged as a capability in the global market. Although one floating offshore substation was installed in 2013 (designed, manufactured, and installed by Japan Marine United Corporation), it handles only 16 MW, which is far from commercial scale. European pilot projects have been too small to require offshore substations and production of floating substructures for substations remains a large gap in the global floating offshore wind market.

Subsea Cable Supply

Subsea cable supply is an established capability in the global market, with Europe owning nearly a third of global subsea cable production capacity. Static export cables are proven solutions and are manufactured at facilities all over the world. Large subsea cable suppliers including Nexans, Prysmian, and Hellenic Cables have established some dynamic export cable production capacity at the European manufacturing facilities that supplied European floating pilot projects. However, the global market has not yet established a standardized baseline of solutions for dynamic cables for commercial scale floating offshore wind. Manufacturers are developing their own tests to qualify new dynamic cable designs. In some cases, manufacturers are partnering with academic or other stakeholders to leverage research or testing capabilities, but there is a bottleneck of testing centers to test cable and ancillaries. Commercial scale dynamic cable manufacturing capacity will further emerge as this testing bottleneck is alleviated and established players qualify their designs.

Electrical Infrastructure Supply

Supply of electrical infrastructure is an established capability in the global market, although opportunities to bring down costs through novel solutions are being explored. Electrical equipment manufactured for commercial scale fixed offshore wind projects can also supply floating projects. Since floating substations are a large technical challenge to commercialization of floating offshore wind, subsea substations, energy islands, and direct connection to onshore grid are solutions being considered as alternatives. These solutions could require new electrical infrastructure, introducing a gap in the commercial scale supply of electrical infrastructure in the global market.

Transportation and Installation

Vessel capacity to support floating offshore wind component transportation and installation is mostly established in the global market, but the capacity of certain vessels is still emerging. Large shipbuilding markets, primarily in China and South Korea, have established vessel construction capability for the global offshore wind industry. These vessels are not purpose-built for individual projects but rather constructed for the industry and offered in service packages to individual projects. These vessels are primary operated by engineering, procurement, construction, and installation (EPCI) contractors in Europe, such as Subsea7, DEME, and Van Oord.

Vessel capacity for floating-specific installation procedures is varied. Anchor handing tugs are available in several different regions in the global market and were mainly built to serve the oil and gas industry rather than being purpose-built for the floating offshore wind industry. As such, these vessels lack some of the features supporting efficient installation, and growing oil and gas activity reduces their availability. Notably, there is also a shortage of dynamic cable laying vessels. Some of these market gaps may be filled by vessel operators in the oil and gas industry.

Operations and Maintenance

O&M is an established capability in the global market, but O&M supply chains tend to be far more localized than other supply chains, creating domestic dependence for O&M. O&M suppliers are most experienced in regions with the greatest offshore wind installed capacity. Floating offshore wind supply chain planning and buildout efforts have prioritized manufacturing because commercial scale O&M supply will not be needed until several years later in the development timeline. A supply chain gap for operations and maintenance supply exists in most new markets.

A large portion of expense in the O&M phase is the procurement of replacement components, which relies on the same manufacturing supply chain as in the installation phase. Generators may need to be replaced if they underperform or fail, or blades may need to be replaced if they erode significantly.

A new supply chain consideration in the O&M phase is that of service providers employed to conduct maintenance, repair, and replacement rather than installation. Infancy of the floating offshore wind industry creates a lack of available data supporting best O&M methods, and there is a long lead time before commercial scale floating O&M services will be required as noted above. These factors create supply gaps for this phase across the global market.