DOCKETED	
Docket Number:	17-MISC-01
Project Title:	California Offshore Renewable Energy
TN #:	250296
Document Title:	Presentation for the May 23, 2023 AB 525 Workshop
Description:	Analytical Guidance and Benefits Assessment for AB 525 Strategic Plan Seaport and Workforce Development for Floating Offshore Wind in California
Filer:	susan fleming
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	5/24/2023 8:53:25 AM
Docketed Date:	5/24/2023

Analytical Guidance and Benefits Assessment for AB 525 Strategic Plan

Seaport and Workforce Development for Floating Offshore Wind in California

Prepared for the California Energy Commission and the Governor's Office of Business and Economic Development

28 April 2023

Innovative solutions for a complex world

Catalyst ENVIRONMENTAL SOLUTIONS

Table of Contents

Appendices

List of Tables

Glossary of Acronyms

AB525 – Assembly Bill 525

AC – Alternating Current

AJP – American Jobs Project

AMTAC – Advanced Manufacturing & Transportation Apprenticeships of California

AS – Associate in Science

BCA – Benefit Cost Analysis

BLS – Bureau of Labor Statistics

BOEM – Bureau of Ocean Energy Management

BOSIET – Basic Offshore Safety Induction and Emergency Training

BSEE – Bureau of Safety and Environmental Enforcement

BST – Basic Safety Training

CAEATFA – California Alternative Energy and Advanced Transportation Financing Authority

CAMAC – California Advanced Manufacturing Apprenticeships Collaborative

CBA – Community Benefits Agreement

CC – Community College

CCT – Certified Composites Technician

CEC – California Energy Commission

CEJA – Clean Energy Jobs Act

CPUC – California Public Utilities Commission

CSU – California State University

CVOW – Coastal Virginia Offshore Wind

CWA – Community Workforce Agreement

CWDB – California Workforce Development Board

DAS – Division of Apprenticeship Standards

DC – Direct Current

DEI – Diversity, Equity and Inclusion

DIR – Department of Industrial Relations

DOE – Department of Energy
DOT – Department of Transportation
ECU – Energy, Construction and Utilities
EJ – Environmental Justice
EPA – US Environmental Protection Agency
EPCI – Engineering-Procurement-Construction-Installation
FAA – Federal Aviation Administration
FIT – Feed-in Tariff
floating OSW – Floating Offshore Wind
FSN – Final Sale Notice
FTE – Full-Time Equivalents (jobs)
GDP – Gross Domestic Product
GE – General Electric
GW – Gigawatt
GWO – Global Wind Organization
HMT – Humboldt Marine Terminal
HRTP – High-Roads Training Partnerships
H&S – Health and Safety
HSE – Health Safety and Environmental
IBEW – International Brotherhood of Electrical Workers
IRA – Inflation Reduction Act of 2022
IRS – Internal Revenue Service
ISO – International Organization for Standardization
ITC – Investment Tax Credit
JEDI – Jobs and Economic Development Impact
LACE – Levelized Avoided Cost of Electricity
LBNL – Lawrence Berkeley National Laboratory
LCOE – Levelized Cost of Electricity
LGBT – Lesbian Gey Bi Transgender
MADOER – Massachusetts Department of Energy Resources
MAMA – Mid-Atlantic Maritime Academy
MassCEC – Massachusetts Clean Energy Center
MBCP – Monterey Bay Community Power
MIG – Stick Welding
MOU – Memorandum of Understanding
MSSC – Marine Safety and Security Center
MW – Megawatt
NABTU – North America's Building Trades Unions
NC – North Carolina
NEED – National Energy Education Development
NEPA – National Environmental Protection Agency
NJ – New Jersey
NJBPU – New Jersey Board of Public Utilities
NJDOL – New Jersey Department of Labor

NJEDA – New Jersey Economic Development Authority
NJIT – New Jersey Institute of Technology
NJWP – New Jersey Wind Port
NOWA – National Offshore Wind Agreement
NOWI – National Offshore Wind Institute
NREL – National Renewable Energy Laboratory
NWTC/NOWTC – National Workforce Training Center
NY – New York
NYSERDA – New York State Energy Research and Development Authority
OCS – Outer Continental Shelf
OEM – Original Equipment Manufacturers
O&M – Operations and Maintenance
OSHA – Occupational Safety and Health Administration
OSHE – Office of the Secretary of Higher Education
OSW – Offshore Wind
OWTI – Offshore Wind Training Institute
PLA – Project Labor Agreement
PTC – Premium Tax Credit
QC – Quality Control
RCSJ – Rowan College of South Jersey
RI – Rhode Island
RPS – Renewables Portfolio Standards
SB – Senate Bill
SERC – Shatz Energy Research Center
SLC – State Lands Commission
SOC – Standard Occupational Codes
SMWVBE – Small Minority Women Veteran Business Enterprise, a certification
STCW – Standards of Training, Certification, and Watchkeeping
TIG – Stick Welding
USACE – US Armey Corps of Engineers
USCG – US Coast Guard
WDI – Wind Development Institute
WEA – Wind Energy Area
WTG – Wind Turbine Generators

Executive Summary

Purpose and Compliance

Pursuant to Assembly Bill 525 (AB 525; Chiu 2021), the California Energy Commission (CEC) is directed to prepare a Strategic Plan that charts a path forward for developing floating offshore wind in California, including establishing goals for maximum installed capacity for 2030 and 2045. As part of this mandate, CEC is tasked with assessing the potential needs and economic benefits of developing a trained offshore wind workforce and seaport(s) that would serve as a manufacturing and logistics hub on the California coast (Section 25991.3 of AB 525). This Assessment approaches satisfying the AB 525 mandate by analyzing the following issues/requirements:

- the necessary investment in a California seaport(s) to support OSW energy activities (Section 2);
- workforce development needs (Section 3);
- outreach to key labor organizations and training/apprenticeship programs (Section 4);
- a review of offshore wind workforce standards and recommendations (Section 5);
- the role, opportunity, and prospective policies for the offshore wind supply chain (Section 6); and,
- the economic benefits of developing a seaport to serve as an offshore wind hub and a trained workforce (Section 7).

Analytical Framework

To organize and address the issues presented in Section 25991.3 of AB 525, this Assessment breaks down the mandates into areas of analysis (e.g., Seaport Development; Workforce Development Needs; etc.) and synthesizes the AB 525 requirements into key questions or issues. This approach allows for each AB 525 issue to be directly addressed and provide CEC with supporting information/data for the development of the Strategic Plan. Key issues and questions are provided in Table ES-1 below.

Table ES-1: Key Analytical Issues or Questions

Area of Analysis	Key Issue or Question
Seaport Development and Investment	Where are the potential seaport locations?
	What are the screening and siting criteria for site selection?
	What is the range of investment (cost) to develop, assemble, and operate/maintain the prospective seaport?
	How would the development of an offshore wind seaport impact the regional and state economies?
Workforce Development Needs	How many workers/jobs will be required to develop the workforce that can meet the demands of the 2030 (2-5 GW) and 2045 (25 GW) goals??
	What is the proportion of jobs for the supply chain, construction, and operations/maintenance phases?
	What types of skills and occupations are needed for the OSW workforce?
	What is the existing occupational workforce supply?
	What workforce elements are missing or limiting development?
	What are the potential skills and occupational gaps for the California OSW workforce?
Engagement with Labor and Apprenticeship Organizations	What are the key issues and obstacles to fielding a floating OSW workforce?
	What are the key skills and occupations needed for the OSW workforce?
	What types of OSW workers need the most training?
	What existing training resources are present in California and what could be

	What measures could be taken to incentivize the hiring of women, veterans, and disadvantaged/under-represented people into OSW workforce?
	What would expedite workforce training and development?
	What role can the State of California play to expedite workforce development?
Workforce Standards, Occupational Safety Requirements, and Training Needs Assessment	What occupational safety requirements should be instituted to protect the OSW workforce?
	How has the East Coast and abroad addressed workforce standards?
	What workforce standards are recommended by industry, EPCIs, and manufacturers?
	How can equity be integrated into the growth of OSW in California? How can workforce development/training programs be created to be consistent with the Justice40 goals, benefiting both historically vulnerable/disadvantaged communities and communities displaced by the decline of the fossil fuel sector?
	How can training programs be financed?
	What are the training requirements to provide the necessary types of skills for OSW development?
	Who or what type of institution can provide the needed training requirement to achieve a sufficiently-trained workforce, and does it already exist or could it be added to an existing program?
	Should the Division of Apprenticeship Standards develop curriculum for in-person classroom and laboratory advanced safety training for workers?
	What are the recommended workforce standards, including prevailing wage, workforce skills, workforce training, apprenticeship programs, local hiring initiatives, targeted hiring standards, and equitable hiring standards?
Supply Chain Assessment	What and how much raw materials are needed to develop the necessary components to achieve the 2030 and 2045 goals?
	What supply chain assets are currently in place?
	What are the key elements missing from the supply chain?
	What are the opportunities for the State of California to capture the economic activity presented by the offshore wind supply chain?
	How can the State capitalize on a new industry?
	What are the potential policies/incentives that California can institute to attract critical supply chain entities?
Beneficial Economic Impacts	What are the economic benefits (i.e., jobs, income, economic activity, fiscal impacts) of developing a seaport and workforce?
	How would developing a seaport impact the local/regional economy and the state economy?
	What beneficial impacts could be realized from workforce training, including the development of a sophisticated training center?
	What are the potential impacts to fiscal (tax) revenues from workforce and seaport development?

Offshore wind energy development on the U.S. East Coast (e.g., New York, Massachusetts, New Jersey, etc.) has taken root and is a fast-growing industry, with approximately 40 GW of fixed bottom offshore wind in the development pipeline.[1] Although offshore wind on the East Coast uses a "fixed bottom" approach, there are valuable lessons on how those states strategically promoted the development of an offshore wind industry to serve as a new economic driver and mechanism to decarbonize. Where feasible throughout this Assessment, case studies from the East Coast are used to highlight successful policies, strategies, investments, and partnerships.

[1] U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. August 16, 2022. Offshore Wind Market Report (2022 Edition). Available online at: https://www.energy.gov/eere/wind/articles/offshore-wind-market-report-2022-edition

Summary of Findings

Table ES-2 below provides a crosswalk of the key AB 525 issues/questions and this Assessment's findings. Section references are also provided to provide direction to the larger discussions on the key issues.

Table ES-2: Summary of Findings per Key AB 525 Issue

OSW Area of Analysis	*AB 525 Issue*	*Key Issue/Question*	*Section of Assessment*	*Summary of Finding*
Seaport Development	…develop a plan to improve waterfront facilities that could support a range of floating offshore wind energy development activities, including construction and staging of foundations, manufacturing of components, final assembly, and long-term operations and maintenance facilities.	• Where are the potential seaport locations?	Section 2.3 Potential Seaport Locations	The California State Lands Commission is preparing a study that charts the path forward for seaport(s) development, as a key supporting facility/hub for offshore wind development. In lieu of the SLC's findings, this Assessment performs an analysis of upgrading the Humboldt Marine Terminal (HMT). In 2021, the State of California issued a $10.5 million grant to the HMT for initial planning and improvements for offshore wind facilities, with another $45m proposed for 2022-2023 to further prepare quayside facilities. With investment starting to flow to the HMT, this Assessment considers the development of HMT as a highly probable scenario. It is recognized that a multi-port strategy may be recommended and implemented but to prepare a conservative analysis of potential beneficial economic impacts from seaport development (see Section 7 below), this Assessment focuses on the likely build out of the HMT.
	A detailed assessment of the necessary investments in California seaports to support offshore wind energy activities, including construction, assembly, and operations and maintenance.	• What is the range of investment (cost) to develop, assemble, and operate/maintain the prospective seaport?	Section 2.4 Seaport Construction Costs	This Assessment relies on a construction cost estimate developed by Moffatt and Nichol to upgrade the HMT to serve as an offshore wind seaport hub. Moffatt and Nichol estimated that the cost to upgrade HMT would be approximately $125m. It is worth noting that the Shatz Energy Research Center (SERC) estimates that $130m-$310m would be required to develop a large commercial OSW seaport.
	The assessment shall consider the potential availability of land and water acreage at each seaport, including competing and current uses, infrastructure feasibility, access to deep water, bridge height restrictions, and potentially impacted natural and cultural resources, including coastal resources, fisheries, and Native American and Indigenous peoples.	• What are the screening and siting criteria for site selection?	Section 2.3.1 Representative Screening and Selection Criteria	Developing a seaport that provides quayside manufacturing, transport, and logistics/storage is a critical element of facilitating offshore wind development in California. Numerous factors, or screening criteria, must be considered when siting the seaport and the National Renewable Energy Laboratory (NREL), US Bureau of Ocean Energy Management (BOEM), the Schatz Energy Research Center, and the California State Lands Commission (SLC) have performed seaport screening and siting analyses. Representative screening criteria may include: • Land ownership and/or lease of proposed locations • Location and size of shore length • Current uses and surrounding uses • Availability of adequate air draft height • Availability of adequate channel draft depth • Availability of upland acreage with appropriate weight capacities

OSW Area of Analysis	*AB 525 Issue*	*Key Issue/Question*	*Section of Assessment*	*Summary of Finding*
				• Availability of existing waterfront infrastructure (quayside/load-bearing capacity) • Adequacy of navigation channels, water depth, air clearance, and other logistics considerations • Engineering considerations/constraints • Skilled labor availability and/or local training and apprenticeship interest • Surrounding ocean conditions • Accessibility to roads, rail, and existing utilities • Potential permitting challenges associated with sensitive environmental resources contamination, or other regulatory issues • Regulatory Constraints – FAA; US Coast Guard designated shipping lanes • Known or likely level of interest of facility in participating OSW infrastructure and/or necessary changes.
Workforce Development Needs	An analysis of the workforce development needs of the California offshore wind energy industry, including occupational safety requirements, the need to require the use of a skilled and trained workforce to perform all work.	• How many workers/jobs will be required to develop the workforce that can meet the demands of the 2030 (2-5 GW) and 2045 (25 GW) goals?	Section 3.3 Number of Jobs Needed for Floating OSW Workforce	Approximately 2,375-8,280 jobs are expected to be required for California's floating offshore workforce by 2030, and 5,063-17,950 jobs by 2045. These estimates/ranges were derived from three keynote studies on forecasting California's workforce needs: • NREL/BOEM. April 2016. "Floating Offshore Wind in California: Gross Potential for Jobs and Economic Impacts from Two Future Scenarios." • American Jobs Project. February 2019. "The California Offshore Wind Project: A Vision for Industry Growth"; BVG/American Jobs Project. January 2019. "CA Jobs Modeling Methodology." • Guidehouse. May 2022. "California Supply Chain Needs Summary." California Energy Commission.
		• What is the proportion of jobs for the supply chain, construction, and operations/maintenance phases?	Section 3.4 Distribution of Workforce Occupations Per Phase	Approximately 2/3rds of the OSW workforce will be in the supply chain and manufacturing sectors. This is a key finding of this Assessment and also represents California's primary opportunity to capture the economic benefits of developing an ambitious offshore wind industry. As observed in the infographic below, the construction and operations/maintenance phases offer similar levels of jobs, around 700-800 jobs, whereas the supply chain is expected to generate 4,020 jobs.
		• What types of skills and occupations are needed for the OSW workforce?	Section 3.5 Occupational Skills Mapping	As provided in the radar/skills graphics in Figure 3-4, Technicians and Trades dominate the needed skills for supply chain, representing over 50% of the skill set needed for those occupations. Construction veered towards Construction and Assembly skills, but also had a significant need in the Technicians and Trades as well. The majority of skills for the Operations/Maintenance phase are in the Technicians and Trades skills, however Administrative and Clerical skills are also required. As observed in Figure 3-5, when compiling all three phases, the Technicians and Trades represent the primary skills area of need, followed by Construction/Assembly, and Administrative/Clerical.

OSW Area of Analysis	AB 525 Issue	Key Issue/Question	Section of Assessment	Summary of Finding
		• What is the existing occupational workforce supply?	Section 3.6.1 Existing Workforce	California maintains a large and diverse workforce, with approximately 16.5 million workers (2021). While the new offshore wind workforce will represent a cross-section of occupational types, requiring a wide variety of jobs to operate the industry, some of the key sectors that will be impacted by the offshore wind industry are Installation, Maintenance, and Repair (approximately 500,000 current workers); Construction and Extraction (approximately 650,000 current workers); and Production (approximately 750,000 current workers).
		• What are the potential skills and occupational gaps for the California OSW workforce?	Section 3.6.2 Gaps Analysis	As observed in Figure 3-6, the majority of California's occupational types/sectors are in a position to internalize the new demand created by the offshore wind industry; however, a few occupational types are currently unprepared to meet the demand of the new industry. Those occupational types that are forecasted to experience an increase of more than 20% by 2030 and more than 60% by 2045 are: • Miscellaneous Plant and System Operators • Tank Care, Truck, and Ship Loaders • Forging Machine Setters, Operators, and Tenders (Metal and Plastic) • Wind Turbine Service Technicians • Engine and Other Machine Assemblers These findings track with the conclusion that nearly two-thirds of the new jobs created by California's offshore wind industry will be located in the supply chain (i.e., manufacturing, assembly, extraction, production, fabrication, etc.). While some speciality occupations, such as wind turbine technician, will essentially be wholly new job types in California, it is the State's supply chain sectors that will experience significant new demand for trained workers.
Engagement with Labor and Apprenticeship Programs	In developing the plan pursuant to subdivision (a), the commission shall consult with representatives of key labor organizations and apprenticeship programs that would be involved in dispatching and training the construction workforce.	• What are the key issues and obstacles to fielding a floating OSW workforce? • What are the key skills and occupations needed for the OSW workforce? • What types of OSW workers need the most training? • What existing training resources are present in California and what could be?	Section 4 Engagement with Labor and Apprenticeship Organizations	Interviews with labor organizations and training/apprenticeship entities were conducted between October 2022 and February 2023. In addition to the AB 525 requirement to engage "key labor organizations and apprenticeship programs," this Assessment expanded the interviewee pool to Engineering-Procurement-Construction- Installation (EPCI) organizations; developers; manufacturers; and OSW training entities and experts to obtain a wider perspective from industry and other key training entities. Section 4 contains a summary of responses from the interviews conducted. Key questions asked/discussed included: • What are the skills that the workforce for this new industry will need to have? • What are some of the obstacles to being able to field an OSW construction workforce? • What would be needed to expedite the creation of this workforce? • What types of incentives would help recruit these new workers? What can the State of California do to facilitate workforce training and development?

OSW Area of Analysis	AB 525 Issue	Key Issue/Question	Section of Assessment	Summary of Finding
		• What measures could be taken to incentivize the hiring of women, veterans, and disadvantaged/under-represented people into OSW workforce? • What would expedite workforce training and development? • What role can the State of California play to expedite workforce development?		• Do you see that this future workforce will be coming mostly from other existing sectors (e.g., manufacturing, maybe fossil fuel workers) or from new untrained workers? • What existing training and apprenticeship programs could be repurposed or expanded to train offshore wind construction workers?
Workforce Standards	An analysis of the workforce development needs of the California offshore wind energy industry, including occupational safety requirements, the need to require the use of a skilled and trained workforce to perform all work, and the need for the Division of Apprenticeship Standards to develop curriculum for in-person classroom and laboratory advanced safety training for workers.	• What occupational safety requirements should be instituted to protect the OSW workforce?	Section 5.3 Occupational Safety Standards	To date, there are no official health and safety requirements for floating offshore wind in the United States. This also extends to the fixed bottom offshore wind industry on the East Coast. As echoed by NREL, the U.S. offshore industry is progressing toward construction and operation sooner than availability of supporting standards, guidelines, and regulatory frameworks. This regulatory gap provides a unique opportunity for California to develop what could be national safety standards for floating offshore wind. The state should consider developing a working group between all regulatory entities and the GWO to establish a common set of health and safety standards for all floating offshore wind workers and environments.
		• How has the East Coast and abroad addressed workforce standards?	Section 5.2.3.4 Workforce Training Case Studies	This Assessment reviewed the status of workforce standards in seven states on the East Coast (e.g., New Jersey, New York, Connecticut, Massachusetts, Rhode Island, North Carolina, Virginia) and summarized the key elements of their workforce training strategies. Each state took a unique path to address workforce training, despite their differences there are key principles that each used to move their workforce training from theory to practice. These correlated principles could serve as guidance in establishing California's workforce training goals and standards .
		• What are the training requirements to provide the necessary types of skills for OSW development?	Section 5.2.3.1 Workforce Training Standards	The majority of offshore wind occupations will require some form of post-secondary education, training, or certification to train workers with the required skills. The following measures could be taken to establish training requirements. • Partnerships between industry, education and training institutions, government entities, and community organizations have been key to addressing offshore wind energy workforce needs efficiently, effectively, and equitably by preparing a workforce that meets the technical, geographic, and timeline needs for anticipated wind projects. Partnerships are also important for the development of internships and apprenticeships needed to give the workforce real on-the-job skills and training.

<table>
<tr><th>OSW Area of Analysis</th><th>AB 525 Issue</th><th>Key Issue/Question</th><th>Section of Assessment</th><th>Summary of Finding</th></tr>
<tr><td rowspan="3"></td><td></td><td></td><td></td><td>California has an opportunity to leverage existing programs (i.e., California High Road Training Partnerships, etc.) to establish partnerships with industry leaders and use state funding to entice others. East Coast examples provide various frameworks for establishing training facilities such as the OWTI and NWTC in New York, which is funded through the state and industry partners, and facilitated through community colleges and university partnerships.
NREL identified the most significant gap identified for offshore wind workforce development is creating a consensus on safety training standards. Safety training standards affect ports and staging, maritime construction, and operations and maintenance. Filling this gap is paramount to workforce hireability and requires input from developers, training entities, community colleges, labor unions, vessel operators, etc. Standards established by GWO are an option for adoption, or at least an industry-led foundation to build upon. Once consensus is established on training standards, the standards need to be communicated to training facilities (i.e., community colleges, universities, union-led training programs, etc.) so workers have the necessary skills to enter the workforce.
As industry prefers GWO training standards, it is advisable to increase the capacity and availability of GWO approved training providers. There is only one present in California currently and this could serve as a bottleneck to yielding a trained workforce.</td></tr>
<tr><td rowspan="2">Recommendations for workforce standards for offshore wind energy facilities and associated infrastructure, including, but not limited to, prevailing wage, skilled and trained workforce, apprenticeship, local hiring, and targeted hiring standards, that ensure sustained and equitable economic development benefits.</td><td>What are the recommended workforce standards, including prevailing wage, workforce skills, workforce training, apprenticeship programs, local hiring initiatives, targeted hiring standards, and equitable hiring standards?</td><td>Sections 5.2.1.4; 5.2.2.2; 5.2.3.4; 5.2.4.1; 5.2.5.1

Recommendations for Workforce Standards</td><td>Recommendations are provided through Section 5.2 for prevailing wage, workforce skills, workforce training, apprenticeship programs, local hiring initiatives, targeted hiring standards, and equitable hiring standards. Many of these recommendations take from successful models and lessons-learned from the East Coast's fixed bottom offshore wind industry.</td></tr>
<tr><td>What workforce standards are recommended by industry, EPCIs, and manufacturers?</td><td>Section 4
Engagement with Labor and Apprenticeship Organizations

Section 5.2.3.2</td><td>Industry, EPCIs, and supply chain entities (see Section 4) prefer the adoption of workforce standards, specifically training standards, established by the Global Wind Organization (GWO). GWO has developed specific training standards for the offshore wind industry, including for:
Advanced Rescue
Basic Safety
Blade Repair
Control of Hazardous Energies</td></tr>
</table>

OSW Area of Analysis	AB 525 Issue	Key Issue/Question	Section of Assessment	Summary of Finding
			Role of Industry Standards	• Enhanced First Aid • Wind Technician • Lift Training • Slinger Signaler • Limited Access Training GWO contends that "Any individual with a GWO certificate in the Wind Industry Database (WINDA) is considered competent and knowledgeable according to the learning objectives of that standard. GWO members accept the certificate as confirmation the individual possesses the required knowledge and competences as described in the standard." This cross-cutting understanding amongst GWO members, which is fairly comprehensive of all turbine manufacturers in the world, provides industry's preferences for the level of training offshore wind workers should acquire.
		• How can equity be integrated into the growth of OSW in California? How can workforce development and/or training programs be created to be consistent with the Justice40 goals, benefiting both historically vulnerable or disadvantaged communities and communities displaced by the decline of the fossil fuel sector?	Section 5.2.6 Equitable and Targeted Hiring Standards	It is recommended that California enact legislation that adds equity criteria to offshore wind procurement evaluations. Criteria could reflect New York's approach of: 40% of the overall benefits from clean energy programs must go to disadvantaged communities for workforce development, low-income energy assistance and housing; community engagement plans that provide opportunities to build community equity; prioritization of job creation and other benefits for disadvantaged communities. Additionally, Project Labor Agreements (PLAs) can be used as an effective mechanism to ensure equity in the industry. Hiring standards can be put in place for the required percentage of women, persons of color, underrepresented populations, low-income populations, and residents from surrounding counties.
	…need for the California Division of Apprenticeship Standards to develop curriculum for in-person classroom and laboratory advanced safety training for workers.	• Who or what type of institution can provide the needed training requirement to achieve a sufficiently-trained workforce, and does it already exist or could it be added to an existing program?	Section 5.4.1 Review of Existing Training Facilities and Apprenticeship Programs	While California has training assets and state-certified apprenticeship programs in place, gaps in the training curriculums are present for floating OSW. As discussed in Section 5.2.3, offshore wind development requires a specific set of training curriculums, especially for the construction workforce, such as working at heights, working in a marine environment, advanced rescue, and maritime safety. As the floating offshore wind industry is yet to take root in California, the specific training requirements are relatively absent from the curriculums provided in Table 5-1. To meet the demand of the new offshore wind workforce, California should consider scaling existing training programs to provide near-term resources to a potentially fast-

OSW Area of Analysis	AB 525 Issue	Key Issue/Question	Section of Assessment	Summary of Finding
				growing industry. These programs can also provide complimentary offshore wind skills to existing trained workers that transition from other industries.
		• Should the Division of Apprenticeship Standards develop curriculum for in-person classroom and laboratory advanced safety training for workers?	Section 5.4.3 Recommendations	It is recommended that the California Department of Industrial Relations – Office of Apprenticeship Standards develop a specific advanced safety training curriculum for floating offshore wind workers. This would best be done collaboratively with industry, regulators, and training experts, as has been done on the East Coast. The GWO training standards are widely recognized by industry and may serve as a basis for the state to build a curriculum around. It is further recommended that the state invest in a training center. Providing a centralized, hands-on training facility (likely near/at the seaport which would serve as an offshore wind hub for supporting enterprise and services) will help ensure workers train with the same components and equipment they will use in their offshore wind jobs. It is advisable that the state (specifically the State Lands Commission) explore public-private partnerships to fund and develop an in-person training center/laboratory, or consider it as a selection criteria in awarding seaport development. A potential model is provided in the Offshore Wind Training Institute in the state of New York. The state should consider introducing a K-12 school program that provides an early career pathway for entry level workers, creating a pipeline of knowledgeable and proficient new workers for the offshore wind workforce.
Supply Chain	No specific AB525 requirements, but represents primary opportunity to capture the economic benefits from supply chain development.	• Why is it important to develop local capacity? • What is the status of local capacity?	Section 6.2 Supply Chain Overview	Significant gaps are present in California's current supply chain capabilities to service future offshore wind development. Guidehouse determined that, "while several manufacturers with large global market share have existing or planned manufacturing presence in the United States, *none* have OSW capable manufacturing facilities in California or elsewhere on the West Coast." While there is currently no capacity in California with demonstrated direct experience in offshore wind, there are sectors that, with the right incentives and investments, could pivot to meet these emerging demands. As California begins to invest in building capacity to deliver offshore wind, developing local supply chain capacity offers several potential benefits and protections including: 1. *Building local capacity* – developing local industry that will support local and state tax bases and providing living wage jobs. 2. *Capturing Greater Economic Multiplier Effect* - the greater the percentage of creation and fabrication that resides in the state, the greater the potential and magnitude for additional expenditures in other California industries.

OSW Area of Analysis	AB 525 Issue	Key Issue/Question	Section of Assessment	Summary of Finding
				3. *Eliminating Vulnerability* - Local control over production eliminates the vulnerability to input price variability and other input supply shocks.
		• Where are the opportunities to develop local capacity? • What are the opportunities for the State of California to capture the economic activity presented by the offshore wind supply chain?	Section 6.3 Supply Chain Opportunities	Since there is currently no supply chain capacity in California that has direct experience in floating offshore wind, and limited capacity elsewhere in the US to support the development of offshore wind, the potential is theoretically unlimited. However, realistically there are physical and temporal constraints relative to California's targets and timelines that make developing aspects of the supply chain more or less feasible in terms of costs and timelines. As discussed in previous sections, there are realistic near-term opportunities for domestic supply chain capacity development related to: • concrete casting and manufacturing capacity in support of towers and foundations; • steel fabrication capacity in support of towers, foundations, mooring lines, and anchors; and, • wire drawing capacity in support of inter array and high voltage cables. Despite not having current manufacturing capacity in California to support floating OSW, the development of domestic supply chain capacity for concrete, steel and wire will enable local construction and assembly of both towers and foundations, which have been identified as components having high potential for local supply chain capacity development.
		• What policy levers/instruments have proven track record of supporting getting there?	Section 6.4 Levers, Policies, and Incentives Section 6.6 Summary of Potential Policy Mechanisms	Policy instruments, tools, tactics, and activities that encourage creativity, reduce uncertainty, and mitigate or incentivize risk have been shown to be effective tools to encourage development of new ventures and new industries. Policy instruments that have been successfully used in other states and in Europe to support the development of inputs and components for the floating offshore wind supply chain include: • *Subsidies* – a direct or indirect payment (could be cash or a tax cut) that provides a financial offset or mitigates uncertainty. • *Feed-In-Tariffs/Tenders* – Feed-In-Tariffs (FIT) are policy tools specifically designed to encourage investment in renewable energy. Originating in Germany, FITs are long term contracts that guarantee that the owners of a renewable energy generation source will receive a set price, typically higher than the retail price for energy, for the energy generated and provided to the grid. • *Tax Credits and Rebates* – provisions that directly reduce a taxpayer's final tax bill after calculation. • *Tax Deductions and Exemptions* - provisions that lower the initial income on which tax is calculated. • *Grants & Cooperative Agreements* – mechanisms authorized by legislation that allow state and federal governments to enter into financial assistance relationships that support competitiveness and the development of innovation

OSW Area of Analysis	*AB 525 Issue*	*Key Issue/Question*	*Section of Assessment*	*Summary of Finding*
				(as opposed to directly procuring a good or service). Economic development agencies typically use grants to promote growth and investment in geographic areas or emerging sectors. • *Direct Public & Private Sector Investment* – long term purchase or acquisition of capital or controlling interest in a concern or venture as opposed to lending money or purchasing shares. • *Project Labor Agreements* – collective bargaining instruments between trade unions and contractors that govern the terms of employment for craft workers and provide structure and stability for large scale construction projects. • *Local Source Requirements* - laws, regulations (and incentives) that require that certain percentages of project inputs come from a particular geography or region. • *Hub/Hive development* - this is a tactic where government creates and incentivizes physical spaces and collaborative agreements (e.g., incubators, technology parks, subject matter expert exchanges) that encourage and support innovation and skills development.
Economic Benefits	On or before December 31, 2022, the commission shall complete and submit to the Natural Resources Agency and the relevant fiscal and policy committees of the Legislature a preliminary assessment of the economic benefits of offshore wind as they relate to seaport investments and workforce development needs and standards.	• What are the economic benefits (i.e., jobs, income, economic activity, fiscal impacts) of developing a seaport and workforce?	Section 7.3 State-Wide Beneficial Economic Impacts from Seaport and Workforce Development	California is positioned to realize significant economic benefits from seaport, training center, and workforce development. IMPLAN modelling forecasted that floating offshore wind could generate $104 million in state-level GDP by 2030 and upwards of $5 billion by 2045. The industry is also expected to generate 500 jobs by 2030 and 14,000 jobs by 2045 (in addition to the direct jobs included in the workforce); $44 million in labor income by 2030 and $1.2 billion by 2045; and, $3.6 million in fiscal revenue by 2030 and $385 million by 2045. These benefits could be increased by approximately 20 percent if the state of California adopts robust policies and incentives to promote in-state supply chain capacity.
		• How would developing a seaport impact the local/regional economy and the state economy?	Section 7.4 Regional Beneficial Economic Impacts from Seaport Development	In addition to the state-level benefits analysis, this Assessment considered a four county region around the greater Humboldt County to also include Del Norte, Trinity, and Mendocino Counties. The IMPLAN model demonstrated the ripple effect of workforce development results in 6,300 (without policy support in 2030) to 18,600 jobs (with policy support in 2045), labor income between $465 million (without policy support in 2030) to $1.4 billion (with policy support in 2045) and between $2.2 to $6.8 billion GDP for the model years 2030 (without policy support) and 2045 (with policy support). For the seaport development and the training center construction combined, the full beneficial impact is between 360 (without policy support) and 540 (with policy support) jobs per year of construction, providing labor income of $23 to $35 million, and $62 to $98 million in GDP annually between 2023 and 2025 (low are without policy support and highs are with policy support).
		• What beneficial impacts could be realized from workforce training, including the	Section 7.3 State-Wide Beneficial	This Assessment reviewed the development of seaports for offshore wind initiatives from the US east coast and abroad, finding that California does need a training facility to serve as a hands-on laboratory for the implementation of specific worker safety classes (i.e., marine safety, at height training), construction protocols, and industry

OSW Area of Analysis	AB 525 Issue	Key Issue/Question	Section of Assessment	Summary of Finding
		development of an in-person training center?	Economic Impacts from Seaport and Workforce Development Section 7.4 Regional Beneficial Economic Impacts from Seaport Development	standards. This Assessment found that the training facility being developed in New York most accurately reflects the type of training facility that California will need to develop. The cost of the New York training facility is approximately $20 million. Training center development could result in almost 100 jobs annually across California, approximately 35 million in annual labor income, and $90 million in state-level GDP. In the Greater Humboldt Region, the training center is forecasted to generate nearly 100 jobs; $6.4 million in regional labor income; and, $14 million in economic activity (GDP).
		• What are the potential impacts to fiscal (tax) revenues from workforce and seaport development?	Section 7.3.4 Fiscal Impacts (State-wide) Section 7.4.4 Fiscal Impacts (Regional)	Workforce development is modeled to generate upwards of $154 million in annual state taxes by 2030 and $387 million by 2045. The seaport will generate approximately $3 million annually in state taxes, with almost $1 million in direct tax benefit.

SECTION 1

Introduction

1.1 Purpose

Pursuant to Assembly Bill 525, the California Energy Commission (CEC) is directed to prepare a Strategic Plan that charts a path forward for developing floating offshore wind in California, including establishing goals for maximum installed capacity for 2030 and 2045.[2] As part of this mandate, CEC is tasked with assessing the potential needs and economic benefits of developing a trained offshore wind workforce and seaport that would serve as a manufacturing and logistics hub on the coast of California (see *Section 25991.3 of AB 525 – The Framework for This Economic and Workforce Assessment* below for a review of the legislative requirements). Specifically, this Assessment approaches satisfying the AB 525 mandate by analyzing the following issues/requirements:

- the necessary investment in California seaports to support OSW energy activities (Section 2);
- workforce development needs (Section 3);
- outreach to key labor organizations and training/apprenticeship programs (Section 4);
- a review of offshore wind workforce standards and recommendations (Section 5);
- the role, opportunity, and prospective policies for the offshore wind supply chain (Section 6); and,
- the economic benefits of developing a seaport to serve as an offshore wind hub and a trained workforce (Section 7).

1.2 Analytical Framework - AB 525 Issues and Questions

To organize and address the issues included in Section 25991.3 of AB 525, this Assessment assigns key framework questions to each primary area of analysis, as provided below. Complementary to the mandates included in Section 25991.3, the following questions serve as the analytical basis for approaching each key technical issue to derive responses that directly satisfy the AB 525 legislative requirements.

1.2.1 Seaport and Infrastructure Assessment

- Where are the potential seaport locations?
- What are the screening and siting criteria for site selection?
- What is the range of investment (cost) to develop, assemble, and operate/maintain the prospective seaport?
- How would the development of an offshore wind seaport impact the regional and state economies?

1.2.2 Workforce Development Needs

- How many workers/jobs will be required to develop the workforce that can meet the demands of the 2030 (2-5 GW) and 2045 (25 GW) goals??
- What is the proportion of jobs for the supply chain, construction, and operations/maintenance phases?
- What types of skills and occupations are needed for the OSW workforce?

---

[2] Chiu, David. Assembly Bill 525: Offshore Wind Generation - Chapter 231, Statutes of 2021. Available online at: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB525

- What is the existing occupational workforce supply?
- What workforce elements are missing or limiting development?
- What are the potential skills and occupational gaps for the California OSW workforce?

Section 25991.3 of AB 525 The Framework for This Economic and Workforce Assessment

a. Based on the sea spaces identified pursuant to Section 25991.2, the commission, in coordination with relevant state and local agencies, shall develop a plan to improve waterfront facilities that could support a range of floating offshore wind energy development activities, including construction and staging of foundations, manufacturing of components, final assembly, and long term operations and maintenance facilities.

b. The plan developed pursuant to subdivision (a) shall include all of the following:

(1) A detailed assessment of the necessary investments in California seaports to support offshore wind energy activities, including construction, assembly, and operations and maintenance. The assessment shall consider the potential availability of land and water acreage at each seaport, including competing and current uses, infrastructure feasibility, access to deep water, bridge height restrictions, and potentially impacted natural and cultural resources, including coastal resources, fisheries, and Native American and Indigenous peoples.

(2) An analysis of the workforce development needs of the California offshore wind energy industry, including occupational safety requirements, the need to require the use of a skilled and trained workforce to perform all work, and the need for the Division of Apprenticeship Standards to develop curriculum for in person classroom and laboratory advanced safety training for workers.

(3) Recommendations for workforce standards for offshore wind energy facilities and associated infrastructure, including, but not limited to, prevailing wage, skilled and trained workforce, apprenticeship, local hiring, and targeted hiring standards, that ensure sustained and equitable economic development benefits.

c. In developing the plan pursuant to subdivision (a), the commission shall consult with representatives of key labor organizations and apprenticeship programs that would be involved in dispatching and training the construction workforce.

d. On or before December 31, 2022, the commission shall complete and submit to the Natural Resources Agency and the relevant fiscal and policy committees of the Legislature a preliminary assessment of the economic benefits of offshore wind as they relate to seaport investments and workforce development needs and standards.

e. The plan developed pursuant to this section shall be included in the chapter of the strategic plan relating to economic and workforce development and identification of port space and infrastructure as specified in paragraph (2) of subdivision (c) of Section 25991.

1.2.3 Engagement with Labor and Apprenticeship Organizations

- What are the key issues and obstacles to fielding a floating OSW workforce?
- What are the key skills and occupations needed for the OSW workforce?
- What types of OSW workers need the most training?
- What existing training resources are present in California and what could be
- What measures could be taken to incentivize the hiring of women, veterans, and disadvantaged/under-represented people into OSW workforce?
- What would expedite workforce training and development?
- What role can the State of California play to expedite workforce development?

1.2.4 Workforce Standards, Occupational Safety Requirements, and Training Needs Assessment

- What occupational safety requirements should be instituted to protect the OSW workforce?

- How has the East Coast and abroad addressed workforce standards?
- What workforce standards are recommended by industry, EPCIs, and manufacturers?
- How can equity be integrated into the growth of OSW in California? How can workforce development/training programs be created to be consistent with the Justice40 goals, benefiting both historically vulnerable/disadvantaged communities and communities displaced by the decline of the fossil fuel sector?
- How can training programs be financed?
- What are the training requirements to provide the necessary types of skills for OSW development?
- Who or what type of institution can provide the needed training requirement to achieve a sufficiently-trained workforce, and does it already exist or could it be added to an existing program?
- Should the Division of Apprenticeship Standards develop curriculum for in-person classroom and laboratory advanced safety training for workers?
- What are the recommended workforce standards, including prevailing wage, workforce skills, workforce training, apprenticeship programs, local hiring initiatives, targeted hiring standards, and equitable hiring standards?

1.2.5 Supply Chain Assessment

- What and how much raw materials are needed to develop the necessary components to achieve the 2030 and 2045 goals?
- What supply chain assets are currently in place?
- What are the key elements missing from the supply chain?
- What are the opportunities for the State of California to capture the economic activity presented by the offshore wind supply chain?
- How can the State capitalize on a new industry?
- What are the potential policies/incentives that California can institute to attract critical supply chain entities?

1.2.6 Beneficial Economic Impacts

- What are the economic benefits (i.e., jobs, income, economic activity, fiscal impacts) of developing a seaport and workforce?
- How would developing a seaport impact the local/regional economy and the state economy?
- What beneficial impacts could be realized from workforce training, including the development of a sophisticated training center?
- What are the potential impacts to fiscal (tax) revenues from workforce and seaport development?

1.3 Literature Review and Key Sources

Appendix A is a detailed review of available literature, technical sources, databases, and other pertinent information sources that were used to support this Assessment. This literature review has been organized into the following primary categories – offshore wind; other renewable energy; ports; systems components; vessels; workforce impacts; economic analysis; tax breaks, incentives, and policies; transmission; LACE and/or LCOE; environmental and social impacts; and workforce training. The literature review includes summaries of the thematic comments/issues for each category and also offers weblinks to each key document. This database serves as a resource to future researchers, analysts, and interested parties that want to find specific information on a key OSW topic. Additionally, boxes are included in each primary section of this Assessment that list the key sources used for that particular topic/issue; readers may learn more about and access these key sources through the literature review.

SECTION 2

Seaport Development and Investment

2.1 Key Issues and Questions

This section frames the development of a seaport(s) that would serve as a logistics, manufacturing, and training hub for offshore wind development. A study is presently being conducted by the California State Lands Commission (SLC) to plan seaport development, and in lieu of this information, this Assessment reviews the role and types of offshore wind port activities; potential site screening and selection criteria for proposed seaport improvements; and the potential range of potential investment (cost) for upgrading an existing seaport to support offshore wind development. The key issues and questions discussed in this section are:

- Where are the potential seaport locations?
- What are the screening and siting criteria for site selection?
- What is the potential development scenario for the purposes of this Assessment?
- What is the range of investment (cost) to develop, assemble, and operate/maintain the prospective seaport?

Section 25991.3(A) and Section 25991.3(B)(1): Basis for Seaport Assessment

Based on the sea spaces identified pursuant to Section 25991.2, the commission, in coordination with relevant state and local agencies, shall develop a plan to improve waterfront facilities that could support a range of floating offshore wind energy development activities, including construction and staging of foundations, manufacturing of components, final assembly, and long term operations and maintenance facilities.

A detailed assessment of the necessary investments in California seaports to support offshore wind energy activities, including construction, assembly, and operations and maintenance. The assessment shall consider the potential availability of land and water acreage at each seaport, including competing and current uses, infrastructure feasibility, access to deep water, bridge height restrictions, and potentially impacted natural and cultural resources, including coastal resources, fisheries, and Native American and Indigenous peoples.

2.2 The Role of Ports in Offshore Wind Development

Ports play a critical role in offshore wind development, serving as hubs for manufacturing, logistics, training, construction, and transportation. Ports on the East Coast are being developed specifically for offshore wind development, with most improvements being funded by public-private partnerships, recognizing that port improvements are a critical first step in developing offshore wind facilities. Offshore wind ports are instrumental in the manufacturing and fabrication of facility components and parts, staging or marshalling of components before they are taken offshore for construction, and for logistics focused on the operation and maintenance of the offshore wind farm.[3] The alternative to not developing a local/regional port for offshore wind is to import components and parts from across the world (primarily China and Europe), which can add substantial transportation cost (and thus a higher levelized cost of electricity - LCOE) to a long-term offshore

---

[3] New York State Energy Research and Development Authority (NYSERDA). 2022. New York Offshore Wind Workforce Gap Analysis. Available online at: https://www-nyserda-ny-gov.webpkgcache.com/doc/-/s/www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/Offshore-Wind/New-York-State-Workforce-Gap-Analysis-2022.pdf

wind development. It is more cost effective and sustainable to improve or develop a local/regional port(s) where a supply chain and workforce can take root and grow with offshore wind development.

These ports require a specific set of siting and development criteria, including, for example, an expansive (re)development area, soil density to withstand the extreme weight of the wind energy components (i.e., floating bases/foundations), accessible workforce, connectivity to other modes of transportation, and scalable to meet changes in turbine technology. The following list provides a quick overview of the characteristics that an offshore wind port may consider:

- *Staging*: Physical size of the port's quayside and surrounding areas (uplands).
- *Wharf & Frontage*: Length of the berth where the vessels can come in and out of port.
- *Load Capacity*: The among of weight port areas can withstand.
- *Navigable Depth*: The water depth of the vessels coming in and out of port.
- *Air Draft*: The vertical clearance of vessels and the cargo they hold.
- *Geographic Location*: Relative proximity to development area with connectivity to modes of transportation.

Most existing ports do not meet all these criteria and offshore wind developments have been relying on multiple ports as a solution. Under a multiple port strategy, activities at various ports would be focused and dependent on each port's specific characteristics and role in offshore wind development. The various types of offshore wind activities that occur at ports are discussed in the sections below and highlight the key role that ports play in offshore wind development.

2.2.1 Types of Offshore Wind Port Activities

2.2.1.1 Manufacturing & Fabrication

The supply chain plays a critical role in facilitating offshore wind development and reducing the cost of offshore wind energy (e.g., Lcoe) over time. Specifically, manufacturing and fabrication facilities are instrumental for building energy components. Developing these components at or in close proximity to a port for construction staging serves as an efficiency and logistics measure, allowing for minimal transportation activity and costs. Supply chain facilities may include major manufacturing, engineering, and construction machinery for the development of turbines, blades, towers, nacelles, foundations, monopiles, and electrical equipment and cables. These facilities typically entail large-scale industrial welding that requires expansive covered workspace. Therefore, while supply chain activities located at ports play a critical role in supporting offshore wind energy development, these manufacturing and fabrication facilities require large lay-down areas that can bear the weight of enormous components. Locating these types of facilities at/near ports helps lower the cost of offshore wind development over time and can provide hundreds of good-paying jobs to the local/regional economy.

2.2.1.2 Staging

The newest nacelles (GE Haliade-X) weigh 600 tons and will be attached to an 850-foot mast, a veritable floating tower in the ocean. For reference, the Eifel Tower is 978 feet tall. Ports require large open areas to store and transport the components that comprise the wind energy facilities, but also need to plan/scale for additional space to account for advancements in technology that may result in larger towers and nacelles. Monopiles range in size, with the larger being 33-feet in diameter, 500-feet long, and weighing up to 2,000 tons. Electrical cables range from medium voltage AC cables that connect the turbine to the substation to high voltage AC and DC cables that connect the substation to their inner connection point on shore. Splicing cables at sea is not ideal and requires the cables to be manufactured in long lengths and stored on carousels that can weigh thousands of tons. Ports provide the space and capability to accommodate the necessary wind energy components, serving as a staging ground for the next step of at-sea construction.

2.2.1.3 Logistics & Transport

Ports serve as the exit point for all offshore wind energy equipment, components, and construction personnel. In particular, staging ports are key for final assembly, storage, and staging prior to marine tow to final development locations. Staging ports can consist of wide dry-docks for assembly, heavy-lift and support cranes, and air-draft with no restrictions. These ports facilitate preparation of key components, construction of key parts, and loading onto installation vessels then taken offshore.

Ports can serve as logistics hubs, a collection point for all the required components and parts, from the smallest facet to an 850-foot mast. Having the wind energy and electrical parts in a central location allows for the efficient dispatch and construction of offshore wind facilities. Ports that are connected to major transportation resources, such as rail lines and highways, are particularly well-positioned to serve as a logistics hub. In addition to needing large laydown/staging grounds, these ports require long and deep quayside loading docks so that components can be routinely transported from the staging grounds to construction vessels.

2.2.1.4 Operations and Maintenance

Operations and maintenance (O&M) activities include routine inspection and upkeep of the installed offshore energy facilities, including electrical transmission facilities and cabling. Ports provide a base of operations for O&M technicians, safety crews, and service providers, whereas O&M activities are long-term through the life of the installed facilities (upwards of 25+ years). These port areas are ideally near the project areas and while not to the level of manufacturing, these port areas need their own space considerations to accommodate open and covered staging areas for spare parts, vessel mooring, office space, and housing for staff.

2.2.1.5 Training

As no floating offshore wind facilities are presently in place off California's coast, training and developing this new workforce plays a critical role in integrating quality and safety of developing offshore wind facilities and this training is likely to take place at ports. Ports offer the opportunity for workers to train on the actual equipment and components they will be constructing. Port training centers can address a wide array of trades, skills, and career types, spanning manufacturing and supply chain to construction of turbines in a marine environment. Locating these training centers at ports allows for on-the-job training and the integration of workforce standards from the beginning of a worker's career. Training facilities may include on-water construction demonstrations, classrooms, and hands-on assembly areas.

2.3 Potential Seaport Locations

2.3.1 Representative Screening and Selection Criteria

Developing a seaport that provides quayside manufacturing, transport, and logistics/storage is a critical element of facilitating offshore wind development in California. Numerous factors, or screening criteria, must be considered when siting the seaport and the National Renewable Energy Laboratory (NREL), US Bureau of Ocean Energy Management (BOEM), the Schatz Energy Research Center, and the California State Lands Commission (SLC) have performed seaport screening and siting analyses. Representative screening criteria may include:

- Land ownership and/or lease of proposed locations
- Location and size of shore length

- Current uses and surrounding uses
- Availability of adequate air draft height
- Availability of adequate channel draft depth
- Availability of upland acreage with appropriate weight capacities
- Availability of existing waterfront infrastructure (quayside/load-bearing capacity)
- Adequacy of navigation channels, water depth, air clearance, and other logistics considerations
- Engineering considerations/constraints
- Skilled labor availability and/or local training and apprenticeship interest
- Surrounding ocean conditions
- Accessibility to roads, rail, and existing utilities
- Potential permitting challenges associated with sensitive environmental resources contamination, or other regulatory issues
- Regulatory Constraints – FAA; US Coast Guard designated shipping lanes
- Known or likely level of interest of facility in participating OSW infrastructure and/or necessary changes.

Key Studies and Sources for Seaport Site Selection/Screening and Investment/Development Costs

- Moffat and Nichol. July 1, 2021. Humboldt Bay Harbor, Recreation, and Conservation District (Meeting Packet) Preliminary Cost Estimates for Conceptual Master Plan for Development of a New Multipurpose Terminal to Support the Emerging West Coast Offshore Wind Industry.
- Schatz Energy Research Center. 2020. California North Coast Offshore Wind Studies Port Infrastructure Assessment Report.
- Garrad Hassan. March 2014. Assessment of Ports for Offshore Wind Development in the United States.
- BOEM. Determining the Infrastructure Needs to Support Offshore Floating wind and Marine Hydrokinetic Facilities on the Pacific West Coast and Hawaii.
- Mott MacDonald. December 15, 2022. Central Coast Emerging Industries Waterfront Siting and Infrastructure Study.

2.3.2 Seaport Development Scenario

In lieu of the SLC's findings, this Assessment performs an analysis of upgrading the Humboldt Marine Terminal (HMT). In 2021, the State of California issued a $10.5 million grant to the HMT for initial planning and improvements for offshore wind facilities, with another $45m proposed for 2022-2023 to further prepare quayside facilities.[4,5] With investment starting to flow to the HMT, this Assessment considers the development of HMT as a highly probable scenario. It is recognized that a multi-port strategy may be recommended and implemented but to prepare a conservative analysis of potential beneficial economic impacts from seaport development (see Section 7 below), this Assessment focuses on the likely build out of the HMT.

As discussed in Section 5.4, this Assessment recommends the development of a hands-on training facility, pursuant to the question posed by AB 525 Section 25991.3(B)(2), what is the "need for the California Division of Apprenticeship Standards to develop curriculum for in-person classroom and laboratory advanced safety training for workers?" With the intent to create a hub for offshore wind development, this Assessment includes $20 million spent over a two-year period to develop a state-of-the-art training facility for workforce development (see Section 5.4).[6]

[4] California Energy Commission (CEC). March 9, 2022. State Approves $10.5 Million to Prepare the Port of Humboldt Bay for Offshore Wind. Available online at: https://www.energy.ca.gov/news/2022-03/state-approves-105-million-prepare-port-humboldt-bay-offshore-wind

[5] Davidson, R. January 14, 2022. California Targets Port Investments for Offshore Wind. Wind Power Monthly. Available online at: https://www.windpowermonthly.com/article/1737526/california-targets-port-investments-offshore-wind

[6] NYSERDA. October 20, 2022. Governor Hochul and Suffolk County Executive Bellone Announce Land Transfer to Bring National Offshore Wind Training Center to Suffolk County and Train New Yorkers for Green Jobs. Available online at: https://www.governor.ny.gov/news/governor-hochul-and-suffolk-county-executive-bellone-announce-land-transfer-bring-national

Offshore Wind Seaport Development and Public Investment   Case Studies and Key Examples

The following excerpts review the role of public investment in recent offshore wind seaport upgrades/development across the U.S. East Coast and abroad. These case studies offer direct insight into the level of investment and economic activity generated by seaport development. These port developments will likely be of similar scale to installing a seaport on California's coast, and as discussed below, the majority of investment flows into establishing supply chain hubs in addition to improving port operating depths (dredging) and quayside facilities/capabilities.

Virginia   Port of Virginia, Portsmouth Marine Terminal

In August 2021, the Port of Virginia agreed to lease the Portsmouth marine Terminal to Dominion Energy to support the development of 2.6 GW; currently the largest offshore wind project in the US and is undergoing federal environmental review (NEPA) and permitting. Pursuant to the agreement, Dominion will develop 72 acres for deep water multi use, including as a staging and pre assembly area for foundations and turbines. In December 2021, the Port of Virginia secured a $20 million grant from the US Department of Transportation (DOT) for upgrades to the Portsmouth Marine Terminal that will support offshore wind development (Buljan 2022).

New York   New York Harbor, Long Island Terminal, and the Hudson River

The state of New York has allocated $200 million for offshore wind port infrastructure and supply chain assets, providing security to strengthen private investment and maximize long term economic benefits throughout the State. As noted in the map to the side, it is not only the Port that is targeted for this funding, with supply chain facilities being developed along the Hudson River all the way up to Albany, NY, on more than 100 miles of riverfront (NYSERDA 2020). This example offers a successful strategy for capturing the economic benefits inherent to the offshore wind supply chain across a region/state   logistics, manufacturing, assembly, fabrication, and training.

New Jersey   New Jersey Wind Port

New Jersey has allocated over $500 million in public funding to develop the New Jersey Wind Port (NJWP), which will be the first purpose built offshore wind marshalling and manufacturing port in the U.S. (BOEM 2022). New Jersey has a goal of installing 7.5 GW by 2035 and the NJWP will serve a critical role in achieving this goal, while also providing funding focused on "…overburdened communities, funding workforce development programs, providing grants for minority and/or woman owned business enterprises that want to become engaged in the offshore wind industry, and participating in civic and business organizations, such as Boys and Girls Clubs and chambers of commerce.   (BOEM 2022). While most offshore wind ports were redeveloped from an existing port, NJWP offers an example of building a port specifically for offshore wind development from the ground up.

Denmark   Port of Esbjerg

Port of Esbjerg plays a critical role in Europe s OSW industry, with components for nearly 80% of all offshore wind installed capacity passing through the Port. In 2019 alone, more than 1.5 GW of offshore wind components were shipping through the Port of Esbjerg. Infranode recently came to agreement with the Port to invest $145 million to support offshore wind development in Europe, which is expected to increase nearly five fold with up to 100 GW proposed for the North Sea by 2030. The majority of the investment will be focused on improving Port supply chain elements, including facilities for logistics, storage, assembly, and manufacturing. Per the Port,   The investment is expected to create as many as 2,000 new jobs…Investments will be made available gradually as manufacturers of wind turbine components and offshore wind service providers expand their businesses in the rapidly growing wind turbine industry,   Port Esbjerg said (Offshore Engineer 2020).

Sources: Buljan, A. August 16, 2022. *USD 223 Million Worth Construction Works Start at Portsmouth Marine Terminal*. Available online at: https://www.offshorewind.biz/2022/08/16/usd-223-million-worth-construction-works-start-at-portsmouth-marine-terminal/

New York State Energy DA. 2020. Port Infrastructure; Potential Port Facilities for Offshore Wind Activities; $200 Million of Public Investments into Ports. Available online at: https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/Supply-Chain-Economic-Development/Port-Infrastructure

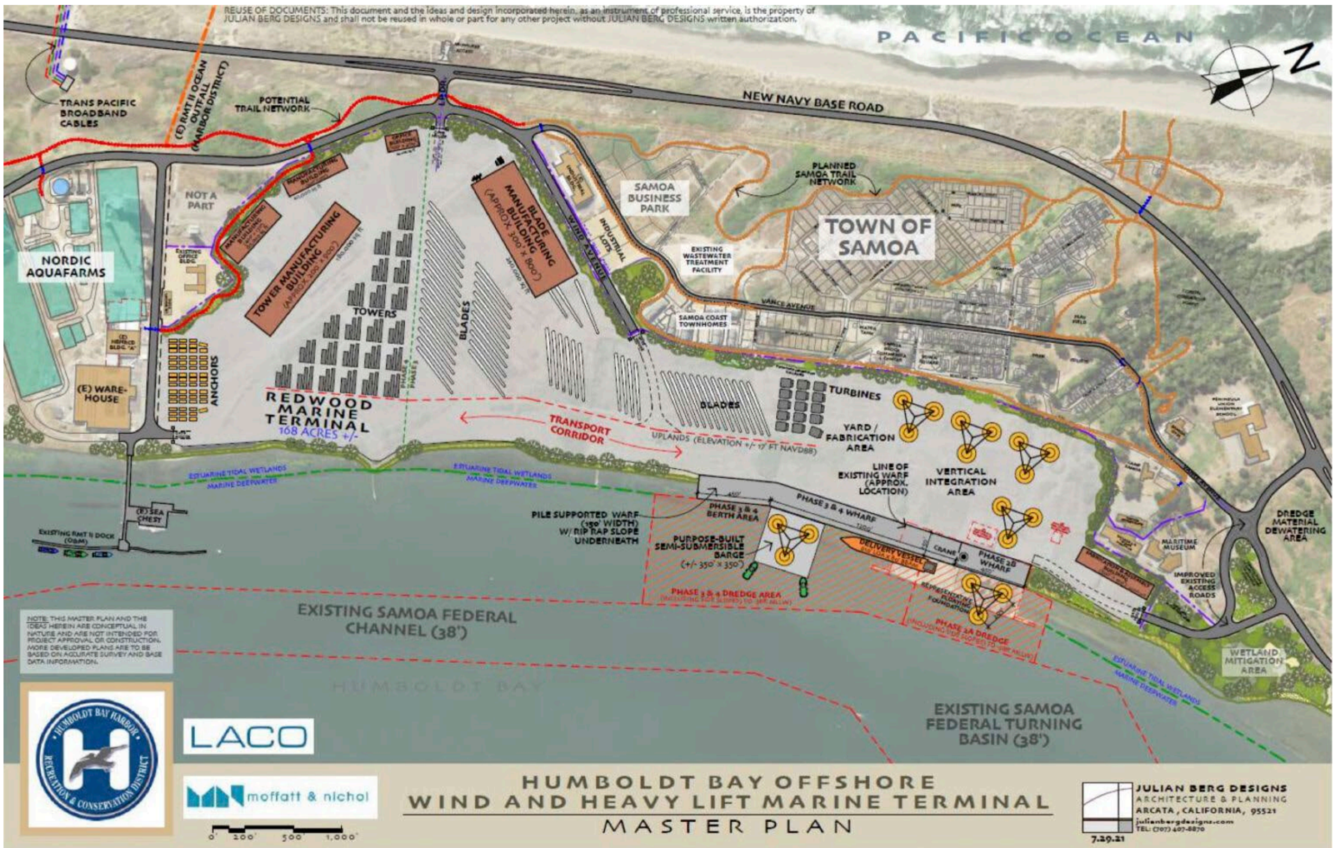
Offshore Engineer. May 14, 2020. *Infranode to Invest Up to $145M in Port Esbjerg's Offshore Wind Facilities*. Available online at: https://www.oedigital.com/news/478478-infranode-to-invest-up-to-145m-in-port-esbjerg-s-offshore-wind-facilities

US Bureau of Ocean Energy Management (BOEM). 2020. A Shared Vision on the Development of an Offshore Wind Supply Chain. Available online at: https://www.boem.gov/renewable-energy/state-activities/boem-ny-nj-shared-vision

2.4 Seaport Construction Cost

This Assessment relies on a construction cost estimate developed by Moffatt and Nichol to upgrade the HMT to serve as a floating offshore wind hub. Moffatt and Nichol estimated that the cost to upgrade HMT would be approximately $125m, as broken down in the preliminary master plan (Figure 2-1) and cost estimate (Table 2-1).[7] It is worth noting that the Shatz Energy Research Center (SERC) estimates that $130m-$310m would be required to develop a large commercial OSW seaport.[8] However, to prepare a conservative analysis of potential beneficial economic impacts (Section 7), this Assessment utilizes the Moffat and Nichol estimate as a reflection of a specific plan to upgrade HMT.

Figure 2-1: Draft Master Plan for Humboldt Port



Source: Moffat and Nichol. July 1, 2021. Humboldt Bay Harbor, Recreation, and Conservation District (Meeting Packet) - Preliminary Cost Estimates for Conceptual Master Plan for Development of a New Multipurpose Terminal to Support the Emerging West Coast Offshore Wind Industry. Available online at: http://humboldtbay.org/sites/humboldtbay2.org/files/Adopted%20Minutes%2007.01.2021_SIGNED.pdf

[7] Moffat and Nichol. July 1, 2021. Humboldt Bay Harbor, Recreation, and Conservation District (Meeting Packet) - Preliminary Cost Estimates for Conceptual Master Plan for Development of a New Multipurpose Terminal to Support the Emerging West Coast Offshore Wind Industry. Available online at: http://humboldtbay.org/sites/humboldtbay2.org/files/Adopted%20Minutes%2007.01.2021_SIGNED.pdf

[8] Schatz Energy Research Center. 2020. California North Coast Offshore Wind Studies – Port Infrastructure Assessment Report.

Table 2-1: Cost Breakdown of Humboldt Port Improvements

Facility	Description	Subtotal	Total
Contractor Mobilization & Demobilization	Construction Mobilization	$3,802,000	$4,952,000
	Hydraulic Dredge Mobilization	$800,000	
	Mechanical Dredge Mobilization	$350,000	
Wharf	Demolition of Existing Structure	$10,499,500	$40,660,400
	Steel Sheet Pile Bulkhead w/ King Piles	$3,480,800	
	Pile-Supported Wharf (Steel Piles, Concrete Superstructure)	$16,380,000	
	Concrete Fill for Wharf Piles (Seismic)	$1,201,700	
	Relieving Platform (Steel Piles, Concrete Superstructure)	$4,341,600	
	Concrete Fill for Relieving Platform Piles (Seismic)	$667,600	
	Installation of Dense Graded Aggregate Topping Surface	$412,500	
	Shoreline Grading at Relieving Platform (From Upland Cut)	$64,200	
	Rip Rap Slope Beneath Wharf	$3,612,500	
Earth Fill and Dredge	Mechanical Dredge in Berth Area	$5,246,500	$7,351,800
	Hydraulic Dredge in Berth Area	$788,300	
	Mechanical Dredge in Semi-Sub Barge Area	$1,036200	
	Hydraulic Dredge in Semi-Sub Barge Area	$2,600	
	Soil Cut from Uplands	$200,800	
	Stockpile of Soil	$77,400	
Upland	Grading and Compaction of Uplands Soils	$752,800	$8,809,800
	Installation of Dense Graded Aggregate Topping Surface	$3,194,500	
	Site Stormwater system	$1,800,000	
	Site Water system	$360,000	
	Site Electrical system	$1,800,000	
	Access Road	$902,500	
Mooring Dolphins	Mooring Dolphins for Vessel	$2,411,900	$6,029,800
	Mooring Dolphins for Semi-submersible Barge	$3,617,900	
Remediation	Environmental Mitigation	$500,000	$500,000
Construction Indirect Costs	Supervision (General Conditions)	$8,196,500	$21,431,200
	Bonds & Insurance	$1,530,100	
	Corporate Overhead & Profit	$11,704,600	
Contingency	Design Contingency	$13,460,300	$26,920,600
	Owner Contingency	$4,486,800	
	Construction Contingency	$8,973,500	
Soft Costs	Planning Studies	$341,600	$7,855,200
	Field Investigations	$683,100	
	Environmental & Permitting	$2,049,200	
	Engineering Design	$3,073,700	
	Construction Management/Support	$1,707,600	
		TOTAL	**$124,510,800**

Source: Moffat and Nichol. July 1, 2021. Humboldt Bay Harbor, Recreation, and Conservation District (Meeting Packet) - Preliminary Cost Estimates for Conceptual Master Plan for Development of a New Multipurpose Terminal to Support the Emerging West Coast Offshore Wind Industry. Available online at: http://humboldtbay.org/sites/humboldtbay2.org/files/Adopted%20Minutes%2007.01.2021_SIGNED.pdf

SECTION 3

Workforce Development Needs

3.1 Key Issues and Questions

This section focuses on the needs for developing a workforce capable of meeting CEC's 2030 and 2045 installed capacity goals, specifically focusing on:

- How many workers/jobs will be required to develop the workforce that can meet the demands of the 2030 (2-5 GW) and 2045 (25 GW) goals?
- What is the proportion of jobs for the supply chain, construction, and operations/maintenance phases?
- What types of skills and occupations are needed for the OSW workforce?
- What is the existing occupational workforce supply?
- What workforce elements are missing or limiting development (workforce gaps analysis)?

Section 25991.3(B)(2): Basis for Workforce Needs Assessment

An analysis of the workforce development needs of the California offshore wind energy industry, including occupational safety requirements, the need to require the use of a skilled and trained workforce to perform all work, and the need for the Division of Apprenticeship Standards to develop curriculum for in person classroom and laboratory advanced safety training for workers.

3.2 2030 and 2045 Generation Goals and Installed Capacity Scenario

In August 2022, CEC released its preliminary planning goals for offshore wind energy generation, establishing a 2030 goal of 2,000 MW to 5,000 MW (2 GW to 5 GW) and a 2045 goal of 25,000 MW (25 GW) (CEC 2022). This Assessment relies on these goals as benchmarks to estimate workforce needs (i.e., number and type of jobs needed for the CA offshore wind workforce). The CEC goals reflect a maximum build out scenario of the Wind Energy Areas (WEAs or Call Areas) identified by NREL/BOEM (Figure 3-1).[9] It is acknowledged by CEC and Governor Newsome that these goals reflect the upper bound of OSW development in California and are inherently "aspirational". As stated by CEC, "These preliminary planning goals are designed to be potentially achievable but aspirational and are established at levels that can contribute significantly to achieving California's climate goals."[10]

For the 2030 goal, the upper bound (5 GW) assumes the full build-out of the Morro Bay Wind Energy Area (WEA) or a combination of a partial build-out of the Morro Bay WEA and Humboldt WEA (Figure 3-1). The lower bound (2 GW) reflects an understanding that achieving a 2030 online date for any proposed offshore wind project will take a significant mobilization of effort and resources, and timely infrastructure investments,

[9] NREL/BOEM. April 2016. "Floating Offshore Wind in California: Gross Potential for Jobs and Economic Impacts from Two Future Scenarios." Available online at: https://www.nrel.gov/docs/fy16osti/65352.pdf

[10] California Energy Commission (CEC). August 2022. Offshore Wind Energy Development Off the California Coast – Maximum Feasible Capacity and Megawatt Planning Goals for 2030 and 2045. Available online at: https://www.energy.ca.gov/filebrowser/download/4361

among other factors.[11] A fast start to OSW development would likely be needed to achieve the 2045 goal of 25 GW, therefore this Assessment assumes that 5 GW by 2035 is more representative of the development pattern needed to near the 2045 goal of 25 GW.

The 2045 goal reflects the maximum installed capacity of the Humboldt WEA, Morro Bay WEA, Diablo Canyon call area, and two additional areas with high wind speeds in northern California.[12] BOEM modeled this scenario and derived a technical feasible generation capacity of up to 21.8 GW of potential capacity. CEC relied on this 21.8 GW estimate as a reference metric in establishing the 2045 goal and recognizes that "the information available supports the feasibility of at least 20 GW by 2045."[13,14,15]

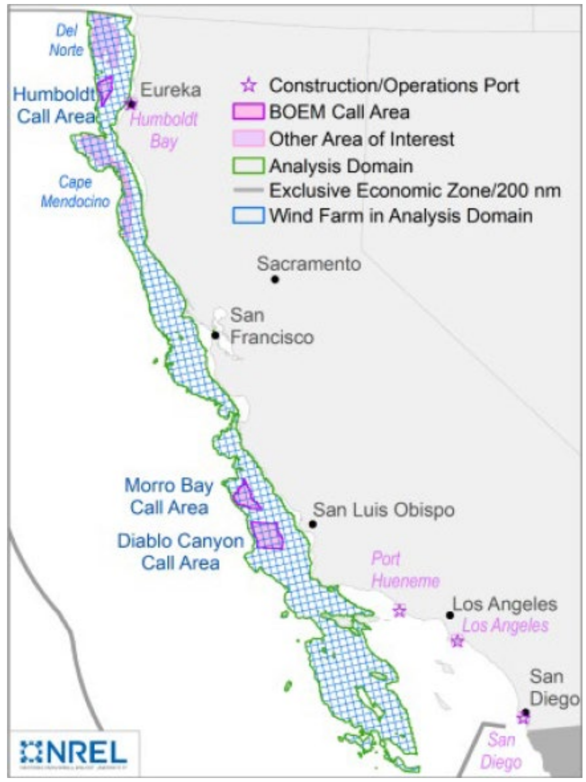


Figure 3-1: Call Areas and NREL Study Area

A maximum installed capacity scenario has been modeled by three prior economic analysis of OSW workforce needs/impacts. This Assessment relies on the following economic studies to assess the type and number of jobs necessary for the creation of an OSW workforce:

- NREL/BOEM. April 2016. "Floating Offshore Wind in California: Gross Potential for Jobs and Economic Impacts from Two Future Scenarios."
- American Jobs Project. February 2019. "The California Offshore Wind Project: A Vision for Industry Growth"; BVG/American Jobs Project. January 2019. "CA Jobs Modeling Methodology."
- Guidehouse. May 2022. "California Supply Chain Needs Summary." California Energy Commission.

Figure 3-2 provides the conceptual OSW development patterns (i.e., installed capacity through 2045/2050) of the CEC 2030/2045 goals and the NREL/BOEM, AJP/BGV, and Guidehouse studies. As discussed in the following section, these patterns serve as the basis for assessment for workforce development, workforce standards, supply chain, and seaport development.

---

[11] *Ibid.*

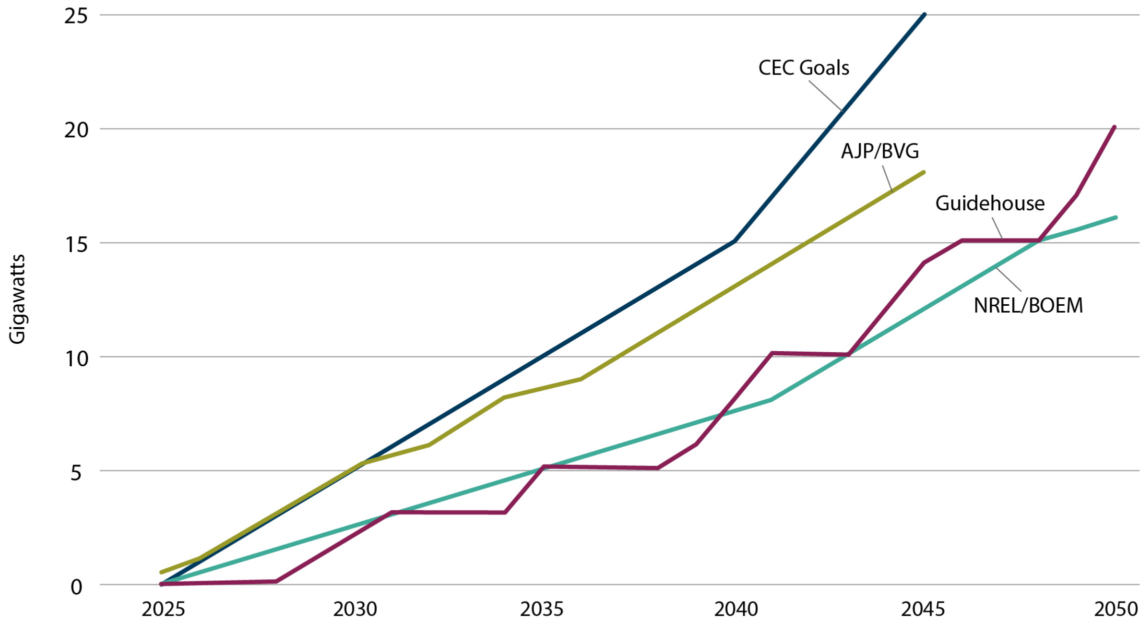
[12] California Energy Commission (CEC). August 2022. Offshore Wind Energy Development Off the California Coast – Maximum Feasible Capacity and Megawatt Planning Goals for 2030 and 2045.

[13] BOEM. July 2021. Area ID Memorandum: Humboldt Wind Energy Area. Available online at: https://www.boem.gov/sites/default/files/documents//App.%20A%20Area%20ID%20Humboldt%20Memo%20Final.pdf.

[14] California Energy Commission (CEC). August 2022. Offshore Wind Energy Development Off the California Coast – Maximum Feasible Capacity and Megawatt Planning Goals for 2030 and 2045.

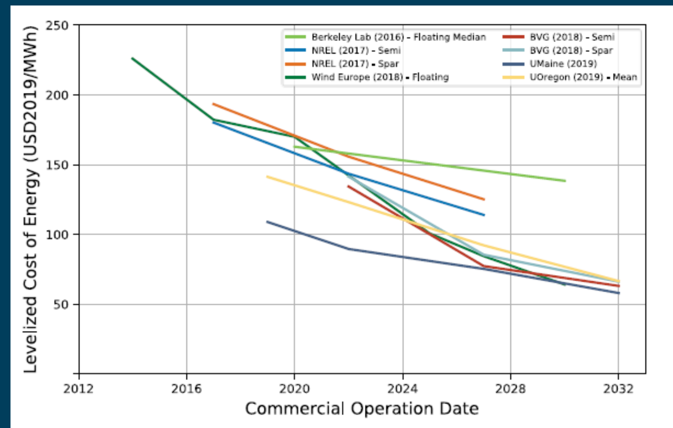
[15] Bureau of Ocean Energy Management. November 2021. Area ID Memorandum: Morro Bay Wind Energy Area. Available online at: https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Area-ID-CA-Morro-Bay.pdf.

Figure 3-2: CEC Goals and Workforce Models' OSW Installed Capacity (GW) Development Patterns (2025 – 2050)

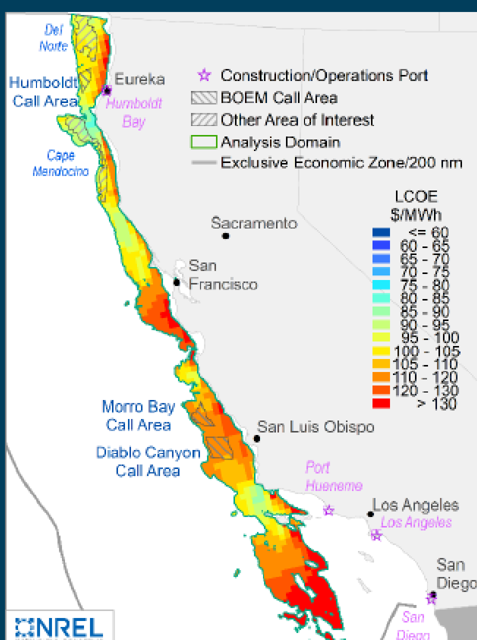


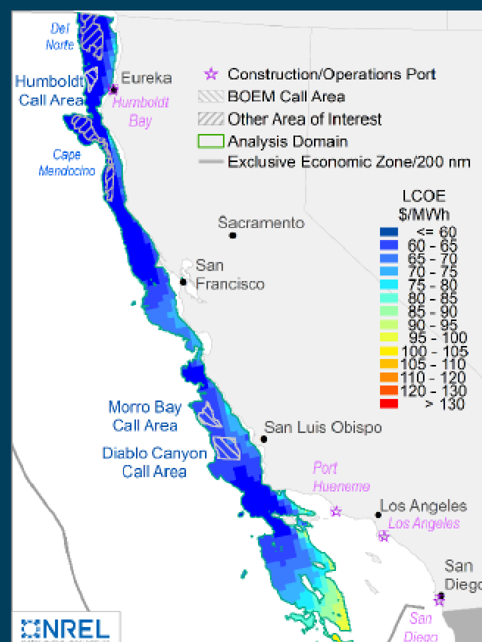
Adopting the Upper Bound: The Levelized Cost of Energy (LCOE) and Technological Advancement for Floating Offshore Wind Projects

A key reason for the adoption of a maximum development scenario (i.e., 2 5 GW by 2030 and 25 GW by 2045) is the forecasted levelized cost of energy (LCOE) over time for floating offshore wind in California. LCOE represents the average revenue per unit of energy generated that would be required to recover the costs of building and operating a generation unit. As provided in the figure to the side, multiple entities have modelled LCOE for floating offshore wind through 2032, including NREL, (AJP), and LBNL. These forecasts indicate a reduction from levels of approximately $110 $175/MWh in 2019 to approximately $60/MWh by 2032, representing an LCOE reduction of more than 50% over the next decade (NREL 2020 The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032).



NREL also modelled the estimated change of LCOE for floating offshore wind in California through 2050. As provided in the figures below, NREL estimates LCOE in 2019 to be $95/MWh $110/MWh and $60/MWh $70/MWh by 2030, representing a 37% reduction in LCOE by 2032.





This significant downward trend in LCOE provides the basis for adopting the upper bound of installed capacity where the pace of floating OSW development increases over time, as provided in the CEC 2030/2045 goals development pattern provided in Figure 3 2 above. This reduction in cost reflects the maturity of the local supply chain and workforce, and subsequently, the reduced costs of the necessary components, equipment, and transportation. Another driver of reducing the LCOE for floating offshore wind is the advancement of wind energy technology, specifically turbines. NREL estimated that turbine generation capacity would achieve 15 MW by 2032, up from 8 MW in 2019.

Sources: Lawrence Berkeley National Laboratory (LBNL). 2018. Estimating the Value of Offshore Wind Along the United States' Eastern Coast. Available online at: https://eta-publications.lbl.gov/sites/default/files/osw_value_es_final.pdf

American Jobs Project (AJP). February 2019. The California Offshore Wind Project: A Vision for Industry Growth. Available online at: http://americanjobsproject.us/wp/wp-content/uploads/2019/02/The-California-Offshore-Wind-Project-Cited-.pdf

National Renewable Energy Laboratory (NREL). November 2020. The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032. Available online at: https://www.nrel.gov/docs/fy22osti/80808.pdf

3.3 Number of Jobs Needed for Floating OSW Workforce

The modeled projections (NREL/BOEM, AJP, and Guidehouse, Section 3.2 above) for the type and number of jobs created for the OSW workforce are used as the basis for analysis in determining workforce needs. While not a direct "apples-to-apples" comparison between the findings due to varying types of economic models (i.e. NREL JEDI, BVG) and modeling assumptions (i.e. pace of OSW development; total installed capacity; technological improvement of turbine generation) and types of quantitative models used (i.e., difference in base algorithms used in calculations), the results of these models provide a bounding-level framework that serves as a suitable representation of the potential range of workforce needs (i.e., number of jobs and types of occupations). Table 3-1 provides a breakdown of the modeled results for the number of jobs needed for the key phases of OSW development (supply chain/manufacturing, construction, operations/maintenance). The models and their results are provided in the following sections.

Each of the models analyzed a range of scenarios that considered varying levels of installed capacity (in GWs). The figures provided in Table 3-1 represent the results from the upper bound scenario (highest levels of installed capacity) for each model. While none of the models considered a development scenario of 25 GW by 2045, as observed in Figure 3-2 above, these figures reflect the most optimistic development scenario of each model and provide a suitable representation of workforce needs. As provided in the table below, the NREL/BOEM forecast generally serves as the upper bound of projected number of jobs needed for the OSW workforce.

Table 3-1: Bounding Estimates for Jobs Needed for Workforce Development for 2030 and 2045

Source/Model	2030				2045			
	Supply Chain	Const.	O&M	Total Jobs	Supply Chain	Const.	O&M	Total Jobs
American Jobs Project [1]	2,100 [2]	350	1,200	3,650	9,000 [3]	1,400	2,600	13,000
NREL/BOEM	5,490	1,130	1,660 [4]	8,280	11,280	2,340	4,330 [5]	17,950
Guidehouse	1,936	125	314	2,375	3,382	173	1,508	5,063
TOTAL RANGE	**1,936 – 5,490**	**125 – 1,130**	**314 – 1,660**	**2,375 – 8,280**	**3,382 – 11,280**	**173 – 2,340**	**1,508 – 4,330**	**5,063 – 17,950**

Notes:

1 Figures provided in table are estimates derived from charts provided in report and are approximations. Figures provided for 2030 reflect a 5 GW development scenario for 2045 where forecasted jobs have been brought forward to 2030 for this bounding assessment. Figures provided for 2045 reflect an 18 GW build out by 2045.

2 Sum or approximately 850 direct manufacturing jobs and 1250 indirect manufacturing jobs.

3 Sum or approximately 3,700 direct manufacturing jobs and 5,300 indirect manufacturing jobs.

4 Includes 1,130 supply chain jobs and 530 on-site jobs.

5 Includes 3,060 supply chain jobs and 1,270 on-site jobs.

Sources:

American Jobs Project (AJP). February 2019. The California Offshore Wind Project: A Vision for Industry Growth.

NREL/BOEM. April 2016. "Floating Offshore Wind in California: Gross Potential for Jobs and Economic Impacts from Two Future Scenarios."

Guidehouse. May 2022. "California Supply Chain Needs Summary." California Energy Commission.

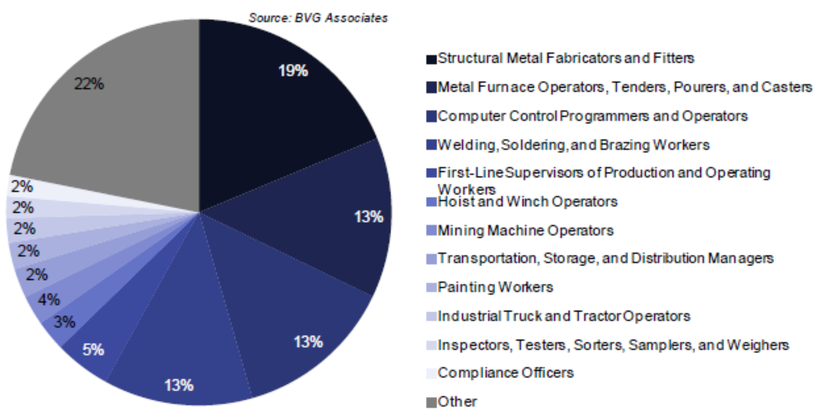
Key Studies and Sources for Assessing Workforce Development Needs

- NREL/BOEM. April 2016. Floating Offshore Wind in California: Gross Potential for Jobs and Economic Impacts from Two Future Scenarios."
- American Jobs Project (BVG Associates). February 2019. The California Offshore Wind Project: A Vision for Industry Growth .
- Guidehouse. May 2022. California Supply Chain Needs Summary. California Energy Commission.
- BVG Associates. 2017. U.S. Job Creation in Offshore Wind.
- U.C. Berkeley Labor Center. September 2019. California Offshore Wind: Workforce Impact and Grid Integration.
- NREL. October 2022. U.S. Offshore Wind Workforce Assessment.

3.4 Distribution of Workforce Occupations Per Phase

To identify the distribution, skills, and types of occupations needed for each phase – supply chain, construction, and operations/maintenance – this Assessment relied on the breakdowns provided in the BVG model used in *U.S. Job Creation in Offshore Wind*[16] and the NREL/JEDI model used by Guidehouse[17]. These studies analyzed workforce distribution by wind energy and transmission component (e.g., foundations, cables, transmission, foundations, nacelles, turbines, etc.) for each development phase, which provide the basis for occupational and skills analysis in the following sections. Figure 3-3 provides an example of the occupational breakdown for foundation manufacturing/supply chain prepared by BVG.[18] Although these studies do not offer an apples-to-apples comparison due to different technical methodologies, models, and/or assumptions, they both approach identifying workforce/occupational needs by component/facility to inform the distribution of workforce for supply chain, construction, and operations/maintenance (Table 3-2, Table 3-3, and Table 3-4 below).

Figure 3-3: Example Breakdown of Occupational Types for Foundation Manufacturing/Supply Chain



Source: BVG. 2017. US Job Creation in Offshore Wind.

---

[16] BVG. October 2017. U.S. Job Creation in Offshore Wind – A Report for the Roadmap Project for Multi-State Cooperation on Offshore Wind (Report 17-22). Available online at: https://www.cesa.org/wp-content/uploads/US-job-creation-in-offshore-wind.pdf

[17] Guidehouse. May 2022. California Supply Chain Needs Summary. California Energy Commission. Available online at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=242928&DocumentContentId=76513

[18] BVG. October 2017. U.S. Job Creation in Offshore Wind – A Report for the Roadmap Project for Multi-State Cooperation on Offshore Wind (Report 17-22).

The BVG model provides workforce distribution for OSW on a national scale, providing a broader perspective of the types of occupations needed. While this information is offered for the national scale, the distribution/percentage of workforce by component can be derived and applied to this Assessment. Combined with the state-level Guidehouse analysis, these analyses provide a balanced perspective in identifying the types and number of workers per phase for California's offshore wind workforce.

3.4.1 Manufacturing and Supply Chain

As observed in Table 3-1 above, approximately 2/3rds of the OSW workforce will be in the supply chain and manufacturing sectors. Table 3-2 below provides a breakdown of the number of jobs for each wind energy component, with nacelle and foundation manufacturing generating the most jobs.

Table 3-2: Number of Supply Chain Jobs by Wind Energy and Transmission Component

Component	NREL JEDI % of Workforce	BVG % of Workforce	Average % of Workforce	Number of Supply Chain Jobs (2030)	Number of Supply Chain Jobs (2045)
Ports and Staging	18.0%	N/A	9.0%	174 - 494	304 – 810
Array & Export Cables	11%	19.8%	15.4%	298 – 845	521 – 1,386
Substation	11%	20.4%	15.7%	304 – 862	531 – 1,413
Foundations	19.5%	20.0%	19.8%	383 – 1,087	670 – 1,782
Towers	7.5%	3.2%	5.3%	103 - 291	179 - 477
Blades	12.0%	9.8%	10.9%	211 - 598	369 – 981
Nacelle**	19.5%	26.8%	23.1%	447 – 1,268	781 – 2,079

Source: BVG 2017; Guidehouse 2022; NREL/BOEM 2016.

Notes: * Includes substation development, and onshore and array/export cabling.
** JEDI model assumed that no jobs would be local for array cable and substation supply chain.

3.4.2 Construction

While the OSW construction workforce will need to be highly skilled and trained, it represents the lowest number (approximately 11%) of the overall workforce. Table 3-3 below provides a breakdown of the construction jobs for each wind energy component and, as observed, turbine, array/export cabling, and foundation construction represent the majority of required jobs.

Table 3-3: Number of Construction Jobs by Wind Energy and Transmission Component

Component	NREL JEDI % of Workforce	BVG % of Workforce	Average % of Workforce	Number of Construction Jobs (2030)	Number of Construction Jobs (2045)
Array & Export Cabling	11.2%	46.2%	28.7%	36 - 324	50 – 672
Turbine	52.0%	14.2%	33.1%	41 – 374	57 – 775
Scour Protection	8.0%	N/A	4.0%	5 – 45	7 – 94
Foundation	24.8%	28.9%	26.9%	34 - 304	47 - 629
Other	4.0%	10.7%	7.4%	9 - 84	13 – 173

Source: BVG 2017; Guidehouse 2022; NREL/BOEM 2016.

Notes: * Includes substation development, and onshore and array/export cabling.
** JEDI model assumed that no jobs would be local for array cable and substation supply chain.
*** Includes substation development, and onshore and array/export cabling.

3.4.3 Operations and Maintenance

The NREL JEDI study did not provide information on operations and maintenance and this Assessment relies on the BVG findings based on the national OSW workforce needs. As observed in Table 3-4, the majority of jobs will be concentrated in maintain wind farm operations and turbine maintenance.

Table 3-4: Number of Operations/Maintenance Jobs by Wind Energy and Transmission Component

Component	BGV (National) %	Number of O&M Jobs (2030)	Number of O&M Jobs (2045)
Wind Farm Operations	27.9%	88 - 463	421 – 1208
Turbine Maintenance and Service	64.6%	57 – 299	272 – 780
Foundation Maintenance and Service	2.1%	1 – 6	6 – 16
Subsea Cable Maintenance and Service	3.7%	0 – 1	0 - 1
Substation Maintenance and Service	1.7%	0 - 1	0 - 1

Source: BVG 2017; Guidehouse 2022; NREL/BOEM 2016.

Notes: * Includes substation development, and onshore and array/export cabling.
** JEDI model assumed that no jobs would be local for array cable and substation supply chain.

Key Studies and Sources for Assessing Workforce Occupational Skills Mapping

- American Jobs Project. February 2019. The California Offshore Wind Project: A Vision for Industry Growth".
- BVG Associates. 2017. U.S. Job Creation in Offshore Wind; BVG/American Jobs Project. January 2019. CA Jobs Modelling Methodology.
- National Renewable Energy Laboratory A National Skills Assessment of the U.S. Wind Industry in 2012
- Workforce Development Institute. 2017. New York State and the Jobs of Offshore Wind Energy.

3.5 Occupational Skills Mapping

Occupational skills mapping entails identifying the primary job types and skills for the OSW workforce. Taking a holistic perspective, this workforce will require a diversity of occupational skills, ranging from the assembly line worker building turbines to the welder constructing towers at-sea to the technician servicing turbines at-sea. While a wide range of skills will be required, there is a correlation between the need/demand for specific skill sets and the number of type of jobs needed for the OSW workforce, as discussed in Section 3.4 above. In other words, some job types and skills will be needed more than others.

Table 3-5 provides a breakdown of the types of jobs needed for the supply chain, construction, and operations/maintenance. This table is a synthesis of the results from those prepared by BVG[19], which provides

[19] BVG. October 2017. U.S. Job Creation in Offshore Wind – A Report for the Roadmap Project for Multi-State Cooperation on Offshore Wind (Report 17-22).

a thorough analysis of the job types organized by Bureau of Labor Statistics (BLS) Standard Occupational Codes (SOC). Those occupational types included in bold in the table are those that are needed for all three phases of OSW development.

Table 3-5: Types of Occupations by Development Phase

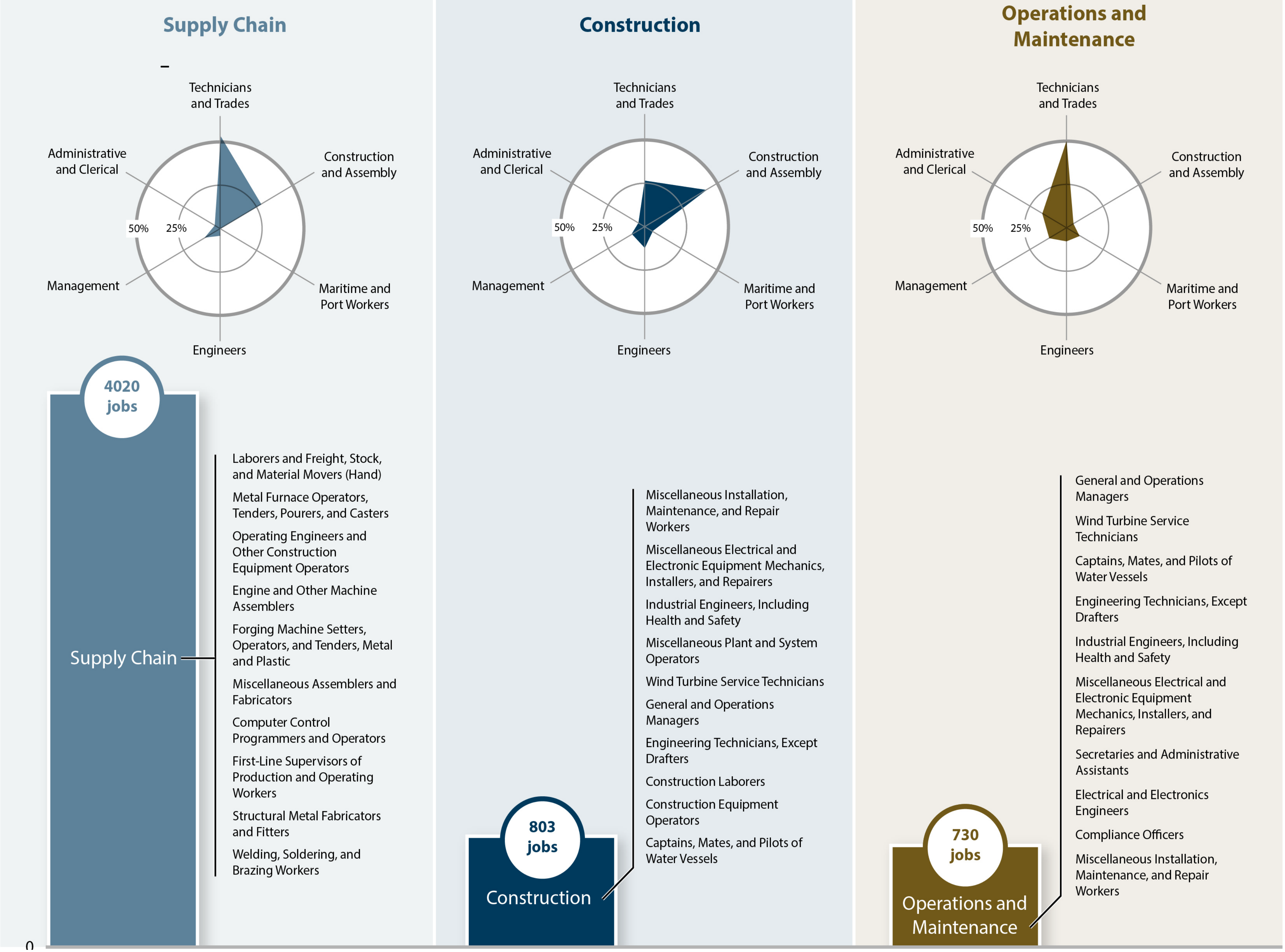
Occupational Group	Occupation	SOC	Supply Chain	Const.	O&M
Administrative and Clerical	Administrative Service Managers	11-3012			•
	Bookkeeping, Accounting, and Auditing Clerks	43-3031	•		
	Compliance Officers	**13-1041**	•	•	•
	Human Resources Workers	13-1071	•		•
	Sales Representatives, Wholesale and Manufacturing	41-4012	•	•	
	Secretaries and Administrative Assistants	**43-6014**	•	•	•
Construction & Assembly	Cement Masons, Concrete Finishers, and Terrazzo Workers	53-5021		•	
	Construction Equipment Operators	47-2073		•	
	Construction Laborers	47-2061		•	
	Crane and Tower Operators	53-7021	•	•	
	Engine and Other Machine Assemblers	51-2031	•		•
	Hoist and Winch Operators	**53-7041**	•	•	•
	Industrial Machinery Installation, Repair, and Maintenance Workers	**49-9041**	•	•	•
	Laborers and Freight, Stock, and Material Movers (Hand)	53-7062	•		
	Mining Machine Operators	47-5041	•		
	Miscellaneous Assemblers and Fabricators	51-2090	•		•
	Misc. Electrical and Electronic Equipment Mechanics, Installers, and Repairers	**49-2093**	•	•	•
	Operating Engineers and Other Construction Equipment Operators	47-2073	•		
	Painting Workers	51-9123	•		
	Reinforcing Iron and Rebar Workers	47-2171		•	•
	Tank Car, Truck, and Ship Loaders	53-7121	•		
	Training and Development Specialists	13-1151		•	•
	Welding, Soldering, and Brazing Workers	51-4122	•		
Engineers	Drafters	17-3011	•		
	Electrical and Electronics Engineers	**17-3023**	•	•	•
	Industrial Engineers, Including Health and Safety	**17-2112**	•	•	•
	Ship Engineers	17-2199		•	•
Management	Computer and Information Systems Managers	11-3021		•	•
	First Line Supervisors of Mechanics, Installers, and Repairers	**49-1011**	•	•	•
	First-Line Supervisors of Production and Operating Workers	**51-1011**	•	•	•
	General and Operations Managers	**11-1021**	•	•	•
	Marketing and Sales Managers	11-2021			•
	Purchasing Managers	**11-3061**		•	•
	Transportation, Storage, and Distribution Managers	11-3071	•		•

Maritime and Port Workers	**Captains, Mates, and Pilots of Water Vessels**	**53-5021**	•	•	•
Technicians and Trades	Chemical Processing Machine Setters, Operators, and Tenders	51-9011	•		
	Computer Control Programmers and Operators	51-9161	•		
	Engineering Technicians, Except Drafters	**17-3029**	•	•	•
	Forging Machine Setters, Operators, and Tenders, Metal and Plastic	51-4022	•		
	Industrial Truck and Tractor Operators	53-7051	•		
	Inspectors, Testers, Sorters, Samplers, and Weighers	51-9061	•		
	Metal Furnace Operators, Tenders, Pourers, and Casters	51-4051	•		•
	Miscellaneous Metal Workers and Plastic Workers	51-4199	•		
	Miscellaneous Plant and System Operators	**51-8090**	•	•	•
	Structural Iron and Steel Workers	47-2221		•	
	Structural Metal Fabricators and Fitters	**51-2041**	•	•	•
	Surveying and Mapping Technicians	17-3031		•	
	Wind Turbine Service Technicians	49-9081		•	•

Source: BVG. 2017. US Job Creation in Offshore Wind.

As provided in Table 3-5 above, to visualize and organize the dozens of job types needed for California's floating offshore workforce, this Assessment grouped job types into six categories – Technicians and Trades; Construction and Assembly; Maritime and Port Workers; Engineers; Management; and Administrative and Clerical. Figure 3-4 below is the compilation of the needed skill groups from the three phases – supply chain, construction, and operations/maintenance – which have their own skills radar graphic. As observed, the majority of skills needed for the (2030) workforce are in the trades, technician, and construction sectors. This finding correlates with the information provided in Section 3.3 above that identifies supply chain and manufacturing with the majority of jobs needed for the OSW workforce (i.e., upwards of 65% of total workforce is in supply chain and manufacturing).

Figure 3-4: Workforce Infographic by Job Type/Sector (2030)

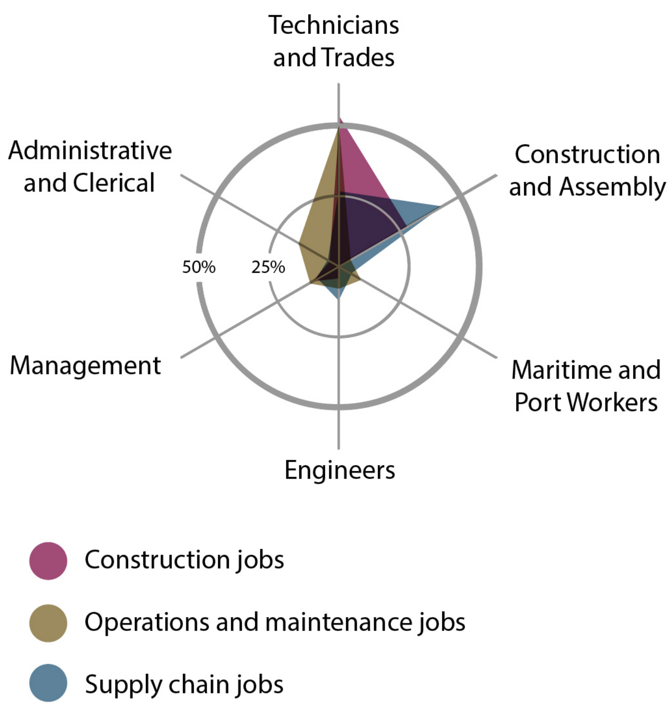


Given the draft goals released by CEC to generate 2-5 GW by 2030 and 25 GW by 2045, the potential economic benefits of creating a new and sizable workforce will be systemic and extensive, as demonstrated by the establishment and growth of the fixed bottom offshore wind industry on the East Coast. The majority of economic benefits from offshore wind workforce development will be in the good-paying jobs created in the manufacturing and supply chain sectors. These jobs will be realized across the state, as the offshore wind supply chain matures and businesses acquire materials, services, and parts from across California, comprised of long-lasting (30+ years) and be good-paying jobs in the trades and technical skills that do not require a bachelor's degree.

The majority of this new workforce will require a form of post-secondary education, training, and/or certification (Section 5.2.3). Since floating offshore wind will be a new industry in California, there will need to be new training standards, curriculums, and facilities to create a trained and skilled offshore wind workforce that can safely scale with the pace of floating offshore wind development (see Section 5 – Workforce Standards, Occupational Safety Requirements, and Training Needs Assessment). Developing a competent and skilled workforce can attract private investors that seek a capable and reliable workforce. States on the East Coast have invested in training centers that can consistently produce workers with the appropriate skill sets in supply chain production and offshore wind construction.

A wide range of skillsets and occupational types will be required for the offshore wind workforce. Figure 3-5 below is the compilation of the skills radar graphics included in Figure 3-4 above to visualize the types of occupations needed for the OSW workforce (by percentage of overall workforce). As observed, the trades/technicians will be the largest workforce type.

Figure 3-5: Radar Graphs of Workforce Skills by Job Sector (By Percentage of Overall Workforce)



Case Study Review: New York's Offshore Wind Workforce

To gleam insights from a real world example, this Assessment reviewed the type and distribution of occupations produced by New York's offshore wind industry. A quality about the BW/NYSERDA study is that it was developed on market based data and findings, as opposed to the BVG analysis which is a modelled forecast. To offer the basis for comparison to the findings above on workforce skills mapping, the figure below provides a snapshot of the top 20 occupational types across all three phases supply chain, construction, and operations/maintenance for New York's offshore wind workforce (prepared by BW Research Partnership for the New York State Energy Research and Development Authority). Collectively, these top 20 occupational types represent approximately 73% of New York's OSW workforce.

While New York's offshore wind market is centered on fixed bottom technology, many of the same types of jobs are applicable to floating offshore wind, with more emphasis on vessels, floating foundations, and tethering would be placed for floating OSW. The workforce gaps analysis performed for New York found that **administrative and clerical occupations** represented the majority of occupation types. This finding offers comparison to the skills mapping provided in Figures 3 4 and 3 5 above, where BVG identified trades and technicians as the most needed types of occupations.

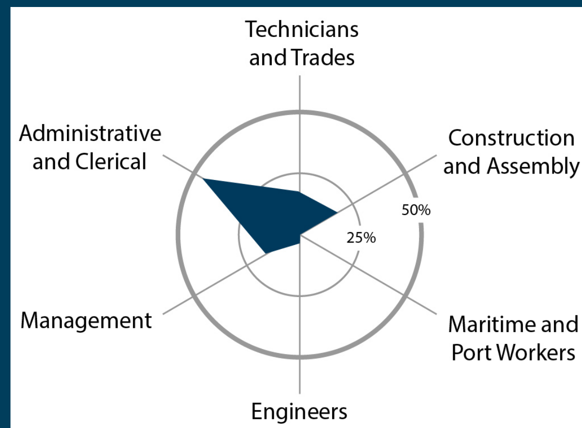
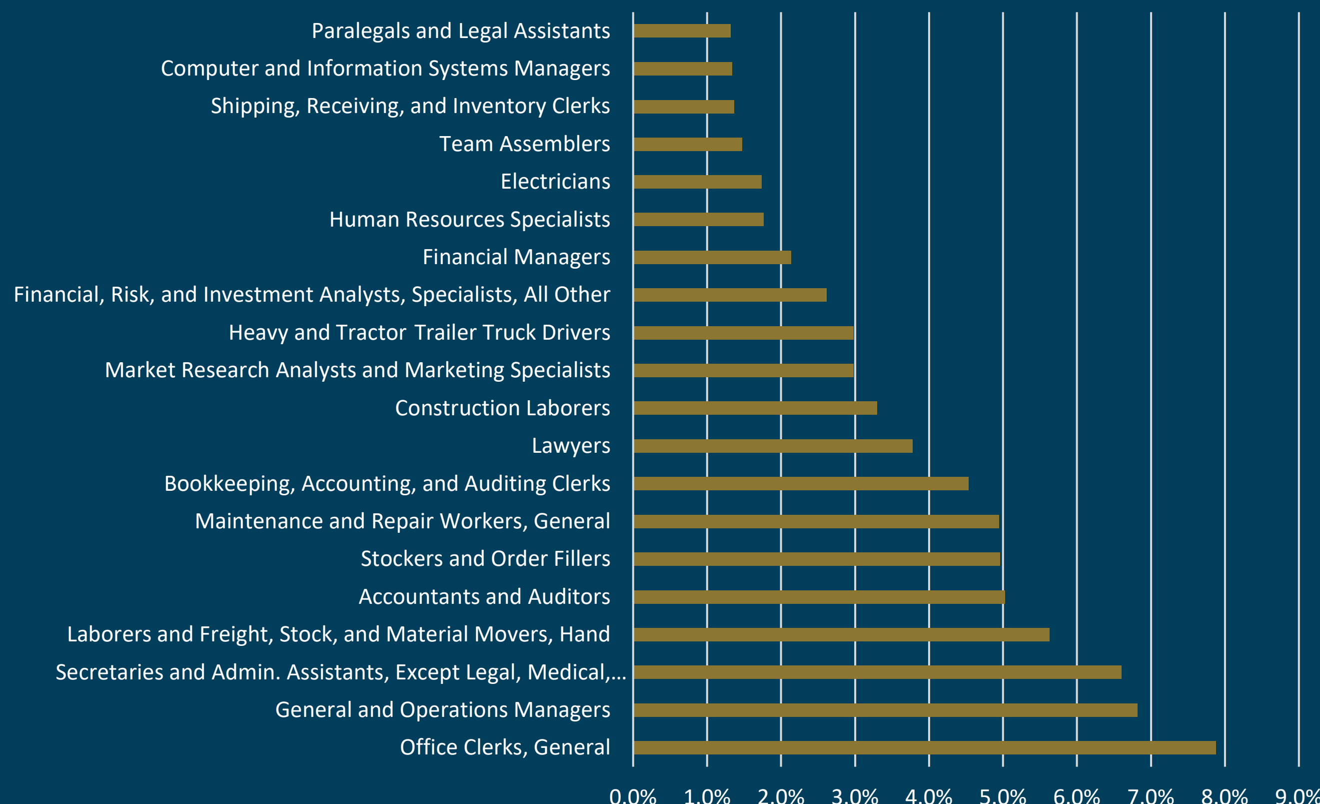


Figure X: Breakdown of Occupational Types of New York's Offshore Wind Workforce



Source: New York State Energy Research and Development Authority (NYSERDA). 2022. New York Offshore Wind Workforce Gap Analysis. Available online at: https://www-nyserda-ny-gov.webpkgcache.com/doc/-/s/www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/Offshore-Wind/New-York-State-Workforce-Gap-Analysis-2022.pdf

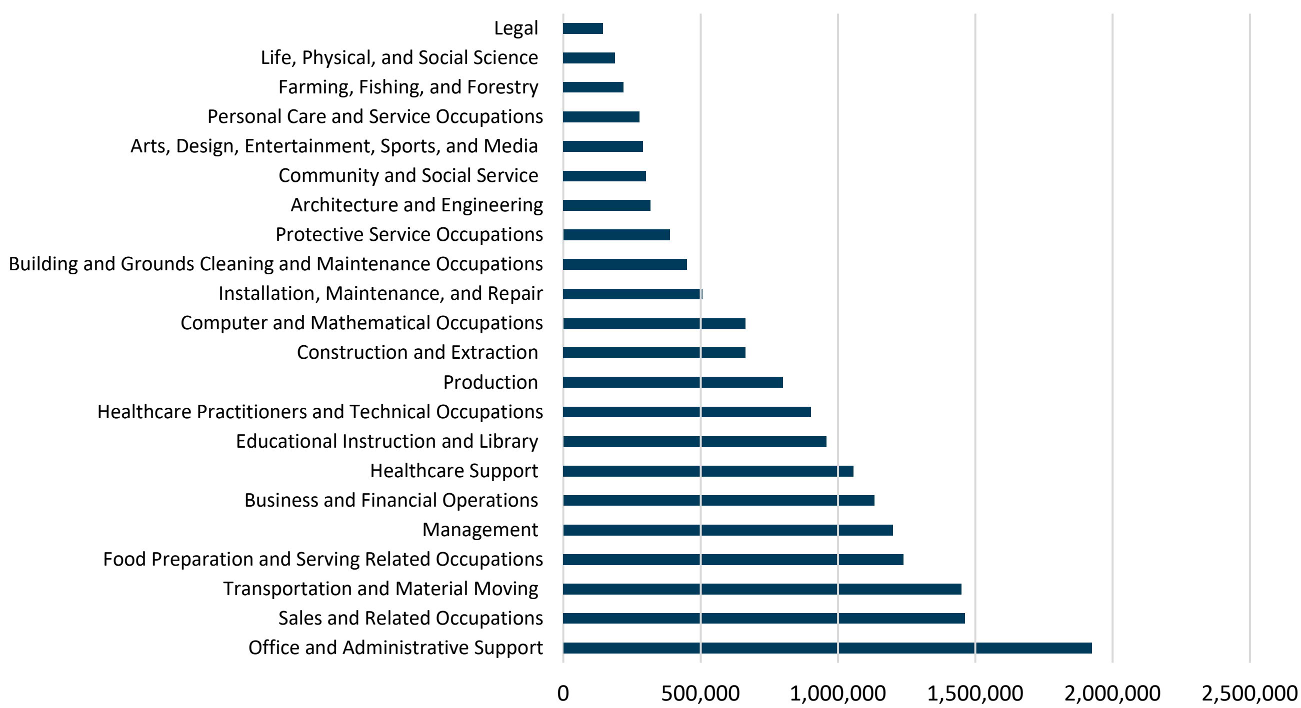
3.6 Workforce Gaps Analysis

This section assesses how prepared California's existing workforce is to accommodate the demand created from a new offshore wind industry. A review of California's current workforce distribution serves as the basis for comparing the existing labor distribution with the expected number of new offshore wind jobs. The results from this comparative analysis show which sectors are more prepared than others to accommodate the new offshore wind jobs.

3.6.1 Existing Workforce

Table 3-7 below provides a breakdown of California's workforce by occupational type, and as observed, approximately 16.5 million workers comprise the State's workforce.[20] Office and Administrative Support is the largest employment sector in the state, representing approximately 11.5 percent of overall workforce.[21] While the new offshore wind workforce will represent a cross-section of occupational types, requiring a wide variety of jobs to operate the industry, some of the key sectors that will be impacted by the offshore wind industry are Installation, Maintenance, and Repair (approximately 500,000 current workers); Construction and Extraction (approximately 650,000 current workers); and Production (approximately 750,000 current workers). As discussed in the following section, some of California's employment sectors are better positioned than others to internalize the demand for new workers created by the offshore wind industry.

Table 3-7: California Employment Breakdown by Occupational Type (2020)



Source: US BLS. May 2021. State Occupational Employment and Wage Estimates.

---

[20] U.S. Bureau of Labor Statistics (BLS). May 2021. State Occupational Employment and Wage Estimates for California. Available online at: https://www.bls.gov/oes/current/oes_ca.htm

[21] *Ibid.*

3.6.2 Gaps Analysis

Applying the data from Sections 3.3 and 3.4 above, this Assessment compared the type and number of expected offshore wind jobs with the capacity of California's existing workforce. Figure 3-6 below portrays the expected number of offshore wind jobs (for both 2030 and 2045) as a percentage of the existing workforce (2020). As observed in Figure 3-6, the majority of California's occupation types/sectors are in a position to internalize the new demand created by the offshore wind industry; however, a few occupational types are currently unprepared to meet the demand of the new industry. Those occupational types that are forecasted to experience an increase of more than 20% by 2030 and more than 60% by 2045 are:

- Miscellaneous Plant and System Operators
- Tank Care, Truck, and Ship Loaders
- Forging Machine Setters, Operators, and Tenders (Metal and Plastic)
- Wind Turbine Service Technicians
- Engine and Other Machine Assemblers

To a lesser extent, Structural Metal Fabricators and Fitters and Mining Machine Operators will also experience a significant increase in demand (Figure 3-6). These results track with the findings discussed in Sections 3.3 through 3.5 above, where nearly two-thirds of the new jobs created by California's offshore wind industry will be located in the supply chain (i.e., manufacturing, assembly, extraction, production, fabrication, etc.). While some speciality occupations, such as wind turbine technician, will almost be wholly new job types in California, it is the State's supply chain sectors that will experience significant new demand for trained workers. **Appendix B** provides the tables breaking down number of jobs, job types, average annual salary, and overall cost of workforce by offshore wind energy component.

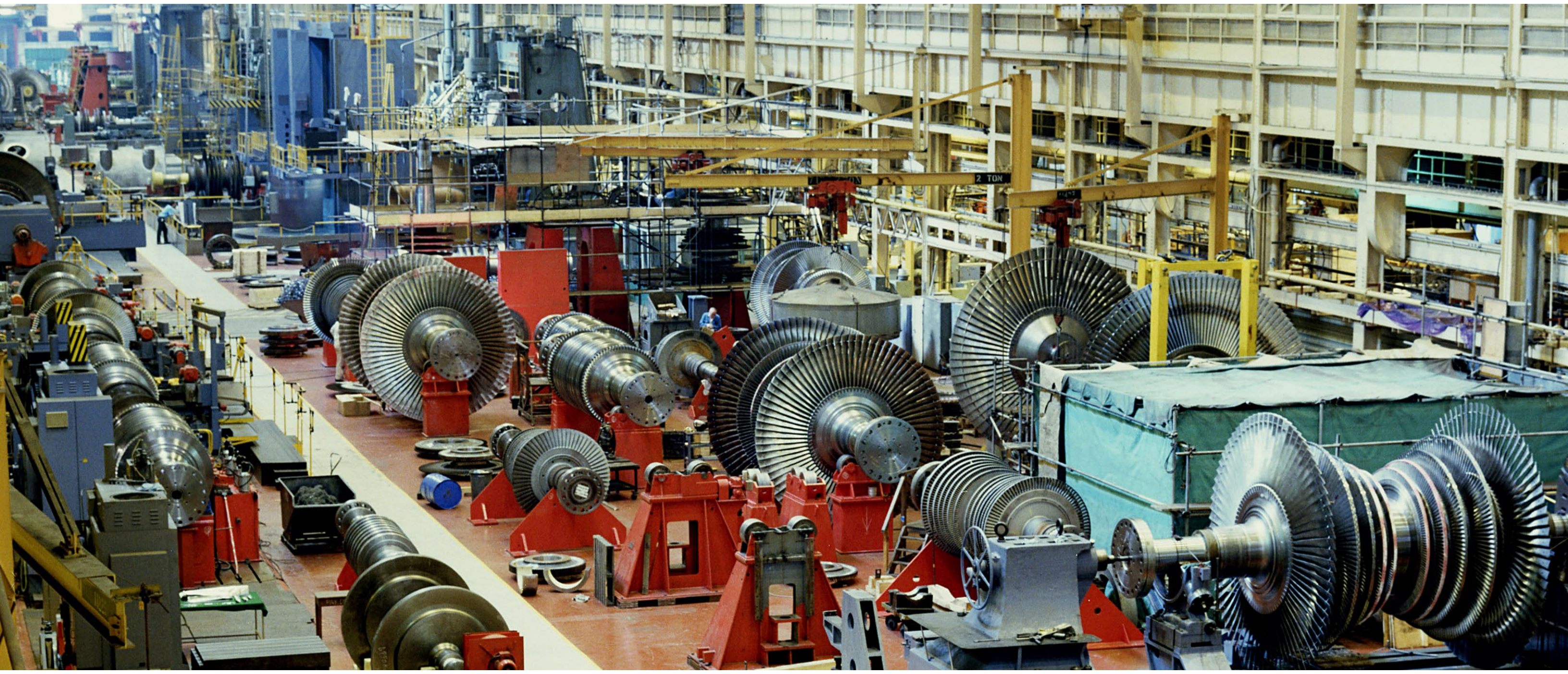
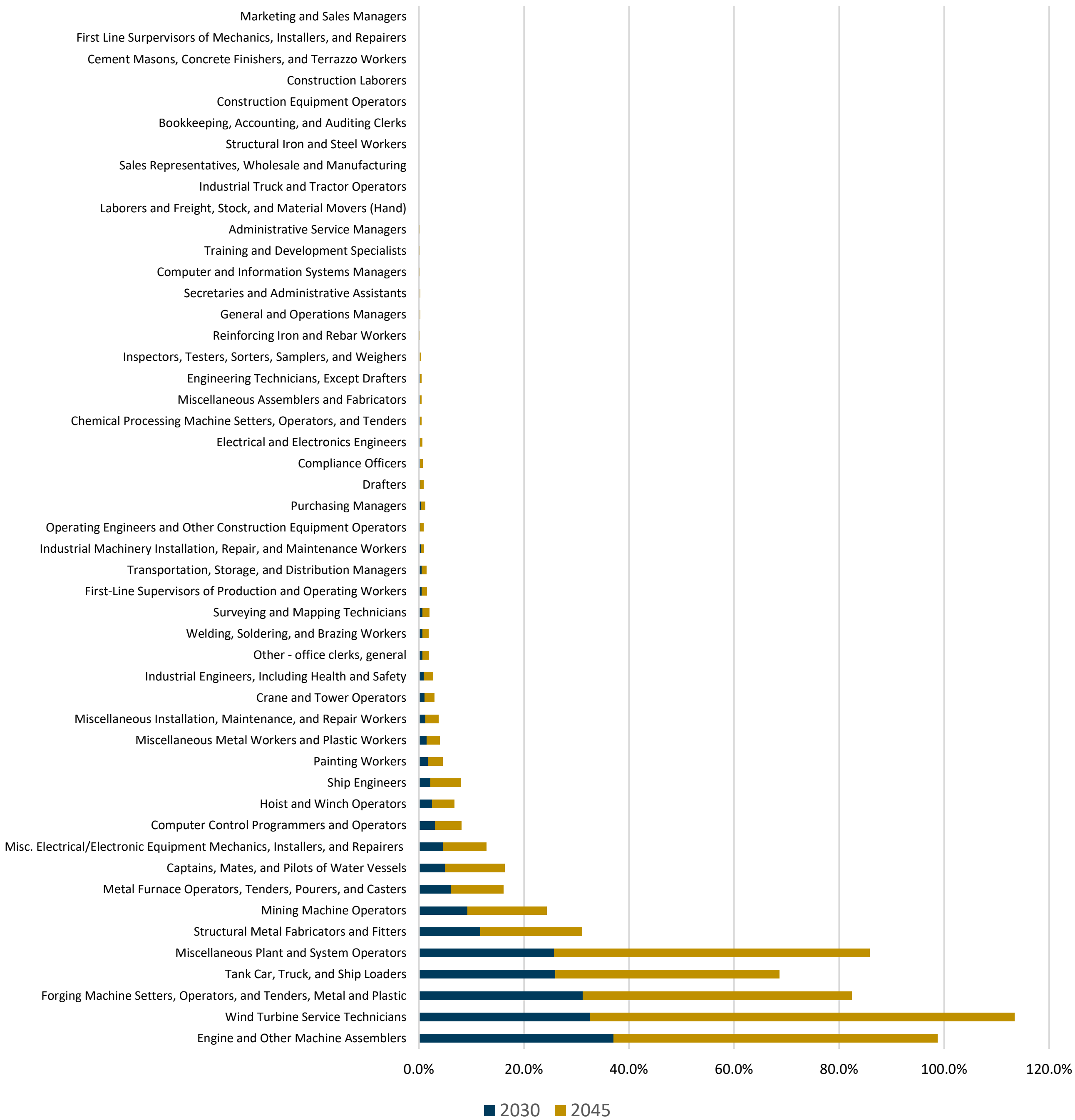


Figure 3-6: Forecasted Percentages (2030, 2045) of Existing Workforce (2020) By Occupational Type



Source: U.S. Bureau of Labor Statistics (BLS). May 2021. State Occupational Employment and Wage Estimates for California. Available online at: https://www.bls.gov/oes/current/oes_ca.htm

SECTION 4

Engagement with Labor and Apprenticeship Organizations

4.1 Key Issues and Questions

This section summarizes the engagement effort conducted with labor organizations, apprenticeship programs, manufacturers/industry, OSW training experts, and EPCIs to integrate input on workforce development, training, and equitable hiring. The interview process was based on the questions in Section 4.3 below, with an emphasis on the following framework questions:

- What are the key issues and obstacles to fielding a floating OSW workforce?
- What are the key skills and occupations needed for the OSW workforce?
- What types of OSW workers need the most training?
- What existing training resources are present in California?
- What measures could be taken to incentivize the hiring of women, veterans, and disadvantaged/under-represented people into OSW workforce?
- What would expedite workforce training and development?
- What role can the State of California play to expedite workforce development?

Section 25991.3(C): Basis for Assessment of Workforce Development Needs

In developing the plan pursuant to subdivision (a), the commission shall consult with representatives of key labor organizations and apprenticeship programs that would be involved in dispatching and training the construction workforce.

4.2 Organizations Interviewed

Interviews with labor organizations and training/apprenticeship entities were conducted between October 2022 and April 2023. In addition to the AB 525 requirement to engage "key labor organizations and apprenticeship programs," this Assessment expanded the interviewee pool to Engineering-Procurement-Construction- Installation (EPCI) organizations; developers; manufacturers; and OSW training entities and experts to obtain a wider perspective from industry and other key training entities.

Table 4-1: Organizations and Types of Organizations Interviewed

Organization	*Type of Organization*
Kiewit	Engineering, Procurement, Construction, Installation
Orsted	Developer; Training
Siemens Gamesa Renewable Energy	Turbine manufacturer/OEM
Siemens Gamesa Renewable Energy	Offshore substation manufacturing
Maersk Training	Training company (in Maersk family of companies)
IBEW	Labor Organization; NREL Advisory Group on OSW Workforce and Training
California State Building & Construction Trades	Labor Organization

Southwest Regional Council of Carpenters	Labor Organization
International Longshore and Warehouse Union	Labor Organization
Center for International Trade and Transportation (California State University – Long Beach)	Academia; Training/Apprenticeship Program
State University of New York Farmingdale	Academia; NREL Advisory Group on OSW Workforce and Training
Bristol Community College	Academia; NREL Advisory Group on OSW Workforce and Training
National Renewable Energy Laboratory	NREL Advisory Group on OSW Workforce and Training
Global Wind Organization	Trade Group; NREL Advisory Group on OSW Workforce and Training
Cape and Islands Self-Reliance	NREL Advisory Group on OSW Workforce and Training
Business Network on Offshore Wind	NREL Advisory Group on OSW Workforce and Training

4.3 Questions and Summary of Responses by Type of Organization/Entity

Table 4-2 below provides a summary of the responses from the interviewees, structured by type of industry or organization the interviewee is associated with and the key questions asked during the interview. Response summaries in the table below are organized by the type of entity, such as labor organizations and apprenticeship programs; EPCI entities; developers; training entities and experts with direct experience training offshore wind workers. Each response summary in the table represents the consensus response from the interviewee groups.

Table 4-2: Summary of Responses from Interviews by Type of Organization

Questions	Industry/Organization				
	Labor	**EPCI**	**Developer**	**Training**	**Safety/Training Expert**
What are the critical skills that this new workforce will need?	The skills needed include onshore wind industry, industrial welders, on and offshore oil and gas workers, drillers, building developers, construction workers, merchant marines, veterans, longshoremen, electricians, and welders.	The skills needed will be like most skilled labor (i.e., skilled trades, welders, electricians, etc.). They will need specific training to work in the offshore environment.	Cannot underplay the need for employees with STEM backgrounds and computer knowledge to troubleshoot component failure and maintenance in addition to skilled trades (i.e., welders, electricians, millwrights, piledrivers, etc.). Additional skills working in the marine environment, attention to detail, and fire awareness are important too.	The big OEMs want their employees to have GWO safety training, but they must have the technical skills as well (i.e., welding, mechanical, knowledge of power plants, turbines, etc.). Need personnel to understand that you aren't just on a turbine but a piece of a powerplant.	A lot of the core skills on the construction side are already present in the workforce. Need additional training to work at sea and in ports. This industry also places safety very high, and the workforce will need this culture. There will be gaps in training and that can be remedied with up-training (i.e., marine safety, developer specific training, etc.). There will also be a need for people with engineering and maritime experience.
What are some of the obstacles and limitations to fielding an offshore wind construction workforce?	Need training specifications from industry and clarity on industry standards. There will be competition for the workforce from other industries looking for similar skillsets. The location of these projects relative to population centers. Challenges with infrastructure upgrades pose another obstacle (i.e., port space, transmission and power grid upgrades, etc.).	This industry will compete for capital and resources from other industries (i.e., oil & gas, solar, onshore wind, etc.). Meeting industry standards and certifications will also be an obstacle. Communication and a clear permitting process needs to be established and communication between all stakeholders needs to be incentivized to ensure workforce is available.	Need the big players in offshore wind and safety on the west coast. Manufacturing facilities need to be established for domestic workforce security.	There is a general lack of offshore wind experience in the U.S. Need training centers on the West Coast and clearly defined requirements surrounding workforce training and collaboration with industry to fund training. There also needs to be a clear understanding of the legal process within each state and how the industry must operation within.	Delays in the process of obtaining leasing and permits. If there are no commitments, then no need to field a workforce. Available training facilities in California need to be inventoried to determine training gaps. The welding standards in the U.S. are not the same for the offshore wind industry and that will need to be remedied. Delays in project timelines will create workforce bottlenecks.
What could expedite the creation of the workforce, workforce training, and workforce development?	The state needs to invest in existing programs such as the High-road Training Partnership. There also needs to be power upgrades and an understanding of what the workforce demand will look like. Outreach targeting k-12th graders and the public to change the narrative around these careers.	Timelines needs to be clear. Industry won't invest and unions can't field crews if the state doesn't have a clear pathway from lease, construction, and finally getting power to the consumer. The industry needs to communicate standards to unions and trade schools, this will ensure the workforce is trained right.	Transparency and long-term energy policy. This will boost industry investment and boost local economic impact. There needs to be diversity in parts manufacturing, this will reduce supply chain delays.	Need to educate the public on the career potential surrounding the offshore wind industry. Utilize the East Coast's offshore wind development as a framework. Leverage Community Colleges and maritime academies and institute industry safety standards into their programs. There also needs to be on-the-job training available.	Communication and a clear permitting process or a process that incentivizes commitments from all the stakeholders so that workforce building can occur and meet the commitments made. The state needs to collaborate with industry, community colleges, and universities to identify workforce needs and fund programs to fill the void.

Questions	Industry/Organization				
	Labor	**EPCI**	**Developer**	**Training**	**Safety/Training Expert**
What types of incentives would help recruit new workers to create a sustainable worker pipeline? What can the State of California do to facilitate workforce training and development?	Stipends for those going through apprenticeship programs to provide wrap-around services (i.e., tool, transportation, child-care, etc.). PLAs and CWAs need to be established that require local and divers candidate hiring. More collaboration between industry, unions, universities, and the state for grants and funding for training programs. Need to mandate pay scales and ensure the industry compensates workers fairly, local hiring, and ensure industry, unions, and the state collaborate and have open dialog.	Most of the workforce will come from existing sectors but will require training to work in ports and in the marine environment. To meet California long term goals outreach to kindergarten- 12th graders will be important. Need to change the stigma around manual labor and trades.	Likely to come from existing sectors but will need up-training to meet industry standards for welding as well as port and at sea work.	The workforce will likely come from existing sectors (i.e., construction, engineering, military, and onshore turbine maintenance, etc.). Some will have skills but require industry specific training, others will need less and require shorter modules to get up to speed (i.e., onshore wind workers, offshore oil and gas, etc.).	Cannot downplay California is an expensive place to live, well paid jobs will entice prospective workforce. Fund programs that already have curriculum and adjusting it for the offshore space (i.e., unions, community colleges, maritime academies, etc.). Training centers in centralized locations so that the workforce can be trained and live near project areas. There needs to be more stipends, scholarships and funding for apprenticeships, transportation costs, tools, and equipment, and especially childcare for single working parents.
Do you see that this future workforce will be coming mostly from other existing sectors (e.g., manufacturing, maybe fossil fuel workers) or from new untrained workers?	The majority of the workers will come from existing sectors (i.e., oil & gas, millwrights, longshoremen, etc.), but some of the workforce will come from those displaced by COVID. Geography will play a large role in where the workforce will come from. Those living near projects might see this as an opportunity for upward mobility.	Unions will play a vital role in training this workforce. They have great programs developed and can work with industry to develop modules and meet specific standards or certifications.	Naval academies, and work with companies that have a training focus and use their framework or partner with them. Focus on training programs that are local to the project regions and ensure they are industry certified.	The offshore oil and gas industry has a lot of similarities and training that could be adjusted to offshore wind. Onshore wind turbine maintenance and installation training with OSW modules could also be utilized.	The onshore wind, and offshore oil and gas industries will likely play an important role in filling workforce needs. Also, IT and the technology sector will likely bring people with little offshore experience but who could play an important role on the technical side of things. In addition, military personnel transitioning out of their service will want to join the workforce and Helmets to Hammers is a great program for such transitions.
What existing training and apprenticeship programs could be repurposed or expanded to train offshore wind construction workers?	Union led training programs are well equipped for this and investments are being made specific to offshore training facilities and curriculum by pairing with industry (e.g., GWO training, etc.).	Unions will play a vital role in training this workforce. They have great programs developed and can work with industry to develop modules and meet specific standards or certifications.	Naval academies, and work with companies that have a training focus and use their framework or partner with them. Focus on training programs that are local to the project regions and ensure they are industry certified.	The offshore oil and gas industry has a lot of similarities and training that could be adjusted to offshore wind. Onshore wind turbine maintenance and installation training with OSW modules could also be utilized.	Apprenticeship programs from the energy sector (i.e., solar, onshore wind, gas, etc.) can be modified with offshore wind modules. Union training centers, maritime academies, community colleges, and universities can all play an important role in training this workforce.

SECTION 5

Workforce Standards, Occupational Safety Requirements, and Training Needs Assessment & Recommendations

5.1 Key Issues and Questions

As floating offshore wind is a nascent industry in California and the United States, with zero floating turbines installed to date, establishing workforce standards will serve to attract skilled workers and provide regulatory certainty to this new industry. Key workforce standards include elements such as prevailing wage, occupational skills/training, local hiring initiatives, equitable and targeted hiring standards. This section reviews how the East Coast states have created and applied workforce standards, as well as other parts of the world, and provides recommendations that will assist California with developing a highly trained, highly skilled, and available workforce. Additionally, this section considers the need to implement occupational safety requirements for workforce safety, as well as the need for the Division of Apprenticeship Standards to develop a safety training curriculum and in-person classroom/laboratory/training facility. Framework questions considered in this section include:

- What occupational safety requirements should be instituted to protect the OSW workforce?
- How has the East Coast addressed workforce standards?
- What workforce standards are recommended by industry, EPCIs, and manufacturers?
- How can equity be integrated into the growth of OSW in California? How can workforce development/training programs be created to be consistent with the Justice40 goals, benefiting both historically vulnerable/disadvantaged communities and communities displaced by the decline of the fossil fuel sector?
- How can training programs be financed?
- What are the training requirements to provide the necessary types of skills for OSW development?
- Who or what type of institution can provide the needed training requirement to achieve a sufficiently-trained workforce, and does it already exist or could it be added to an existing program?
- Should the Division of Apprenticeship Standards develop curriculum for in-person classroom and laboratory advanced safety training for workers?
- What are the recommended workforce standards, including prevailing wage, workforce skills, workforce training, apprenticeship programs, local hiring initiatives, targeted hiring standards, and equitable hiring standards?

Section 25991.3(B)(2) and (3): Basis for Workforce Standards, Occupational Safety Requirements, and Training Needs Assessment & Recommendations

An analysis of the workforce development needs of the California offshore wind energy industry, including occupational safety requirements, the need to require the use of a skilled and trained workforce to perform all work, and the need for the Division of Apprenticeship Standards to develop curriculum for in person classroom and laboratory advanced safety training for workers.

Recommendations for workforce standards for offshore wind energy facilities and associated infrastructure, including, but not limited to, prevailing wage, skilled and trained workforce, apprenticeship, local hiring, and targeted hiring standards, that ensure sustained and equitable economic development benefits.

Key Studies and Sources for Workforce Standards, Occupational Safety Requirements, and Training Needs Assessment

- Northeast Offshore Renewable Energy Training Center U.S. Offshore Wind Training, A Comprehensive Survey and Categorization of Training Elements
- Pitre, K.H. November 2021. Regulation of Safety and Health on U.S. Offshore Wind Energy Facilities.
- Transportation Research Board of the National Academies. 2013. Worker Health and safety on Offshore Wind Farms (Special Report 310).
- Global Wind Organisation. November 2021. Ensuring a Safe and Renewable Future.
- RenewableUK. 2014. Offshore Wind and Marine Energy Health and Safety Guidelines (Issue 2).
- Department of the Interior. October 2019. Policy Statement on Regulating Workplace Safety and Health Conditions on Renewable Energy Facilities on the Outer Continental Shelf.
- American Jobs Project (BVG Associates). February 2019. The California Offshore Wind Project: A Vision for Industry Growth .
- National Renewable Energy Laboratory. 2022. U.S Offshore Wind Workforce Assessment.

5.2 Workforce Standards

Establishing workforce standards is a critical element in creating safe working environments, instituting quality in all phases of offshore wind development, and attracting developers that appreciate a competent and available workforce. This section reviews the primary factors that constitute workforce standards (e.g., prevailing wage; skills; training; etc.) and captures lessons-learned from states on the East Coast that have already established these types of standards for offshore wind development.

Considering that most of the open water construction will occur approximately 20 miles off California's coast, and well beyond the three-mile boundary for state jurisdiction, California's purview for workforce standards will be primarily limited to on-shore activities (i.e., supply chain, manufacturing, logistics, seaport operations). Recently, in early 2023, the Bureau of Safety and Environmental Enforcement (BSEE) assumed primacy over instituting a safe work environment on the outer continental shelf (OCS).[22] However, as discussed above in Section 3, nearly 2/3rds of the offshore wind workforce is expected to be on-shore in the supply chain, manufacturing, and logistics vocations. California, under the Department of Industrial Relations (DIR), will have the opportunity to shape this workforce by adopting specific standards for offshore wind-related activities that create solid baselines for worker safety, skills, training, and hiring. DIR, including Cal/OSHA, already regulate the key supply chain sectors, including manufacturing, fabrication, and materials mining/handling, but creating a specific set of workforce standards for offshore wind supply chain industries in California will help provide a known-quantity regulatory framework to prospective supporting businesses and service providers.

5.2.1 Prevailing Wage

Prevailing wage reflects the average wage paid to similarly employed workers in a specific occupation in the area of intended employment.[23] This Assessment considers the occupational types and skill sets discussed in

---

[22] Federal Register. January 31, 2023. Reorganization of Title 30-Renewable Energy and Alternate Uses of Existing Facilities on the Outer Continental Shelf. Available online at: https://www.federalregister.gov/documents/2023/01/31/2023-00871/reorganization-of-title-30-renewable-energy-and-alternate-uses-of-existing-facilities-on-the-outer

[23] U.S. Department of Labor. 2022. Prevailing Wages. Available online at: https://flag.dol.gov/programs/prevailingwages#:~:text=The%20prevailing%20wage%20rate%20is,the%20area%20of%20intended%20employment.

Section 3.5 (Occupational Skills Mapping) as the basis for reviewing prevailing wage rates (mean hourly wage rate and mean annual salary). While not entirely comprehensive, this workforce breakdown will comprise the bulk of the new offshore wind workforce in California, which will require a wide range of occupational types and skill sets, some of which will be relatively new to the California workforce (Section 3.6).

5.2.1.1 California Annual Salaries and Hourly Wages for Offshore Wind Workforce

The U.S. Department of Labor's Bureau of Labor Statistics (BLS) maintains a database of wage and salary information for California workers, as well as for each state and nationally. Carrying forward the occupational skills mapping provided in Section 3.5 above, Table 5-1 provides a comparison mean hourly wage and mean annual salary for the expected workforce job types (provided in BLS Standards Occupational Codes – SOCs) for California, New York, and nationally. New York was included in the table as its offshore wind market is firmly established and expanding.

As observed in Table 5-1, California wages and salaries are generally higher than the national averages, but California and New York's average annual salaries and wages are more in line with each other, with New York offering some significantly higher paying positions in construction, equipment operation, and management. However, California offers higher wages and salaries than both New York and the greater U.S. in some of the most critical occupational types related to offshore wind development including, engineering; captains/mates/pilots; and, technicians/trades. Having higher wages/salaries in these key areas can help attract out-of-state workers to the new offshore wind workforce.

Pursuant to California Senate Bill 3 (2016), the statewide minimum wage was increased to $15.50 per hour and $62,400 minimum salary in 2022 for businesses with 26 or more employees and for small businesses with 25 or fewer employees.[24] These pay rates represent a significant increase over some of the lower paying jobs listed in Table 5-1 below, particularly the minimum salary requirement. Focusing on some of the key labor positions, metal workers, truck operators, welders, and machine operators were earning roughly $45,000 per year in salary (2021), and these positions will realize a near 39% increase in salary to $62,400 in 2022. These high paying wages/salaries can help attract skilled workers to California's new offshore wind workforce, which will need to attract skilled and available workers from other existing industries or geographies to satisfy the demand created by the offshore wind industry.

[24] California Department of Industrial Relations. December 14, 2022. California's Minimum Wage to Increase to $15.50 per Hour (Release No. 2022-102). Available online at: https://www.dir.ca.gov/DIRNews/2022/2022-102.html#:~:text=An%20employee%20must%20earn%20no,to%20meet%20this%20threshold%20requirement.

Table 5-1: Mean Annual Salary and Hourly Wage Data for California Compared to New York State and the US

Occupational Group	Occupation	Standard Occupational Code	California Mean Annual Salary	California Mean Hourly Wage	New York Mean Annual Salary	New York Mean Hourly Wage	National Mean Annual Salary	National Mean Hourly Wage
Administrative and Clerical	Administrative Service Managers	11-3012	**$115,290**	**$55.43**	$144,810	$69.62	$113,030	$54.34
	Bookkeeping, Accounting, and Auditing Clerks	43-3031	**$51,080**	**$24.56**	$50,720	$24.38	$45,140	$21.70
	Compliance Officers	13-1041	**$86,030**	**$41.36**	$85,900	$41.30	$75,810	$36.45
	Human Resources Workers	13-1071	**$81,360**	**$39.12**	$84,200	$40.48	$70,720	$34.00
	Sales Representatives, Wholesale and Manufacturing	41-4012	**$77,800**	**$37.40**	$78,440	$37.71	$72,390	$34.81
	Secretaries and Administrative Assistants	43-6014	**$47,930**	**$23.04**	$44,570	$21.43	$41,080	$19.75
Construction & Assembly	Cement Masons, Concrete Finishers, and Terrazzo Workers	47-2051	**$60,650**	**$29.16**	$70,700	$33.99	$50,900	$24.47
	Construction Equipment Operators	47-2073	**$78,320**	**$37.65**	$81,840	$39.35	$56,280	$27.06
	Construction Laborers	47-2061	**$52,790**	**$25.38**	$60,410	$29.04	$44,130	$21.22
	Crane and Tower Operators	53-7021	**$81,070**	**$38.97**	$125,450	$60.31	$65,270	$31.38
	Engine and Other Machine Assemblers	51-2031	**$48,010**	**$23.08**	$51,460	$24.74	$48,110	$23.13
	Hoist and Winch Operators	53-7041	**$70,310**	**$33.81**	$52,350	$25.17	$58,450	$28.10
	Industrial Machinery Installation, Repair, and Maintenance Workers	49-9041	**$65,700**	**$31.59**	$61,950	$29.78	$58,780	$28.26
	Laborers and Freight, Stock, and Material Movers (Hand)	53-7062	**$37,940**	**$18.24**	$38,990	$18.74	$34,950	$16.80
	Mining Machine Operators	47-5041	**$62,040**	**$29.83**	N/A	N/A	$57,430	$27.61
	Miscellaneous Assemblers and Fabricators	51-2090	**$38,950**	**$18.73**	$38,160	$18.35	$37,780	$18.17
	Misc. Electrical and Electronic Equipment Mechanics, Installers, and Repairers	49-2093	**$72,870**	**$35.04**	$76,050	$36.56	$70,650	$33.97
	Operating Engineers and Other Construction Equipment Operators	47-2073	**$78,320**	**$37.65**	$81,840	$39.35	$56,280	$27.06
	Painting Workers	51-9123	**$42,800**	**$20.58**	$42,010	$20.20	$38,250	$18.39
	Reinforcing Iron and Rebar Workers	47-2171	**$67,480**	**$32.44**	$73,600	$35.38	$58,960	$28.35
	Tank Car, Truck, and Ship Loaders	53-7121	**$57,970**	**$27.87**	$56,950	$27.38	$55,330	$26.60
	Training and Development Specialists	13-1151	**$77,510**	**$37.26**	$75,390	$36.25	$67,620	$32.51
	Welding, Soldering, and Brazing Workers	51-4122	**$47,210**	**$22.70**	$47,020	$22.61	$42,950	$20.65

Engineers	Drafters	17-3011	**$66,140**	**$31.80**	$64,020	$30.78	$60,620	$29.14
	Electrical and Electronics Engineers	17-3023	**$73,910**	**$35.53**	$68,170	$32.78	$69,070	$33.21
	Industrial Engineers, Including Health and Safety	17-2112	**$109,460**	**$52.63**	$95,880	$46.10	$95,200	$45.77
	Ship Engineers	17-2199	**$117,990**	**$56.73**	$106,340	$51.13	$107,800	$51.83
Management	Computer and Information Systems Managers	11-3021	**$193,500**	**$93.03**	$195,900	$94.18	$162,930	$78.33
	First Line Supervisors of Mechanics, Installers, and Repairers	49-1011	**$83,620**	**$40.20**	$81,450	$39.16	$73,590	$35.38
	First-Line Supervisors of Production and Operating Workers	51-1011	**$70,510**	**$33.90**	$72,370	$34.79	$67,330	$32.37
	General and Operations Managers	11-1021	**$131,080**	**$63.02**	$144,830	$69.63	$115,250	$55.41
	Marketing and Sales Managers	11-2021	**$175,150**	**$84.21**	$190,760	$91.71	$153,440	$73.77
	Purchasing Managers	11-3061	**$145,390**	**$69.90**	$157,330	$75.64	$134,590	$64.71
	Transportation, Storage, and Distribution Managers	11-3071	**$110,390**	**$53.07**	$120,670	$58.02	$105,580	$50.76
Maritime and Port Workers	Captains, Mates, and Pilots of Water Vessels	53-5021	**$103,910**	**$49.96**	$96,100	$46.20	$98,330	$47.27
Technicians and Trades	Chemical Processing Machine Setters, Operators, and Tenders	51-9011	**$52,540**	**$25.26**	$48,950	$23.54	$52,450	$25.22
	Computer Control Programmers and Operators	51-9161	**$48,770**	**$23.45**	$44,870	$21.57	$46,240	$22.23
	Engineering Technicians, Except Drafters	17-3029	**$68,460**	**$32.91**	$59,110	$28.42	$68,290	$32.83
	Forging Machine Setters, Operators, and Tenders, Metal and Plastic	51-4022	**$46,920**	**$22.56**	$54,660	$26.28	$44,410	$21.35
	Industrial Truck and Tractor Operators	53-7051	**$43,040**	**$20.69**	$44,130	$21.22	$40,950	$19.69
	Inspectors, Testers, Sorters, Samplers, and Weighers	51-9061	**$47,280**	**$22.73**	$22.51	$46,820	$21.54	$44,810
	Metal Furnace Operators, Tenders, Pourers, and Casters	51-4051	**$49,540**	**$23.82**	$22.29	$46,360	$22.33	$46,440
	Miscellaneous Metal Workers and Plastic Workers	51-4199	**$40,510**	**$19.48**	$43,970	$21.14	$39,480	$18.98
	Miscellaneous Plant and System Operators	51-0899	**$68,660**	**$33.01**	$54,010	$25.96	$55,480	$26.67
	Structural Iron and Steel Workers	47-2221	**$70,870**	**$34.07**	$90,280	$43.41	$61,270	$29.46
	Structural Metal Fabricators and Fitters	51-2041	**$47,640**	**$22.90**	$53,720	$25.83	$45,730	$21.99
	Surveying and Mapping Technicians	17-3031	**$71,700**	**$34.47**	$57,510	$27.65	$49,810	$23.95
	Wind Turbine Service Technicians	49-9081	**$65,670**	**$31.57**	$67,010	$32.22	$58,580	$28.16

Notes: Cells highlighted in gold are where California has higher wages and salaries than both New York State and the national average.

Source: BVG. 2017. US Job Creation in Offshore Wind.

U.S. Bureau of Labor Statistics (BLS). May 2021. State Occupational Employment and Wage Estimates for California.

5.2.1.2 Federal Prevailing Wage Standards for Offshore Wind

On March 29, 2021, the Biden administration issued a fact sheet announcing a "set of bold actions that will catalyze offshore wind energy, strengthen the domestic supply chain, and create good-paying, union jobs."[25] The Inflation Reduction Act of 2022 (IRA), which was signed into law by President Joe Biden on August 16, 2022, further emphasizes the goal of developing good-paying jobs. Among other things, the IRA provides beneficial changes to the tax credits available for renewable energy developers, including offshore wind developers. Specifically, the IRA includes a two-tier "base" rate and "increased" rate structure for renewable energy tax credits. The "increased" rate is worth five times the value of the base rate and is applicable if a project meets the prevailing wage and apprenticeship requirements. To meet the prevailing wage requirement, the project owner must ensure that any laborers and mechanics employed by contractors and subcontractors are paid prevailing wages not only during construction, but also for any repairs or alterations that may be needed during the applicable tax credit period. The term "prevailing wages" in this context refers to wages at rates for similar work in the location of the project site as determined by the U.S. Secretary of Labor.

On November 30, 2022, the U.S. Department of Treasury and the Internal Revenue Service (IRS) published guidance on the IRA's prevailing wage and apprenticeship requirements.[26] The publication of this guidance means that in order to receive increased incentives, taxpayers (i.e., energy developers) must meet the prevailing wage and apprenticeship requirements for facilities where construction begins on or after January 29, 2023. The prevailing wage requirements set forth by the IRS are summarized as follows:

> (2) Prevailing Wage Requirements. Section 45(b)(7)(A) provides that to meet the prevailing wage requirements with respect to any qualified facility, a taxpayer must ensure that any laborers and mechanics employed by the taxpayer or any contractor or subcontractor in: (i) the construction of such facility, and (ii) the alteration or repair of such facility (with respect to any taxable year, for any portion of such taxable year that is within the 10-year period beginning on the date the qualified facility is originally placed in service), are paid wages at rates not less than the prevailing rates for construction, alteration, or repair of a similar character in the locality in which such facility is located as most recently determined by the Secretary of Labor, in accordance with subchapter IV of Chapter 31 of Title 40, United States Code (Prevailing Wage Rate Requirements). Section 45(b)(7)(B) provides correction and penalty mechanisms for a taxpayer's failure to satisfy the requirements under § 45(b)(7)(A).

For wind projects, the determination of whether the prevailing wage requirement is satisfied is made on a "qualified facility" basis. The IRS generally considers each turbine, pad and tower a separate facility. It is unclear how the requirements will apply to the balance of the wind project. Recordkeeping will be critical in deals claiming the full tax credit rates. Investors are likely to ask sponsors to make representations that the prevailing wage requirements are met, if applicable. Sponsors will need to coordinate with contractors to ensure the requirements are met and may attempt to push these risks on to contractors. It is worth noting that

---

[25] White House. 2021. Executive Order 13990 of January 20, 2021: Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis. Federal Register, 86(14), 7037–7043. Available at: https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/. Accessed October 13, 2022.

[26] Internal Revenue Service. 2022. Federal Register / Vol. 87, No. 229 / Wednesday, November 30, 2022 / Notices. Available at: https://www.govinfo.gov/content/pkg/FR-2022-11-30/pdf/2022-26108.pdf. Accessed January 4, 2023.

the start of construction deadline for claiming an ITC for an offshore wind project was pulled forward by one year, but projects under construction in 2025 or later may be eligible for a technology-neutral ITC or PTCs.

On October 21, 2022, BOEM issued the Final Sale Notice (FSN) for commercial leasing for these projects, which included a stipulation for any projects proposed under the lease areas to enter into a Project Labor Agreement (PLA) covering any stage of construction (Stipulation 8/8.1). PLA clauses typically include prevailing wage provisions. However, construction components like the wind turbine's floating base are potentially outside the scope of the agreement.

5.2.1.3 State Strategies for Prevailing Wage Standards for Offshore Wind

Under the Commerce Clause of the U.S. Constitution, states and local jurisdictions can impose labor and wage requirements on state and local government procurement contracts and subsidy programs but cannot impose such requirements on private, third-party contracts, unless a state agency is directly a party to those contracts. This is a crucial difference between California and many East Coast states. In California, the Public Utilities Commission (CPUC) does not directly control power procurement and thus cannot impose labor standards or prevailing wage requirements, except where explicitly authorized by legislation, for example, SB 350 (De León 2017), which increased the Renewables Portfolio Standard (RPS), requires all transmission line work to be done under the prevailing wage.

In contrast, many East Coast states' energy regulatory authorities can impose labor standards and other contract conditions on offshore wind developers because they were explicitly given that authority legislatively. Of the East Coast states that have taken the lead on offshore wind, most have created bidding preferences related to labor standards. New York, New Jersey, Rhode Island, and Maryland all have some variation of a PLA or prevailing wage standard. In New York, developers must "include commitments to negotiate project labor agreements, labor peace agreements and prevailing wages" in their applications to the Maryland Public Service Commission.[27] Similarly, in New Jersey, the last offshore wind solicitation asked developers to describe their plans to use unionized labor for construction, operation, and maintenance, including "considerations related to prevailing wages, union neutrality agreements…and participation in community benefit agreements that include commitments to local hiring and skills training for local residents."[28] In Rhode Island, developers pursuing long-term contracts must enter into a labor peace agreement with at least one labor organization that represents employees conducting construction, maintenance, and operations work. Developers must provide wages and benefits for construction, operations, and maintenance employees at prevailing levels set by the state Department of Labor and Training.[29] In Maryland, the Clean Energy Jobs Act (CEJA) states that community benefit agreements must ensure that skilled craft workers are paid the prevailing wage as determined by the Maryland Commissioner of Labor and Industry.[30] In Maine, the legislation authorizing the power purchase

---

[27] New York State Energy Research and Development Authority (NYSERDA). 2022. 2022 Offshore Wind Solicitation. Available at: https://www.nyserda.ny.gov/offshore-wind-2022-solicitation. Accessed January 4, 2023.

[28] New Jersey Board of Public Utilities. 2022. New Jersey Offshore Wind Solicitation #3, Solicitation Guidance Document. November 30, 2022, p. 25. Available at: https://njoffshorewind.com/third-solicitation/solicitation-documents/Draft-Solicitation-Guidance-Document-with-attachments.pdf. Accessed January 4, 2023.

[29] Rhode Island. 2022 General Assembly, An Act Relating to Public Utilities and Carriers – Affordable Clean Energy Security Act, state. Available at: https://trackbill.com/bill/rhode-island-senate-bill-2583-an-act-relating-to-public-utilities-and-carriers-affordable-clean-energy-security-act-amends-the-affordable-clean-energy-security-act-and-the-long-term-contracting-standard-for-renewable-energy/2241957/. Accessed January 4, 2023.

[30] Maryland. 2019. Maryland Clean Energy Jobs Act. Available at: https://mgaleg.maryland.gov/2019RS/Chapters_noln/CH_757_sb0516e.pdf. Accessed January 4, 2023.

agreement for the state-proposed floating offshore wind research array in federal waters also includes a requirement for a Project Labor Agreement.

5.2.1.4 Recommendations for Prevailing Wage

- To launch a new skilled workforce dedicated to offshore wind development, California should offer highly competitive prevailing wage hourly rates/salaries, especially in the critical job sector of Technicians/Trades and Construction/Assembly. As provided in Table 5-1 above, California is well-positioned to offer upper bound rates/salaries for some skilled labor occupations, but the state should carry forward this trend with recruiting already skilled workers to the new offshore wind workforce. Offering upper bond rates/salaries will attract workers from other existing industries and geographies and provide California with the jump start it will need to develop the offshore wind workforce relatively quick.
- As noted in Section 3.6 above, some significant gaps are present in California's existing workforce versus the expected need for the offshore wind workforce, specifically for:
    - Miscellaneous Plant and System Operators
    - Tank Care, Truck, and Ship Loaders
    - Forging Machine Setters, Operators, and Tenders (Metal and Plastic)
    - Wind Turbine Service Technicians
    - Engine and Other Machine Assemblers

  Offering upper bound prevailing wages specifically for these occupations will help close the gap in the needed skills by recruiting out-of-state or out-of-industry workers with the necessary skills and experience.

5.2.2 Workforce Skills

Workforce skills pertain to the education, training, capabilities, and applied learning that workers develop and maintain to perform specific occupational tasks. As discussed in Section 3.5 above, California's new offshore wind workforce will require a wide range of occupation types and skill sets. For example, a study conducted by the Workforce Development Institute (WDI) found that an estimated 74 occupations were required to develop an offshore wind power plant, highlighting the required diversity of the technical workforce.[31] To illustrate the distribution of expected workers by the occupational sector of California's floating offshore wind workforce, Figure 5-1 provides a breakdown of workforce information developed by NREL/BOEM and BVG Associates.[32,33] As observed, a concentration of new jobs are

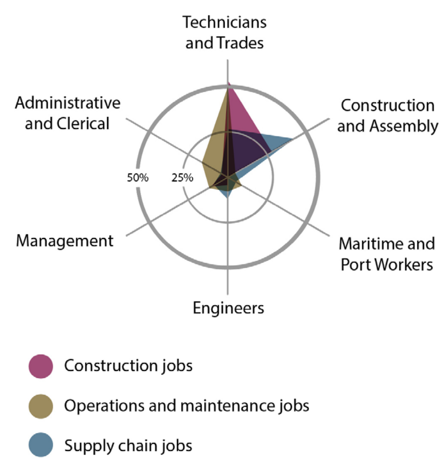


Figure 5-1: Distribution of Workforce by Occupational Sector

[31] Workforce Development Institute. 2017. New York State and the Jobs of Offshore Wind Energy. Available online at: https://wdiny.org/Portals/0/New%20York%20State%20and%20The%20Jobs%20Of%20Offshore%20Wind%20Energy_%20WDI2017.pdf?ver=2017-05-03-150746-023

[32] NREL. October 2022. U.S. Offshore Wind Workforce Assessment. Available online at: https://www.nrel.gov/docs/fy23osti/81798.pdf

[33] BVG Associates. 2017. U.S. Job Creation in Offshore Wind. Available online at: https://www.cesa.org/wp-content/uploads/US-job-creation-in-offshore-wind.pdf

anticipated to occur in the Technicians and Trades and Construction/Assembly sectors.

As purported by industry/training stakeholders during interviews conducted on workforce training, safety, and standards (Section 4), establishing standards for worker skills will provide a solid foundation for implementing workforce safety and quality of build. While it is recognized that construction workers will be subject to federal jurisdiction while working at sea (three or more miles off the coast), those positions related to supply chain, manufacturing, transportation, and other on-shore activities will be subject to state-level standards. One relevant precedent is the California state law (SB 54) mandating a “skilled and trained workforce” in private sector construction or maintenance work in refineries—meaning that a specified share of workers must be either enrolled in or have graduated from a specified list of state-certified apprenticeship programs.[34]

5.2.2.1 Types of Skills Needed for Each Phase of Offshore Wind Development

The Workforce Development Institute (WDI) performed an analysis of New York’s offshore wind workforce and derived a list of common skills utilized for offshore wind development. Albeit fixed bottom facilities, these worker skillsets are representative of floating offshore wind development as well. Table 5-2 below provides a list of the common technical, soft, safety, and offshore-specific skills identified by WDI.

Table 5-2: Common Technical, Soft, Safety, and Offshore-Specific Skills

Skill Category	*Specific Skills*
Technical Skills	Carpentry
	Composites/advanced materials
	Data analysis
	Diving
	Energy resource management
	Experience with power plant, renewable energy, and electrical grid projects
	Experience with wind power plants, land-based or offshore
	Hydraulics
	Logistics
	Machining
	Proficiency with office productivity software
	Rigging and materials handling
	Understanding of electromechanical systems
	Welding
Soft Skills	Ability to lead and motivate staff
	Ability to work independently and in groups
	Analytical thinking
	Working at heights
	Working on open water
	Commitment to the job
	Continuous quality and process improvement
	Customer service

[34] California Senate Bill 54. 2012. Hazardous Materials Management. Available online at: http://www.leginfo.ca.gov/pub/13-14/bill/sen/sb_0051-0100/sb_54_bill_20131013_chaptered.htm

	Physical stamina
	Strong written, verbal, and interpersonal communication
	Troubleshooting
Safety and Offshore Specific Skills	Advanced Rescue
	Vessel fleet coordination
	Familiarity with offshore safety standards and USCG protocols
	Fire Awareness/Fire fighting
	First Aid
	Marine Safety Training
	Regional Compliance/OSHA 10
	Saturation Diving
	Sea Survival
	Strong understanding of safety and health standards
	Weather prediction/meteorology

Source: Workforce Development Institute (WDI). 2017. New York States and the Jobs of Offshore Wind Energy. Available online at: https://wdiny.org/Portals/0/New%20York%20State%20and%20The%20Jobs%20Of%20Offshore%20Wind%20Energy_%20WDI2017.pdf?ver=2017-05-03-150746-023

Guidehouse utilized the NREL Jobs and Economic Development Impact (JEDI) model to breakdown the type of skilled workers needed for each phase of offshore wind development and for each offshore wind energy component. Table 5-3 below provides a summary of the JEDI model results and applies WDI's list of common skills needed for each level of skilled workers. While *soft skills* (i.e., analytical thinking; physical stamina; commitment to the job; etc.) will be an important factor in cultivating a high-quality workforce, those skills will be ubiquitous to the entire workforce at all phases of offshore wind development.

Table 5-3: Skills Needed Per Phase of Offshore Wind Development (By Offshore Wind Component)

OSW Phase	*OSW Component*	*Skilled Workers Needed*	*Common Skills Needed*
Manufacturing, Supply Chain, and Support Services	Ports and Staging	• Tugboat Operators • Components Mobilization Vessel Operators • Dockworkers	• Logistics • Equipment operation • Rigging and materials handling • Vessel coordination
	Onshore Transmission	• Heavy Equipment Operators • Electricians • Lineworkers	• Logistics • Electromechanical systems • Machining • Welding • Equipment operation • Carpentry
	Foundation (Steel)	• Steel workers • Welders	• Logistics • Welding • Machining • Equipment operation • Carpentry
	Foundation (Concrete)	• Ready-Mix Concrete Manufacturers • Concrete Casting workers	• Logistics • Hydraulics • Equipment operation

	Towers and Blades	• Fiberglass Molding Workers • Assembly Workers	• Logistics • Welding • Machining • Equipment operation • Composites/advanced materials
	Nacelle	• Steel Casting and Forming • Fiberglass Molding Workers	• Logistics • Welding • Equipment operation • Machining • Composites/advanced materials
Construction, Installation, and Development	Array and Export Cabling	• Cable Layers • Cable Laying Vessel Operators • Deckhands	• Diving • Marine Safety • Vessel Fleet Coordination • Equipment operation • Rigging and materials handling
	Turbine	• Crane Operators • Tugboat Operators • Millwrights • Deckhands	• Marine Safety • Vessel Fleet Coordination • Equipment operation • Rigging and materials handling • Carpentry • Welding • Electromechanical systems
	Foundation	• Heavy Lift Vessel Operators • Mooring System Installers • Anchor Handling Vessel Operators • Deckhands	• Diving • Marine Safety • Vessel Fleet Coordination • Equipment operation • Rigging and materials handling • Carpentry • Welding
Operations and Maintenance	Technicians and Management	• Maintenance and Inspection, Service Operating, and Crew Transfer Vessel Operators • Heavy Lift Vessel Operators • Maintenance and Repair Technicians • Tugboat Operators	• Marine Safety • Vessel Fleet Coordination • Equipment operation • Rigging and materials handling • Carpentry • Welding • Electromechanical systems
	Supply Chain and Support Services	• Supply Vessel Operators	• Vessel Fleet Coordination • Logistics

Source: WDI, 2017; Guidehouse, 2022.

5.2.2.2 Recommendations for Workforce Skills

- While construction and operations/maintenance skills are a critical element of developing California's offshore wind workforce, nearly 2/3rds of the jobs will be the supply chain. It is recommended that California institute a diverse and robust skills training program specifically geared towards offshore

wind manufacturing/supply chain, construction and operations/maintenance, in addition to providing the new skills required for open ocean transport, construction, and operation.
- Recruiting skilled workers from other industries or out-of-state is a viable labor source, especially workers that have been trained in offshore wind on the East Coast. It is recommended that California supplement its offshore wind construction workforce with experienced technicians and trades workers that already have advanced training and skills.
- California DIR should engage offshore wind developers, manufacturers, and training entities to review specific trainings required for the manufacturing and development of wind energy components, and also adopt technical, health, and safety training programs established by industry trade groups and training enterprises (i.e., GWO training standards). This would be in addition to the existing federal (USGC) requirement that all offshore workers attain certification under the Standards of Training, Certification, and Watchkeeping for Seafarers.[35]

5.2.3 Workforce Training Standards

Establishing workforce training standards is a critical element in integrating advanced safety practices, quality of build, and assurance to the offshore wind industry that California offers a skilled, competent, and available workforce capable of manufacturing, fabricating, transporting, constructing, and maintaining floating offshore wind facilities.

5.2.3.1 Training Requirements

As discussed in Section 3 above, California's offshore wind workforce will require a diverse set of occupations and skill sets to facilitate all phases of development. Table 5-4 below provides a snapshot of the likely required level of education, certification, or credential for most occupations in the offshore wind workforce. This table illustrates that worker training will need to occur at all levels of education and certification and also demonstrates that the majority of occupations will require some form of post-secondary education/training (i.e., Bachelor's degree; apprenticeship; technical certification) to obtain the necessary skills for the offshore wind workforce. California will need to develop training infrastructure (i.e., curriculum, facilities, faculty) to help launch and sustain this industry (see Section 5.4).

Table 5-4: Likely Required Level of Education, Certification, or Credential of Offshore Wind Workforce

Occupational Group	Occupation	SOC	Likely Required Level of Education, Certification, or Credential
Administrative and Clerical	Administrative Service Managers	11-3012	Bachelor's Degree
	Bookkeeping, Accounting, and Auditing Clerks	43-3031	High School Diploma or Equivalent
	Compliance Officers	13-1041	Bachelor's Degree
	Human Resources Workers	13-1071	Bachelor's Degree
	Sales Representatives, Wholesale and Manufacturing	41-4012	Bachelor's Degree
	Secretaries and Administrative Assistants	43-6014	High School Diploma or Equivalent
Construction & Assembly	Cement Masons, Concrete Finishers, and Terrazzo Workers	47-2051	Apprenticeship; Post-Secondary or Technical Certification
	Construction Equipment Operators	47-2073	Apprenticeship; Post-Secondary or Technical Certification
	Construction Laborers	47-2061	Apprenticeship; Post-Secondary or Technical Certification

[35] U.S. Coast Guard. 2021. The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers. Available online at: https://www.dco.uscg.mil/nmc/stcw/

	Crane and Tower Operators	53-7021	Apprenticeship; Post-Secondary or Technical Certification
	Engine and Other Machine Assemblers	51-2031	Apprenticeship; Post-Secondary or Technical Certification
	Hoist and Winch Operators	53-7041	Apprenticeship; Post-Secondary or Technical Certification
	Industrial Machinery Installation, Repair, and Maintenance Workers	49-9041	Apprenticeship; Post-Secondary or Technical Certification
	Laborers and Freight, Stock, and Material Movers (Hand)	53-7062	Apprenticeship; Post-Secondary or Technical Certification
	Mining Machine Operators	47-5041	Apprenticeship; Post-Secondary or Technical Certification
	Miscellaneous Assemblers and Fabricators	51-2090	Apprenticeship; Post-Secondary or Technical Certification
	Misc. Electrical and Electronic Equipment Mechanics, Installers, and Repairers	49-2093	Apprenticeship; Post-Secondary or Technical Certification
	Operating Engineers and Other Construction Equipment Operators	47-2073	Apprenticeship; Post-Secondary or Technical Certification
	Painting Workers	51-9123	Apprenticeship; Post-Secondary or Technical Certification
	Reinforcing Iron and Rebar Workers	47-2171	Apprenticeship; Post-Secondary or Technical Certification
	Tank Car, Truck, and Ship Loaders	53-7121	Apprenticeship; Post-Secondary or Technical Certification
	Training and Development Specialists	13-1151	Apprenticeship; Post-Secondary or Technical Certification
	Welding, Soldering, and Brazing Workers	51-4122	Apprenticeship; Post-Secondary or Technical Certification
Engineers	Drafters	17-3011	Bachelor’s Degree
	Electrical and Electronics Engineers	17-3023	Bachelor’s Degree
	Industrial Engineers, Including Health and Safety	17-2112	Bachelor’s Degree
	Ship Engineers	17-2199	Bachelor’s Degree
Management	Computer and Information Systems Managers	11-3021	Bachelor’s Degree
	First Line Supervisors of Mechanics, Installers, and Repairers	49-1011	Bachelor’s Degree
	First-Line Supervisors of Production and Operating Workers	51-1011	Bachelor’s Degree
	General and Operations Managers	11-1021	Bachelor’s Degree
	Marketing and Sales Managers	11-2021	Bachelor’s Degree
	Purchasing Managers	11-3061	Bachelor’s Degree
	Transportation, Storage, and Distribution Managers	11-3071	Bachelor’s Degree
Maritime and Port Workers	Captains, Mates, and Pilots of Water Vessels	53-5021	Apprenticeship; Post-Secondary or Technical Certification
Technicians and Trades	Chemical Processing Machine Setters, Operators, and Tenders	51-9011	Apprenticeship; Post-Secondary or Technical Certification
	Computer Control Programmers and Operators	51-9161	Apprenticeship; Post-Secondary or Technical Certification
	Engineering Technicians, Except Drafters	17-3029	Apprenticeship; Post-Secondary or Technical Certification
	Forging Machine Setters, Operators, and Tenders, Metal and Plastic	51-4022	Apprenticeship; Post-Secondary or Technical Certification
	Industrial Truck and Tractor Operators	53-7051	Apprenticeship; Post-Secondary or Technical Certification
	Inspectors, Testers, Sorters, Samplers, and Weighers	51-9061	Apprenticeship; Post-Secondary or Technical Certification
	Metal Furnace Operators, Tenders, Pourers, and Casters	51-4051	Apprenticeship; Post-Secondary or Technical Certification
	Miscellaneous Metal Workers and Plastic Workers	51-4199	Apprenticeship; Post-Secondary or Technical Certification
	Miscellaneous Plant and System Operators	51-8090	Apprenticeship; Post-Secondary or Technical Certification
	Structural Iron and Steel Workers	47-2221	Apprenticeship; Post-Secondary or Technical Certification

	Structural Metal Fabricators and Fitters	51-2041	Apprenticeship; Post-Secondary or Technical Certification
	Surveying and Mapping Technicians	17-3031	Apprenticeship; Post-Secondary or Technical Certification
	Wind Turbine Service Technicians	49-9081	Apprenticeship; Post-Secondary or Technical Certification

Source: BVG. 2017. US Job Creation in Offshore Wind.

U.S. Bureau of Labor Statistics (BLS). May 2021. State Occupational Employment and Wage Estimates for California.

Workforce Development Institute (WDI). 2017. New York State and the Jobs of Offshore Wind Energy.

As discussed at the beginning of Section 5, California's purview for implementing workforce training standards will primarily occur in the supply chain phase, whereas BSEE will oversee construction on California's OCS. Regardless of regulatory entity, workers throughout the offshore wind workforce will require specific types of training to perform their occupations. As observed in occupational cross-section provided in Table 5-4 above, a wide range of occupations will be required for the offshore wind workforce, meaning that a wide range of training types and curriculums will also be required to safely and effectively field the workforce. Some of these training assets and curriculums are already in place, especially for supply chain entities (manufacturing, fabrication, logistics; see Section 5.4 below). Furthermore, the East Coast's burgeoning offshore wind industry provides a template for training types, assets, and curriculums. While not completely comprehensive, Table 5-5 below provides a snapshot of the training types being practiced and instituted on the East Coast specifically for offshore wind.

Table 5-5: Types of Training Per Offshore Wind Phase

OSW Phase	Type of Training
Supply Chain	Workplace and Occupational Safety and Health
	Safety and Health Compliance
	Manufacturing Systems Training
	Equipment/Machinery Operation
	Soft Skills Development (Communications, Leadership, Teamwork, Ethics, Time Management, Problem Solving, Adaptability, etc.)
	Quality Assurance/Quality Control
	Access, Diversity, Equity, and Inclusion Training
	Sales and Customer Service
	Technical and Trade Skills (Fabrication, Fitting, Testing, Welding, etc.)
Construction and Installation	Wind Energy Systems
	Electrical Systems Management
	Permitting and Compliance
	Maritime Safety and Health
	Safety and Health Compliance
	Working At Heights
	Working on Open Ocean
	Technical and Trade Skills (Electrical, Installation, Fitting, Testing, Welding, etc.)
	Advanced Rescue
	Confined Spaces, Safe Access, and Limited Access
	Vessel Operation and Fleet Management
	Rigging and Materials Handling
Operations and Maintenance	Component Repair (Blades, Turbine, Cabling, etc.)

	Wind Energy Systems
	Electrical Systems Management
	Maritime Safety and Health
	Safety and Health Compliance
	Working At Heights
	Working on Open Ocean
	Advanced Rescue
	Confined Spaces, Safe Access, and Limited Access
	Vessel Operation and Fleet Management
	Rigging and Materials Handling
	Facility Decommissioning

Sources: Arcon Training Center. Courses. Available online at: https://www.arcontraining.com/gwo-offshore-basic-safety- training

GWO. 2022. GWO Training Standards. Available online at: https://www.globalwindsafety.org/trainingstandards/trainingstandards

DOE Office of Energy Efficiency and Renewable Energy. 2023. Workforce Training and Education. Available online at: https://windexchange.energy.gov/training

Maersk. 2023. Renewables. Available online at: https://www.maersktraining.com/renewables/

National Offshore Wind Institute. 2022. NOWI Training Services. Available online at: https://nowi.org/nowiservices.html

NYSERDA. 2023. Training Opportunities in Offshore Wind. Available online at: https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/Supply-Chain-Economic-Development/Workforce-Development

University of Delaware. 2018. Offshore Wind Skills Academy. Available online at: https://www.pcs.udel.edu/wind/

Several training entities offer training curriculums specifically geared towards the offshore wind industry. BW Research Partnership analyzed Massachusetts' offshore wind workforce training practices and identified the following training entities and certifications provided in Table 5-6. Certification programs serve an important role in workforce development and serve as a post-secondary education/training mechanism that can install the necessary skills under the instruction and supervision of industry experts, academics, and professionals. Certification programs are offered by a wide range of entities, including government entities (i.e., U.S. Coast Guard, OSHA), academia (universities, community colleges), and professional training outfits, however, as discussed in the section below, the Global Wind Organization (GWO) has established training standards specifically for offshore wind occupations and partnered with specific training entities to offer an industry-approved set of training requirements.

Table 5-6: Common Types of Offshore Wind Certifications

Training Entity	*Description of Training/Certification*
U.S. Occupational Safety and Health Administration (OSHA) Certificates	The Occupational Safety and Health Administration has established industry-recognized curricula for general and specific safety trainings of manufacturing, installation, and O&M workers. Certification programs are widespread and hosted by third-party institutions. Common certifications needed in the OSW industry include 10-Hour Training for General Industry, Confined Space Entry Training, and Fall Protection. To note, BSEE has established itself as the primary workforce safety regulator for construction and operations tasks conducted offshore but is still in the process of developing standards or training curricula.
Global Wind Organization (GWO) Certificates	The Global Wind Organization (GWO) had developed a certification for the onshore and offshore wind industries. The training providers are certified by third-party certification bodies, with 12 training providers currently certified in North America. RelyOn Nutec (working with Mass Maritime Academy) and Maersk Training (working with Bristol Community College) are the two largest GWO-certified training providers worldwide. Certificates include Basic Safety Training, Basic Technical Training, and Blade Repair, among others.
Lean Six Sigma Certificates	The American Quality Society is the principal certifying agency for Lean Six Sigma Green and Black Belt certificates, which focus on team collaboration and efficiency. Six Sigma training is offered through universities, community colleges, for-profit, and not-for-profit businesses, and organizations and is generally readily available.
Certified Composites Technician (CCT) Certificates	CCT certification – both Open Molding and Wind Blade Repair – is offered through the American Composites Manufacturers Association. It is widely recognized in the composites industry for the production and/or management personnel working with or producing composite components, such as blades, or nacelle and rotor housings.
International Organization for Standardization (ISO) Certificates	ISO has developed global industrial and commercial standards. Third-party training providers host courses on relevant standards like quality management systems (9001) and the newly developed offshore wind energy (29400) standards.
QC Inspector Certificates	QC Inspector certification is needed for welding inspection throughout the turbine construction and installation processes. The American Welding Society offers QC Inspector certification, and MassDOT offers Field Weld Inspection certification.
U.S. Coast Guard (USGC) Certificates	The United States Coast Guard is the primary worker safety regulator for OSW vessels. They offer certificates and training curricula in accordance with the international Standards of Training, Certification and Watchkeeping (STCW), as well as Captain's licensure.

Source: BW Research Partnership. September 2021. Offshore Wind Workforce Training and Development in Massachusetts. Available online at: https://files-cdn.masscec.com/reports/MassCEC%20OSW%20Workforce%20Final%20Report_Sept%202021.pdf

5.2.3.2 The Role of Industry Standards – Global Wind Organization

GWO is widely recognized as the industry standard for offshore wind training. The GWO is a non-profit organization created by the offshore wind industry, specifically wind turbine manufacturers and owners/operators.[36] GWO released its first offshore wind guidance in the Basic Safety Training Standards in 2012 and followed up with the Basic Technical Training Standards in 2017. GWO has refined its standards as the offshore wind industry evolves and publishes training standards for:

[36] GWO. 2022. About GWO. Available online at: https://www.globalwindsafety.org/about/about

- Advanced Rescue
- Basic Safety
- Blade Repair
- Control of Hazardous Energies
- Enhanced First Aid
- Wind Technician
- Lift Training
- Slinger Signaler
- Limited Access Training[37]

GWO contends that "*Any individual with a GWO certificate in the Wind Industry Database (WINDA) is considered competent and knowledgeable according to the learning objectives of that standard. GWO members accept the certificate as confirmation the individual possesses the required knowledge and competences as described in the standard*."[38] This cross-cutting understanding amongst GWO members, which is fairly comprehensive of all turbine manufacturers in the world, provides industry's preferences for the level of training offshore wind workers should acquire. Furthermore, taking from the interviews conducted (Section 4), industry expects insurance companies to require that all offshore construction workers have training that meets GWO standards.[39] Presently, only one GWO training provider is located in California – the High Plains Technology Center by Pearce Renewables in Tehachapi, California.[40] This limitation is a potential gap in workforce development in California as industry will continue to prefer workers trained to GWO standards.

5.2.3.3 High Road Training Partnerships

While the winners of the BOEM auction process are awarded development rights solely on price criteria, state and local governments can adopt policies and practices that optimize high-road economic impacts. California could utilize its existing toolbox of climate workforce policies as levers over permitting, port siting and reconstruction, and transmission planning. Notably, the California Workforce Development Board (CWDB) submitted the report, "*Putting California on the High Road: A Jobs and Climate Action Plan for 2030,*" pursuant to Assembly Bill 398.[41] The report offers a vision for integrating high road economic and workforce development strategies into major climate policies and programs. It focuses on issues of job quality and economic equity in assessing the impacts of climate measures on employment and training and emphasizes strategies to ensure disadvantaged communities and workers realize the economic gains generated by work to stabilize the climate. Furthermore, the report aligns with California's Unified Strategic Workforce Development Plan, which emphasizes job quality, equity, and climate resilience as pillars of a high road vision for the economy and workforce. In addition, this report identifies opportunities to use PLAs, CWAs, and CBAs. Note that not all CBAs follow a commonly accepted standard, as proved in November 2018 when the wind developer

---

[37] GWO. 2022. GWO Training Standards. Available online at: https://www.globalwindsafety.org/trainingstandards/trainingstandards

[38] *Ibid.*

[39] Interview with Mr. Alex Obell – Head of Business Development for Maersk Training. October 14, 2022.

[40] GWO. 2022. Find A Training Provider. Available online at: https://www.globalwindsafety.org/trainingproviders/findttraningprovider

[41] California Workforce Development Board. 2020. Putting California on the High Road: A Jobs and Climate Action Plan for 2030. Available at: https://cwdb.ca.gov/wp-content/uploads/sites/43/2020/09/AB-398-Report-Putting-California-on-the-High-Road-ADA-Final.pdf. Accessed January 4, 2023.

Castle Wind signed a deal with the City of Morro Bay related to a 1 GW offshore wind farm that the company had proposed nearby.[42] The deal, which both sides termed a "Community Benefits Agreement," made a number of non-specific, non-binding promises for local economic benefits. The deal was atypical of most CBAs as it did not include mention of prevailing wage or joint apprenticeship programs, make any binding commitments to hire local residents or members of disadvantaged communities, or did it incorporate any other commonly accepted elements of a CBA. A subsequent Memorandum of Understanding between Castle Wind and with Monterey Bay Community Power (MBCP) to provide up to 1 GW of power — almost the entire output of the wind farm — did not include a binding commitment to labor standards or community hiring, although recent MBCP power purchase agreements have included a prevailing wage requirement.[43]

High-Road Training Partnerships (HRTP) are a new state program of industry-specific training programs that prioritize job quality, equity, and environmental sustainability. Through the San Luis Obispo County Office of Education, industry leaders and workers are coming together to create a model for high road labor practices and community engagement for the upcoming CADEMO project. As part of this project, CADEMO has reached agreement with California's labor unions to build and operate the state's first offshore wind project with a union workforce. Under the agreement, announced in November 2022, the CADEMO project will partner with the State Building and Construction Trades Council of California and covers all of CADEMO's contractors and subcontractors that will perform construction, assembly, installation, and maintenance on the four-turbine, 60 MW project in state waters off Vandenberg Space Force Base in Santa Barbara County. This agreement is likely to serve as a standard framework for PLAs for offshore wind in the state of California moving forward.

5.2.3.4 Workforce Training Case Studies

The state of California has a unique opportunity to develop its workforce training requirements/programs using knowledge gained from successful strategies on the East Coast and continued assessments made by NREL.[44] The case studies described below provide a framework that can be adjusted and built upon to meet the demands of workforce training in California's soon-to-be burgeoning floating offshore wind industry.

This Assessment reviewed the status of workforce training in seven states on the East Coast (e.g., New Jersey, New York, Connecticut, Massachusetts, Rhode Island, North Carolina, Virginia) and summarized the key elements of their workforce training strategies. Each state took a unique path to address workforce training, despite their differences there are key principles that each used to move their workforce training from theory to practice. These correlated principles could serve as guidance in establishing California's workforce training goals and standards.

New Jersey

---

[42] Morro Bay City Council. 2018. "Community Benefit Agreement between City of Morro Bay and Castle Wind, LLC". Available: https://www.morro-bay.ca.us/ArchiveCenter/ViewFile/Item/4820. Accessed: December 6, 2022.

[43] Castle Wind. 2019. "Castle Wind and Monterey Bay Community Power Sign Agreement in Anticipation of Offshore Wind Project off the Coast of Morro Bay," Castle Wind Offshore (blog), August 16, 2019. Available: http://castlewind.com/castle-wind-and-monterey-bay-community-power-sign-agreement-in-anticipation-of-offshore-wind-project-off-the-coast-of-morro-bay/; Monterey Bay Community Power, "Renewable Power Purchase Agreement," October 10, 2018, https://mbcommunity.onbaseonline.com/1800AgendaAppNet/Documents/ViewDocument/Attachment%20for%20Adopt%20Resolution%20Authorizing%20the%20CEO%20to%20Execute%20a%2015-Year%20Power.pdf?meetingId=199&documentType=Agenda&itemId=1792&publishId=2004&isSection=false.

[44] NREL. 2022. U.S. Offshore Wind Workforce Assessment – Section 3.2 (Education and Training). Available online at: https://www.nrel.gov/docs/fy23osti/81798.pdf

In August 2019, Governor Murphy signed Executive Order No. 79, establishing a Council for the Wind Innovation and New Development Institute, charged with developing and implementing a plan to create a regional hub for New Jersey's burgeoning offshore wind industry and build upon the Murphy Administration's commitment to making New Jersey a national leader in offshore wind. The New Jersey Economic Development Authority (NJEDA), as part of its effort to develop the Wind Institute, is working closely with New Jersey Board of Public Utilities (NJBPU) and New Jersey Department of Labor (NJDOL) to support offshore wind industry workforce training and education by including more offshore wind-specific modules in traditional training and trades programs and directing funding towards launching offshore wind-specific workforce programs. For example, New Jersey has a strong welding workforce, and most current welding training programs focus on what is known as MIG, TIG, or stick welding. However, large-scale steel component manufacturing, such as the fabrication of steel foundations known as monopiles that EEW Offshore Structures will produce in Paulsboro, NJ, require an additional type of welding known as submerged arc (subarc) welding. To address this need, NJEDA is providing funding to local vocational schools to expand their welding training programs to include subarc welding for both high school and post-secondary students.

NJEDA, in collaboration with NJBPU, NJDOL and Office of the Secretary of Higher Education (OSHE), has funded additional offshore wind-specific training programs including Atlantic Cape Community College's construction of a Global Wind Organization (GWO) Basic Safety and Sea Survival facility, Rowan College of South Jersey's development of stackable offshore wind turbine technician training programs, and the creation of a Wind Institute Fellowship Program for students at Rutgers University, Rowan University, Montclair State University and New Jersey Institute of Technology.[45] Additional programs are currently in development at other schools and labor unions, including a Protected Species Observer program at Stockton University and an underwater welding program operated by the Eastern Atlantic States Regional Council of Carpenters.

The New Jersey Wind Institute for Innovation and Training capitalizes on the resources of its research universities in order to build a pipeline of industry experts in the offshore wind sector. Specifically, the New Jersey Economic Development Authority (NJEDA) announced plans to provide a total of more than $1 million to Rutgers University, Rowan University, Montclair State University, and New Jersey Institute of Technology (NJIT) to advance academic research and investment in offshore wind workforce training. In particular, the NJEDA Board authorized staff to enter into memoranda of understanding with the universities to develop both the New Jersey Wind Institute Fellowship Program (Fellowship Program) and the University Initiatives to Advance Offshore Wind (University Initiatives). In its pilot year, the Fellowship Program is expected to support 24 graduate and undergraduate students from diverse backgrounds and disciplines with stipends and resources as they conduct independent research on topics that will further offshore wind development in New Jersey. Selected students will participate as a cohort in workshops, site visits, and guest lectures with industry stakeholders and have the chance to present their research to government, academic and industry experts at the end of their fellowship. The University Initiatives will be designed to provide long-term, industry valued expertise for students, faculty, and staff. Potential initiatives can include new curriculum development, pre- and post-doctoral student positions, faculty training in offshore wind, or other activities that support offshore wind learning. The NJEDA will utilize funding from the New Jersey Board of Public Utilities (NJBPU) to fund both the Fellowship Program and the University Initiatives.

NJEDA's *New Jersey Wind Turbine Tech Training Challenge* is a competitive grant program to create educational opportunities for New Jersey residents seeking to enter the offshore wind industry. In collaboration with the NJEDA and the New Jersey Secretary of Higher Education, three academic partners, South Jersey labor unions

---

[45] New Jersey Economic Development Authority. 2022. New Jersey's Offshore Wind Workforce Assessment Through 2035. Available at: https://www.njeda.com/wp-content/uploads/2022/09/2022-NewJersey-OSW-Workforce-Assessment-Report.pdf. Accessed October 13, 2022.

and global training powerhouse, Maersk Training, Rowan College of South Jersey (RCSJ) will offer a Global Wind Organization (GWO) certified Basic Technical Training credential along with a Wind Turbine Technician Career Certificate program that will lead to a credit-bearing, stackable credential at the profession's entry level. RCSJ plans to launch its Basic Technical Training and Wind Turbine Technician certificate programs in January 2023. The Associate of Applied Science degree will follow in September 2023.

In addition, the NJEDA has developed an *Offshore Wind Workforce and Skills Development Grant Challenge* as a competitive funding opportunity that will award grants to launch or expand workforce development and skills training programs focused on strengthening and diversifying the New Jersey offshore wind workforce. A total of $3,725,000 will be available through this program, with individual awards ranging from a minimum of $100,000 to a maximum of $1,000,000. Priority in this grant challenge will be given to applicants that propose initiatives supporting training and job access for residents of Overburdened Communities. All applications must include at least one Community-Based Organization with demonstrated experience serving a New Jersey Overburdened Community, as defined by New Jersey's Environmental Justice Law. The Community-Based Organization must either be the primary applicant or a strategic collaborator with the primary applicant. This Grant Challenge is part of NJEDA's efforts to develop the Wind Institute for Innovation and Training.

Connecticut

Connecticut has several existing and effective workforce training programs that it uses to develop its workforce, not all of which are specific to OSW-specific jobs, but programs that could be effective at developing and expanding the supply chain. Workforce training programs are offered by the Connecticut Office of Workforce Strategy, as well as local Workforce Investment Boards. A model program administered by the Eastern Connecticut Workforce Investment Board is the Manufacturing Pipeline Initiative. This seven to ten-week training program has trained thousands of people and is a model being exported to other parts of the state and the nation. Another exemplary program is the Workforce Development Program Administered by the Aerospace Components Manufacturers Association. This is a 10-month course that teaches subjects from applied shop math through the machine operator process, quality controls and safety and supervisory requirements.

At the Community College level, the nine campuses of the Connecticut State Community Colleges offer a 24-week advanced manufacturing course. As part of those local programs, there is also the Center for Next Generation Manufacturing which is led by the Connecticut College of Technology.

Park City Wind, as part of its commitment to the State, is actively working to develop program and training opportunities, with a focus around the Bridgeport area. They are developing a partnership with Goodwin University to develop a program focus on O&M activities associated with OSW farms. Park City Wind is also developing partnerships with local high schools and community colleges for their advanced manufacturing training to expand those programs towards offshore wind-related engineering. Housatonic Community College has one such program that offers a certificate for a OSW technicians.

Further, Connecticut's recent Public Act 19-71 for purchase of energy from offshore wind encourages use of apprenticeship training programs.

Massachusetts

The Massachusetts Clean Energy Center (MassCEC) has recognized the benefits of preparing a local workforce to develop offshore wind farms in-state and beyond, investing $2 million—alongside Vineyard Wind and Mayflower Wind, the Commonwealth's second project—to support offshore wind technical training and career development programs for Massachusetts residents. The funding includes specific contributions to the International Brotherhood of Electrical Workers (IBEW) Local Union #223 and the Piledrivers and Divers Local Union #56. Local 56—the predominant provider of marine construction labor in the Northeast—has used the funds to sponsor member participation in the Global Wind Organization's Basic Safety Training program, a necessity for offshore wind labor. IBEW Local 223 is partnering with offshore wind cable supplier, JDR Cables, to establish an electrician training program for offshore work at their training facility in Taunton, Massachusetts.

In cooperation with Maersk Training, Bristol Community College has developed the National Offshore Wind Institute (NOWI) to offer a hub for offshore wind workforce training and certification. NOWI provides workforce training in both the construction of offshore wind facilities and supply chain skills, implementing a more holistic approach to workforce training. The training curriculum at NOWI is guided by Maersk Training, which unlike US based firms, has more than 40 years experience training workers in the onshore and offshore wind energy industries. Partnering with an industry stalwart such as Maersk allows workers to obtain training from an outfit that can bring global experience, including the implementation of European training/safety standards, to US workers.

New York

In a collaborative funding effort, NYSERDA, Stony Brook University, and SUNY's Farmingdale State College invested $20m in developing a new training center focused on offshore wind energy. This represents the largest public investment in offshore workforce development in the U.S. to date. The Offshore Wind Training institute (OWTI) will seek "to advance offshore wind training programs and the educational infrastructure needed to establish a skilled workforce that can support the emerging national offshore wind industry" (NYSERDA 2022). This training center will not only support New York in its endeavor to install 9GW of offshore wind by 2030 but also serve as an asset for the greater East Coast's offshore wind workforce. The OWTI alone with certify and train upwards of 2,500 New York workers in 2022 to be deployed on onshore and offshore wind projects (NYSERDA 2022).

In addition to Farmingdale State College's investment in the OWTI, the college partnered with General Electric (GE) Renewable Energy to offer a 5-week Wind Turbine Technical Training free of charge. The training taught basic technical skills in a hands-on intensive training for wind turbine operation and maintenance, motor components and controls, and safety, hand tools, and test equipment.

Using funds from the $20 million OWTI invest fund NYSERDA has awarded a combined $569,618 to two community colleges (CC) in New York to support early training and skills development for disadvantaged communities. Hudson Valley CC, in Troy NY will provide a two-year associates degree providing partial and full scholarships to urban and rural disadvantaged communities. The program partners with manufacturers to provide a career pipeline and LaGuardia CC in Queens, NY has partnered with Siemens Gamesa to train fifty low-income individuals from the Brooklyn-Queens area to become offshore wind technicians.

Through Sunrise Wind a joint venture of Orsted, the leading U.S. clean energy company and the New England based Eversource energy company have invested $10 million dollars to fund the National Workforce Training Center (NWTC). The nations first training facility dedicated to the U.S. offshore wind workforce. The center will focus on providing training particularly for high school and college-age individuals. NWTC will be hosted by Suffolk County Community College in Long Island. The facility was created in partnership with the Long Island Federation of Labor-AFLCIO, the Nassau and Suffolk Building and Construction Trades, Suffolk County Community College, International Brotherhood of Electric Workers, the Utility Workers Union of America, BlueGreen Alliance and Minority Millennials. The NOWTC is expected to train thousands of workers under Global Wind Organization (GWO) training standards for offshore wind. In addition, NOWTC will offer curriculum and support services for entryways into pre-apprenticeship training for the construction industry as well as manufacturing certifications that will benefit regional employment.

The Governor of New York Kathy Hochul launched a $9 million solicitation through OWTI for proposals on new workforce development and training from technical/ high schools, community colleges, universities, unions, training and job placement intermediaries, community-based organizations, and non-profit organizations. The goal is to expand offshore wind workforce development and training initiatives to address workforce gaps and prepare New Yorkers for high-growth jobs in the wind power industry.

Lastly, with a grant from the New York State Clean Energy Center the Maritime College, State University of New York has created the Center of Excellence for Offshore Energy. The center provides in-person and online courses for offshore renewable energy for credit and non-credit leading to certificates and degrees. The courses focus on wind operations, offshore vessel operations, and offshore energy production, installation, and maintenance.

Rhode Island

Rhode Island boasts the first offshore wind farm in the country, Block Island. Block Island Wind Farm established the state's existing skilled offshore workforce and leveraged this to partner the Community College of Rhode Island with the GWO to offer GWO's Basic Safety Training (BST), which is a five-module industry standard safety certification.

In addition, the state has invested in preparing for the demands of future offshore wind projects through exposing middle school and high school students to its growing offshore wind industry. Specifically, the Jobs RI's WindWinRI program exposes middle school students to opportunities in offshore wind and offers high school certificate programs. The program also develops post-secondary education pathways, supports incumbent, underemployed, and unemployed workers, as well as works with Industry and educational partners.

North Carolina

In June 2021, North Carolina governor Cooper signed Executive Order 218, Advancing North Carolina's Economic and Clean Energy Future with Offshore Wind. The executive order established the North Carolina Taskforce for Offshore Wind Economic Resource Strategies (NC Towers). The taskforce provides expert advice to the Governor, identifying economic and workforce opportunities, supply chain, infrastructure, and support of environmental justice and equitable access to opportunities for underserved communities within offshore wind (North Carolina Department of Commerce, 2021).

North Carolina has won two BOEM held offshore wind auctions for the Carolina Long Bay area. The win allows France's TotalEnergies Renewables USA, LLC and Charlotte, North Carolina's Duke Energy Renewables to develop an area of more than 110,000 acres. If fully developed, the leases could result in about 1.3 gigawatts of offshore wind energy, enough to power about 500,000 homes. BOEM, the agency overseeing the lease auction included a new 20 percent credit for bidders that committed to a monetary contribution to programs or initiatives that support workforce training programs for the offshore wind industry, development of a U.S. domestic supply chain for the offshore wind energy industry, or both. This credit will result in $42 million for these critical programs or initiatives (USDI, 2022).

The contributions can go toward workforce training and/or domestic supply chain development and can be made in support of existing programs, or for the establishment of new programs or incentives associated with the planning, design, construction, operation, maintenance, or decommissioning of offshore wind energy projects, or manufacturing or assembling of their components, in the United States (USDI, 2022). BOEM requirements ensure the contributions and the entity receiving them are not the Lessee, its parent company, or affiliated companies. This stipulation ensures the contributions will help establish the offshore wind industry workforce and its supply chain in the United States. In addition, contributions must be made to private, public, or municipal corporations, companies, associations, partnerships, and other legal entities organized under the laws of any State of the United States, the District of Columbia, or any territory or insular possession subject to U.S. jurisdiction (USDI, 2022).

Virginia

In September 2020, former Virginia Governor Ralph Northam announced the creation of the Mid-Atlantic Wind Training Alliance (the Alliance). The Alliance is made up of host institution New College Institute and partners Centura College and the Mid-Atlantic Maritime Academy. The partnership provides courses certified by the GWO and National Center for Construction, Education, and Research. The courses focus on wind technician training important to Virginia and the Mid-Atlantic region's on and offshore industries. Programs will range from specific certifications to a year-long wind turbine technician program that bundles several industry-recognized certifications and prepares students to serve as certified installation technicians, inspectors, and maintenance technicians. The Alliance plans to start offering programs in early 2021 (Commonwealth of Virginia, 2020).

The partners of the Alliance represent a wide range of disciplines. Centura College has the largest welding training center in Virginia. The Mid-Atlantic Maritime Academy (MAMA) is the largest training center of the United States Coast Guard on the East Coast and holds engineering courses that are critical to the safe operation of the United States commercial fleet. New College Institute is a Commonwealth Higher Education Center that partners with industry and academia to provide post-secondary education, industry relevant workforce development and training opportunities in cutting-edge industries (Commonwealth of Virginia, 2020). Together they will help the Mid-Atlantic region develop and maintain a healthy offshore wind industry.

The Coastal Virginia Offshore Wind (CVOW) Project will be the largest offshore wind project in the U.S and the only project developed and owned by an electric utility (Dominion A, 2022). The 2.6-gigawatt project will have 176 800 ft wind turbines, three offshore substations, undersea cables, and new offshore transmission infrastructure to deliver clean energy to homes and businesses. The project will be completed in 2026.

The CVOW is supporting a well-trained and qualified workforce through education partnerships. Specifically, the Dominion Energy Charitable Foundation has provided grant funding to the National Energy Education Development (NEED) project. The NEED project produces K-12 education curriculum focused on energy. With Dominion Energy funding NEED has developed curriculum specific to offshore wind energy and holds workshops to familiarize teachers with the curriculum and provide hands-on learning classroom kits for student learning (Dominion B, 2022).

Dominion Energy is also working with the Hampton Roads Workforce Council, K-12 educators, community colleges, colleges and universities, North American Building Trades Union and their state affiliate, Virginia Building Trades, and other partners. The utility has partnered with Old Dominion University, the Tidewater Community College, and the Mid-Atlantic Wind Training Alliance. Together the collaborative hopes to build a pipeline for skilled trades, engineers, supply chain managers, and ship builders and repairers (Dominion C, 2022).

5.2.3.5 Recommendations for Workforce Training Standards

- Partnerships between industry, educational and training institutions, government entities, and community organizations have been key to addressing offshore wind energy workforce needs efficiently, effectively, and equitably. A common vision and curriculum amongst all training entities will allow for the development of a statewide offshore wind workforce that meets the technical, geographic, and timeline needs for anticipated wind projects.[46] Partnerships are also important to program development, curriculum building, and funding. Stakeholder buy-in also increases knowledge

[46] NREL. 2022. U.S. Offshore Wind Workforce Assessment. Available online at: https://www.nrel.gov/docs/fy23osti/81798.pdf

sharing, industry resiliency to future challenges, and allows for a more equitable workforce. Partnerships are also important for the development of internships and apprenticeships needed to give the workforce real on-the-job skills and training.

- California has an opportunity to leverage existing programs (i.e., California High Road Training Partnerships, etc.) to establish partnerships with industry leaders and use state funding to entice other potential supporting businesses. East Coast examples provide various frameworks for establishing training facilities such as the OWTI and NWTC in New York, which is funded through the state and industry partners, and facilitated through community colleges and university partnerships.
- NREL identified the most significant gap identified for offshore wind workforce development is creating a consensus on safety training standards.[47] Safety training standards affect ports and staging, maritime construction, and operations and maintenance. Filling this gap is paramount to workforce hireability and requires input from developers, training entities, community colleges, labor unions, vessel operators, etc. Standards established by GWO are an option for adoption, or at least an industry-led foundation to build upon. Once consensus is established on training standards, the standards need to be communicated to training facilities (i.e., community colleges, universities, union-led training programs, etc.) so workers have the necessary skills to enter the workforce.
- As industry prefers GWO training standards, it is advisable to increase the capacity and availability of GWO approved training providers. There is only one present in California currently and this could serve as a bottleneck to yielding a trained workforce.

5.2.4 Apprenticeship Programs

An apprenticeship is where workers earn a paycheck while learning on-the-job training to develop a skilled trade under the guidance of experienced workers and related classroom training.[48] These critical training programs provide the opportunity to unskilled entry-level workers to develop long-term careers in the trades and technical vocations. As an integral part of workforce development, apprenticeship programs have been a point of emphasis in federal and state legislation and labor policies.

The Inflation Reduction Act of 2022 (IRA), which was signed into law by President Joe Biden on August 16, 2022, emphasizes the goal of developing good-paying jobs. Among other things, the IRA provides beneficial changes to the tax credits available for renewable energy developers, including offshore wind developers. Specifically, the IRA includes a two-tier “base” rate and “increased” rate structure for renewable energy tax credits. The “increased” rate is worth five times the value of the base rate and is available if a project meets the prevailing wage and apprenticeship requirements. To meet the apprenticeship requirement, a certain percentage of the total labor hours for the construction, alteration or repair work with respect to the facility (including work by contractors or subcontractors) must be performed by qualified apprentices. The percentage is 10% for projects under construction before 2023, 12.5% for projects under construction in 2023, and 15% for projects under construction after 2023. A “qualified apprentice” is an apprentice employed by the taxpayer or its contractors or subcontractors and who participates in certain registered apprenticeship programs. Additionally, any taxpayer, contractor or subcontractor who employs four or more individuals to perform construction, alteration or repair work with respect to the facility must employ at least one qualified apprentice.

---

[47] *Ibid.*

[48] NYSERDA. 2020. What Is An Apprenticeship? Available online at: https://www.offshorewindtraining.ny.gov/faq

While the IRA undoubtedly will produce a surge in demand for apprenticeships in California, it does little to address the supply. California does not currently have any OSW-specific education or training programs (see Section 5.4). It does, however, have a well-established and responsive training and education infrastructure in place. In addition, Education Code Section 79148.1 established the California Apprenticeship Initiative New and Innovative Grant Program with the goal of creating new and innovative apprenticeship opportunities in priority and emerging sectors and areas where apprenticeship training is not fully established or non-existent. The California Division of Apprenticeship Standards (DAS) administers California apprenticeship law and enforces apprenticeship standards regarding wages, hours, working conditions, and the specific skills required for state certification as a journeyperson in an occupation that is appropriate for apprenticeship. The DAS has two goals: matching the needs of workers in the acquisition of skills that allow them to obtain and keep a well-paying job with those of employers seeking motivated workers with the skills they need for open positions; and strengthening the alliance among industry, labor, education, and government to recruit workers and teach them the skills needed to support industry. Because it is funded and driven by industry's needs, the apprenticeship system provides an effective balance between learning by doing and theoretical instruction and developing workers with marketable skills.

Although the state has a strong workforce training system, including the construction industry's state-certified apprenticeships, skills gaps are likely to be a challenge for offshore wind on the North Coast. High-Road Training Partnerships (HRTP) are a new state program of industry-specific training programs that prioritize job quality, equity, and environmental sustainability. For example, through the San Luis Obispo County Office of Education, industry leaders and workers are coming together to create a model for high road labor practices and community engagement at the upcoming CADEMO project. As part of this initiative, a negotiated Community Workforce Agreement (CWA) is being developed in coordination with local trade unions, that provides priority populations access to good jobs via local pre-apprenticeship programs. It also aims to provide support to employers, unions, workforce developers, and educational institutions to shape training programs that build a workforce for the offshore wind industry.

A model that has been the most effective on the East Coast thus far for workforce development and training are project labor agreements (PLA) associated with individual offshore wind projects. With offshore wind developing along the East Coast, whether or not a PLA is required is state-dependent. The following states require some kind of PLA that includes wage standards and training or apprentice requirements: Connecticut, Maryland, Massachusetts, New York and New Jersey. In June 2019, the state Board of Public Utilities awarded a contract to Ørsted for its 1.1 GW Ocean Wind project. As part of its application, Ørsted signed a Memorandum of Understanding (MOU) with three local universities—Rowan, Stockton and Rutgers—to create wind apprenticeship programs and professional/ technical development programs with Stockton and Rutgers Universities.[49] In addition, the Maryland Department of Labor will support the growing offshore wind industry by implementing a new apprenticeship model. In partnership with employers such as Chesapeake Shipbuilding, Crystal Steel Fabricators, US Wind and Ørsted as well as seven local unions, the department will build a training model that meets the needs of employers and local communities. With a focus on formerly incarcerated individuals, veterans, disconnected youth and other underserved populations, the program will train thousands of individuals to enter well-paying jobs in the industry. Local regulations can further enhance the expansion of apprenticeships. One example is the City of Bridgeport, Connecticut which has developed an ordinance (Municipal Code 3.29.020) that requires 20 percent of the workforce or apprenticeships for publicly funded projects be Bridgeport residents. In response, Vineyard Wind's Park City Wind project includes commitments to

---

[49] Collier, R., Hull, S., Sawyer, O., et al. 2019. California Offshore Wind: Workforce Impacts and Grid Integration. Center for Labor Research and Education, University of California, Berkeley. Available at: http://laborcenter.berkeley.edu/offshore-wind-workforce-grid. Accessed October 17, 2022.

partner with Connecticut workforce development and educational institutions like Building Pathways CT, Career Resources Inc, and Survival Systems USA which are specifically focused on bringing workforce opportunities to the City of Bridgeport.[50]

Pre-apprenticeship programs can also help individuals prepare to participate in formal apprenticeship programs. Unions have indicated that these types of programs are a key mechanism that they use to attract and train underserved populations to enter the union workforce. The latest workforce report from Massachusetts Clean Energy Center includes pre-apprenticeship programs in their key findings and suggests that Massachusetts expand these types of programs.[51] In response, the Massachusetts Clean Energy Center committed to this goal by funding the organization Building Pathways in 2021 to support pre-apprenticeship programs and wrap-around services like transportation and childcare. In New York, Ørsted and Eversource, have committed to support the Multi-Craft Apprenticeship Preparation Program training center in Albany. It is drawn from the $1 million Upper Hudson Workforce Development Fund created by the Sunrise Wind project. This pre-apprenticeship program recruits and trains workers for unionized construction apprenticeships and aims to recruit low-income and workers of color from the Capital Region, providing a path to family-sustaining careers while bringing more diversity to the building trades.

5.2.4.1 Recommendations for Apprenticeship Programs

- Apprenticeship and pre-apprenticeship programs can offer a structured pathway to recruit and train skilled workers. A steady pipeline of skilled technicians and tradesmen will be integral to supply the necessary labor over the next 20+ years as California's offshore wind industry ramps up. As observed on the East Coast, there a multiple labor models and partnerships with labor organizations (unions), universities, and community colleges that can be instituted to serve as targeted front door to the offshore wind industry for underserved populations. It is recommended that California explore Community Workforce Agreements (CWAs), Project Labor Agreements (PLAs), and partnerships to establish an apprenticeship program. A robust and coordinated apprenticeship program will yield a steady stream of skilled workers for good paying jobs in the offshore wind workforce.

5.2.5 Local Hiring Initiatives

Local jobs serve as the backbone of strong communities and local economies. A number of policy tools can be used to ensure local hiring. There are a number of approaches that support the generation of local jobs and those targeted to specific populations and businesses within the community. They include: 1) Local hiring requirements, 2) Community Benefit agreements (CBA) and CWAs, 3) Partnering with local employers, and 4) Equitable access to contracts. Understanding the context of specific local environments is an important precursor to leveraging these tools.

At the forefront of offshore wind development in the U.S., the New Jersey Council of the Green Economy developed the *Green Jobs for a Future Sustainable Future* report, defining the pathways for green job creation and development of workforce capacity in support of local economic development.[52] The report identified local

---

[50] Massachusetts Clean Energy Center. 2021. Offshore Wind Workforce Training & Development in Massachusetts. Available at: https://files-cdn.masscec.com/reports/MassCEC%20OSW%20Workforce%20Final%20Report_Sept%202021.pdf.

[51] *Ibid*.

[52] New Jersey Council on the Green Economy. 2022. Green Jobs for a Sustainable Future. Available at: https://www.nj.gov/governor/climateaction/documents/CGE%20Roadmap.pdf. Accessed October 14, 2022.

requirements that enforce specific geographic hiring targets as a foundational strategy. Best practices identified in the report include outlining wage requirements and addressing specific populations in need, targeting criteria such as poverty, diversity, and returning citizens. One such existing program is the New Jersey Emerge Program (NJ Emerge) offered by the New Jersey Economic Development Authority (NJEDA). NJ Emerge promotes local job creation by offering tax credits to projects that operate within one of the outlined priority sectors, clean energy included, while investing private capital into targeted communities within the state. To qualify for benefits from NJ Emerge, projects are required to create a minimum of 35 new full-time jobs with position-specific prevailing wage requirements and ensure that at least 80 percent of incentivized employee work time is spent within the state.

For offshore wind, CBAs and CWAs can be used by developers for infrastructure projects like port improvements. A CBA is a contract between community groups and the developer to provide specific amenities to the local community or neighborhood; some ensure that particular projects create opportunities for local workers and communities. In comparison, a CWA is jointly developed among trade unions, developers, and community organizations to include an agreement on local hiring, apprenticeship programs, and other terms through Project Labor Agreements (PLAs). PLAs are multi-union collective bargaining agreements negotiated to establish wage rates, hours, project length, and health and pension benefits. Past offshore wind projects like Block Island in Rhode Island have benefited from strong PLAs with local unions. In May 2022, the North America's Building Trades Unions (NABTU) and Ørsted, the U.S. leader in offshore wind energy, announced a Project Labor Agreement (PLA) to construct the company's U.S. offshore wind farms with an American union workforce, which will lead to more local hiring and investment opportunities for workforce development. Another example is the PLA that is in effect for At-Risk Construction Management Services for New Jersey Wind Port Project, which has a community component supporting both diversity and local workforce targets. However, it is important to note that as such PLAs are implemented, many northeastern state government officials admit that rather than each state competing directly with its neighbors for a local workforce, a more logical strategy would be regional cooperation, with each major wind factory and port serving a multi-state area.

5.2.5.1 Recommendations for Local Hiring Initiatives

- With the creation of the offshore wind industry in California, the state has the opportunity to implement local hiring initiatives as part of conditions to PLAs, CWAs, CBAs, and labor partnerships. Specific hiring elements, such as identifying wage requirements and specific underserved populations, to serve as program objectives and criteria should be established by the state. These standards would have to be established through California legislation. A policy lever that the state can use to promote local job creation include tax credits to projects that meet the local hiring objectives (i.e., taking from New Jersey, create a minimum of 35 new full-time jobs with position-specific prevailing wage requirements and ensure that at least 80 percent of incentivized employee work time is spent within the state).

5.2.6 Equitable and Targeted Hiring Standards

As California prepares for significant growth in the offshore wind industry, it will be important to ensure an industry-wide commitment to equitable hiring standards and building a strong economy with environmental/social justice at the forefront.

At the federal level, the White House has announced that economic development will be a key focus of its Environmental Justice (EJ) Advisory Council, which demonstrates a stronger national commitment to equitable hiring standards. Further, in order to meet the goal of the Justice40 Initiative (Executive Order 14008), the Biden Administration is transforming hundreds of federal programs across the government to ensure that disadvantaged communities receive the benefits of new and existing federal investments in clean energy. Through the Inflation Reduction Act, Bipartisan Infrastructure Law, and the American Rescue Plan, Federal agencies are making historic levels of investment to advance environmental justice. In addition, states and developers have worked toward codifying such efforts through a range of legislative changes, procurement rules and philanthropic initiatives funded by developers. One such model includes legislation that adds equity criteria to state-level energy procurement evaluation and thus supply chain decision-making on the part of developers. Most states that are driving offshore development have such criteria, and, in fact, those criteria are becoming increasingly ambitious. One example is California's 2015 Clean Energy and Pollution Reduction Act. In developing this policy, the state tracked the participation of disadvantaged workers in all energy efficiency programs across the state, casting a wide net to include low-income workers, workers on public assistance, single parents, the formerly incarcerated, non-English speakers, and workers who have grown up in the foster care system. Massachusetts's Senate Bill 9 - A*n Act Creating a Next Generation Roadmap for Massachusetts Climate Policy* passed in March 2021, is another example. In addition to requiring a more rapid emissions reduction target and an additional 2.4-GW procurement of offshore wind, the act also required a range of new and expanded protections and opportunities for EJ communities. After passage of the act, the Massachusetts Department of Energy Resources (MADOER) released a Request for Proposals for long-term offshore wind contracts that contained the following description of what would be evaluated in proposals:

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

Prior to the bids being submitted, the Environmental League of Massachusetts, funded an informal workshop that brought together potential bidders with EJ groups, women and minority business leaders and other actors in the clean energy justice space. The goals were to create a deeper network and connections and expose bidders to interests of EJ groups and firms that could advance the equity goals of the procurement and to expose firms to possible opportunities and enter into the growing supply chain. New York took a similar approach with its passage of the Climate Leadership and Community Protection Act of 2019. The act required that solicitations for offshore wind projects include provisions for the following: 40% of the overall benefits from clean energy programs must go to disadvantaged communities for workforce development, low-income energy assistance and housing; community engagement plans that provide opportunities to build community equity; prioritization of job creation and other benefits for disadvantaged communities.

Project Labor Agreements (PLAs) are another effective mechanism to ensure equity in the industry. A leading example is the PLA announced in May 2021 by North America's Building Trades Unions (NABTU) and Ørsted, the U.S. leader in offshore wind energy, to construct the company's U.S. offshore wind farms with an American union workforce. A first-of-its-kind in the United States, the National Offshore Wind Agreement (NOWA) sets the bar for workforce equity by creating apprenticeship and career opportunities for communities most impacted by environmental injustice. Authorized by 15 International Union Presidents and their local affiliates, the NOWA covers all of Ørsted's contractors and subcontractors that will perform offshore windfarm construction from Maine down to Florida. With diversity targets, local training programs, and workforce diversity performance monitoring, the NOWA is designed to foster a diverse, equitable, and inclusive workforce. It establishes project-by-project Workforce Equity Committees to prioritize recruiting and retaining people of color, women, gender nonconforming people and local environmental justice communities.

The PLA that is in effect for At-Risk Construction Management Services for the NJ Wind Port Project, which has a community component supporting both diversity and local workforce targets. Hiring targets include 6.9% women and 18% minority workers, with at least 15% of construction management contract value for SMWVBE firms. It also provides resources that prepare women and minority members for apprenticeship programs and outlines requirements for monitoring and public reporting on progress towards diversity goals.[53] In 2021, Vineyard Wind and the Southeastern Massachusetts Building Trades Council signed a PLA setting a goal of achieving a workforce that is 10% women, 20% people of color, and 51% residents from the surrounding counties. The agreement also commits $500,000 to the training program Building Pathways, which works to prepare people from low-income and underrepresented communities to apply for and enter building trades apprenticeship programs. In addition, the Vineyard Wind has committed to creating a working group including all major contractors that will assess the project's diversity and equity goals, monitor movement toward achieving them, and recommend strategies for improving progress.

5.2.6.1 Recommendations for Equitable and Targeted Hiring Standards

- It is recommended that California enact legislation that adds equity criteria to offshore wind procurement evaluations. Criteria could reflect New York's approach of 40% of the overall benefits from clean energy programs must go to disadvantaged communities for workforce development, low-income energy assistance and housing; community engagement plans that provide opportunities to build community equity; prioritization of job creation and other benefits for disadvantaged communities.
- PLAs can be used as an effective mechanism to ensure equity in the industry. Hiring standards can be put in place for the required percentage of women, persons of color, underrepresented populations, low-income populations, and residents from surrounding counties.

5.3 Occupational Safety and Health Standards

Occupational safety and health standards are rules that describe the methods that employers must use to protect their employees from hazards.[54] At the federal level, BSEE is responsible for overseeing worker safety on the OCS and OSHA oversees worker safety on-shore. At the state level, the California Division of Occupational Safety and Health (Cal/OSHA) sets and enforces standards; provides outreach, education, and assistance; and, issues permits, licenses, certifications, registrations, and approvals.[55] Therefore, offshore wind workers will be subject to a layered regulatory framework.

---

[53] New Jersey Economic Development Authority (NJEDA). 2021. Overview of Required Project Labor Agreement Provisions for At-Risk Construction Management Services for New Jersey Wind. Available at: https://www.nj.gov/windport/docs/20210427_EXHIBITJ-PLA1.pdf.

[54] Society for Human Resource Management. 2020. What are OSHA standards? Available online at: https://www.shrm.org/resourcesandtools/tools-and-samples/hr-qa/pages/industrystandards.aspx#:~:text=Examples%20of%20OSHA%20standards%20include,other%20safety%20equipment%2C%20and%20provide

[55] Cal/OSHA. 2023. About Cal/OSHA. Available online at: https://www.dir.ca.gov/dosh/

To date, there are no official health and safety requirements for floating offshore wind in the United States. This also extends to the fixed bottom offshore wind industry on the East Coast. As echoed by NREL, the U.S. offshore industry is progressing toward construction and operation sooner than availability of supporting standards, guidelines, and regulatory frameworks.[56] This regulatory gap provides a unique opportunity for California to develop what could be national safety standards for floating offshore wind.

A Look at Europe's Approach to Safety and Health Standards for Offshore Wind

Europe's offshore wind industry (floating and fixed bottom) has a strong safety culture that starts at the company level and flows throughout their organizations. Continuing this culture in the United States may be important to partnerships with European Wind Turbine Generators (WTGs) and Original Equipment Manufacturers (OEMs).

As the European offshore wind market has steadily grown over the past 15 years, a key approach that Europe has adopted is the development of technical working groups specifically tasked with developing industry wide best practices. The Global Offshore Wind Health and Safety Organization (G+) brings together the offshore industry to develop model safety rules for general safety and processes that safeguards persons from the mechanical plant and the associated system derived hazards. The G+, in partnership with the Energy Institute of London, produces the Wind Turbine Safety Rules report. This report provides the industry with good practices to safeguard employees from inherent dangers surrounding wind turbines, assists in the development of safe systems of work, and showcases how to find legal compliance with relevant health and safety regulations.

Sources: Global Offshore Wind Health and Safety Organization. 2023. Available online at: https://www.gplusoffshorewind.com/work-programme/wtsr.

Energy Institute. 2023. Wind Turbine Safety Rules. Available online at: https://www.energyinst.org/industry/wind-turbine-safety-rules

Given this complicated regulatory environment, collaboration between state and federal regulators is imperative in establishing health and safety standards. The typical regulatory relationship involves the federal government establishing baseline standards that states can apply more stringent requirements in addition to the federal requirements, whereas states cannot mandate a lesser requirement than the federal government. To streamline occupational safety requirements, a common set of health and safety standards should be adopted at all levels so that workers clearly understand the requirements as they move across regulatory jurisdictions. This is highlighted by the various federal agencies that are involved in the regulation and permitting of health and safety aspects of offshore wind farms:

- Bureau of Ocean Energy Management (BOEM)
- Bureau of Safety and Environmental Enforcement (BSEE)
- Occupational Safety and Health Administration (OSHA)
- U.S. Coast Guard (USCG)

---

[56] NREL. 2020. Offshore Wind Electrical Safety Standards Harmonization. Available online at: https://www.nrel.gov/docs/fy20osti/76849.pdf

- U.S. Army Corps of Engineers (USACE)
- U.S. Environmental Protection Agency (EPA)
- Federal Aviation Administration (FAA)[57]

5.3.1 Recommendations

- The state should consider developing a working group between all regulatory entities and the GWO to establish a common set of health and safety standards for all floating offshore wind workers and environments.

5.4 Safety Training Curriculum and Facility Assessment

California has extensive training resources for manufacturing and supply chain occupations (see Table 5-7 below) but as there are presently no floating offshore wind turbines in California, a new and specialized workforce will need to be trained for the manufacturing of wind energy components; constructing wind energy and transmission facilities in a marine environment; and operating/maintaining the new facilities. To understand the need for a specific offshore wind training classroom/laboratory, the sections below review the existing training programs present in the state of California that offers courses/certifications in renewable energy (wind) technologies; maritime safety; and advanced manufacturing.

Section 25991.3(B)(2): Safety Training Curriculum and Facility Assessment

An analysis of the workforce development needs of the California offshore wind energy industry, including....the need for the Division of Apprenticeship Standards to develop curriculum for in person classroom and laboratory advanced safety training for workers.

5.4.1 Review of Existing Training Facilities and Apprenticeship Programs

Table 5-7 below provides a review of the existing training and apprenticeship programs in California for wind energy systems, maritime safety, and manufacturing. These programs provide some of the skills and health/safety training that the new offshore wind workforce will need (see Section 5.2.3.1).

Table 5-7: Review of Existing Training and Apprenticeship Programs in California for Renewable Energy Systems, Maritime Safety, and Manufacturing

Training Area	Organization/Program	Summary
Renewable Energy Systems	Environmental Resource Engineering Program at Humboldt State University	Humboldt State's program trains students in the design and operation of renewable energy technologies such as wind and solar.
	Power Systems and Sustainable Energy Program at Santa Clara University	The program offers curriculum that features wind energy, awarding graduates certificates in renewable energy and master's degrees in power systems and sustainable energy.

[57] BOEM. 2022. U.S. and International Electrical Safety Standards for Offshore Wind. Available online at: https://www.bsee.gov/what-we-do/renewable-energy/report-us-and-international-electrical-safety-standards-for-offshore-wind

	Renewable Energy and Communication Tower Technician Program	Airstreams Renewables Inc. offers safety and technical lessons to prepare students for entry-level positions in the wind industry. Airstream is a vocational training provider whose curriculum has been used as a model for college and other educational programs around the U.S.
	Alternative Energy Technology Certificate at Rio Hondo College	The certification prepares studies for employment as an Alternative Energy technician, with special emphasis in the installation of wind and solar power systems.
	U.C. Davis – California Wind Energy Collaborative	Offers a wind energy technology and industry primer course for technicians but is appropriate for business office personnel, decision makers, or anyone seeking a better understanding of the technology and science driving the wind industry.
	Steven-Taylor Center for Energy Policy and Finance at Stanford University	The center offers a course in Sustainable Energy; Business Opportunities and Public Policy that features wind related material.
	Energy Efficiency and Renewable Energy Program at Golden West College	The program offers courses and materials related to wind energy.
	Wind Energy Courses at College of the Desert	The community college offers a Building and Energy Systems Professional major with certificates in the Energy, Construction, and Utilities (ECU) Sector.
Maritime Safety	California State University Maritime Academy	The only degree-granting maritime academy on the West Coast. A team from the academy won the 2018 U.S. Department of Energy Collegiate Wind Competition.
	Marine Safety and Security Center (MSSC)	CSU Maritime Academy operates the MSSC, which provides comprehensible safety and security planning and response and mitigation training for maritime activities.
	California Apprenticeship Programs	As of January 2019, California was home to over 600 active apprenticeship programs, including Advanced Manufacturing & Transportation Apprenticeships of California (AMTAC) and California Advanced Manufacturing Apprenticeships Collaborative (CAMAC).
Manufacturing	Office of Energy Efficiency and Renewable Energy	Directory of Apprenticeship Opportunities
	West Hills College Lemoore	industrial technologies (contains course work on power transmission, electrical theory and components)
	Long Beach City College	Associate in Science (AS), Advanced Manufacturing Technology
	MiraCosta Community College District	Advanced Manufacturing Leadership Certificate (Manufacturing Basics)
	Los Medanos College	Students Learn Advanced Manufacturing skills. PTEC graduates are well prepared to: Operate complex manufacturing facilities, Troubleshoot complex machinery and operations, Manage automated computer control systems.
	Norco College	CNC Operator, CNC Programming, Manufacturing Technology
	City College of San Francisco	Machining Technology Certificates (Manufacturing Processes, CNC Machining)
	El Camino College	Manufacturing Technology Associate in Science and Certificate Programs
	College of the Canyons	Manufacturing Fundamentals Certificate + CNC
	Reedly College	Reedley College Manufacturing program is the only program in the valley that combines welding, machining, fabrication, electrical and hydraulics.
	Butte College	Advance Manufacturing (AS)
	Sierra college	Multiple Advanced Manufacturing Degrees and Certifications

	Solano Community College	Advance Manufacturing (automation, maintenance tech, mechatronics)
	Los Angeles Valley College	Learn Manufacturing Theory and Applied Principles
	Los Angeles Trade-Technical College	Advanced Transportation and Manufacturing
	Modesto Junior College	Manufacturing Certificate of Achievement
	Porterville College	Industrial Technology (JSC)
	Fullerton College	Manufacturing Technology (AS)
	NTMA Training Centers of Southern California	High Tech Manufacturing Machinist Training
	California Tooling and Machining Apprenticeship Association	CNC Machinist / Technician, Industrial Machinery Mechanic
	AMTAC Apprenticeships	Advanced Manufacturing and Transportation Apprenticeships

5.4.2 Need for an In-Person Curriculum and Training Classroom/Laboratory

While California has training assets and state-certified apprenticeship programs in place, gaps in the training curriculums are present for floating OSW.[58] As discussed in Section 5.2.3, offshore wind development requires a specific set of training curriculums, especially for the construction workforce, such as working at heights, working in a marine environment, advanced rescue, and maritime safety. As the floating offshore wind industry is yet to take root in California, the specific training requirements are relatively absent from the curriculums provided in Table 5-7 above. It is acknowledged that these curriculums are currently offered at training institutions on the East Coast, but the sheer number of workers that need to be trained in California increases the need to locate a training center within the state, as it would not be feasible to repeatedly send workers back east for training over the course of the next 25 years.

[58] University of California – Berkeley. September 2019. California Offshore Wind: Workforce Impacts and Grid Integration. Available online at: https://laborcenter.berkeley.edu/pdf/2019/CA-Offshore-Wind-Workforce-Impacts-and-Grid-Integration.pdf

Scaling Existing Training Programs to Meet the Need of the Floating Offshore Wind Workforce

The floating offshore wind industry will have competing interests for workers (e.g., other renewable energies, construction, chip manufacturing developing in the United States, etc.). This will particularly affect manufacturing and supply chain facilities, ports and staging, and maritime construction crews. To address this challenge, industry stakeholders reported (Section 4) that scaling existing training programs is a near term way to provide the necessary training. Community colleges and union led training programs and apprenticeships are well suited for this task. However, they will need to be scaled to achieve the number of workers needed to meet CEC's installed capacity goal of 2 5 GWs by 2030 and 25 GWs by 2045. Each East Coast state has addressed this by partnering with industry, unions, training entities, and academic/educational institutions.

In addition to scaling existing training programs, the new workforce will also draw from existing skilled labour and create additional training curriculums specific to offshore wind (i.e., GWO Basic Safety Training, GWO Sea Survival Training, etc.). Being GWO certified alone does not guarantee a worker a career in offshore wind, they must also possess technical skills, but the GWO certification is widely recognized by industry. Because this segment of the workforce will have base technical skills desired in the industry, partnerships with universities, community colleges, and union led training programs will play an important role is providing supplemental education.

Additionally, initiatives aimed at educating K 12 students about the floating offshore wind industry should be established. This is an important step in ensuring workforce demand will be met as the industry matures in California over the next 25 years. Programs such as Rhode Island's WindWinRI and the National Energy Education Development (NEED) project provide good frameworks for curriculum and program development aimed at educating K 12 students about offshore wind. Both programs bring the offshore wind industry into the classroom, educate students about the industry, and increase student awareness about potential career opportunities. The WindWinRI program also provides a certificate program for high school seniors looking to enter the offshore wind industry.

Source: NREL. 2022. U.S. Offshore Wind Workforce Assessment. Available online at: https://www.nrel.gov/docs/fy23osti/81798.pdf

WindWinRI. 2022. Pimary and Secondary Education Career Pathways. Available online at: https://windwinri.com/career-pathway/

5.4.3 Recommendations

- The California Department of Industrial Relations – Office of Apprenticeship Standards should develop a specific advanced safety training curriculum for floating offshore wind workers. This would best be done collaboratively with industry, regulators, and training experts, as has been done on the East Coast. The GWO training standards are widely recognized by industry and may serve as a basis for the state to build a curriculum around.
- California should invest in an advanced training center to provide a centralized, hands-on training facility (likely near/at the seaport which would serve as an offshore wind hub for supporting enterprise and services) to help ensure workers train with the same components and equipment they will use in their offshore wind jobs. It is advisable that the state (specifically the State Lands Commission) explore public-private partnerships to fund and develop an in-person training center/laboratory, or consider it as a selection criteria in awarding seaport development. A potential model is provided in the Offshore Wind Training Institute in the state of New York.
- To meet the demand of the new offshore wind workforce, California should consider scaling existing training programs to provide near-term resources to a potentially fast-growing industry. These programs can also provide complimentary offshore wind skills to existing trained workers that transition from other industries.
- The state should consider introducing a K-12 school program that provides an early career pathway for entry level workers, creating a pipeline of knowledgeable and proficient new workers for the offshore wind workforce.

SECTION 6

Supply Chain Assessment

6.1 Key Issues and Questions

California can realize numerous benefits from developing floating offshore wind generation capabilities, with two areas standing to experience significant impacts: 1) a diversified energy portfolio reduces reliance on fossil fuels; and 2) developing state-level domestic supply chain capacity to meet the needs of this emerging industry can be a powerful engine for economic growth in the state. As discussed in Section 3 above, nearly 2/3rds of the expected jobs will be in the supply chain sectors (i.e., manufacturing, logistics, fabrication, etc.), as will much of the economic activity associated with developing offshore wind energy projects. These supply chain entities will require raw and fabricated materials (inputs) to develop key wind energy and transmission components. Exploratory research and analysis has been performed by Guidehouse (2022) to identify the raw materials needed, as well as the fabrication, construction, operation, and maintenance capacities - the "supply chain" that will be needed to support launching this industry. As California has made the commitment to develop offshore wind, these supply chain inputs play a critical role in facilitating offshore wind development and, most importantly, reducing the levelized cost of energy (Lcoe) over time. The more localized the supply chain becomes, the more economic efficiencies are realized, leading to lower Lcoe over time. As initial OSW projects rely on out-of-state and international suppliers, a key factor is the rate and extent that developers rely on in-state supply chain inputs. This section explores this concept and asks the following key questions:

- What supply chain assets are currently in place?
- What are the key elements missing from the supply chain?
- Why is it important to develop local capacity?
- What is the status of local capacity?
- Where are the opportunities to develop local capacity?
- What are the opportunities for the State of California to capture the economic activity presented by the offshore wind supply chain?
- What would it take to get there?
- What policy levers/instruments have proven track record of supporting getting there?

Utilizing data from an extensive literature review (over 70 national and international papers and impact studies – Appendix A) as well as recommendations and insights from stakeholder interviews and discussions with industry leaders (Section 4), this Assessment identifies key areas of opportunity for developing domestic (i.e., within California) supply chain capabilities as well as potential policy levers and incentives that have proven effective in supporting and stimulating capacity development on the East Coast. Some background on the economic importance of developing California-based supply chain industries provides some technical context for an overview of needs, opportunities, and policy options.

6.2 Supply Chain Overview

NREL developed a roadmap for creating a domestic supply chain at a national level to support building capacity to achieve national offshore wind energy targets, including the targets for California.[59,60] They concluded that while there were significant challenges, there were also significant opportunities for potential economic growth, activity, and benefits. Creating floating offshore wind power generation capabilities not only ensures a brighter, more sustainable energy future for California, but offers the potential to develop an in-state/domestic (i.e., indigenous to California) supply chain industry. These new supply chain industries would serve as a new engine for economic growth for the State.

However, there are significant gaps in California's current supply chain capabilities. Guidehouse evaluated overall manufacturing capacity nationally and in California to support the development of floating OSW and determined that, "*while several manufacturers with large global market share have existing or planned manufacturing presence in the United States, **none** have OSW capable manufacturing facilities in California or elsewhere on the West Coast*."[61] In particular, the Guidehouse authors noted the following with regard to existing capacity:

- **Blades:** There are four major firms with confirmed manufacturing capacity in the US, but none in California.
- **Turbines:** Three major firms with confirmed manufacturing capacity in the US, but none in California.
- **Towers:** Two potential major firms that are planning to build manufacturing capacity in the US. However only one is in the planning phase, while the other is merely under consideration.
- **Platforms:** Two platform manufacturers/engineers with confirmed manufacturing capacity in the US. None in California.
- **Mooring:** There is not enough data in the offshore database or publicly available to analyze wind-farm grade mooring. However, mooring and anchoring manufacturers that produce for other purposes do exist in California (italics added).
- **Cables:** There are six major firms with confirmed manufacturing capacity in the US, none in California.

While there is currently no capacity in California with demonstrated direct experience in offshore wind, there are sectors that, with the right incentives and investments, could pivot to meet these emerging demands. As

---

[59] Shields, Matt, Ruth Marsh, Jeremy Stefek, Frank Oteri, Ross Gould, Noé Rouxel, Katherine Diaz, Javier Molinero, Abigayle Moser, Courtney Malvik, and Sam Tirone. 2022. The Demand for a Domestic Offshore Wind Energy Supply Chain. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-81602. https://www.nrel.gov/docs/fy22osti/81602.pdf.

[60] Shields, Matt, et al. 2023, January. A Supply chain Road Map for Offshore Wind Energy in the United States. Available here: https://www.nrel.gov/docs/fy23osti/84710.pdf.

[61] Guidehouse. May 2022. California Supply Chain Needs Summary Report. Available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=242928&DocumentContentId=76513

California begins to invest in building capacity to deliver offshore wind, developing local supply chain capacity offers several potential benefits and protections including:

- **Building Local Capacity** – developing local skills capacity to support not only the construction, but the ongoing operations and maintenance of floating OSW facilities represents a generational opportunity to create a cohort of skills laborers and living wage job opportunities on a scale similar to what occurred with the development of the aerospace and oil and gas sectors. Additionally, given that artificial intelligence and automation are key aspects of floating OSW operations, there is the added opportunity to capitalize on the technology innovation capacity that already resides within the state.
- **Capturing Greater Economic Multiplier Effect** - expenditures in one sector generate expenditures in other sectors and while there will be some revenue and multiplier effects from importing component parts, assembly and operations and maintenance, the greater the percentage of creation and fabrication that resides in the state, the greater the potential and magnitude for ripple on impacts.
- **Eliminating Vulnerability** - as the demand for inputs to support the build out of OSW capabilities increases, regionally, nationally, and globally – costs of inputs are going to increase (assuming supply even exists) so to the degree that California will need to rely on imports to meet their OSW build out targets, they will be vulnerable to price increases for those inputs. Local control over production eliminates that vulnerability and ensures that the components California needs are available when and where they are needed, at a predictable price.

There are several key factors to consider when trying to identify which elements of the floating OSW supply chain might be targets for further support, expansion, and development, including:

- What local capacity already exists that can be re-trained or repurposed to meet the supply chain needs of floating OSW?
- What will it cost to re-train existing, or to develop new capacity in terms of labor supply, facilities, transportation assets etc.?
- What is the time horizon for development and deployment relative to the timeline for installing floating OSW?
- What are the alternative supply sources and how vulnerable are they?
- What is the potential for continued demand and “export” of an input or supply chain component industry outside of California once California’s floating OSW development needs are met.

While deeper dives into these questions is necessary, careful analysis and synthesis of existing research results and themes, combined with interviews with industry leaders yields some insights and recommendations. The remainder of this chapter explores some of these possibilities and identifies policy instruments and incentives that have proven effective in other environments.

Key Studies and Sources for Supply Chain Assessment

- Guidehouse. May 2022. “California Supply Chain Needs Summary.” California Energy Commission.
- U.C. Berkeley Labor Center. September 2019. California Offshore Wind: Workforce Impact and Grid Integration.
- NREL. June 2022. “The Demand for a Domestic Offshore Wind Energy Supply Chain.”
- NREL. January 2023. “A Supply Chain Roadmap for Offshore Wind Energy in the United States.”

6.3 Development Needs/Demand Assessment

Evaluating supply chain development opportunities begins with an understanding of what will be required to support the manufacture, installation, and operation of floating OSW capabilities. As part of the 2022 analysis, the Guidehouse authors identified materials and components and the quantities needed of each to build a 2 GW offshore wind farm, as provided in Table 6-1.

Table 6-1: Materials Needed for a 2 GW Wind Farm[62]

Component	Quantity (Total Length)	Material(s)	Unit Weight	Total Weight
Towers	134	Steel	860 tons/tower	115,300 tons
Blades	402	Fiberglass	65 tons/blade	26,130 tons
Nacelles	134	Copper, Steel, Fiberglass	700 tons/nacelle	93,800 tons
Floating Foundations (semi-submersible)	134	Steel or Concrete	6,000 tons/structure (steel); 22,500 tons/structure (concrete)*	804,000 tons (steel); 3,015,000 tons (concrete)
Mooring Lines	402**	Steel or Synthetic Rope (Polyester or HMPE)	114kg/m (steel); 26.5 kg/m (polyester)	146,000 tons (steel); 35,000 tons (polyester)
Anchors (piles)	402	Steel	200 tons/anchor	80,400 tons
Array Cables (66kV, 630mm)	134*** (225,000 miles)	Three-core Aluminum conductor, lead sheath	40.1 kg/m	9,030 tons
Export Cables (220kV, 1000mm)	6**** (120 miles)	Three-core Aluminum conductor, lead sheath	85.1 kg/m	16,450 tons

Notes:

* Estimate of the weight of concrete foundations based on existing pilot projects
** Assuming 3 mooring lines per turbine, unit length of 3200m per line
*** Assuming turbine spacing of 7 times rotor diameter, unit length of 1680m per cable
**** Unit length of 20 miles based on distance to shore from BOEM assessments of Humboldt and Morro Bay

This 2 GW "model" was used as the basis to develop several buildout scenarios and to then estimate the total input requirements and manufacturing, assembly, operation, and maintenance requirements to meet the 10 GW target set by California. Table 6-1 illustrates not only the volume of raw materials that will be required, but also the fabrication, manufacturing, and assembly capacity that will need to be in place, somewhere, to support this effort.

[62] Guidehouse. May 2022. "California Supply Chain Needs Summary." California Energy Commission. Available online at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=242928&DocumentContentId=76513

6.4 Supply Chain Opportunities

For each component referenced in Table 6-1 above, Guidehouse identified the primary input, determined whether there was an existing manufacturing presence for that component or input, either in the US or in California and then made a recommendation as to whether or not that component (and its inputs) was "fit for local content", using a "high", "medium" or "low" score to identify those components that were potentially fit for local development, with the implication being that those inputs or components with a "high" score would be good candidates for local supply chain capacity development.[63] The rankings were based on a combination of data related to existing and potential upscale capacity, the potential for job creation and employment opportunities among existing site-specific trades, and skills and logistics associated with transport and assembly. This is not to suggest that other aspects of the supply chain would not be candidates for developing local capacity at some point in the future, rather that these components represent "low hanging fruit" because of some existing condition (labor force with particular skills, similar manufacturing capacity with unused potential, proximity to locations where towers might be sited, etc.).

As shown in Table 6-2 below, the Guidehouse analysis suggests that towers and foundations have a high potential for local content, and that there is "medium" potential for blades, mooring lines & anchors, and inter-array and high voltage cables.

Table 6-2: Supply Chain Opportunities Overview

Component	Input	Input Type	Component Manufacturer Presence in US	Component Manufacturer Presence in CA	Existing Manufacturing Labor Capacity In CA	Fit for Local Content
Towers	Steel	Material	Yes	No	No Existing Capacity	High
	Concrete	Material	Yes	No	Very High	High
	Steel Product Fabrication	Process	Yes	No	Low	High
	Concrete Casting	Process	Yes	No	Medium	High
	Primary Concrete Manufacturers	Labor	Yes	No	Very High	High
	Concrete Product Manufacturers	Labor	Yes	No	Very High	High
	Primary Steel Manufacturers[64]	Labor	Yes	No	No Existing Capacity	Low
	Steel Fabricators	Labor	Yes	No	Low	High
Foundations	Steel	Material	Yes	No	No Existing Capacity	High
	Concrete	Material	Yes	No	Very High	High
	Steel Product Fabrication	Process	Yes	No	Low	High
	Concrete Casting	Process	Yes	No	Medium	High

[63] **High:** It makes sense to produce the component locally. This can be due to an abundance of input industry, significant employment benefits, or logistic requirements that heavily favor local production. • **Medium:** The component could be produced locally or imported based on California's priorities (usually, limited job creation vs. cheaper importation) and the pipeline/incentives for manufacturers. • **Low:** Due to specialized subcomponents and industrial processes, or attractive options for importation, the component would be difficult to produce locally. (Guidehouse 2022 pg. 56)

[64] Experts have expressed concerns about the economic viability of creating primary steel production in California or scaling/upgrading secondary fabrication capabilities, as this might represent a substantial investment in firms that would go obsolete after floating OSW buildout is complete. (Guidehouse, pg. 50)

Component	Input	Input Type	Component Manufacturer Presence in US	Component Manufacturer Presence in CA	Existing Manufacturing Labor Capacity In CA	Fit for Local Content
	Primary concrete Manufacturers	Labor	Yes	No	Very High	High
	Concrete Product Manufacturers	Labor	Yes	No	Very High	High
	Primary Steel Manufacturers[65]	Labor	Yes	No	No Existing Capacity	Low
	Steel Fabricators	Labor	Yes	No	Low	High
Blades	Turbine Generator Set Manufacturing	Process	Yes	No	Low	Medium
	Glass Fiber Reinforced Plastic	Material	Yes	No	N/A	Medium
Mooring Lines	Steel[66]	Material	Yes	Yes	No Existing Capacity	Medium
	Steel Product Fabrication	Process	Yes	Yes[67]	Low	Medium
Anchors	Steel	Material	Yes	Yes[68]	No Existing Capacity	Medium
Inter-Array Cables/ High Voltage Export Cables	Copper	Material	Yes	No	N/A	Medium
	Aluminum	Material	Yes	No	N/A	Medium
	Copper Drawing	Process	Yes	No	N/A	Medium
	Steel Wire Drawing	Process	Yes	No	High	Medium
	Aluminum Drawing	Process	Yes	No	N/A	Medium

Scaling these input and component requirements to the capacity required to meet the 10 GW floating OSW target set by California, and evaluating current capacity in California, illustrates that while there are gaps in capacity, there are also opportunities. Using standard industry definitions (Tier 1- direct suppliers of final products, Tier 2- fabricators, suppliers and subcontractors for Tier 1 and Tier 3- raw materials suppliers and subcontractors to Tier 2) Guidehouse identified the number of firms and employees of those firms that currently exist in California.

As shown in Table 6-3 below, California firms and workers already have over 75 percent of the necessary capacity to meet the demand for gear and transmission equipment assembly, as well as over 50 percent of steel product fabrication capacity and nearly 25 percent of the capacity required to manufacture turbine generator steel investment castings. These components were also identified by Guidehouse (see Table 6-2 above) as being "fit for local content". Steel wire drawing (9%) and concrete production (16%) are additional areas where there is existing capacity that could be retrained and ramped up.

[65] Experts have expressed concerns about the economic viability of creating primary steel production in California or scaling/upgrading secondary fabrication capabilities, as this might represent a substantial investment in firms that would go obsolete after floating OSW buildout is complete. (Guidehouse, pg. 50)

[66] Synthetic mooring lines are possible, but further research is needed to determine if firms in California could develop synthetic mooring lines. (Guidehouse, pg. 56)

[67] There is limited mooring manufacturing in California, and it is unclear if these firms can produce lines to the specifications required by floating wind farms (Guidehouse, pg. 56)

[68] There is limited anchor manufacturing in California, and it is unclear if these firms can produce anchors to the specifications required by floating wind farms. (Guidehouse, pg. 56)

Table 6-3: California Supply Chain Capacity Overview

Industry	OSW Element	No. of Firms	No. of Employees	% Capacity Required to Attain 10GW target
Tier 1 Parts Production	Gear/Transmission equipment assembly	26	1136	78
	Turbine Generator Set Manufacturing	11	6121	26
	Steel Wire Drawing	29	567	9
Tier 2 Fabrication	Concrete production	111	4986	16
	Steel Product fabrication	57	1653	52
	Steel Investment Casting	8	926	23
Tier 3 Raw Materials	Concrete manufacturing	112	8808	2
	Primary Steel Manufacturing	0	0	0

Source: Guidehouse. May 2022. California Supply Chain Needs Summary (slide 47, pg 48) and (slides 48-52, pg 49-53). California Energy Commission.

Embedded in the percentages shown in Table 6-3 is the assumption that some of this capacity resides in adjacent industries that would need to upscale or re-train to convert to floating OSW production, which would require specific investments and incentives.

While these components and industries are not the only opportunities for developing local content and supply chain capacity, they represent those aspects of the supply chain where local capacity could be developed on a shorter time horizon and with less effort and investment relative to other aspects of the supply chain. Assuming that these are the sectors chosen for local capacity development, the question then becomes one of which policy instruments and incentives are most effective at stimulating investment in these supply chain areas.

6.5 Levers, Policies, and Incentives

If California were to develop in-state manufacturing and labor capacity to support the production of floating OSW components, there are policies and incentives that have been utilized both internationally and by East Coast states that could be adopted and applied in California.

Policy instruments, tools, tactics, and activities that encourage creativity, reduce uncertainty, and mitigate or incentivize risk have been shown to be effective tools to encourage development of new ventures and new industries. Policy instruments that have been successfully used in other states and in Europe to support the development of inputs and components for the floating offshore wind supply chain include:

- ***Subsidies***[69] – a direct or indirect payment (could be cash or a tax cut) that provides a financial offset or mitigates uncertainty.
- ***Feed-In-Tariffs/Tenders***[70]– Feed-In-Tariffs (FIT) are policy tools specifically designed to encourage investment in renewable energy. Originating in Germany, FITs are long term contracts that guarantee

[69] World Trade Organization. 2006. World Trade Report: Subsidies, Trade and the WTO. Available online at: https://www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report06_e.pdf.

[70] US Energy Information Administration. 2013. Feed-in Tariff: A Policy Tool Encouraging Deployment of Renewable Electricity Technologies. May 30th. Available online at: https://www.eia.gov/todayinenergy/detail.php?id=11471.

that the owners of a renewable energy generation source will receive a set price, typically higher than the retail price for energy, for the energy generated and provided to the grid.

- ***Tax Credits and Rebates*** – provisions that directly reduce a taxpayer's final tax bill after calculation.
- ***Tax Deductions and Exemptions*** - provisions that lower the initial income on which tax is calculated.
- ***Grants & Cooperative Agreements***[71] – mechanisms authorized by legislation that allow state and federal governments to enter into financial assistance relationships that support competitiveness and the development of innovation (as opposed to directly procuring a good or service). Economic development agencies typically use grants to promote growth and investment in geographic areas or emerging sectors.
- ***Direct Public & Private Sector Investment*** – long term purchase or acquisition of capital or controlling interest in a concern or venture as opposed to lending money or purchasing shares.
- ***Project Labor Agreements***[72] – collective bargaining instruments between trade unions and contractors that govern the terms of employment for craft workers and provide structure and stability for large scale construction projects.
- ***Local Source Requirements*** - laws, regulations (and incentives) that require that certain percentages of project inputs come from a particular geography or region.
- ***Hub/Hive Development*** - this is a tactic where government creates and incentivizes physical spaces and collaborative agreements (e.g., incubators, technology parks, subject matter expert exchanges) that encourage and support innovation and skills development.

These tools and tactics often generate benefits and have impacts across multiple aspects of the supply chain. A summary of how different policy instruments have been successfully utilized in other contexts to develop aspects of the floating OSW supply chain is provided below. The focus of this Assessment is on those sectors identified as having "high" or "medium" potential supply chain development – steel and steel product fabrication, component manufacturing, and labor/workforce development.

6.5.1 Steel and Steel Product Fabrication

As indicated in Table 6-2 and Table 6-3 above, steel and steel product fabrication were both rated "high" in terms of potential for local supply chain development in relation to towers, foundations, mooring lines and anchors. California currently has no primary steel manufacturers and few steel fabricators. Creating primary steel production facilities and/or upgrading steel fabrication facilities will require substantial investment. For example, a federal investment of $20 million alongside a $30 million private investment were used to upgrade a former steel mill and its port in Maryland to support floating OSW.[73] An additional private investment in Crystal Steel Fabricators enabled Maryland to establish the state's first floating OSW steel fabrication center. A

---

[71] U.S. Department of Commerce. 2016. Grants and Cooperative Agreements Manual. Available online at: https://www.eia.gov/todayinenergy/detail.php?id=11471.

[72] Executive Order on Use of Project Labor Agreements for Federal Construction Projects. Feb 4, 2022. Available online at: https://www.whitehouse.gov/briefing-room/presidential-actions/2022/02/04/executive-order-on-use-of-project-labor-agreements-for-federal-construction-projects/.

[73] Xodus Group. 2022. Offshore Wind Supply Chain & Workforce Opportunity Assessment: Assessment of OSW Supply Chain Opportunity. Available online at: https://www.maine.gov/energy/sites/maine.gov.energy/files/inline-files/Maine%20Offshore%20Wind%20Supply%20Chain%20Assessment%202022.pdf

combination of private and public funding has enabled Maryland to reestablish its presence in the steel industry to help serve East Coast offshore wind farms.

A primary concern related to the development of steel manufacturing capabilities is the uncertainty regarding the economic viability of steel production/fabrication facilities after the initial completion of the floating OSW buildout. California could utilize feed-in tariffs and other subsidies to ensure a steady pipeline of floating OSW projects to entice steel manufacturers with long-term contracts and projects. As discussed in the table below, several European countries utilized feed-in tariffs to encourage floating OSW farm installations and part manufacturing including Germany, Denmark, and the Netherlands. In the Netherlands, a feed-in tender scheme was used where the lowest qualified bidder was granted a 15-year subsidy guarantee.[74] By offsetting some of the input costs, which did not then have to be passed on to the consumer, the tariff made initial floating OSW projects competitive, which encouraged the development of a local supply chain and workforce.

Policies Successfully Used Elsewhere	***Opportunity for California***
Direct Public and Private Sector Investment (Maryland)	Create partnerships with floating OSW developers and combine funds to invest in a new steel manufacturing/fabrication facility or provide the needed upgrades to current steel fabrication facilities to support floating OSW manufacturing
Subsidies (Europe)	Offer tax breaks for steel manufacturing/fabrication facilities that support floating OSW production – this incentive could encourage facilities to invest in the equipment and training needed to support floating OSW component production
Local Source Requirements (East Coast & Europe)	Requiring local sources to support floating OSW production will guarantee local work and a consistent pipeline of projects that include steel manufacturing and fabrication

6.5.2 Component Manufacturing

Concrete, steel, and turbine generator set manufacturing were also identified as having “high” or “medium” potential for local content. In addition to subsidies and feed-in tariffs, commitment of public funds has been successfully used in several states to develop manufacturing capacity. Several New England states have committed millions in investment to support OSW manufacturing facilities, often with support from a private partner. For example, New York has announced they will be investing in a tower and transition piece fabrication facility using public and private funds, and New Jersey is using $250 million joint public-private investment to establish foundation manufacturing capabilities.[75] Committing public funds to the development of a Tier 1 component facility would create certainty for Tier 2 and 3 suppliers that California is invested in developing a local supply chain and serve as an incentive for Tier 2 and 3 steel and concrete facilities to invest in upgrading or adapting to serve an emerging floating OSW industry.

Competitive grant funding for supply chain development, which has been successfully utilized by New Jersey, Maryland, and the federal government, is another option that could fund development of steel and concrete manufacturing facilities or upgrade current facilities. In this case direct cash injections from the state helped offset some of the costs associated with upgrading and/or building new facilities. The use of competitive grants

---

[74] Sathe, et al. 2020. Research and Development Opportunities for Offshore Wind Energy in California. August. Available at: https://www.energy.ca.gov/sites/default/files/2021-05/CEC-500-2020-053.pdf

[75] Xodus Group. 2022. Offshore Wind Supply Chain & Workforce Opportunity Assessment: Assessment of OSW Supply Chain Opportunity. Available online at: https://www.maine.gov/energy/sites/maine.gov.energy/files/inline-files/Maine%20Offshore%20Wind%20Supply%20Chain%20Assessment%202022.pdf

for research and product development might also promote innovations and new ideas that might reduce the amount of steel needed for tower manufacturing or lead to streamlining a workforce training program for blade manufacturing. While dedicated investments highlight the state's commitment to local supply chain development, competitive grants could allow for more innovative solutions to creating an in-state OSW tower supply. There are benefits to both policy approaches, which is why states like New Jersey and Maryland have created competitive grant programs and invested public funds in component or Tier 2 facilities.

There are several other policies and incentives California could utilize to lower the risk associated with developing floating OSW facilities including floating OSW industry tax credits. The Guidehouse report makes note of New Jersey's floating OSW tax credit program in which the state provides reimbursement for capital investment in floating OSW industry specific facilities located in New Jersey. California has a similar program, the Capital Investment Incentive Program, that authorizes a local government to rebate the value of property taxes owed on the manufacturing property in excess of the first $150 million for up to 15 years. Additionally, the California Alternative Energy and Advanced Transportation Financing Authority caters to manufacturers that promote alternative energy by offering them a sales and use tax exclusion. Both programs offer returns to investors that reduce the total investment needed to create these large facilities that range in cost from $100 million to $350 million.

Promoting tax credit and rebate programs as floating OSW supply chain incentives could help encourage shareholders to invest in floating OSW component manufacturing facilities. The US Department of Energy has developed other tax credits to incentivize floating OSW projects and the development of a domestic supply chain. Included is the Business Energy Investment Tax Credit (ITC) is a one-time federal income tax credit for capital investments in renewable energy projects determined by the amount invested.[76] Educating potential investors about the state and federal programs already in place could make the development of component facilities more appealing in California than other West Coast states. Expanding or creating additional tax incentives could further encourage the development of riskier investments, like steel fabrication, which is essential for a number of floating OSW component parts.

Policies Successfully Used Elsewhere	***Opportunity for California***
Direct Public and Private Sector Development (New Jersey, New York)	Create partnerships with floating OSW developers and combine funds to invest in component part manufacturing facilities
Grants and Cooperative Agreements (New Jersey, Maryland, Federal Govt.)	Institute a grant program that covers necessary upgrades for Tier 2 facilities that support component manufacturing facilities. Design Cooperative Agreements that supply a percentage of the initial investment needed to build a floating OSW component manufacturing facility to lessen the risk for potential investors
Tax Credits and Rebates & Tax Deductions and Exemptions (East Coast & Europe)	Adapt the Capital Investment Incentive Program, increase sales use and tax exclusion program for all facilities that support floating OSW development

[76] U.S. Department of Energy Office of Energy Efficiency & Renewable Energy. 2021. Advancing the Growth of the US Wind Industry: Federal Incentives, Funding, and Partnership Opportunities. June. Available at: https://www.energy.gov/sites/default/files/2021-07/us-wind-industry-federal-incentives-funding-partnership-opportunities-fact-sheet-v2.pdf

6.5.3 Supply Chain Workforce Development

Both towers and foundations are ranked as “high” in terms of potential for local supply chain capacity development in the Guidehouse analysis. In both cases, while there is no current manufacturing presence in California, (with the exception of primary steel manufactures and steel fabricators), the existing labor capacity is rated as “very high” or “high”. This suggests that, in terms of workforce development, there are both opportunities to re-train an existing work force (particularly concrete and concrete products), and to develop a new cohort of skilled labor (steel fabricators). Although the Guidehouse analysis did not identify labor requirements related to manufacturing related to blades, mooring lines, anchors, or cables, that does not necessarily imply that there are not opportunities for workforce development associated with those components. In terms of the potential to benefit the economy of California directly and indirectly, workforce development may be the single biggest long-term opportunity associated with developing a state-level supply chain.

A number of East Coast states have committed to adapting industry-based or union-based construction training programs for floating OSW and have invested in completely new training programs or facilities that are floating OSW aligned. New York and Rhode Island have committed to both tactics. California has already created the initiative for a High-Road Training Partnership program and has an Employment Training panel that provides funds to employers to safely train their employees. These two programs could be expanded to include training and partnerships between industry and labor needed to fabricate steel for floating OSW towers or foundations. The Employee Training Panel could provide funding to employers in the concrete manufacturing industry to incentive their transition to supporting the production of floating OSW component parts.

As additional examples, New York is investing $30 million in the New York Offshore Wind Training Institute, New Jersey has passed legislation to create the Wind Innovation and New Development Institute, Maryland has developed the Arcon Training Center for floating OSW training, and Rhode Island and Massachusetts have invested in a number of higher education training programs to support floating OSW development. Many of these are collaborations with state schools and industries. California could create something similar by investing in training programs and partnerships between schools like Cal Poly Humboldt, industry leaders, and unions. Creating these collaborations can help ensure that workers are receiving the proper training to join the floating OSW manufacturing industry and introduce more people to the OSW industry (including traditionally underrepresented constituencies including women and people of color).

Interviews with floating OSW developers, labor and union representatives, training organizations, researchers/experts, and engineering, procurement, construction, installation (EPCI) representatives were undertaken as part of this analysis in order to better understand what steps could be taken to prepare California for floating OSW supply chain development (Section 4). Of the 13 people interviewed, seven commented on the importance of establishing local source requirements. Requiring local sources benefits each aspect of the industry in California. Local source stipulations equate to the use of the local workforce and indicate to EPCI groups that local facilities are needed and will be utilized. Interviewees noted that project labor agreements and local use mandates from the State or floating OSW authority are some of the ways in which local resources, manufacturers and workers can be prioritized as the floating OSW industry integrates into the West Coast. One EPCI interviewee stated, “*In order to maximize the number of California workers in the floating OSW industry, the state needs to develop manufacturing facilities and continue to expand the type of component production facilities as the local supply chain matures*.” Local source requirements will encourage investors to fund new facilities and begin developing the local floating OSW supply chain in California. Another noted that: “*Establishing project labor agreements means the industry can commit to local sources*.”

Rhode Island, New York, New Jersey, Massachusetts, and Virginia have relied on project labor agreements (PLAs) to mandate some degree of local manufacturing, utilization of local workforces and favorable work conditions for East Coast floating OSW projects. In fact, New York’s Energy Research and Development

Authority has mandated PLAs for all floating OSW projects in state waters.[77] California's floating OSW authority could instate a similar mandate, requiring all floating OSW projects to complete community workforce agreements and community benefits agreements. These agreements would involve local unions and ensure the use of a local workforce in the floating OSW supply chain.

Policies Successfully Used Elsewhere	*Opportunity for California*
Project Labor Agreements (East Coast)	Institute workforce agreements that require local supply chain and labor force.
Instituting New or Adapting Current Labor Training Programs (East Coast & Europe)	Adapt High-Road Training Partnership program to support floating OSW labor training and expand Employee Training Panel so it can support floating OSW labor employers by providing funds for proper training. Invest in a new training facility or program dedicated to floating OSW development.

6.6 Cross Cutting Initiatives

Creating a collaborative space or alliance connecting local suppliers/workforce/investors within the floating OSW industry is another highly successful tactic used to promote OSW supply chain and workforce development. The UK and Denmark prioritized collaboration between the government, industry and unions whilst developing their respective floating OSW industries. Doing so allowed these nations to streamline workforce training, connect local suppliers and workforces with floating OSW projects and prioritize funding. Many East Coast states have followed suit by creating a collaborative space to connect and engage local suppliers with their respective floating OSW projects. New Jersey and Maine have developed an floating OSW supply chain registry that matches investors with state-based partners and suppliers.[78] Massachusetts's Act Local Program encourages a local approach for floating OSW supply chain needs and hosts buyer/employer matchmaking event. Virginia's floating OSW landing is a platform for companies to work, connect and access resources to support floating OSW development.[79] California could create a similar collaborative space to encourage local supply chain development and connect companies that might not be aware of the opportunities available in the floating OSW industry. The US Department of Energy's State Energy Competitive Financial Assistance offers competitive grants through its State Energy Program to help develop public and private partnerships to deploy renewable energy technology with high potential for regional and local

[77] Collier, Robert, Sanderson Hull, Oluwafemi Sawyer, Shenshen Li, Manohar Mogadali, Dan Mullen, and Arne Olson. California Offshore Wind: Workforce Impacts and Grid Integration. Center for Labor Research and Education, University of California, Berkeley. September 2019. http://laborcenter.berkeley.edu/offshore-wind-workforce-grid.

[78] Guidehouse. May 2022. California Supply Chain Needs Summary Report. Available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=242928&DocumentContentId=76513

[79] Xodus Group. 2022. Offshore Wind Supply Chain & Workforce Opportunity Assessment: Assessment of OSW Supply Chain Opportunity. Report to the Governor's Energy Office. Available here: https://www.maine.gov/energy/sites/maine.gov.energy/files/inline-files/Maine%20Offshore%20Wind%20Supply%20Chain%20Assessment%202022.pdf

economic impact.[80] California could utilize this federal grant opportunity, or institute a similar one to encourage these collaborations, which in turn spur the development of a local supply chain for floating OSW.

Policies Successfully Used Elsewhere	*Opportunity for California*
Hub/Hive Development (East Coast & Europe)	Create a hub or hive for floating OSW development, training, manufacturing, innovation, and collaboration near a major port dedicated to floating OSW.

6.7 Summary of Potential Policy Mechanisms

As observed on the U.S. East Coast and abroad, there are significant economic benefits associated with developing local supply chain capacity. Initial research has been conducted to highlight areas of potential focus for investment and development in California. Table 6-4 below summarizes the various policies and incentives that could be used in California to develop local supply chain capacity.

Table 6-4: Policy Instruments Supporting Local Supply Chain Capacity Development

Policy/Incentive/Tax Break	Geography (who instituted the policy)	Component Supported	Input Supported	How California Could Adopt/Adapt Policy
Feed-in Tariffs and Other Subsidies	The Netherlands, Denmark, Germany	All	All	Develop a feed-in tariff and/or subsidy scheme to make floating OSW energy competitive and encourage the development of a local supply chain
Industry-based Training Programs	New York, Rhode Island	Towers Foundations	Primary Concrete Laborers & Manufacturers Concrete Product Laborers & Manufacturers Steel Fabrication Laborers & Manufacturers	Adapt California's initiative for a High-Road Training Partnership Program for floating OSW, Expand Employment Training Panel funding to support floating OSW industry
Competitive Grant Funding	New Jersey, Maryland, US federal government	All	All	Dedicate state funding to an floating OSW supply chain improvement grant to promote creative collaborations & supply chain development
Local Source Requirements	New York, New Jersey, Massachusetts, Virginia, Rhode Island	All	All	Community workforce agreements or community benefits agreements
Direct Investment in Training Programs	Maryland, New Jersey, New York, Rhode Island, Massachusetts	All	All Component Part Production Labor Forces	Create partnership with academia (Cal Poly Humboldt and other local JCs) and fund floating OSW training opportunities through these facilities
Tax Credits	US federal government, New Jersey, Rhode Island	All	All Component Part Manufacturers & Investors	Adapt Capital Investment Incentive Program, promote CAEATFA sales and use tax credit

[80] Wind Industry: Federal Incentives, Funding, and Partnership Opportunities. June. Available at: https://www.energy.gov/sites/default/files/2021-07/us-wind-industry-federal-incentives-funding-partnership-opportunities-fact-sheet-v2.pdf

Policy/Incentive/Tax Break	Geography (who instituted the policy)	Component Supported	Input Supported	How California Could Adopt/Adapt Policy
Public-Private Partnerships	Maryland, New Jersey, New York, Rhode Island, Massachusetts	All	All Component Part Manufacturers	Collaborate with floating OSW project investors and dedicate state funding to manufacturing facilities
Hive-Hub Development	Virginia, Maryland, North Carolina, Maine, Denmark, UK	All	All	Could create an floating OSW hub or center (near Humboldt Bay or San Francisco)

6.8 Summary and Conclusions

Developing supply chain capabilities to support the build out of floating OSW in California has the potential to bring significant economic benefit to the state in terms of:

- **Building Local Capacity** – developing local industry that will support local and state tax bases and providing living wage jobs.
- **Capturing Greater Economic Multiplier Effect** - the greater the percentage of creation and fabrication that resides in the state, the greater the potential and magnitude for additional expenditures in other California industries.
- **Eliminating Vulnerability** - Local control over production eliminates the vulnerability to input price variability and other input supply shocks.

Since there is currently no supply chain capacity in California that has direct experience in floating OSW, and limited capacity elsewhere in the US to support the development of floating OSW, the potential economic impact could be theoretically immense. However, realistically there are physical and temporal constraints relative to California's targets and timelines that make developing aspects of the supply chain more or less feasible in terms of costs and timelines. As discussed in previous sections, there are realistic near-term opportunities for domestic supply chain capacity development related to:

- concrete casting and manufacturing capacity in support of towers and foundations;
- steel fabrication capacity in support of towers, foundations, mooring lines, and anchors; and
- wire drawing capacity in support of inter array and high voltage cables.

These are all inputs that were identified and discussed (Table 6-2) as being "fit for local content." In all three of these cases California has existing capacity (both in terms of facilities and labor force) in other sectors which can be retrained and retooled to meet floating OSW demand (Table 6-3).

Despite not having current manufacturing capacity in California to support floating OSW, the development of domestic supply chain capacity for concrete, steel and wire as listed above will enable local construction and assembly of both towers and foundations, which have been identified as components having high potential for local supply chain capacity development.

The high scores for towers and foundations (and the associated inputs) are due in large part to existing labor capacity in adjacent sectors. This suggests that, in terms of workforce development, there are both opportunities to re-train an existing work force (particularly concrete and concrete products), and to develop a new cohort of skilled labor (steel fabricators). In terms of the potential to benefit the economy of California directly and indirectly, workforce development may be the single biggest long-term opportunity associated with developing a domestic floating OSW supply chain.

It is important to recognize that the identified policy instruments have the potential to provide positive impact and generate incentives and momentum across multiple aspects of the supply chain. Experience on the East Coast and in Europe has shown that public and private sector investments and ensuring a steady pipeline through use of power purchase agreements and feed in tariffs have had the greatest impact on spurring the development of manufacturing and assembly capacity. There are several policies and incentives California could utilize to lower the risk associated with developing floating OSW facilities including floating OSW industry tax credits. The California Capital Investment Incentive Program and the California Alternative Energy and Advanced Transportation Financing Authority both already offer returns to investors that reduce the total investment needed to create these large facilities that range in cost from $100 million to $350 million.

Table 6-5 summarizes the various policy instruments that have been used elsewhere to support domestic supply chain development, their use, and the potential for California. While there are certainly additional long-term opportunities to develop domestic supply chain capacity particularly related to ongoing operations and maintenance, these sectors represent "quick wins" for California.

Table 6-5: Summary of Policy Instruments and California Opportunities

Sectors	*Policy Lever Used Elsewhere*	*Expenditure Example*	*Opportunities for California*
Steel manufacturing and Product Fabrication	Public/Private Investment	$50 million in MD	Create primary steel manufacturing and steel fabrication capacity
	Feed In Tariffs	15-year guarantees- Netherlands	Encouraged investment in parts manufacturing capacity
Component Manufacturing	Public/Private Investment	$250 million -NJ	Establish manufacturing facilities, offset upgrade costs for existing manufacturing facilities
	Tax Credits/Rebates	Capital Investment Incentive Program and California Alternative Energy and Advanced Transportation Authority- existing CA mechanisms that offer rebates and credits and exclusions for large capital projects	
Labor and Workforce Development	Public Investment	$30 million OSW training institute in NY	Develop training centers, build workforce capacity, encourage new entrants into the labor force
	Buy Local and PLA agreements		
Cross Cutting	Public Funding	UK, Denmark MA, VA,	Create knowledge and innovation hubs

SECTION 7

Economic Benefits Analysis

7.1 Key Issues and Questions

A key theme to this Assessment is that creating a new workforce and seaport to support the launch a floating offshore wind industry in California will require significant investment, including initial sunk capital costs to develop the physical facilities (e.g., seaport development, training center) and long-term investment to facilitate worker training, safety, and standards. These investments will generate considerable economic benefits that will ripple throughout the state economy as this nascent industry takes root. Pursuant to the AB 525 mandate, this section examines the potential beneficial economic effects of workforce and seaport development, assessing issues and questions such as:

- What are the economic benefits (i.e., jobs, income, economic activity, fiscal impacts) of developing a seaport and workforce?
- How would developing a seaport impact the local/regional economy and the state economy?
- What beneficial impacts could be realized from workforce training, including the development of a sophisticated training center?
- What are the potential impacts to fiscal (tax) revenues from workforce and seaport development?

Section 25991.3(D): Basis for Economic Benefits Analysis for Workforce and Seaport Development

On or before December 31, 2022, the commission shall complete and submit to the Natural Resources Agency and the relevant fiscal and policy committees of the Legislature a preliminary assessment of the economic benefits of offshore wind as they relate to seaport investments and workforce development needs and standards.

7.2 Technical Approach

An economic benefit is any activity that can be quantified in terms of the money that it generates, such as net income, revenue, profit, and cash flow. It is recognized that there are other types of economic benefits, including quality of life, property values, social capital, and supply chain risk reduction. This Assessment focuses on the quantifiable benefits to provide decisionmakers and stakeholders with specific figures that simulate the economic impact of offshore wind seaport and workforce development.

A common approach to measuring the economic feasibility of public investment is to conduct a benefit-cost analysis, or BCA. For such an analysis, the economic term “benefit” is strictly defined, and the evaluation follows a formal process. While BCA provides important information for decision making, the approach often leaves out the estimate of how investment(s) will influence the economy of a state or community. These regional economic impacts are significant to a state or local jurisdiction that risks losing out on revenue and economic activity to a nearby competing state or region. In particular, understanding these economic “ripple effects” is critical to members of legislative bodies who are tasked to protect and enhance the overall economic and ecological resilience of a region. Therefore, this Assessment, per the AB 525 mandate above, analyses potential benefits and does not consider costs (i.e., adverse economic impacts to existing industries or stakeholders).

To quantify the potential regional economic impact benefits (or "beneficial impacts"), this Assessment uses the input-output model IMPLAN. As described below, this model and approach serves as an economic simulation, forecasting how the cost/investment of developing a seaport and workforce would impact a local economy (i.e., Greater Humboldt Area) and the greater California state-wide economy.

7.2.1 About the IMPLAN Model

The regional economic impacts were estimated using an input-output model for the State of California and a smaller four-county area. An input-output model is a technique that quantifies the interactions between industries in an economy. Input-output models yield multipliers that are used to calculate the total direct, indirect, and induced impact on jobs, income, and output resulting from a dollar of spending on goods and services in the study area. The model used to estimate economic impacts for this study is IMPLAN, an input-output model developed by the United States government and the University of Minnesota (available from the Minnesota IMPLAN Group, Inc.). IMPLAN was chosen for this Assessment because it requires regional data, which have been compiled from multiple sources and include hundreds of industrial sectors, which fuels IMPLAN's reliability in calculating multiple levels of economic impact. In addition to being widely used in regional economic analysis, the model and its methodology have been extensively reviewed in professional and economic journals.

The data used in the IMPLAN model comes from various sources. Employment, wage and salary income at the state and county levels are provided by the Bureau of Labor Statistics. National-, state-, and county-level proprietors, proprietor income, and the relationship between employee compensation and wage and salary income (to infer benefits) are provided by the Bureau of Economic Analysis. the number of firms by size at the national, state, county, and zip-code levels are provided by the U.S. Census Bureau.

The IMPLAN model produces estimates of economic contributions at three levels: (1) direct effects, (2) indirect effects, and (3) induced effects. These impacts represent different yet related responses to the operation of these businesses. The sum of the three different impacts represents the total impact of the floating offshore wind industry development in the state (or smaller area in the second analysis). Each of the three economic impact levels is described briefly below:

- ***Direct impacts*** indicate the initial change in economic activity related to the development of the offshore wind industry. Direct impacts capture both activities within these defined sectors for construction and operations of offshore wind and activities in other industries that directly support those industries. Direct impacts measure the total amount of economic activity in terms of the monetary value and jobs that are injected into the local economy directly from the sectors. The analysis identifies and assesses the impacts of these industries to the regional economy.
- ***Indirect impacts*** measure the response of local industries to increased demand from inter-industry transactions. The indirect impacts trace the ripple effect through the local economy as local industries increase supply because of the increase in demand generated from the construction and operation of offshore wind projects.
- ***Induced impacts*** measure the response of local industries to the increased expenditures resulting from new household income generated from direct and indirect effects.

Figure 7-1 provides a visual representation of how investment in offshore wind ripples through the economy, from direct effects to indirect effects to induced effects. IMPLAN models this ripple effect.

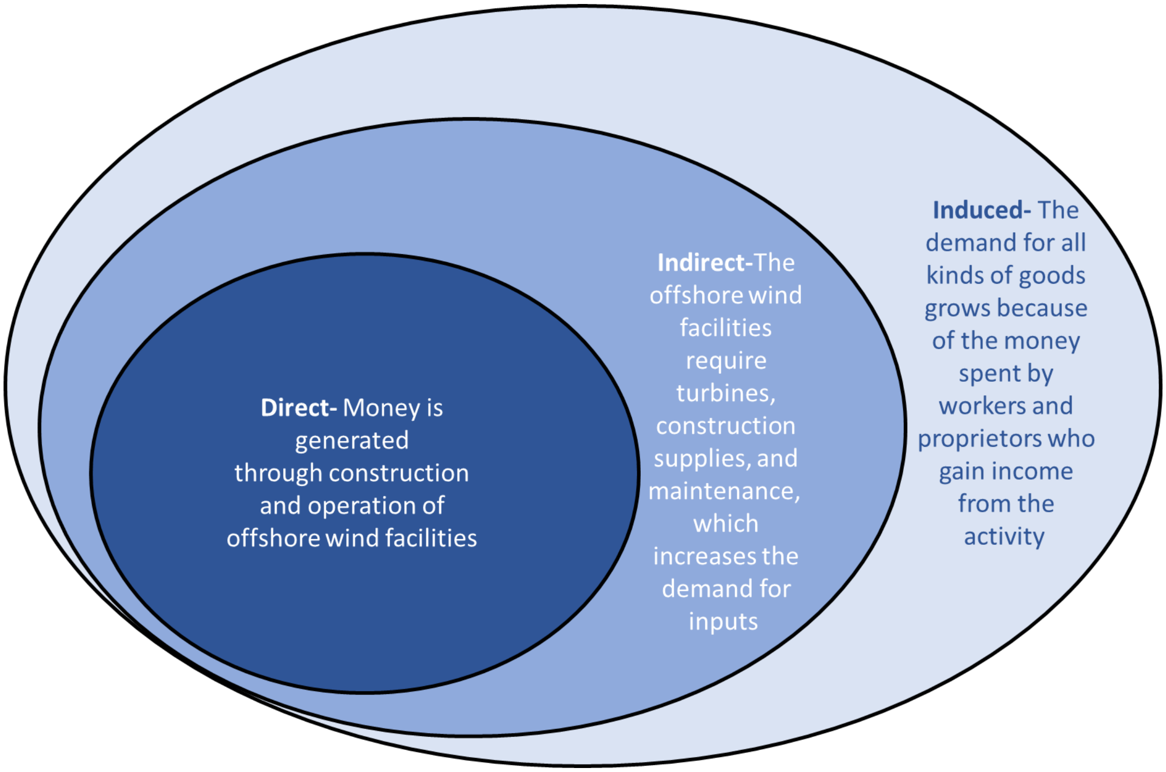


Figure 7-1: Types of Beneficial Economic Impacts Measured by IMPLAN Input-Output Model

The IMPLAN system models government revenues, taxes, and fiscal impacts associated with the aggregated industries as well. These outputs are also developed at the three levels of impact. This study will analyze the regional economic impacts of the developing the offshore wind industry, including the construction and operation of wind projects over time. All results are reported in terms of the annual impacts and are provided for specified years. Employment impacts are measured in number of jobs, while labor income and output are measured in US 2023 dollars.

7.2.2 Input Data and Sources

This section reviews the data and sources that were used to populate the IMPLAN model, serving as the input values for the algorithm. Pursuant to the AB525 mandate, the economic models were focused on workforce and seaport development. Section 2 (Seaport Development and Investment) and Section 3 (Workforce Development Needs) provide the input datasets for the IMPLAN models, which are also briefly summarized in the following sections.

7.2.2.1 Workforce Development

As discussed in Section 3.3 above, an estimation of the number and types of jobs needed for the floating offshore wind workforce (by component and phase) was performed, primarily relying on the analysis performed by Guidehouse (2022), AJP/BVG (2019), and NREL/BOEM (2016). After the number and type (workforce distribution) factors were identified, annual average salary data for California workers from the US BLS (see Section 5.2.1) was applied to derive labor income estimates for 2030 and 2045, as provided in Table 7-

1 below.[81] It is important to understand that the supply chain employment presented in section 3.3 includes both the direct and indirect sector employment while IMPLAN inputs only include the direct jobs from the development of an offshore wind energy industry, as the indirect employment impacts are derived from those direct jobs. In consultation with the analysts that oversee the IMPLAN model, the types of workforce occupations were allocated to a correlating IMPLAN input sector.[82] As summarized in Table 7-1, over 2,500 direct jobs totaling $189 million in labor income is forecasted for 2030 and over 5,500 direct jobs totaling nearly $419 million in labor income is forecasted for 2045. These are significant input values, reflecting the immensity of creating a workforce to meet the demand of a rapidly growing new industry and statewide economic driver. Please note that IMPLAN defines jobs to mean individual jobs and not full-time equivalents (FTEs).

Table 7-1: IMPLAN Inputs for Workforce Development

IMPLAN Sector	Workforce Area	2030		2045	
		Jobs	Labor Income	Jobs	Labor Income
56 - Construction of Other New Non-residential Structures (includes Harbor and Port Facilities)	Ports and Staging	494	$33,617,688	810	$55,122,120
52 - Construction of New Power and Communications Structures	Wind Farm Construction	759	$54,318,518	1,574	$112,661,342
281 - Turbine and Turbine generator set units manufacturing	Turbine Construction	374	$25,813,069	775	$53,489,648
43 - Electric Power Generation - Wind	Wind Farm Operations	918	$75,693,826	2,393	$197,269,227
	Total	**2,575**	**$189,443,101**	**5,552**	**$418,542,337**

7.2.2.2 Seaport Development

As discussed in Section 2.3 above, seaport development will entail an upfront capital investment to develop the necessary quayside and supporting seaport facilities. This Assessment focuses on the potential economic impact of (re)developing a single seaport that will serve as a hub for floating offshore wind development, as is the focus of the AB 525 mandate (see Section 2). It is acknowledged that operational costs (i.e., trainer salaries, insurance, utilities, repairs, etc.) would also generate long-term recurring benefits, especially in the area of the seaport, but this Assessment focuses on the economic impact of constructing the seaport. This Assessment relies on a construction estimate prepared by Moffatt and Nichol for the Humboldt Marine Terminal, estimating that approximately $125 million would be required to upgrade the seaport to serve as an offshore wind development hub. For the IMPLAN model, this Assessment assumed that seaport construction would be performed over a three-year period with $41 million spent annually (Table 7-2). This investment was mapped to IMPLAN sector 56 for the construction of harbor and port facilities.

[81] U.S. Bureau of Labor Statistics (BLS). May 2021. State Occupational Employment and Wage Estimates for California. Available online at: https://www.bls.gov/oes/current/oes_ca.htm

[82] Pers. Comm. September 28, 2022 through October 21, 2022. Michael Nealy (IMPLAN) communique with Jeri Sawyer (Greene Economics).

Table 7-2: IMPLAN Inputs for Seaport Development

IMPLAN Sector	Area of Development	Annual Investment	No. of Years Under Development
56 - Construction of Other New Non-residential Structures (includes Harbor and Port Facilities)	Seaport	$41,666,667	3

7.2.2.3 Training Facility Development

A new training facility is also included in the seaport beneficial impacts analysis. As discussed in Section 5.4, this Assessment reviewed the development of seaports for offshore wind initiatives from the US East Coast and abroad, finding that workforce development would benefit from a training facility to serve as a hands-on laboratory for the implementation of specific worker safety classes (i.e., marine safety, at height training), construction protocols, and industry standards. This Assessment identified the training facility being developed in New York as the most accurate reflection of the type of training facility that California should develop. The cost of the New York training facility is approximately $20 million.[83] This Assessment assumes this training center would be developed at the seaport and relies on the $20 million estimate as the IMPLAN input value with construction occurring over a two-year period (Table 7-3).

Table 7-3: IMPLAN Inputs for Workforce Development

IMPLAN Sector	Area of Development	Annual Investment	No. of Years Under Development
53 – Construction of New Educational and Vocational Structures	Training Center	$10,000,000	2

7.2.3 IMPLAN Model Scenarios

To assess beneficial economic impacts under different conditions, four IMPLAN model scenarios are considered. The model scenarios examine two different regions: the whole state of California, and a smaller region (area) surrounding a likely location for seaport development. The modelled scenarios also consider conditions with policy support to ensure all direct and intermediate activities related to floating offshore wind development occur within the state or the smaller area to the extent possible, and without that policy support.

The difference between with and without policy support in terms of how IMPLAN is run, is that the without policy support model includes the default IMPLAN parameters for all industries, so the model and base data are not modified from what IMPLAN provides. For the with policy support scenarios, the IMPLAN sectors included in the analysis are modified and are set to provide all direct and intermediate inputs from within the defined region only (as long as the intermediate industry exists within the region). Or in other words, that there are no (or very limited) economic leakages.

The Greater Humboldt Area includes Humboldt, Trinity, Del Norte, and Mendocino counties in northern California. The four scenarios are identified as beneficial economic impacts to:

[83] NYSERDA. October 20, 2022. Governor Hochul and Suffolk County Executive Bellone Announce Land Transfer to Bring National Offshore Wind Training Center to Suffolk County and Train New Yorkers for Green Jobs. Available online at: https://www.governor.ny.gov/news/governor-hochul-and-suffolk-county-executive-bellone-announce-land-transfer-bring-national

1. California with policy support
2. California without policy support
3. Greater Humboldt Area with policy support
4. Greater Humboldt Area without policy support

The IMPLAN model required modifications to sectors where development is to occur but do not currently exist in the defined study area/region. The Greater Humboldt Area does not include any activity in the sectors for 281 - Turbine and Turbine generator set units manufacturing or 43 - Electric Power Generation – Wind, so for both of the Greater Humboldt Area scenarios, the data was modified, pursuant to IMPLAN practices, to include these two sectors. Further, for Scenario 3, Greater Humboldt Area with policy support, sector 335 – Fiber optic cable manufacturing, was also modified, pursuant to IMPLAN practices, as there is currently no activity in that sector, to allow for cable manufacturing within the area.

The inputs for both the California and Greater Humboldt Area models are identical and are modeled to identify a range of possible economic benefits within the specified geography due to development of offshore wind within each geographic region. Please note that these are not additive, nor are they truly comparable, due to the limitations of the IMPLAN model and the introduction of aggregation bias when the four counties are aggregated into one region, so each must be assessed individually.[84]

7.3 State-Wide Beneficial Economic Impacts from Seaport and Workforce Development

The following sections present the results of the California state-wide IMPLAN model, providing breakdowns for economic activity (GDP), job creation, labor income, and fiscal impacts. The summary tables in the following sections provide tabulations on the potential impact of the overall scenarios (workforce, seaport, and training facility development), as well as specific estimates for investment in each development initiative. Estimates are provided for 2023, 2024, 2025, 2030, and 2045 to reflect the impact of the initial (short-term) investments required for facility development (i.e., seaport and training facilities) in the near term, and the longer-term impacts for AB 525 planning years 2030 and 2045, which represent the ongoing operation of the offshore wind developments. For simplicity and to avoid duplication, as the annual results for years 2024 and 2025 are identical, these annual values are presented one time only under the column titled "2024/2025 annual", so please note these are the annual values for both 2024 and 2025.

Table 7-4 presents a summary of the regional economic impacts to the State of California for the initial years 2023, 2024, and 2025, and the longer-term representative years 2030 and 2045, under the without policy support and the with policy support scenarios. As observed in the table, the first column for each year (grey with text not bolded) presents the without policy support scenario results and the second column for each year (white with bolded text) presents the with policy support scenario results, providing a range of possible benefits for each investment type for each model year. Table 7-4 illustrates the ripple effect of workforce development results in 6,300 (without policy support in 2030) to 16,600 jobs (with policy support in 2045), labor income between $550 million (without policy support in 2030) to $1.6 billion (with policy support in 2045) and between $2.4 billion to $6.9 billion GDP in 2030 without policy support and 2045 with policy support, respectively. For the seaport development and the training center construction combined, between

[84] Aggregation bias stems from the loss of detail that occurs when one Combines Regions or aggregates Industries. When multiple regions or industries are combined prior to calculating multipliers, the characteristics of the new aggregated region or Industry becomes the weighted average of the included pieces, which creates aggregation-induced error, or bias. (IMPLAN. Aggregation Bias. 2023. Available online at: https://support.implan.com/hc/en-us/articles/115009668588-Aggregation-Bias)

400 and 550 jobs are needed per year of construction, providing labor income of $34 to $45 million, and $85 to $115 million in GDP annually between 2023 and 2025, with the lows related to the without policy support scenario and the highs consistent with the with policy support scenario.

Table 7-4: Summary of Floating OSW Industry Beneficial Impacts in State of California

Investment	2023		2024/2025 annual		2030		2045	
Number of Jobs								
Workforce Development					6,279	**7,306**	14,137	**16,610**
Seaport Development	406	**444**	406	**444**				
Training Center Construction			98	**98**				
Total	406	**444**	504	**542**	6,279	**7,306**	14,137	**16,610**
Labor Income (in millions of $)								
Workforce Development					$550.5	**$671.2**	$1,266	**$1,562**
Seaport Development	$33.5	**$36.8**	$33.5	**$36.8**				
Training Center Construction			$8.1	**$8.1**				
Total	$33.5	**$36.8**	$41.6	**$44.9**	$550.5	**$671.2**	$1,266	**$1,562**
Output GDP (in millions of $)								
Workforce Development					$2,395	**$2,833**	$5,803	**$6,883**
Seaport Development	$85.2	**$96.6**	$85.2	**$96.6**				
Training Center Construction			$18.7	**$18.7**				
Total	$85.2	**$96.6**	$103.9	**$115.3**	$2,395	**$2,833**	$5,803	**$6,883**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

7.3.1 Economic Activity

Economic activity reflects how an investment or project impacts a defined economic area (i.e., statewide, regional, local), capturing the multiplier, or ripple effect of introducing a new source of production, spending, or purchasing. Economic activity is typically estimated as a measure of Gross Domestic Product (GDP), which is the total market value of all final goods and services produced within a defined area in a given period of time (typically a quarter year or year).[85]

[85] IMPLAN. Measures of GDP: Value Added and Final Demand. 2021. Available online at: https://support.implan.com/hc/en-us/articles/115002815494-Measures-of-GDP-Value-Added-and-Final-Demand

Table 7-5 demonstrates the beneficial economic impact realized for the State of California through the development of the offshore wind workforce, seaport development, and training center construction in terms of economic output or GDP, under both the without and with policy scenarios. Total economic output ranges from just over $85 million without policy support in 2023 to $6.9 billion in 2045 with policy support for the entire state.

The development of an offshore wind workforce contributes heavily to the economic output determined by the IMPLAN model. Workforce development directly results in over $1.5 billion in GDP per year in 2030 and nearly $3.7 billion per year in 2045. Offshore wind workforce development contributes an additional $900 million to $1.3 billion to the state's GDP per year in terms of indirect and induced impacts in 2030 (without and with policy support respectively) and $2 billion (without policy support) to $3 billion (with policy support) per year in 2045.

Over the three years of seaport development, a total of $256 million to $290 million in GDP is generated (without and with policy support respectively). Of this total, $125 million is generated via direct impacts from seaport development, $65 million to $93 million via indirect impacts (without and with policy support respectively), and $65 million to $71 million via induced impacts (without and with policy support respectively). More than $37 million in GDP is created over the two years of training center construction. Unlike workforce and seaport development, training center construction contributes a greater economic output via induced impacts compared to indirect impacts, due to a higher multiplier for consumer purchases by construction employees than for intermediate inputs for the actual construction. In other words, construction of the training center is more labor intensive than material focused. Of the $37 million generated in GDP, $20 million come from direct impacts, $6.8 million from indirect impacts and $10.6 million from induced impacts, regardless of policy support.

Table 7-5: Floating Offshore Wind Industry Economic Activity (GDP) in State of California (in millions of $)

Investment	2023		2024/2025 annual		2030		2045	
DIRECT IMPACT								
Workforce Development					$1,504	**$1,504**	$3,694	**$3,694**
Seaport Development	$41.8	**$41.8**	$41.8	**$41.8**				
Training Center Construction			$10.0	**$10.0**				
Total	$41.8	**$41.8**	$51.8	**$51.8**	$1,504	**$1,504**	$3,694	**$3,694**
INDIRECT IMPACT								
Workforce Development					$535.2	**$895.5**	$1,292	**$2,180**
Seaport Development	$21.8	**$30.9**	$21.8	**$30.9**				
Training Center Construction			$3.4	**$3.4**				
Total	$21.8	**$30.9**	$25.2	**$34.3**	$535.2	**$895.5**	$1,292	**$2,180**
INDUCED IMPACT								
Workforce Development					$355.5	**$433.6**	$817.3	**$1,009**

Investment	2023		2024/2025 annual		2030		2045	
Seaport Development	$21.6	**$23.8**	$21.6	**$23.8**				
Training Center Construction			$5.3	**$5.3**				
Total	$21.6	**$23.8**	$26.9	**$29.1**	$355.5	**$433.6**	$817.3	**$1,009**
TOTAL IMPACT								
Workforce Development					$2,395	**$2,833**	$5,803	**$6,883**
Seaport Development	$85.2	**$96.6**	$85.2	**$96.6**				
Training Center Construction			$18.7	**$18.7**				
Total	$85.2	**$96.6**	$103.9	**$115.3**	$2,395	**$2,833**	$5,803	**$6,883**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

7.3.2 Job Creation

As seen in Table 7-6, the development of the floating offshore wind workforce and construction of the seaport and training center result in thousands of new jobs between 2023 and 2045. Combined, these sectors create between 400 and 16,600 jobs a year including direct, indirect and induced jobs created.

The regional economic impact stimulated by the development of a floating offshore wind workforce results in the creation of approximately 2,900 direct jobs in 2030 and 6,300 in 2045. The development of a floating offshore wind workforce also has the greatest indirect and induced impact in terms of job creation. In 2045 workforce development results in 3,900 (without policy support) to 5,500 (with policy support) indirect jobs and 3,900 to 4,800 induced jobs (without and with policy support respectively).

For this analysis, seaport development is considered over a 3-year period. During this time, between 400 and 440 annual jobs are created to support seaport development. Broken down, seaport development results in 220 direct jobs, 80 to 110 indirect jobs (without and with policy support respectively), and 100 to 110 induced jobs (without and with policy support respectively). The training center construction is assumed to occur over a 2-year period. Though the timeframe is shorter for the development of this facility, it still creates a total of 100 annual jobs. Of these 100 jobs, 60 are direct jobs, 10 are indirect and 25 are induced, regardless of policy support.

Table 7-6: Floating OSW Industry Job Creation in State of California (Number of Jobs)

Investment	2023		2024/2025 annual		2030		2045	
DIRECT IMPACT								
Workforce Development					2,933	**2,933**	6,312	**6,312**
Seaport Development	223	**223**	223	**223**				
Training Center Construction			60	**60**				

Investment	2023		2024/2025 annual		2030		2045	
Total	223	**223**	283	**283**	2,933	**2,933**	6,312	**6,312**
INDIRECT IMPACT								
Workforce Development					1,641	**2,293**	3,905	**5,459**
Seaport Development	80	**107**	80	**107**				
Training Center Construction			12	**12**				
Total	80	**107**	92	**119**	1,641	**2,293**	3,905	**5,459**
INDUCED IMPACT								
Workforce Development					1,705	**2,079**	3,920	**4,839**
Seaport Development	104	**114**	104	**114**				
Training Center Construction			25	**25**				
Total	104	**114**	129	**139**	1,705	**2,079**	3,920	**4,839**
TOTAL IMPACT								
Workforce Development					6,279	**7,306**	14,137	**16,610**
Seaport Development	406	**444**	406	**444**				
Training Center Construction			98	**98**				
Total	406	**444**	504	**542**	6,279	**7,306**	14,137	**16,610**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

7.3.3 Labor Income

Labor income reflects the total value of all forms of employment income paid throughout a defined economy during a specified period of time. Further, labor income represents the combined cost of total payroll paid to employees (e.g. wages and salaries, benefits, payroll taxes) and payments received by self-employed individuals and/or unincorporated business owners across the defined economy. [86] As provided in Table 7-7, labor income will have both short-term and long-term effects, representing the initial impact of a burgeoning floating offshore wind industry that reaches full maturity by 2045. Labor income from workforce development is $550 million to $670 million by 2030 (without and with policy support respectively). By 2045, these values more than double, in excess of $1.2 billion without policy support to $1.5 billion with policy support.

[86] IMPLAN. Understanding Labor Income, Employee Compensation, and Proprietor Income. 2021. Available online at: https://support.implan.com/hc/en-us/articles/360024509374-Understanding-Labor-Income-LI-Employee-Compensation-EC-and-Proprietor-Income-PI-

Seaport development results in between $33.5 million and $36.8 million in total labor income annually (without and with policy support respectively), $18.7 in direct labor income annually, and between $15 million without policy support and $18 million with policy support in indirect and induced labor income annually. Training center construction results in $8 million of total labor income annually. Of the total, $5 million is direct, $1 million is indirect, and $2 million is induced labor income, regardless of policy support.

Table 7-7: Floating OSW Industry Labor Income in State of California (in millions of $)

Investment	2023		2024/2025 annual		2030		2045	
DIRECT IMPACT								
Workforce Development					$257.2	**$257.2**	$573.7	**$573.7**
Seaport Development	$18.7	**$18.7**	$18.7	**$18.7**				
Training Center Construction			$5.2	**$5.2**				
Total	$18.7	**$18.7**	$23.9	**$23.9**	$257.2	**$257.2**	$573.7	**$573.7**
INDIRECT IMPACT								
Workforce Development					$168.0	**$261.2**	$403.7	**$632.7**
Seaport Development	$7.1	**$9.7**	$7.1	**$9.7**				
Training Center Construction			$1.1	**$1.1**				
Total	$7.1	**$9.7**	$8.2	**$10.8**	$168.0	**$261.2**	$403.7	**$632.7**
INDUCED IMPACT								
Workforce Development					$152.8	**$221.4**	$288.1	**$355.7**
Seaport Development	$7.6	**$8.4**	$7.6	**$8.4**				
Training Center Construction			$1.9	**$1.9**				
Total	$7.6	**$8.4**	$9.5	**$10.3**	$152.8	**$221.4**	$288.1	**$355.7**
TOTAL IMPACT								
Workforce Development					$550.5	**$671.2**	$1,266	**$1,562**
Seaport Development	$33.5	**$36.8**	$33.5	**$36.8**				
Training Center Construction			$8.1	**$8.1**				
Total	$33.5	**$36.8**	$41.6	**$44.9**	$550.5	**$671.2**	$1,266	**$1,562**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

7.3.4 Fiscal Impacts

New jobs and economic growth, stemming from the creation of California's floating offshore wind industry, will produce new revenue streams for the state, through its contribution to state and local taxes. These are modelled and estimated in IMPLAN on an annual basis for several levels of taxing jurisdictions, from local to federal. For the purposes of this analysis, the taxes paid to the State of California are the primary focus. Table 7-8 provides a breakdown by type of impact of the expected tax revenues to the State of California for 2030 and 2045 due to the workforce development for offshore wind. With a direct tax impact of $117 in 2030 to $299 million in 2045, the total impact to state revenues ranges from $154 (without policy support in 2030) to $433 million (with policy support in 2045). This represents an approximate 0.06 to 0.2 percent increase in total state revenues when compared to 2021 total California tax revenues of nearly $250 billion.[87]

Table 7-8: Floating Offshore Wind Industry Annual State Taxes in State of California for Workforce Development (in millions of $)

Year	Direct		Indirect		Induced		Total By Year	
2030	$116.9	**$116.9**	$21.7	**$36.7**	$15.5	**$18.9**	$154.2	**$172.5**
2045	$299.3	**$299.3**	$51.9	**$89.5**	$35.7	**$44.0**	$386.8	**$432.8**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

As shown in Table 7-9, the total annual tax contributions to the state coffers for investment in seaport development (for three years) is between $2.9 and $3.3 million (without and with policy support respectively), with nearly $1 million from direct tax impacts. For the training center construction (for two years) the total annual contribution is just over $600,000, regardless of policy support, with nearly $30,000 in direct state taxes.

Table 7-9: Floating Offshore Wind Industry Annual State Taxes in State of California for Seaport and Training Center Development (in millions of $)

Area of Investment	Years Under Development	Direct		Indirect		Induced		Total by Year	
Seaport	3	$0.96	**$0.96**	$1.0	**$1.3**	$0.94	**$1.0**	$2.9	**$3.3**
Training Center	2	$0.28	**$0.28**	$0.14	**$0.14**	$0.23	**$0.23**	$0.66	**$0.66**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

7.4 Regional Beneficial Economic Impacts from Seaport Development

Along with the analysis of the economic impacts of floating offshore wind development to the State of California, a smaller four-county area sample analysis around the area of one likely port development project is included here, identified as the Greater Humboldt Area (defined above). The following sections present the results of the Greater Humboldt Area IMPLAN model, assuming the same input data and sources as the full state model for investment in workforce, seaport, and training center development, under the same scenario assumptions as the California model. These sections provide breakdowns for economic activity (GDP), job creation, labor income, and fiscal impacts for both the With Policy Support and Without Policy Support

---

[87] Statista. State government tax revenue in the United States in the fiscal year of 2021, by state (in billion U.S. dollars). Available online at: https://www.statista.com/statistics/248932/us-state-government-tax-revenue-by-state/.

scenarios. The summary tables in the following sections provide tabulations on the potential impact of the overall scenarios (workforce, seaport, and training facility development), as well as specific estimates for investment in each development initiative. As with the full state analysis, estimates are provided for 2023, 2024/2025, 2030, and 2045 to reflect the impact of the initial (short-term) investments required for facility development (i.e., seaport and training facilities) in the near term, and the longer-term impacts for AB525 planning years 2030 and 2045, which represent the ongoing operation of the Offshore Wind Developments. The IMPLAN model used in the local area analysis for the With Policy Support scenario is specified to minimize or eliminate imports, to the extent feasible, meaning the majority of the direct and intermediate inputs would originate within the four-counties included in the area. As with the California model, the "without policy support" scenario includes no such limitations. Again, the results in the following tables include two columns for each year, with the first column showing the without policy support scenario results and the second column displaying the with policy support scenario results, providing a range of possible benefits for each investment type for each model year.

As mentioned previously, these results cannot be compared directly to the California results presented above, due to the limitations of the IMPLAN model and the introduction of aggregation bias when the four counties are aggregated into one region. If compared directly, there are several cases where the local area beneficial impacts appear greater than the state beneficial impacts, which may be counter-intuitive. However, using IMPLAN, "these comparisons would never match up, nor would we want them to, because that is the core difference between regions and Multipliers."[88] So the results presented here should be assessed on their own merits, as they are a completely separate analysis.

Table 7-10 provides the summary results of the Greater Humboldt Area model for the initial years 2023, 2024, and 2025, and the longer-term representative years 2030 and 2045, under the without policy support and the with policy support scenarios. This table shows that the ripple effect of workforce development results in 6,300 (without policy support in 2030) to 18,600 jobs (with policy support in 2045), labor income between $465 million (without policy support in 2030) to $1.4 billion (with policy support in 2045) and between $2.2 to $6.8 billion GDP for the model years 2030 (without policy support) and 2045 (with policy support). For the seaport development and the training center construction combined, the full beneficial impact is between 360 (without policy support) and 540 (with policy support) jobs per year of construction, providing labor income of $23 to $35 million, and $62 to $98 million in GDP annually between 2023 and 2025 (low are without policy support and highs are with policy support).

Table 7-1: Summary of Floating Offshore Wind Industry Beneficial Impacts in Greater Humboldt Area

Investment	2023		2024/2025 annual		2030		2045	
Number of Jobs								
Workforce Development					6,302	**8,448**	13,642	**18,613**
Seaport Development	362	**448**	362	**448**				
Training Center Construction			93	**93**				

[88] Pers. Comm. February 9, 2023. Meg Philipp (IMPLAN) communique with Jeri Sawyer (Greene Economics); and IMPLAN. MRIO vs. Larger Study Area: Leakage, Aggregation Bias, and Other Considerations. 2022. Available online at: https://support.implan.com/hc/en-us/articles/115002799373-MRIO-vs-Larger-Study-Area-Leakage-Aggregation-Bias-and-Other-Considerations.

Total	362	**448**	455	**541**	6,302	**8,448**	13,642	**18,613**
Labor Income (in millions of $)								
Workforce Development					$465.7	**$616.4**	$1,028	**$1,382**
Seaport Development	$23.4	**$28.6**	$23.4	**$28.6**				
Training Center Construction			$6.4	**$6.4**				
Total	$23.4	**$28.6**	$29.8	**$35.0**	$465.7	**$616.4**	$1,028	**$1,382**
Output GDP (in millions of $)								
Workforce Development					$2,153	**$2,862**	$5,126	**$6,820**
Seaport Development	$62.0	**$83.2**	$62.0	**$83.2**				
Training Center Construction			$14.4	**$14.4**				
Total	$62.0	**$83.2**	$76.4	**$97.6**	$2,153	**$2,862**	$5,126	**$6,820**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

7.4.1 Economic Activity

Table 7-11 demonstrates the regional economic beneficial value realized for the Greater Humboldt Area through the development of the floating offshore wind workforce, seaport development, and training center construction in terms of economic output or GDP. Total economic output ranges from $62 million (without policy support) in 2023 to $6.8 billion (with policy support) in 2045.

Workforce development directly results in over $1.6 billion in GDP per year in 2030 and nearly $4.0 billion per year in 2045. Offshore wind workforce development contributes an additional $500 million (without policy support) to $1.2 billion (with policy support) to the state's GDP per year in terms of indirect and induced impacts in 2030, and $1.1 billion (without policy support) to just over $2.8 billion (with policy support) per year in 2045.

Over the three years of seaport development, a total of $186 million (without policy support) to $250 million (with policy support) in GDP is generated. Of this total, $125 million is generated via direct impacts from seaport development, $30 to $87 million via indirect impacts (without and with policy support, respectively), and $31 to $37 million via induced impacts (without and with policy support, respectively). Nearly $29 million in GDP is created over the two years of the local area training center construction. Similar to the state analysis, local area construction of the training center is more labor intensive than material focused. Of the $29 million generated in GDP, $20 million come from direct impacts, $3 million from indirect impacts and $6 million from induced impacts, regardless of policy support.

Table 7-2: Floating Offshore Wind Industry Economic Activity (GDP) in Greater Humboldt Area (in millions of $)

Investment	2023		2024/2025 annual		2030		2045	
DIRECT IMPACT								
Workforce Development					$1,658	**$1,658**	$3,986	**$3,986**
Seaport Development	$41.8	**$41.8**	$41.8	**$41.8**				
Training Center Construction			$10.0	**$10.0**				
Total	$41.8	**$41.8**	$51.8	**$51.8**	$1,658	**$1,658**	$3,986	**$3,986**
INDIRECT IMPACT								
Workforce Development					$293.5	**$938.5**	$695.7	**$2,238**
Seaport Development	$10.0	**$28.9**	$10.0	**$28.9**				
Training Center Construction			$1.5	**$1.5**				
Total	$10.0	**$28.9**	$11.5	**$30.4**	$293.5	**$938.5**	$695.7	**$2,238**
INDUCED IMPACT								
Workforce Development					$201.3	**$265.6**	$443.9	**$595.1**
Seaport Development	$10.2	**$12.4**	$10.2	**$12.4**				
Training Center Construction			$2.8	**$2.8**				
Total	$10.2	**$12.4**	$13.0	**$15.2**	$201.3	**$265.6**	$443.9	**$595.1**
TOTAL IMPACT								
Workforce Development					$2,153	**$2,862**	$5,126	**$6,820**
Seaport Development	$62.0	**$83.2**	$62.0	**$83.2**				
Training Center Construction			$14.4	**$14.4**				
Total	$62.0	**$83.2**	$76.4	**$97.6**	$2,153	**$2,862**	$5,126	**$6,820**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

7.4.2 Job Creation

As seen in Table 7-12, investment in the development of the floating offshore wind workforce and construction of the seaport and training center combined create between 360 (without policy support) and 18,600 (with policy support) total local area jobs between 2023 and 2045. The regional economic impact stimulated by the development of a floating offshore wind workforce results in the creation of approximately 3,800 direct jobs in 2030 and 8,000 in 2045. In 2045 workforce development creates between 3,000 and 7,000 indirect jobs (without policy support and with policy support, respectively), and 2,700 (without policy support) to 3,600 (with policy support) induced jobs.

Over the 3-year period more than 360 annual jobs are created to support seaport development without policy support. That number increases to nearly 450 with policy support. Broken down, seaport development results in 250 direct jobs, between 50 and 120 indirect jobs (without and with policy support, respectively), and 60 to 80 induced jobs (without and with policy support, respectively). As with the state analysis, the training center construction is assumed to occur over a 2-year period. Though the timeframe is shorter for the development of this facility than the seaport construction, it still creates a total of over 90 annual jobs during those years. Of these, approximately 70 are direct jobs, 10 are indirect and 15 are induced jobs, regardless of policy support.

Table 7-3: Floating OSW Industry Job Creation in Greater Humboldt Area (number of jobs)

Investment	2023		2024/2025 annual		2030		2045	
DIRECT IMPACT								
Workforce Development					3,800	**3,800**	7,973	**7,973**
Seaport Development	248	**248**	248	**248**				
Training Center Construction			69	**69**				
Total	248	**248**	317	**317**	3,800	**3,800**	7,973	**7,973**
INDIRECT IMPACT								
Workforce Development					1,268	**3,020**	2,948	**6,994**
Seaport Development	52	**124**	52	**124**				
Training Center Construction			8	**8**				
Total	52	**124**	60	**132**	1,268	**3,020**	2,948	**6,994**
INDUCED IMPACT								
Workforce Development					1,234	**1,628**	2,720	**3,646**
Seaport Development	62	**76**	62	**76**				
Training Center Construction			17	**17**				
Total	62	**76**	79	**93**	1,234	**1,628**	2,720	**3,646**
TOTAL IMPACT								
Workforce Development					6,302	**8,448**	13,642	**18,613**
Seaport Development	362	**448**	362	**448**				
Training Center Construction			93	**93**				
Total	362	**448**	455	**541**	6,302	**8,448**	13,642	**18,613**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

7.4.3 Labor Income

As presented in Table 7-13, labor income will have both short-term and long-term effects, between workforce development, seaport development, and the construction of a training center. Labor income as a result of the direct investment in workforce development of $323 million in the local area totals between $465 to over $600 million by 2030 (without policy support and with policy support, respectively), and with the direct investment of over $700 million in 2045, more than doubles the 2030 impacts to $1 billion (without policy support) to nearly $1.4 billion (with policy support).

Seaport development results in between $23.4 million and $28.6 million in total labor income annually (without policy support and with policy support, respectively), $17.2 in direct labor income annually, and between $6.3 million and $11.4 million in indirect and induced labor income annually (without policy support and with policy support, respectively). Training center construction results in a contribution of $6.4 million to total labor income annually. Of the total, $5 million is direct, $0.4 million is indirect, and $1 million is induced labor income, regardless of policy support.

Table 7-4: Floating OSW Industry for Labor Income in Greater Humboldt Area (in millions of $)

Investment	2023		2024/2025 annual		2030		2045	
DIRECT IMPACT								
Workforce Development					$322.8	**$322.8**	$701.6	**$701.6**
Seaport Development	$17.2	**$17.2**	$17.2	**$17.2**				
Training Center Construction			$5.1	**$5.1**				
Total	$17.2	**$17.2**	$22.3	**$22.3**	$322.8	**$322.8**	$701.6	**$701.6**
INDIRECT IMPACT								
Workforce Development					$78.2	**$208.2**	$183.3	**$489.4**
Seaport Development	$3.0	**$7.4**	$3.0	**$7.4**				
Training Center Construction			$0.4	**$0.4**				
Total	$3.0	**$7.4**	$3.4	**$7.8**	$78.2	**$208.2**	$183.3	**$489.4**
INDUCED IMPACT								
Workforce Development					$64.7	**$85.4**	$142.7	**$191.3**
Seaport Development	$3.3	**$4.0**	$3.3	**$4.0**				
Training Center Construction			$0.9	**$0.9**				
Total	$3.3	**$4.0**	$4.2	**$4.9**	$64.7	**$85.4**	$142.7	**$191.3**
TOTAL IMPACT								
Workforce Development					$465.7	**$616.4**	$1,028	**$1,382**
Seaport Development	$23.4	**$28.6**	$23.4	**$28.6**				
Training Center Construction			$6.4	**$6.4**				
Total	$23.4	**$28.6**	$29.8	**$35.0**	$465.7	**$616.4**	$1,028	**$1,382**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

7.4.4 Fiscal Impacts

For the Greater Humboldt Area analysis, the taxes paid to the State of California are one focus of the fiscal analysis, but the total local taxes due to the investment in workforce development, seaport development and a local area training center are also identified in this section, to show the potential impact of such investment to the local government fiscal resources in rural northern California. However, again due to the limitations of IMPLAN, these fiscal beneficial impacts are broad estimates, so only the summary totals are presented here to provide some estimated ranges of potential fiscal benefits to both the state and the local area.

Table 7-14 provides the total beneficial fiscal impact by type of expected tax revenues to the Greater Humboldt Area and the State of California for 2030 and 2045 due to workforce development for floating offshore wind. Total fiscal impacts to the State could range between $172 million (without policy support in 2030) to $543 million (with policy support in 2045), with local (county and sub-county entities) fiscal beneficial impacts potentially ranging between $117 million (without policy support in 2030) to $368 million (with policy support in 2045).

Table 7-5: Floating OSW Industry Impacts to Annual State and Local Taxes in Greater Humboldt Area for Workforce Development (in millions of $)

	2030		2045	
State Taxes	$172.3	**$217.5**	$431.4	**$543.3**
Local Taxes	$117.3	**$145.0**	$299.4	**$368.4**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

Table 7-15 provides the annual tax impacts to the State of California and the Greater Humboldt Area due to investment of development in a seaport and a training center. Total annual fiscal impacts to the State from seaport development could range between $2.2 million (without policy support) to $3 million (with policy support), and with investment in a local area training center, impacts are estimated at $0.5 million, regardless of policy support. At the local level (county and sub-county entities) the seaport could provide taxes just under $1 million without policy support and $1.2 million with policy support on an annual basis. Investment in a local area training center could provide annual taxes to local entities of approximately $0.2 million, regardless of policy support.

Table 7-6: Floating OSW Industry Beneficial Impacts to Annual State and Local Taxes in Greater Humboldt Area for Seaport and Training Center Development (in millions of $)

Area of Investment	Years Under Development	Total Annual	
STATE TAXES			
Seaport	3	$2.2	**$3.0**
Training Center	2	$0.5	**$0.5**
LOCAL TAXES			
Seaport	3	$0.8	**$1.2**
Training Center	2	$0.2	**$0.2**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

7.5 Summary of Findings

The summary tables for this analysis include Table 7-16, Table 7-17, Table 7-18, and Table 7-19, which provide tabulations on the potential impact of the overall scenarios (workforce, seaport, and training facility development), as well as specific estimates for investment in each development initiative for the state and the Greater Humboldt Area. Monetary values are recorded in millions of dollars. Estimates are provided for representative years 2025 and 2045 to reflect the impact of the initial (short-term) investments required for facility development (i.e., seaport and training facilities) in the near-term, and the longer-term impacts, which represent the ongoing operation of the Floating Offshore Wind Developments. As mentioned previously, the Greater Humboldt Area results cannot be compared directly to the state results due to the limitations of the IMPLAN model and the introduction of aggregation bias when the four counties are aggregated into one region. Therefore, the results presented below should be assessed on their own merits, as they are completely separate analyses.

However, it is appropriate to compare the with- and without- policy scenarios for each geographic region. Table 7-16 includes the total estimated output for GDP, jobs, labor income, and fiscal impacts with and without policy in 2025 and 2045 for the state of California. Table 7-17 includes the total estimated outputs for each category in the near and longer-term for both state scenarios and compares these values by highlighting the difference in value between the two scenarios and the percent increase in value under the with policy support scenario. The economic impact estimates for the near-term are slightly greater in the with policy support scenario, as seen in the difference between with and without policy row in Table 7-17. The near-term results with policy support are between 7.5 and 11 percent greater than the results from the without policy support. Yet, the economic impact estimates in the longer-term scenarios indicate that policy support is significantly more impactful and results in greater economic outputs in 2045. GDP is 19 percent greater with policy support in 2045, number of jobs is 18 percent greater, labor income is 23 percent greater and fiscal impacts are 12 percent greater.

Table 7-7: Summary of Floating OSW Industry Beneficial Impacts in State of California With and Without Policy (in millions of dollars)

Scenario	Investment	Output GDP		Number of Jobs		Labor Income		Fiscal Impacts	
	Year	2025	2045	2025	2045	2025	2045	2025	2045
Without Policy	Workforce Development		$5,803		14,137		$1,266		$386.8
	Seaport Development	$85.2		406		$33.5		$2.9	
	Training Center Construction	$18.7		98		$8.1		$0.66	
	Total	$103.9	$5,803	504	14,137	$41.6	$1,266	$3.6	$386.8
With Policy	Workforce Development		**$6,883**		**16,610**		**$1,562**		**$432.8**
	Seaport Development	**$96.6**		**444**		**$36.8**		**$3.3**	
	Training Center Construction	**$18.7**		**98**		**$8.1**		**$0.66**	
	Total	**$115.3**	**$6,883**	**542**	**16,610**	**$44.9**	**$1,562**	**$4.0**	**$432.8**

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

Table 7-8: Summary of Difference between floating OSW Industry Beneficial Impacts in State of California With and Without Policy

	Output GDP		Number of Jobs		Labor Income		Fiscal Impacts	
Year	2025	2045	2025	2045	2025	2045	2025	2045
Additional Potential Impacts with Policy	$11.4	$1,080	38	2,473	$3.3	$296	$0.4	$46
Percent Increase with Policy	11%	19%	7.5%	17.5%	8%	23%	11%	12%

Notes: Grey cells contain values without policy support; White cells with bolded values are with policy support.

Table 7-18 includes the total estimated output for GDP, jobs, labor income, and fiscal impacts with and without policy in 2030 and 2045 for the Greater Humboldt Area. Like Table 7-17, Table 7-19 highlights the difference in categorical values between the two policy scenarios and the percent increase in value under the with policy support scenario. Monetary values are recorded in millions of dollars and the fiscal impacts column for both Table 7-18 and Table 7-19 include only state level fiscal impacts. The economic output estimates for both the near- and longer-term are significantly greater under the scenario with policy support compared to the scenario without policy support. In 2030, the with policy scenario economic outputs are 17 to 30 percent greater than the economic outputs under the without policy scenario. The longer-term economic impacts are 36 percent greater in terms of number of jobs under the policy scenario and 34 percent greater in terms of labor income. Fiscal impacts and GDP are also at least 26 percent greater for the local area under the policy support scenario.

Table 7-9: Summary of Floating OSW Industry Beneficial Impacts in Greater Humboldt Area With and Without Policy

Scenario	Investment	Output GDP		Number of Jobs		Labor Income		Fiscal Impacts	
	Year	2025	2045	2025	2045	2025	2045	2025	2045
Without Policy	Workforce Development		$5,126		13,642		$1,028		$431.4
	Seaport Development	$62.0		362		$23.4		$2.2	
	Training Center Construction	$14.4		93		$6.4		$0.5	
	Total	$76.4	$5,126	455	13,642	$29.8	$1,028	$2.7	$431.4
With Policy	Workforce Development		**$6,820**		**18,613**		**$1,382**		**$543.3**
	Seaport Development	**$83.2**		**448**		**$28.6**		**$3.0**	
	Training Center Construction	**$14.4**		**93**		**$6.4**		**$0.5**	
	Total	**$97.6**	**$6,820**	**541**	**18,613**	**$35.0**	**$1,382**	**$3.5**	**$543.3**

Table 7-10: Summary of Difference Between Floating OSW Industry Beneficial Impacts in Greater Humboldt Area With and Without Policy

	Output GDP		Number of Jobs		Labor Income		Fiscal Impacts	
Year	2025	2045	2025	2045	2025	2045	2025	2045
Additional Potential Impacts with Policy	$21.2	$1,694	86	4,971	$5.2	$354	$0.8	$111.9
Percent Increase with Policy	28%	33%	19%	36%	17%	34%	30%	26%

For both the state and Greater Humboldt Area, the with policy scenarios result in greater economic outputs than the without policy scenarios. Though policy support does not impact Training Center Construction economic outputs, it impacts the indirect and induced outputs for workforce and seaport development. These impacts could result in smaller economic benefits in 2030 and significantly larger economic benefits in 2045.

Under both with and without policy scenarios at the state and Greater Humboldt Area level, Offshore Wind Development has the potential to create considerable economic impacts that could significantly impact the state and local area's economies.

SECTION 8

References

American Jobs Project (AJP). February 2019. The California Offshore Wind Project: A Vision for Industry Growth. Available online at: http://americanjobsproject.us/wp/wp-content/uploads/2019/02/The-California-Offshore-Wind-Project-Cited-.pdf

Arcon Training Center. Courses. Available online at: https://www.arcontraining.com/gwo-offshore-basic-safety-training

Bureau of Ocean Energy Management. November 2021, Area ID Memorandum: Morro Bay Wind Energy Area. Available online at: https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Area-ID-CA-Morro-Bay.pdf.

BOEM. July 2021. Area ID Memorandum: Humboldt Wind Energy Area. Available online at: https://www.boem.gov/sites/default/files/documents//App.%20A%20Area%20ID%20Humboldt%20Memo%20Final.pdf.

Buljan, A. August 16, 2022. *USD 223 Million-Worth Construction Works Start at Portsmouth Marine Terminal*. Available online at: https://www.offshorewind.biz/2022/08/16/usd-223-million-worth-construction-works-start-at-portsmouth-marine-terminal/

BVG Associates. October 2017. U.S. Job Creation in Offshore Wind – A Report for the Roadmap Project for Multi-State Cooperation on Offshore Wind (Report 17-22). Available online at: https://www.cesa.org/wp-content/uploads/US-job-creation-in-offshore-wind.pdf

BW Research Partnership. September 2021. Offshore Wind Workforce Training and Development in Massachusetts. Available online at: https://files-cdn.masscec.com/reports/MassCEC%20OSW%20Workforce%20Final%20Report_Sept%202021.pdf

California Department of Industrial Relations. December 14, 2022. California's Minimum Wage to Increase to $15.50 per Hour (Release No. 2022-102). Available online at: https://www.dir.ca.gov/DIRNews/2022/2022-102.html#:~:text=An%20employee%20must%20earn%20no,to%20meet%20this%20threshold%20requirement.

California Energy Commission (CEC). August 10, 2022. CEC Adopts Historic California Offshore Wind Goals, Enough to Power Upwards of 25 Millions Homes. Available online at: https://www.energy.ca.gov/news/2022-08/cec-adopts-historic-california-offshore-wind-goals-enough-power-upwards-25

California Energy Commission (CEC). August 2022. Offshore Wind Energy Development Off the California Coast – Maximum Feasible Capacity and Megawatt Planning Goals for 2030 and 2045. Available online at: https://www.energy.ca.gov/filebrowser/download/4361

California Energy Commission (CEC). March 9, 2022. State Approves $10.5 Million to Prepare the Port of Humboldt Bay for Offshore Wind. Available online at: https://www.energy.ca.gov/news/2022-03/state-approves-105-million-prepare-port-humboldt-bay-offshore-wind

California Senate Bill 54. 2012. Hazardous Materials Management. Available online at: http://www.leginfo.ca.gov/pub/13-14/bill/sen/sb_0051-0100/sb_54_bill_20131013_chaptered.htm

California Workforce Development Board. October 2018. High Road Training Partnerships. Available online at: https://cwdb.ca.gov/initiatives/high-road-training-partnerships/.

California Workforce Development Board. 2020. Putting California on the High Road: A Jobs and Climate Action Plan for 2030. Available at: https://cwdb.ca.gov/wp-content/uploads/sites/43/2020/09/AB-398-Report-Putting-California-on-the-High-Road-ADA-Final.pdf.

Castle Wind. 2019. "Castle Wind and Monterey Bay Community Power Sign Agreement in Anticipation of Offshore Wind Project off the Coast of Morro Bay," Castle Wind Offshore (blog), August 16, 2019. Available online at: http://castlewind.com/castle-wind-and-monterey-bay-community-power-sign-agreement-in-anticipation-of-offshore-wind-project-off-the-coast-of-morro-bay/; Monterey Bay Community Power, "Renewable Power Purchase Agreement," October 10, 2018, https://mbcommunity.onbaseonline.com/1800AgendaAppNet/Documents/ViewDocument/Attachment%20for%20Adopt%20Resolution%20Authorizing%20the%20CEO%20to%20Execute%20a%2015-Year%20Power.pdf?meetingId=199&documentType=Agenda&itemId=1792&publishId=2004&isSection=false.

Chiu, David. Assembly Bill 525: Offshore Wind Generation - Chapter 231, Statutes of 2021. Available online at: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB525

Collier, R., et.al. 2019. California Offshore Wind: Workforce Impacts and Grid Integration. Center for Labor Research and Education, University of California, Berkeley. http://laborcenter.berkeley.edu/offshore-wind-workforce-grid.

Davidson, R. January 14, 2022. California Targets Port Investments for Offshore Wind. Wind Power Monthly. Available online at: https://www.windpowermonthly.com/article/1737526/california-targets-port-investments-offshore-wind

Executive Order on Use of Project Labor Agreements for Federal Construction Projects. Feb 4, 2022. Available online at: https://www.whitehouse.gov/briefing-room/presidential-actions/2022/02/04/executive-order-on-use-of-project-labor-agreements-for-federal-construction-projects/.

Federal Register. January 31, 2023. Reorganization of Title 30-Renewable Energy and Alternate Uses of Existing Facilities on the Outer Continental Shelf. Available online at: https://www.federalregister.gov/documents/2023/01/31/2023-00871/reorganization-of-title-30-renewable-energy-and-alternate-uses-of-existing-facilities-on-the-outer

Global Wind Organization. 2022. GWO Training Standards. Available online at: https://www.globalwindsafety.org/trainingstandards/trainingstandards

Guidehouse. May 2022. "California Supply Chain Needs Summary." California Energy Commission. Available online at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=242928&DocumentContentId=76513

IMPLAN. Measures of GDP: Value Added and Final Demand. 2021. Available online at: https://support.implan.com/hc/en-us/articles/115002815494-Measures-of-GDP-Value-Added-and-Final-Demand

IMPLAN. Understanding Labor Income, Employee Compensation, and Proprietor Income. 2021. Available online at: https://support.implan.com/hc/en-us/articles/360024509374-Understanding-Labor-Income-LI-Employee-Compensation-EC-and-Proprietor-Income-PI-

Internal Revenue Service. 2022. Federal Register / Vol. 87, No. 229 / Wednesday, November 30, 2022 / Notices. Available at: https://www.govinfo.gov/content/pkg/FR-2022-11-30/pdf/2022-26108.pdf. Accessed January 4, 2023.

Lawrence Berkeley National Laboratory (LBNL). 2018. Estimating the Value of Offshore Wind Along the United States' Eastern Coast. Available online at: https://eta-publications.lbl.gov/sites/default/files/osw_value_es_final.pdf

Lawrence Berkeley National Laboratory (LBNL). September 2019. California Offshore Wind: Workforce Impacts and Grid Integration. Available online at: https://laborcenter.berkeley.edu/pdf/2019/CA-Offshore-Wind-Workforce-Impacts-and-Grid-Integration.pdf

Maersk. 2023. Renewables. Available online at: https://www.maersktraining.com/renewables/

Maryland. 2019. Maryland Clean Energy Jobs Act. Available at: https://mgaleg.maryland.gov/2019RS/Chapters_noln/CH_757_sb0516e.pdf.

Massachusetts Clean Energy Center. 2021. Offshore Wind Workforce Training & Development in Massachusetts. Available at: https://files-cdn.masscec.com/reports/MassCEC%20OSW%20Workforce%20Final%20Report_Sept%202021.pdf.

Moffat and Nichol. July 1, 2021. Humboldt Bay Harbor, Recreation, and Conservation District (Meeting Packet) - Preliminary Cost Estimates for Conceptual Master Plan for Development of a New Multipurpose Terminal to Support the Emerging West Coast Offshore Wind Industry. Available online at: http://humboldtbay.org/sites/humboldtbay2.org/files/Adopted%20Minutes%2007.01.2021_SIGNED.pdf

Monterey Bay Community Power, "Renewable Power Purchase Agreement," October 10, 2018, https://mbcommunity.onbaseonline.com/1800AgendaAppNet/Documents/ViewDocument/Attachment%20for%20Adopt%20Resolution%20Authorizing%20the%20CEO%20to%20Execute%20a%2015-Year%20Power.pdf?meetingId=199&documentType=Agenda&itemId=1792&publishId=2004&isSection=false.

Morro Bay City Council. 2018. "Community Benefit Agreement between City of Morro Bay and Castle Wind, LLC". Available: https://www.morro-bay.ca.us/ArchiveCenter/ViewFile/Item/4820.

MRIO vs. Larger Study Area: Leakage, Aggregation Bias, and Other Considerations. 2022. Available online at: https://support.implan.com/hc/en-us/articles/115002799373-MRIO-vs-Larger-Study-Area-Leakage-Aggregation-Bias-and-Other-Considerations.

National Offshore Wind Institute. 2022. NOWI Training Services. Available online at: https://nowi.org/nowiservices.html

New Jersey Council on the Green Economy. 2022. Green Jobs for a Sustainable Future. Available at: https://www.nj.gov/governor/climateaction/documents/CGE%20Roadmap.pdf.

New Jersey Economic Development Authority. 2022. New Jersey's Offshore Wind Workforce Assessment Through 2035. Available at: https://www.njeda.com/wp-content/uploads/2022/09/2022-NewJersey-OSW-Workforce-Assessment-Report.pdf.

New Jersey Economic Development Authority (NJEDA). 2021. Overview of Required Project Labor Agreement Provisions for At-Risk Construction Management Services for New Jersey Wind. Available at: https://www.nj.gov/windport/docs/20210427_EXHIBITJ-PLA1.pdf.

NREL/BOEM. April 2016. "Floating Offshore Wind in California: Gross Potential for Jobs and Economic Impacts from Two Future Scenarios." Available online at: https://www.nrel.gov/docs/fy16osti/65352.pdf

National Renewable Energy Laboratory (NREL). November 2020. The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032. Available online at: https://www.nrel.gov/docs/fy22osti/80808.pdf

National Renewable Energy Laboratory (NREL). October 2022. U.S. Offshore Wind Workforce Assessment. Available online at: https://www.nrel.gov/docs/fy23osti/81798.pdf

New Jersey Board of Public Utilities. 2022. New Jersey Offshore Wind Solicitation #3, Solicitation Guidance Document. November 30, 2022, p. 25. Available at: https://njoffshorewind.com/third-solicitation/solicitation-documents/Draft-Solicitation-Guidance-Document-with-attachments.pdf.

New York State Energy DA. 2020. Port Infrastructure; Potential Port Facilities for Offshore Wind Activities; $200 Million of Public Investments into Ports. Available online at: https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/Supply-Chain-Economic-Development/Port-Infrastructure

New York State Energy Research and Development Authority (NYSERDA). October 20, 2022. Governor Hochul and Suffolk County Executive Bellone Announce Land Transfer to Bring National Offshore Wind Training Center to Suffolk County and Train New Yorkers for Green Jobs. Available online at: https://www.governor.ny.gov/news/governor-hochul-and-suffolk-county-executive-bellone-announce-land-transfer-bring-national

New York State Energy Research and Development Authority (NYSERDA). 2022. New York Offshore Wind Workforce Gap Analysis. Available online at: https://www-nyserda-ny-gov.webpkgcache.com/doc/-/s/www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/Offshore-Wind/New-York-State-Workforce-Gap-Analysis-2022.pdf

New York State Energy Research and Development Authority (NYSERDA). 2022. 2022 Offshore Wind Solicitation. Available at: https://www.nyserda.ny.gov/offshore-wind-2022-solicitation

New York State Energy Research and Development Authority (NYSERDA). 2023. Training Opportunities in Offshore Wind. Available online at: https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/Supply-Chain-Economic-Development/Workforce-Development

Offshore Engineer. May 14, 2020. *Infranode to Invest Up to $145M in Port Esbjerg's Offshore Wind Facilities*. Available online at: https://www.oedigital.com/news/478478-infranode-to-invest-up-to-145m-in-port-esbjerg-s-offshore-wind-facilities

Rhode Island. 2022 General Assembly, An Act Relating to Public Utilities and Carriers – Affordable Clean Energy Security Act, state. Available at: https://trackbill.com/bill/rhode-island-senate-bill-2583-an-act-relating-to-public-utilities-and-carriers-affordable-clean-energy-security-act-amends-the-affordable-clean-energy-security-act-and-the-long-term-contracting-standard-for-renewable-energy/2241957/.

Sathe, et al. 2020. Research and Development Opportunities for Offshore Wind Energy in California. August. Available at: https://www.energy.ca.gov/sites/default/files/2021-05/CEC-500-2020-053.pdf

Schatz Energy Research Center. 2020. California North Coast Offshore Wind Studies – Port Infrastructure Assessment Report.

Shields, Matt, et al. 2023, January. A Supply chain Road Map for Offshore Wind Energy in the United States. Available here: https://www.nrel.gov/docs/fy23osti/84710.pdf

Shields, Matt, Ruth Marsh, Jeremy Stefek, Frank Oteri, Ross Gould, Noé Rouxel, Katherine Diaz, Javier Molinero, Abigayle Moser, Courtney Malvik, and Sam Tirone. 2022. The Demand for a Domestic Offshore Wind Energy Supply Chain. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-81602. https://www.nrel.gov/docs/fy22osti/81602.pdf

Statista. State government tax revenue in the United States in the fiscal year of 2021, by state (in billion U.S. dollars). Available online at: https://www.statista.com/statistics/248932/us-state-government-tax-revenue-by-state/

University of California Berkely Center for Labor Research and Education. September 2019. California Offshore Wind – Workforce Impact and Grid Integration. Available online at: https://laborcenter.berkeley.edu/pdf/2019/CA-Offshore-Wind-Workforce-Impacts-and-Grid-Integration.pdf

University of Delaware. 2018. Offshore Wind Skills Academy. Available online at: https://www.pcs.udel.edu/wind/

U.S. Bureau of Labor Statistics (BLS). May 2021. State Occupational Employment and Wage Estimates for California. Available online at: https://www.bls.gov/oes/current/oes_ca.htm

U.S. Bureau of Ocean Energy Management (BOEM). 2020. A Shared Vision on the Development of an Offshore Wind Supply Chain. Available online at: https://www.boem.gov/renewable-energy/state-activities/boem-ny-nj-shared-vision

U.S. Coast Guard. 2021. The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers. Available online at: https://www.dco.uscg.mil/nmc/stcw/

U.S. Department of Commerce. 2016. Grants and Cooperative Agreements Manual. Available online at: https://www.eia.gov/todayinenergy/detail.php?id=11471.

U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. 2021. Advancing the Growth of the US Wind Industry: Federal Incentives, Funding, and Partnership Opportunities. June. Available at: https://www.energy.gov/sites/default/files/2021-07/us-wind-industry-federal-incentives-funding-partnership-opportunities-fact-sheet-v2.pdf

U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. August 16, 2022. Offshore Wind Market Report (2022 Edition). Available online at: https://www.energy.gov/eere/wind/articles/offshore-wind-market-report-2022-edition

U.S. DOE Office of Energy Efficiency and Renewable Energy. 2023. Workforce Training and Education. Available online at: https://windexchange.energy.gov/training

U.S. Department of Energy – Office of Energy Efficiency and Renewable Energy. 2020. Wind Energy Education and Training Programs. https://windexchange.energy.gov/training-programs

U.S. Department of Labor. 2022. Prevailing Wages. Available online at: https://flag.dol.gov/programs/prevailingwages#:~:text=The%20prevailing%20wage%20rate%20is,the%20area%20of%20intended%20employment

U.S. Energy Information Administration. 2013. Feed-in Tariff: A Policy Tool Encouraging Deployment of Renewable Electricity Technologies. May 30th. Available online at: https://www.eia.gov/todayinenergy/detail.php?id=11471

U.S. Energy Information Administration. March 2022. Levelized Costs of New Generation Resources in the Annual Energy Outlook. Available online at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf.

White House. 2021. Executive Order 13990 of January 20, 2021: Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis. Federal Register, 86(14), 7037–7043. Available at:

https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/. Accessed October 13, 2022.

Wind Industry: Federal Incentives, Funding, and Partnership Opportunities. June. Available at: https://www.energy.gov/sites/default/files/2021-07/us-wind-industry-federal-incentives-funding-partnership-opportunities-fact-sheet-v2.pdf

Workforce Development Institute (WDI). 2017. New York States and the Jobs of Offshore Wind Energy. Available online at: https://wdiny.org/Portals/0/New%20York%20State%20and%20The%20Jobs%20Of%20Offshore%20Wind%20Energy_%20WDI2017.pdf?ver=2017-05-03-150746-023

World Trade Organization. 2006. World Trade Report: Subsidies, Trade and the WTO. Available online at: https://www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report06_e.pdf.

Xodus Group. 2022. Offshore Wind Supply Chain & Workforce Opportunity Assessment: Assessment of OSW Supply Chain Opportunity. Report to the Governor’s Energy Office. Available here: https://www.maine.gov/energy/sites/maine.gov.energy/files/inline-files/Maine%20Offshore%20Wind%20Supply%20Chain%20Assessment%202022.pdf

Appendix A

Literature Review

Catalyst
ENVIRONMENTAL SOLUTIONS

Literature Review – Seaport Development

Seaports play a crucial role in offshore wind (OSW) construction, assembly and maintenance. Seaports play an even larger role in the development of floating OSW, which is currently the only form of OSW under consideration for the West Coast due to deep-water conditions. Floating turbines are assembled at port rather than at sea, resulting in more portside jobs and construction than fixed-bottom OSW. Hence, seaport development in California is of utmost importance if 3-5 GW are to be installed by 2030. A significant amount of literature has been written on port development for OSW in California and elsewhere. This summary of that literature centers on three important themes for addressing the increased capacity of ports to accommodate the OSW sector. The first is the **seaport requirements**, the second is the **costs of port expansions for OSW including some lessons learned** from development elsewhere. A third section deals specifically with **the California port needs**, and a final theme addresses **challenges** and costs associated with seaport development to support OSW in California.

OSW Seaport Requirements

There are many ports along the California coast that vary in size, capacity, specialty, and location. Yet none of them meet the specific requirements needed to support OSW deployment. According to a report on California Supply Chain Needs for OSW by Guidehouse written earlier this year for the California Energy Commission,[1] port channel and berth draft, or depth, must be 12m or deeper to accommodate for semi-submersible floating platforms needed for OSW in California. As technology advances and turbines increase in capacity and size, port draft requirements may increase as well.

Also, since floating turbines are assembled at port, air draft is an important consideration. Fully assembled floating turbines require 150 m of unrestricted airspace. Like water draft, this restriction will increase as turbine capacity and size increases. Portside storage area, load-bearing capacity and quayside length are all dependent on the size of OSW projects supported by a port, the types of vessels used to transport and install the floating turbines, and the type of support the port will offer OSW development. The general requirements for these characteristics and the ones mentioned above can be found in the table[1, 2] below.

Seaport Characteristic	Minimum Requirement
Channel/Berth Depth	12 meters
Overhead Air draft	150 meters
Storage/staging Area	12-16 hectare
Load-Bearing Capacity	Pre-assembly: 15 t/m^2
Quayside Length	660 meters

[1] Guidehouse, 2022. Guidehouse California Supply Chain Needs Summary Report. Report prepared for the California Energy Commission, May 4th. Available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=242928&DocumentContentId=76513

[2] Shields, Matt, et al., 2022. The Demand for a Domestic OSW Energy Supply Chain. Report prepared by NREL June. Available at: https://www.nrel.gov/docs/fy22osti/81602.pdf

Yet not all seaports are expected to meet every need for OSW development. A report determining the infrastructure needs to support OSW on the pacific west coast released by BOEM[3] considered three types of seaports; quick reaction ports (QRP), fabrication/construction ports (FCP), and assembly ports (AP) – each with a unique set of requirements. QRPs are meant to be located with 40 nautical miles of an OSW farm and act as the homebase for OSW farm maintenance and repairs. These ports require a channel width of 100 meters, channel depth of 4 meters, air draft of 30 meters and have one berth available. FCPs are meant to host OSW manufacturing facilities and act as a place holder for component parts until they can be transported to an assembly facility. FCPs require a channel width of 100 meters, channel depth of 8 meters, a storage area of at least 70 acres, 45 meters of unrestricted air draft, and must have a rail or highway connection. APs are meant to be the final assembly location for the floating turbines. Fully assembled turbines are towed to the installation location from APs. These ports require a channel width of at least 100 meters, channel depth of 10-12 meters, unlimited air draft, and a minimum of 15 acres of storage/staging area.

It should be noted that these are the minimum requirements for each type of OSW seaport, and that bearing capacity, crane capacity and other equipment are important secondary criteria to consider during seaport development.

It is also important to consider some of the benefits associated with upgrading seaports to meet the requirements for OSW support. Co-benefits refer to the positive effects that port upgrades intended for OSW development have on other industries and port users. The Schatz Energy Research Center at Cal Poly Humboldt evaluated the co-benefits linked to OSW development along the north coast of California,[4] finding reductions in vessel delays and overall improved port functionality for all industrial shippers. A few of the co-benefits in the report are listed in the table below.

OSW Port Improvement	***Co benefit***
Enhanced harbor entrance and channel maintenance	Fewer vessels delays and improved freight vessel terminal access
Increase in vessel maintenance and repair facilities	Reduced transit costs to other ports for vessel maintenance and repair
Increase in port-related upland storage space	Improved port functionality for all industrial shippers

Seaport Development Costs and Experiences in Other Geographies

The OSW industry has been a staple in Europe for the past two decades. Asia has also recently become a big player in OSW development. In fact, in 2020 the global pipeline for floating OSW energy more than tripled from 7,663 MW to 26,529 MW, and the majority of this growth was attributed to OSW expansion

[3] Porter, A., and Phillips, S., 2016. Determining the Infrastructure Needs to Support Offshore Floating Wind and Marine Hydrokinetic Facilities on the Pacific West Coast and Hawaii. Report prepared for BOEM, March 3rd. Available at: https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Pacific-Region/Studies/BOEM-2016-011.pdf

[4] Hackett, S., 2020. Coastal Infrastructure Co-Benefits Linked to OSW Development. Prepared by the Schatz Research Center at Cal Ply Humboldt, September. Available at: http://schatzcenter.org/pubs/2020-OSW-R11.pdf

in Asia.[5] Like the future OSW projects in California, these international projects required seaport development to provide the support needed for OSW. These OSW development experiences offer broad insights into the cost of port upgrades to support OSW. For example, the European experience shows that seaport redevelopment costs typically range from $275 million to $485 million according to research compiled by the University of Delaware Special Initiative on OSW for NYSERDA.[6] Another report covering the cost of floating OSW energy in California [7] found that "On the Atlantic coast where the industry is already making OSW infrastructure investments, costs for large-scale port upgrades to support OSW development are in the range of $100–400 million."

In the state of New Jersey multiple ports have been built or upgraded to support OSW projects. For example, the New Jersey Economic Development Authority began construction on a custom OSW energy port in 2021. The reported costs to develop four state-of-the-art OSW berths at this facility is estimated to be $300-$400 million including supporting manufacturing, storage and assembly resources[8]. The New York OSW cost reduction report prepared for NYSERDA[6] noted that "The State of New Jersey has invested an estimated $100 million on redevelopment efforts at the Port of Paulsboro including environmental remediation of the former petroleum distribution center, as well as the construction of an access road and bridge connecting the port directly to an interstate highway." They expect other customized upgrades for OSW development to be funded by a developer or as part of a lease negotiation. The same report found that wharf upgrades to ports in Rhode Island to support OSW development are expected to be privately funded in the range of $75 to $100 million in addition to just over $20 million in grant funded upgrades.[6]

East Coast seaport development has and is relying on a combination of private and public funding. The U.S. Department of Transportation's Maritime Administration's Funding Opportunity Announcement via the Port Infrastructure Development Program made $230 million available for port upgrades, including offshore-wind-energy-related efforts. The 2022 OSW Market Report[9] prepared by NREL for the DOE found that this program has supported the seaport upgrades for OSW:

---

[5] Musial, Walter and Spitsen, Paul, 2021. OSW Market Report: 2021 Edition. Report prepared for the Department of Energy. Available at: https://www.energy.gov/sites/default/files/2021-08/Offshore%20Wind%20Market%20Report%202021%20Edition_Final.pdf

[6] McClellan, Stephanie, et al., 2019. New York OSW Cost Reduction Study Final Report. Report prepared for the New York Energy Research and Development Authority by the University of Delaware Special Initiative on Offshore Wind. Available at: https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/EERP/Renewables/New-York-Offshore-Wind-Cost-Reduction-Study-2014.pdf

[7] Beiter, P., et al., 2020. The Cost of Floating OSW Energy in California Between 2019 and 2032. Report prepared for BOEM by NREL, November. Available at: https://www.nrel.gov/docs/fy21osti/77384.pdf

[8] Lantz, Eric, et al. 2021. Power Sector, Supply Chain, Jobs, and Emissions Implications of 30 Gigawatts of OSW Power by 2030. Report prepared by NREL, October. Available at: www.nrel.gov/docs/fy21osti/80031.pdf.

[9] Musial, et al., 2022. OSW Market Report: 2022 Edition. Report prepared by NREL for the Department of Energy. Available at: https://www.energy.gov/sites/default/files/2022-09/offshore-wind-market-report-2022-v2.pdf

- *The Port of Albany in New York received $29.5 million to develop a vacant industrial area into a tower manufacturing facility*
- *The South Brooklyn Marine Terminal in New York received $25 million to add a barge berth and an additional crane pad*
- *The Portsmouth Marine Terminal in Virginia received $20 million to create storage and staging areas for wind turbines, monopiles, and other project components*[9]

The DOE Loan Programs Office announced that approximately $3 billion in existing guaranteed loans will support innovative renewable energy technologies including OSW as well.

Port Location	Port Upgrade	Cost
New Jersey Wind Port	4 new berths and supporting facilities	$300-$400 million
New Jersey Port of Paulsboro	Distribution center remediation, access road and bridge construction	$100 million
Rhode Island Ports	Wharf upgrades, other upgrades	$75-$100 million Over $20 million
New York Port of Albany	Tower manufacturing facility at port	$29.5 million
New York South Brooklyn Marine Terminal	Additional barge berth, additional crane pad	$25 million
Virginia Portsmouth Marine Terminal	Storage and staging area for wind turbine components	$20 million

Seaport Development for OSW in California Wind Energy Areas (WEA)

There are currently two WEAs scheduled to be leased by BOEM before the end of 2022 along the California coast. The first WEA is located off the coast of Northern California and is referred to as the Humboldt WEA. The second WEA is located off the coast of Central California and is referred to as the Morro Bay WEA. While one port has the potential to support future projects in both WEAs, the areas in question can support almost 5 GW of OSW energy.[10] If both WEAs are fully utilized, each will require the construction, assembly and installation of hundreds of turbines. It is therefore likely that multiple seaports will be developed to support these deployments.

Humboldt Bay has been the most highly considered and assessed port locations to support the development of OSW in California. While the port is difficult to access via land due to poor railway and road access, it has the potential to serve future projects in the Humboldt WEA as an assembly and quick reactions port according to the Floating OSW Turbine Development Assessment[11] released by BOEM. Not only is Humboldt Bay close to the WEA, the port area has ample dry storage space and the channel width and depth meets to requirements for OSW development. The port has been relatively inactive since the decline of the forestry industry, and would require upgrades and additional dredging to become OSW ready. The Humboldt Bay Harbor Board of Commissioners determined the upgrades and

[10] Musial, W., et al., 2016. Potential OSW Energy Areas in California: An Assessment of Locations, Technology, and Costs. Report prepared by NREL for BOEM, December. Available at: https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Pacific-Region/Studies/BOEM-2016-074.pdf

[11] ABSG Consulting Inc., 2021. Floating OSW Report prepared for BOEM, March 1st. Available at: https://www.boem.gov/sites/default/files/documents/renewable-energy/studies/Study-Number-Deliverable-4-Final-Report-Technical-Summary.pdf

costs needed to make the port ready for OSW development in preparation to apply to the MARAD federal grant. The values are listed in the table[12] below.

Estimated Costs for Humboldt Port Upgrades	
Contractor Mobilization/Demolition	$4,952,000
Wharf upgrades	$40,660,400
Earth Fill and Dredge	$7,351,800
Uplands Upgrades	$8,809,800
Mooring Dolphins	$6,029,800
Remediation	$500,000
Construction Indirect Costs	$21,431,200
Contingency	$26,920,600
Soft Costs	$7,855,200
TOTAL PROJECT COST	**$124,510,800**

The Schatz Center Port Infrastructure Assessment[13] deduced that port development would take between 5-7 years and depend on the availability to work outside the typical in-water construction window for Humboldt Bay.

There has been some consideration of seaport development to support future OSW projects in the Morro Bay WEA as well. Cal Poly State University San Luis Obispo released a report[14] focused on the economic impact of OSW development off the cast of central California and how the development of a specialized port facility on Diablo Canyon Power Plant property would affect the county's economy. The report determined that "Constructing a specialized wind port for OSW will require an estimated 1,100 construction jobs per year at a total direct cost in the range of between $1.7 and $2.5 billion." The proposed construction would occur over a 5-year period, though a more in-depth assessment of the site and costs would be necessary before moving forward.

Seaport Development Challenges in California

Seaport development needs to commence as soon as possible to support upcoming OSW projects if California is to install 3-5 GW by 2030. Port upgrades require large upfront investments, detailed engineering designs/plans, environmental impact assessments and many other considerations before construction can begin. The BOEM leasing process makes it challenging to justify the investment in port upgrades to support OSW today as projects approval won't occur for another 4-6 years. Until a project is approved, there is no guarantee that OSW installments will occur. Support from legislation on seaport

[12] Board of Commissioners Humboldt Bay Harbor, Recreation and Conservation District, 2021. Humboldt Harbor OSW Port Infrastructure Development. Report prepared Board of Commissioners Meeting and Grant Application Preparations, July. Available at: https://greeneeconomics-my.sharepoint.com/:b:/p/ggreene/ESPofSgIqFFErQhuXnOrZUsBIdC4cauBzwiZcL7BAtvIHw?e=VaBclu

[13] Porter, A., and Phillips, S., 2020. Port Infrastructure Assessment Report. Prepared by the Schatz Research Center at Cal Poly Humboldt, December. Available at: http://schatzcenter.org/pubs/2020-OSW-R19.pdf

[14] Hamilton, Stephen, et al. 2021. Economic Impact of OSW Farm Development on the Central Coast of California. Report prepared by Cal Poly State University San Luis Obispo, April. Available at: https://reachcentralcoast.org/wp-content/uploads/Economic_Value_OSW_REACH.pdf

development and OSW development can push this process along. A streamlined permitting process and guaranteed OSW pipeline would also help expedite seaport development and prevent it from becoming a lynchpin in California's OSW development.

Literature Review – Workforce Development

Having an available, trained workforce to meet the needs of the OSW industry will be one of the key challenges for California. As pointed out in the California Offshore Wind Project report, *A Vision for Industry Growth*,[1] produced by the American Jobs Project, opportunities for employment in this sector run the spectrum from "white collar" engineering, science, and legal services to opportunities in the trades and in support sectors. The potential for employment in this sector presents a "once in a lifetime" opportunity to shape the trajectory of the industry. The authors of the same report write,

> *California has a "Front Door" opportunity to set what "right" looks like-/build multi-layered employment opportunities that cater variety of phases of development (from lawyers to metal workers etc.). (page 17)*

Similarly in a report on California offshore wind workforce impacts from UC Berkeley Labor Center,[2] the authors state,

> *Offshore wind could be a high-road industry that not only helps the state achieve its climate policy goals for emissions reductions, but also spurs broad-based growth, creates quality jobs, and benefits communities. (page 6)*

And a final statement, again from the American Jobs Project: [3]

> *The state has the right infrastructure to make the offshore wind industry a reality: active labor unions, apprenticeships, training programs, technical high schools, and colleges and universities that rank some of the best in the nation. Policymakers, industry leaders, unions, and colleges should consider workforce development strategies that align with the phases of project development (page 39).*

However, while there is broad agreement on the types of workforce opportunities associated with OSW, there is not consensus on how many jobs will be needed/created, where that workforce will come from and or what incentives will be needed. Based on current research, this section summarizes some of the key challenges and opportunities related to workforce needs for offshore wind. The literature highlights are organized by four thematic categories:

- **Workforce Needs by Phase and Sector**;
- **Skill Gaps and Solutions**;
- **Training Needs**, and
- **Challenges**.

---

[1] American Jobs Project, 2019. The California Offshore Wind Project: A vision for Industry Growth. Report prepared in February. Available at: http://americanjobsproject.us/wp/wp-content/uploads/2019/02/The-California-Offshore-Wind-Project-Cited-.pdf . Pg. 18.

[2] Collier, et al., 2019. California Offshore Wind: Workforce Impacts and Grid Integration. Report prepared in April. Available at: http://laborcenter.berkeley.edu/ offshore-wind-workforce-grid. pg. 6.

[3] American Jobs Project, February 2019. pg. 39.

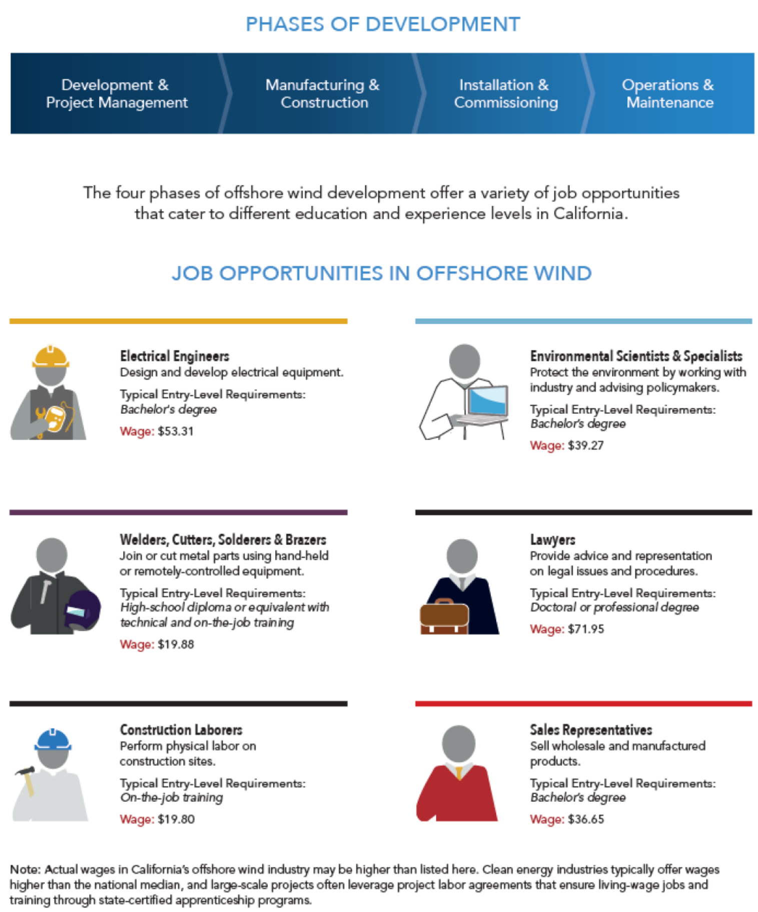
Workforce needs by phase and sector

Fourteen sources were reviewed to understand the workforce demand needs in CA, across the United States and internationally. Six of those sources were specific to California.

All sources reviewed identify some variant of four distinct phases to the development of OSW. These are,

- Development and Project Management;
- Manufacturing and Construction;
- Installation and Commission, and
- Operations and Maintenance.

The American Jobs Project report has a particularly useful visualization of these phases as well as the types of employment opportunities associated with them.[4]



The number, types, and timing of the workforce needs will be heavily influenced by the timelines adopted by the state and the GW targets. Shorter timelines and greater GW brought into service will

[4] American Jobs Project, February 2019. pg. 19.

result in larger workforce opportunities and higher labor demand. Six different reports were reviewed for this effort, with each estimating the workforce demand by GW.

The table below illustrates the range of projected jobs across different time and GW scenarios. Studies by Collier, Guidehouse, and Speer all consider 10 GW scenarios, with timelines ranging from 2045 to 2050. Some of the research makes the critical distinction between construction jobs – which last only through construction – and operations and maintenance jobs, which are sustained. Across all three cases the 10 GW scenario results in the creation of between 5,275 (Guidehouse) on the low estimation to 16,610 (Speer) on the high estimation for combined construction and operations labor. The differences in can be attributed to different assumptions with respect to labor force composition and local sourcing requirements, particularly with respect to construction and manufacturing. This correlation between tighter, or more comprehensive local sourcing and greater local job creation potential is consistent across all sources reviewed, regardless of the time horizon or the number of GW's.

It should be noted that the report prepared by Rose has significantly higher employment estimates because this work includes the 'ripple effect' of the offshore wind industry, or the regional economic impacts. These numbers count employment in all the industries that supply inputs to offshore wind, and also the economic stimulus that is produced when household income increases with the additional industry spending.

Existing Skill Base

Having an existing pool of qualified workers to draw from will be key to California's ability to meet workforce labor demands from the local talent pool. Sources reviewed indicated that there is a large potential within California to retrain and redirect skilled workers from legacy industries (oil and gas, nuclear, ship building/repair etc.) and that while there are unique aspects to developing OSW platforms off the coast of California, with the right effort, retraining workers from these sectors to work in OSW would not be unrealistic. Both the American Jobs Project report (pg. 17) and the report from the UC Berkeley Labor Center (pg. 11) make reference to the potential to retrain workers from existing legacy industries to meet the workforce supply needs of OSW.

Experience in Europe and in particular on the east coast of the United States has also shown success with retraining the existing workforce. As noted by the American Jobs Project report, another report written on job creation in the offshore wind industry in New England[5], a study for the UK offshore wind industry[6], a study for the Massachusetts clean energy center Offshore Wind Workforce Training and Development in MA- Analysis & Strategic Recommendations[7], The Demand for Domestic Offshore Wind

---

[5] BVG Associates Limited, 2017. U.S. Job Creation in Offshore Wind A Report for the Roadmap Project for Multi-State Cooperation on Offshore Wind. Report prepared NYSERDA, Massachusetts Clean Energy Center, Massachusetts Department of Energy Resources, Rhode Island Office of Energy Resources, Clean Energy Alliance, October. Available at: https://www.cesa.org/wp-content/uploads/US-job-creation-in-offshore-wind.pdf

[6] Energy and Utility Skills, 2018. Skills and Labour Requirements of the UK Offshore Wind Industry: 2018 to 2032. Report prepared October. Available at: https://aura-innovation.co.uk/wp-content/uploads/2020/04/Aura-EU-Skills-UK-Offshore-Wind-Skills-Study-Full-Report-October-2018.pdf

[7] Frongillo, Cobi and Jordan, Phillip, 2021. Offshore Wind Workforce Training& Development in Massachusetts: Analysis and Strategic Recommendations. Report prepared the Massachusetts Clean

Energy Supply Chain[8], Power Sector Supply Chain Jobs and Emissions- Implications of 30 GW of OSW Power by 2030[9] & Offshore Wind Workforce Assessment[10].

Workforce Needs by Timeline and GW	
Data Source	Workforce Demand Projection
American Jobs Project, 2019, February. The California Offshore Wind Project: A vision for Industry Growth.	5 GW by 2045- 12,300 across construction, operations, and maintenance 18 GW by 2045- 35,400 across construction, operations, and maintenance
Collier, et al., 2019, September. California Offshore Wind: Workforce Impacts and Grid Integration. pgs 12 & 13	10GW build out by 2050- 5,800 Construction/2,230 Operations 16GW build out by 2050- 13,620 Construction/4,330 Operations 5 GW build out by 2045- 3,202 Construction/2,095 Operations 18 GW by 2045- 12,950 Construction/4,828 Operation
Guidehouse Outwit Complexity, 2022, May. Guidehouse California Supply Chain Needs Summary Report. pg. 79-82	10 GW by 2050- 4,122 Construction & Installation/1,153 operations and maintenance 18 GW by 2050- 3,555 Construction & Installation/1,759 operations and maintenance 20 GW by 2050- 3,555 Construction & Installation/1,990 operations and maintenance
Hamilton, Stepen F., C. Ramezani, C. Almacne, B. Stephan,2021. Economic Impact of Offshore Wind Farm Development On the Central Coast of California, California Poly technic State University pgs. 8-11	15,925- creation of a port 11,368 construction, installation of 1 GW 6,612 initial operation of 1 GW 1,098 operation of mature 3 GW field 2,488 operation of mature 7 GW field
Rose, Adam, et al., 2021, August. California's Offshore Wind Electricity Opportunity.pg. 29	3GW between 2020 and 2030- 31,691 low RPC /63,656 high RPC 7GW between 2030 and 2040 62,792 low RPC/126,264 high RPC
Speer, Bethany, et al., 2016, April. Floating Offshore Wind in California: Gross Potential for Jobs and Economic Impacts from Two Future Scenarios. (pg. v)	16 GW by 2050- 23,780 Construction/4,270 Operations 10 GW by 2050- 14,890 Construction/1,720 Operations

However, it is important to note that across Europe there have been overall labor shortages due to an aging work force and a declining interest in trades and that, according to the Skills and Labor Requirements of the UK Offshore Wind Industry 20188-203211 these trends will have an adverse impact on workforce supply if not addressed. Both the CA Offshore Wind Workforce Impacts and Grid

Energy Center, September. Available at: https://files-cdn.masscec.com/reports/MassCEC%20OSW%20Workforce%20Final%20Report_Sept%202021.pdf

[8] Shields, Matt, et al., 2022. The Demand for a Domestic Offshore Wind Energy Supply Chain. Report prepared by NREL, June. Available at: https://www.nrel.gov/docs/fy22osti/81602.pdf

[9] Lantz, Eric, et al., 2021. Power Sector, Supply Chain, Jobs, and Emissions Implications of 30 Gigawatts of Offshore Wind Power by 2030. Report prepared by NREL, August. Available at: www.nrel.gov/docs/fy21osti/80031.pdf.

[10] Stefek, Jeremy, et al., 2022. U.S. Offshore Wind Workforce Assessment. Report prepared by NREL. Available at: https://www.nrel.gov/docs/fy23osti/81798.pdf

[11] Energy and Utility Skills, 2018. Skills and Labour Requirements of the UK Offshore Wind Industry: 2018 to 2032. Report prepared October. Available at: https://aura-innovation.co.uk/wp-content/uploads/2020/04/Aura-EU-Skills-UK-Offshore-Wind-Skills-Study-Full-Report-October-2018.pdf

Integration report[12] the Vision for Industry the Skills and Labor Requirements[13] reports identify concerns that there will be competition from all trade and manufacturing sectors for skilled labor and if OSW is to be competitive in attracting skilled labor wage and benefit packages will have to keep pace with and be more attractive than other sectors (pgs. 11 & 18; pg. 48).

Not only is there competition between sectors within countries, but there is also competition between countries for skilled workers. As noted in the CA Offshore Wind Workforce Impacts and Integration Report (pg 18), the UK and Scotland pulled skilled labor from Denmark, Norway and Germany to support the development of their OSW sector,- now these workers are being "poached" by East Asia. This is a global industry and there is global demand for labor. If CA isn't competitive, and doesn't include local sourcing provisions in contracts- supply will come from cheaper sources (Spain, Portugal, Poland, China) and CA won't be able to realize the anticipated domestic job creation projections (pg. 19).

China in particular is an emerging "threat" both in terms of competition for skilled labor and as an emerging supplier of components to the industry.

China is becoming very cost competitive on wind, and in some years from now, it could be able to

compete around the Pacific, including on the U.S. West Coast," said Edgare Kerkwijk, a Singapore-based wind investor and a board member of the Asia Wind Energy Association, in an interview (pg. 21)

Skill Gaps, Solutions & Training Needs

As mentioned in the previous section, skilled workers are aging out of the workforce. Younger workers and potential workers from nontraditional sectors (women, minorities etc.) are not choosing careers in the trades. To address these gaps east coast states are forming public private partnerships and are investing in linked programs that couple community colleges, trade schools, institutions of higher education and the private sector to create opportunities for integrated training and employment. The CA Offshore Wind Project Vision for Industry report clearly identifies that:

California has an opportunity to develop a phased OSW workforce development program, including: continual workforce analysis, interdepartmental stakeholder roundtables, higher education programs/trade schools, diversity and inclusion (including equalized pay), workforce development partnerships with industry leaders and colleges/universities, and investment in standardized safety training for OSW[14]

And that long-term efforts could help build a diverse and inclusive workforce, formalize partnerships between industry and training providers, and ensure investments in offshore wind safety training, operations and maintenance (O&M), monitoring and verification, and technology research and development. (pg. 8)

---

[12] Collier, et al., 2019. California Offshore Wind: Workforce Impacts and Grid Integration. Report prepared in April. Available at: http://laborcenter.berkeley.edu/ offshore-wind-workforce-grid.

[13] Energy and Utility Skills, 2018. Skills and Labour Requirements of the UK Offshore Wind Industry: 2018 to 2032. Report prepared October. Available at: https://aura-innovation.co.uk/wp-content/uploads/2020/04/Aura-EU-Skills-UK-Offshore-Wind-Skills-Study-Full-Report-October-2018.pdf

[14] American Jobs Project, 2019. The California Offshore Wind Project: A vision for Industry Growth. Report prepared in February. Available at: http://americanjobsproject.us/wp/wp-content/uploads/2019/02/The-California-Offshore-Wind-Project-Cited-.pdf . Pg. 8.

The CA Offshore Wind Workforce Impacts and Grid Integration report (pg. 7) provides an in-depth treatment of the concept of the "high road training" approach as a way forward.

Although the state has a strong workforce training system, including the construction industry's state-certified apprenticeships, skills gaps are likely to be a challenge for offshore wind on the North Coast. The state should consider creating a High-Road Training Partnership (HRTP) for offshore wind to fill these gaps and broaden community access to offshore wind jobs. HRTPs are a new state program of industry-specific training programs that prioritize job quality, equity, and environmental sustainability (pg. 7)

"But what's most important for employers in offshore wind or any other industry is that we have not just specifically trained workers, but an established, adaptable system. We don't just have the exact widget makers you need, but we know how to train your widget makers in any skill as fast as possible." [15]

According to the Offshore Wind Workforce Training and Development in MA- Analysis and Strategic Recommendations, Massachusetts has successfully utilized virtual training; vocational/technical HS system in MA, university training, UMass Lowell, Power—US; Mass- CEC Clean Energy internships; workforce re-entry, regional workforce strategy (Northeast) to address skilled worker shortages[16]

To further incentivize investment in workforce development, the Vision for Industry promotes the concept of "cluster-based development (pgs. 20-25), which CA already has some experience within other sectors as a way forward to jump start workforce development for the OSW industry.

Clusters are regionally situated groups of interconnected companies and institutions that are engaged in a particular industry and supported by repeated exchanges of information and resources. In today's competitive globalized economy, businesses are more likely to thrive in regions that cultivate the building blocks of cluster development: a rich innovation ecosystem, fertile ground for capital investment, a highly skilled workforce, clear policy signals, and a robust value chain…. In industries that are dependent on manufacturing, such as offshore wind, clusters have been shown to expand access to talent and boost economic activity…. By leveraging an environment of coordination and cooperation, clusters can offer workers fair wages and simultaneously stimulate innovation and economic development.

Challenges

Uncertainty is the biggest challenge to meeting the workforce needs of the OSW industry. Uncertainty over where fields are to be cited; uncertainty over the size of the fields; uncertainty over the time horizon for brining fields into operation; uncertainty over local content requirements… all contribute to reluctance and unwillingness both to invest in developing and building out the necessary infrastructure and forming the necessary partnerships to ensure that workforce demands are met. Vision for Industry[17]

---

[15] Collier, et al., 2019. California Offshore Wind: Workforce Impacts and Grid Integration. Report prepared in April. Available at: http://laborcenter.berkeley.edu/ offshore-wind-workforce-grid. Pg. 24, re Rhode Island.

[16] Frongillo, Cobi and Jordan, Phillip, 2021. Offshore Wind Workforce Training& Development in Massachusetts: Analysis and Strategic Recommendations. Report prepared for Massachusetts Clean Energy Center, September. Available at: https://files-cdn.masscec.com/reports/MassCEC%20OSW%20Workforce%20Final%20Report_Sept%202021.pdf pg. 5.

[17] American Jobs Project, 2019. The California Offshore Wind Project: A vision for Industry Growth. Report prepared in February. Available at: http://americanjobsproject.us/wp/wp-content/uploads/2019/02/The-California-Offshore-Wind-Project-Cited-.pdf .

the Report for the Roadmap Project for Multi-State Cooperation on Offshore Wind[18], Skills and Labor Requirements of UK Offshore Wind Industry 2018-2032[19], Offshore Wind Workforce Training and Development in MA- Analysis & Strategic Recommendations[20], The Demand for Domestic Offshore Wind Energy Supply Chain[21], Power Sector Supply Chain Jobs and Emissions- Implications of 30 GW of OSW Power by 2030[22] & Offshore Wind Workforce Assessment[23] all reference the role of uncertainty in determining the trajectory for workforce development.

And in the CA Offshore Wind Workforce Impacts and Grid Integration report[24] reiterates this reality*: " the Volume of project pipeline most critical factor for developing local manufacturing and supply chain… the degree of state policy intervention determines high/low outcomes (pg. 11)*

The Workforce Impacts and Grid Integration report[25] also points out that *East Coast states (NY, RI, MA, NJ,) have been able to take positive tangible action towards meeting their immediate workforce demands and building systems to grow their future workforce by setting capacity commitments, created partnerships with labor, industry, prevailing wage guarantees, apprenticeships, PLAs, … all leading to investments in workforce development*[26]

---

[18] BVG Associates Limited, 2017. U.S. Job Creation in Offshore Wind A Report for the Roadmap Project for Multi-State Cooperation on Offshore Wind. Report prepared for NYSERDA, Massachusetts Clean Energy Center, Massachusetts Department of Energy resources, Rhode Island Office of Energy Resources, Clean Energy States Alliance, October. Available at: https://www.cesa.org/wp-content/uploads/US-job-creation-in-offshore-wind.pdf

[19] Energy and Utility Skills, 2018. Skills and Labour Requirements of the UK Offshore Wind Industry: 2018 to 2032. Report prepared October. Available at: https://aura-innovation.co.uk/wp-content/uploads/2020/04/Aura-EU-Skills-UK-Offshore-Wind-Skills-Study-Full-Report-October-2018.pdf

[20] Frongillo, Cobi and Jordan, Phillip, 2021. Offshore Wind Workforce Training& Development in Massachusetts: Analysis and Strategic Recommendations. Report prepared for Massachusetts Clean Energy Center, September. Available at: https://files-cdn.masscec.com/reports/MassCEC%20OSW%20Workforce%20Final%20Report_Sept%202021.pdf

[21] Shields, Matt, et al., 2022. The Demand for a Domestic Offshore Wind Energy Supply Chain. Report prepared by NREL, June. Available at: https://www.nrel.gov/docs/fy22osti/81602.pdf

[22] Lantz, Eric, et al., 2021. Power Sector, Supply Chain, Jobs, and Emissions Implications of 30 Gigawatts of Offshore Wind Power by 2030. Report prepared by NREL, August. Available at: www.nrel.gov/docs/fy21osti/80031.pdf.

[23] Stefek, Jeremy, et al., 2022. U.S. Offshore Wind Workforce Assessment. Report prepared by NREL. Available at: https://www.nrel.gov/docs/fy23osti/81798.pdf

[24] Collier, et al., 2019. California Offshore Wind: Workforce Impacts and Grid Integration. Report prepared in April. Available at: http://laborcenter.berkeley.edu/ offshore-wind-workforce-grid.

[25] Collier, et al., 2019. California Offshore Wind: Workforce Impacts and Grid Integration. Report prepared September. Available at: http://laborcenter.berkeley.edu/ offshore-wind-workforce-grid

[26] Collier, et al., 2019. California Offshore Wind: Workforce Impacts and Grid Integration. Report prepared September. Available at: http://laborcenter.berkeley.edu/ offshore-wind-workforce-grid

Appendix B

Workforce Data Tables

Catalyst
ENVIRONMENTAL SOLUTIONS

Component	Average		Number of Supply Chain Jobs (Upper Bound 2030)		Number of Supply Chain Jobs (Upper Bound 2045)	Types of Jobs Needed	SOC Labor Code	Average Salary	Percent of Component Workforce	Number of Workers (high 2030)	Number of Workers (high 2045)	Income Value (2030)	Income Value (2045)
Ports and Staging	9.00%		494		810	Captains, Mates, and Pilots of Water Vessels	53-5021	$103,910	5%	24.7	40.5	$2,566,577	$4,208,355
			494		810	Tank Car, Truck, and Ship Loaders	53-7121	$57,970	10%	49.4	81	$2,863,718	$4,695,570
			494		810	Hoist and Winch Operators	53-7041	$70,310	10%	49.4	81	$3,473,314	$5,695,110
			494		810	Laborers and Freight, Stock, and Material Movers (Hand)	53-7062	$37,940	20%	98.8	162	$3,748,472	$6,146,280
			494		810	Operating Engineers and Other Construction Equipment Operators	47-2073	$78,320	15%	74.1	121.5	$5,803,512	$9,515,880
			494		810	Crane and Tower Operators	53-7021	$81,070	5%	24.7	40.5	$2,002,429	$3,283,335
			494		810	Transportation, Storage, and Distribution Managers	11-3071.	$110,390	10%	49.4	81	$5,453,266	$8,941,590
			494		810	Other	N/A	$62,400	25%	123.5	202.5	$7,706,400	$12,636,000
Array Cable and Export Cable	15.4		845		1386	Forging Machine Setters, Operators, and Tenders, Metal and Plastic	51-4022	$46,920	34%	287.3	471.24	$13,480,116	$22,110,581
			845		1386	Computer Control Programmers and Operators	51-9161	$48,770	13%	109.85	180.18	$5,357,385	$8,787,379
			845		1386	Inspectors, Testers, Sorters, Samplers, and Weighers	51-9061	$47,280	7%	59.15	97.02	$2,796,612	$4,587,106
			845		1386	Industrial Machinery Installation, Repair, and Maintenance Workers	49-9041	$65,700	5%	42.25	69.3	$2,775,825	$4,553,010
			845		1386	First-Line Supervisors of Production and Operating Workers	51-1011	$70,510	4%	33.8	55.44	$2,383,238	$3,909,074
			845		1386	Secretaries and Administrative Assistants	43-6014	$47,930	3%	25.35	41.58	$1,215,026	$1,992,929
			845		1386	Sales Representatives, Wholesale and Manufacturing	41-4012	$77,800	2%	16.9	27.72	$1,314,820	$2,156,616
			845		1386	Compliance Officers	13-1041	$86,030	2%	16.9	27.72	$1,453,907	$2,384,752
			845		1386	Industrial Engineers, Including Health and Safety	17-2112	$109,460	2%	16.9	27.72	$1,849,874	$3,034,231
			845		1386	General and Operations Managers	11-1021	$131,080	2%	16.9	27.72	$2,215,252	$3,633,538
			845		1386	Engineering Technicians, Except Drafters	17-3029	$68,460	2%	16.9	27.72	$1,156,974	$1,897,711
			845		1386	Electrical and Electronics Engineers	17-3023	$73,910	2%	16.9	27.72	$1,249,079	$2,048,785
			845		1386	Other	N/A	$62,400	22%	185.9	304.92	$11,600,160	$19,027,008
Substation	15.7		862		1413	Computer Control Programmers and Operators	51-9161	$48,770	15%	129.3	211.95	$6,305,961	$10,336,802
			862		1413	Structural Metal Fabricators and Fitters	51-2041	$47,640	13%	112.06	183.69	$5,338,538	$8,750,992
			862		1413	Metal Furnace Operators, Tenders, Pourers, and Casters	51-4051	$49,540	8%	68.96	113.04	$3,416,278	$5,600,002
			862		1413	Engine and Other Machine Assemblers	51-2031	$48,010	7%	60.34	98.91	$2,896,923	$4,748,669
			862		1413	Welding, Soldering, and Brazing Workers	51-4122	$47,210	6%	51.72	84.78	$2,441,701	$4,002,464
			862		1413	First-Line Supervisors of Production and Operating Workers	51-1011	$70,510	4%	34.48	56.52	$2,431,185	$3,985,225
			862		1413	Industrial Engineers, Including Health and Safety	49-9041	$65,700	4%	34.48	56.52	$2,265,336	$3,713,364
			862		1413	General and Operations Managers	11-1021	$131,080	4%	34.48	56.52	$4,519,638	$7,408,642
			862		1413	Transportation, Storage, and Distribution Managers	11-3071.	$110,390	3%	25.86	42.39	$2,854,685	$4,679,432
			862		1413	Compliance Officers	13-1041	$86,030	3%	25.86	42.39	$2,224,736	$3,646,812
			862		1413	Sales Representatives, Wholesale and Manufacturing	41-4012	$77,800	2%	17.24	28.26	$1,341,272	$2,198,628
			862		1413	Crane and Tower Operators	53-7021	$81,070	2%	17.24	28.26	$1,397,647	$2,291,038
			862		1413	Other	N/A	$62,400	29%	249.98	409.77	$15,598,752	$25,569,648
Foundations	19.8		1087		1782	Structural Metal Fabricators and Fitters	51-2041	$47,640	19%	206.53	338.58	$9,839,089	$16,129,951
			1087		1782	Metal Furnace Operators, Tenders, Pourers, and Casters	51-4051	$49,540	13%	141.31	231.66	$7,000,497	$11,476,436
			1087		1782	Computer Control Programmers and Operators	51-9161	$48,770	13%	141.31	231.66	$6,891,689	$11,298,058
			1087		1782	Welding, Soldering, and Brazing Workers	51-4122	$47,210	13%	141.31	231.66	$6,671,245	$10,936,669
			1087		1782	First-Line Supervisors of Production and Operating Workers	51-1011	$70,510	5%	54.35	89.1	$3,832,219	$6,282,441
			1087		1782	Hoist and Winch Operators	53-7041	$70,310	3%	32.61	53.46	$2,292,809	$3,758,773
			1087		1782	Mining Machine Operators	47-5041	$62,040	4%	43.48	71.28	$2,697,499	$4,422,211
			1087		1782	Transportation, Storage, and Distribution Managers	11-3071.	$110,390	2%	21.74	35.64	$2,399,879	$3,934,300
			1087		1782	Painting Workers	51-9123	$42,800	2%	21.74	35.64	$930,472	$1,525,392
			1087		1782	Industrial Truck and Tractor Operators	53-7051	$43,040	2%	21.74	35.64	$935,690	$1,533,946
			1087		1782	Inspectors, Testers, Sorters, Samplers, and Weighers	51-9061	$47,280	2%	21.74	35.64	$1,027,867	$1,685,059
			1087		1782	Compliance Officers	13-1041	$86,030	2%	21.74	35.64	$1,870,292	$3,066,109
			1087		1782	Other	N/A	$62,400	22%	239.14	392.04	$14,922,336	$24,463,296
Towers	5.3		291		477	Metal Furnace Operators, Tenders, Pourers, and Casters	51-4051	$49,540	19%	55.29	90.63	$2,739,067	$4,489,810
			291		477	Structural Metal Fabricators and Fitters	51-2041	$47,640	19%	55.29	90.63	$2,634,016	$4,317,613
			291		477	First-Line Supervisors of Production and Operating Workers	51-1011	$70,510	8%	23.28	38.16	$1,641,473	$2,690,662
			291		477	Welding, Soldering, and Brazing Workers	51-4122	$47,210	6%	17.46	28.62	$824,287	$1,351,150
			291		477	Mining Machine Operators	47-5041	$62,040	5%	14.55	23.85	$902,682	$1,479,654
			291		477	Industrial Truck and Tractor Operators	53-7051	$43,040	4%	11.64	19.08	$500,986	$821,203
			291		477	General and Operations Managers	11-1021	$131,080	4%	11.64	19.08	$1,525,771	$2,501,006
			291		477	Inspectors, Testers, Sorters, Samplers, and Weighers	51-9061	$47,280	4%	11.64	19.08	$550,339	$902,102
			291		477	Miscellaneous Plant and System Operators	51-8090	$68,660	3%	8.73	14.31	$599,402	$982,525
			291		477	Painting Workers	51-9123	$42,800	2%	5.82	9.54	$249,096	$408,312
			291		477	Secretaries and Administrative Assistants	43-6014	$47,930	3%	8.73	14.31	$418,429	$685,878
			291		477	Drafters	17-3011	$66,140	2%	5.82	9.54	$384,935	$630,976
			291		477	Other	N/A	$62,400	21%	61.11	100.17	$3,813,264	$6,250,608
Blades	10.9		598		981	Miscellaneous Assemblers and Fabricators	51-2090	$38,950	31%	185.38	304.11	$7,220,551	$11,845,085
			598		981	First-Line Supervisors of Production and Operating Workers	51-1011	$70,510	8%	47.84	78.48	$3,373,198	$5,533,625
			598		981	Computer Control Programmers and Operators	51-9161	$48,770	7%	41.86	68.67	$2,041,512	$3,349,036
			598		981	Miscellaneous Metal Workers and Plastic Workers	51-4199	$40,510	6%	35.88	58.86	$1,453,499	$2,384,419
			598		981	Industrial Machinery Installation, Repair, and Maintenance Workers	49-9041	$65,700	4%	23.92	39.24	$1,571,544	$2,578,068
			598		981	Transportation, Storage, and Distribution Managers	11-3071.	$110,390	3%	17.94	29.43	$1,980,397	$3,248,778
			598		981	Drafters	17-3011	$66,140	3%	17.94	29.43	$1,186,552	$1,946,500
			598		981	Chemical Processing Machine Setters, Operators, and Tenders	51-9011	$52,540	2%	11.96	19.62	$628,378	$1,030,835
			598		981	General and Operations Managers	11-1021	$131,080	2%	11.96	19.62	$1,567,717	$2,571,790
			598		981	Secretaries and Administrative Assistants	43-6014	$47,930	2%	11.96	19.62	$573,243	$940,387
			598		981	Bookkeeping, Accounting, and Auditing Clerks	43-3031	$51,080	2%	11.96	19.62	$610,917	$1,002,190
			598		981	Other	N/A	$62,400	28%	167.44	274.68	$10,448,256	$17,140,032
Nacelle**	23.1		1268		2079	Engine and Other Machine Assemblers	51-2031	$48,010	27%	342.36	561.33	$16,436,704	$26,949,453
			1268		2079	Structural Metal Fabricators and Fitters	51-2041	$47,640	11%	139.48	228.69	$6,644,827	$10,894,792
			1268		2079	First-Line Supervisors of Production and Operating	51-1011	$70,510	5%	63.4	103.95	$4,470,334	$7,329,515
			1268		2079	General and Operations Managers	11-1021	$131,080	4%	50.72	83.16	$6,648,378	$10,900,613
			1268		2079	Industrial Engineers, Including Health and Safety	49-9041	$65,700	3%	38.04	62.37	$2,499,228	$4,097,709
			1268		2079	Secretaries and Administrative Assistants	43-6014	$47,930	3%	38.04	62.37	$1,823,257	$2,989,394
			1268		2079	Miscellaneous Assemblers and Fabricators	51-2090	$38,950	3%	38.04	62.37	$1,481,658	$2,429,312
			1268		2079	Drafters	17-3011	$66,140	2%	25.36	41.58	$1,677,310	$2,750,101
			1268		2079	Bookkeeping, Accounting, and Auditing Clerks	43-3031	$51,080	2%	25.36	41.58	$1,295,389	$2,123,906
			1268		2079	Miscellaneous Electrical and Electronic Equipment Mechanics, Installers, and Repairers	49-2093	$72,870	2%	25.36	41.58	$1,847,983	$3,029,935
			1268		2079	Miscellaneous Plant and System Operators	51-8090	$68,660	2%	25.36	41.58	$1,741,218	$2,854,883
			1268		2079	Other	N/A	$ 62,400.00	34%	431.12	706.86	$26,901,888	$44,108,064
										5,429	**8,902**	**$319,717,874**	**$524,229,115**

Component	Average	Number of Supply Chain Jobs (Upper Bound 2030)	Number of Supply Chain Jobs (Upper Bound 2045)	Example Types of Jobs Needed	Labor Code	Average Salary	Percent of Component Workforce	Number of Workers (high 2030)	Number of Workers (high 2045)	Income Value (2030)	Income Value (2045)
Foundations	26.9	303.00	628	Miscellaneous Installation, Maintenance, and Repair Workers	49-9099	$46,780	31%	93.93	194.68	$4,394,045	$9,107,130
		303.00	628	General and Operations Managers	11-1021	$131,080	5%	15.15	31.4	$1,985,862	$4,115,912
		303.00	628	Industrial Engineers, Including Health and Safety	17-2112	$109,460	5%	15.15	31.4	$1,658,319	$3,437,044
		303.00	628	Captains, Mates, and Pilots of Water Vessels	53-5021	$103,910	4%	12.12	25.12	$1,259,389	$2,610,219
		303.00	628	Miscellaneous Plant and System Operators	51-8090	$68,660	4%	12.12	25.12	$832,159	$1,724,739
		303.00	628	Computer and Information Systems Managers	11-3021	$193,500	3%	9.09	18.84	$1,758,915	$3,645,540
		303.00	628	Secretaries and Administrative Assistants	43-6014	$47,930	3%	9.09	18.84	$435,684	$903,001
		303.00	628	Electrical and Electronics Engineers	17-3023	$73,910	3%	9.09	18.84	$671,842	$1,392,464
		303.00	628	Ship Engineers	17-2199	$117,990	3%	9.09	18.84	$1,072,529	$2,222,932
		303.00	628	Surveying and Mapping Technicians	17-3031	$71,700	3%	9.09	18.84	$651,753	$1,350,828
		303.00	628	Engineering Technicians, Except Drafters	17-3029	$68,460	2%	6.06	12.56	$414,868	$859,858
		303.00	628	Training and Development Specialists	13-1151	$77,510	2%	6.06	12.56	$469,711	$973,526
		303.00	628	Other	N/A	$62,400	32%	96.96	200.96	$6,050,304	$12,539,904
Cable	28.7	324	672	Miscellaneous Installation, Maintenance, and Repair Workers	49-9099	$46,780	19%	61.56	127.68	$2,879,777	$5,972,870
		324	672	Industrial Engineers, Including Health and Safety	17-2112	$109,460	9%	29.16	60.48	$3,191,854	$6,620,141
		324	672	Miscellaneous Electrical and Electronic Equipment Mechanics, Installers, and Repairers	49-2093	$72,870	7%	22.68	47.04	$1,652,692	$3,427,805
		324	672	Miscellaneous Plant and System Operators	51-8090	$68,660	7%	22.68	47.04	$1,557,209	$3,229,766
		324	672	Industrial Machinery Installation, Repair, and Maintenance Workers	49-9041	$65,700	5%	16.2	33.6	$1,064,340	$2,207,520
		324	672	Secretaries and Administrative Assistants	43-6014	$47,930	5%	16.2	33.6	$776,466	$1,610,448
		324	672	General and Operations Managers	11-1021	$131,080	5%	16.2	33.6	$2,123,496	$4,404,288
		324	672	Ship Engineers	17-2199	$117,990	3%	9.72	20.16	$1,146,863	$2,378,678
		324	672	First-Line Supervisors of Production and Operating Workers	51-1011	$70,510	3%	9.72	20.16	$685,357	$1,421,482
		324	672	Computer and Information Systems Managers	11-3021	$193,500	3%	9.72	20.16	$1,880,820	$3,900,960
		324	672	Engineering Technicians, Except Drafters	17-3029	$68,460	3%	9.72	20.16	$665,431	$1,380,154
		324	672	Electrical and Electronics Engineers	17-3023	$73,910	2%	6.48	13.44	$478,937	$993,350
		324	672	Other	N/A	$62,400	30%	97.2	201.6	$6,065,280	$12,579,840
Turbine	33.1	374	775	Miscellaneous Installation, Maintenance, and Repair Workers	49-9099	$46,780	30%	112.2	232.5	$5,248,716	$10,876,350
		374	775	Wind Turbine Service Technicians	49-9081	$65,670	18%	67.32	139.5	$4,420,904	$9,160,965
		374	775	General and Operations Managers	11-1021	$131,080	4%	14.96	31	$1,960,957	$4,063,480
		374	775	Industrial Engineers, Including Health and Safety	17-2112	$109,460	4%	14.96	31	$1,637,522	$3,393,260
		374	775	Computer and Information Systems Managers	11-3021	$193,500	3%	11.22	23.25	$2,171,070	$4,498,875
		374	775	Captains, Mates, and Pilots of Water Vessels	53-5021	$103,910	3%	11.22	23.25	$1,165,870	$2,415,908
		374	775	Miscellaneous Plant and System Operators	51-8090	$68,660	3%	11.22	23.25	$770,365	$1,596,345
		374	775	Electrical and Electronics Engineers	17-3023	$73,910	2%	7.48	15.5	$552,847	$1,145,605
		374	775	Secretaries and Administrative Assistants	43-6014	$47,930	2%	7.48	15.5	$358,516	$742,915
		374	775	Surveying and Mapping Technicians	17-3031	$71,700	2%	7.48	15.5	$536,316	$1,111,350
		374	775	Engineering Technicians, Except Drafters	17-3029	$68,460	2%	7.48	15.5	$512,081	$1,061,130
		374	775	Compliance Officers	13-1041	$86,030	2%	7.48	15.5	$643,504	$1,333,465
		374	775	Other	N/A	$62,400	25%	93.5	193.75	$5,834,400	$12,090,000
Scour Protection	4	45	94	Captains, Mates, and Pilots of Water Vessels	53-5021	$103,910	15%	6.75	14.1	$701,393	$1,465,131
		45	94	Surveying and Mapping Technicians	17-3031	$71,700	15%	6.75	14.1	$483,975	$1,010,970
		45	94	Other	N/A	$62,400	30%	13.5	28.2	$842,400	$1,759,680
		45	94	Miscellaneous Installation, Maintenance, and Repair Workers	49-9099	$46,780	40%	18	37.6	$842,040	$1,758,928
Other	7.4	83	172	Construction Laborers	47-2061	$52,790	17%	14.11	29.24	$744,867	$1,543,580
		83	172	Miscellaneous Installation, Maintenance, and Repair Workers	49-9099	$46,780	13%	10.79	22.36	$504,756	$1,046,001
		83	172	Engineering Technicians, Except Drafters	17-3029	$68,460	10%	8.3	17.2	$568,218	$1,177,512
		83	172	Construction Equipment Operators	47-2073	$78,320	7%	5.81	12.04	$455,039	$942,973
		83	172	First-Line Supervisors of Production and Operating Workers	51-1011	$70,510	3%	2.49	5.16	$175,570	$363,832
		83	172	Purchasing Managers	11-3061	$145,390	4%	3.32	6.88	$482,695	$1,000,283
		83	172	Structural Iron and Steel Workers	47-2221	$70,870	2%	1.66	3.44	$117,644	$243,793
		83	172	Reinforcing Iron and Rebar Workers	47-2171	$67,480	2%	1.66	3.44	$112,017	$232,131
		83	172	Cement Masons, Concrete Finishers, and Terrazzo Workers	47-2051	$60,650	2%	1.66	3.44	$100,679	$208,636
		83	172	First Line Supervisors of Mechanics, Installers, and Repairers	49-1011	$83,620	2%	1.66	3.44	$138,809	$287,653
		83	172	General and Operations Managers	11-1021	$131,080	2%	1.66	3.44	$217,593	$450,915
		83	172	Sales Represenatatives, Wholesale and Manufacturing	41-4011	$116,990	2%	1.66	3.44	$194,203	$402,446
		83	172	Other	N/A	$62,400	35%	29.05	60.2	$1,812,720	$3,756,480
								1,133	**2,349**	**$80,131,587**	**$166,150,990**

COMPUTATIONAL TABLE - OPERATIONS & MAINTENANCE

Component	Average	Number of Supply Chain Jobs (Upper Bound 2030)	Number of Supply Chain Jobs (Upper Bound 2045)	Example Types of Jobs Needed	Labor Code	Average Salary	Percent of Component Workforce	Number of Workers (high 2030)	Number of Workers (high 2045)	Income Value (2030)	Income Value (2045)
		463.00	1208	General and Operations Managers	11-1021	$131,080	16%	74.08	193.28	$9,710,406	$25,335,142
		463.00	1208	Captains, Mates, and Pilots of Water Vessels	53-5021	$103,910	14%	64.82	169.12	$6,735,446	$17,573,259
		463.00	1208	Industrial Engineers, Including Health and Safety	17-2112	$109,460	9%	41.67	108.72	$4,561,198	$11,900,491
		463.00	1208	Secretaries and Administrative Assistants	43-6014	$47,930	7%	32.41	84.56	$1,553,411	$4,052,961
		463.00	1208	Compliance Officers	13-1041	$86,030	7%	32.41	84.56	$2,788,232	$7,274,697
		463.00	1208	Purchasing Managers	11-3061	$145,390	5%	23.15	60.4	$3,365,779	$8,781,556
Wind Farm Operations		463.00	1208	Secretaries and Administrative Assistants	43-6014	$47,930	3%	13.89	36.24	$665,748	$1,736,983
		463.00	1208	Ship Engineers	17-2199	$117,990	3%	13.89	36.24	$1,638,881	$4,275,958
		463.00	1208	Computer and Information Systems Managers	11-3021	$193,500	3%	13.89	36.24	$2,687,715	$7,012,440
		463.00	1208	Administrative Service Managers	11-3012	$115,290	2%	9.26	24.16	$1,067,585	$2,785,406
		463.00	1208	Transportation, Storage and Distribution Managers	11-3071	$110,390	2%	9.26	24.16	$1,022,211	$2,667,022
		463.00	1208	Hoist and Winch Operators	53-7041	$70,310	2%	9.26	24.16	$651,071	$1,698,690
		463.00	1208	Miscellaneous Plant and System Operators	51-8090	$68,660	27%	125.01	326.16	$8,583,187	$22,394,146
		463.00	1208	Other	N/A	$62,400	32%	148.16	386.56	$9,245,184	$24,121,344
		299	780	Wind Turbine Service Technicians	49-9081	$65,670	67%	200.33	522.6	$13,155,671	$34,319,142
		299	780	Engine and Other Machine Assemblers	51-2031	$48,010	4%	11.96	31.2	$574,200	$1,497,912
		299	780	Structural Metal Fabricators and Fitters	51-2041	$47,640	2%	5.98	15.6	$284,887	$743,184
		299	780	Miscellaneous Assemblers and Fabricators	51-2090	$38,950	2%	5.98	15.6	$232,921	$607,620
		299	780	Training and Development Managers	11-3131	$147,520	2%	5.98	15.6	$882,170	$2,301,312
		299	780	First-Line Supervisors of Production and Operating Workers	51-1011	$70,510	2%	5.98	15.6	$421,650	$1,099,956
Turbines	15.7	299	780	Miscellaneous Plant and System Operators	51-8090	$68,660	2%	5.98	15.6	$410,587	$1,071,096
		299	780	Computer and Information Systems Managers	11-3021	$193,500	2%	5.98	15.6	$1,157,130	$3,018,600
		299	780	Administrative Service Managers	11-3012	$115,290	1%	2.99	7.8	$344,717	$899,262
		299	780	Metal Furnace Operators, Tenders, Pourers, and Casters	51-2090	$38,950	1%	2.99	7.8	$116,461	$303,810
		299	780	General and Operations Managers	11-1021	$131,080	1%	2.99	7.8	$391,929	$1,022,424
		299	780	Transportation, Storage and Distribution Managers	11-3071	$110,390	1%	2.99	7.8	$330,066	$861,042
		299	780	Other	N/A	$62,400	13%	38.87	101.4	$2,425,488	$6,327,360
		6	16	Engineering Technicians, Except Drafters	17-3029	$68,460	25%	1.5	4	$102,690	$273,840
		6	16	Industrial Engineers, Including Health and Safety	17-2112	$109,460	15%	0.9	2.4	$98,514	$262,704
		6	16	General and Operations Managers	11-1021	$131,080	13%	0.78	2.08	$102,242	$272,646
		6	16	Miscellaneous Installation, Maintenance, and Repair Workers	49-9099	$46,780	9%	0.54	1.44	$25,261	$67,363
		6	16	Computer and Information Systems Managers	11-3021	$193,500	6%	0.36	0.96	$69,660	$185,760
		6	16	Captains, Mates, and Pilots of Water Vessels	53-5021	$103,910	6%	0.36	0.96	$37,408	$99,754
Foundations	19.8	6	16	Miscellaneous Plant and System Operators	51-8090	$68,660	2%	0.12	0.32	$8,239	$21,971
		6	16	Industrial Machinery Installation, Repair, and Maintenance Workers	49-9041	$65,700	2%	0.12	0.32	$7,884	$21,024
		6	16	Secretaries and Administrative Assistants	43-6014	$47,930	2%	0.12	0.32	$5,752	$15,338
		6	16	Training and Development Specialists	13-1151	$77,510	1%	0.06	0.16	$4,651	$12,402
		6	16	Ship Engineers	17-2199	$117,990	1%	0.06	0.16	$7,079	$18,878
		6	16	Human Resources Workers	13-1071	$81,360	1%	0.06	0.16	$4,882	$13,018
		6	16	Other	N/A	$62,400	17%	1.02	2.72	$63,648	$169,728
		1	1	Miscellaneous Installation, Maintenance, and Repair Workers	49-9099	$46,780	15%	0.15	0.15	$7,017	$7,017
		1	1	Engineering Technicians, Except Drafters	17-3029	$68,460	13%	0.13	0.13	$8,900	$8,900
		1	1	Industrial Engineers, Including Health and Safety	17-2112	$109,460	9%	0.09	0.09	$9,851	$9,851
		1	1	Miscellaneous Plant and System Operators	51-8090	$68,660	7%	0.07	0.07	$4,806	$4,806
		1	1	Electrical and Electronics Engineers	17-3023	$73,910	5%	0.05	0.05	$3,696	$3,696
		1	1	Industrial Machinery Installation, Repair, and Maintenance Workers	49-9041	$65,700	5%	0.05	0.05	$3,285	$3,285
Subsea Cable		1	1	Secretaries and Administrative Assistants	43-6014	$47,930	5%	0.05	0.05	$2,397	$2,397
		1	1	General and Operations Managers	11-1021	$131,080	5%	0.05	0.05	$6,554	$6,554
		1	1	Miscellaneous Electrical and Electronic Equipment Mechanics, Installers, and Repairers	49-2093	$72,870	5%	0.05	0.05	$3,644	$3,644
		1	1	Ship Engineers	17-2199	$117,990	3%	0.03	0.03	$3,540	$3,540
		1	1	First Line Surpervisors of Mechanics, Installers, and Repairers	49-1011	$83,620	3%	0.03	0.03	$2,509	$2,509
		1	1	Other	N/A	$62,400	23%	0.23	0.23	$14,352	$14,352
		1	1	Engineering Technicians, Except Drafters	17-3029	$68,460	42%	0.42	0.42	$28,753	$28,753
		1	1	General and Operations Managers	11-1021	$131,080	12%	0.12	0.12	$15,730	$15,730
		1	1	Miscellaneous Electrical and Electronic Equipment Mechanics, Installers, and Repairers	49-2093	$72,870	12%	0.12	0.12	$8,744	$8,744
		1	1	Electrical and Electronics Engineers	17-3023	$73,910	10%	0.1	0.1	$7,391	$7,391
		1	1	Secretaries and Administrative Assistants	43-6014	$47,930	5%	0.05	0.05	$2,397	$2,397
Substation	5.3	1	1	Marketing and Sales Managers	11-2021	$175,150	3%	0.03	0.03	$5,255	$5,255
		1	1	Industrial Engineers, Including Health and Safety	17-2112	$109,460	3%	0.03	0.03	$3,284	$3,284
		1	1	Training and Development Specialists	13-1151	$77,510	2%	0.02	0.02	$1,550	$1,550
		1	1	Administrative Service Managers	11-3012	$115,290	2%	0.02	0.02	$2,306	$2,306
		1	1	Purchasing Managers	11-3061	$145,390	2%	0.02	0.02	$2,908	$2,908
		1	1	Other	N/A	$62,400	5%	0.05	0.05	$3,120	$3,120
								918	**2,393**	**$75,693,826**	**$197,269,227**

Catalyst
ENVIRONMENTAL SOLUTIONS

www.ce.solutions