Maine
Offshore Wind
Initiative

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Maine Offshore Wind Talent Analysis

REPORT TO THE MAINE GOVERNOR'S ENERGY OFFICE AND MAINE OFFSHORE WIND ROADMAP

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[bw] RESEARCH PARTNERSHIP

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Executive Summary

Introduction

This Offshore Wind (OSW) Talent Analysis provides data-driven conclusions and recommendations to the Supply Chain, Workforce Development, Ports, and Marine Transportation Working Group, with a particular focus on the job creation potential and workforce needs of the sector. Maine's leadership has embraced the growth in clean energy jobs; alongside a commitment to become carbon-neutral by 2045, Governor Janet Mills has announced a goal of 30,000 clean energy jobs in Maine by 2030. This vision is supported by the announcement of $4 million in funding from the Maine Jobs & Recovery Plan for a Clean Energy Workforce Program, which will prepare Maine residents for jobs in clean energy. OSW, both in and outside of Maine, presents a wide variety of job opportunities for Mainers. The OSW industry is rapidly growing across the Eastern Seaboard, and services ranging from surveying and permitting to construction and installation will be needed from North Carolina to Eastport. Developing a world-class workforce is essential to ensure that Mainers get the maximum benefit from the clean energy transition.

This research was developed with extensive input and feedback from an array of stakeholders. Plans are too often developed without consultation and consideration of the stakeholders who would be trusted on to enact the recommendations, resulting in strategies that are inefficient or ineffective. To prevent this type of top-down development of policy, the research team conducted five executive interviews and held three public workshop convenings to develop a nuanced understanding of Maine's OSW economy and workforce and to brainstorm solutions from key stakeholder groups. For more information on these workshops and how various stakeholder groups were engaged, please see Appendix A on page 34.

This report begins with an examination of the existing potential OSW workforce with direct or relevant experience and skills, as well as an analysis of the demographics of that workforce. The report then examines the existing talent pools and pipelines that can work in OSW activities in and outside of the state, as well as the potential gaps in workers needed to complete the proposed non-commercial 155MW test and research array installations in the Gulf of Maine. Finally, the research examines wind-specific and relevant training programs around the state to better understand the capacity of existing pipelines and highlights other domestic and international OSW training programs.

Key Findings

1. **Maine's existing wind-related workforce is already strong, accounting for more than 1,300 jobs in 2020, or about 10% of Maine's clean energy workforce.** Maine's wind energy workforce has also seen strong growth in recent years; between 2016 and 2020 the number of workers grew by 7.1%. The sector also demonstrated resiliency through the pandemic, growing 4% between 2019 and 2020.[1] OSW has the potential to add substantially to Maine's economy, generating new opportunities for the current workforce and future generations.

2. **The research team identified 117 occupations that will be crucial to the development and operation of OSW projects.** These occupations fall into five project phases: Planning and Development; Manufacturing & Assembly; Construction & Installation; Operations & Maintenance; and Support Services. Employment in each of these five of these phases is lower in concentration than the national average.

3. **The Maine workforce is largely prepared to build out the estimated 155 MW of OSW activity in the Gulf of Maine by 2030, though addressing the gaps in specialized skillsets will require strategic planning and**

[1] 2021 Maine Clean Energy Industry Report.

deliberate efforts. There are four occupations in which the estimated additional demand for workers is more than ten percent of the current number of workers in that occupation in the state, and another 40 occupations will likely have some workforce gap. There is also potential to transition displaced or unemployed workers from adjacent occupations, or jobs that have similar skillsets. Among the 12 occupations with the greatest estimated workforce gaps, there are more than 600 people who are estimated to be currently unemployed but worked in adjacent occupations that have similar skills and abilities to the in-demand OSW jobs.

4. **There are several key occupations and industries in Maine that are well positioned to provide services in and outside of the state, for both floating and fixed-bottom OSW activities.** One strength is within Surveying, Permitting, and Marine Monitoring and Other Activities; Maine has 3 times the national average of Zoologists and Wildlife Biologists. There is also a high concentration of engineers and architects; Maine has more than 8 times the national average concentration of Marine Engineers and Naval Architects. These types of occupations suggest that Maine is not only prepared to support relevant OSW activities within the state, but support activities across the country as the OSW industry grows.

5. **Maine's training providers are well-positioned in many regards, though specialized training in OSW-specific skills will be needed.** The state currently has 10 different wind-specific training programs across the state, covering a range of subjects. The state can also likely produce an adequate number of electricians and welders under current training and education systems--two certifications that are among the highest anticipated demand. Maine does not presently have certified Global Wind Organization (GWO) training programs, which provide the industry-standard safety certifications for OSW, though such programs may already be in the early stages of development. Neighboring states may also be able to assist Maine in preparing its more specialized OSW workforce; 35 different wind-specific trainings were identified across New England, New York, and eastern Canada, suggesting opportunity for regional collaboration.

6. **Community colleges around the state have historically produced dozens of graduates prepared for manufacturing trades, but registered apprenticeships and partnerships with organized labor will be necessary to fill training gaps.** The research team identified 67 registered apprenticeship programs around the state that can prepare workers for specialized OSW roles. Some of these apprenticeship programs may require additional specialized curriculum to meet the specific needs of OSW, but many of the apprenticeships already offer specialized training for roles such as Crane Electrician, Composite Plastic Fabricator, and Marine Machinery Mechanic. The state's recent funding in apprenticeship and pre-apprenticeship programs can help foster a workforce for many of the occupations that have the largest estimated workforce gaps.
7. **Maine has several industries that are well poised to grow and support the increasing number of OSW projects in New England. However, without strong regional collaboration or commitments to procure OSW generation, the opportunity for job creation in Maine is limited.** Northeastern states, such as Massachusetts, New York, and New Jersey, with large commitments to developing OSW capacity, are investing hundreds of millions in developing ports, supporting local supply chains, and preparing their local workforce for OSW. These states are increasingly requiring developers to ensure that these projects create the maximum number of jobs and economic activity in their state. Given that developers are incentivized to maximize economic opportunity within the states that are developing these projects, sub-state cross-border regional collaboration may be the greatest opportunity to participate in the growing regional OSW developments.

Recommendations

This section contains preliminary action plan recommendations that the research team has developed in consideration to addressing the challenges and opportunities revealed while developing this report. The research team tested, refined, and expanded these recommendations during three human-centered design sessions with relevant stakeholders.

1. **Leverage federal and state funding for pre-apprenticeship and apprenticeship programs that prepare workers for relevant OSW occupations.** Many of the occupations with the greatest estimated workforce needs require some initial training phase of apprenticeship or pre-apprenticeship but no formal education beyond a high school diploma. Apprenticeship programs also offer the opportunity to earn while students learn, making these roles more accessible for all Mainers. This funding can be directed towards existing registered apprenticeships (RA), such as the Composite Plastic Fabricator RA in York, or towards new RAs for roles like Hoist and Winch Operators.

2. **Ensure training programs and workforce initiatives are geared towards developing a representative workforce.** Women make up roughly a third (37%) of the current workforce in key OSW occupations even though they make up half of Maine's workforce. One recommendation from stakeholders was to engage with community-based organizations (CBOs) and immigrant community leaders to diversify the OSW workforce. It will also be important to ensure training and upskilling programs are available to a wide range of workers; some job seekers will have substantial barriers (i.e. childcare needs, transportation challenges, long-term unemployed) that will require further support services to ensure these opportunities are accessible. Coordinating OSW programs with the state's existing resources will be important to maximize existing resources and expertise.

3. **Develop strategies to engage unemployed workers from adjacent occupations.** The research team found that there were an estimated 600 unemployed workers in adjacent occupations most closely related to the 12 occupations with the greatest estimated employment gaps. This presents a substantial potential workforce that is already skilled and out of work.

4. **Encourage the state to formalize the requirement for GWO or another comparable certification for OSW work.** While GWO certifications appear to be the early favorite among U.S. OSW activity, the state should solidify its choice. Employers and training providers alike expressed that they cannot begin to build towards a certification if they do not know for certain which certification will be required. Once a common certification is identified by the state, there should be an effort to work with training provider partners to produce GWO or other state-required certifications. One potential option is to follow the model deployed at the Massachusetts Maritime Academy through Maine's own Maritime Academy. The state may also want to consider engaging community colleges or relevant firms within the state. There is also opportunity for regional collaboration, since several other New England states have developed GWO certification programs.

5. **Engage K-12 students to enhance the number of students flowing into pipelines for programs relevant to OSW occupations.** Fostering interest and attention towards OSW careers early in the education pipeline can help students find OSW careers that are right for them. Many of these careers will require STEM backgrounds, which means OSW curriculum and materials could be inserted into existing STEM programs. Other recommendations from stakeholders to enhance K-12 engagement with OSW activities include coordinating field trips to OSW facilities, creating summer programs for HS students, and developing OSW-specific curriculum in high schools and trade schools.

   A range of jobs for workers with a range of expertise and education will be required for OSW. Jobs such as Structural Metal Fabricators and Fitters and Assemblers and Fabricators are projected to see relatively

strong demand, and typically require technical training amounting to an Associate's degree or less. A substantial workforce with a four-year degree or more will also be required, particularly in the planning and development stage. These occupations cover a range of interests and include Zoologists and Wildlife Biologists, Environmental, Civil, and Industrial Engineers, Geoscientists, and Environmental Scientists and Specialists. Stakeholders expressed interest in career exploration programs, such as mainecareers.net and having OSW workers visit local middle schools and high schools.

6. **Work with existing educational institutions and training providers to prepare to scale and specialize training programs relevant to each institution's strengths.** Different educational institutions will have different strengths and opportunities to bolster the OSW workforce. UMaine is well positioned to lead floating OSW research and development while also producing the engineering talent pool needed for a range of OSW activities. Private colleges and universities can help meet the anticipated demand for other OSW roles involving data science, autonomous vehicles, and professional services. Community colleges can help prepare a range of students from production roles to operations and maintenance technicians. Many programs may simply be adapted to include an OSW component.

7. **Consider Maine's opportunities to become national and international leaders in specific OSW activities.** Maine has several talent advantages that can help the state become a regional, national, or international leader in parts of the OSW economy. As an early adopter of floating OSW, Maine and its workforce will have the leading understanding in floating OSW in the United States. This advantage has been formed, in part, through UMaine's Advanced Structures and Composites Center, which has pioneered floating wind designs. Continued research and development can help keep Maine at the cutting-edge of OSW engineering and design. Maine also has a strong surveying and permitting workforce, and strong potential to provide marine support activities. Developing this workforce could help the state become an exporter in OSW surveying and permitting, and other marine activities ranging from port logistics to marine biological research and monitoring.

   Stakeholders identified several strategies that may best help make Maine a leader in floating OSW, including ensuring clear and manageable business rules and permitting processes, investing in Maine ports for floating OSW, and develop a Jones Act-compliant construction support fleet for both the construction and operations phases of OSW. There was also a call to engage early with other east coast states that are pursuing OSW projects in order to learn and partner to address the industry's challenges early on.

8. **Ensure that OSW jobs are high-quality jobs that offer family supporting wages and that these jobs are accessible to a wide variety of Mainers.** Many east coast OSW projects have Project Labor Agreements (PLAs) for OSW work, which typically require the contractor to meet certain wage and diversity requirements. Under Bureau of Ocean Energy Management (BOEM)'s recent guidance, projects with PLAs for OSW work--particularly for construction that will occur portside--will be considered favorably. The future of Maine's ability to win federal OSW leases depends on its assurance of high-quality employment opportunities accessible to a diverse pool of workers. For more information on PLAs, please see page 23.

9. **Continue dialogue and outreach to fishermen and mariners.** Maine's fishing industry plays a crucial role in the state's economy, and many fishermen are financially content. However, the state should ensure opportunities for fishermen and mariners to supplement or expand their income through OSW support activities are available to them if they so choose. Offshore experience is a vital skill and serving as a marine monitor or transporting crew to and from OSW sites should be an opportunity available for experienced mariners who are interested. Streamlining necessary safety certifications and requirements, where possible, is a first step in making sure the door is open.

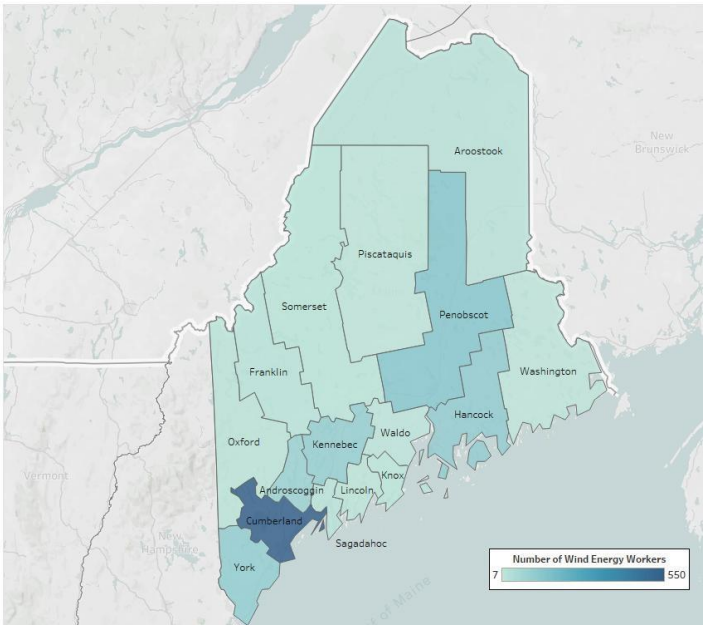
OSW Workforce in Maine

STATEWIDE TARGETS & CAPACITIES

Guided by the bipartisan legislature aimed at fighting climate change, Maine has plans to install roughly 155MW of floating OSW capacity by 2030 through the Monhegan project (11MW) and the research array (144MW). These non-commercial scale projects aim to provide valuable proof of concept and research data that can be utilized to develop future OSW projects. Maine is also home to a number of business and workers who have skills and abilities that are important in the OSW sector, and these firms are well positioned to offer their services to support neighboring states in their pursuits of OSW. The Maine Offshore Wind Initiative and Roadmap effort is working to review near and long-term energy targets, and the scale of the opportunity in the Gulf of Maine is large. The proposed and future offshore wind installations also present an opportunity for the state of Maine and its residents. The development of offshore wind projects will require billions of dollars in investment and has the potential to create and support thousands of local jobs. This section of the report aims to highlight some of the economic and workforce opportunities and challenges that Maine faces and offers some insight into strategies Maine can deploy to leverage its existing labor pool and training resources and support local economic growth.

In 2020, Maine had more than 1,300 workers across the state involved in wind renewable electric power generation. This number is 7% higher than it was in 2016, and wind electric power generation was one of the few industries that saw growth between 2019 and 2020 despite the pandemic. Clean energy workers involved in wind were most frequent in Cumberland County, where there are more than 500 wind-related workers. Penobscot, Hancock, York, and Kennebec counties each have more than 100 workers involved in wind electric power generation (Figure 1).

FIGURE 1. WORKERS INVOLVED IN WIND RENEWABLE ELECTRIC POWER GENERATION



Deep Dive into Potential Offshore Wind Talent

SECTION OVERVIEW

Substantial offshore wind activity in Maine presents the opportunity for significant positive impacts for Maine workers. This analysis examines the types of workers that will be in greatest demand as the currently planned 155 MW of OSW projects come online by 2030. This section also examines the current supply of existing talent that may be able to enter the OSW industry.

It is important to note that this research is a preliminary examination of the offshore wind talent supply in Maine. As demand for these workers increases over the coming years, future studies may focus more on specific occupational skill profiles and regional training capacities to help inform curriculum and program development. Additionally, economic impact research and analyses may be conducted to understand which industries and occupations will see projected employment growth over the next several decades.[2]

METHODOLOGY OVERVIEW

Relying on a comprehensive review of existing offshore wind workforce literature, the research team created a detailed occupational matrix of key jobs required for offshore wind project development. This proprietary database includes all occupations involved in each phase of offshore wind project development and is segmented by project phase and occupational group.

Because floating offshore wind's nascency, the offshore wind workforce reports and analyses the research team were able to review were based on fixed-bottom foundations. Additionally, despite local purchasing agreements, it is unlikely that 100% of the structures would be produced in Maine, particularly the blades and turbines which are often shipped from overseas. This would affect the types and number of jobs created in the state. To address these differences in the model and the practical execution of any development, the research team spoke with several stakeholders to identify the differences in occupational demand.

While there are workforce differences between floating and fixed-bottom foundations, most of the employment projections are unlikely to change significantly. The most likely changes may be slightly fewer fabrication jobs (since there are no foundation jackets to build), and fewer seafloor drilling jobs (contingent upon anchoring devices used). Regarding changes around local content, jobs involved in blade and turbine manufacturing (some composite technicians, machinists, and assemblers) would likely occur in lesser frequency than the model suggests.

All statewide occupational data was sourced from the Bureau of Labor Statistics Occupational Employment Statistics and supplemented with the JobsEQ labor market database where needed. All data is referenced using Standard Occupational Classification (SOC) codes.

[2] *For an example of industry and occupational employment growth projections for offshore wind, see generally:* The American Clean Power Association. 2021 Clean Energy Labor Supply. https://cleanpower.org/resources/cleanenergylaborsupply/.

OFFSHORE WIND OCCUPATIONS

The occupation map identifies 117 distinct occupations for OSW and organizes the offshore wind project development into five phases: Planning and Development, Manufacturing and Assembly, Construction and Installation, Operations and Maintenance, and Support Services. It is important to note that these 117 distinct occupations are not exclusive to each phase, as some occupations are needed across multiple phases. Below is a brief description of each phase:

Planning and Development takes at least two years, typically longer, depending on the project.[3] This phase is responsible for an estimated two percent of lifetime costs according to previous OSW projects abroad.[4] Eventually, this stage will account for an estimated 15 percent of the direct workforce addition in the U.S. OSW industry.[5] The database currently identifies **46 occupations** within this phase, including engineers, financial analysts, and lawyers.

The **Manufacturing and Assembly** phase takes several years—though OSW original equipment manufacturers (OEMs) will likely be involved in supplying multiple projects or orders at once. This phase is responsible for an estimated 44 percent of lifetime costs. It is estimated that job creation in this phase will account for seven percent of total job additions in the U.S. OSW industry. The database currently identifies **76 occupations** within this phase, including engineers, metal workers, operators, assemblers, and administrative staff.

Construction and Installation on average takes two to five years and is responsible for about 12 percent of lifetime costs. Many of the jobs in this phase are temporary but, in total, will account for an estimated 41 percent of the direct U.S. workforce increase as Maine aims to meet the OSW targets over the next five to 10 years. The database currently identifies **70 occupations** within this phase, including crane operators, electricians, mechanical engineers, line workers, and welders.

The **Operations and Maintenance (O&M)** phase can occur over 20 years or more, depending on lease and energy agreements, and accounts for 40 percent of lifetime costs. Workers involved in regular inspection and repair of the structure, general operations of an OSW local industry, and finances are expected to account for 17 percent of direct U.S. workforce addition from an expanded OSW industry. The database currently identifies **61 occupations** within this phase, including administrative staff, wind turbine technicians, marine operators, and plant managers.

Support Services—including transportation, training, research, and consulting—account for the final 20 percent of estimated direct U.S. workforce additions to arise from an expanded OSW market. These services occur during all phases, with involvement lasting months or years depending upon the project. The database currently identifies **38 occupations** within this phase, including meteorologists, vessel mechanics, lawyers, and policy experts.

Although this report does not analyze the end-of-cycle phase of an OSW project in Maine, it is an important long-term consideration. The estimated life-cycle for an OSW project is about 30 years, at which point the structures will need to be decommissioned or replaced. The decommissioning of an OSW project is a phase that imposes high costs and requires a specific collection of occupations. It is the phase of an OSW project that has the most uncertainty, since there are few specific regulations in place to work as a guide on what should be done, and few OSW projects have been decommissioned as of 2021.

[3] All time frame estimates were compiled from the *UK Offshore Wind Industry: Supply Chain Review* and *The Workforce Opportunity of Offshore Wind in New York* reports.

[4] All lifetime cost estimates were compiled from the *UK Offshore Wind Industry: Supply Chain Review* report.

[5] All workforce addition estimates were compiled from the *New York State and the Jobs of Offshore Wind Energy* report.

Table 1 below provides an overview of the number of distinct occupations within each offshore wind project development phase, as well as the total number of jobs in Maine as of Q1 2021. This data also includes the location quotient (LQ) for each phase. Location quotients measure the relative labor supply for an industry or occupational group in Maine compared to the labor supply in the United States; the LQ metric helps measure a region's specialization relative to a larger geographic area (typically the national average). For example, a location quotient of 1.5 indicates that an occupation is 1.5 times, or 50 percent, more concentrated in Maine compared to its proportion of total jobs in the nation overall.

It should be noted that because occupations can overlap across multiple phases, the number of occupations will sum to more than the 117 distinct occupations in the database. Similarly, total jobs as of 2020 will include overlap across these occupations, and double-counting will occur if jobs are summed across project phases.

Maine has a lower concentration of employment across all five employment phases compared to the national average. Employment in all five phases is at least 7% less concentrated in Maine compared to the national average (Table 1). While these concentrations are only slightly lower than the national average, this may suggest the need to ramp up relevant training for potential OSW workers.

TABLE 1. OSW OCCUPATIONS BY PROJECT PHASE

Project Phase	Time Horizons	Number of Occupations in each Category	Total Jobs in Maine, 2021[6]	Location Quotient (LQ)
Planning & Development	Immediate	46	74,324	0.93
Manufacturing & Assembly	Short-Term	76	136,583	0.92
Construction & Installation	Long-Term	70	131,221	0.94
Operations & Maintenance (O&M)	Long-Term	61	115,439	0.92
Support Services	Throughout Project	38	45,291	0.93

[6] Q1 2021. JobsEQ

Maine as a Leader in Floating OSW Research and Development

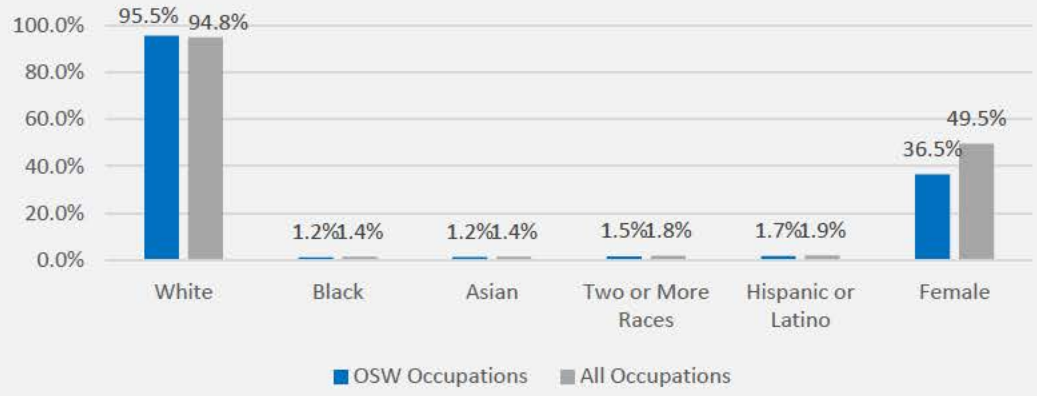
Although research and development is not included in the project phases above, it plays an important role in the development of the OSW industry in Maine. The University of Maine designed and developed the VolturnUS floating concrete hull technology, which is capable of supporting floating OSW turbines in water depths of 45 meters or more. The technology has received 70 patents in the US and around the world and is designed to be fabricated locally, in Maine. This means that these turbine designs, turbines can likely be constructed using resources and workers largely in Maine—meaning more jobs are created for Mainers.

The research and development by UMaine is also economically significant for Maine because it positions Maine to be a regional leader in floating OSW design. Experts feel it is likely that east coast OSW installations planned in 2030 and beyond are likely to be floating rather than fixed-foundation. East coast states including Massachusetts, New York, New Jersey, Virginia, Maryland, and North Carolina have all made significant commitments to OSW. While these states are currently planning to deploy fixed-foundation turbines, future lease sales and OSW projects will likely be floating. Furthermore, UMaine's extensive work with floating offshore wind makes it a premier institute to for training engineers to work in OSW. This presents significant opportunity for Maine to serve as a knowledge and research and development hub for future east coast wind projects.

CHARACTERISTICS OF KEY OSW OCCUPATIONS

Given the scale of job creation from OSW, policies should ensure that the jobs created go to workers that are representative of Maine's population. For this analysis, the research team examined the characteristics of the existing workforce that makes up the 117 key OSW occupations. This workforce is largely reflective of Maine's overall workforce across race and ethnicity, however, women are notably underrepresented. In Maine's overall economy, women make up almost exactly half of the workforce, but women only account for only 37% of the workforce for key OSW occupations (Figure 2). This discrepancy is largely driven by manufacturing occupations, which historically and nationally, have been majority male occupations. Efforts that expand manufacturing opportunities—which often offer well-paying jobs with benefits—for women will be particularly important in ensuring an equitable recovery from the pandemic.

FIGURE 2. CHARACTERISTICS OF KEY OSW OCCUPATIONS



Projected OSW Workforce Needs and Gaps

The research team developed a proprietary model of 117 occupations that are essential to offshore wind projects. [7] By modeling[8] the estimated occupation-level demands for combined 155MW of OSW (11 MW at the Monhegan project and another 144 MW at the proposed research array project), the research team was able to identify the difference, or gap, between the anticipated number of Full-Time Equivalents (FTEs) needed during each phase of the OSW project and the share of existing available workers and those available through existing talent pipelines. This analysis highlights which occupations will likely face the greatest demand for additional workers relative to existing talent supply.

Each project phase is aggregated into three time horizons; the Planning & Development phase is considered the "Immediate" time horizon because planning is already underway. Manufacturing and Assembly and the workers needed to complete the work are in what is considered the "Short-Term," or roughly through the year 2024. The Construction & Installation phase and accompanying workforce are considered the "Long-Term" because this phase begins later in the project timeline. Support Services are needed throughout the duration of the project and are therefore not incorporated into the following workforce analyses.

$$\text{Workforce Gaps} = \frac{\text{Total Annual Demand for Workers} - \text{Annual Available Workers}}{\text{Total Workers Employed in the Occupation}}$$

The research team estimated total demand and gap in workforce demand and supply for each time horizon and by an occupation's educational requirements. By highlighting estimated demand and gaps side by side, the tables below quickly demonstrate the occupations which will require the greatest amount of assistance and preparation to ensure a workforce is ready. The tables below contain occupations in descending order of greatest estimated workforce gaps.

Severe	Demand exceeds supply ***and*** this gap is 10% or more of the existing workforce
Moderate	Demand exceeds supply but the gap is less than 10% of the existing workforce
Mild	Supply exceeds demand

OCCUPATIONS IN THE IMMEDIATE TERM

Commercial Divers are expected to have among the greatest demand in the Immediate term and also projected to have the largest workforce gap (Table 2). Atmospheric and Space Scientists are anticipated to have a gap equating to greater than 10% of the existing workforce, and other occupations, including Public Relations Specialists, and Health and Safety Engineers may require additional supply in the Immediate term of the project (Table 3).

[7] For list of works cited and consulted, please refer to Appendix C of this report.

[8] NREL's Offshore Wind JEDI model was used. Local content was modeled after the 1/8th scale test project local content.

TABLE 2. SELECT OCCUPATIONS WITH LESS THAN A BACHELOR'S DEGREE IN IMMEDIATE TERM

Five Occupations with Greatest Demand	Five Occupations with Greatest Estimated Gap
Administrative Services Managers	Commercial Divers
Captains, Mates, and Pilots of Water Vessels	Mechanical Engineering Technologists and Technicians
Commercial Divers	Occupational Health and Safety Specialists
Commercial Pilots	Mechanical Drafters
Paralegals and Legal Assistants	Administrative Services Managers

TABLE 3. SELECT OCCUPATIONS WITH A BACHELOR'S DEGREE OR MORE IN IMMEDIATE TERM

Five Occupations with Greatest Demand	Five Occupations with Greatest Estimated Gap
Architectural and Engineering Managers	Atmospheric and Space Scientists
General and Operations Managers	Public Relations Specialists
Compliance Officers	Electrical Engineers
Public Relations Specialists	Environmental Engineers
Market Research Analysts and Marketing Specialists	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors

OCCUPATIONS IN THE SHORT-TERM (THROUGH 2024)

Structural Metal Fabricators and Fitters and Assemblers and Fabricators are among the occupations projected to be in greatest demand in the Short-Term Time Horizon, though occupations like Continuous Mining Machine Operators and Hoist and Winch Operators are estimated to have the greatest gap in current talent relative to estimated demand (Table 4). Transportation, Storage, and Distribution Managers have the greatest anticipated demand, but Industrial Engineers and Electronics Engineers are estimated to have the greatest workforce gap and exceed 10% of the existing workers (Table 5).

TABLE 4. SELECT OCCUPATIONS WITH LESS THAN A BACHELOR'S DEGREE IN SHORT-TERM

Five Occupations with Greatest Demand	Five Occupations with Greatest Estimated Gap
Structural Metal Fabricators and Fitters	Continuous Mining Machine Operators
Assemblers and Fabricators, All Other	Hoist and Winch Operators
Stockers and Order Fillers	Occupational Health and Safety Specialists
Inspectors, Testers, Sorters, Samplers, and Weighers	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors
Maintenance and Repair Workers, General	Material Moving Workers, All Other

TABLE 5. SELECT OCCUPATIONS WITH A BACHELOR'S DEGREE OR MORE IN SHORT-TERM

Five Occupations with Greatest Demand	Five Occupations with Greatest Estimated Gap
Transportation, Storage, and Distribution Managers	Industrial Engineers
Industrial Production Managers	Electronics Engineers, Except Computer
General and Operations Managers	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors
Human Resources Managers	Public Relations Specialists
Engineers, All Other	Engineers, All Other

OSW Design and Manufacturing in Maine

Although nationwide manufacturing of OSW turbines is in the very early stages in the United States, Maine already has a number of partnerships geared towards OSW development. The University of Maine is working with New England Aqua Ventus LLC—a joint venture between Diamond Offshore Wind and RWE Renewables—to develop a floating offshore wind demonstration project off the coast of Maine. UMaine's Advanced Structures and Composites Center is in charge of the designing, engineering, research and development, and post-construction monitoring. In addition to this project, the Advanced Structures and Composites Center was recently awarded $2.8 million from the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy to develop a rapid, low-cost additive manufacturing solution for fabricating large wind blade molds. The UMaine Advanced Structures and Composites Center will play an integral role in Maine's OSW economy.

Alongside its leading floating OSW research and development, UMaine is also aligned with regional manufacturers. UMaine's Advanced Manufacturing Center (AMC) has a partnership with Maine Manufacturing Extension Partnership (MEP), an initiative that provides support to manufacturing clients throughout the state. Partnerships and initiatives such as these at UMaine will be essential as Maine looks to develop its floating OSW capacity.

OCCUPATIONS IN THE LONG-TERM (2025 AND BEYOND)

Electricians, Construction Laborers, and Excavating and Loading Machine and Dragline Operators are the occupations (requiring less than a Bachelor's degree) in the Long-Term that have the largest workforce demands. Commercial Divers are projected to have the most severe workforce gaps in the long-term (Table 6). Logisticians are estimated to have the greatest demand and Atmospheric and Space Scientists are projected to have the greatest workforce gap (Table 7).

TABLE 6. SELECT OCCUPATIONS WITH LESS THAN A BACHELOR'S DEGREE IN LONG-TERM

Five Occupations with Greatest Demand	Five Occupations with Greatest Estimated Gap
Electricians	Commercial Divers
Construction Laborers	Calibration Technologists and Technicians and Engineering Technologists and Technicians, Except Drafters, All Other
Excavating and Loading Machine and Dragline Operators	Occupational Health and Safety Specialists
Plant and System Operators, All Other	Elevator and Escalator Installers and Repairers
Wind Turbine Service Technicians	Excavating and Loading Machine and Dragline Operators, Surface Mining

TABLE 7. SELECT OCCUPATIONS WITH A BACHELOR'S DEGREE OR MORE IN LONG-TERM

Five Occupations with Greatest Demand	Five Occupations with Greatest Estimated Gap
Logisticians	Atmospheric and Space Scientists
General and Operations Managers	Public Relations Specialists
Construction Managers	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors
Industrial Production Managers	Operations Research Analysts
Electrical and Electronic Engineering Technologists and Technicians	Industrial Engineers

ADJACENT OCCUPATIONS

The research team also examined the supply and availability of workers in "adjacent occupations" that could potentially help meet the workforce gaps among the OSW occupations with the most severe gaps. "Adjacent occupations" were identified using O*NET's Career Changers Matrix,[9] which links occupations which have similar skills and experience, allowing workers to transition between the occupations with relatively little training or reskilling. Examining the 12 occupations[10] with the significant workforce gaps (occupations with estimated workforce needs that are greater or equal to 5% of the current workforce) highlights potential opportunities to transition unemployed workers in adjacent occupations into OSW-related occupations (Table 8).

TABLE 8. ADJACENT OCCUPATIONS FOR OSW OCCUPATIONS WITH THE MOST SEVERE WORKFORCE GAPS[11]

OSW Occupation	Timeframe	Education	Total ME ADJ Jobs	Unemployed Adjacent Workers
Atmospheric and Space Scientists	Immediate	Bachelor's or More	1,247	30
Industrial Engineers	Short-Term	Bachelor's or More	5,348	96
Electronics Engineers, Except Computer	Short-Term	Bachelor's or More	3,103	67
Commercial Divers	Long-Term	Less than 4-Year Degree	6,098	208
Continuous Mining Machine Operators	Short-Term	Less than 4-Year Degree	154	15
Atmospheric and Space Scientists	Long-Term	Bachelor's or More	1,247	30
Public Relations Specialists	Long-Term	Bachelor's or More	4,613	167
Commercial Divers	Immediate	Less than 4-Year Degree	6,098	208
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	Short-Term	Bachelor's or More	2,080	34
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	Long-Term	Bachelor's or More	2,080	34
Operations Research Analysts	Long-Term	Bachelor's or More	291	6
Industrial Engineers	Long-Term	Bachelor's or More	5,348	96

CAREER PATHWAYS

This section highlights the five occupations with the largest estimated demand in workers. Most of these occupations typically require a few months to a year working with experienced employees before attaining full employment. These programs are often formal or informal apprenticeships. It should also be noted that labor markets roiled by the

[9] The five most-closely related occupations were selected.
https://www.onetcenter.org/dictionary/26.0/excel/career_changers_matrix.html
[10] Wind Turbine Service Technicians and Plant and Systems Operators (with severe gaps in both the Short-Term and Long-Term) did not have direct adjacent occupations available in O*NET because of the uniqueness of their roles. These figures also exclude adjacent occupations that have previously been identified as key OSW occupations.
[11] JobsEQ. Bureau of Labor Statistics Quarterly Census of Employment and Wages. 2021Q2

pandemic have seen greater disruption in the past two years than the five years prior. Wage estimates are based on 2019 figures, though wages have become notably dynamic and are likely to have changed.

TABLE 9. STRUCTURAL METAL FABRICATORS AND FITTERS[12]

	Role	2021 Jobs	Average Hourly Wages[13]	Typical Entry-Level Education	Credentials & Certifications
Entry-Level	Structural Metal Fabricators and Fitters Apprentice	481	$17.29	High school diploma or equivalent	ISO Occupational Health and Safety + OSHA
Mid-Level	Structural Metal Fabricators and Fitters	481	$19.52	High school diploma or equivalent	ISO Occupational Health and Safety + OSHA
Senior-Level	First-Line Supervisors of Production and Operating Workers	3,018	$32.37	High school diploma or equivalent	ISO Occupational Health and Safety + OSHA

TABLE 10. ASSEMBLERS AND FABRICATORS[14]

	Role	2020 Jobs	Average Hourly Wages[15]	Typical Entry-Level Education	Credentials & Certifications
Entry-Level	Assemblers and Fabricators Apprentice	5,977	$14.58	High school diploma or equivalent	ISO Occupational Health and Safety + OSHA
Mid-Level	Assemblers and Fabricators	5,977	$17.48	High school diploma or equivalent	ISO Occupational Health and Safety + OSHA
Senior-Level	First-Line Supervisors of Production and Operating Workers	3,018	$32.37	High school diploma or equivalent	ISO Occupational Health and Safety + OSHA

TABLE 11. STOCKERS AND ORDER FILLERS[16]

	Role	2020 Jobs	Average Hourly Wages[17]	Typical Entry-Level Education	Credentials & Certifications
Entry-Level	Stockers and Order Fillers	10,844	$14.23	High school diploma or equivalent	
Mid-Level	First-Line Supervisors of Retail Sales Workers	6,764	$20.12	High school diploma or equivalent	
Senior-Level	General and Operations Managers	10,774	$43.14		ISO Occupational Health and Safety + OSHA

[12] JobsEQ. Bureau of Labor Statistics. 2020 Occupation Employment Statistics.
[13] Apprenticeship wages are set to be in the bottom 25% of earnings. Mid-level wages are median wages. Senior-level wages are median wages of new occupation or 75^{h} percentile.
[14] JobsEQ. Bureau of Labor Statistics. 2020 Occupation Employment Statistics.
[15] Apprenticeship wages are set to be in the bottom 25% of earnings. Mid-level wages are median wages. Senior-level wages are median wages of new occupation or 75th percentile.
[16] JobsEQ. Bureau of Labor Statistics. 2020 Occupation Employment Statistics.
[17] Apprenticeship wages are set to be in the bottom 25% of earnings. Mid-level wages are median wages. Senior-level wages are median wages of new occupation or 75th percentile.

TABLE 12. INSPECTORS, TESTERS, SORTERS, SAMPLERS, AND WEIGHERS[18]

	Role	2020 Jobs	Average Hourly Wages[19]	Typical Entry-Level Education	Credentials & Certifications
Entry-Level	Inspectors, Testers, Sorters, Samplers, and Weighers	1,694	$13.85	High school diploma or equivalent	(Maybe) Quality Control Certification
Mid-Level	Assemblers and Fabricators	5,977	$17.48	High school diploma or equivalent	ISO Occupational Health and Safety + OSHA
Senior-Level	First-Line Supervisors of Production and Operating Workers	3,018	$32.37	High school diploma or equivalent	ISO Occupational Health and Safety + OSHA

TABLE 13. ELECTRICIANS[20]

	Role	2020 Jobs	Average Hourly Wages[21]	Typical Entry-Level Education	Credentials & Certifications
Entry-Level	Electricians Apprentice	3,261	$22.16	High school diploma or equivalent	(Maybe GWO), ISO Occupational Health and Safety + OSHA
Mid-Level	Electricians	3,261	$26.97	High school diploma or equivalent	(Maybe GWO) ISO Occupational Health and Safety + OSHA
Senior-Level	First-Line Supervisors of Construction Trades and Extraction Workers	3,017	$28.40	High school diploma or equivalent	(Maybe GWO) ISO Occupational Health and Safety + OSHA

[18] JobsEQ. Bureau of Labor Statistics. 2020 Occupation Employment Statistics.

[19] Apprenticeship wages are set to be in the bottom 25% of earnings. Mid-level wages are median wages. Senior-level wages are median wages of new occupation or 75th percentile.

[20] JobsEQ. Bureau of Labor Statistics. 2020 Occupation Employment Statistics.

[21] Apprenticeship wages are set to be in the bottom 25% of earnings. Mid-level wages are median wages. Senior-level wages are median wages of new occupation or 75th percentile.

Opportunities for Mariners

OSW provides opportunity for mariners to supplement their incomes by leveraging their local knowledge and abilities to successfully navigate offshore waters. A February 2021 report by the New York State Energy Research and Development Authority (NYSERDA) highlights several opportunities for mariners to bolster their incomes through part-time OSW work. These opportunities include working as Marine Mammal Observers and Fishing Liaisons, who are able to help OSW crews successfully navigate local fisheries and fishing gear to avoid fouling. This work may done on a part-time capacity or seasonal basis. There will also be opportunity for fishermen to provide their vessels for the necessary surveying, planning, and monitoring activities.

The NYSERDA report also cites several barriers that may prevent fishermen from maximizing their benefit from OSW activities. These barriers include the often developer-required certifications (including Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) Training, GWO Basic Safety, and Able Seamen (AB) certifications and licenses) and vessel safety requirements. Offering subsidized training or licensing and relaxing the most burdensome regulation may be useful in increasing OSW opportunities for Maine's mariners.

Maine's OSW Workforce Advantages

Maine's existing workforce and education pipelines and facilities make present opportunity to make the state a national, and potentially even international, leader in specific sectors of the offshore wind economy. Maine's existing workforce in surveying, permitting, and marine monitoring, its high concentration of marine and other specialized engineers, and its early role as a leader in floating OSW Hull Design and Development put Maine in a position to assist other states as they eventually transition from fixed-bottom to floating OSW.

SURVEYING, PERMITTING, AND MARINE MONITORING

Maine has above-average concentrations of workers in four key occupations often involved in surveying, permitting[22], and marine monitoring activities. Table 14 highlights the location quotient (LQ) that measures employment concentration in each state. An LQ of more than 1 suggests that the region has a higher concentration of these occupations than the national average. An LQ of less than 1 suggests that the region has a lower-than-average concentration of these workers. From this analysis it is clear that states like Connecticut, New York, New Jersey, and North Carolina will likely have a strong need for these types of workers as the install OSW capacity. Even Massachusetts, which otherwise has a strong representation of workers in these careers, has a very low concentration of Surveying and Mapping Technicians—an occupation of which Maine has a higher-than-average concentration. Exporting workers and their services may be a boon to many existing Maine companies. It is also notable that Maine has strong concentrations of workers who are familiar with operating in a marine environment, including Fishing and Hunting Workers and Sailors and Marine Oilers. In fact, Maine has more than 14 times the concentration of Fishing and Hunting workers than the national average.

[22] While permitting may not require explicit backgrounds in these fields, employers have noted that knowledge of marine and ecological systems is a beneficial background to have.

TABLE 14. CONCENTRATION OF SURVEYING, PERMITTING, AND MARINE MONITORING OCCUPATIONS[23]

	Zoologists and Wildlife Biologists	Surveying and Mapping Technicians	Atmospheric and Space Scientists	Environmental Scientists and Geoscientists	Fishing and Hunting Workers	Sailors and Marine Oilers
Maine	**3.06**	**1.11**	**1.46**	**1.00**	**14.30**	**0.93**
Massachusetts	1.03	0.61	1.20	1.13	2.40	0.43
Connecticut	0.36	0.67	0.79	0.72	0.50	0.57
New York	0.37	0.56	0.86	0.76	0.44	0.69
New Jersey	0.35	0.46	1.27	0.93	0.78	0.86
Maryland	1.21	0.87	3.47	1.36	1.00	1.33
Virginia	0.85	1.33	1.32	1.20	0.87	2.92
North Carolina	0.75	1.80	0.73	1.05	0.91	0.30

FLOATING OSW AND MARINE ENGINEERING

Maine also has a relatively high concentration of engineers that could perform work related to the OSW sector. In fact, Maine has more than eight-times the concentration of Marine Engineers and Naval Architects as the national average. The state also has a roughly average concentration of Materials Engineers and Miscellaneous Engineers. Other Atlantic states with substantial planned offshore wind projects, including New York, New Jersey, and North Carolina, have lower concentrations of these types of engineers (Table 15).

TABLE 15. CONCENTRATION OF OSW ENGINEERS[24]

	Marine Engineers and Naval Architects	Materials Engineers	Miscellaneous Engineers
Maine	**8.33**	**0.91**	**0.92**
Massachusetts	2.40	1.07	0.90
Connecticut	2.66	1.47	0.99
New York	0.44	0.55	0.55
New Jersey	0.53	0.65	0.93
Maryland	1.49	1.48	1.74
Virginia	6.07	0.65	1.12
North Carolina	0.26	0.60	0.54

It is also worth noting that engineering roles (including Industrial Engineers, Electronics Engineers, and Health and Safety Engineers) have some of the most severe occupational gaps. Supporting Maine's four-year colleges and universities engineering departments can help ensure that Maine has an adequate pipeline of qualified workers.

[23] JobsEQ. Bureau of Labor Statistics Quarterly Census of Employment and Wages. 2021Q2
24 JobsEQ. Bureau of Labor Statistics Quarterly Census of Employment and Wages. 2021Q2

CENTER OF EXCELLENCE FOR FLOATING OSW RESEARCH AND DEVELOPMENT

UMaine's Advanced Structures and Composites Center (ASCC) is already a national and international leader in designing, testing, and developing floating offshore wind structures. Alongside the 1/8th scale turbine and the planned AquaVentus project, the ASCC is discussing potential projects in several US states as well as European countries. This head start in the floating OSW space, combined with the ASCC's blade testing and wave wind basin facilities, make UMaine a leader in research and design. There is opportunity to leverage this strength and the state's strong concentration of Marine Engineers to lead the state to become a national center for floating OSW research and development. An executive order from the Governor declaring UMaine as a Center of Excellence could assist in attracting additional attention from industry partners, fostering supply chain partnerships, and attracting research funding to help drive down the costs of floating OSW. UMaine already has the expertise and facilities, but a formal recognition of these assets could put the ASCC on the map and help accelerate OSW activity and innovation. The Floating Offshore Wind Center of Excellence in the UK provides blueprint of what a similar center of excellence could look like in Maine. Developing the state as a world-leader in this space could draw new talent and companies to the state, and present opportunities for exporting expertise and services to other states and countries.

Workforce Stakeholder Priorities

In the first week of January 2022, the research team held three human-centered design meetings in order to better understand the workforce interests and priorities of different stakeholder groups. The three stakeholder groups were education and training providers, employers and industry associations (comprised primarily of "open shop" employers), and organized labor. The top priorities these stakeholders identified were:

- Engaging and Exposing K-12 Students to OSW Careers
- Making Maine a Leader in Floating OSW
- High Quality Jobs

Within each of these priorities, the research team asked participants to rank each proposed solution by its relative importance and its difficulty to achieve or execute. This allowed the research team to divide solutions into "quick wins" or low-hanging fruit that might require less effort to accomplish, and "strategic efforts" which will require greater planning and coalition building to achieve. The top solutions for each priority and for each category are listed below. These stakeholder priorities have been incorporated into the recommendations found at the beginning of this report.

Strategies for Improving Pathways into K-12

These findings are based on the combined ratings from the education and training provider convening and the employer and industry association convening.

Strategic Efforts

- Coordinate high school, college student, and educator team visits to OSW facilities in other states and share stories at Maine outreach events.
- Develop a curriculum for high schools and trade schools that may help foster interest in OSW certifications and careers.
- Create summer programs for high school students for hands-on experiences.

Low-Hanging Fruit

- Create a special award or incentives for OSW-related project awards at Maine's existing STEM competitions.
- Develop video, websites, social media content to demonstrate the range of OSW jobs and the education and skills required.
- Organize career fairs and guest talks featuring OSW employers and workers.

Strategies to Make Maine a Leader in Floating OSW

The Employer and Industry Association stakeholder group identified making Maine a leader in floating OSW as a top priority.

Strategic Efforts

- Ensure business rules and permitting processes are clear and support is provided for those looking to navigate them.
- Invest in Maine Ports for floating wind. Examine opportunities to 'export' floating wind port expertise to outside US to Asian-Pacific.
- Develop a Jones Act-compliant support fleet for construction and operations & maintenance activities and for transporting crew.

Low-Hanging Fruit

- Early engagement with existing east coast projects in OSW to learn best practices and form strategic partnerships.

- Learn from firms that have constructed similar structures in the past. Given that the most established offshore wind projects have occurred overseas, it may be necessary to reach out to OEMs in the UK, Germany, or China. This would include an examination of best practices and workforce lessons learned.
- Engage in holistic grid planning to provide more certainty about the resources that will be required.

High Quality Jobs

The organized labor convening focused on efforts that can ensure OSW brings high quality jobs to Maine.

Strategic Efforts

- Require Project Labor Agreements (PLAs) for OSW projects.
- Require or incentivize local content requirements with labor standards.
- Attach labor standards to construction activities in ports (PLAs, apprenticeship, and collective bargaining rate).

Low-Hanging Fruit

- Mandate any jobs have benefits, including health and retirement.
- Attach PLA requirements to port development.
- Attach registered apprenticeship & pre apprenticeship requirements as PLA or mandate.

Project Labor Agreements

Many OSW projects along the east coast use Project Labor Agreements (PLAs), and the Bureau of Ocean Energy Management (BOEM), an office under the Department of Interior, has encouraged the use of PLAs in all federal OSW projects. PLAs are agreements that outline specific stipulations on wage rates, benefits, training, and diversity requirements for project workers. Companies using both organized labor and "open shop" work are able to develop a PLA. Below are a few examples from neighboring states that are further along in their OSW projects. These states' frequent use of PLAs suggest that consideration of PLAs will be important for Maine.

BOEM on PLAs[25]

In December 2021, BOEM indicated that it is encouraging the use of PLAs, specifying "a lease stipulation encouraging lessees to make every reasonable effort to enter into Project Labor Agreement(s) (PLAs) covering the construction stage of any project proposed for the leased area. This stipulation for PLAs was visible during the recent New York Bight lease sale. Offshore wind projects are large complex construction efforts and are well suited for PLAs."[26] The PLAs would encourage all construction stage contractors, union or nonunion, to adhere to collectively bargained terms and conditions. BOEM also encouraged PLAs with training and apprenticeship provisions to promote and expand the workforce of well-trained personnel for current and future OSW projects. BOEM highlighted the potential to standardize safety protocols for offshore work through safety provisions in PLAs. Dispute resolution procedures established in PLAs were identified as one method to facilitate a more coordinated workforce and the timely completion of offshore construction projects.

Although BOEM will not mandate the use of PLAs, the bureau is requiring potential lessees exhaust possible efforts to incorporate them into construction phases of OSW projects, and projects with PLAs will likely be more competitive than those without.

Massachusetts

[25] https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/new-york-bight/ATLW-8%20NY%20Bight%20Final%20Lease%20Sale%20Decision%20Memorandum.pdf
[26] https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/new-york-bight/ATLW-8%20NY%20Bight%20Final%20Lease%20Sale%20Decision%20Memorandum.pdf

Vineyard Wind and the Southeastern Massachusetts Building Trades Council signed a PLA in July 2021, two months after Vineyard Wind 1 became the first federally approved commercial-scale OSW project in the United States.[27] The 800MW OSW project based off the coast of Martha's Vineyard is projected to create approximately 500 union jobs in construction, installation, and maintenance onshore and offshore. The PLA provisions include concrete hiring targets for women and people of color, local community hiring targets, and a $500,000 allocation for pre-apprenticeship and recruitment programs for low-income residents, particularly those from underserved communities. While there is some skepticism of labor union capacity to meet PLA diversity requirements based on historical exclusion of women and communities of color from union ranks, supporters of the PLA cite the potential to build strong pipelines of underrepresented workers as evidence of progressive movement to representation. In her remarks, U.S. Senator Elizabeth Warren applauded the Vineyard Wind project, highlighting how it will "generate clean energy for Massachusetts families and businesses, create thousands of good jobs and is a bold step forward towards fighting the climate crisis."[28]

New Jersey

The New Jersey Wind Port project is led by the New Jersey Economic Development Authority (NJEDA) on behalf of the state[29]. The NJEDA, which uses PLAs as one tool to meet labor standards, identified labor unions as a key part of the labor supply chain in the state's 2020 *Offshore Wind Strategic Plan*. AECOM-Tishman, hired by the NJEDA as the overall construction manager, is subject to a PLA which requires apprenticeship programs, compliance with workforce and vendor goals concerning women and minorities, and monitoring and public reporting of diversity goals progress. AECOM-Tishman signed a PLA with the United Building Trades Council of Southern New Jersey AFL-CIO in September 2021, committing to create hundreds of union construction jobs at the port. Governor Phil Murphy, among other enthusiastic supporters, noted how the project will "create thousands of high-quality jobs, bring millions of investment dollars to our state, and establish New Jersey as the national capital of offshore wind."[30]

Virginia

Dominion Energy Virginia— designated as the lease operator by Virginia's Department of Mines, Minerals and Energy (DMME) for the Coastal Virginia Offshore Wind (CVOW) project— announced a partnership with North America's Building Trades Unions (NABTU) and their state affiliate Virginia Building Trades in September 2021[31]. Dominion Energy indicated early interest in a PLA with Virginia trade unions, announcing plans to enter negotiations as early as January 2020. Commitments include utilizing local workers, hiring and training veterans, and prioritizing workers from historically economically disadvantaged communities. Robert M. Blue, Dominion Energy CEO, indicated that Virginia

[27] https://massbuildingtrades.org/boston-globe-vineyard-wind/ https://www.vineyardwind.com/masswinds https://energynews.us/2021/08/23/vineyard-winds-labor-deal-exposes-tensions-overs-unions-worker-diversity/, https://massbuildingtrades.org/shns-union-labor-for-wind-project/ https://www.vineyardwind.com/press-releases/2021/5/11/vineyard-wind-receives-record-of-decision https://www.boem.gov/vineyard-wind

[28] https://www.vineyardwind.com/press-releases/2021/5/11/vineyard-wind-receives-record-of-decision

[29] https://www.nj.gov/windport/about/pdf/20211215OSWQandA.pdf, https://www.nj.gov/windport/docs/20210427_EXHIBITJ-PLA1.pdf https://www.nj gov/governor/news/news/562021/approved/20210909a.shtml https://nj.gov/windport/about/index.shtml https://aecom.com/press-releases/aecom-to-serve-as-construction-manager-on-the-first-purpose-built-offshore-wind-project-in-the-united-states/, https://www.njeda.com/njeda-issues-rfq-for-new-jersey-wind-port-construction-manager/, https://www.nj.gov/bpu/pdf/Draft_NJ_OWSP_7-13-20_highres.pdf, https://www.nj.gov/bpu/pdf/boardorders/2020/20201118/8D%20-%20ORDER%20Offshore%20Wind%20Transmission.pdf

[30] https://www.nj.gov/governor/news/news/562021/approved/20210909a.shtml

[31] https://www.boem.gov/renewable-energy/state-activities/coastal-virginia-offshore-wind-project-cvow, https://www.enr.com/articles/52951-giant-virginia-offshore-wind-project-makes-five-key-construction-awards, https://news.dominionenergy.com/2021-09-16-Dominion-Energy -Trade-Unions-Announce-Coastal-Virginia-Offshore-Wind-Partnership, https://coastalvawind.com/about-offshore-wind/creating-jobs.aspx https://dailyenergyinsider.com/news/24050-dominion-energy-to-negotiate-project-labor-agreement-for-virginia-offshore-wind-project-work/, https://www.permits.performance.gov/permitting-project/coastal-virginia-offshore-wind-commercial-project, https://www.wtkr.com/news/gov-northam-announces-virginia-to-have-first-offshore-wind-turbine-blade-facility-in-the-u-s

would reap additional economic benefits, including "more than 1,000 new direct and indirect jobs in Southeastern Virginia and hundreds of millions of dollars in payroll and annual economic benefits and tax revenue."[32]

New York

In April 2021, New York State passed the FY 2022 budget which included a renewable energy job standards package.[33] Outlined provisions included prevailing wage and Project Labor Agreement requirements for construction on renewable energy projects that are 5 MW or larger. Sunrise Wind— one of the New York State Energy Research & Development Authority's (NYSERDA) offshore wind projects in active development— is an 880 MW wind farm which is estimated to power over 600,000 homes with 100% renewable energy. Of the 230 construction jobs that the project will create, 115 will be union jobs as outlined in a supply chain contract signed by Ørsted and Eversource, Sunrise Wind's joint development partners, and Riggs Distler & Company, Inc. Ørsted and Eversource are expected to negotiate a PLA with the Greater Capital Region Building and Construction Trades Council; the PLA will cover all onshore construction work of advanced foundation components for wind turbines at the Port of Coeymans by Riggs Distler. Governor Hochul expressed enthusiasm for the project, stating that the partnership "will infuse $86 million into New York's economy which directly benefits New York companies and creates quality construction and manufacturing jobs in local communities."[34]

Given the preference at the federal level for the use of PLAs, as well as the successful implementation of PLAs in many east coast state OSW projects, Maine should carefully consider the role of PLAs in Maine's OSW development projects. PLAs also present an opportunity for the state to express a clear commitment to ensuring that the jobs created through the construction activities of OSW are well-paying and are fulfilled by a representative workforce.

Offshore Wind Training Inventory

This section highlights the current training programs around the state of Maine that are presently or could be involved in developing the state's offshore wind workforce. The first segment focuses on training programs that offer wind-specific material or expertise. The second segment discusses training programs around the state that will be essential in producing an OSW workforce, though these programs do not presently include—and may not require—OSW-specific training material before being able to contribute Maine's OSW economy. Plant and System Operators is an occupation that was identified to have a severe gap in both the "Short-Term" and the "Long-Term" and subsequently appears twice.

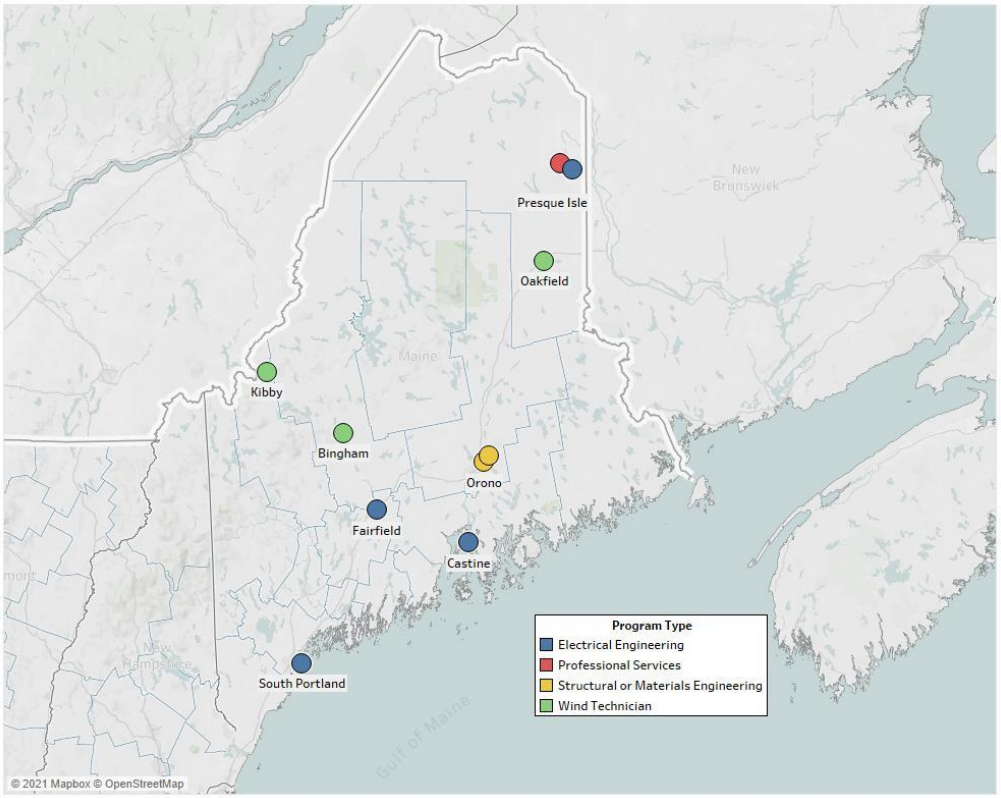
WIND-SPECIFIC TRAININGS

The research team identified ten different wind-specific training programs in seven different institutions across the state. While some of these trainings are not specific to wind power that is offshore, much of training is transferrable. Four of the programs are geared towards electrical engineering and electrical technician roles, three programs (all through Sky Climber Renewables) offer trainings for Wind Service Technician apprenticeships, two programs are geared towards structural or materials engineering, and one program will allow graduates to work in professional or

[32] https://www.dailypress.com/opinion/vp-ed-column-blue-mcgarvey-1012-20211011-32uompgerra7hhgl33wx66ude4-story.html
[33] https://www.climatejobsny.org/news/2021/4/6/cjnys-statement-on-new-yorks-historic-renewable-energy-job-standards https://openbudget.ny.gov/ https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/Offshore-Wind-Solicitations/2020-Solicitation, https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/NY-Offshore-Wind-Projects, https://sunrisewindny.com/about-sunrise-wind, https://www.tdworld.com/distributed-energy-resources/article/21177915/new-york-state-signs-offshore-wind-supply-contract-with-rsted-eversource, https://www.cleanegroup.org/new-york-state-announces-second-offshore-wind-solicitation/ , https://www.prnewswire.com/news-releases/centuri-company-riggs-distler-selected-for-offshore-wind-contract-301396326.html
[34] https://sunrisewindny.com/news/2021/10/governor-hochul-announces-largest-single-new-york-state-offshore-wind-supply-chain-award

support service roles related to OSW. Three community colleges host wind-specific programs, along with three public universities (Figure 3). Maine also enjoys relatively strong wind-specific regional training programs in neighboring regions; thirty-five wind-specific training programs can be found in New England states, New York, and eastern Canada.

FIGURE 3. WIND-SPECIFIC TRAINING PROGRAMS IN MAINE



TRAININGS, APPRENTICESHIPS, AND CERTIFICATIONS RELEVANT TO MAINE OSW

This section highlights training programs, apprenticeships, and certifications that will be essential to Maine's OSW industry. An analysis of the most in-demand certifications and credentials reveals that Global Wind Organization certificates, Composite Technician, CNC Machinist, Welding, and Quality Control Inspection certifications are in the greatest demand. Additionally, electrician licenses and various OSHA certificates are estimated to be in high demand.

During the 2019-2020 academic year, community colleges and universities across the state issued an estimated 74 awards for Welding Technology, one award for Computer Numerically Controlled (CNC) Machinist Technology, 10 and Composite Materials Technician awards, zero Quality Control Inspection Technician awards, and 85 Electrician certifications and two-year awards. Eastern Maine Community College in Bangor, Kennebec Valley Community College in Fairfield, and Southern Maine Community College in Portland issued the greatest number of these awards (Table 16). Though not captured in these figures, it is important to note that organized labor and union-sponsored apprenticeship programs are a substantial training provider for many of these--and other related--occupations.

TABLE 16. PROGRAM COMPLETIONS FOR IN-DEMAND OSW OCCUPATIONS (2019-2020) [35]

	Welding Technology	CNC Machinist Technology	Composite Materials Technician	Quality Control Inspection	Electrician
Eastern Maine Community College	27	0	0	0	24
Beal University	24	0	0	0	0
Kennebec Valley Community College	10	0	0	0	27
Washington County Community College	9	0	0	0	7
Northern Maine Community College	4	0	0	0	6
Southern Maine Community College	0	1	10	0	21
Total	**74**	**1**	**10**	**0**	**85**

Registered Paid Apprenticeships

Apprenticeships are a crucial source of the training that is receiving greater attention in workforce development. The Maine Department of Labor recently received $6 million in federal grants to expand Registered apprenticeships in healthcare and infrastructure. $1.85 million of this will be available to expand pre-apprenticeship programs, offering an important on-ramp into the industry that prepares participants for apprenticeship roles. An additional $11 million from the Maine Jobs & Recovery Plan is planned to similarly expand apprenticeships. These apprenticeship funding opportunities have strong potential to assist in remediating many of the estimated workforce gaps in OSW construction and manufacturing roles highlighted in this report.

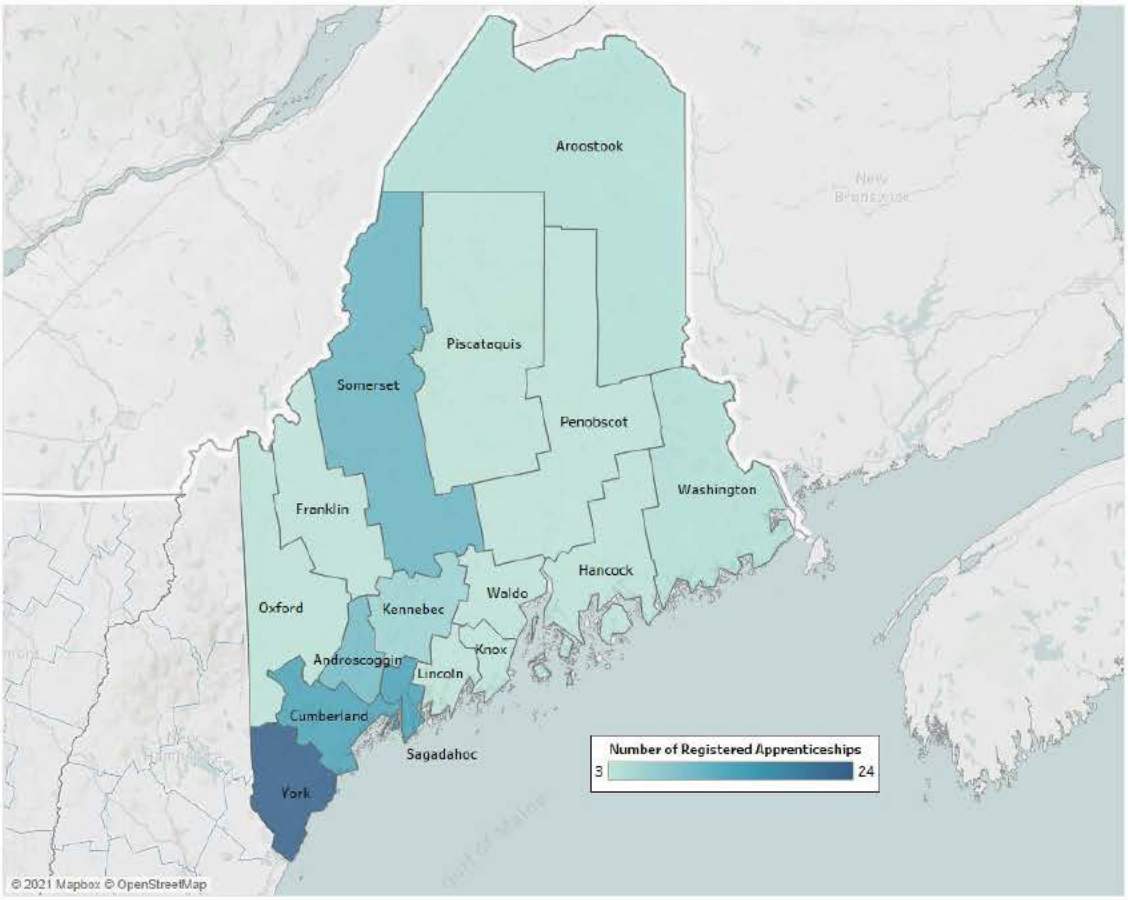
Apprenticeships are valuable because they allow students to earn while they learn experientially, meaning they can gain real-world experience while also earning a paycheck. Given the opportunity that registered apprenticeships offer for students and employers alike, this segment focuses on the registered apprenticeships across Maine that offer trainings relevant to OSW.

The research team identified 67 registered apprenticeships[36] offered by 34 different employers, unions, and community colleges across the state. These apprenticeships offer entry into roles such ranging from electricians, technicians, welders, fabricators, and supervisors. The most common registered apprenticeships offer pathways into electrician, machinist, and maintenance mechanic roles. York, Cumberland, Sagadahoc, and Somerset counties have the greatest number of relevant registered apprenticeship programs (Figure 4).

[35] JobsEQ. Data from the National Center for Education Statistics.

[36] Data from Maine Department of Labor and Maine's Apprenticeship Program.

FIGURE 4. RELEVANT CONSTRUCTION AND MANUFACTURING REGISTERED APPRENTICESHIPS



Occupation	# of Programs	Occupation	# of Programs
Electrician	19	Maintenance Supervisor	1
Machinist	4	Electronic Industrial Control Mechanic	1
Maintenance Mechanic	3	Manufacturing Production Technician I	1
Ironworker	2	Electronics Mechanic	1
Sheet Metal Worker	2	Marine Machinery Mechanic	1
Water Systems Operation Specialist	1	Engineering Assistant	1
Pipe Fitter (Construction)	1	Pipe Fitter (Ship & Boat)	1
Maintenance Technician	1	Industrial Manufacturing Mechanical Maintenance Technician	1
Construction Craft Concrete Laborer	1	Plastics Fabricator	1
Production Machinery Electrician	1	Building Construction Craft Laborer	1
Construction Craft Laborer	1	Production Machinery Mechanic	1
Composite Plastic Fabricator	1	Sheet Metal Mechanic	1
Construction Equipment Operator	1	Construction Carpenter	1
Marine Electrician	1	Shipwright (Ship & Boat)	1
Crane Electrician	1	Line Installer-Repairer	1
Pipefitter	1	Substation Technician	1

Crane Mechanic	1	Lineworker	1
Project Manager/ Installation	1	Welder, Arc	1
Basic Surveyor	1	Welder, Combination	1
Boilermaker Fitter	1	Basic Production Technician	1
Electrician (Ship & Boat)	1		

Global Wind Organization (GWO) and OSHA Certifications

Among international OSW projects and the domestic projects thus far, GWO certifications are the industry standard and are subsequently in high demand. The GWO certifications projected to be in greatest demand are Basic Safety Training (including First Aid, Manual Handling, Fire Awareness, and Working at Heights) and Basic Technical Training. The nearest GWO Certified Training Providers are:

- New Heights Inc. & Nouvelle Hauteur Inc. in Montreal, Canada
- Massachusetts Maritime Academy & Relyon Nutec in Buzzards Bay, Massachusetts
- National Offshore Wind Institute - Bristol Community College and Maersk Training in New Bedford, Massachusetts
- ENSA North America Inc.- Survival Systems USA in Groton, Connecticut

Partnership with these existing institutions or development of Maine's own GWO Certification program will likely be a key component of preparing the state's OSW Workforce.

OSHA certifications are also an important criterion for many OSW workers, though many of these courses can be taken online. The most in-demand OSHA certifications are projected to be:

- OSHA 10hr, OSHA 30hr, OSHA 1910 Std, OSHA Bloodborn Pathogens, OSHA Confined Space, OSHA Ergonomics Cert, OSHA Full Protection Cert, and OSHA Detection & Prevention Safety.

The ISO Occupational Health & Safety (OHSAS 18001) certification is also seen as an important health and safety training for many workers involved in OSW.

Offshore Wind Training Best Practices

This section begins with a summary of the identified training programs and then proceeds to a granular examination of specific offshore wind training organizations and workforce partnerships. Identifying what has effective elsewhere can help guide initiatives and programs in Maine.

Summary Findings

Overseas OSW training is handled by several institution types, including OEMs, private companies, and public education institutions. The majority of institutions adhere to Global Wind Organization (GWO) standards and offer GWO modules that are essential to work in the industry. GWO courses are specific to OSW, but do not include technical skills training, often referred to as VET. There are examples of cross-institutional partnerships, including the East of England Offshore Wind Skills Centre in the UK and the Taiwan International Windpower Training Corporation in Taiwan. Several new OSW training partnerships in the United States have followed a similar model as the East of England Offshore Wind Skills Centre, where existing educational institutions have received public and private funding alongside training assistance from OEMs or private training companies. Examples include Massachusetts Maritime Academy's partnership with Relyon Nutec and the National Offshore Wind Institute, a partnership at Bristol Community College with training support from Maersk.

While training for the OSW industry is more established overseas, several challenges have been identified in recent years. The 2019 Maritime Alliance for Fostering the European Blue Economy through a Marine Technology Skilling Strategy (MATES) report indicated considerable training gaps, especially for technician-level training. Only 5% of available programs in Europe directly addressed OSW, with most providing a general renewable skills education with graduates moving into the offshore industry. The same report found that 44% of OSW-identified programs were for Master's level education, with "very few" VET programs offering OSW technical skills.[37] These findings are consistent with an earlier 2013 report, indicating that the majority of VET training was occurring "in-house" at OEMs.

DOMESTIC TRAININGS

Massachusetts Maritime Academy/Relyon Nutec

Massachusetts Maritime Academy (MMA) is a public college located in Buzzards Bay, Massachusetts. In partnership with Relyon Nutec, an industrial workforce development and training company headquartered in Copenhagen, MMA offers GWO-approved coursework for workers seeking entry into the offshore wind industry. Currently, MMA offers GWO Basic Safety Training (BST). Additional funding for MMA's program and partnership has come from state grant funding, including $184,000 from the Baker-Polito Administration to establish the GWO BST modules.[38]

[37] https://www.projectmates.eu/wp-content/uploads/2019/07/MATES-Strategy-Report-September-2019.pdf, p.10.
[38] https://www.masscec.com/about-masscec/news/baker-polito-administration-awards-funding-offshore-wind-workforce-training

National Offshore Wind Institute - Bristol Community College and Maersk Training

The National Offshore Wind Institute (NOWI) is an offshore wind training center located in New Bedford, Massachusetts. NOWI is a unique partnership of Bristol Community College (BCC), who operates NOWI, and Maersk Training, a Danish firm with extensive experience in offshore wind training. Announced in August of 2020, NOWI is currently in early stage development and is not currently offering a full contingent of GWO coursework. Upon full opening, Maersk Training will provide GWO-approved training in Basic Technical Training (BTT) and Basic Safety Training (BST), and other offshore wind industry modules at NOWI facilities. NOWI will help provide essential skills for the 43,000 jobs that the US Department of Energy predicts will be created in offshore wind on the east coast of the United States, with projects totaling 26 GW of capacity already approved.[39] Funding for NOWI comes from BCC and has been supplemented by state grants, including a $125,125 grant and a $861,097 grant from the Baker-Polito Administration.[40,41]

Wind Academy USA - Siemens Gamesa

Wind Academy USA is a wind energy training school run by Siemens Gamesa in Orlando, Florida. Wind Academy USA is unique in that it is the only on and offshore wind energy training provider directly funded and operated by an offshore wind turbine OEM. Courses at Wind Academy USA are GWO-approved and are taught by Siemens Gamesa professional trainers. Enrolled students engage in a three week course that covers seven GWO modules, including BST and BTT. Successful students receive transferable certificates. Wind Academy USA's course costs a total of $13,800 and claims a 100% 2021 student job placement rate.[42]

Connect4Wind - Regional Offshore Wind Resource Sharing Partnership

Connect4Wind is a regional agreement between several high education institutions in Massachusetts regarding resource sharing and cooperative curriculum development for offshore wind training programs. Signed as a memorandum of understanding in 2018, Connect4Wind was initially an agreement between Bristol Community College, Massachusetts Maritime Academy, and UMass Dartmouth. On October 19, 2021, a further three institutions signed onto Connect4Wind, with Bridgewater State University, Cape Cod Cod Community College, and Massasoit Community College joining the agreement.[43] The Connect4Wind framework includes four major facets in the agreement:

- Student Participation: Inclusion in degree or non-degree granting offshore wind academic programs at each partner institution.
- Research Collaborations: Each institution will encourage research collaborations in areas of mutual interest.
- Visit of Faculty Members: An institution's faculty members will submit teaching or research proposals for establishing visiting lectures, presentations and services at partner institutions.
- Shared Facility Utilization: Parties will identify specific teaching and research facilities to be made available for the utilization at their respective institutions.

Connect4Wind intends to address workforce needs of the offshore wind industry, with the Department of Energy's projecting 43,000 new jobs being created in the industry by 2030 and MassCEC predicting 3,000 jobs being created in Massachusetts alone.[44]

INTERNATIONAL TRAININGS

Boston Energy - GWO Courses and upskilling

[39] http://www.nowi.org/
[40] https://www.oedigital.com/news/480438-massachusetts-institutions-get-grants-for-offshore-wind-workforce-training
[41] https://www.windpowerengineering.com/massachusetts-community-college-receives-funding-to-launch-offshore-wind-training-program/
[42] https://www.windacademyusa.com/
[43] https://www.umassd.edu/news/2021/umass-dartmouth-connect-institutions-connect4wind-partnership.html
[44] https://www.bristolcc.edu/about/pressandmedia/bristolumdandmassmaritimeconnect4wind/

Boston Energy is a UK-based company that offers services including training to the offshore wind energy sector. Boston Energy is funded via sales and service offerings, with current customers including Siemens Gamesa, GE, Vestas, and Nordex. Their training center, located in Beverly, East Yorkshire, UK, offers 13 GWO-approved courses for offshore wind technicians as well as several additional training programs pertaining to the offshore wind industry. Boston Energy also hires technicians with pre-existing experience in other industries, such as aviation, heavy machinery, electrical, and the Armed Forces of the UK. Boston Energy then provides training to GWO standards for accepted applicants to work in various offshore wind roles.[45]

Orsted - Denmark

Orsted is a Danish renewable energy company. In 2020, they signed a landmark MOU with the North America's Building Trades Unions (NABTU) to help transition union workers into the offshore wind industry by developing the skills necessary for offshore wind employment. This agreement also includes collaboration from the 14 NABTU affiliates and the AFL-CIO. The agreement sets forth a framework for labor-management cooperation and workforce development, including the creation and implementation of certification and training requirements. Orsted has already constructed one US-based offshore wind farm, the Block Island Wind Farm, with the assistance of union labor. This project employed 300 union employees. Currently, 15 active commercial leases for offshore wind sites exist in the US. The American Wind Energy Association predicts that the building of these sites would create approximately 83,000 jobs and $25 billion in economic output in addition to 30 gigawatts of clean offshore wind capacity.[46]

Team Humber Marine Alliance - UK

Team Humber Marine Alliance is a training and business organization based in the UK. They focus on supporting networking and facilitating the relationship between government and educational organizations with workers in marine and offshore wind industries. There are over 200 member companies of the organization who employ and work with over 17,000 people. THMA has a strong focus in offshore wind, specifically manufacturing, operation and maintenance (O&M) and marine engineering. In 2008, the received significant funding from the regional development company Yorkshire Forward. In 2010 THMA became a not-for-profit organization and is still to this day.[47] THMA supports workers along the supply chain and supports working regionally, nationally and globally.

[45] https://bostonenergy.co.uk/about-us/
[46] https://us.orsted.com/news-archive/2020/11/nabtu-and-orsted-sign-landmark-mou-for-us-offshore-wind-workforce-transition

[47] http://www.thma.co.uk/about/history/

Arch Safety - Ireland
Arch Safety is an Ireland based company specializing in safety and training. They are certified by Global Wind Organisation and IRATA International as an approved training provider. Arch is the only GWO (global wind organization) approved training provider in Northern Ireland. Arch Safety was independently authorized by the Industrial Rope Access Trade Association (IRATA International), and is a Full IRATA Operator Member Company and Full Trainer Member Company.

OffTec - Germany
OffTec is a training company based in Germany. They specialize in onshore and offshore safety courses as well as first aid and technology courses. Offshore wind conditions are significantly better than onshore, and the German government has a goal to promote offshore wind energy up to a capacity of 15,000 megawatts by 2030. This means more employees and an increased need for safety training. All training courses are held at one facility.

Taiwan International Windpower Training Corporation - GWO Training Centre at Taichung Harbor
Taiwan International Windpower Training Corporation (TIWTC) is a GWO certified and registered training center located at Taichung Harbor in Taiwan. It is a joint venture between several companies, including Taiwan Port Corporation, China Iron and Steel, Taiwan International Shipbuilding, Taiwan Power Company, Tai Ying Wind Power, and Shangwei New Energy. TIWTC offers GWO courses in BTT and BST. The course culminates in a two-year certificate that is required by most wind farm developers, wind turbine manufacturers, and other companies that are engaged in the offshore wind industry. According to TIWTC, 5,021 members have been trained at the institute with a 96% pass rate amongst students.[48] Demographic and post-certificate information is currently unavailable.

East of England Offshore Wind Skills Centre
East of England Offshore Wind Skills Center is a collaborative regional training center based at East Coast College in Great Yarmouth, UK. The center provides support for workers wishing to reskill for the offshore wind workforce on the New Anglia Energy Coast. Currently, the center offers two courses. For those without existing skills, a 12 week, full-time Level 2 Diploma in Safe Working Practice in the Wind Turbine Industry is available. For those with technical experience in similar fields, such as engineers or other technicians in closely aligned industries, a 3-4 week Transition to Offshore course is available. Funding for the center comes from the New Anglia Local Enterprise Partnership (NALEP) Skills Deal program and from offshore wind industry companies across the OSW value chain. Training at the center is provided by CWIND Training, a UK-based offshore wind training company.[49]

[48] https://www.tiwtc.com/index_tw.php
[49] https://www.eastcoast.ac.uk/locations/offshore-wind-centre/

Appendix A: Stakeholder Engagement

Alongside participating in the regular Supply Chain, Workforce Development, Ports, and Marine Transportation Working Group, the research team conducted executive interviews with a range of stakeholders including education and innovation professionals, private sector employers involved in surveying and permitting, and fisheries industry association groups. The research team also hosted three separate Human-Centered Design convenings that sought ideation and direct feedback from stakeholder groups. One convening was held for regional employers and industry associations, another for education and training providers, and a third for organized labor representatives. The findings from these convenings are summarized below.

Key Themes and Takeaways from Convenings

The following is a list of the key themes and takeaways from the human-centered design convenings for education and training providers, employers and industry associations, and organized labor representatives.

1. **Desire for stability and predictability of requirements and expectations.** Across all convenings, stakeholders noted a desire for certainty. This includes the desire to know the exact number of workers needed, requirements around offshore certifications (if GWO will be the Maine standard) and regulations, and project labor agreements.

2. **There is strong interest in early introductions to OSW for students.** The efforts for garnering student interest and participation in OSW voted to be most important by stakeholders were planned visits to OSW facilities, curriculum designed to expose students to OSW, special incentives for STEM and OSW competitions, summer programs, and media content conveying the range of OSW careers. Several other efforts received strong interest as well.

3. **Strategies to make Maine a leader in floating OSW and to ensure OSW jobs are high quality jobs are also a high priority for stakeholders.** Employers and industry associations and organized labor participants respectively voted each of the above strategies as most important for the state to pursue. Stakeholders outside of these groups emphasized that these goals were of great importance as well.

A key objective of these stakeholder convenings was to get buy in and ownership of recommendations from a group that is broader than those who gave feedback to the draft recommendations sent to the advisory group. A second objective was to highlight any issues and generate ideas not covered in the draft objectives. Some examples of specific unique efforts generated are workforce housing, incentivizing OSW-specific STEM competitions, and ACE program and other after school programs. The third objective was to identify any additional areas of concern. These include PLAs for all projects, insufficient market development, lack of certainty, and more. The final objective was to develop and prioritize more detailed and actionable ideas, which are listed below.

The efforts below are categorized in three ways. First, all efforts generated by stakeholders are listed in order of descending importance, as voted by the stakeholder groups. Second, those efforts voted to have the greatest importance are broken into two categories: strategic efforts and low-hanging fruit.

- **Strategic efforts** are those that were considered to be more difficult to implement by the stakeholder groups.
- **Low-hanging fruit** are the efforts that were considered to be less difficult to implement by the stakeholder groups.

Efforts in both of these categories are listed in descending order of importance.

Overall Findings for Improving Pathways into K-12

These findings are based on the combined ratings from the education and training provider convening and the employer and industry association convening.

Strategic Efforts

- Coordinate high school, college student, and educator teams visit OSW facilities in other states and share stories at Maine outreach events
- Develop curriculum for HS and trade schools that might foster interest in OSW certs/careers
- Create summer programs for HS students for hands-on experiences
- Give tours or field trips of existing wind farms to inspire
- Create mobile hands-on training and education modules to take to schools
- Engage with Community-Based Organizations (CBOs) and immigrant leaders to diversify the workforce
- Create a teacher training program to design OSW related curriculum linked to Maine's learning standards
- After school club or team (robotics club model)
- Input to K - 8 STEM programs using OSW as a reason to do STEM

Low-Hanging Fruit

- Create a special award or incentives for OSW related project awards at Maine's STEM competitions
- Develop video, websites, social media content to demonstrate the breadth and range of OSW jobs.
- Career fairs and guest talks
- Leverage community college and other credentialing
- ACE program and other after school STEM groups implementing OW
- Work with local community colleges in enhancing OSW certs/careers.

Education and Training Provider Convening Findings

The education and training providers group voted to focus on engaging K-12 students and addressing workforce housing challenges.

ENGAGING K-12 STUDENTS

Most important (in descending order):

- Develop curriculum for HS and trade schools that might foster interest in OSW certs/careers
- Engage with Community-Based Organizations (CBOs) and immigrant leaders to diversify the workforce
- Create summer programs for HS students for hands-on experiences
- Leverage existing community college and other credentialing by adding OSW-specific modules or curriculum to existing coursework.
- Coordinate high school, college student, and educator teams visit OSW facilities in other states and share stories at Maine outreach events
- ACE program and other after school STEM groups implementing OW
- Create mobile hands on training and education modules to take to schools
- Work with local community colleges in enhancing awareness of OSW certs/careers.

- Internship opportunities with research lab
- Input OSW material into K - 8 STEM programs. The idea is to use OSW as a reason to do STEM.
- Create a teacher training program to design OSW related curriculum linked to Maine's learning standards
- Create a special award or incentives for OSW related project awards at Maine's STEM competitions
- Create an after-school club or team (robotics club model)
- Demonstrations at wind-testing facility at UMaine
- Look for ways to create opportunities during non-traditional instructional time to engage students.
- Develop video, websites, social media content to demonstrate the breadth and range of OSW jobs.
- Career fairs and guest talks

Strategic Efforts

- Develop curriculum for HS and trade schools that might foster interest in OSW certs/careers
- Engage with Community-Based Organizations (CBOs) and immigrant leaders to diversify the workforce
- Coordinate high school, college student, and educator teams visit OSW facilities in other states and share stories at Maine outreach events
- Input OSW material into K - 8 STEM programs. The idea is to use OSW as a reason to do STEM.
- Create a teacher training program to design OSW related curriculum linked to Maine's learning standards
- Create an after-school club or team (robotics club model)

Low-Hanging Fruit

- Create summer programs for HS students for hands-on experiences
- Leverage existing community college and other credentialing by adding OSW-specific modules or curriculum to existing coursework.
- ACE program and other after school STEM groups implementing OW
- Work with local community colleges in enhancing awareness of OSW certs/careers.
- Internship opportunities with research lab
- Create a special award or incentives for OSW related project awards at Maine's STEM competitions

Employers and Industry Associations Findings

The education and industry associations group focused on the two themes of making Maine a leader in floating OSW and increasing student (K-12) interest

MAKING MAINE A LEADER IN FLOATING OSW

Most important to least (in descending order):

- Ensure business rules and permitting process are clear and supported
- Invest in Maine Ports for floating wind; 'export' floating wind port expertise to outside US to Japan, Asia, Pacific, Europe
- Develop Jones Act Compliant support fleet for crewing, construction, and operations and maintenance
- Early engagement with existing east coast projects in OW to learn and partner
- Learn from firms that have constructed similar structures in the past. Best practices and workforce lessons learned
- Engage in holistic grid planning to provide more certainty about the resources that will be required.
- Welcome multiple floating technologies
- Develop marketing initiatives that align with all groups/stakeholders.
- In full consultation with all stakeholders, consider accelerating BOEM lease ID process for GOM

- Support University-based R&D
- Align and coordinate primary stakeholders with strategic vision of what Leader in OSW looks like for Maine"
- Train ocean going workers to handle the demand for offshore wind in the Atlantic
- Support development of Maine as a leader in floating OSW
- Attract and retain out-of-state students, educators, and researchers
- Expand Opportunity Maine Tax Credit

Strategic Efforts

- Ensure business rules and permitting process are clear and supported
- Invest in Maine Ports for floating wind; 'export' floating wind port expertise to outside US to Japan, Asia, Pacific, Europe
- Develop Jones Act Compliant construction support fleet for both crewing and construction

Low-Hanging Fruit

- Early engagement with existing east coast projects in OW to learn and partner
- Learn from firms that have constructed similar structures in the past. Best practices and workforce lessons learned
- Engage in holistic grid planning to provide more certainty about the resources that will be required.
- Welcome multiple floating technologies
- Develop marketing initiatives that align with all groups/stakeholders.

ENGAGING K-12 STUDENTS

Most important (in descending order):

- Create a special award or incentives for OSW related project awards at Maine's STEM competitions
- Give tours or field trips of existing wind farms to inspire
- Coordinate high school, college student, & educator teams visit OSW facilities in other states and share stories at Maine outreach events
- Video, websites, social media content to demonstrate the breadth and range of OSW jobs.
- Special outreach to students in fishing community. Programs that review fishing and offshore wind co-existing; student research opportunities

- Coops/Internships for HS and College Students
- Support OSW outreach activities for students (wind blade challenge; etc.)
- Internship subsidy program (Innovate for Maine)
- Work with local community colleges in enhancing OSW certs/careers.
- Input to K - 8 STEM programs using OSW as a reason to do STEM
- After school club or team (robotics club model)
- Create mobile hands-on training and education modules to take to schools
- Career fairs and guest talks
- Create a teacher training program to design OSW related curriculum linked to Maine's learning standards
- More offshore wind specific courses at undergraduate/graduate levels
- Create summer programs for HS students for hands-on experiences
- The University of Maine's Windstorm Challenge
- Demonstrations at UMaine testing facility.
- Engage with Community-Based Organizations (CBOs) and immigrant leaders to diversify the workforce

- Pay special attention to designing outreach programs with equity in mind from the start - highlight women and underrepresented populations in outreach
- Some sort of program where students can go to school and also work like BOCES in NYS
- Develop curriculum for HS and trade schools that might foster interest in OSW certs/careers
- Internship opportunities with research lab
- Leverage community college and other credentialing
- ACE program and other after school STEM groups implementing OW
- Apply for an NSF ATE grant around OSW awareness for students
- Taking a Climate Solutions approach and using offshore wind development as a lens, Climate clubs in schools could be networked
- ELO's Extended Learning Ops
- JMG specialists in the area of ELO's engaged
- Targeted outreach and coordination with Student Navigators- especially those working with CTE partners.
- Not seeing a lot of marketing of OSW development and work that might be in demand.
- Virtual seminars created with partners like E2Tech that promote these pathways
- Look for ways to create opportunities during non-traditional instructional time to engage students.
- Foster student interest and engagement in OSW

Strategic Efforts

- Give tours or field trips of existing wind farms to inspire
- Coordinate high school, college student, & educator teams visit OSW facilities in other states and share stories at Maine outreach events
- Work with local community colleges in enhancing OSW certs/careers.
- After school club or team (robotics club model)
- Create mobile hands-on training and education modules to take to schools
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Low-Hanging Fruit

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- Special outreach to students in fishing community. Programs that reviews fishing and offshore wind co-existing; student research opportunities
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- Support OSW outreach activities for students (wind blade challenge; etc.)
- Internship subsidy program (Innovate for Maine)
- Input to K - 8 STEM programs using OSW as a reason to do STEM
- Career fairs and guest talks
- More offshore wind specific courses at undergraduate/graduate levels
- Create summer programs for HS students for hands-on experiences

Organized Labor Convening

The organized labor convening focused on efforts that can ensure OSW brings high quality jobs to Maine.

HIGH QUALITY JOBS

Most important (in descending order):

- Require PLAs for OSW projects
- Require or incentivize local content requirements w/ labor standards
- Attach labor standards to ports work (PLAs, apprenticeship, Labor peace, collective bargaining rate)
- Mandate any jobs have benefits, including health and retirement
- Attach PLA requirements to port development
- Attach registered apprenticeship & pre apprenticeship requirements as PLA or mandate
- Ensure that any jobs connected with OSW pay the collectively bargained rate
- Ensure any training occurs in conjunction with JATC's with a defined pathway to career advancement
- Require provisions for collectively bargained rates, esp. for those that receive state

Strategic Efforts

- Require PLAs for OSW projects
- Require or incentivize local content requirements w/ labor standards
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- Ensure that any jobs connected with OSW pay the collectively bargained rate

Low-Hanging Fruit

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- Attach registered apprenticeship & pre apprenticeship requirements as PLA or mandate
- Ensure any training occurs in conjunction with JATC's with a defined pathway to career advancement
- Require provisions for collectively bargained rates, esp. for those that receive state

Appendix B: Maine Offshore Wind Occupational Data

The following table includes all occupations identified as participatory in the life cycle of an offshore wind project. The table presents the total number of economy-wide jobs in Maine for each occupation to demonstrate workforce availability for offshore wind projects. Data is organized by location quotient, a metric which relays the concentration of workers relative to the national average. For example, an LQ of 8.37 means that Marine Engineers and Naval Architects are more than eight times more concentrated in Maine than the national average.

SOC	Occupation	LQ, 2021	Total Jobs, 2021	Percent Change, 2016-2021
17-2121	Marine Engineers and Naval Architects	8.37	343	26.7%
17-3013	Mechanical Drafters	3.48	784	-7.9%
49-9096	Riggers	3.44	315	20.2%
19-1023	Zoologists and Wildlife Biologists	3.09	225	0.0%
17-3098	Calibration Technologists and Technicians and Engineering Technologists and Technicians, Except Drafters, All Other	2.47	864	1.3%
51-9199	Production Workers, All Other	2.21	1,975	-11.4%
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	2.13	459	23.7%
51-8021	Stationary Engineers and Boiler Operators	2.04	254	-13.4%
53-5021	Captains, Mates, and Pilots of Water Vessels	2.03	253	-2.3%
51-8099	Plant and System Operators, All Other	1.94	117	-0.9%
51-2041	Structural Metal Fabricators and Fitters	1.61	481	-5.8%
51-8013	Power Plant Operators	1.54	236	-3.3%
19-2021	Atmospheric and Space Scientists	1.48	58	11.5%
53-7021	Crane and Tower Operators	1.46	271	3.1%
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	1.31	181	-6.7%
11-9021	Construction Managers	1.30	2,585	-3.2%
47-5022	Excavating and Loading Machine and Dragline Operators, Surface Mining	1.28	221	-22.0%
27-3031	Public Relations Specialists	1.27	1,408	-4.0%
17-3027	Mechanical Engineering Technologists and Technicians	1.24	226	4.8%
51-4121	Welders, Cutters, Solderers, and Brazers	1.23	2,200	10.0%
47-2073	Operating Engineers and Other Construction Equipment Operators	1.19	2,048	3.7%
11-9121	Natural Sciences Managers	1.16	355	47.4%

SOC	Occupation	LQ, 2021	Total Jobs, 2021	Percent Change, 2016-2021
51-1011	First-Line Supervisors of Production and Operating Workers	1.15	3,018	-1.1%
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	1.15	688	2.3%
13-2053	Insurance Underwriters	1.13	489	4.7%
17-3031	Surveying and Mapping Technicians	1.13	266	-3.3%
19-2041	Environmental Scientists and Specialists, Including Health	1.13	413	7.1%
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	1.12	1,263	-4.3%
53-7065	Stockers and Order Fillers	1.11	10,844	1.2%
47-2111	Electricians	1.08	3,261	12.8%
53-3032	Heavy and Tractor-Trailer Truck Drivers	1.08	9,000	-1.8%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	1.07	3,017	4.8%
11-1021	General and Operations Managers	1.06	10,774	8.6%
43-3031	Bookkeeping, Accounting, and Auditing Clerks	1.06	7,090	-13.3%
47-2051	Cement Masons and Concrete Finishers	1.06	907	3.5%
53-5031	Ship Engineers	1.04	32	-15.4%
47-2061	Construction Laborers	1.03	5,948	11.9%
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	1.02	8,491	-4.6%
17-3019	Drafters, All Other	1.00	61	-6.3%
47-4021	Elevator and Escalator Installers and Repairers	1.00	106	-13.2%
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	1.00	2,026	0.4%
49-9092	Commercial Divers	1.00	18	21.4%
53-6098	Aircraft Service Attendants and Transportation Workers, All Other	1.00	140	-8.5%
13-1022	Wholesale and Retail Buyers, Except Farm Products	0.99	465	-17.1%
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	0.98	98	4.4%
43-9061	Office Clerks, General	0.98	11,970	-3.9%
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic	0.98	156	5.5%
11-3051	Industrial Production Managers	0.97	755	11.2%
11-3061	Purchasing Managers	0.97	310	6.0%
43-4161	Human Resources Assistants, Except Payroll and Timekeeping	0.97	455	-16.3%
53-5011	Sailors and Marine Oilers	0.97	105	-12.2%
25-1032	Engineering Teachers, Postsecondary	0.96	151	-3.8%

SOC	Occupation	LQ, 2021	Total Jobs, 2021	Percent Change, 2016-2021
11-3012	Administrative Services Managers	0.95	127	0.0%
13-1051	Cost Estimators	0.95	821	4.3%
49-9041	Industrial Machinery Mechanics	0.95	1,590	9.3%
13-2031	Budget Analysts	0.94	195	-4.0%
51-4041	Machinists	0.94	1,414	-3.4%
49-9081	Wind Turbine Service Technicians	0.93	31	14.8%
49-9051	Electrical Power-Line Installers and Repairers	0.92	476	20.2%
17-2131	Materials Engineers	0.91	97	11.8%
17-2199	Engineers, All Other	0.91	638	6.0%
51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	0.91	36	-46.2%
53-7199	Material Moving Workers, All Other	0.91	108	-15.2%
19-5011	Occupational Health and Safety Specialists	0.90	380	26.9%
47-2221	Structural Iron and Steel Workers	0.89	272	9.9%
11-9041	Architectural and Engineering Managers	0.88	743	14.5%
53-7051	Industrial Truck and Tractor Operators	0.88	2,518	-9.8%
11-3031	Financial Managers	0.87	2,506	12.7%
13-2011	Accountants and Auditors	0.87	5,130	4.4%
17-2051	Civil Engineers	0.87	1,151	14.8%
11-3071	Transportation, Storage, and Distribution Managers	0.86	505	9.1%
49-9071	Maintenance and Repair Workers, General	0.86	5,124	-4.1%
11-3121	Human Resources Managers	0.85	595	31.8%
17-2071	Electrical Engineers	0.85	696	20.1%
17-2141	Mechanical Engineers	0.85	1,097	16.8%
53-7041	Hoist and Winch Operators	0.85	16	-11.1%
13-1041	Compliance Officers	0.84	1,167	24.1%
17-2081	Environmental Engineers	0.84	182	5.9%
23-2011	Paralegals and Legal Assistants	0.84	1,197	5.1%
49-9098	Helpers--Installation, Maintenance, and Repair Workers	0.82	323	-17.1%
15-2031	Operations Research Analysts	0.81	331	23.0%
51-2092	Team Assemblers	0.81	3,764	4.1%

SOC	Occupation	LQ, 2021	Total Jobs, 2021	Percent Change, 2016-2021
51-9162	Computer Numerically Controlled Tool Programmers	0.81	86	16.2%
51-2099	Assemblers and Fabricators, All Other	0.79	739	-13.9%
17-2112	Industrial Engineers	0.78	989	21.4%
11-2022	Sales Managers	0.77	1,369	3.6%
17-2011	Aerospace Engineers	0.77	195	20.5%
23-1011	Lawyers	0.74	2,507	0.2%
53-2012	Commercial Pilots	0.74	126	5.1%
13-1071	Human Resources Specialists	0.73	2,054	20.9%
43-5071	Shipping, Receiving, and Inventory Clerks	0.73	2,356	-6.3%
11-3021	Computer and Information Systems Managers	0.72	1,449	23.1%
13-1081	Logisticians	0.72	573	30.7%
13-1151	Training and Development Specialists	0.71	968	10.3%
13-2098	Financial and Investment Analysts, Financial Risk Specialists, and Financial Specialists, All Other	0.70	1,399	12.2%
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	0.70	1,694	10.9%
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	0.69	19	12.5%
17-3023	Electrical and Electronic Engineering Technologists and Technicians	0.69	340	-2.6%
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	0.67	876	-12.2%
51-4199	Metal Workers and Plastic Workers, All Other	0.67	63	-31.0%
19-4042	Environmental Science and Protection Technicians, Including Health	0.66	88	3.6%
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	0.65	436	6.8%
19-3091	Anthropologists and Archeologists	0.64	21	16.7%
17-2072	Electronics Engineers, Except Computer	0.62	322	6.7%
51-4051	Metal-Refining Furnace Operators and Tenders	0.61	37	-2.6%
19-2042	Geoscientists, Except Hydrologists and Geographers	0.58	70	13.1%
47-2171	Reinforcing Iron and Rebar Workers	0.58	48	-6.0%
41-9031	Sales Engineers	0.56	152	-8.1%
15-1299	Computer Occupations, All Other	0.55	926	13.2%
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	0.54	6,466	4.3%
51-2031	Engine and Other Machine Assemblers	0.47	80	15.9%
13-1161	Market Research Analysts and Marketing Specialists	0.46	1,397	30.8%

SOC	Occupation	LQ, 2021	Total Jobs, 2021	Percent Change, 2016-2021
11-3131	Training and Development Managers	0.40	68	17.2%
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	0.39	453	12.4%
51-9011	Chemical Equipment Operators and Tenders	0.39	154	54.0%
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	0.24	179	-4.3%
47-5041	Continuous Mining Machine Operators	0.22	15	36.4%

Appendix C. BOEM Local Content

BOEM on Local Supply Chain Development[50]

As an incentive for lessees to source major wind facility components domestically, BOEM indicates that lessees may be eligible for a 1% operating fee rate for five years if they procure the major components domestically. To be eligible for the rate, lessees would have to demonstrate that four or more of the following were meaningfully and substantially manufactured or assembled in the United States:

- Nacelles
- Turbine blades
- Towers
- Foundations
- Transition pieces
- Inter-array cables
- Export cables
- Offshore substations

BOEM anticipates increased demand for domestically manufactured materials and components which, in turn, will create jobs, increase tax revenues, mitigate the risk of depending on foreign markets for major components, and encourage lessees to make substantial investments in the domestic supply chain.

[50] Stipulation 7 in https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/new-york-bight/ATLW-8%20NY%20Bight%20Final%20Lease%20Sale%20Decision%20Memorandum.pdf

Appendix D. List of Sources

The following list captures the reports whose findings directly informed the background information and literature review for this research. Importantly, this review helped develop the database of relevant occupations that are key to developing a healthy, domestic offshore wind industry. This database is the foundation of all occupational analyses.

BVG Associates Limited, U.S. Job Creation in Offshore Wind: A Report for the Roadmap Project for Multi-State Cooperation on Offshore Wind. (2017)

BVG Associates Limited, The Virginia Advantage: the roadmap for the offshore wind supply chain in Virginia (2018)

Massachusetts Clean Energy Council, 2018 Massachusetts Offshore Wind Workforce Assessment.

New York State Energy Research and Development Authority, 2019 OSW Jobs Fact Sheet

New York State Energy Research and Development Authority, The Workforce Opportunity of Offshore Wind in New York (2017)

Offshore Wind Industry Council, The U.K. Offshore Wind Industry: Supply Chain Review January 2019

Pereira, Sydney. What New York's Offshore Wind Expansion Could Mean for Your Electricity Bill, Curbing Emissions, and Your Health (2021)

Topham and McMillan. Renewable Energy Journal, Sustainable Decommissioning of an Offshore Wind Farm (2016)

Wood Mackenzie, Economic Impact of New Offshore Wind Lease Auctions by BOEM (2021)

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

Appendix E. Projected Occupational Gaps

Occupations are listed in descending severity of estimated occupation gaps.

Description	Education	Phase	Gap Rank	Mean Annual Wage	Jobs in Maine	Online Job Ads[51]
Atmospheric and Space Scientists	Bachelor's Degree or More	Immediate	Severe	$84,400	58	4
Industrial Engineers	Bachelor's Degree or More	Short-Term	Severe	$87,100	989	212
Electronics Engineers, Except Computer	Bachelor's Degree or More	Short-Term	Severe	$94,500	322	6
Commercial Divers	Less than a 4-Year Degree	Long-Term	Severe	$67,700	18	1
Continuous Mining Machine Operators	Less than a 4-Year Degree	Short-Term	Moderate	$51,200	15	*
Atmospheric and Space Scientists	Bachelor's Degree or More	Long-Term	Moderate	$84,400	58	4
Public Relations Specialists	Bachelor's Degree or More	Long-Term	Moderate	$54,500	1408	149
Commercial Divers	Less than a 4-Year Degree	Immediate	Moderate	$67,700	18	1
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	Bachelor's Degree or More	Short-Term	Moderate	$88,100	98	6
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	Bachelor's Degree or More	Long-Term	Moderate	$88,100	98	6
Operations Research Analysts	Bachelor's Degree or More	Long-Term	Moderate	$73,300	331	205
Industrial Engineers	Bachelor's Degree or More	Long-Term	Moderate	$87,100	989	212
Public Relations Specialists	Bachelor's Degree or More	Immediate	Moderate	$54,500	1408	149
Hoist and Winch Operators	Less than a 4-Year Degree	Short-Term	Moderate	$60,900	16	*
Public Relations Specialists	Bachelor's Degree or More	Short-Term	Moderate	$54,500	1408	149
Electrical Engineers	Bachelor's Degree or More	Immediate	Moderate	$92,600	696	161
Engineers, All Other	Bachelor's Degree or More	Short-Term	Moderate	$93,400	638	21
Environmental Engineers	Bachelor's Degree or More	Short-Term	Moderate	$88,500	182	20
Environmental Engineers	Bachelor's Degree or More	Immediate	Moderate	$88,500	182	20
Calibration Technologists and Technicians and Engineering Technologists and Technicians, Except Drafters, All Other	Less than a 4-Year Degree	Long-Term	Moderate	$81,500	864	9
Occupational Health and Safety Specialists	Less than a 4-Year Degree	Long-Term	Moderate	$74,900	380	50
Materials Engineers	Bachelor's Degree or More	Short-Term	Moderate	$101,300	97	*
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	Bachelor's Degree or More	Immediate	Moderate	$88,100	98	6

[51] Data from online job postings active within past 30 days (November 2021)

* Data not available

Elevator and Escalator Installers and Repairers	Less than a 4-Year Degree	Long-Term	Moderate	$84,800	106	2
Lawyers	Bachelor's Degree or More	Long-Term	Moderate	$99,000	2507	46
Electronics Engineers, Except Computer	Bachelor's Degree or More	Immediate	Moderate	$94,500	322	6
Mechanical Engineering Technologists and Technicians	Less than a 4-Year Degree	Immediate	Moderate	$58,700	226	*
Cost Estimators	Bachelor's Degree or More	Immediate	Moderate	$66,700	821	32
Computer and Information Systems Managers	Bachelor's Degree or More	Long-Term	Moderate	$133,000	1449	138
Occupational Health and Safety Specialists	Less than a 4-Year Degree	Immediate	Moderate	$74,900	380	50
Occupational Health and Safety Specialists	Less than a 4-Year Degree	Short-Term	Moderate	$74,900	380	50
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	Less than a 4-Year Degree	Short-Term	Moderate	$88,100	98	6
Budget Analysts	Bachelor's Degree or More	Immediate	Moderate	$94,300	195	13
Lawyers	Bachelor's Degree or More	Immediate	Moderate	$99,000	2507	46
Lawyers	Bachelor's Degree or More	Short-Term	Moderate	$99,000	2507	46
Engineers, All Other	Bachelor's Degree or More	Long-Term	Moderate	$93,400	638	21
Civil Engineers	Bachelor's Degree or More	Long-Term	Moderate	$89,300	1151	75
Civil Engineers	Bachelor's Degree or More	Immediate	Moderate	$89,300	1151	75
Material Moving Workers, All Other	Less than a 4-Year Degree	Short-Term	Moderate	$34,400	108	*
Calibration Technologists and Technicians and Engineering Technologists and Technicians, Except Drafters, All Other	Less than a 4-Year Degree	Short-Term	Moderate	$81,500	864	9
Engineers, All Other	Bachelor's Degree or More	Immediate	Moderate	$93,400	638	21
Excavating and Loading Machine and Dragline Operators, Surface Mining	Less than a 4-Year Degree	Long-Term	Moderate	$42,900	221	3
Mining and Geological Engineers, Including Mining Safety Engineers	Bachelor's Degree or More	Long-Term	Moderate	$96,600	19	*
Training and Development Managers	Bachelor's Degree or More	Long-Term	Moderate	$98,100	70	12
Mechanical Drafters	Less than a 4-Year Degree	Short-Term	Mild	$59,000	784	8
Mechanical Drafters	Less than a 4-Year Degree	Immediate	Mild	$59,000	784	8
Logisticians	Bachelor's Degree or More	Immediate	Mild	$76,600	573	17
Chemical Equipment Operators and Tenders	Less than a 4-Year Degree	Short-Term	Mild	$45,800	165	*
Metal Workers and Plastic Workers, All Other	Less than a 4-Year Degree	Short-Term	Mild	$45,900	63	*
Logisticians	Bachelor's Degree or More	Long-Term	Mild	$76,600	573	17
Sales Managers	Bachelor's Degree or More	Immediate	Mild	$117,200	1369	163
Sales Managers	Bachelor's Degree or More	Short-Term	Mild	$117,200	1369	163

Sales Managers	Bachelor's Degree or More	Long-Term	Mild	$117,200	1369	163
Logisticians	Bachelor's Degree or More	Short-Term	Mild	$76,600	573	17
Logisticians	Less than a 4-Year Degree	Short-Term	Mild	$76,600	573	17
Surveying and Mapping Technicians	Less than a 4-Year Degree	Long-Term	Mild	$47,500	266	19
Power Plant Operators	Bachelor's Degree or More	Long-Term	Mild	$72,300	236	5
Financial Managers	Bachelor's Degree or More	Immediate	Mild	$122,900	2506	313
Accountants and Auditors	Bachelor's Degree or More	Short-Term	Mild	$70,700	5130	472
Accountants and Auditors	Bachelor's Degree or More	Immediate	Mild	$70,700	5130	472
Administrative Services Managers	Less than a 4-Year Degree	Immediate	Mild	$82,000	127	*
Human Resources Managers	Bachelor's Degree or More	Short-Term	Mild	$121,200	595	93
Financial Managers	Bachelor's Degree or More	Long-Term	Mild	$122,900	2506	313
Construction Managers	Bachelor's Degree or More	Short-Term	Mild	$85,300	2585	69
Financial and Investment Analysts, Financial Risk Specialists, and Financial Specialists, All Other	Bachelor's Degree or More	Long-Term	Mild	$71,600	1399	256
Financial and Investment Analysts, Financial Risk Specialists, and Financial Specialists, All Other	Less than a 4-Year Degree	Short-Term	Mild	$71,600	1399	256
Accountants and Auditors	Bachelor's Degree or More	Long-Term	Mild	$70,700	5130	472
Welders, Cutters, Solderers, and Brazers	Less than a 4-Year Degree	Long-Term	Mild	$51,900	2200	26
Training and Development Specialists	Bachelor's Degree or More	Long-Term	Mild	$59,500	968	127
Electrical Power-Line Installers and Repairers	Less than a 4-Year Degree	Long-Term	Mild	$62,600	476	15
Structural Metal Fabricators and Fitters	Less than a 4-Year Degree	Long-Term	Mild	$42,400	481	6
Human Resources Specialists	Bachelor's Degree or More	Immediate	Mild	$64,100	2054	587
Mechanical Engineers	Bachelor's Degree or More	Short-Term	Mild	$91,500	1097	43
Financial Managers	Bachelor's Degree or More	Short-Term	Mild	$122,900	2506	313
Industrial Machinery Mechanics	Less than a 4-Year Degree	Short-Term	Mild	$53,000	1590	8
General and Operations Managers	Bachelor's Degree or More	Immediate	Mild	$105,400	10774	146
Aerospace Engineers	Bachelor's Degree or More	Short-Term	Mild	$116,900	195	4
Administrative Services Managers	Less than a 4-Year Degree	Long-Term	Mild	$82,000	127	*
Structural Metal Fabricators and Fitters	Less than a 4-Year Degree	Short-Term	Mild	$42,400	481	6
Industrial Machinery Mechanics	Less than a 4-Year Degree	Long-Term	Mild	$53,000	1590	8

First-Line Supervisors of Mechanics, Installers, and Repairers	Less than a 4-Year Degree	Short-Term	Mild	$68,400	2026	119
Computer Occupations, All Other	Bachelor's Degree or More	Short-Term	Mild	$80,600	942	649
Transportation, Storage, and Distribution Managers	Less than a 4-Year Degree	Long-Term	Mild	$85,700	505	90
Bookkeeping, Accounting, and Auditing Clerks	Less than a 4-Year Degree	Immediate	Mild	$40,600	7090	195
First-Line Supervisors of Mechanics, Installers, and Repairers	Less than a 4-Year Degree	Immediate	Mild	$68,400	2026	119
Industrial Production Managers	Bachelor's Degree or More	Long-Term	Mild	$102,400	755	51
Welders, Cutters, Solderers, and Brazers	Less than a 4-Year Degree	Short-Term	Mild	$51,900	2200	26
Construction Managers	Bachelor's Degree or More	Long-Term	Mild	$85,300	2585	69
Purchasing Managers	Bachelor's Degree or More	Immediate	Mild	$117,500	310	29
Human Resources Specialists	Bachelor's Degree or More	Long-Term	Mild	$64,100	2054	587
Market Research Analysts and Marketing Specialists	Bachelor's Degree or More	Immediate	Mild	$68,200	1438	213
Market Research Analysts and Marketing Specialists	Bachelor's Degree or More	Short-Term	Mild	$68,200	1438	213
Mechanical Engineers	Bachelor's Degree or More	Immediate	Mild	$91,500	1097	43
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	Less than a 4-Year Degree	Immediate	Mild	$39,300	8491	561
Architectural and Engineering Managers	Bachelor's Degree or More	Immediate	Mild	$130,800	743	287
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	Less than a 4-Year Degree	Long-Term	Mild	$94,400	876	185
Architectural and Engineering Managers	Bachelor's Degree or More	Short-Term	Mild	$130,800	743	287
Paralegals and Legal Assistants	Less than a 4-Year Degree	Immediate	Mild	$50,900	1197	52
Paralegals and Legal Assistants	Less than a 4-Year Degree	Short-Term	Mild	$50,900	1197	52
Computer Occupations, All Other	Bachelor's Degree or More	Immediate	Mild	$80,600	942	649
First-Line Supervisors of Construction Trades and Extraction Workers	Less than a 4-Year Degree	Long-Term	Mild	$60,600	3017	103
Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	Less than a 4-Year Degree	Short-Term	Mild	$50,000	181	12
Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	Less than a 4-Year Degree	Long-Term	Mild	$36,000	472	7
Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	Less than a 4-Year Degree	Long-Term	Mild	$47,600	459	1
Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	Less than a 4-Year Degree	Short-Term	Mild	$42,100	36	*
Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	Less than a 4-Year Degree	Short-Term	Mild	$40,600	183	7

Electrical and Electronic Engineering Technologists and Technicians	Bachelor's Degree or More	Short-Term	Mild	$65,200	340	16
Drafters, All Other	Less than a 4-Year Degree	Short-Term	Mild	$62,500	61	1
Mechanical Engineers	Bachelor's Degree or More	Long-Term	Mild	$91,500	1097	43
Electrical and Electronic Engineering Technologists and Technicians	Less than a 4-Year Degree	Immediate	Mild	$65,200	340	16
Computer Occupations, All Other	Bachelor's Degree or More	Long-Term	Mild	$80,600	942	649
First-Line Supervisors of Production and Operating Workers	Less than a 4-Year Degree	Long-Term	Mild	$66,900	3018	250
Wholesale and Retail Buyers, Except Farm Products	Bachelor's Degree or More	Immediate	Mild	$70,000	465	7
Marine Engineers and Naval Architects	Bachelor's Degree or More	Short-Term	Mild	$95,900	343	3
Marine Engineers and Naval Architects	Bachelor's Degree or More	Long-Term	Mild	$95,900	343	3
First-Line Supervisors of Mechanics, Installers, and Repairers	Less than a 4-Year Degree	Long-Term	Mild	$68,400	2026	119
Bookkeeping, Accounting, and Auditing Clerks	Less than a 4-Year Degree	Long-Term	Mild	$40,600	7090	195
Heavy and Tractor-Trailer Truck Drivers	Less than a 4-Year Degree	Short-Term	Mild	$43,700	9000	980
Sailors and Marine Oilers	Less than a 4-Year Degree	Long-Term	Mild	$38,000	105	2
Anthropologists and Archeologists	Bachelor's Degree or More	Immediate	Mild	$63,600	21	18
Commercial Pilots	Less than a 4-Year Degree	Immediate	Mild	$70,500	126	4
Crane and Tower Operators	Less than a 4-Year Degree	Short-Term	Mild	$53,300	271	8
Financial and Investment Analysts, Financial Risk Specialists, and Financial Specialists, All Other	Bachelor's Degree or More	Short-Term	Mild	$71,600	1399	256
Transportation, Storage, and Distribution Managers	Bachelor's Degree or More	Long-Term	Mild	$85,700	505	90
Machinists	Less than a 4-Year Degree	Short-Term	Mild	$52,300	1414	36
Insurance Underwriters	Bachelor's Degree or More	Short-Term	Mild	$72,700	489	35
Insurance Underwriters	Bachelor's Degree or More	Long-Term	Mild	$72,700	489	35
Insurance Underwriters	Bachelor's Degree or More	Immediate	Mild	$72,700	489	35
Purchasing Managers	Bachelor's Degree or More	Long-Term	Mild	$117,500	310	29
Material Moving Workers, All Other	Less than a 4-Year Degree	Long-Term	Mild	$34,400	108	*
Production Workers, All Other	Less than a 4-Year Degree	Long-Term	Mild	$36,600	1975	313
Market Research Analysts and Marketing Specialists	Bachelor's Degree or More	Long-Term	Mild	$68,200	1438	213
Office Clerks, General	Less than a 4-Year Degree	Immediate	Mild	$36,800	11970	138
Electrical, Electronic, and Electromechanical Assemblers,	Less than a 4-Year Degree	Short-Term	Mild	$36,000	472	7

Except Coil Winders, Tapers, and Finishers						
Sales Engineers	Bachelor's Degree or More	Short-Term	Mild	$95,500	152	7
Human Resources Assistants, Except Payroll and Timekeeping	Less than a 4-Year Degree	Short-Term	Mild	$42,700	455	7
Hoist and Winch Operators	Less than a 4-Year Degree	Long-Term	Mild	$60,900	16	*
Architectural and Engineering Managers	Bachelor's Degree or More	Long-Term	Mild	$130,800	743	287
Paralegals and Legal Assistants	Less than a 4-Year Degree	Long-Term	Mild	$50,900	1197	52
Bookkeeping, Accounting, and Auditing Clerks	Less than a 4-Year Degree	Short-Term	Mild	$40,600	7090	195
Laborers and Freight, Stock, and Material Movers, Hand	Less than a 4-Year Degree	Short-Term	Mild	$31,900	6721	456
Transportation, Storage, and Distribution Managers	Less than a 4-Year Degree	Short-Term	Mild	$85,700	505	90
Aircraft Service Attendants and Transportation Workers, All Other	Less than a 4-Year Degree	Immediate	Mild	$33,800	140	5
Aircraft Service Attendants and Transportation Workers, All Other	Less than a 4-Year Degree	Short-Term	Mild	$33,800	140	5
Electricians	Less than a 4-Year Degree	Long-Term	Mild	$55,200	3261	54
Wind Turbine Service Technicians	Less than a 4-Year Degree	Long-Term	Mild	$55,900	31	3
General and Operations Managers	Bachelor's Degree or More	Short-Term	Mild	$105,400	10774	146
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	Less than a 4-Year Degree	Long-Term	Mild	$39,300	8491	561
Marine Engineers and Naval Architects	Bachelor's Degree or More	Immediate	Mild	$95,900	343	3
Assemblers and Fabricators, All Other	Less than a 4-Year Degree	Long-Term	Mild	$37,600	739	25
Metal-Refining Furnace Operators and Tenders	Less than a 4-Year Degree	Long-Term	Mild	$37,800	37	1
Heavy and Tractor-Trailer Truck Drivers	Less than a 4-Year Degree	Long-Term	Mild	$43,700	9000	980
Commercial Pilots	Less than a 4-Year Degree	Long-Term	Mild	$70,500	126	4
Purchasing Managers	Bachelor's Degree or More	Short-Term	Mild	$117,500	310	29
Environmental Science and Protection Technicians, Including Health	Bachelor's Degree or More	Short-Term	Mild	$39,800	88	14
Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	Less than a 4-Year Degree	Short-Term	Mild	$43,600	436	12
Environmental Science and Protection Technicians, Including Health	Bachelor's Degree or More	Long-Term	Mild	$39,800	88	14
Environmental Science and Protection Technicians, Including Health	Less than a 4-Year Degree	Immediate	Mild	$39,800	88	14
Industrial Production Managers	Bachelor's Degree or More	Short-Term	Mild	$102,400	755	51
Plating Machine Setters, Operators, and Tenders, Metal and Plastic	Less than a 4-Year Degree	Short-Term	Mild	$35,700	156	1

Crane and Tower Operators	Less than a 4-Year Degree	Long-Term	Mild	$53,300	271	8
Team Assemblers	Less than a 4-Year Degree	Short-Term	Mild	$37,600	3764	10
Natural Sciences Managers	Bachelor's Degree or More	Immediate	Mild	$134,100	355	81
Inspectors, Testers, Sorters, Samplers, and Weighers	Less than a 4-Year Degree	Long-Term	Mild	$46,900	1694	75
Captains, Mates, and Pilots of Water Vessels	Less than a 4-Year Degree	Short-Term	Mild	$78,000	253	12
Office Clerks, General	Less than a 4-Year Degree	Long-Term	Mild	$36,800	11970	138
General and Operations Managers	Bachelor's Degree or More	Long-Term	Mild	$105,400	10774	146
Operating Engineers and Other Construction Equipment Operators	Less than a 4-Year Degree	Long-Term	Mild	$43,800	2048	44
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	Less than a 4-Year Degree	Short-Term	Mild	$39,300	8491	561
Engine and Other Machine Assemblers	Less than a 4-Year Degree	Long-Term	Mild	$49,600	79	2
First-Line Supervisors of Production and Operating Workers	Less than a 4-Year Degree	Short-Term	Mild	$66,900	3018	250
Aircraft Service Attendants and Transportation Workers, All Other	Less than a 4-Year Degree	Long-Term	Mild	$33,800	140	5
Industrial Truck and Tractor Operators	Less than a 4-Year Degree	Short-Term	Mild	$38,100	2518	41
Laborers and Freight, Stock, and Material Movers, Hand	Less than a 4-Year Degree	Long-Term	Mild	$31,900	6721	456
Geoscientists, Except Hydrologists and Geographers	Bachelor's Degree or More	Immediate	Mild	$78,500	70	1
Shipping, Receiving, and Inventory Clerks	Less than a 4-Year Degree	Short-Term	Mild	$38,100	2356	86
Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	Less than a 4-Year Degree	Short-Term	Mild	$50,400	688	32
Engine and Other Machine Assemblers	Less than a 4-Year Degree	Short-Term	Mild	$49,600	79	2
Construction Laborers	Less than a 4-Year Degree	Long-Term	Mild	$36,000	5948	117
Cement Masons and Concrete Finishers	Less than a 4-Year Degree	Long-Term	Mild	$45,800	907	*
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	Less than a 4-Year Degree	Short-Term	Mild	$94,400	876	185
Riggers	Less than a 4-Year Degree	Long-Term	Mild	$54,300	315	6
Environmental Science and Protection Technicians, Including Health	Bachelor's Degree or More	Immediate	Mild	$39,800	88	14
Maintenance and Repair Workers, General	Less than a 4-Year Degree	Long-Term	Mild	$42,300	5124	663
Stockers and Order Fillers	Less than a 4-Year Degree	Short-Term	Mild	$32,000	10844	1131
Structural Iron and Steel Workers	Less than a 4-Year Degree	Long-Term	Mild	$51,300	272	2
Compliance Officers	Bachelor's Degree or More	Immediate	Mild	$72,900	1167	52
Zoologists and Wildlife Biologists	Bachelor's Degree or More	Immediate	Mild	$64,600	225	4

Compliance Officers	Bachelor's Degree or More	Long-Term	Mild	$72,900	1167	52
Captains, Mates, and Pilots of Water Vessels	Less than a 4-Year Degree	Immediate	Mild	$78,000	253	12
Plant and System Operators, All Other	Less than a 4-Year Degree	Short-Term	Mild	$47,300	117	*
Electricians	Less than a 4-Year Degree	Short-Term	Mild	$55,200	3261	54
Computer Numerically Controlled Tool Programmers	Less than a 4-Year Degree	Short-Term	Mild	$46,600	86	4
Metal-Refining Furnace Operators and Tenders	Less than a 4-Year Degree	Short-Term	Mild	$37,800	37	1
Ship Engineers	Less than a 4-Year Degree	Long-Term	Mild	$64,400	32	*
Environmental Scientists and Specialists, Including Health	Bachelor's Degree or More	Immediate	Mild	$67,500	413	23
Maintenance and Repair Workers, General	Less than a 4-Year Degree	Short-Term	Mild	$42,300	5124	663
Transportation, Storage, and Distribution Managers	Bachelor's Degree or More	Short-Term	Mild	$85,700	505	90
Electrical and Electronic Engineering Technologists and Technicians	Bachelor's Degree or More	Long-Term	Mild	$65,200	340	16
Compliance Officers	Bachelor's Degree or More	Short-Term	Mild	$72,900	1167	52
Inspectors, Testers, Sorters, Samplers, and Weighers	Less than a 4-Year Degree	Short-Term	Mild	$46,900	1694	75
Stationary Engineers and Boiler Operators	Bachelor's Degree or More	Short-Term	Mild	$51,500	254	12
Office Clerks, General	Less than a 4-Year Degree	Short-Term	Mild	$36,800	11970	138
Assemblers and Fabricators, All Other	Less than a 4-Year Degree	Short-Term	Mild	$37,600	739	25
Reinforcing Iron and Rebar Workers	Less than a 4-Year Degree	Long-Term	Mild	$48,000	48	1
Plant and System Operators, All Other	Less than a 4-Year Degree	Long-Term	Mild	$47,300	117	*
Helpers--Installation, Maintenance, and Repair Workers	Less than a 4-Year Degree	Long-Term	Mild	$32,600	323	*
Captains, Mates, and Pilots of Water Vessels	Less than a 4-Year Degree	Long-Term	Mild	$78,000	253	12
Helpers--Installation, Maintenance, and Repair Workers	Less than a 4-Year Degree	Short-Term	Mild	$32,600	323	*