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AB 525 WORKFORCE DEVELOPMENT READINESS PLAN

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List of Acronyms and Abbreviations

Acronym	Meaning
ACCP	American Society of Nondestructive Testing Central Certification Program
ACS	American Community Survey
AHTS	Anchor handling tug supply vessel
API	American Petroleum Institute
AWS	American Welding Society
BBGI	Building a Better Grid Initiative
BOEM	Bureau of Ocean Energy Management
BoP	Balance of plant
CA	California
CCO	Certification of Crane Operators
COD	Commercial operation date
CTV	Crew transfer vessel
DOE	United States Department of Energy
e.g.	Exempli gratia, "for example"
EPC	Engineering, procurement and construction
etc.	Et cetera, "and others especially of the same kind"
FEED	Front End Engineering and Design
FERC	Federal Energy Regulatory Commission
FTE	Full-Time Equivalent
FROSIO	Norwegian Professional Council for Education and Certification of Inspectors of Surface Treatment
GW	Gigawatt
GWO	Global Wind Organization
i.e.	Id est, "that is"
IRA	Inflation Reduction Act
ISO	Independent system operator
JATC	Joint Apprenticeship Training Centers
MW	Megawatt
NAICS	North American Industry Classification System

Acronym	Meaning
No.	Number
O&M	Operation and maintenance
OEM	Original equipment manufacturer
OSHA	Occupational Safety and Health Administration
OSW	Offshore Wind
ROV	Remotely operated vehicle
RTOs	Regional transmission operators
S&I	Staging and integration
SOC	Standard Occupational Classification
SOV	Service operation vessel
SSPC	The Society for Protective Coatings
TFP	Transmission Facilitation Program
USCG	United States Coast Guard

Glossary

Adjacent industry In this report, adjacent industry refers to sectors closely related or connected to the offshore wind industry, including but not limited to construction and manufacturing, maritime and shipping, and offshore engineering.

Balance of plant (BoP) - Includes all the components of the wind farm except the wind turbines, including transmission assets built as a direct result of the wind farm.

Commercial operation date (COD) - The date under a long-term power purchase agreement when the commissioning tests have been passed and the facility starts to generate power to earn revenue.

Developer - An offshore wind Developer is the owner and operator of an offshore wind farm. Generally, they are large multi-national energy producers and responsible for the delivery of the project in alignment with an agreed Power Purchase Agreement.

Direct Employment - Refers to work that is done directly on the activity being analyzed (while indirect employment refers to the employment further down the supply chain that supports the development of ports). This study considers direct employment only.

Full-Time Equivalent (FTE) - Units that represent a full-time workload of 2,080 hours (40 hours per week for 52 weeks). FTEs are not equivalent to full-time jobs; they represent the number of hours worked to complete the work done by one full-time employee in one year.

Highly skilled workforce - In this report, highly skilled workforce refers to job roles which require four-plus years of training. The qualification level associated with this workforce includes: scientist, engineer, all other university degree, skilled trade specialist, and manager level roles.

Location Quotient – A ratio that measures an area's concentration for an occupational group relative to a larger geographic area. Location quotients are useful in identifying if a region specializes in a certain occupational cluster compared to state- or nationwide averages.

OSW-Related Jobs – Through workforce analyses, these are the jobs that have been deemed necessary to support both OSW and port site development in California. For a full list of both offshore wind and port development jobs, please refer to Appendix D and Appendix E. In Section 4.1, the Workforce Supply Assessment, the total number of workers *currently* employed in these OSW-related positions is profiled.

Projected baseline demand - Projected baseline demand in this report refers to the labor force growth in a given year (year 2030). This is an annual estimate, meaning it represents how many jobs will be needed in 2030 to fill the workforce demand based on projected adjacent industry growth, worker transitions, and retirements.

Tier 1 - Tier 1 contractors are considered the main suppliers of equipment or services to the project and contract directly with the Developer. Tier 1 suppliers include original equipment manufacturers (OEMs). Contracts are typically worth tens or hundreds of millions for the Tier 1 packages such as turbine supply and installation or BoP supply and installation.

Tier 2 - Tier 2 contractors supply directly to the Tier 1 contractors. These provide products or services that enable Tier 1 suppliers to fulfill their contract with the Developer. Tier 2 contracts can include specialized components such as turbine towers, secondary steel, cable protection systems or electrical equipment. Tier 2 contractors are supplied by Tier 3 contractors.

In many cases Tier 1s will have a Tier 2 supply chain from which they exclusively source certain materials, equipment or services (to guarantee price and schedule certainty). However, often, they will issue a competitive tender process to encourage competition in the supply chain.

Readily available workforce – In this report, readily available workforce refers to the job roles which require two years or fewer of training. The qualification level associated with this workforce includes non-skilled labor, tradesperson, support staff, and skilled trade-standard level roles.

Worker - This study considers a worker as an individual employed to perform work. The worker has a specific job role that may require specific training.

Executive Summary

The purpose of this *Assembly Bill (AB) 525 Workforce Development Readiness Plan* is to provide recommendations for workforce development efforts ahead of the necessary seaport investments and activities identified in the *AB 525 Port Readiness Plan*.

The workforce development readiness plan was developed considering the workforce required in California to deliver 25 GW of offshore wind power generation capacity by year 2045.This assessment includes the potential direct workforce required for the delivery of offshore wind projects, the workforce required for related port infrastructure upgrades as outlined in the *AB 525 Port Readiness Plan*, and the workforce requirement related to transmission network upgrades.

The workforce development assessment consists of three discrete pieces: (1) a needs assessment that analyzed the scale, timing and necessary skills of the required workforce; (2) an assessment of the currently available workforce and training infrastructure in California to support the growth of the offshore wind industry; and (3) a gap and opportunity analysis between the needs and availability assessments.

Special consideration was placed on analyzing the need for occupational safety requirements, the need to require the use of a skilled and trained workforce, and the need for the Division of Apprenticeship Standards to develop curriculum for in-person classroom and laboratory advanced safety training for workers.

The workforce needs assessment reveals a substantial demand for workers in the delivery of offshore wind projects and port infrastructure upgrades. The number of workers required in this field depends on various factors: project quantity, in-state manufacturing, project stage, and specific worker types and quantities needed at each stage. The attraction and establishment of in-state manufacturing has the potential to generate a significant number of workforce opportunities within California. Occupations that represent the manufacturing workforce such as welders and protective coating specialists, typically necessitate specialized certifications, indicating potential upskilling needs (i.e., obtaining new skills) for several workforce categories.

The analyzed hypothetical port upgrade projects will also require a significant workforce, with the potential for several thousand workers to be required depending on the volume and location of future port infrastructure upgrade work. This port infrastructure workforce would require fewer specializations than the required offshore wind workforce, but still needs significant investment and upskilling due to the large number of required workers.

This study's gap and opportunity analysis examined four regions of California: the North Coast, the Bay Area, the Central Coast, and Southern California. This analysis presents several key findings, including the projected workforce needs for offshore wind projects compared against the projected annual growth for several key occupations. The North

Coast and Central Coast regions, which have relatively low workforce populations, have many anticipated gaps in overall workforce numbers. The Bay Area and Southern California regions have a more balanced overall workforce with fewer gaps, but they exhibit shortages in a specialized workforce that will be required in the region(s).

Through the gap and opportunity analysis, this study makes five specific recommendations, along with several action items, for the successful development of a California workforce that will deliver the pipeline of offshore wind projects in California. These recommendations (which are expanded on in **Section 6**), are to:

- Identify a primary state agency for the economic development of California's offshore wind industry;
- Align workforce investments with regional port strategies as well as the strengths and needs of each region;
- Develop training programs and curriculum sequentially, according to workforce demands;
- Engage early with unions, trade organizations, universities, and technical schools, and;
- Invest in research and innovation for manufacturing, assembly, staging, and port logistics.

1 Introduction

Assembly Bill (AB) 525 requires the California Energy Commission (CEC) to evaluate and quantify the maximum feasible capacity of offshore wind (OSW) to achieve reliability, ratepayer, employment, and decarbonization benefits. *AB 525* also requires the CEC, in coordination with specified agencies, to develop a strategic plan for offshore wind energy developments installed off the California coast in federal waters, which must include four key sections: identification of suitable sea space of wind energy areas in federal waters, a plan to improve waterfront facilities that could support a range of floating offshore wind activities, an assessment of the transmission investments needed to support offshore wind, and the development of a permitting roadmap that describes timeframes and milestones for permitting offshore wind activities.

To support the development of the *AB 525 Port Readiness Plan*, this report, the *AB 525 Workforce Development Readiness Plan,* has been drafted to provide key recommendations for the anticipated workforce development efforts ahead of the necessary seaport investments and activities.

To develop these key recommendations, this study conducts three pieces of analysis: 1) a needs assessment that analyzed the scale, timing and required skills of the required workforce; (2) an analysis of the currently available workforce and training infrastructure in California to support the growth of the OSW industry; and (3) a gap and opportunity analysis between the needs and availability assessments.

Section 2 of this report examines the workforce and training needs for California to achieve its 2030 and 2045 OSW development goals. This section also highlights key safety requirements for both relevant onshore and offshore occupations.

Section 3 of this study analyzes the workforce demand needed for the port upgrade projects presented in the *AB 525 Port Readiness Plan*. This analysis utilizes economic impact modelling to showcase the employment demands by industry, by region, and by occupation.

Section 4 focuses on assessing both the existing workforce and training supply for relevant occupations. This section looks at the labor market at a regional level and examines both the OSW and port upgrade supply.

Section 5 provides a regional gap analysis based on the port investments outlined in the *AB 525 Port Readiness Plan*. This gap analysis reflects the potential gaps should the region be fully developed and does not aim to predict which regions and ports will be developed.

Section 6 presents the key recommendations, along with specific action items, to support California's workforce development strategy for ports and OSW. These recommendations are presented in three broad stages, grouped by levels of priority and type of activity.

2 OSW Industry Workforce Demand

The purpose of this OSW industry workforce analysis was to determine the demand for workers that could be generated through the development of California OSW projects.

This study assumes an OSW capacity buildout which meets the State of California's goals of two to five gigawatts (GW) of installed OSW capacity by 2030 and 25 GW by 2045. The total project pipeline is composed of 17 individual floating OSW projects, each with a generation capacity between 500 to 2,250 megawatts (MW). These assumptions were based on known OSW developments in federal waters near California, supplemented by additional theoretical capacity representative of future projects. The timeline of annual and cumulative capacity buildout used as a basis of analysis in this study is shown in **Figure 2.1**.

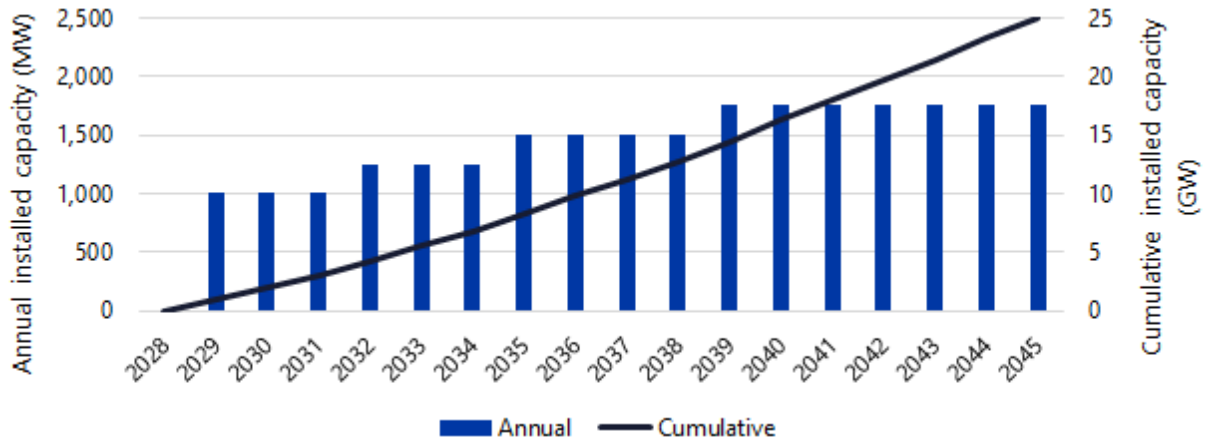

Figure 2.1. Annual and cumulative installed OSW capacity in California. (See Appendix Table J.1 for source data)

The component products and services required in the design, manufacture, installation, and operation of 25 GW of floating offshore wind energy in California can be organized into five primary supply areas: project development, wind turbine supply, balance of plant (BoP) supply, installation and commissioning, and operations and maintenance (O&M).

The **project development** phase of an OSW project consists of the supply of services to support project permitting, surveys, engineering and design, and project management.

Wind turbine supply consists of the manufacture of turbine nacelles, blades and towers.

BoP supply includes the manufacture of turbine foundations, array and export cables, anchors, mooring systems, offshore substations, and onshore electrical infrastructure.

The **installation and commissioning** phase includes the supply of services to install offshore the anchors, mooring systems, array and export cables, and offshore substations. The phase also includes services to integrate the turbine with the foundation at port before tow out and hook-up of the combined unit with the installed offshore infrastructure. It additionally includes port staging and logistics services and the construction of onshore infrastructure.

The **O&M** phase includes services related to wind farm operations and the maintenance and service of turbine and BoP components.

The analysis of the workforce required to deliver OSW projects was carried out through an assessment of workers employed by current companies providing the products and services described in the five supply areas, where alternative approaches to model workforce requirements based on would likely not capture the specific labor requirements, skills sets, and workforce dynamics unique to the OSW sector.

Relying solely on economic impact data may lead to including labor associated with lower Tier 2 or Tier 3 materials and components required for the final product (e.g. turbines), which are produced or sourced from a separate location than the final product itself. One example of this could be the supply of primary steel from outside California or the U.S. compared to the manufacturing of foundations at the respective facility within California. Where alternative economic data lead approaches can be well suited to modeling workforce impacts in established industries, a workforce analysis for the OSW industry requires a more comprehensive approach that takes into account factors such as project stages, job roles, skills requirements, and regional considerations.

To focus on the local demand within California, for the workforce assessment of each supply element only Tier 1 contracts and work performed at local manufacturing or supply facilities within California for the final demand for products and services was considered. For example, at a Tier 1 turbine nacelle assembly facility only the workers employed directly at the facility were considered, whereas the workforce required to supply Tier 2 sub-components, equipment and materials manufactured off-site was not.

The workforce numbers used in the analysis were derived from industry data and through engagement and validation with developers and original equipment manufacturers (OEMs) that determined the number of workers required to provide the products and services in each supply area. A description of the activities included for the elements within each supply area is provided in Appendix A. List of Supply Elements by Project Supply Area.

The job roles included for the delivery of each supply element were considered alongside the associated level of professional qualification, the need for specialist certifications, and the number of workers required to fulfill the supply requirement.

The sequencing of each workforce requirement over the lifetime of the OSW project is a key consideration for California's workforce development strategy. An approximate

timeline by year of the workforce requirement for each supply element relative to the Commercial Operation Date (COD) for a generic floating OSW project is shown in **Figure 2.2**.

Mapping the workforce demand timeline for an OSW project against the capacity buildout schedule enables an estimation of the total workforce demand, where year 0 represents the year of COD. Project development can begin long in advance of COD, with project development teams being formed and development services procured around five years prior. The supply of manufactured components, including the turbines and BoP such as foundations, cables, and substations, typically begins up to two years prior to COD. Offshore installation services begin for some components, such as substations, subsea cables, anchors, and moorings, in the year before COD, after which turbines will be integrated with their foundation and towed to site for hook-up with the pre-installed infrastructure and final commissioning. O&M services are needed from COD throughout the lifetime of the project, which is typically 25+ years.

	Project Development/Manufacturing/Installation					Operations			25+yr Lifetime>>
Supply Element	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**
Development and permitting	X	X	X	X					
Surveys	X	X	X	X					
Engineering and design	X	X	X	X					
Project management	X	X	X	X	X	X			
Nacelle					X	X			
Rotor					X	X			
Tower					X	X			
Floating Foundation					X	X			
Secondary steel components					X	X			
Foundation assembly					X	X			
Offshore substation				X	X				
Onshore substation					X	X			
Array cables				X	X				
Export cables				X	X				
Anchors				X	X				
Mooring				X	X				
Foundation tow out/hook up						X	X		
Offshore substation installation					X				
Subsea cable installation					X	X			
Anchors installation					X	X			
Mooring installation					X	X			
Turbine intergration (crane)						X	X		
Ports and logistics						X	X		
Onshore construction				X	X				
Operations						X	X	X	X
Turbine maintenance and service						X	X	X	X
BoP maintenance and service						X	X	X	X

Figure 2.2 Workforce requirement for each supply element relative to OSW project Commercial Operation Date.

To account for the high degree of uncertainty in the necessary supply chain and workforce requirements for California's floating OSW industry, this analysis uses three

scenarios to describe the impact on workforce demand for different levels of local investment in OSW supply chain infrastructure.

The **high scenario** is based on the assumption that a significant investment is made in multiple local, major component manufacturing facilities to enable high domestic supply chain content and economic benefits. This would include investment in three ports for turbine staging and integration (S&I), one turbine nacelle assembly facility, two blade manufacturing facilities, one tower manufacturing facility, two foundation manufacturing facilities, two subsea cable manufacturing facilities, one mooring line manufacturing facility, and one anchor fabrication facility. This is considered a highly ambitious scenario that represents an optimistic upper limit for local workforce demand. While the high scenario is descriptive of the maximum workforce possible in each supply category, it is highly unlikely that all supply categories will be provided within the state.

The **medium scenario** is based on the assumption that some investment is made in local major component manufacturing facilities that supports a hybrid approach between domestic and global suppliers. Investment associated with this scenario includes three ports for turbine S&I, one tower manufacturing facility, one foundation manufacturing facility, one subsea cable manufacturing facility, one mooring line manufacturing facility, and one anchor fabrication facility. This scenario is considered ambitious and represents an upper limit for a realistic local workforce demand.

The **baseline scenario** is based on the assumption that no additional investment is made in local major component manufacturing facilities. The workforce requirements in the low scenario are descriptive of current local capacity as well as logical assumptions that workforce demand will be created through the buildout of nearby OSW projects alone. This scenario is considered cautious and represents a plausible lower limit for local workforce demand.

The anticipated timing for components and servicing support for each scenario is shown in **Table 2.1**. Additional assumptions used in determining workforce demand are discussed according to supply area.

Project development: Early-stage project development activities are assumed to be local starting in year 2024, with full capabilities expected for project development activities including detailed engineering and design and a full-range of surveying capacity beginning in year 2035.

Wind turbine supply and BoP supply: The workforce supplying the manufacturing components considers the individuals required at the endpoint of the supply chain. The numbers and roles are derived from the individuals needed at the manufacturing facility, required to manufacture and transport the supply components. The manufacturing of Tier 2 and Tier 3 supply components was not considered. The foundation supply element was modeled using both steel and concrete as primary materials to describe each possible supply outcome and the relative workforce

considerations. For the purpose of this work, the results depict the workforce required for concrete foundations, as the workforce demand is highest for concrete supply.

Installation and commissioning: Offshore crew for large installation vessels were not assumed to be supplied by California for any scenario, with the exception of project managers and engineers seen in the project development phases. In the installation phase, S&I will occur in-state and assumes the use of a quayside workforce and a local offshore workforce for support tugs.

O&M: The O&M activities do not consider major component replacement; however, the entire workforce is anticipated to come from California. Eleven distinct O&M bases have been identified in the *AB525 Port Readiness Plan*, and as such, eleve 11 11 distinct workforces were considered.

For a complete list of the workforce considered in each supply element, see Appendix A.

Table 2.1. Timing of workforce availability in each supply area for each of three analysis scenarios.

Supply Area	Baseline Scenario	Medium Scenario	High Scenario
Project development	Entire supply can be delivered by local workforce from **2035**.	Entire supply can be delivered by local workforce from **2035**.	Entire supply can be delivered by local workforce from **2035**.
Wind turbine supply	Without local manufacturing facilities, no supply anticipated.	Local workforce for tower manufacturing from **2030**.	Nacelle assembly by **2030**, (2) blade manufacturing facilities by **2030** and **2035**, and towers manufacturing from **2030**.
Balance of plant supply	Concrete supply for floating hulls and some onshore substation supply from **2030**.	Local workforce for foundation assembly by **2030,** nacelle manufacturing by **2030**, cable, moorings and anchors manufacturing from **2035**.	Local workforce for foundation assembly by **2030**, nacelle manufacturing by **2030**, (2) cables manufacturing facilities, mooring and anchors manufacturing from **2035**.
Installation & commissioning	Quayside workforce for (S&I), loadout, offshore logistics and onshore construction, where ports will come online in **2029**, **2030** and **2035**.	Quayside workforce for (S&I), loadout, offshore logistics and onshore construction, where ports will come online in **2029**, **2030** and **2035**.	Quayside workforce for (S&I), loadout, offshore logistics and onshore construction, where ports will come online in **2029**, **2030** and **2035**.
Operations & maintenance	Local workforce used for operations and maintenance from **2030**.	Local workforce used for operations and maintenance from **2030**.	Local workforce used for operations and maintenance from **2030**.

The annual workforce demand for the offshore wind industry in California was determined based on the following input variables: the annual installed capacity (**Figure 2.1**), the project delivery timeline for each offshore wind project (**Figure 2.2**),

and the local content assumptions in the three scenarios (**Table 2.1**). **Figure 2.3** shows the annual workforce demand in California for the high, medium, and baseline local content scenarios, organized by project phase. The year 2040 represents the highest annual workforce demand, with approximately 7,000 workers required in the medium scenario and over 8,000 workers in the high scenario.

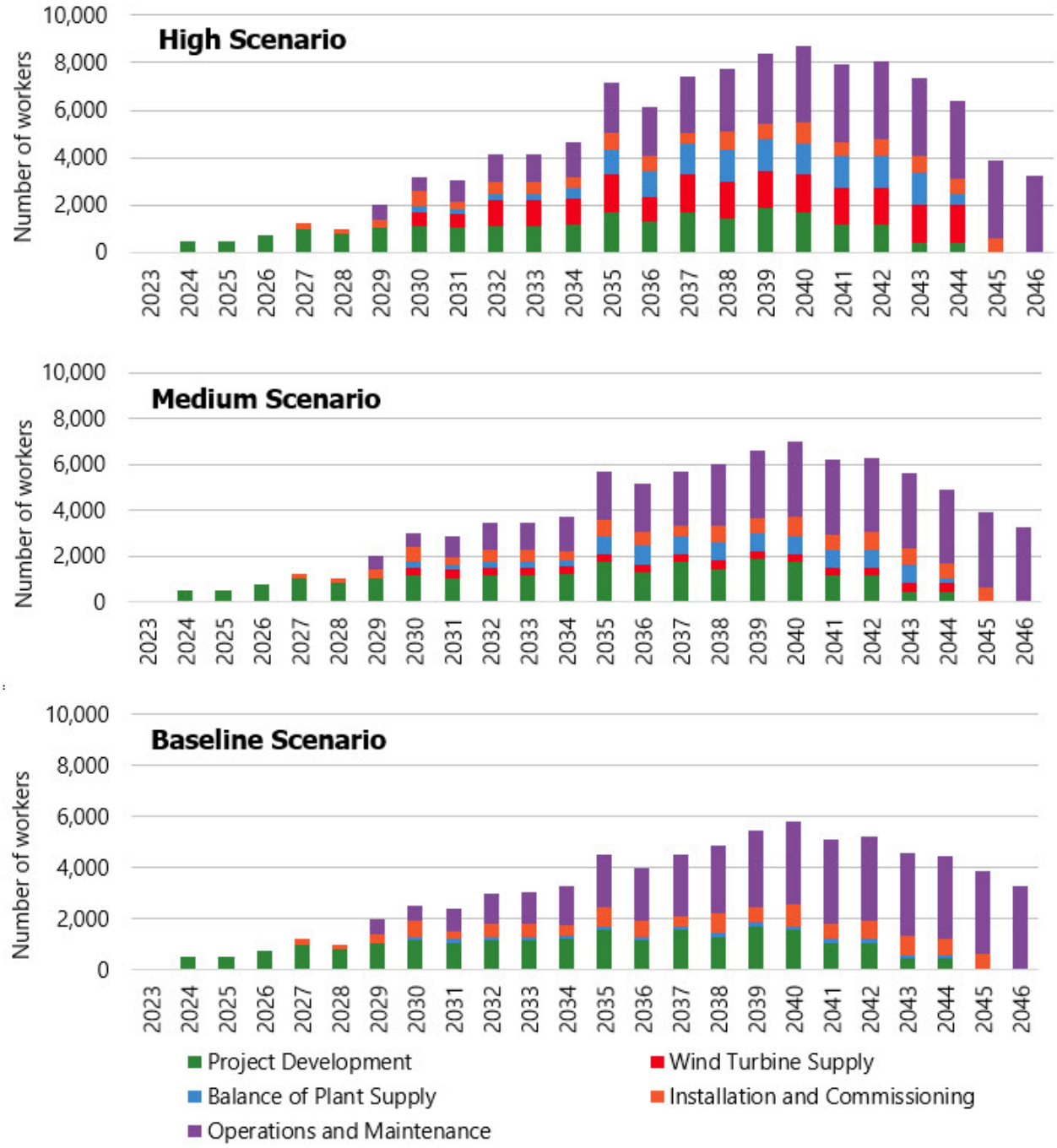

Figure 2.3. Comparison of workforce requirements by project area under High (top), Medium (middle), and Baseline (bottom) Scenarios. (See Appendix Table J.2, Table J.3, and Table J.4 for source data)

The analysis highlights a consistent demand for labor in the project development and O&M phases. All three scenarios show the workforce required for the project development and O&M phases. This workforce is consistent in all scenarios regardless of the proportion of local manufacturing. In the medium scenario where a majority of

production of components become localized, there is a significant increase in labor demand, nearly doubling that of the baseline scenario.

Job roles associated with the OSW industry have been categorized by qualification level, based on minimum training required and the length in years of obtaining these experience and/or training requirements. **Table 2.2** provides the description for the various qualifications considered in this study.

Table 2.2. Qualification levels OSW workforce.

Qualification level	Description of Minimum Training and/or Certification	Training Length
Manager	Formal education/combination of education and experience	5+ years
Skilled trade – Specialist	Requires training and apprenticeship pls additional experience or specialization (e.g., senior vessel crew, supervisory roles, etc.).	5+ years
Engineer	Engineering degree from university	4+ years
Scientist	Science degree from university	4+ years
Other University Degree	University degree other than engineering/science	4+ years
Skilled trade - Standard	Requires skilled vocational training	2+ years
Support staff	Requires some formal training (e.g., admin, HR, etc.)	2+ years
Tradesperson	Requires training/certification/apprenticeship	1+ years
Non-skilled labor	Requires no formal training, only on-the-job experience	>1 year

The workforce can be broadly categorized into two areas based on the length of training required for their role. A readily available workforce includes job roles which require two years or less of training. A highly skilled workforce can be defined as those job roles which require four-plus years of training. **Figure 2.4** and **Figure 2.5** demonstrate the annual workforce demand for the high, medium, and baseline scenarios by qualification level for a readily available and highly skilled workforce.

This study found an immediate demand for a highly skilled workforce to support project development activities, with an opportunity for over 650 workers by 2026, and as many as 1,600 by 2039 for the high scenario. This demand may be addressed through recruitment efforts aimed at developing teams with prior experience in OSW from other geographical areas, or by attracting workers with similar experience in offshore environments from adjacent industries.

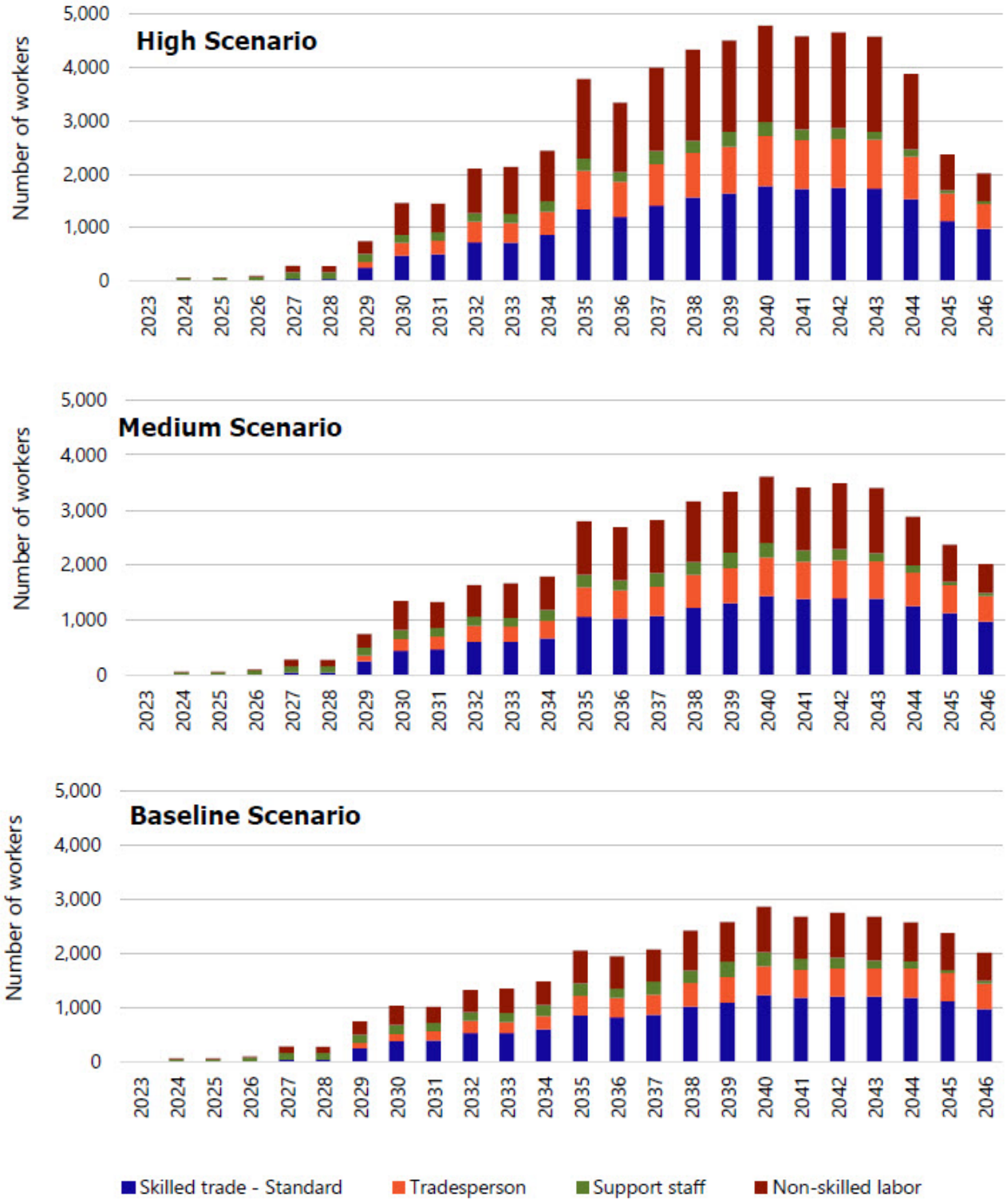

Figure 2.4. Comparison of workforce requirements by training level for a readily available workforce under High (top), Medium (middle), and Baseline (bottom) Scenarios. (See Appendix Table J.5, Table J.6, and Table J.7 for source data)

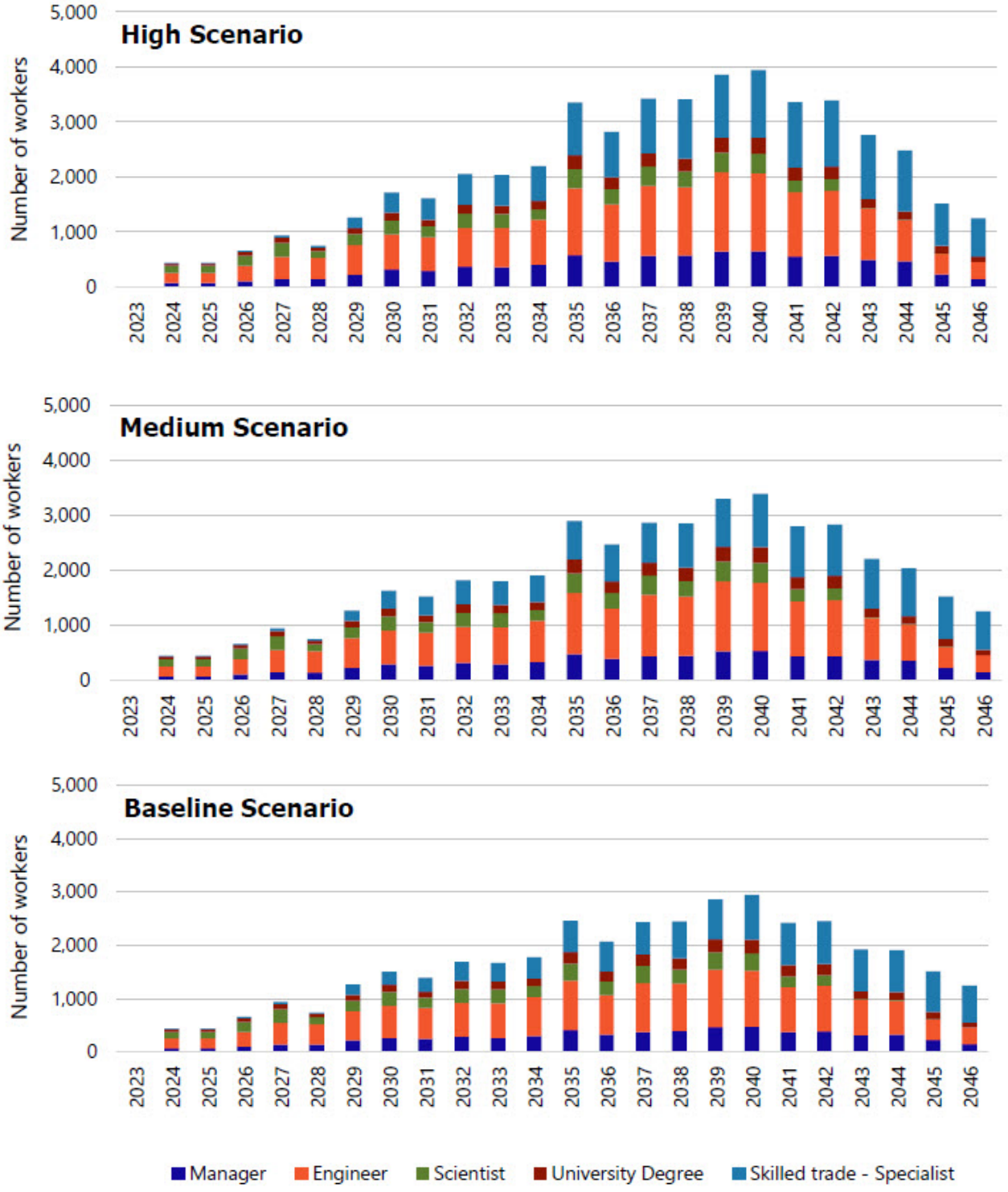

Figure 2.5. Comparison of workforce requirements by training level for a highly skilled workforce under High (top), Medium (middle), and Baseline (bottom) Scenarios. (See Appendix Table J.8, Table J.9, and Table J.10 for source data)

2.1 Workforce Demand for Key Occupations

Workforce demand has been measured as the number of workers required annually to deliver the pipeline of California projects under each scenario. Occupations projected to have the most significant growth through year 2045 are shown in **Table 2.3** and **Figure 2.6**, where the workforce demand for each scenario reflects the approximate maximum annual demand. Each job role was aligned with the appropriate Standard Occupational Classification (SOC) code, for easier comparison and analysis with employment trends and workforce statistics in each region.

Table 2.3. List of job roles, respective apprenticeship opportunity, and maximum annual demand through 2045.

Job Role	SOC Code(s)	Opportunity for apprenticeship learning	Baseline Max. annual workforce demand	Medium Max. annual workforce demand	High Max. annual workforce demand
Crane operator	53-7021.00	Yes	112	142	175
Heavy equipment operator	49-3042.00	Yes	147	187	269
Ironworker	47-2221.00	Yes	78	138	287
Laborer	47-2061.00	No	360	475	625
Machinist	51-4041.00	Yes	84	145	222
Onshore Engineer	Varies, mostly comprised of: 17-2141.00 17-2071.00 17-2112.00 17-2051.00	No	345	458	637
Offshore Engineer	Varies, mostly comprised of: 17-2141.00 17-2051.00 17-2071.00 53-5031.00	No	338	338	338
Production operative	51-9199.00	No	5	125	315
Protective coating technician	51-9124.00	Yes	177	221	3966
Rigger	49-9096.00	Yes	186	225	317

Job Role	SOC Code(s)	Opportunity for apprenticeship learning	Baseline Max. annual workforce demand	Medium Max. annual workforce demand	High Max. annual workforce demand
Scaffolder	47-2061.00	No	66	91	127
Welder	51-4121.00	Yes	156	248	450

Skilled-trade standard and skilled trade specialist jobs will be in the highest demand due to their involvement in activities across a broad range of project phases. The observed variation in workforce demand between the three scenarios can be directly attributed to the introduction of manufacturing supply in-state.

As the OSW industry expands in California, the corresponding workforce needs will be significantly impacted. In the high scenario, which involves localizing all major OEM supply components in-state, the state must be prepared to increase its skilled-trades workforce by almost double when compared with the baseline scenario, as shown in **Figure 2.6**.

In the baseline scenario, engineers and laborers represent the highest-demand job roles, due to their skills being required in multiple phases of an OSW project. These roles are less dependent on the presence of local manufacturing facilities and increase based on size of total project pipeline. Given the high volume of engineering work required for project development activities, this presents a potential opportunity for a higher-earning engineering workforce to be developed and sustained in California.

In the high scenario, laborers, engineers, and welders are projected to be in greatest demand, as their skills are essential for the manufacturing, installation, and operations of a project.

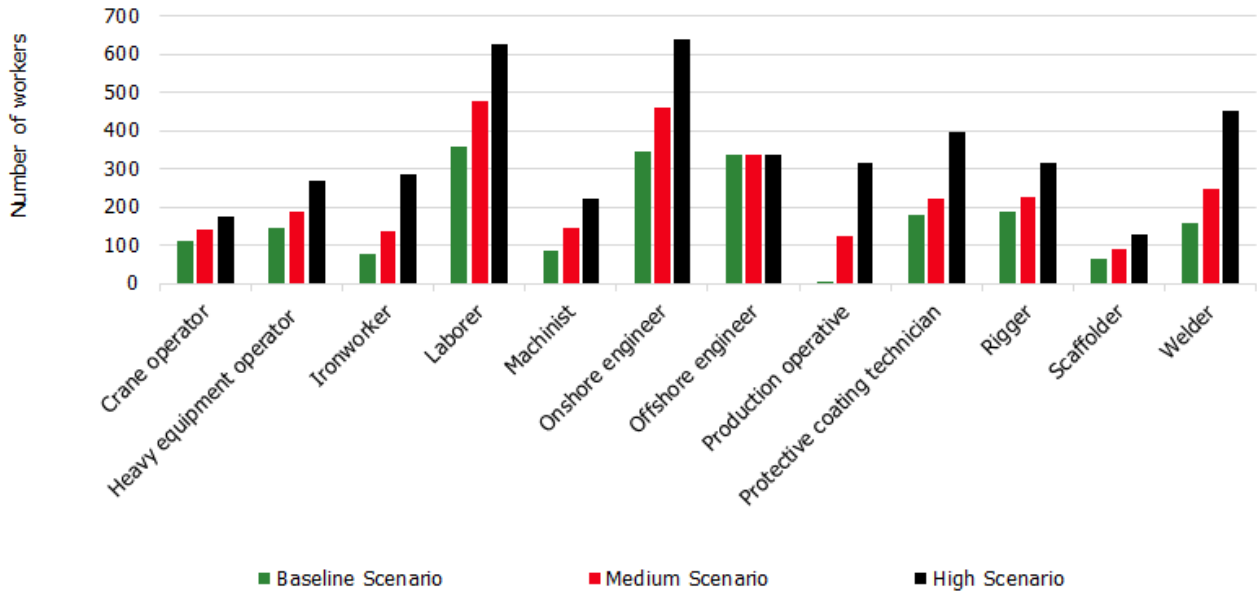

Figure 2.6. Number of workers required in the year with maximum workforce demand for each job role across the high, medium, and baseline scenarios. (See Appendix Table J.11 for source data)

California is poised for significant growth in onshore construction and manufacturing-related skilled-trades jobs, many of which require specific certifications through apprenticeship programs. **Figure 2.7** illustrates the annual apprenticeship opportunities under all three scenarios, where the demand for apprentices nearly doubles between the baseline and high scenario.

Apprentice opportunities play a key role in developing a sustainable workforce as they provide a pathway for developing important skills that will become increasingly critical as the California OSW industry develops. Additionally, several pieces of legislation, including the newly introduced Inflation Reduction Act (IRA), have provisions that require specific apprenticeship use rates and prevailing wages.

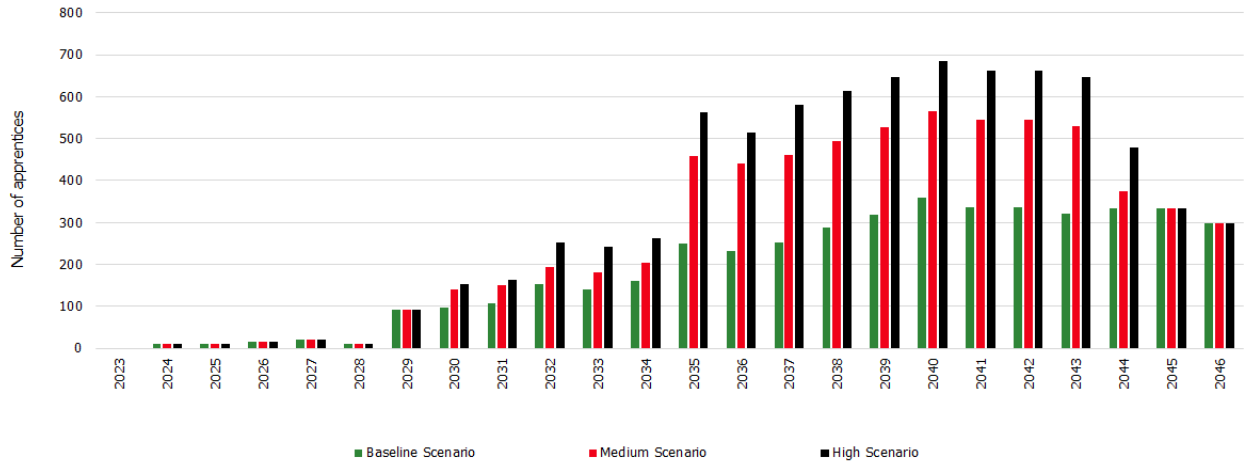

Figure 2.7. Number of apprentices required in each year for the baseline, medium, and high scenarios. (See Appendix Table J.12 for source data)

2.2 Workforce Qualifications by Supply Area

To better understand the workforce needs and associated training requirements in each of the five primary supply areas associated with delivering of an offshore wind project, a summary of the workforce opportunities and required qualifications is provided below.

2.2.1 Project Development

Project development includes the work undertaken by the OSW farm developer and the services contracted prior to the developer reaching the final investment decision on the project.

Opportunities for the local workforce typically can include:

- Permitting services
- Environmental impact assessment
- Offshore environmental surveys
- Offshore geological and hydrological surveys
- Onshore environmental surveys
- Legal services
- Financial services
- Community liaison
- Electrical design
- Installation design
- Construction management
- Health, Safety, Environment and Quality HSEQ services
- Front-End Engineering Design (FEED) scopes

The job roles for this project phase do not require specific certifications, outside of the safety certifications required to work on a vessel (which is relevant for the survey sub-

element). Many of the job roles in this project phase are likely to be fulfilled by individuals with undergraduate degrees.

2.2.2 Wind Turbine Supply

Wind turbine supply is a labor-intensive activity that requires a sizeable and skilled workforce to ensure product delivery. Production of OSW turbines requires knowledge and certification of working with steel that meets the grade requirements for offshore use. Production also requires use of heavy lift machinery, specialized testing, and specialized design work. Certifications needed for this phase include:

- American Society of Nondestructive Testing Central Certification Program (ACCP) Level II Certification
- American Welding Society (AWS) Submerged Arc Welding Certification
- AWS D1.1, D1.2, D1.3, D1.4 Certification/Endorsement
- AWS Certified Welding Inspector
- American Petroleum Institute (API) 1104 Certification
- 6G Certification
- Certified Safety Professional
- Construction Safety and health Technician
- Phased Array and Manual Ultrasonic Testing Certification
- Magnetic Particle and Penetrant Certification
- Norwegian Professional Council for Education and Certification of Inspectors of Surface Treatment (FROSIO) – Level 3
- The Society for Protective Coatings (SSPC) Protective Coating Specialist
- Certification of Crane Operators (CCO) Mobile Crane Operator Certification

To obtain these certifications, individuals will need to participate in various training and apprenticeship programs. These programs differ in length (from several weeks to multiple years) and are determined by the level of specialization required. Some of the specific welding certifications (such as the API 1104 Certification or the AWS Submerged Arc Welding Certification), may not be widely taught in current apprenticeship and vocational educational programs, and may require additional training resources.

2.2.3 Balance of Plant Supply

BoP supply covers the delivery of main components of an offshore wind farm outside the wind turbine supply, such as supply of foundations, cables, and mooring systems.

Floating foundation designs can vary significantly from large semisubmersible hulls comprised of columns and trusses to monopile-like spars to tubular semi-spars.

The fabrication of a concrete foundation adds a unique skill set required for the balance of plant supply. The unique certifications that may be required for this operation are:

- American Concrete Institute Concrete Field-Testing Technician Level 1
- CCO Pump Operator Certification
- Concrete Laboratory Testing Technician - Level 1

Steel foundation fabrication requires a much greater reliance on complex welding and ironwork. Anchor fabrication will also rely heavily on specialized welding and ironwork skills and requires the processing and handling of large quantities of material. Mooring production is assumed to be largely automated, but also still relies on welding and production personnel. The specializations required for the supply of the balance of plant with a steel semisubmersible foundation include:

- ACCP Level II Certification
- AWS Submerged Arc Welding Certification
- AWS D1.1, D1.2, D1.3, D1.4 Certification/Endorsement
- AWS Certified Welding Inspector
- API 1104 Certification
- 6G Certification
- Certified Safety Professional
- Construction Safety and Health Technician
- Phased Array Ultrasonic Testing Certification
- Magnetic Particle and Penetrant Certification
- Ultrasonic Testing Level 2
- CCO Mobile Crane Operator Certification
- Ironworker Rigger and Signal Person Certification
- Qualified Rigger Certification (Level 1 and Level 2)
- SSPC Protective Coating Specialist
- FROSIO – Level 3

Similar to the certifications required for the wind turbine supply area, the above certifications are typically obtained through apprenticeship and other vocational educational programs. Other certifications, such as the FROSIO – Level 3 Certification, will require individuals to actively pursue additional accreditation and will need the prerequisite levels of experience to become certified.

2.2.4 Installation and Commissioning

Installation and commissioning include the services contracted to construct a floating OSW project. Companies can be contracted during the project installation phase to

support construction, staging, marshaling, and associated port services. This takes place for components that are stored at a port close to the offshore project location prior to installation, such as turbine nacelles and blades. Some components, however, such as the subsea cables, are typically picked up for installation offshore directly from the manufacturing facility. Support services for OSW project installation include marine coordination, weather forecasting, supply of guard vessels, feeder barges, and crew transfer vessels (CTVs).

Opportunities for local workforce typically can include:

- Port services
- Marshalling
- Crawler cranes
- Stevedoring
- Bunkering
- Transport services
- Towing tugs
- Marine coordination
- Crew transfer vessels
- Onshore services
- Sitework
- Crewing services
- Onshore logistics
- Meteorological forecasting
- Scour supply, transport, and installation
- Guard vessels
- Onshore construction scopes
- Land surveys
- Architects
- Construction and building contractors
- Electrical contractors

The education requirements for this phase include manufacturing and construction certifications and are:

- AWS Certified Welding Inspector
- Certified Safety Professional
- Construction Safety and Health Technician
- CCO Mobile Crane Operator Certification
- Global Wind Organization (GWO) Training
- United States Coast Guard (USCG) Master License
- Transportation Worker Identification Credential (TWIC)
- Merchant Marine Credential (MMC)
- Standards of Training, Certification and Watchkeeping for Seafarers (STWC)
- Protected Species Observation Certification
- National Electric Code Exam

The certifications required for this project phase largely revolve around the requirements needed to work at sea (in addition to other construction certifications),

such as the TWIC, MMC, STWC, and USCG Master License. The qualifications usually take from several weeks to several months to obtain and are accredited by varying bodies such as the USCG and the Transportation Security Administration.

2.2.5 Operations and Maintenance

Offshore wind farm operations require a supply of services that support the management and optimization of the project including control room equipment and software to deliver asset performance, health and safety, and environmental monitoring. A range of services and software are required to support marine coordination and planning such as communications and weather forecasting.

Opportunities for local workforce typically can include:

- Meteorological forecasting
- Port services as per installation support scopes
- Marine warranty surveying
- Mechanical inspection
- Electrical inspection
- Blade inspection
- Structural inspection
- Equipment inspection
- Remotely Operated Vehicle (ROV)

With the O&M phase of the project consisting of at least a 25-year period, there is significant opportunity for engagement with a large and diverse workforce. The certifications that would be required for the O&M phase are listed below.

- AWS Certified Welding Inspector
- Certified Safety Professional
- Construction Safety and health Technician
- CCO Mobile Crane Operator Certification
- Airline Transport Pilot Certificate
- Ironworker Rigger and Signal Person Certification (OSHA Qualified)
- Qualified Rigger Certification (Level 1 and Level 2)
- GWO Training
- USCG Master License
- TWIC
- MMC
- Commercial Diver Certification
- National Electric Code Exam

The O&M project phase has many of the certifications that are required in previously addressed project phases. GWO certifications are critical in this project phase, as technicians who provide turbine maintenance will be required to be GWO certified. While the GWO Basic Safety Training will likely be the highest in demand, other GWO certifications such as the Basic Technical Training are also likely to be highly utilized in this project phase.

2.3 General Workforce Safety Requirements

The U.S. offers a modular approach when it comes to gaining the necessary certification to work on an OSW farm. This approach allows personnel to obtain their required training by completing a variety of courses, rather than one specific OSW program for their respective position. Many of the safety and skill certifications that workers will need to work at their existing professions will overlap with the requirements they will need for working on an OSW farm. Additional certifications will likely be needed when an individual is changing their work setting (i.e., working at sea, working at heights, working on a turbine, etc.).

2.3.1 Global Wind Organization Standards

The Global Wind Organization (GWO) has published a wide range of training standards and certifications that educate individuals who will be working on/with wind turbines. The Basic Safety Training Standard is one of the most universally accepted safety programs for wind energy professionals. GWO training consists of five modules, listed below, that are typically completed within seven to ten days, as an additional and/or supplemental course taught at maritime-specific educational organizations. The sea survival course is an additional module required for offshore workers.

- First Aid
- Manual Handling
- Fire Awareness
- Working at Heights
- Sea Survival

In both the baseline and medium scenario, nearly 400 workers will need to have a GWO certificate by year 2035, shown in **Figure 2.8**.

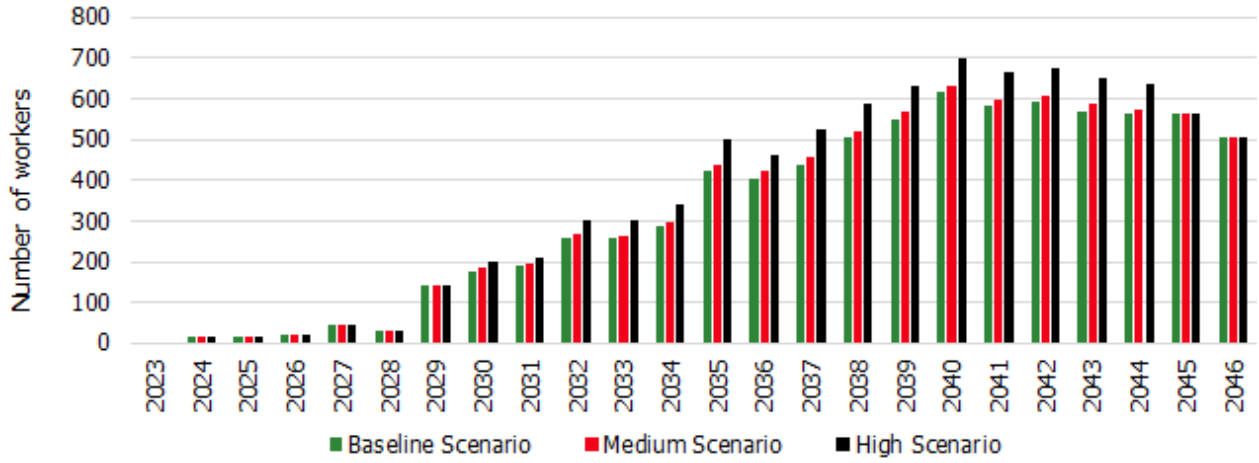

Figure 2.8. Approximate number of workers requiring GWO training in each year for the baseline, medium and high scenarios. (See Appendix Table J.13 for source data)

2.3.2 Offshore Safety Governance and Certifications

The United States Coast Guard (USCG) is responsible for the inspection and oversight of U.S. vessels that support OSW installation, operations, and maintenance. This oversight includes U.S. mariner licensing and vessel manning requirements, lifesaving and firefighting equipment approvals, vessel machinery, electrical systems, and stability. Special equipment and operations (e.g., cranes and commercial diving) may be subject to USCG review if installed on or conducted from a vessel that is supporting OSW operations.

Individuals will need specific training to certify that they understand the necessary safety protocols and are medically able to work offshore. In addition to the GWO Sea survival module, the Basic Offshore Safety Induction and Emergency Training certification is often mandatory to work at sea. This certification is taught by several educational bodies, such as the Offshore Petroleum Industry Training Organization, and usually takes three to four days to complete. Additionally, individuals will need a certified medical certificate, like the ENG1 medical certificate. For the ENG1 certificate, a person would get medically examined by a Maritime and Coastguard Agency-approved doctor.

Figure 2.9 shows the annual demand of workers with offshore safety training, with a peak demand of over 3,000 workers in 2040. The annual values do not change across the three scenarios, as the locality of the workforce involved in offshore work does not change.

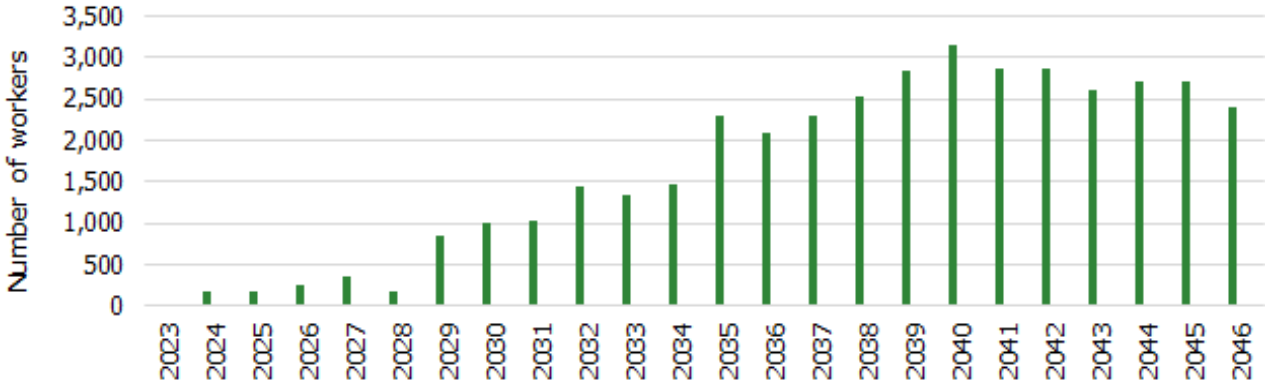

Figure 2.9. Approximate number of workers requiring offshore safety training in each year. (See Appendix Table J.14 for source data)

2.3.3 Onshore Safety Governance and Certifications

Regulating the safety of onshore construction falls under the authority of the OSHA, which enforces safety and health in the workplace and mandates training for workers. Many roles in the construction of an OSW farm will overlap between the Bureau of Safety and Environmental Enforcement and OSHA, and some individuals may require multiple specific training courses that fall under both organizations.

OSHA's occupational safety and health regulations are organized by employment type and the specific safety requirements of different disciplines and roles. General Industry certification is obtained through the OSHA Outreach Training Program's 10-hour and 30-hour safety courses. OSHA 10 covers most non-specific job roles, and OSHA 30 may be required when the individual is responsible for the safety and health of others.

Specific roles that require the use of motorized equipment, the handling of dangerous materials, cranes and vehicles, or specialized industrial equipment usually require additional training certifications obtained through OSHA. These certifications are organized under a series of codes and are discipline specific.

3 Infrastructure Upgrade Workforce Demand

3.1 Port Infrastructure Workforce Needs

The opportunity for infrastructure upgrades in California is dependent on the total offshore wind deployment schedule for OSW generation, along with the subsequent ability for California to attract OSW manufacturing facilities. The exact buildout of the California OSW project capacity pipeline and associated timing and extent of associated infrastructure upgrades continues to be subject to considerable uncertainty. To enable the modeling of a full buildout of the OSW sector in California and the resulting implications on workforce demand, the assessed workforce needs in each California region are based on a scenario of all manufacturing facilities and associated demand for manufacturing skills being realized. The total range of port options identified in the *AB525 Port Readiness Plan* will not each be required to meet the demand for OSW manufacturing facilities in California and thus the total of port infrastructure upgrade options identified in each region may not be necessary. However, this study does not make assumptions about the likelihood of specific ports undertaking infrastructure upgrades. The workforce demand results analyze each region assuming that all port upgrade options identified by the *AB525 Port Readiness Plan* are implemented. In other words, though it is unlikely the state will upgrade all ports, decisions have not yet been made on which ports will be upgraded, and as such, this study analyzes the workforce needs assuming all ports will be upgraded.

The job creation findings from the analysis are presented in terms of direct[1] **Full-Time Equivalents (FTEs)**, which are units that represent a full-time workload of 2,080 hours (40 hours per week for 52 weeks). This unit of measurement is useful to normalize and compare the workforce implications of different investment streams. It should be noted that FTEs are not equivalent to full-time jobs, they merely represent the number of hours worked to complete the work done by one full-time employee in one year. For example, one full-time employee that works 2,080 hours and two part-time workers that each work 1,040 hours in the same activity, both represent 1 FTE.

3.1.1 Key Findings

Job creation differs both by region and port construction timelines. Southern California alone—including both the Long Beach and Los Angeles ports—could support the greatest number of annual FTEs. In total, this region could support almost 4,800 direct FTEs each year between 2027 and 2034.

[1] Direct employment refers to work that is done directly on the activity being analyzed (where indirect employment would consider the employment further down the supply chain that supports port development). In this study, only direct employment is considered.

Port upgrades in the North Coast could support 3,300 FTEs in construction and the professional services—engineering and architecture—from 2026 until 2030. The vast majority of these FTEs would be found in construction-related activities (3,100 FTEs).

The Bay Area could support more than 1,500 FTEs each year between 2026 and 2030. This would include upgrades to the ports of San Francisco, Stockton, and two Private Terminals, one in Antioch and one in Pittsburg.

Across the ports of Morro Bay and San Luis, the Central Coast could experience the lowest job (FTE) growth, supporting 110 FTEs annually between 2027 and 2030. About 95% of these FTEs would be in construction, while the remaining five percent would be in professional services industries, such as engineering, design, and architecture.

Between 2032 and 2035, the Los Angeles and Long Beach ports would be the only ports in the state to continue their upgrade activities, with the potential to support 3,300 FTEs every year.

3.1.2 Methodology and Inputs

The modeled employment for port upgrades in California was derived using the IMPLAN Input-Output (I/O) modeling tool as well as local industry multipliers, using data from previous evaluations from Moffat & Nichol's *AB 525 Port Readiness Plan* of potential OSW industry ports in the state. These data include total investment dollars, port locations, length of construction period, and scenario descriptions.

The model outputs provide insight into the economic benefits from port upgrade investments in different locations across California, using the industry interdependencies at the local level for each port. FTE outputs represent the estimated amount of work hours that result from the modeled investment streams, and the research team assumed an even distribution of the investment streams throughout the years of port upgrades to provide annual FTEs for each location.

The following table shows the timeline of construction for all the ports being upgraded in California. This timeline assumes the ports are able to secure all necessary permits and approvals and meet the schedule that is needed to achieve the state's offshore wind planning goals. The "x" denotes a full year during which construction activities occur for port upgrades.

Table 3.1. Construction timeline by port.

Port	Region	Port Use	Construction Years	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Port of Humboldt	North Coast	S&I and Manufacturing	5	x	x	x	x	x					
Port of Los Angeles	Southern California	S&I and Manufacturing	8		x	x	x	x	x	x	x	x	

Port	Region	Port Use	Construction Years	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Port of Long Beach	Southern California	S&I and Manufacturing	9		x	x	x	x	x	x	x	x	x
Port of San Francisco	Bay Area	Manufacturing	5	x	x	x	x	x					
Port of Stockton	Bay Area	Manufacturing	5	x	x	x	x	x					
Bay Area Private Terminal - Amports Antioch	Bay Area	Manufacturing	6	x	x	x	x	x	x				
Bay Area Private Terminal - Pittsburg	Bay Area	Manufacturing	6	x	x	x	x	x	x				
Crescent City	North Coast	O&M	5		x	x	x	x	x				
Port of Humboldt	North Coast	O&M	4		x	x	x	x					
Morro Bay Harbor	Central Coast	O&M	4		x	x	x	x					
Port San Luis	Central Coast	O&M	4		x	x	x	x					
Port of San Francisco	Bay Area	O&M	4		x	x	x	x					

The total investments for each port, categorized by region and port use, is provided in **Table 3.2** where the investment numbers were taken directly from *AB 525 Port Readiness Plan*.

Table 3.2. Total investments by port.

Port	Region	Site Use	Total Investment
Port of Humboldt	North Coast	Staging & Integration + Manufacturing / Fabrication	$2,700,000,000
Port of Los Angeles	Southern California	Staging & Integration + Manufacturing / Fabrication	$2,100,000,000
Port of Long Beach	Southern California	Staging & Integration + Manufacturing / Fabrication	$5,400,000,000
Port of San Francisco	Bay Area	Manufacturing / Fabrication	$345,000,000
Port of Stockton	Bay Area	Manufacturing / Fabrication	$350,000,000
Bay Area Private Terminal - Amports Antioch	Bay Area	Manufacturing / Fabrication	$520,000,000
Bay Area Private Terminal - Pittsburg	Bay Area	Manufacturing / Fabrication	$520,000,000
Crescent City	North Coast	Operations & Maintenance	$35,000,000
Port of Humboldt	North Coast	Operations & Maintenance	$15,000,000

Port	Region	Site Use	Total Investment
Morro Bay Harbor	Central Coast	Operations & Maintenance	$50,000,000
Port San Luis	Central Coast	Operations & Maintenance	$20,000,000
Port of San Francisco	Bay Area	Operations & Maintenance	$20,000,000
Port of Hueneme	Central Coast	Operations & Maintenance	$0

[1] **Port of Hueneme** can **be used for O&M but does not require further upgrades.**

3.1.3 Employment by Industry for Port Upgrades in California

As shown on **Figure 3.1**, about 95% of the direct FTEs for port upgrades would be in the construction industries; this represents almost 9,300 FTEs every year between 2027 and 2030, which are the years of highest workforce demand.

Close to five percent of all direct employment required for port upgrades in California would be in the professional services industries, and more specifically, in engineering, architecture, and design. In the peak years of upgrades, these industries could support over 530 annual FTEs.

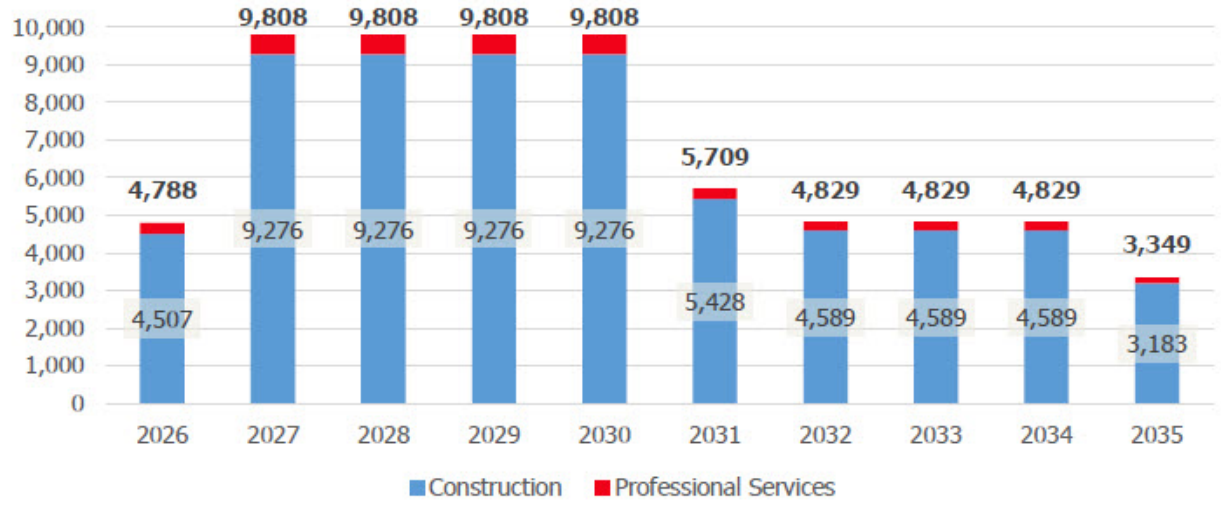

Figure 3.1. Industry FTE employment outputs for statewide port upgrades. (See Appendix Table J.15 for source data)

3.1.4 Employment by Region for Port Upgrades in California

To meet the state offshore wind planning goals, the North Coast and Bay Area would start port upgrade construction activities beginning in 2026. **Figure 3.2** shows that in 2026, activity at these ports would support close to 4,800 FTEs. Between 2027 and 2030, California would see the highest demand for workers in port upgrades, supporting over 9,800 annual FTEs during these four years.

Between 2031 and 2035, California could finalize upgrades to its ports and the number of FTEs supported by these activities will naturally decline. Employment supported from port upgrades would thus be expected to go from 5,700 FTEs in 2031 to 3,300 FTEs in 2035, the final year of upgrades.

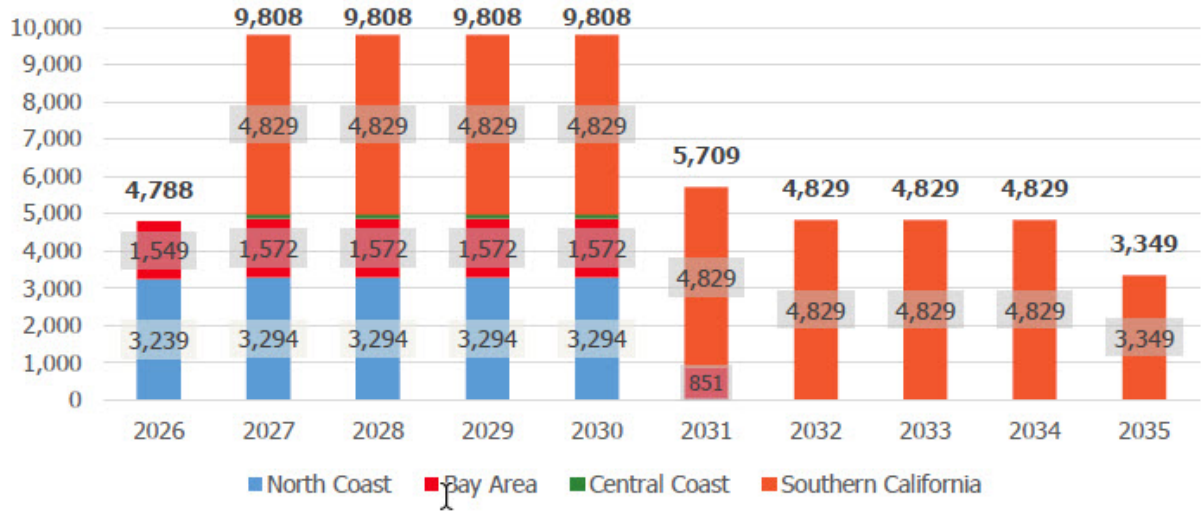

Figure 3.2. FTE employment outputs for port upgrades by region. (See Appendix Table J.16 for source data)

3.1.4.1 North Coast

The North Coast could have upgrades to the Crescent City and Humboldt ports that represent a total investment of over $2.7 billion between 2026 and 2031. The upgrades at the Port of Humboldt, which start in 2026 and finish in 2030, would include improvements for S&I as well as manufacturing activities, and would support over 3,200 FTEs. Between 2027 and 2030, O&M upgrades at both Crescent City and Humboldt would support another 55 annual FTEs.

Most of these FTEs would be in construction industries, and about 6% would be in professional services (i.e., engineering and architecture).

3.1.4.2 Bay Area

The ports in the Bay Area have been identified as being potentially suitable for manufacturing and assembly activities. In 2026, the ports of San Francisco, Stockton, and the two Bay Area Private Terminals could begin upgrade activities to prepare for the manufacturing and assembly of blades, nacelles, and towers.

These port upgrades would provide over 1,500 FTEs annually from 2026 to 2030 and an estimated 850 FTEs in 2031. About 95% of these FTEs would be in construction.

The Port of San Francisco could also be upgraded between 2027 and 2030 to support O&M activities, supporting about 25 FTEs for every year of the upgrade activities. Investments in the region would total about $1.8 billion across these six years of port developments and upgrades. The Bay Area would support the most jobs FTEs out of all four regions between 2027 and 2030, with close to 1,600 FTEs required annually for port upgrades.

3.1.4.3 Central Coast

Port upgrades could happen in the Central Coast between 2027 and 2030 to prepare the Morro Bay Harbor and Port San Luis for O&M activities in OSW. Investments in these ports would total $70 million, smaller than the investments in other regions. Port Hueneme in the Central Coast could also be expected to be used as an O&M hub, but it is not anticipated to be upgraded. Upgrades to these ports would support more than 110 FTEs every year starting in 2027 and running through 2030.

3.1.4.4 Southern California

The two Southern California ports, Los Angeles and Long Beach, could begin upgrades in 2027. This region would have the highest investment in port upgrades, with an expected investment of $7.5 billion over nine years of construction.

The Port of Long Beach could be upgraded between 2027 and 2035, with $5.4 billion in investments. This would support more than 3,300 annual FTEs across the nine years required for the upgrade. The Port of Los Angeles could invest $2.1 billion between 2027 and 2034, which would support almost 1,500 FTEs each year over the course of the upgrades.

Combined, these two ports could support over 4,800 FTEs every year between 2027 and 2034. Almost 4,600 of these FTEs would be in construction industries, and about 240 in engineering and architecture. The Port of Los Angeles could complete construction at the end of 2034, and in 2035 the region could still support 3,300 FTEs for the final year of upgrades to the Port of Long Beach.

3.1.5 Employment by Occupation for Port Upgrades in California

In 2030, under the high scenario, more than half of all FTEs generated from port development and upgrades would be construction and extraction occupations (55%). Management occupations would account for about one in ten jobs (9%), followed by office and administrative support occupations (8%), installation, maintenance, and repair occupations (8%), business and financial operations occupations (7%), architecture and engineering positions (5%), transportation and material moving occupations (3%), production occupations (2%), sales and related occupations (1%), and all other jobs (2%).

The top five occupations that would be projected to see the greatest growth include construction laborers; electricians; first-line supervisors of construction workers; carpenters; and plumbers, pipefitters, and steamfitters. Altogether, these occupations would account for 4,136 FTEs in 2030, or roughly a third (34%) of total FTEs in 2030 across all four regions. For more information on the occupational demand for port developments and upgrades, please see Appendix H.

3.2 OSW Transmission Workforce Needs

There are several major industry sectors that would be needed to cover the breadth of work required to upgrade transmission infrastructure. The federal government delineates these industries using the North American Industry Classification System (NAICS) codes. Workers identified in these industries and their associated occupations below are the backbone of California's transmission infrastructure. The occupations typically found within each of these industries provide insight as to what types of jobs will be necessary to support transmission infrastructure upgrades.

The industries needed for transmission upgrades include the following:

- Professional and business services
- Supply chain and other (includes wholesale trade and utilities)
- Manufacturing
- Construction

The below list offers a closer look at the specific detailed industry definitions of each sector. Most industry sectors found in this list are part of traditional transmission work, except for heavy and civil engineering construction. Heavy and civil engineering construction relate most specifically to port facility construction and OSW projects.

- Professional and Business Services
  - Engineering Services (NAICS 541330)
  - Architectural Services (NAICS 541310)
- Supply Chain and Other
  - Electrical Apparatus and Equipment, Wiring Supplies, and Related Equipment Wholesalers (NAICS 423610)
  - Electric Bulk Power Transmission and Control (Utilities) (NAICS 221121)
- Manufacturing
  - Fabricated Structural Metal Manufacturing (NAICS 332312)
  - Plate Work Manufacturing (NAICS 332313)
  - Ball and Roller Bearing Manufacturing (NAICS 332991)

  - Turbine and Turbine Generator Set Units Manufacturing (NAICS 333611)
  - Electric Lamp Bulb and Other Lighting Equipment Manufacturing (NAICS 335139)
  - Power, Distribution, and Specialty Transformer Manufacturing (NAICS 335311)
  - All Other Miscellaneous Electrical Equipment and Component Manufacturing (NAICS 335999)
- Construction
  - Nonresidential Electrical Contractors (NAICS 238212)
  - Nonresidential Site Preparation Contractors (238912)
  - Power and Communication Line and Related Structures Construction (NAICS 237130)
  - Heavy and Civil Engineering Construction (Port Facility Construction) (NAICS 237990)

These industry sectors and the corresponding occupations within each industry are required at different phases of a transmission project. Identifying which industry sector and which occupations will be needed for each phase will allow for better strategic planning and investment in the future. The below phases are focused on transmission projects and are separate to the OSW-related phases and supply categories outlined in previous sections of this report.

- **Planning and Design:** This phase includes activities such as investment allocation analysis, assessing resources and their probability of development, and ensuring that transmission plans comply with regulatory requirements. Such activities require workers such as environmental consultants, architects, and engineers who have the qualifications and necessary work experience to provide expertise to developers.
- **Commissioning:** This phase includes activities such as wholesaling energy, power capacity, and ancillary services. Activities in this phase require workers from the wholesale trade and utilities industry sectors, such as general operations managers, sales representatives, and inventory clerks.
- **Manufacturing:** Manufacturing transmission cables and power transformers involves technical jobs such as electrical assemblers and welders. These individuals will be manufacturing all the equipment needed to be installed in the next phase, construction.
- **Construction:** This phase requires workers to build foundations and anchors, assemble transmission towers, install the conductors, and conduct site restoration transmission lines installation is completed. These activities require

workers such as electricians, laborers, operating engineers, and in the context of OSW interconnection, would also require vessel workers and personnel capable of installing submarine cables.

- **Operations and Maintenance:** O&M is the last phase of transmission projects and will likely require workers in manufacturing and construction. This phase includes repairs to cables and power transformers as well as the installation of replacement equipment.

3.2.1 Workforce Considerations and Implications for Transmission in California

Transmission upgrades ahead of OSW development will cause a significant increase in demand for associated workforce roles in both Northern and Southern California.

The required skills and training associated with these job roles is well-aligned with traditional transmission jobs and not specifically tailored to OSW except for roles involving offshore cable installation.

Transmission jobs typically offer competitive salaries and benefits and tend to be unionized. However, recruitment for these roles can be a challenge, highlighting the need for campaigns to increase awareness of these occupations. Labor unions will therefore play a critical role in recruitment and training of the needed workers to ensure these opportunities are created in California. This also reduces the reliance on a transient workforce, mitigating potential bottlenecks in recruitment.

Future work on transmission upgrades should be analyzed with consideration of the role of labor unions, workforce development boards, and regional training centers, and seek opportunities to partner with labor leaders to plan for the industry's needs. These institutions are aware of the difficulty of creating a stable employment pipeline through training and recruitment. Knowing how many workers will be needed and where upcoming projects will be located for each industry sector will avoid bottlenecks and, ultimately, energy curtailment issues.

California is a union-friendly state, and public officials and utilities can raise awareness of union training and job openings by campaigning to non-union workers and younger individuals in vocational schools, high schools, and youth programs. New union recruits will receive higher wages and benefits and will provide California with a steady pipeline of skilled transmission workers for all its upcoming renewable energy connectivity projects.

4 Existing Workforce and Training Assessment

4.1 Workforce Supply Assessment

This section provides a current snapshot of the quantity and distribution of the types of workers that will be needed for both port site and OSW development along California's coast. The research also provides a socioeconomic and demographic overview of the workforce along the port site regions in California, including age, educational attainment, unemployment rate, and English fluency. Together with the occupational supply analysis, these demographic and socioeconomic indicators will help to inform workforce development decision-making for California's OSW sector.

A variety of workforce is required to upgrade and build port sites for OSW component manufacturing and O&M as well as for the development of floating OSW projects. While the previous section identifies the quantity and type of jobs needed for OSW project delivery and port site development through 2046, this section highlights the *current supply* of these workers as well as the projected baseline demand in 2030, assuming baseline economic conditions without OSW growth.[2] This analysis will provide the foundation for the workforce gap analysis in the next section.

4.1.1 Workforce Regions Defined

Workforce supply is identified across four main regions which are home to the 11 port sites that will likely be upgraded to meet the OSW industry's needs.

Table 4.1 highlights the port sites, their associated zip codes, and overall region classification. The radius around each region represents the average commute time for workers within the region's zip codes, which are based on federal data from the American Community Survey (ACS).

Average commute times are used as a proxy to estimate the surrounding area from which port site and OSW developers are most likely to hire local workers. Though it is possible that workers may commute in from outside these regions, the average drive time assumption is used to develop a proxy for workforce hiring regions.

[2] Since 2030 is the year with the highest projected annual demand, 2030 is used for both the baseline economic projections (assuming little to no OSW growth) as well as the occupational demand in the previous section. In other words, 2030 will have the highest potential demand for port and OSW development workers in California.

Table 4.1. Locations and drive time assumptions for each port.

Port	ZIP	County	Region	Drive Time Assumption[3]
Port of Humboldt	95501	Humboldt	North Coast	16 mins
Crescent City	95531	Del Norte	North Coast	16 mins
Port of San Francisco	94111	San Francisco	Bay Area	34 mins
Port of Stockton	95203	San Joaquin	Bay Area	34 mins
Bay Area Private Terminal – Amports Antioch	94509	Contra Costa	Bay Area	34 mins
Bay Area Private Terminal – Pittsburgh	94577	Alameda	Bay Area	34 mins
Morro Bay Harbor	93442	San Luis Obispo	Central Coast	22 mins
Port San Luis	93405	San Luis Obispo	Central Coast	22 mins
Port of Hueneme	93041	Ventura	Central Coast	22 mins
Port of Los Angeles	90731	Los Angeles	Southern California	32 mins
Port of Long Beach	90802	Los Angeles	Southern California	32 mins

Figure 4.1 shows the specific zip codes in the North Coast, Bay Area, Central Coast, and Southern California regions that are within commuting distance of the ports that were analyzed before potential upgrades. These ports are shown and labeled as yellow dots on the map.

[3] Based on average commute times from the ACS 2021 5-Year Estimates for the identified zip codes.

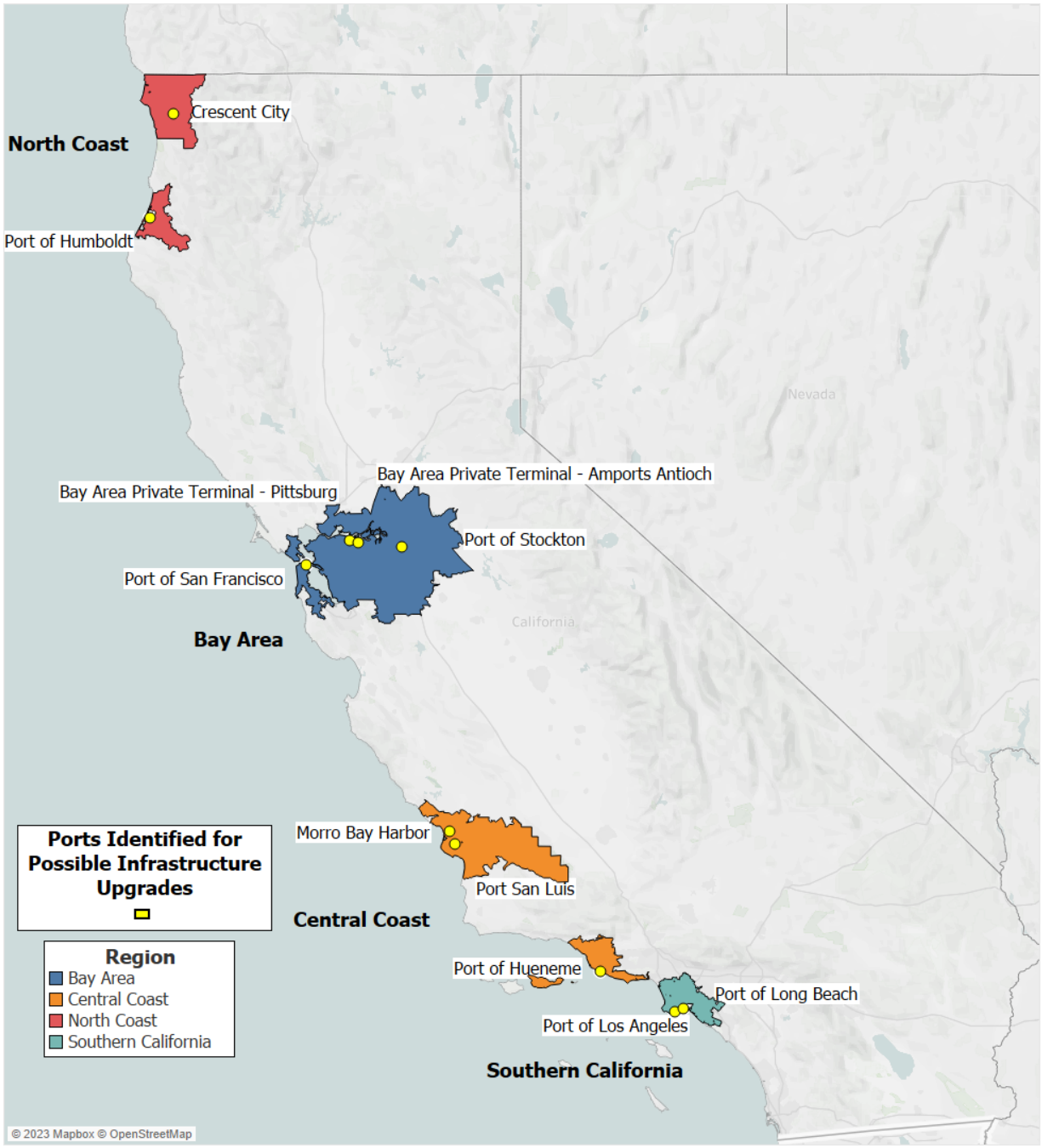

Figure 4.1. Map of port sites and surrounding workforce regions.

4.1.2 Regional Labor Market Overview

This section provides a profile of each of the four region's workforce demographics and socioeconomic characteristics. Unemployment rates, educational attainment, age, and English fluency are highlighted to provide an understanding of the region's labor market and key indicators that will influence workforce development decisions.

Demographic and Socioeconomic Profile

Overall, California's labor market has an unemployment rate of 4.1%—slightly higher than the national average of 3.9%. Unemployment rates by region are presented in **Figure 4.2** Regionally, the four workforce regions have unemployment rates that are about one point higher than the state and nationwide averages. All four regions have an unemployment rate of about five percent.

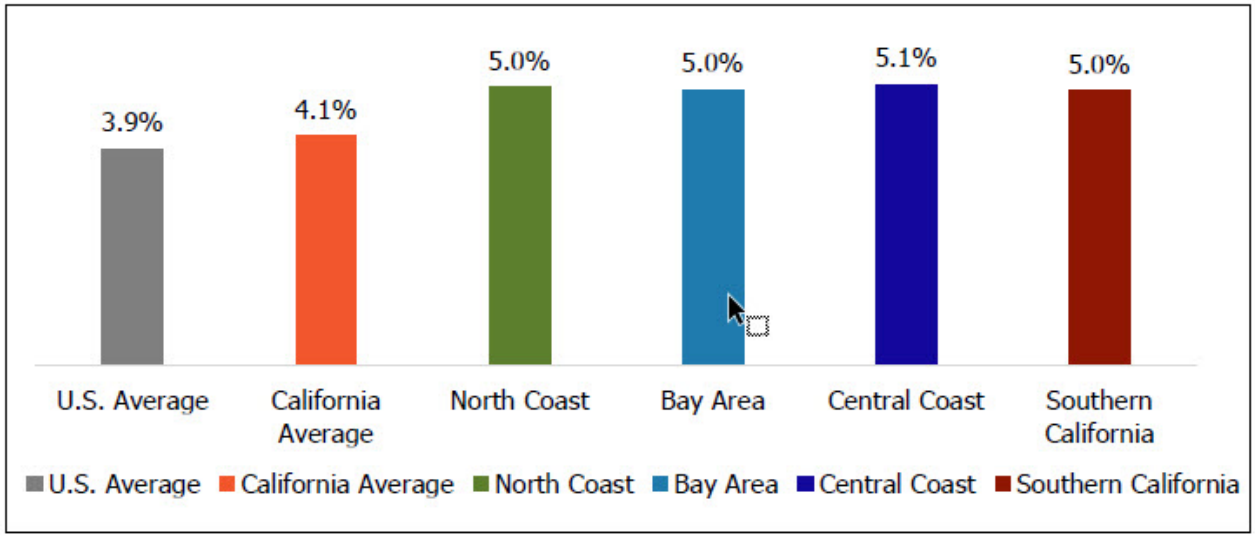

Figure 4.2. Unemployment rate by region[4]. (See Appendix Table J.17 for source data)

Across California, just over a third of the population aged 25 and over have a high school diploma or less (36.2%). The North Coast and Bay Area have a higher proportion of individuals with a high school diploma or less, at 42.8% and 43.1%, respectively. Southern California is on par with the statewide average (**Figure 4.3**).

[4] American Community Survey (ACS) 2021 5-Year Estimates

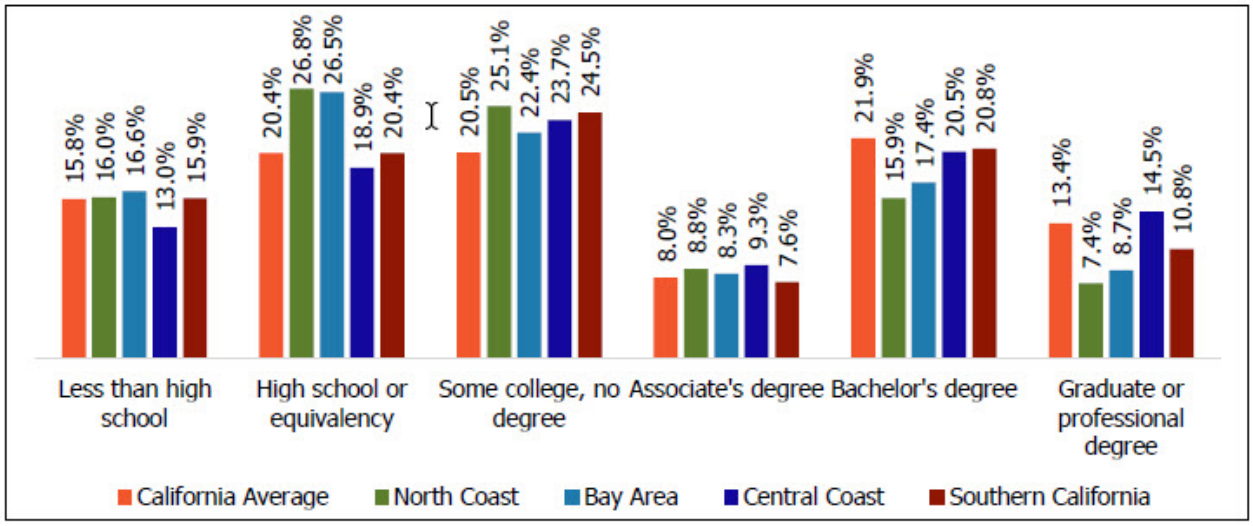

Figure 4.3. Educational attainment by region (population 25 years and over)[5]. (See Appendix Table J.18 for source data)

The Central Coast has the highest proportion of "working age" individuals that can support the OSW sector compared to the statewide average and the other workforce regions. Just over a third (34.9%) of individuals are between 20 and 34 years of age in the Central Coast, compared to a statewide average of 21.3% (**Figure 4.4**).

The U.S. and California have the same proportion of individuals who speak English "less than very well"—about 17% of the population. Both the North and Central Coast are below the state and nationwide averages, with only 7.3% and 8.5% of the population who speak English "less than very well". The Bay Area is equivalent to the statewide average, while 14.8% of individuals in Southern California speak English "less than very well"—about two points below the state average (**Figure 4.5**).

[5] American Community Survey (ACS) 2021 5-Year Estimates

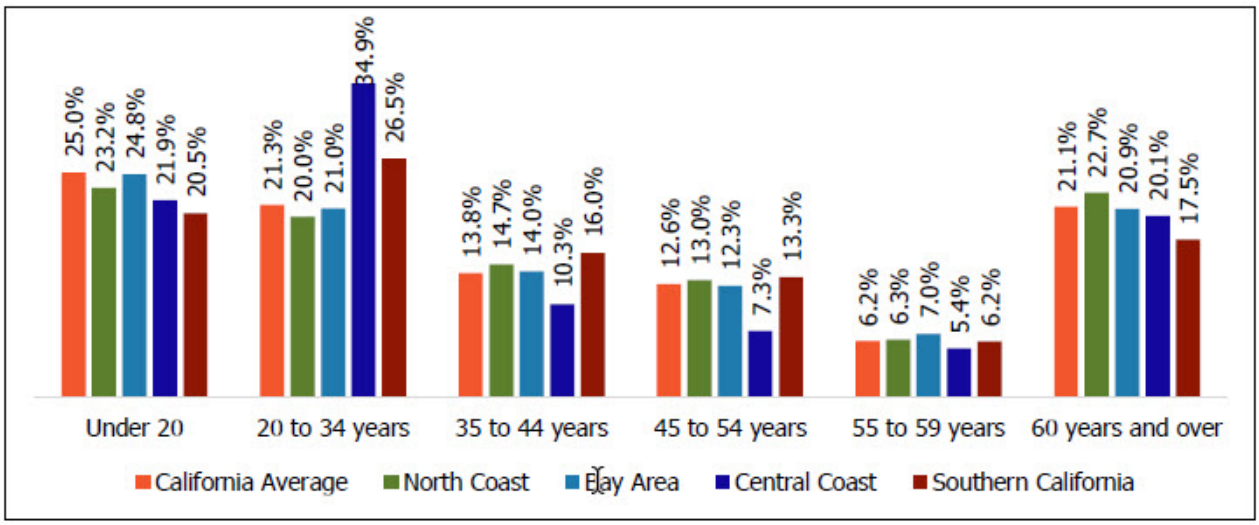

Figure 4.4. Age range by region[6]. (See Appendix Table J.19 for source data)

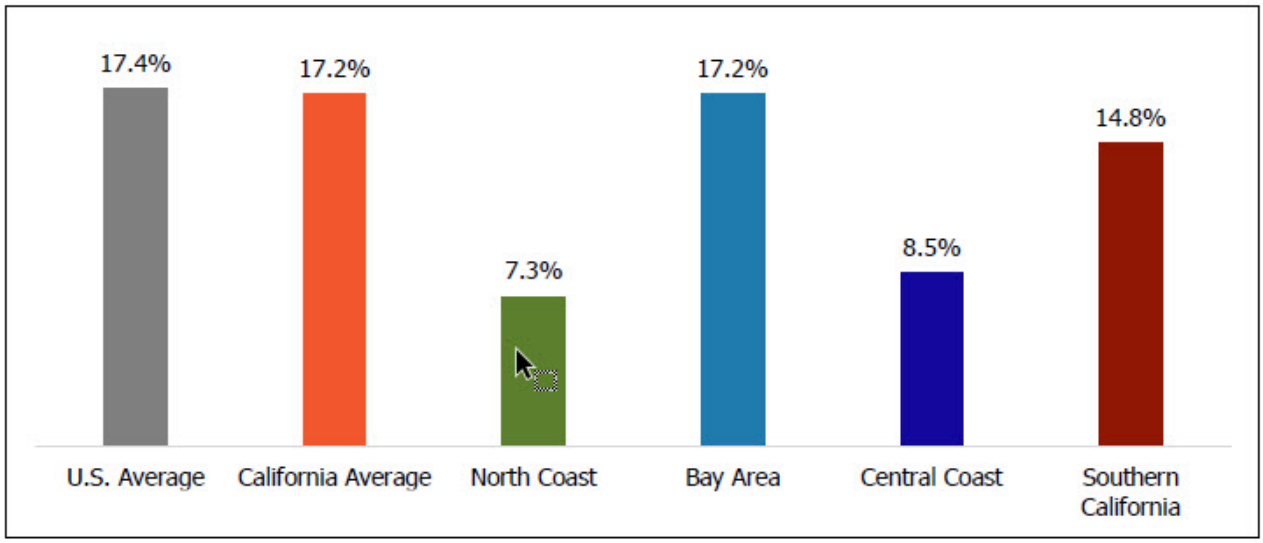

Figure 4.5. Percentage of population that speaks English "less than very well" by region[7]. (See Appendix Table J.20 for source data)

4.1.3 Offshore Wind & Port Development Workforce Supply

Due to the significant overlap in occupations across port site and OSW development, an overall occupational supply analysis is provided for all jobs needed across both OSW development and port site development.

[6] American Community Survey (ACS) 2021 5-Year Estimates
[7] American Community Survey (ACS) 2021 5-Year Estimates

Development of port sites will require a variety of jobs throughout the supply chain. For the purposes of this report, the occupational distribution, or staffing patterns, within the following industries were examined:

1. Construction
2. Transportation and warehousing
3. Professional, scientific, and technical services

For more detail on the specific industries, or NAICS codes, used to define the above industry cluster for port development activities, please refer to Appendix C: Port Development Industry Definition. For a full list of Port Development Occupations, please refer to Appendix D: Port Development Occupational Definition.[8]

The OSW workforce needs assessment informed the definition for occupations within the supply chain that support the development of a floating OSW farm. For a full list of OSW occupations and SOC codes, please refer to Appendix E: OSW Occupational Definition.

The workforce supply and gap analysis research exclude "indirect" jobs that are further along the supply chain, such as manufacturing and wholesale trade.

Occupational Supply Overview

Across all four regions and the major occupational groups, which are comprised of OSW and port site development jobs, there were a total of 2.8 million OSW-related jobs as of the fourth quarter of 2022. These 2.8 million OSW-related jobs represent the total number of all workers across the four regions that are currently working in the OSW-related occupations identified in Appendix E. In other words, this number represents the current supply of workers in California that could be ready to support OSW and port development across the four regions.

Professional services, which are comprised of architecture and engineering occupations, and all other occupations, which account for support jobs, such as sales, marketing, administrative, and other support occupations, represent the bulk of employment.

All regions have a higher proportion of the professional services and all other occupational group employment. The Bay Area and Southern California, overall, have the greatest share of all OSW-related employment. Together, these two regions represent 94.7% of OSW-related jobs (**Figure 4.6).**

[8] Only occupations that had at least ten jobs in demand from the modeling outputs are included in this analysis.

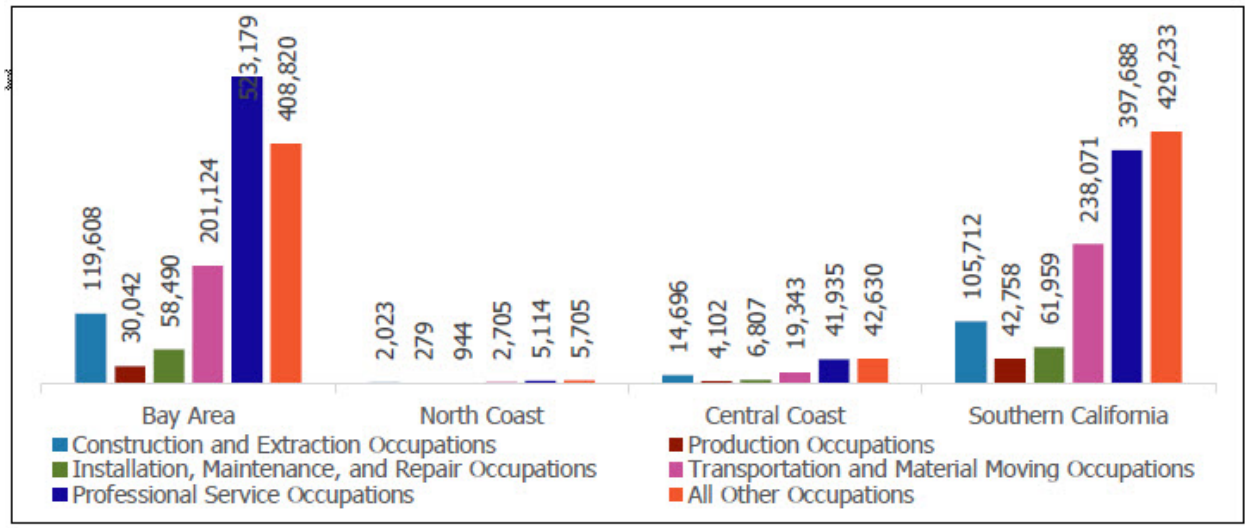

Figure 4.6. Total jobs in major occupational groups by region, 2022 Q3[9]. (See Appendix Table J.21 for source data)

Location quotients are a ratio that measures an area's concentration for an occupational group relative to a larger geographic area. Location quotients are useful in identifying if a region specializes in a certain occupational cluster compared to the state, or nationwide averages. For example, a location quotient greater than one would indicate that the region has an above-average concentration of these jobs, while a location quotient lower than one would indicate a below-average concentration. A location quotient of one indicates that the regional concentration of jobs is equivalent to the broader region to which it is being compared.

In the figure below, the Bay Area has an above-average concentration of professional service occupations, with a location quotient of 1.21. This indicates that professional service occupations, which consist of architecture and engineering jobs, are 1.21 times more concentrated in the Bay Area compared to California overall. Similarly, the Central Coast and Southern California lead the state in proportion of production[10]/manufacturing. Production occupations are 1.13 times more concentrated in the Central Coast and 1.34 times more concentrated in Southern California compared to the statewide average.

The North Coast region has a below-average concentration of all occupations required for OSW and port site development, particularly for production and professional service occupations. The concentration of production occupations in the North Coast is 0.52 times that of the concentration of these occupations in California overall, indicating that this occupational group comprises a smaller share of the North Coast employment total

[9] JobsEQ 2022 Q4

[10] A production job typically refers to a role that involves manufacturing or assembling products. It involves working on the production line or in a manufacturing facility, where individuals are responsible for operating machinery, following production processes, and quality control for the production of goods.

than it does for the state as a whole. The same is true for professional service occupations, which are 0.73 times that of the concentration in California overall (**Figure 4.7**).

For more information on specific detailed occupations by region, including current total employment as of the fourth quarter of 2022 and location quotients compared to the national average, see Appendix I.

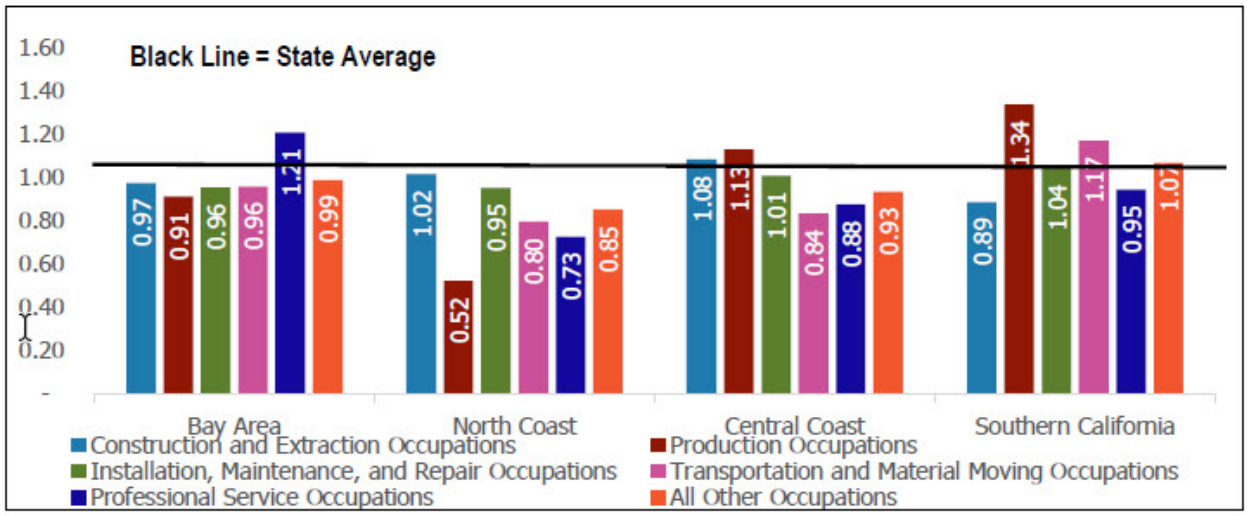

Figure 4.7. Location quotients for major occupational groups by region, 2022 Q3[11]. (See Appendix Table J.22 for source data)

4.2 Training Assessment

The following section provides detail on the currently available OSW and OSW-related training programs and registered apprenticeships that are available across California. The research team, with input from CEC and other workforce development stakeholders, developed a database of training programs that would help to prepare California's offshore wind and port development workforce. This database of training programs is focused on the four major workforce regions surrounding the 12 port sites:

1 North Coast
2 Bay Area
3 Central Coast
4 Southern California

A total of 145 apprenticeship, certification, and degree programs were identified across 69 different labor unions, community colleges, technical schools, universities, maritime

[11] JobsEQ 2022 Q4

academies, and other training providers. For a full list of the training resources available, please see Appendix G: Training Resources Database.

The following analysis discusses geographic distribution as well as the various educational outcomes, occupational focuses, and program providers that support OSW training in California.

4.2.1 Key Findings

Out of the four regions, Southern California offers the most OSW-related training programs. Southern California and the Bay Area accounted for 54% and 22% of training programs, respectively.

The top two most common training programs available are for electrical and welding work. Twenty-eight percent of training programs in the inventory are to prepare workers for electrician jobs. Many of these programs are apprenticeships offered across the Bay Area, Southern California, and the Central Coast. Welding programs represent 17% of the training inventory. Many of these welding programs confer associate degrees and certificates and are offered by community colleges and community adult schools. Sheet metal, maritime, operating engineer, ironworking, and manufacturing training programs account for about a third of the training inventory, while the remaining programs are focused on general construction, laborers, GWO safety, OSHA, among others.

Apprenticeships make up roughly 41% of the overall number of training programs available. Apprenticeships are offered by a variety of providers such as community adult schools, local union chapters and their Joint Apprenticeship Training Centers (JATCs), community colleges, and training centers. Labor unions are the providers that offer the most apprenticeships, with programs offered in construction, ironworking, sheet metal, and more. These apprenticeships typically lead to full-time jobs once training is completed.

This study has identified an inventory of training programs that can support the development and training of a workforce needed for both port upgrades and OSW activities. Based on the desktop research conducted in this study, community adult schools and local union chapters support most of the training programs needed to develop port sites. These two providers offer over half of the available programs (59%) and train and re-skill adults to work in construction and manufacturing jobs once they have completed the necessary hours of training. They are followed by community colleges (16%), training centers (13%), universities (4%), and technical schools (4%).

More than 70 percent of training programs identified in the inventory offer on-the-job training (OJT) through apprenticeships and other OJT training programs; these programs often result in full-time jobs once completed. Twenty percent of programs result in a certificate from a variety of institutions such as community colleges, universities, and training centers. Programs that lead to an associate degree or higher

tend to be in engineering and environmental policy, with employment outcomes such as a civil engineer and environmental consultant.

4.2.2 Geographic Distribution

As of 2023, Southern California offers the majority of available training programs accounting for 54% of the overall programs. The Bay Area region ranks second, with 22% of the overall available programs. The Central Coast follows closely with 15% of programs, followed by the North Coast that accounts for nine percent of available OSW-related programs (**Table 4.2**).

While most programs and training are distributed throughout the state, Los Angeles offers 17 programs out of the 145 available across the state (12%). Eureka on the North Coast follows closely, with 11 programs (8%). La Puente and Walnut, both in Southern California, each offer six programs (4%).

Table 4.2. OSW-Related Training Resources by Region

Region	Total Number of Programs	Percent of Programs
Southern California	79	54.5%
Bay Area	32	22.1%
Central Coast	21	14.5%
North Coast	13	9.0%

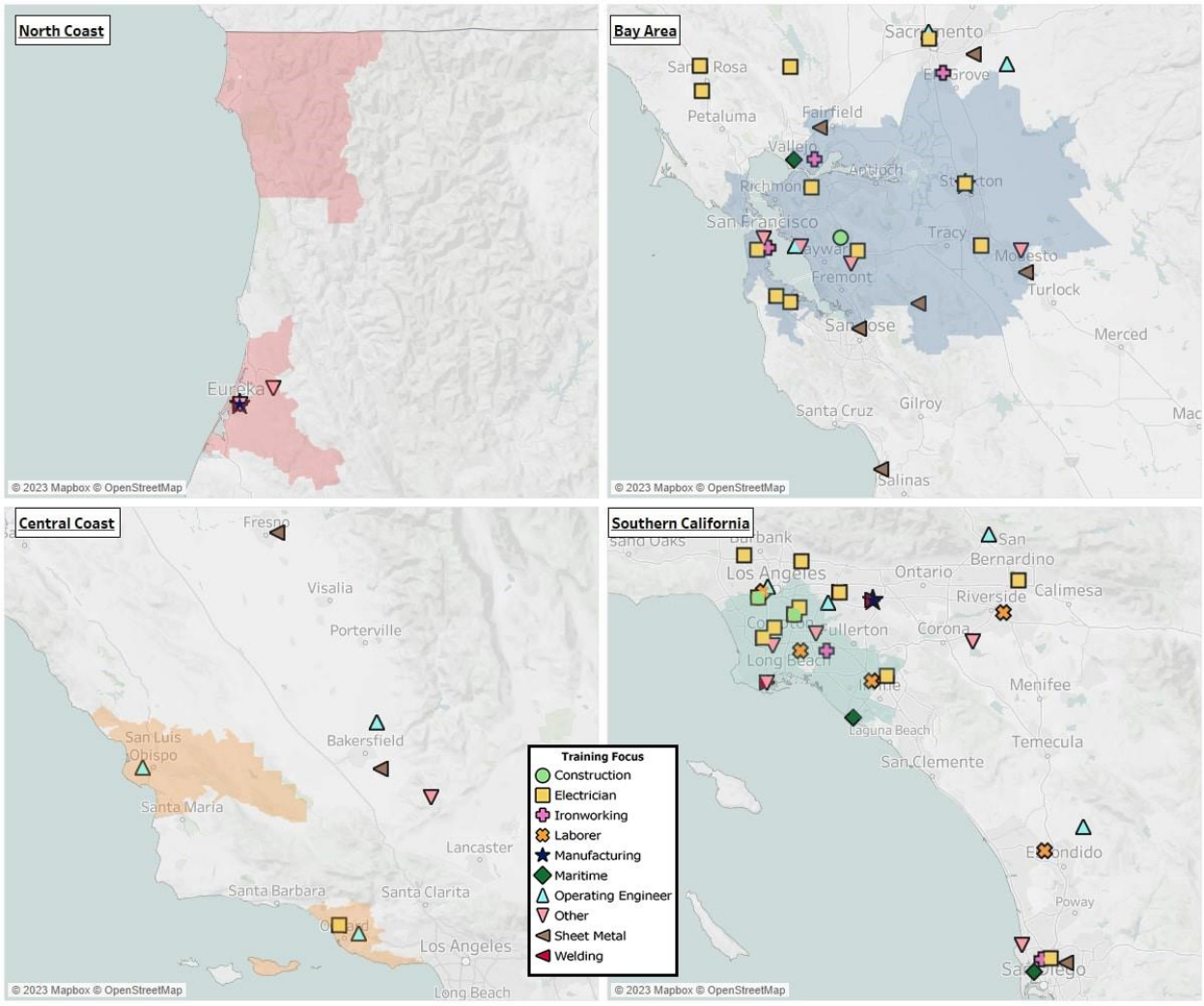

Figure 4.8. OSW-Related Training Resources by Training Focus

Figure 4.8 is a map of the California coast highlighting the four port upgrade regions in the North Coast, Bay Area, Central Coast, and Southern California. Symbols are used to highlight where OSW-related training programs exist along the coast. Each symbol denotes the training focus of the program (i.e., construction, electrical, ironwork, maritime, etc.).

4.2.3 Occupational Focus and Apprenticeship Offerings

OSW-related training programs offered across California prepare for a variety of occupations. Out of the 145 programs offered, electrician programs (29%), welding programs (17%), sheet metal (9%), maritime (8%). and operating engineer (7%) training programs and apprenticeships are offered in the highest numbers. However, other necessary training such as GWO safety, laborer, and operating engineer apprenticeships are also available, albeit at a lower rate (**Table 4.3**).

The distribution of occupational focuses among the OSW-related training programs is visualized in **Figure 4.9**.

Table 4.3 OSW-Related Training Resources by Occupational Focus.

Occupational Focus	Total Number of Programs	Percent of Total Programs
Electrician	41	28.3%
Welding	24	16.6%
Sheet Metal	13	9.0%
Maritime	12	8.3%
Operating Engineer	10	6.9%
Ironworking	8	5.5%
Manufacturing	8	5.5%
Construction	6	4.1%
Laborer	5	3.4%
GWO Safety	3	2.1%
OSHA Maritime	3	2.1%
Drafting Technology	2	1.4%
Engineering	2	1.4%
Forklift	2	1.4%
Plumbing	2	1.4%
Engineering/Policy	1	0.7%
OSHA Construction	1	0.7%
Piledriver	1	0.7%
Truck Driving	1	0.7%

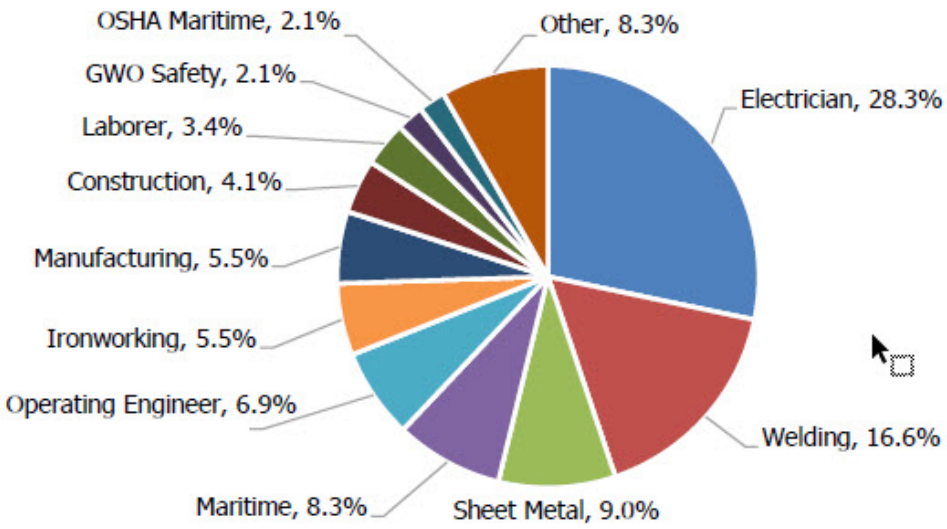

Figure 4.9. OSW-Related Training Resources by Occupational Focus.

Apprenticeships make up approximately 40% of the 145 programs available across the state. They are mostly offered by local union chapters, though they are also offered by community adult schools, community colleges, and training centers. These apprenticeships are typically tailored for trades such as construction, ironworking, sheet metal, operating engineers, laborers, and more. Apprenticeships offer on-the-job training coupled with hours of formal training, compensated at a fair rate. Unions typically expect that apprentices will accept full-time positions once they complete their training.

4.2.4 Provider Type

The OSW-related training programs are displayed by provider type in **Table 4.4**. Just over one-third of training programs offered are provided by local union chapters (32%), who offer on-the-job training through apprenticeships. They are followed by community adult schools (27%), which are vocational high schools that offer education to adults with a focus on technical skills. Community colleges account for 16% of programs, followed by training centers (12%), public universities (5%), and technical schools (34.

Table 4.4. OSW-Related Training Resources by Provider Type

Provider Type	Total Number of Programs	Percent of Total Programs
Union	46	31.7%
Community Adult School	39	26.9%
Community College	23	15.9%
Training Center	18	12.4%
Public University	7	4.8%

Provider Type	Total Number of Programs	Percent of Total Programs
Technical School	5	3.4%
Private Training Center	4	2.8%
Private Company	3	2.1%

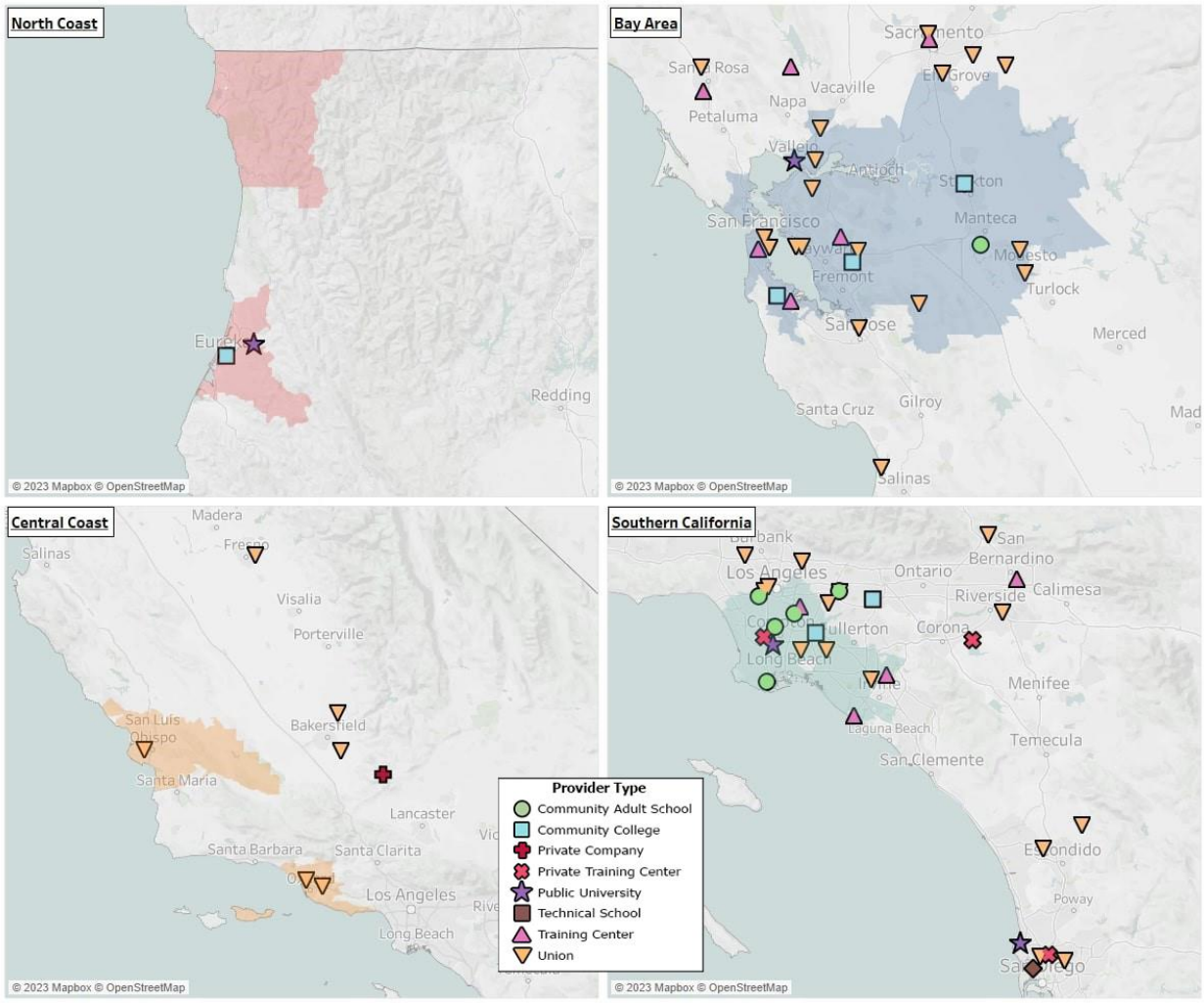

Figure 4.10. OSW Training Resources by Provider Type.

Figure 4.10 is a map of the four port development regions—North Coast, Bay Area, Central Coast, and Southern California, showing the location of all the OSW-related training programs along the coast, while the symbols denote various provider types (i.e., community college, university, technical school, union, etc.).

4.2.5 Educational Outcomes

The OSW-related resources can be analyzed by the final degree or immediate outcome from the training type, as shown in **Table 4.5**. Out of the 145 available programs, 70% increased employability (70%); these are training programs that do not provide a certification or license but will likely result in full-time employment. Many of these programs are apprenticeships or short-term training programs that give trainees the skills, on-the-job training, and work experience needed to enter the workforce as a full-time employee.

Twenty percent of programs result in a certificate from a variety of institutions such as community adult schools, community colleges, and training centers. These certificates are offered for trades such as electrician, manufacturing, welding, and maritime. Certificates typically attest to a professional's learning of a new technical skill or increased proficiency in a specific skill (see Appendix G: Training Resources Database for more details).

About eight percent of11 programs result in an associate degree or higher, up to a master's degree. Those programs are mostly in engineering and environmental policy, with outcomes such as civil engineer and environmental consultant.

Table 4.5: OSW-Related Training Resources by Educational Outcome

Degree/Outcome	Total Number of Programs	Percent of Total Programs
Increased Employability	102	70.3%
Certificate	27	18.6%
Associate Degree	7	4.8%
Certification	4	2.8%
Bachelor's Degree	3	4.3%
License	1	0.7%
Master's Degree	1	0.7%

4.3 Workforce Outreach

The following section provides a qualitative synthesis of key findings from interviews conducted with OSW developers and workforce development training stakeholders, including community colleges, unions, maritime academies, and training centers.

The primary focus of these interviews was to better understand the perceptions of workforce needs and possible challenges for future OSW projects in California.

4.3.1 Training Considerations

There remains some uncertainty among developers regarding the specific skills and job types needed in California, pending technological and other

logistical decisions. Stakeholders have argued that it is too early to determine precise workforce needs, where a range of competing potentially viable technology options remain in development, necessary supporting grid and port infrastructure has not been upgraded, and requirements or expectations from the state have not been explicitly defined. Listed below are comments from stakeholders that are representative of these views.

- "We have not done a detailed dive [into workforce needs]. We have been advocating for and pushing for the state to do a pretty comprehensive assessment that will look at what the jobs, skills, certifications, and trainings required are… and is the state suited up to train and address any gaps?"
- "Technology plays a major role in this… there's a wide range of options between concrete and steel and anything else in between… a difference in workers, skills needed at the ports. That's a big bottleneck."
- "It's unclear to me whether the state will coalesce around a single technology…"
- "It's a bit too early to answer the workforce question… we're still trying to work out what floater system and anchor system would match up. We need to go through that exercise first and then go through skillsets that are needed."
- "The project needs to be further defined (…) We have to know what we are talking about before we can define the workforce that will be needed to be re-mapped to this new need."
- "For offshore, there has to be a holistic look at the sector, no piecemeal approach to this because you need the contractor and labor contracts to train workers for jobs that will exist."

Though there are many similarities between onshore and offshore skill requirements, further understanding of the key differences and additional skillsets needed for OSW development is required. Labor union leaders have detailed the type of trades that will be needed for onshore assembly and offshore work, based on California's experience with onshore wind projects. Operating engineers would be needed to operate large cranes and lift nacelles, while electricians will be needed to hook power to transmission lines. Based on their experiences on the East Coast interviewees noted that they will need to partner with global wind organizations to obtain certifications that will allow them to work offshore. Listed below are comments from stakeholders that are representative of these views.

- "A lot of what we're doing now onshore translates to offshore. It's similar products, similar work processes."
- "There's a big conversation now about whether you create the platform in Humboldt Bay and tow it out to sea or do you do the work at sea, and I don't think those questions have been answered yet…"

- "The entire installation set up is different… we need fewer offshore workers because most of the assembly is done at the port. You're going to need a lot more tugs and anchor barges, which is a different type of workforce…"
- "We see three major crafts, maritime carpenters, maritime pile drivers, and maritime millwrights … partners east have a dive school, GWO certs, and a curriculum already approved by the diving national school… we work as a team, we will be implementing training on the west coast once our training center is set up."
- "Demand on the construction side will be laborers, operators, electricians… A lot of different crafts but with a priority on operators and laborers."

4.3.2 Collaboration

Cross-country collaboration on training resources and curriculum can help California capitalize on lessons learned on the Eastern Seaboard. There was a broad consensus among developers that cross-country and regional partnerships with states that have more expertise in OSW, such as New York, New Jersey, and Massachusetts, would be beneficial. Such partnerships would allow for a successful workforce development strategy based on lessons learned on the East Coast. Workers from California could shadow projects and gain experience with a workforce that is more accustomed to offshore projects and bring that experience back to Morro Bay or Humboldt. Listed below are comments from stakeholders that are representative of these views.

- "The first turbine that [California workers] work on should not be in California, it should be on the East Coast… we are advocating for collaborative approach between states—New York or New Jersey. We can do integration and lessons learned across states."
- "There is opportunity for partnerships across states. You can take a person from Morro Bay in California and have them shadow and work on a project in New York. As the Northeast states look to do floating OSW, then we can cross-collaborate with them."

4.3.3 Key Actors and Training Organizations

Maritime training will play a pivotal role in the OSW workforce development ecosystem. Developers have coalesced around the fact that there is a lack of experience in maritime work in California, relative to the East Coast. They have pointed out that developing key partnerships would help in overcoming that hurdle, along with making sure the state's maritime academy, California State University Maritime Academy, will be willing to train the necessary pool of workers. Another idea would be to create cross-curriculum partnerships between labor unions and maritime academies

to ensure a steady workforce supply willing to be trained. Listed below are comments from stakeholders that are representative of these views.

- "The maritime workforce in California is not present, not to the level that will be needed for floating OSW."
- "It's also important the state has a view on who the academic partner is for marine science stuff… identifying who those technical experts are, a trusted third party we can engage with."
- "Vessels are few and far between on the west coast. They are hardly available… and the workforce coming into operate [these] vessels… getting marine experience is difficult. Various marine contractors have their own requirements, we can't just impose requirements on them. That's going to be the hardest."
- "Marine experience is experience that has to be gleaned over the time period."
- "We tapped for potential cross-curriculum development between maritime academies and unions. I don't know where else we're going to attract that kind of workforce out here and get them trained."
- "The other thing from the workforce standpoint are the mariners… having local mariners, installation crews on those vessels, by the time we're going to be introducing installation…"
- "More technical and higher paid jobs are likely to remain with foreign crews at initial phases of the industry… cabling, mooring, etc., require robotic and diving skills."

Operating engineers, laborers, carpenters, and electricians are the main labor unions primarily engaged in OSW training conversations. Although these workers are not necessarily trained for OSW projects, they will be needed for pre-assembly work, which is mostly construction, to connect the plants to transmission lines, and for the offshore portion of the work. Listed below are comments from stakeholders that are representative of these views.

- "Laborers, carpenters, electricians, ironworkers, and operating engineers – these are the key unions… [we need to identify] which ones fit into buckets for offshore work, pre-assembly, onshore, etc."
- "There will be infrastructure to build onshore… There is a lack of port capabilities, we will have to work on redeveloping these ports and facilities, which will be most of the work hours before starting offshore."

Unions are able to ramp up training when needed, meaning they are well-positioned to grow to meet the needs and demands of the OSW industry. Union partners have unanimously declared that unions have historically risen to each industry challenge. As long as there is a need, unions have large training centers and resources to create curriculums targeted at OSW. Ultimately, they will need the state

and developers to signal for their workforce needs, and they will create training programs to provide the right supply of workers. Listed below are comments from stakeholders that are representative of these views.

- "Our wind partners are going to tell us what they need, and our programs will ramp up the training to meet the need. And we can do that because we talk to each other."
- "I think [the unions] would be ramping up any new kind of training that's needed."
- "The existing apprenticeship training system can ebb and flow with the realities… they can train the workforce as long as there is work out there."
- "The trades have been phenomenal at growing to meet the need… overall, the trades have grown by 400 percent to meet high speed rail needs. The trades would argue that they have scaled to meet the needs of their opportunities…"
- "Historically the trades have been able to expand and provide enough training, for each individual craft… It could be potentially complicated work so you would want to have experience. If they feel there's enough hours for apprentices to learn that trade, it should be fine for them to increase staffing."

State-level investments and active policy goals/targets are key to signaling consistent and reliable market growth to OSW developers, which will in turn signal training providers to ramp up their offerings. Many developers noted that they will need more robust commitments and targets from the state before they can start developing OSW projects. Developers noted that state involvement in workforce development discussions is in response to the 25GW by 2045 goal, a goal the state developed as a result of legislation but one that, in and of itself, is not part of a state statute. Listed below are comments from stakeholders that are representative of these views.

- "I think the investment needs to be made at the state-level to get the industry going… and the training will follow."
- "We have a whole system already created to get people into jobs… the training part of the system is ready; it's just where is the investment coming from to get the industry going…"
- "We need the state to own that role."
- "There are strategies the state can use to support workforce development… providing competitive funding to allow trainers to come forward and provide solutions… deploying resources in a way that allows training providers to meet needs…"
- "We need firm commitments and targets from the state, not just goals… that's what will bring OEMs."

- "It's important for the state to lean hard on developers and unions to sign PLAsProject Labor Agreements sooner rather than later…"
- "If you build workforce standards within solicitations in ways that connect demand for workers to supply on the ground through solicitation language, it will give [developers] a signal to work with the trades and give them the most competitive bid."

4.3.4 Talent Pool

Unions have historically been leaders in reducing barriers to work for disadvantaged populations and creating inclusionary hiring practices. Labor union stakeholders noted that Californian unions have hired people of color, women, and formerly incarcerated people through target-hiring. Union leaders proudly declared that their organizations are "color-blind," meaning that gender, creed, or race do not influence a worker's professional outcomes in the trades, which have otherwise been dominated by white males in non-union contexts. Listed below are comments from stakeholders that are representative of these views.

- "Construction is one of the only industries where it does not matter if you are male or female or what race you are, the collective bargaining agreement says that you are going to make X dollars per the agreement, no matter what."
- "Earning less as a woman is not a problem in the unionized construction industry because the collective bargaining agreement is color blind. If you're a journeyperson, you are going to make this much."
- "[The trades] started target hiring before people thought of target hiring… formerly incarcerated individuals as well… they've led on these initiatives to reduce barriers."
- "Many programs in L.A. have been created to get the formerly incarcerated into the trades."

Pre-apprenticeship training offered through union training centers is pivotal for OSW workforce development. Labor unions are partnering with high-schools and vocational high-schools to ensure a steady workforce supply among the youths and are offering pre-apprenticeships that give them an opportunity to try out many different trades before starting an apprenticeship they enjoy. Listed below are comments from stakeholders that are representative of these views.

- "The trades in California have really led the development of pre-apprenticeship programs that allow people to get into the trades."
- "We have started doing pre-apprenticeship now… we're getting young people in and exposing them to all the crafts to they figure out where they want to go before they start an ironworkers apprenticeship…"

- "The High Road Construction Careers program feeds all the crafts, it is a multi-craft pre-apprenticeship program approved by the national building trades council… There is a lot of demand for apprentices because of the Jobs Act."

Marketing and promotion of employment opportunities in the OSW industry, particularly to high schoolers, job seekers, priority populations, and others, will ensure that there is sufficient future supply of OSW workers. Most stakeholders have agreed that there is a general need to change the narrative around trades and blue-collar work. Although these jobs provide financial security and collective bargaining and benefits, parents are often against their children working in a trade and would rather send them to college to pursue a job requiring a college degree. Bringing awareness to the benefits of working in construction and making an impact by working on clean energy projects could help mitigate future potential bottlenecks and a reliance on a transient workforce. Listed below are comments from stakeholders that are representative of these views.

- "We spend a bit of time in the high school space trying to get a lot more vocational training… It's something that's gone away in the last few generations…"
- "[We want to] get people in the right direction at the start."
- "It's less about the [OSW] industry and more about getting them in construction in general. There's a societal viewpoint on blue collar work…"
- "So much demand to get into the trades. They have done work to raise awareness at the high school level. There is no shortage of people, including youths, that want to be in the trades."
- "Community Colleges provide classroom training in English language and quantitative training to bridge that gap."
- "We are working with several high schools to start recruitment of indigenous people and MOUs that will direct them to our apprenticeship."

Workforce competition from growth in other industries, such as other renewable energy and infrastructure projects, for key OSW job roles will be an important consideration for the state. Currently, workers are pulled in every direction, from onshore wind to hydrogen which will inevitably create bottlenecks unless training programs targeting OSW ramp up, in addition to proper incentives. Listed below are comments from stakeholders that are representative of these views.

- "The biggest challenge is competition for the workforce."
- "…especially as you're seeing a lot more industrial growth in the U.S. again, which is pulling from the same labor pools that we'll need… so when you think about unionized labor, apprenticeships, pre-apprenticeship programs… that

capacity needs to be built as quickly as possible to be there when we need them."

5 Regional Gap Analysis

In the *AB 525 Port Readiness Plan*, port investments have been outlined that would enable several ports in California to service major component manufacturing, installation, and O&M. The *AB 525 Port Readiness Plan* provides different options for where major component supply may be located. This gap analysis reflects the potential gaps should all the ports in the region be fully developed and does not aim to predict which regions/ports will be developed. **Table 5.1** summarizes the type and quantity of supply elements considered in each region, informing the workforce demand.

Table 5.1. The number of OSW facilities in the California regions supplying various supply elements.

Supply Element	North	Bay	Central	South
Foundations	1			1
Tower		1		1
Blades	1	1		1
Nacelle		1		
Staging & Integration	1			2
Operations and Maintenance	7	1	3	

A gap analysis for the workforce was conducted for both port upgrades and for OSW activity within each region. A Red-Amber-Green analysis was used to highlight the workforce demand and projected workforce gap for the top in-demand jobs. Priority levels were categorized based on total demand for jobs (i.e., the absolute number of workers required for each occupation in each region), occupation-specific considerations regarding training and upskilling, the projected workforce gap in 2030 for port upgrades and in 2040 for OSW activity.

Table 5.2 and **Table 5.3.** provide the scoring criteria for potential workforce demand and for projected gap, respectively. The parameters were set against baseline economic projections derived from Bureau of Labor Statistics (BLS) data for each occupation category. These projections are established by taking into account various economic demand and supply factors that may impact the level of demand for workforce within the specific occupation category and establish a minimum level of demand for workers in this category. The current BLS dataset assumes little to no growth for the OSW industry. Consequently, any workforce demand driven by OSW projects or associated port upgrades established in this assessment would represent an increase over the general growth of workforce demand expected due to non-OSW related activity in each occupation category. The gap analysis then compares the baseline economic growth projections with the growth anticipated from both offshore wind activity and port upgrades.

The projected workforce gap highlights this additional workforce required for port infrastructure upgrades and OSW activity that exceeds the BLS baseline economic projections for 2030.

Table 5.2. Scoring criteria for potential workforce demand for OSW activty and port infrastructure upgrades

Assessment	Criteria
R	Potential demand is >75 workers
A	Potential demand is 25-75 workers
G	Potential demand is <25 workers

Table 5.3. Scoring criteria for projected workforce gap between BLS projected baseline economic demand for each occupation category and workforce requirement for OSW activity and port infrastructure upgrades

Assessment	Criteria
R	Potential workforce demand is >100% of projected baseline economic demand
A	Potential workforce demand is 50 – 100% of projected baseline economic demand
G	Potential workforce demand is <50% of the projected baseline economic demand

Given that port upgrade construction activities do not differ significantly across each region, the top in-demand occupations are the same across all four regions. However, the magnitude of demand and overall projected workforce gaps differ depending on the labor market realities across the four regions.

The regional gap analysis for meeting the OSW workforce and port upgrade workforce considers only the manufacturing, installation, and O&M work attributed regionally to ports in the *AB 525 Port Readiness Plan*. Where OSW work has not been attributed to any regional ports in the *AB 525 Port Readiness Plan*, including project development work, and manufacturing of cables, mooring lines, and anchors, the potential workforce demand has not been included in this regional gap analysis. It is important to note that some wind turbine supply activities in the Bay Area and Southern California are mutually exclusive, and this is denoted with a dashed line for the potential workforce opportunity outlined in the following sections.

5.1 North Coast

5.1.1 Demographics and Available Workforce

Of the four regions identified for port upgrades, the North Coast has the smallest labor force available. The population density in this area is generally low, with 16,800 workers currently in occupations relevant to OSW project delivery and port

infrastructure upgrades. Baseline economic projections estimate little employment growth in this area, indicating that to meet workforce demand for OSW and port development, this region will have to mobilize significant workforce recruitment and training to supply the needed jobs, likely relying on out-of-region support and transient workers.

The North Coast has a higher proportion of adults with a high school diploma or less compared to the state average, which factors into workforce development and training decision-making when considering the local population available for the talent pool.

5.1.2 Training Capacity

In addition to low population density and overall workforce availability, there is minimal training capacity in the North Coast for construction-related trade positions. The College of the Redwoods is available for some manufacturing-related training but there were no construction-related union apprenticeships or other training programs found in this region. Of the four regions, the North Coast accounts for only 9%, or 13 programs, of all relevant training programs identified.

5.1.3 Port Upgrade Workforce Gap Analysis

There is low workforce concentration in the North Coast region, but relatively high demand needs out of the four regions. The occupations with highest demand, displayed in **Table 5.4**, are all high priority for workforce development stakeholders.

The North Coast currently has about 2,800 workers employed in these highest demand roles. Baseline economic projections indicate that the labor market will require only 290 more workers across these ten occupations in 2030.

The highest demand roles will require another 1,800 workers by 2030 to meet the current predicted workforce demand needed to deliver port infrastructure upgrades. This means that for each of these occupation roles, **the region will have to more than double the expected baseline workforce in 2030 to meet the demand created by developing and upgrading the Humboldt and Crescent City ports in the North Coast.**

Table 5.4. Ten SOC occupations with greatest demand required for port upgrades in the North Coast, their demand and gap, and the priority level for the state to expand their associated workforce.

SOC Code	Occupation	Potential Workforce Demand (no. of workers)	% Growth Above 2030 Projections	Priority
47-2061	Construction Laborers	345	>100%	High priority due to significant demand, lack of supply, and insufficient regional training infrastructure
47-2111	Electricians	345	>100%	
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	220	>100%	
47-2031	Carpenters	188	>100%	
47-2152	Plumbers, Pipefitters, and Steamfitters	155	>100%	
11-9021	Construction Managers	135	>100%	
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	116	>100%	
13-1082	Project Management Specialists	101	>100%	
43-9061	Office Clerks, General	95	>100%	
47-2051	Cement Masons and Concrete Finishers	89	>100%	

5.1.4 OSW Workforce Gap Analysis

The North Coast is projected to have significant gaps in all the highest demand occupations needed for its OSW workforce. In addition to the highest demand occupations, the North Coast also possesses a large gap in wind turbine technicians. This gap is significant considering the anticipated high volume of O&M that could be required from activities in-region and the current lack of GWO training facilities.

The North Coast currently has a very small maritime workforce, which also presents one of the most significant gaps for the region. Maritime workers will play a key role in multiple project phases and will likely need to be filled by an out-of-region workforce or a newly created workforce.

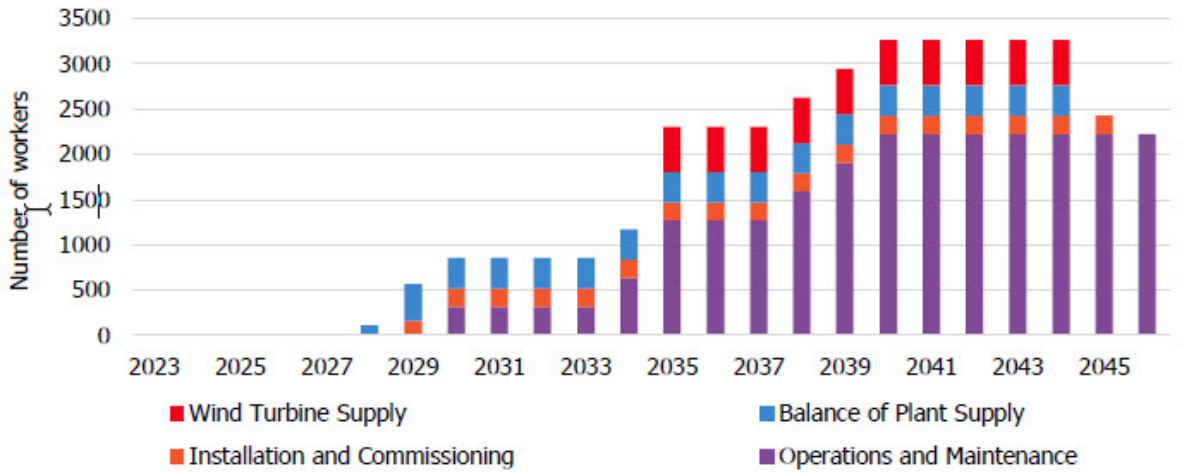

Figure 5.1. North Coast OSW workforce demand by supply chain area. (See Appendix Table J.23 for source data)

Table 5.5. Ten SOC occupations with greatest demand required for OSW development supported by the North Coast, their demand and gap, and the priority level for the state to expand their associated workforce.

SOC Code	Occupation	Potential Workforce Demand	% Growth Above 2030 Projections	Priority
47-2061	Construction Laborers	296	>100%	High priority due to high demand and large gap
51-4121	Welders, Cutters, Solderers, and Brazers	194	>100%	
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	182	>100%	
49-9096	Rigger	131	>100%	
47-2221	Structural Iron and Steel Workers	122	>100%	
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	114	>100%	
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic	104	>100%	
53-7041	Hoist and winch operator	90	>100%	
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	88	>100%	
47-2111	Electricians	84	>100%	

5.2 Bay Area

5.2.1 Demographics and Available Workforce

The Bay Area is home to a significant labor market that will be key to fulfilling port infrastructure and OSW upgrades. In total, there are currently just over 1.3 million workers in occupations related to OSW and port infrastructure related—the largest current supply of these types of jobs across all four regions. In particular, the Bay Area is most strongly positioned to supply professional service occupations, such as architecture and engineering workers.

The Bay Area has a high proportion of adults with a high school diploma or less as well as a high proportion of non-native English speakers who speak English less than very well. These demographic elements are important to consider when designing, marketing, and implementing workforce development strategies to recruit talent for the OSW labor pool.

5.2.2 Training Capacity

The Bay Area has significant union apprenticeships for electrical, sheet metal, ironwork, maritime, and operating engineer work. Community colleges and training centers also offer electrical, maritime, and construction-related coursework and job training. Of the four regions, the Bay Area accounts for 22%, or 32 programs total, of all relevant training programs identified.

5.2.3 Port Upgrade Gap Analysis

In the Bay Area, due to high workforce supply availability, each of the highest demand occupations shown in **Table 5.6** are low priority for workforce development action. It is projected that these occupations will require only around 900 jobs in 2030 for port infrastructure work.

As of the last quarter of 2022, there are just over 169,000 workers currently employed in the ten occupations listed in **Table 5.6**, and baseline economic conditions project that these occupations will require almost 20,000more workers in 2030, even without port infrastructure upgrades for the OSW industry. Given the significant training capabilities in the region, workforce development priorities for these occupations in the Bay Area are low.

Table 5.6. Ten SOC occupations with greatest demand required for port upgrades in the Bay Area, their demand and gap, and the priority level for the state to expand their associated workforce.

SOC Code	Occupation	Potential Workforce Demand	% Growth Above 2030 Projections	Priority
47-2061	Construction Laborers	168	7%	Low priority due to significant workforce supply and supportive training infrastructure
47-2111	Electricians	168	11%	
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	107	8%	
47-2031	Carpenters	91	5%	
47-2152	Plumbers, Pipefitters, and Steamfitters	75	9%	
11-9021	Construction Managers	66	8%	
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	57	9%	
13-1082	Project Management Specialists	49	1%	
43-9061	Office Clerks, General	46	1%	
47-2051	Cement Masons and Concrete Finishers	43	15%	

5.2.4 OSW Workforce Gap Analysis

The Bay Area is projected to have a large demand for a manufacturing workforce to support the anticipated wind turbine supply that is projected to happen in-region. While the Bay Area workforce is largely sufficient in terms of size, there will need to be upskilling to address specific and/or more specialized certifications needed for OSW project delivery.

Outside of the highest in demand occupations, the Bay Area has a gap in apprenticeship roles. These roles will be able to support both the construction and manufacturing phases of an OSW project.

The workforce requirement in the Bay Area is highly dependent on the presence of manufacturing facilities in the region. If no major component manufacturing is delivered in this region, workforce development in the Bay Area may become a lower priority, where the focus could be on training a highly skilled workforce to support project development supply.

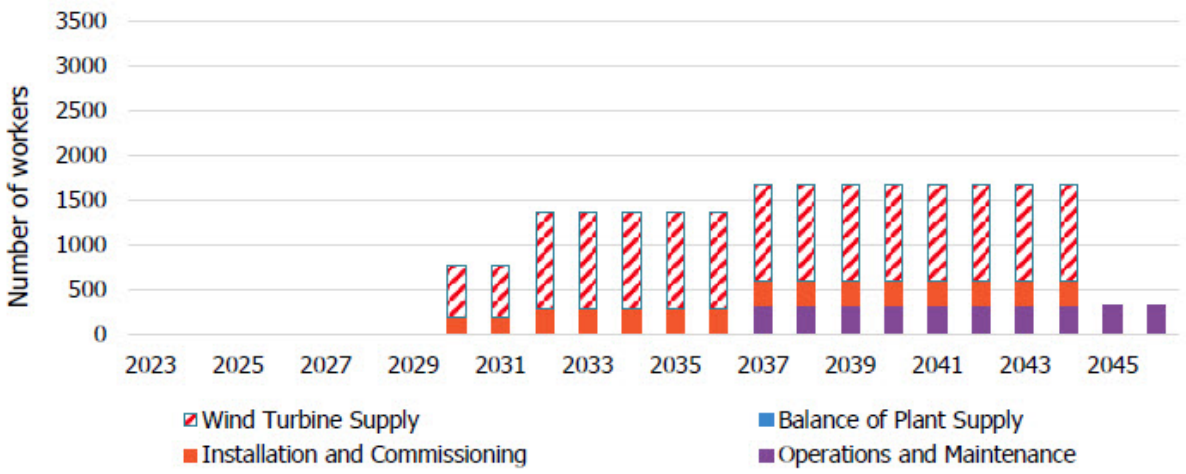

Figure 5.2. Bay Area workforce demand by OSW supply chain area[12]. (See Appendix Table J.24 for source data)

[12] Intra-California competition for blades and tower supply (in the Wind Turbine Supply area) means this component will either come from the Bay Area or Southern California, but not both, and is therefore designated with a pattern.

Table 5.7. Gap analysis for high demand occupations related to OSW activities in the Bay Area.

SOC Code	Occupation Title	Potential Workforce Demand	% Growth Above 2030 Projections	Priority
47-2061	Construction Laborers	180	7%	Low priority due to small gap
51-4121	Welders, Cutters, Solderers, and Brazers	172	27%	Medium priority due to need to upskill available workforce
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	124	44%	
51-9199	Production Workers, All Other	110	21%	Low priority due to small gap
47-2221	Structural Iron and Steel Workers	105	80%	Medium priority due to high demand and medium-sized gap
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic	90	>100%	High priority due to high demand and large gap
51-4041	Machinist	66	13%	Low priority due to small gap
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	58	26%	Low priority due to small gap
49-9044	Millwrights	55	95%	Medium priority due to medium demand and medium-sized gap
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	47	22%	Low priority due to small gap

5.3 Central Coast

5.3.1 Demographics and Available Workforce

The Central Coast has a relatively small labor market, with around 130,000 current workers in OSW-related and port upgrade occupations. Given the low demand for port infrastructure jobs in the Central Coast, only two occupations meet the criteria for in-demand jobs.

Despite overall low demand and workforce needs in this region, the Central Coast stands out for having the highest proportion of "working age" adults (aged 20-34) compared to the state-wide average and the other three regions. This may be beneficial for supporting workforce demand in the North Coast, where there may be a need to

import workers from outside the region to meet the demand for port infrastructure upgrades.

5.3.2 Training Capacity

The Manteca Adult School offers training in the Central Coast region for electrical, welding, and forklift work, while San Joaquin Delta College provides manufacturing and welding coursework. Training centers and unions provide additional apprenticeship and on-the-job training for electricians, ironworkers, sheet metal workers, and operating engineers. Of the four regions, the Central Coast accounts for 14%, or 21 programs total, of all relevant training identified.

5.3.3 Port Upgrade Workforce Gap Analysis

There is low demand in the Central Coast region for a port infrastructure upgrade workforce and little to no projected workforce gaps; both occupations at the top of the in-demand list for the Central Coast are low priority for workforce development.

As of the fourth quarter of 2022, the Central Coast was home to almost 4,400 electricians and construction laborers. Port infrastructure upgrades in this region will require fewer than 30 new jobs across these two occupations and baseline economic projections expect almost 450 new jobs in 2030**.**

Table 5.8. SOC occupations with greatest demand required for port upgrades in the Central Coast, their demand and gap, and the priority level for the state to expand their associated workforce.

SOC Code	Occupation	Potential Workforce Demand	% Growth Above 2030 Projections	Priority
47-2111	Electricians	12	9%	Low priority due to very low demand
47-2061	Construction Laborers	12	4%	

5.3.4 OSW Workforce Gap Analysis

The Central Coast has been identified to only support O&M activities and no other OSW services. With four O&M bases being identified in this region, the moderate demand for workers in quayside roles and the current lack of workers will result in large projected workforce gaps.

In addition to quayside roles, several maritime and offshore-related roles will be amongst the highest demand occupations for OSW activities. However, based on the 2030 BLS data, minimal to no growth is expected to be required in these occupational categories in the Central Coast, which implies the economy will not be prepared to support the training, development, and recruitment of these roles.

The current lack of GWO training facilities in the Central Coast region paired with the GWO requirement for many of the highest demand occupations could necessitate the development of additional training resources to support the OSW market.

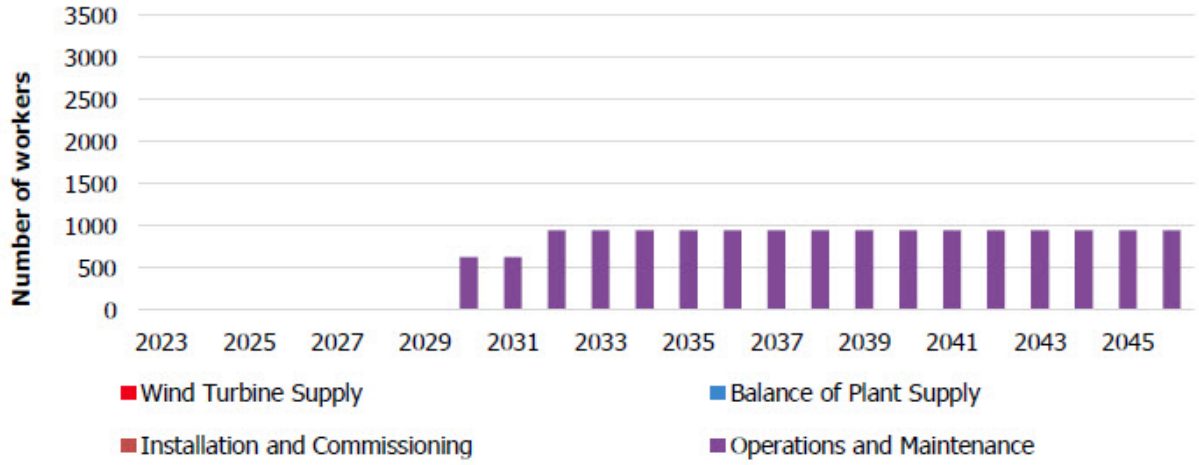

Figure 5.3. Central Coast workforce demand by OSW supply chain area. (See Appendix Table J.25 for source data)

Table 5.9. Gap analysis for high demand occupations related to OSW activities in the Central Coast.

SOC Code	Occupation	Potential Workforce Demand	% Growth Above 2030 Projections	Priority
47-2061	Construction Laborers	60	19%	Low priority due to small gap
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	45	>100%	High priority due to large gap and need to upskill available workforce
53-7041	Hoist and winch operator	36	>100%	
49-9096	Rigger	36	>100%	
51-4121	Welders, Cutters, Solderers, and Brazers	36	42%	Medium priority due to need to upskill available workforce
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	33	47%	Low priority due to small gap
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	30	>100%	Medium priority due to medium-sized demand and large gap
53-5011	Sailors and Marine Oilers	30	>100%	High priority due to medium-sized demand and large gap
53-5021	Captains, Mates, and Pilots of Water Vessels	30	>100%	High priority due to medium-sized demand and large gap
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	30	>100%	High priority due to medium-sized demand and large gap

5.4 Southern California

5.4.1 Demographics and Available Workforce

Southern California has the second largest labor market to supply OSW and port infrastructure jobs. There are almost 1.3 million workers currently employed in these positions in Southern California.

Relative to the other three regions, Southern California has a high proportion of adults who speak English less than very well, though the percentage is slightly below the state and nationwide averages. This is an important consideration for workforce development stakeholders when recruiting talent for the OSW industry.

5.4.2 Training Capacity

Southern California is home to the majority of OSW-related training programs. Of the four regions, Southern California accounts for 54%, or 79 programs total, of all relevant training programs identified. Several adult schools, community colleges, private companies and training centers, universities, technical schools, and union apprenticeships in this region support training for the following trades: electrical, ironworking, construction laborer, manufacturing, maritime, operating engineer, sheet metal, and welding.

5.4.3 Port Upgrade Workforce Gap Analysis

The highest demand occupations in Southern California will require just over 2,600 workers by2030 for port infrastructure upgrades. As of the last quarter of 2022, there were a total of 437,000 workers across these occupations in Southern California. Baseline economic projections indicate the need for almost 22,000 additional workers across occupation categories; this assumes little to no OSW industry and ports growth.

Given the large labor market in this region and high training capacities, the projected workforce gap is minimal for the majority of jobs, making most of these positions a low priority for workforce development.

Table 5.10. Ten SOC occupations with greatest demand required for port upgrades in Southern California, their demand and gap, and the priority level for the state to expand their associated workforce.

SOC Code	Occupation	Potential Workforce Demand	% Growth Above 2030 Projections	Priority
47-2061	Construction Laborers	514	25%	Low priority due to significant workforce supply and supportive training infrastructure
47-2111	Electricians	513	40%	
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	328	31%	
47-2031	Carpenters	280	18%	
47-2152	Plumbers, Pipefitters, and Steamfitters	230	32%	
11-9021	Construction Managers	201	30%	
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	173	30%	
13-1082	Project Management Specialists	150	6%	
43-9061	Office Clerks, General	142	1%	
47-2051	Cement Masons and Concrete Finishers	132	51%	Medium priority due to significant demand above baseline economic projections

5.4.4 OSW Workforce Gap Analysis

The Southern California region does not have large gaps in OSW workforce numbers but likely possesses gaps in the specialized workforces needed for OSW development. These gaps suggest that the local workforce will require upskilling, particularly in specialized roles such as welders, protective coating specialists, and crane operators. Of the occupations in highest demand, riggers present the largest gap in the region. Local training providers will likely need to include additional rigger certification courses to ensure the proper supply for this occupation.

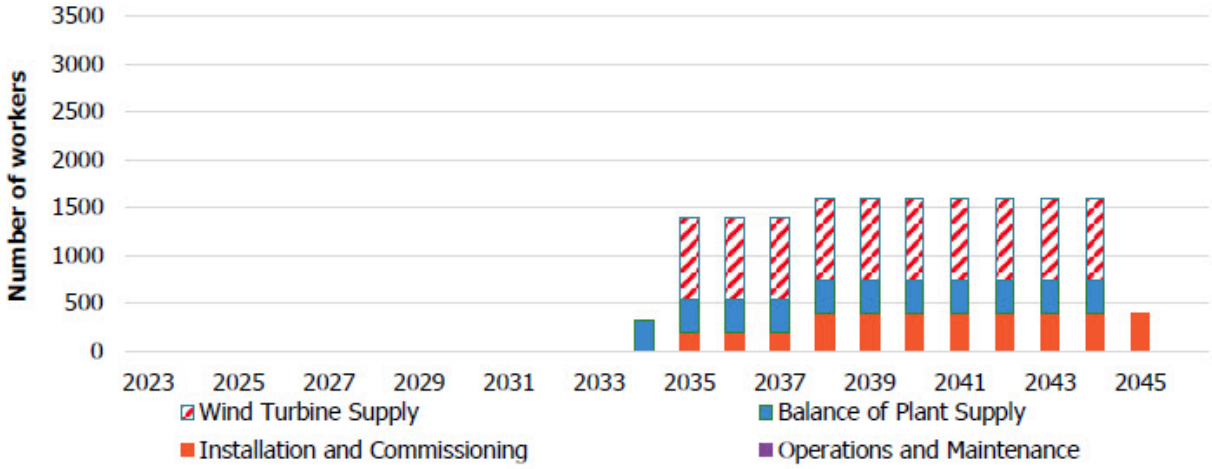

Figure 5.4. Southern California workforce demand by OSW supply chain area[13]. (See Appendix Table J.26 for source data)

[13] Intra-California competition for tower supply (in the Wind Turbine Supply area) means this component will either come from the Bay Area or Southern California, but not both, and is therefore designated with a pattern.

Table 5.11. Gap analysis for high demand occupations related to OSW activities in Southern California.

SOC Code	Occupation Title	Potential Workforce Demand	% Growth Above 2030 Projections	Priority
47-2061	Construction Laborers	216	11%	Low priority due to small gap
51-4121	Welders, Cutters, Solderers, and Brazers	178	26%	Medium priority due to need to upskill available workforce
47-2221	Structural Iron and Steel Workers	117	96%	Medium priority due to high demand and medium-sized gap
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	112	32%	Medium priority due to need to upskill available workforce
51-9199	Production Workers, All Other	95	13%	Low priority due to small gap
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic	89	62%	Medium priority due to medium-sized demand and large gap
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	82	34%	Low priority due to small gap
49-9096	Rigger	70	>100%	High priority due to high demand and large gap
51-4041	Machinist	66	8%	Low priority due to small gap
53-7021	Crane and Tower Operators	42	48%	Medium priority due to need to upskill available workforce

6 Recommendations for Workforce Development Strategy

This section presents five key recommendations, along with specific action items, to support California's workforce development strategy for OSW and port infrastructure. These recommendations are provided in three broad stages, grouped by priority level and activity type.

The immediate priority for the state of California is to prepare and recruit the workforce required to develop the ports and infrastructure needed ahead of OSW development. Increasing the ability for, and likelihood of, California to localize supply of OSW components directly relates to the development of its ports, making this an essential first step.

The second stage is to support the establishment and/or growth of OEMs, Tier 2, and Tier 3 manufacturing companies in California, which can be supported by developing the manufacturing workforce through transitioning, training, upskilling, and recruitment. As the procurement structure for the supply of components for California's OSW projects is currently uncertain, developing the local workforce can lead to increased OEM confidence, improving the likelihood of localization and optimized economic benefits.

The third stage focuses on the recruitment and training of the workforce needed to support OSW O&M. This workforce will be required for the entire 25+ year lifespan of an OSW project and thus represents a significant long-term workforce development and retention opportunity for California. Although this workforce will not be needed until after 2030, it is essential to plan ahead to ensure a skilled workforce is available when needed. This stage also includes implementing OSW-specific training modules within primary education up to undergraduate and graduate degrees to ensure the availability of a local supply of professionals for project development activities and white-collar jobs. These could include introductory courses and basic skills and knowledge training related to the offshore wind industry to raise awareness generally of these job opportunities and prepare individuals to enter these career pathways.

The five key recommendations with action items are:

1. Identify a primary state agency for economic development of California's OSW industry.
2. Align workforce investments with regional port strategies as well as the strengths and needs of each region.
3. Develop training programs and curriculum sequentially, according to workforce demands.

4. Engage early with unions, trade organizations, universities, and technical schools.
5. Invest in research and innovation for manufacturing, assembly, staging, and port logistics.

These items are discussed below along with specific action recommendations.

1. Identify a primary state agency for economic development of California's OSW industry.

As port, supply chain, and workforce investments increase in scale and complexity, a central state economic development agency dedicated to the floating OSW industry can help focus investments and avoid redundant efforts. State organizations like the New York State Energy Research and Development Authority or The Massachusetts Clean Energy Center can serve as models for this type of institution. Examples of economic development programs may include continuous state-led supply chain and workforce analysis programs; state-curated databases of local businesses, investments, and workforce initiatives; and state-sponsored research and development funding to build in-state capacity and expand existing assets.

To further support OSW development, several action items should be prioritized. First, a centralized state-level economic development platform dedicated to OSW should be designed with developer participation. Second, a continuous state-led supply chain and workforce development program will keep information up-to-date and readily available. Lastly, California should focus on regional collaboration with Oregon and Washington to optimize workforce mobilization, align port development, share best practices and strategies, and maximize supply chain and manufacturing assets. Multi-state collaboration initiatives could jointly leverage IRA funding designated for transmission initiatives.

2. Align workforce investments with regional port strategies as well as the strengths and needs of each region.

The state's port and infrastructure investments will be distributed across several geographically and demographically distinct areas, each with its unique growth capacity, population, and existing infrastructure. A strategic approach is required to effectively address these regional differences. Major commitments to the development of a transient workforce for North Coast upgrades and a significant upskilling of the existing workforce in other regions will require coordination and project-specific workforce strategies.

Region-specific recommendations include upskilling current electricians, plumbers, pipefitters, and electrical technicians for port site development in the North Coast and Southern California regions, as well as preparing construction managers and related supervisors for work in OSW port upgrades. Electricians, technicians, and construction

managers in the Bay Area and Southern California will require training on a 10-year time horizon, but this will be challenging to implement.

The North Coast's shrinking workforce and low population necessitate development and expansion ahead of port infrastructure construction, and this buildout is likely to have a high degree of difficulty and high investment. In the Central Coast region, workforce planning and preparation will be required due to labor market tightness, housing challenges, and distance from larger labor pools. Action items include focusing workforce investments in the North Coast, conducting workforce planning and preparation in the Central Coast, and upskilling relevant professionals for work in OSW and port infrastructure upgrades.

Action Items for Recommendation #2

- **Invest in programs and resources, like workforce housing projects, that expand the current and potential OSW workforce in and around the North Coast.** The regional gap analysis revealed that almost 3,300 FTEs would be needed for port upgrade work in the North Coast for each year from 2026 through 2030. Given the tight labor market, the relatively low concentration of comparable occupations in the region, and the large number of jobs that will be needed for the North Coast, this is a high priority action item that will soon require attention.
- **Develop shared programs and resources that expand the pipeline for carpenters, plumbers, pipefitters, and electrical technicians:** Over 1,300 additional FTE positions for carpenters, plumbers, pipefitters and electrical technicians will be needed in 2030 to support the port upgrades in Southern California, the Bay Area, and the North Coast. These are occupations that are already in high demand and typically require considerable on-the-job training to be fully functional and productive. Given the high demand for these occupations in other industries, and the large number of jobs that will be needed across California for OSW alone, this is a medium to high priority action item that will require attention within the next few years.

3. Develop training programs and curriculum sequentially, according to workforce demands.

Investments in training programs, pre-apprenticeships, and OSW must align with the requirements for the industry workforce at different stages of development. California should prioritize the expansion of training programs across roles related to port development and transmission over longer-term OSW-specific training. Region-specific development timelines will help ensure that investments made in the workforce are a strong fit for development needs in any given year.

State-led initiatives could involve building capacity at educational institutions, supporting local training programs, collaborating with East Coast institutions through a

"sister schools" model, and engaging with stakeholders to create career pathways in California beginning in early education.

To facilitate this development, State-led actions may include enhancing capacity at community colleges, vocational schools, pre-apprenticeship programs, and apprenticeship programs to address workforce needs for port development, transmission infrastructure, and other imminent projects. Investment in local institutions for comprehensive training programs in project development and O&M-related curricula, such as creating offshore wind-specific undergraduate programs and GWO training, should be a secondary consideration. Partnerships with East Coast institutions with established industry connections will help develop California's curriculum.

Additional action items include: prioritizing workforce development for the required infrastructure upgrades; expanding training programs focusing on manufacturing and fabrication skills in the Bay Area, Southern California, and the North Coast; developing programs for supporting ports services work in the North Coast and Southern California; offering relevant GWO modules in Central Coast O&M training programs; and investing in general project development training programs at the undergraduate and graduate levels. Providing OSW-focused training programs to California decision-makers from economic development organizations, publicly funded training centers, and educational institutions will also promote informed decision-making.

Action Items for Recommendation #3

- **Develop and provide training programs and/or seminars that prepare current electricians to work in the OSW industry.** Southern California will need over 500 additional FTE electricians in 2030 to support the port upgrade work. Over 1,000 additional FTE electricians will be needed across the state in 2030 to support the investments in the ports for the OSW industry. Given the high demand for electricians in the current job market and the sizable increase that will be needed for OSW-related ports upgrades, this is a high to medium priority action item that will require attention within the next year or two.
- **Develop training programs and/or resources so current construction and project managers and supervisors can transition into the OSW industry.** Construction and project managers typically require considerably more industry-specific expertise and experience than other building, construction, and design occupations. Given the new and emerging nature of the OSW industry in California, these workers will need additional training and education to be prepared to work in this industry. Over 400 new FTE construction managers will be needed in Southern California, the Bay Area, and the North Coast to support the port upgrade work in 2030. Given the importance of having construction managers to safely and effectively direct work at the ports to support the

burgeoning OSW industry, this is a high priority action item that will require immediate attention.

4. Engage early with unions, trade organizations, universities, and technical schools.

Trade organizations and unions have historically provided a highly trained and skilled workforce for new industry development in California. Many roles relating to the production or installation of balance-of-plant facilities and on-shore transmission facilities fall under the current skill sets and certifications of the existing trades and union workforce. Therefore, it is essential to engage with unions to streamline their transition to this new industry.

To effectively engage with labor unions and trade associations, collaboration with the California Division of Apprenticeship Standards under the Department of Industrial Relations is needed to align curriculum with industry needs. Investment in pre-apprenticeship and apprenticeship training programs should target training programs based on development activities anticipated in each region. California must also coordinate with unions on anticipated workforce mobilization efforts from the Bay Area and Southern California to both the North and Central Coast, as well as resourcing for port and transmission projects. Expanding the pipeline for electricians, plumbers, pipefitters, and electrical technicians across the state will ensure that workforce demands are met, as 1,100 FTE electricians alone will be needed by 2030 beyond the current Bureau of Labor Statistics estimate.

Action Item for Recommendation #4

- **Work collaboratively with unions, industry organizations, key employers and educators, like California Community Colleges, High Schools, Universities and workforce development boards, to develop career pathways and lattices for the OSW workforce in California.** This specific action item should not only provide a foundation for marketing and communication materials for students and potential workers, but also connect and provide shared priorities for those that are most able to support workforce development in the OSW industry. Given the need to communicate with students and jobseekers about the future employment opportunities in the OSW industry, this is a high priority action item that requires more immediate attention.

5. Invest in research and innovation for manufacturing, assembly, staging, and port logistics.

The manufacturing and assembly process for floating wind has not yet been established at a true commercial scale anywhere in the world, presenting opportunities for investment in innovation to decrease the levelized cost of energy for future projects and solutions to be tailored to fit California's supply chain. State investments in innovation

and research at partnering universities and colleges or regional innovation hubs and accelerators could yield significant returns through lower energy costs for consumers over the long-term. Research funding should focus on manufacturing, assembly, port logistics, and supply chain optimization. This will be an important step before developing the workforce, as choices related to the technology type and manufacturing methods of floating OSW projects will directly impact the skillsets required in California.

To support innovation, investments may include developing and supporting advanced manufacturing technologies, processes, and training programs tailored to the unique requirements of floating wind production through region-specific clean energy technology incubators and accelerators. Encouraging public-private partnerships between developers, OEMs, universities, research institutions, and government agencies can distribute the risk and cost of innovation, accelerating the development of new technologies and best practices in the sector. Additionally, investigating new areas of innovation and research focus, such as autonomous vehicles and digital twinning, can further drive progress. Action items include providing funding avenues for continued R&D of floating OSW technology, developing and supporting innovation hubs, and encouraging public-private partnerships between state agencies, universities, and developers.

Action Item for Recommendation #5

- **Work collaboratively with regional and statewide economic development entities to ensure workforce requirements and skillsets for chosen technology and innovations are communicated in a timely manner.** Through research and innovation, lowered cost of manufacturing will be focused on standardized designs and serial manufacturing approaches. In order to ensure California is prepared to support the floating OSW industry, the workforce associated with innovative technology type(s) and manufacturing method(s) must be communicated with the economic development agencies, where workforce assessments should be updated with appropriate data. This is an important action item as the innovative solutions can directly impact workforce needs. This action item also includes identifying, supporting and developing California companies that provide services and/or products to the OSW industry. Given the large number of design and manufacturing jobs that could be developed in a new and growing industry, this is a high priority action item that requires more immediate attention.

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8 Appendices

Appendix A. List of Supply Elements by Project Supply Area

Project Development

Supply Element	Workforce Includes	Workforce Excludes
Development and Permitting	Environmental impact assessment, permitting services for Site Assessment Plan (SAP), Construction & Operation Plan (COP), etc.	
Surveys	Benthic, pelagic, ornithological, marine mammal, etc. surveys; onshore environmental and socioeconomic studies and surveys; geophysical and geotechnical surveys; hydrographic surveys; metocean surveys	
Engineering and Design	Concept, pre-FEED and FEED studies, detailed design, certification	
Project Management	Internal and external project management, financial services, legal services	

Wind Turbine Supply

Supply Element	Workforce Includes	Workforce Excludes
Nacelle	OEM-delivered nacelle assembly	Manufacturing of specific turbine sub-components such as gearbox, generator, power take-off, bearings, yaw system, structural fasteners, etc. Supply of raw materials.
Rotor	OEM-delivered blade manufacturing	Manufacture of specific rotor sub-components such as hub castings, pitch system, fasteners, blade bearings, etc. Supply of raw materials.
Tower	OEM-delivered tower manufacturing (incl. internal steel components such as access platforms, ladders, etc.)	Manufacture of tower internal components such as lighting, etc. Supply of raw materials.

Balance of Plant Supply

Supply Element	Workforce Includes	Workforce Excludes
Foundation (Concrete Semisub)	Construction and batch plant operation	Manufacture and fabrication of secondary steel components. Supply of raw materials.
Foundation (Steel Semisub)	Manufacture of primary steel sub-structures	Substructure assembly. Manufacture and fabrication of secondary steel components. Supply of raw materials.
Secondary Steel Components	Foundation secondary steel components (boat landings, ladders, platforms, etc.)	Supply of raw materials.
Foundation Assembly	Assembly of primary steel substructures	
Anchors (Suction)	Manufacture of primary steel structures	Manufacture of ancillary components. Supply of raw materials
Mooring (Synthetic)	Production of mooring line	Manufacture of ancillary components. Supply of raw materials
Mooring (Steel)	Production of mooring line	Manufacture of ancillary components. Supply of raw materials
Offshore Substation	Engineering, procurement and construction (EPC) of offshore substation topside and foundation structures	Manufacturing and fabrication of electrical infrastructure sub-components such as switchgear, transformers, converters, power compensation, auxiliary systems, etc. Supply of raw materials.
Onshore Electricals	EPC of onshore substation structure	Manufacturing of electrical infrastructure sub-components such as switchgear, transformers, converters, power compensation, auxiliary systems, etc. Supply of raw materials. Manufacturing of ancillary components of onshore cables
Array Cables	OEM-delivered HV cable manufacture	Manufacture of ancillary components. Supply of raw materials
Export Cables	OEM-delivered HV cable manufacture	Manufacture of ancillary components. Supply of raw materials

Installation and Commissioning

Supply Element	Workforce Includes	Workforce Excludes
Foundation Tow Out/Hook Up (AHTS)	AHTS vessel crew, client and OEM representative, ROV	Vessel construction.
Foundation Tow Out/Hook Up (Support Tugs)	Support tug crew	Vessel construction.
Offshore Substation Installation	Vessel crew, commissioning, ROV	Vessel construction.
Subsea Cable Installation	Vessel crew, commissioning, ROV	Vessel construction.
Anchor Installation	Vessel crew, ROV	Vessel construction.
Mooring Installation	Vessel crew, ROV	Vessel construction.
Turbine Installation (Heavy Lift)	Heavy lift vessel crew, onshore support crew, commissioning	Vessel construction.
Turbine Installation (Crane)	Quayside heavy lift crane operations, commissioning	Crane manufacturing.
Ports and Logistics	Port services, marine coordination, weather forecasting and metocean data	
Onshore Construction	Onshore civils, onshore substation construction, operations base construction	

Operations and Maintenance

Supply Element	Workforce Includes	Workforce Excludes
Operations	Wind farm operations, software and IT support, occupational safety and health (OSHA), port services, marine coordination, warehousing, training	
Turbine Maintenance and Services	Blade inspection and repair, main component refurbishment/replacement and repair, CTV/Service operation vessel (SOV) crew	Vessel construction.
Balance of Plants Maintenance and Services	Foundation inspection and repair, cable inspection and repair, scour monitoring and management, substation maintenance and service, CTV/SOV crew	Vessel construction.

Appendix B. OSW Workforce Demand Tables

This table provides the number of workers required for each occupation in each year across the buildout in the high scenario.

SOC	Occupation	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
11-3012	Administrative Services Managers	0	28	28	42	56	56	70	70	70	70	70	84	98	70	98	84	112	98	70	70	42	42	0	0
53-6032	Aircraft Service Attendants	0	0	0	0	0	0	4	4	6	8	8	10	14	14	16	18	20	22	22	22	22	22	22	22
49-3011	Aircraft Mechanics and Service Technicians	0	0	0	0	0	0	4	4	6	8	8	10	14	14	16	18	20	22	22	22	22	22	22	22
53-2022	Airfield Operations Specialist	0	0	0	0	0	0	10	10	15	20	20	25	35	35	40	45	50	55	55	55	55	55	55	55
53-2011	Airline Pilots, Copilots, and Flight Engineers	0	0	0	0	0	0	4	4	6	8	8	10	14	14	16	18	20	22	22	22	22	22	22	22
19-1011	Animal Scientists	0	8	8	12	16	8	12	16	12	16	16	12	20	16	20	16	20	20	12	12	0	0	0	0
19-3091	Archeologist	0	10	10	15	20	10	15	20	15	20	20	15	25	20	25	20	25	25	15	15	0	0	0	0
17-1011	Architects, Except Landscape and Naval	0	0	0	0	4	4	2	4	2	2	6	4	12	12	14	14	14	14	10	12	6	0	0	0
11-9041	Architectural and Engineering Managers	0	0	0	0	0	0	2	2	1	2	1	1	3	2	1	2	2	3	2	2	2	3	3	0
19-2021	Atmospheric and Space Scientists	0	16	16	24	32	16	26	36	26	36	34	26	46	36	42	36	44	46	28	28	4	6	6	0
19-1029	Biological Scientists, All Other	0	26	26	39	52	26	39	52	39	52	52	39	65	52	65	52	65	65	39	39	0	0	0	0
17-3028	Calibration Technologists and Technicians	0	0	0	0	0	0	8	13	17	26	26	30	43	38	47	51	55	59	59	59	59	59	44	44
53-5021	Captains, Mates, and Pilots of Water Vessels	0	16	16	24	32	16	50	58	57	78	75	77	125	114	129	134	152	165	146	146	122	119	119	110
17-2199	Chemical Technicians	0	0	0	0	0	0	0	2	2	2	2	4	4	2	4	4	4	4	4	4	4	4	0	0
17-2051	Civil engineer	0	44	44	66	96	92	122	151	145	165	169	196	278	227	292	278	324	312	256	260	202	164	56	44
17-2051	Civil Engineers	0	4	4	6	8	4	18	24	22	32	28	30	60	64	66	72	78	86	78	78	72	56	56	44
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	0	0	0	0	0	0	30	92	107	184	184	214	324	259	351	366	381	396	396	396	396	366	165	165
49-9092	Commercial Diver	0	0	0	0	0	0	10	10	15	20	20	25	35	35	40	45	50	55	55	55	55	55	55	55
13-1041	Compliance Officers	0	4	4	6	8	4	6	8	6	8	8	6	10	8	10	8	10	10	6	6	0	0	0	0

SOC	Occupation	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
15-1299	Computer Occupations, All Other	0	8	8	12	16	12	16	18	16	18	18	18	34	26	34	28	36	34	22	22	6	6	0	0
15-1211	Computer Systems Analysts	0	4	4	6	14	14	13	16	13	13	19	18	17	16	20	21	22	20	16	19	15	6	0	0
47-4011	Construction and Building Inspectors	0	0	0	0	0	0	12	12	18	24	24	30	42	42	48	54	60	66	66	66	66	66	66	66
47-2061	Construction Laborers	0	0	0	0	100	100	100	326	286	371	461	522	622	516	672	752	722	752	742	792	792	617	250	220
11-9021	Construction Managers	0	0	0	0	0	0	4	6	5	8	6	7	13	11	10	13	14	17	15	15	15	17	17	11
35-2012	Cooks, Institution and Cafeteria	0	0	0	0	0	0	14	14	15	22	19	23	46	43	44	51	55	62	59	59	59	53	53	44
53-7021	Crane and Tower Operators	0	0	0	0	0	0	27	56	53	77	66	82	144	130	140	159	167	186	175	175	175	157	121	88
43-4051	Customer Service Representatives	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-2051	Data scientist	0	8	8	12	20	12	14	20	14	18	22	16	22	20	24	22	24	24	16	18	6	0	0	0
17-3019	Drafters, All Other	0	0	0	0	0	0	0	18	18	23	23	31	75	67	85	80	85	85	75	75	60	36	0	0
17-2071	Electrical engineer	0	12	12	18	34	34	49	61	60	73	81	88	139	142	165	170	185	187	169	174	156	105	72	66
47-2111	Electricians	0	0	0	0	12	12	30	45	45	69	77	81	113	105	121	141	145	159	155	161	161	147	122	110
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	0	0	0	0	0	0	20	20	30	40	40	50	70	70	80	90	100	110	110	110	110	110	110	110
47-4021	Elevator and Escalator Installers and Repairers	0	0	0	0	0	0	11	12	16	22	21	26	38	37	41	47	52	58	57	57	57	58	58	55
11-9161	Emergency Management Directors	0	0	0	0	0	0	10	10	15	20	20	25	35	35	40	45	50	55	55	55	55	55	55	55
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	0	0	0	0	0	0	20	51	61	83	83	99	157	161	189	199	209	219	219	219	219	171	110	110
17-2199	Engineers, All Other	0	0	0	0	0	0	10	17	19	30	28	32	69	58	69	71	79	85	75	75	63	65	50	44
17-2081	Environmental consultant/engineer	0	24	24	36	48	24	36	48	36	48	48	36	60	48	60	48	60	60	36	36	0	0	0	0
17-2081	Environmental Engineer	0	16	16	24	32	16	24	32	24	32	32	24	40	32	40	32	40	40	24	24	0	0	0	0
11-3013	Facilities Managers	0	0	0	0	0	0	4	4	6	8	8	10	14	14	16	18	20	22	22	22	22	22	22	22
13-2054	Financial Risk Specialist	0	0	0	0	0	0	0	0	0	0	0	0	10	8	10	8	10	10	6	6	0	0	0	0
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	0	0	0	0	2	2	3	18	15	21	21	24	34	27	33	36	35	37	35	36	36	30	6	0

SOC	Occupation	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
19-4071	Forest and Conservation Technicians	0	8	8	12	16	8	16	20	14	20	18	14	26	20	22	20	24	26	16	16	4	6	6	0
11-1021	General and Operations Managers	0	0	0	0	4	4	3	6	3	4	7	5	5	6	5	8	6	7	6	8	8	3	3	0
19-4043	Geological Technicians, Except Hydrologic Technicians	0	8	8	12	16	8	12	16	12	16	16	12	20	16	20	16	20	20	12	12	0	0	0	0
19-2042	Geoscientists, Except Hydrologists and Geographers	0	8	8	12	16	8	12	16	12	16	16	12	20	16	20	16	20	20	12	12	0	0	0	0
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	0	0	0	0	0	0	22	22	33	44	44	55	77	77	88	99	110	121	121	121	121	121	121	121
53-7041	Hoist and winch operator	0	0	0	0	0	0	30	36	42	60	54	66	144	150	156	174	186	204	198	198	198	150	150	132
13-1071	Human Resource Specialists	0	16	16	24	32	32	40	40	40	40	40	48	56	40	56	48	64	56	40	40	24	24	0	0
13-1071	Human Resources Specialists	0	4	4	6	8	8	10	10	10	10	10	12	14	10	14	12	16	14	10	10	6	6	0	0
19-2043	Hydrologists	0	8	8	12	16	8	12	16	12	16	16	12	20	16	20	16	20	20	12	12	0	0	0	0
17-3026	Industrial Engineering Technologists and Technicians	0	0	0	0	4	4	2	4	2	2	6	4	2	4	4	6	4	4	4	6	6	0	0	0
17-2112	Industrial Engineers	0	0	0	0	0	0	6	20	20	29	27	31	82	79	90	90	96	100	90	90	78	52	28	22
11-3051	Industrial Production Managers	0	0	0	0	2	2	4	22	18	31	30	36	60	47	61	65	64	67	64	65	65	50	9	0
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	0	0	0	0	0	0	16	43	45	65	61	75	117	105	125	135	141	151	147	147	147	129	78	66
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	0	0	0	0	0	0	12	14	17	24	22	27	41	39	42	49	54	61	59	59	59	61	61	55
23-1011	Lawyer	0	8	8	12	16	12	16	18	16	18	18	18	24	18	24	20	26	24	16	16	6	6	0	0
13-1081	Logisticians	0	0	0	0	0	0	9	26	26	37	34	41	61	51	60	66	69	75	72	72	72	70	42	33
51-4041	Machinist	0	0	0	0	0	0	18	66	66	96	90	114	192	162	198	210	216	228	222	222	222	180	84	66
11-9199	Managers, All Other	0	66	66	99	132	124	163	179	175	188	186	213	268	198	266	236	301	276	206	206	133	135	28	22
17-2121	Marine Engineers and Naval Architects	0	0	0	0	0	0	12	12	18	24	24	30	53	64	70	76	82	88	88	88	88	66	66	66
17-2131	Materials Engineer	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	0	0	0

SOC	Occupation	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
17-2141	Mechanical engineer	0	0	0	0	10	10	15	27	24	35	43	42	74	80	89	98	99	105	99	104	98	65	50	44
17-2141	Mechanical Engineers	0	108	108	162	216	216	270	270	270	270	270	324	378	270	378	324	432	378	270	270	162	162	0	0
49-9044	Millwright	0	0	0	0	0	0	18	46	46	70	64	73	132	123	138	150	156	168	162	162	162	133	84	66
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	0	0	0	0	0	0	36	94	85	124	106	136	223	182	206	233	242	269	251	251	251	238	153	99
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	0	0	0	0	0	0	5	10	5	10	5	5	15	10	5	10	10	15	10	10	10	15	15	0
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	0	0	0	0	0	0	0	0	0	0	0	0	12	22	22	22	22	22	22	22	22	0	0	0
19-5012	Occupational Health and Safety Technicians	0	0	0	0	4	4	12	35	29	42	40	48	72	59	68	78	78	86	80	82	82	73	40	22
47-2073	Operating Engineers and Other Construction Equipment Operators	0	0	0	0	0	0	0	0	0	0	0	0	10	8	10	8	10	10	6	6	0	0	0	0
47-2141	Painters, Construction and Maintenance	0	0	0	0	0	0	6	12	6	12	6	6	18	12	6	12	12	18	12	12	12	18	18	0
23-2011	Paralegal	0	8	8	12	16	12	16	18	16	18	18	18	24	18	24	20	26	24	16	16	6	6	0	0
51-8099	Plant and System Operators, All Other	0	0	0	0	0	0	0	2	2	2	2	4	4	2	4	4	4	4	4	4	4	4	0	0
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic	0	0	0	0	0	0	10	64	69	124	124	148	218	149	223	228	233	238	238	238	238	228	55	55
47-2152	Plumbers, Pipefitters, and Steamfitters	0	0	0	0	4	4	4	6	5	6	10	9	9	11	12	15	14	15	15	17	17	11	11	11
51-8013	Power Plant Operators	0	0	0	0	0	0	0	10	10	10	10	20	20	10	20	20	20	20	20	20	20	20	0	0
51-9199	Production Workers, All Other	0	0	0	0	0	0	0	65	65	115	115	120	250	260	315	315	315	315	315	315	315	170	0	0
13-1082	Project Management Specialists	0	2	2	3	4	4	5	5	5	5	5	6	7	5	7	6	8	7	5	5	3	3	0	0
27-3031	Public relations specialist	0	8	8	12	16	8	12	16	12	16	16	12	20	16	20	16	20	20	12	12	0	0	0	0
53-7072	Pump Operators, Except Wellhead Pumpers	0	0	0	0	0	0	0	5	5	5	5	10	10	5	10	10	10	10	10	10	10	10	0	0
11-3061	Purchasing manager	0	2	2	3	4	4	14	24	24	35	32	37	59	50	58	63	68	73	68	68	66	63	42	33
53-7081	Refuse and Recyclable Material Collectors	0	0	0	0	2	2	7	8	8	11	12	13	24	24	25	29	30	33	32	33	33	25	25	22
49-9096	Rigger	0	0	0	0	0	0	66	102	87	144	117	141	259	212	227	266	278	317	290	290	290	285	213	132

SOC	Occupation	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
53-5011	Sailors and Marine Oilers	0	10	10	15	20	10	85	90	70	110	85	90	230	200	190	220	235	270	235	235	220	185	185	110
41-9099	Sales and Related Workers, All Other	0	4	4	6	8	8	10	10	10	10	10	12	14	10	14	12	16	14	10	10	6	6	0	0
41-4011	Sales Representative, Wholesale and Manufacturing, Technical and Scientific Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33-9032	Security Guard	0	0	0	0	0	0	11	16	14	22	17	20	36	31	29	37	40	48	43	43	43	48	48	33
53-5031	Ship Engineers	0	14	14	21	28	14	41	50	46	64	60	60	98	87	97	101	115	126	108	108	87	89	89	77
47-2221	Structural Iron and Steel Workers	0	0	0	0	0	0	12	91	97	153	153	189	263	183	269	275	281	287	287	287	287	275	66	66
49-9052	Telecommunications Line Installers and Repairers	0	0	0	0	0	0	12	12	18	24	24	30	52	62	68	74	80	86	86	86	86	66	66	66
11-3131	Training and Development Managers	0	0	0	0	6	6	3	6	3	3	9	6	3	6	6	9	6	6	6	9	9	0	0	0
11-3071	Transportation , Storage, and Distribution Managers	0	0	0	0	0	0	27	40	34	54	41	48	88	75	69	89	96	116	103	103	103	116	116	77
53-6051	Transportation Inspectors	0	0	0	0	0	0	4	6	5	8	6	7	13	11	10	13	14	17	15	15	15	17	17	11
11-3071	Transportation, Storage, and Distribution Managers	0	2	2	3	4	4	5	5	5	5	5	6	7	5	7	6	8	7	5	5	3	3	0	0
51-4121	Welders, Cutters, Solderers, and Brazers	0	0	0	0	0	0	30	158	164	244	238	292	402	292	402	420	432	450	444	444	444	438	150	132
49-9081	Wind Turbine Service Technicians	0	0	0	0	0	0	22	28	30	44	38	46	74	68	70	84	92	106	100	100	100	106	106	88
19-1023	Zoologists and Wildlife Biological Scientists, All Others	0	4	4	6	8	4	6	8	6	8	8	6	10	8	10	8	10	10	6	6	0	0	0	0

Appendix C. Port Development Industry Definition

NAICS Code	Industry Name	2-digit NAICS	Major Industry Group
236220	Commercial and Institutional Building Construction	23	Construction
237110	Water and Sewer Line and Related Structures Construction	23	Construction
237990	Other Heavy and Civil Engineering Construction	23	Construction
238112	Nonresidential Poured Foundation Contractors	23	Construction
238122	Nonresidential Structural Steel Contractors	23	Construction
238212	Nonresidential Electrical Contractors Installation	23	Construction
238222	Nonresidential Plumbing and HVAC Contractors	23	Construction
238322	Nonresidential Painting Contractors	23	Construction
238352	Nonresidential Finish Carpentry Contractors	23	Construction
238912	Nonresidential Site Preparation Contractors	23	Construction
238992	All Other Nonresidential Trade Contractors	23	Construction
541310	Architectural Services	54	Professional Services
541330	Engineering Services	54	Professional Services

Appendix D: Port Development Occupational Definition

SOC	Occupation
11-2022	Sales Managers
11-3012	Administrative Services Managers
11-3031	Financial Managers
11-9021	Construction Managers
11-9041	Architectural and Engineering Managers
11-9199	Managers, All Other
11-1011	Chief Executives
11-1021	General and Operations Managers
13-1023	Purchasing Agents, Except Wholesale, Retail, and Farm Products
13-1051	Cost Estimators
13-1071	Human Resources Specialists
13-1082	Project Management Specialists
13-1161	Market Research Analysts and Marketing Specialists
13-1199	Business Operations Specialists, All Other
13-2011	Accountants and Auditors
15-1232	Computer User Support Specialists
15-1252	Software Developers
15-1299	Computer Occupations, All Other
17-1011	Architects, Except Landscape and Naval
17-1022	Surveyors
17-2051	Civil Engineers
17-2071	Electrical Engineers
17-2141	Mechanical Engineers
17-2199	Engineers, All Other
17-3011	Architectural and Civil Drafters
17-3012	Electrical and Electronics Drafters
17-3022	Civil Engineering Technologists and Technicians
17-3023	Electrical and Electronic Engineering Technologists and Technicians
19-5011	Occupational Health and Safety Specialists
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners
37-3011	Landscaping and Groundskeeping Workers
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products
43-1011	First-Line Supervisors of Office and Administrative Support Workers
43-3021	Billing and Posting Clerks
43-3031	Bookkeeping, Accounting, and Auditing Clerks
43-3051	Payroll and Timekeeping Clerks

43-4051	Customer Service Representatives
43-4171	Receptionists and Information Clerks
43-5032	Dispatchers, Except Police, Fire, and Ambulance
43-5061	Production, Planning, and Expediting Clerks
43-5071	Shipping, Receiving, and Inventory Clerks
43-6011	Executive Secretaries and Executive Administrative Assistants
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive
43-9061	Office Clerks, General
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers
47-2011	Boilermakers
47-2021	Brick masons and Block masons
47-2031	Carpenters
47-2044	Tile and Stone Setters
47-2051	Cement Masons and Concrete Finishers
47-2061	Construction Laborers
47-2071	Paving, Surfacing, and Tamping Equipment Operators
47-2072	Pile Driver Operators
47-2073	Operating Engineers and Other Construction Equipment Operators
47-2081	Drywall and Ceiling Tile Installers
47-2111	Electricians
47-2121	Glaziers
47-2141	Painters, Construction and Maintenance
47-2151	Pipelayers
47-2152	Plumbers, Pipefitters, and Steamfitters
47-2161	Plasterers and Stucco Masons
47-2171	Reinforcing Iron and Rebar Workers
47-2181	Roofers
47-2211	Sheet Metal Workers
47-2221	Structural Iron and Steel Workers
47-2231	Solar Photovoltaic Installers
47-3012	Helpers--Carpenters
47-3013	Helpers--Electricians
47-3014	Helpers--Painters, Paperhangers, Plasterers, and Stucco Masons
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters
47-3019	Helpers, Construction Trades, All Other
47-4011	Construction and Building Inspectors
47-4031	Fence Erectors
47-4099	Construction and Related Workers, All Other
47-5022	Excavating and Loading Machine and Dragline Operators, Surface Mining
47-5023	Earth Drillers, Except Oil and Gas
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers

49-2022	Telecommunications Equipment Installers and Repairers, Except Line Installers
49-2097	Audiovisual Equipment Installers and Repairers
49-2098	Security and Fire Alarm Systems Installers
49-3042	Mobile Heavy Equipment Mechanics, Except Engines
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers
49-9044	Millwrights
49-9051	Electrical Power-Line Installers and Repairers
49-9052	Telecommunications Line Installers and Repairers
49-9071	Maintenance and Repair Workers, General
49-9098	Helpers--Installation, Maintenance, and Repair Workers
49-9099	Installation, Maintenance, and Repair Workers, All Other
51-4121	Welders, Cutters, Solderers, and Brazers
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors
53-3032	Heavy and Tractor-Trailer Truck Drivers
53-3033	Light Truck Drivers
53-7021	Crane and Tower Operators
53-7051	Industrial Truck and Tractor Operators
53-7062	Laborers and Freight, Stock, and Material Movers, Hand
53-7065	Stockers and Order Fillers

Appendix E: OSW Occupational Definition

SOC	Occupation
11-3012	Administrative Services Managers
11-3013	Facilities Managers
11-3051	Industrial Production Managers
11-3061	Purchasing Managers
11-3071	Transportation, Storage, and Distribution Managers
11-3131	Training and Development Managers
11-9021	Construction Managers
11-9041	Architectural and Engineering Managers
11-9161	Emergency Management Directors
11-9199	Managers, All Other
13-1071	Human Resource Specialists
13-1081	Logisticians
13-1082	Project Management Specialists
13-2054	Financial Risk Specialist
15-1253	Software Quality Assurance Analysts and Testers
15-1299	Computer Occupations, All Other
15-2051	Data scientist
17-1011	Architects, Except Landscape and Naval
17-2041	Chemical Engineer
17-2051	Civil Engineers
17-2071	Electrical Engineer
17-2081	Environmental Engineer
17-2112	Industrial Engineers
17-2121	Marine Engineers and Naval Architects
17-2131	Materials Engineer
17-2141	Mechanical Engineers
17-2199	Engineers, All Other
17-3019	Drafters, All Other
17-3023	Electrical and Electronic Engineering Technologists and Technicians
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians
17-3026	Industrial Engineering Technologists and Technicians
17-3028	Calibration Technologists and Technicians
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other
19-1011	Animal Scientists
19-1023	Zoologists and Wildlife Biologists
19-1029	Biological Scientists, All Other
19-2021	Atmospheric and Space Scientists
19-2042	Geoscientists, Except Hydrologists and Geographers

SOC	Occupation
19-2043	Hydrologists
19-3091	Anthropologists and Archeologists
19-4043	Geological Technicians, Except Hydrologic Technicians
19-4071	Forest and Conservation Technicians
19-4099	Life, Physical, and Social Science Technicians, All Other
19-5011	Occupational Health and Safety Specialists
19-5012	Occupational Health and Safety Technicians
23-1011	Lawyer
23-2011	Paralegals and Legal Assistants
27-3031	Public relations specialist
33-9032	Security Guard
35-2012	Cooks, Institution and Cafeteria
41-4011	Sales Representative, Wholesale and Manufacturing, Technical and Scientific Products
41-9099	Sales and Related Workers, All Other
43-4051	Customer Service Representatives
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers
47-2061	Construction Laborers
47-2073	Operating Engineers and Other Construction Equipment Operators
47-2141	Painters, Construction and Maintenance
47-2152	Plumbers, Pipefitters, and Steamfitters
47-2221	Structural Iron and Steel Workers
47-4011	Construction and Building Inspectors
47-4021	Elevator and Escalator Installers and Repairers
49-3011	Aircraft Mechanics and Service Technicians
49-3042	Mobile Heavy Equipment Mechanics, Except Engines
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers
49-9044	Millwright
49-9081	Wind Turbine Service Technicians
49-9092	Commercial Diver
49-9096	Rigger
51-4041	Machinist
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic
51-4121	Welders, Cutters, Solderers, and Brazers
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic
51-8013	Power Plant Operators
51-8099	Plant and System Operators, All Other
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic

SOC	Occupation
51-9199	Production Workers, All Other
53-2011	Airline Pilots, Copilots, and Flight Engineers
53-2022	Airfield Operations Specialist
53-5011	Sailors and Marine Oilers
53-5021	Captains, Mates, and Pilots of Water Vessels
53-5031	Ship Engineers
53-6032	Aircraft Service Attendants
53-6051	Transportation Inspectors
53-7021	Crane and Tower Operators
53-7041	Hoist and winch operator
53-7062	Laborers and Freight, Stock, and Material Movers, Hand
53-7072	Pump Operators, Except Wellhead Pumpers
53-7081	Refuse and Recyclable Material Collectors

Appendix F: Literature Review of Transmission Upgrades

Technology and Investments Made to Transmission Systems

Transmission is at the core of decarbonization. California's future economic stability will depend on its ability to develop a robust transmission system to support the grid which can support the effective integration of clean energy infrastructure.

Transmission lines and power transformers are critical to moving energy from the two federally designated Wind Energy Areas to more populated regions. This infrastructure requires upgrades in order to expand transmission capacity. Regions identified to date off the coast of California as viable for wind farms tend to be in remote locations; therefore, achieving zero percent carbon emissions by 2035 depends in-part on the ability to modernize and expand transmission lines and power transformers in order to bring that electricity to populated areas.[14]

Studies have found that over 70% of transmission lines and power transformers are over 25 years old. To achieve the White House's goal of attaining zero-carbon emissions in the power sector by 2035, transmission investments would need to increase by $500 billion over the next few years to achieve a carbon-free electricity sector.[15]

Studies by Princeton University and the National Renewable Energy Laboratory have found that transmission systems will have to increase their capacity two- to five-fold to support high renewable scenarios. Without such upgrades, solar and wind power will have to be curtailed and renewable energy sources may not match local demand. Difficulties with expansion often arise due to siting, permitting, and other administrative roadblocks, which could be mitigated with the creation of a federal transmission oversight committee and with increased regional cooperation by States.[16]

Transmission lines are typically managed by either state regulators or independent system operators/regional transmission operators (ISOs/RTOs). Whether transmission is administered by a state public utility or by an ISO/RTO, modifying a transmission system involves several governmental agencies, at various levels of government.[17]

Technology Overview

Historically, transmission lines have transported power generated from fossil fuels such as coal, oil, and natural gas to populated areas in a predictable fashion. However, clean energy technologies such as solar and offshore wind will need more flexibility and

[14] "The Transmission Mission: Building an Infrastructure for Our Clean Energy Future," Energy.gov, December 2022,
[15] Ewelina Czapla et al., "The Cost of Upgrading Electricity Transmission," AAF, August 16, 2021,
[16] "To Enable the Clean Energy Future, Electric Transmission Planning Needs an Upgrade," Yale Environment Review, March 29, 2022.
[17] The Federal Register., "Building for the Future Through Electric Regional Transmission Planning and Cost Allocation and Generator Interconnection. Federal Register: Request Access, 2022.

geographical coverage from transmission systems to be a reliable source of power for households and businesses.

Costs occurring from transmission projects are typically incurred by spur (a transmission line that connects to the transmission facility) and point of interconnection (POI). Rarely does an interconnection study find it necessary to also expand the bulk transmission system.[18]

The electricity from most OSW projects will have to be delivered to consumers via the onshore grid, which will require submarine cables, beach crossings, POI to the existing grid, upgrades to the onshore grid near those POIs, as well as additional transmission to reach load centers. Generation projects need to enter an "interconnection queue", where the managing authority runs studies to determine the impact of said generation project on the existing system. According to a previous study, time spent in these interconnecting queues increased from 1.9 years for projects built between 2000–2009, to 3.5 years for projects built between 2010–2020. [19]

Improvements to new, lesser developed technologies could make upgrades to transmission infrastructure less costly and more efficient. For instance, power flow controls, dynamic line ratings, and topology optimization could develop more flexible transmission systems by pushing power off an overutilized transmission line onto an underutilized power line. However, investments made in transmission infrastructure compensate utilities based on the amount of capital it costs, in a "risks and challenges" approach. Therefore, this approach incentivizes utilities to invest in capital-intensive technologies such as raising and reconductoring lines and building new transmission. Although newer technologies such as power flow controls are typically ten percent of the cost of building new lines, there are no incentives that prioritize software over capital equipment.[20]

The Federal Energy Regulatory Commission (FERC) has proposed a change in rulemaking regarding electric transmission incentive policies so that the paradigm shifts from the current "risks and challenges" approach towards an approach that reduces costs and benefits customers, as capital expenditure falls on the latter's utility bill.[21]

Transmission Upgrades Investments

FERC Order 2003, published in the same year, allowed for ISOs and RTOs to hold developers responsible for the upgrades they need to interconnect their projects to the

[18] Ewelina Czapla et al., "The Cost of Upgrading Electricity Transmission," AAF, August 16, 2021,
[19] "To Enable the Clean Energy Future, Electric Transmission Planning Needs an Upgrade," Yale Environment Review, March 29, 2022.
[20] Robert Walton, "Propelling the Transition: New and Better Transmission Is Key to Zero Carbon; Here's What's Driving It," Utility Dive, August 19, 2020.
[21] Iulia Gheorghiu, "FERC Launches Long-Delayed Revision of Transmission Incentives, Bringing Benefits into the Equation," Utility Dive, March 20, 2020.

electric grid. That order did not consider clean energy resources, as wind and solar tend to be the most productive in remote locations, and therefore account for 90% of interconnection requests today.[22]

As OSW projects ramp up across the country, system and transmission operators such as CAISO in California are witnessing an uptick in interconnection requests, that will keep on increasing as OSW projects move forward. A study that surveyed a large array of electricity transmission stakeholders has found that almost half of respondents planned on upgrading their transmission and substations. Although utilities and developers alike are eager to modernize the transmission infrastructure, they realize that it is a daunting task that requires billions of dollars in investment, with acute planning and collaboration across the entire ecosystem.[23]

However, utilities and developers will benefit from financial support from the Biden-Harris administration, through its Building a Better Grid Initiative (BBGI), and its more recent program, the Transmission Facilitation Program (TFP). The TFP is the first down payment into the BBGI Initiative, and it authorizes the Department of Energy (DOE) to borrow up to $2.5 billion to help finance new and upgraded transmission line projects through three different instruments. Most notably, the DOE can participate in public-private partnerships on eligible projects and act as an "anchor customer", which commits the DOE to purchasing 50% of the maximum capacity of the transmission line for up to 40 years. This instrument is innovative, as it buys capacity until customer demand increases enough to cover the costs, taking away risk from initial investment and spurring the development of transmission projects that would otherwise not be built.[24]

This policy is important to consider, since building new transmission lines and upgrading existing ones is mostly expensive to utilities in terms of upfront costs. For instance, the midwestern interconnection system operator, which manages the grid for 14 states, has found that recent transmission upgrades made between 2012 and 2014 have saved over $16 billion since they were built, which is 3.5 times their upfront cost. On the demand side, transmission upgrades alleviate power congestions, which create inefficiencies and cost consumers over $6 billion each year.[25]

Status of Development in California

California's power system is part of a larger cooperation agreement that administers planning and resource sharing. The California Independent System Operator (CAISO) manages over 80% of the state's electricity, across 26,000 miles of transmission lines.

[22] Jeff St. John, "Report: Renewables Are Suffering from Broken US Transmission Policy," Greentech Media, January 12, 2021.
[23] "Renewables, Resiliency Drive Transmission Upgrades | T&D World," n.d.
[24] "Biden Administration Launches $2.5 Billion Fund to Modernize and Expand Capacity of America's Power Grid," Energy.gov, n.d.
[25] ACP. "Clean Energy Transmission". ACP, January 3, 2023.

Although several studies and experts argue that a regional system would make the state's clean energy goals more attainable, CAISO is currently governed by a five-member board appointed by the governor. As other states would want to have parity in decision-making, California lawmakers have requested a study to determine other governance options through the ACR 188. [26]

Experts have determined that transmission is a challenge in the North, while ports are a challenge for central California. According to CAISO, it would cost $5–8 billion to upgrade the North Coast infrastructure, assuming 4GW of OSW energy generation is realized. Experts believe that a full upgrade of this extent will happen by the end of the decade, especially as geopolitical challenges such as the Ukraine war have destabilized the price of fossil fuels. [27]

OSW projects are being developed across the state, along with solar and electrification efforts in the transportation sector, which has pushed CAISO to adopt an aggressive approach towards electric transmission planning in the latest iteration of its yearly transmission outlook plan. The system operator has determined the need for a $3 billion investment in transmission infrastructure in its 10-year outlook, a big departure from its $217 million worth of investments over the past five years. It has also determined that upcoming interconnecting projects will require $30.5 billion worth of transmission upgrades in the next two decades.

Most notably, these investments will go towards projects such as two HDVC projects in the San Francisco South Bay region that will serve the San Jose/Silicon Valley Power area, or projects such as a new 500/230 kV substation in the East Bay area that will create access to wind power sources.[28]

OSW Transmission Upgrades: Domestic and International Case Studies

The following examples illustrate two aspects of transmission upgrades that California can learn from. On the one hand, emulating New York's upgrades would allow for more connectivity and less congestion, saving costs to utilities and customers. On the other hand, investing in innovative software, like the United Kingdom, could reduce buildout costs and make California's transmission infrastructure more efficient.

East Coast

The East Coast is the most advanced region when it comes to OSW development. The main system operators are ISO New England (ISO-NE), New York ISO (NYISO), and PJM Interconnection (which covers the coastline from New Jersey to North Carolina).

[26] National Renewable Energy Laboratory. "Impacts of Expanded Regional Cooperation on California and the Western Grid". January 13, 2023.
[27] National Wind Watch, "Challenges Face Wind Energy Project off the Humboldt County Coast," National Wind Watch, June 5, 2022.
[28] California ISO. "Decision on the ISO's 2021-2022 Transmission Plan". March 9, 2022.

These operators will need their transmission to interconnect 40GW, 25GW, and up to 70GW through 2050, respectively.

NYISO has five transmission upgrade-related projects underway to relieve transmission congestion and increase the flow of clean energy to consumers. The most notable projects are:

- The Western New York public policy project: A 20-mile transmission line project, added to an existing right-of-way from Niagara to Erie counties. This project will make 2,700 MW from Niagara fully available, and will transfer an additional 1,000MW from Ontario after retirement of fossil fueled power plants in the region.
- The AC Transmission Upgrade Project: This project includes 93 miles of high voltage transmission lines from Oneida to Albany counties, and 54 miles of high voltage transmission lines from Rensselaer to Dutchess counties.
- The Northern New York Project (undertaken by New York Power Authority): The project aims to rebuild over 200 miles of transmission lines in the North County and Central New York areas to a higher voltage.[29]

Europe

The European Union has made OSW a key item of its energy transition agenda. This effort has been facilitated by a fall in technology costs, dedicated support from policymakers and regulators, and economic success in recent auctions. The largest wind projects on the continent are in the UK, Germany, Denmark, the Netherlands, France, and Poland. Each of these will have a market share of five percent or more by 2030. [30]

The United Kingdom is currently testing Power Flow Controls technology devices. So far, the technology has solved a critical bottleneck on a 132-kV power line and has enabled an additional 95MW of renewable energy to connect to the grid without any additional transmission infrastructure buildout, saving over $10 million. The use of new technologies not only saves on building new infrastructure, but also provides relief during outages or while a new line is being constructed.

All in all, adopting new technologies that are software-oriented, rather than equipment-focused, reduces transmission congestion and energy curtailment. Studies have found that these technology options can save up to $110 million annually for an average transmission system operator of 100 kV+ assets.[31]

[29] NYISO. "OSW and the Role of New Transmission", 2021.
[30] Dolly Khattar, "OSW Transmission Trends in Europe - Reglobal - Mega Trends & Analysis," REGlobal, September 21, 2020.
[31] "Innovation in Transmission Operation with Advanced Technologies," n.d.

Key Findings

- Windfarms tend to be located in remote areas; therefore, zero percent carbon emissions by 2035 zero percent carbon emissions by 2035 depend in-part on the ability to modernize and expand transmission lines and power transformers to bring that electricity to populated areas.
- Transmission infrastructure is aging, with over 70% of transmission lines and power transformers being over 25 years old. Investments in transmission infrastructure will have to increase by $500 billion over the next few years to achieve a carbon-free electricity sector.
- Most electricity from OSW projects will have to be delivered to the onshore grid and will require submarine cables, beach crossings, POI to the existing grid, upgrades to the existing grid, and additional transmission to reach load centers.
- Although implementing new, lesser developed technologies could make transmission upgrades more efficient and less costly, investments made in transmission infrastructure compensate utilities based on the capital it costs. There are currently no incentives that prioritize software over capital equipment.
- Building new transmission lines and upgrading existing ones is mostly expensive to utilities due to upfront costs. System operators across the country have found that transmission upgrades have saved them up to 3.5 times the initial cost.
- Utilities and developers will benefit from financial support through the Building a Better Grid Initiative (BBGI) and its related program, the Transmission Facilitation Program (TFP). The TFP will commit the Department of Energy to buy capacity on transmission lines until customer demand increases enough to cover the costs, which takes risks away from initial investments.
- Industry experts have determined that transmission is mainly a challenge in Northern California. According to the CAISO, it would cost $5–8 billion to upgrade the North Coast infrastructure, assuming 4GW of OSW energy generation.
- The New York Independent System Operator (NYISO) has five transmission upgrade projects underway which are aimed at relieving transmission congestion and increasing the consumer's access to clean energy.
- The United Kingdom has been testing newer transmission technology that has saved on building new infrastructure, provided relief during power outages, and reduced transmission congestion and energy curtailment.
- Demand for transmission workers will dramatically increase as windfarm projects ramp up. In the OSW context, the challenge will be to find people that have enough quantitative knowledge to enter training programs to replace the aging workforce.

- Transmission jobs typically pay higher wages and tend to be unionized. There is a need to increase exposure to these jobs, so that California does not rely on transient workers, which avoids bottlenecks.
- Future research on transmission upgrades should provide quantitative data such as the supply of workers and should identify the areas most in need of transmission upgrades across the State. Such research would support labor unions, workforce development boards, and regional training centers' efforts to plan for the industry's needs.

Appendix G: Training Resources Database

Org Name	Provider Type	Program Name	Apprenticeship? Y/N	Training Focus	Educational Outcomes	City	Region
Airstreams Renewables, Inc (GWO Training Provider)	Private Company	GWO Basic Safety Training	N	GWO Safety	On-the-Job Training	Tehachapi	Southern California
Airstreams Renewables, Inc (GWO Training Provider)	Private Company	GWO Basic Technical Training	N	GWO Safety	On-the-Job Training	Tehachapi	Southern California
America Truck Driving School-Riverside - America Truck Driving School-Compton	Private Training Center	Commercial Driving License	N	Truck Driving	License	Riverside	Central Coast
Bassett Adult School	Community Adult School	Electrician Code Class/ Journeyman Recertification	N	Electrician	Certificate	La Puente	Southern California
Bassett Adult School	Community Adult School	Electrician Trainee #1 & #2	N	Electrician	On-the-Job Training	La Puente	Southern California
Bassett Adult School	Community Adult School	Electrician Trainee #3	N	Electrician	On-the-Job Training	La Puente	Southern California
Bassett Adult School	Community Adult School	Electrician Trainee #4	N	Electrician	On-the-Job Training	La Puente	Southern California
California Polytechnic University, Humboldt	Public University	B.S. Energy Systems Engineering	N	Engineering	Bachelor's Degree	Arcata	North Coast
California Polytechnic University, Humboldt	Public University	M.S. Energy Technology and Policy	N	Engineering/Policy	Master's Degree	Arcata	North Coast
Cal State University Dominguez Hills - OSHA Training Institute Education Center	Public University	OSHA 30-Hour Construction Industry	N	OSHA Construction	On-the-Job Training	Carson	Southern California
Cal State University Dominguez Hills - OSHA Training Institute Education Center	Public University	OSHA 5410: Occupation Safety and Health Standards for the Maritime Industry	N	OSHA Maritime	On-the-Job Training	Carson	Southern California
California State University Maritime Academy	Public University	B.S Marine Transportation	N	Maritime	Bachelor's Degree	Vallejo	Bay Area
California State University Maritime Academy	Public University	Facility Engineering Technology Program	N	Maritime	Bachelor's Degree	Vallejo	Bay Area

Org Name	Provider Type	Program Name	Apprenticeship? Y/N	Training Focus	Educational Outcomes	City	Region
Cerritos College	Community College	Industrial Engineering Design Technician Certificate of Achievement	N	Engineering	Certificate	Norwalk	Southern California
Chabot - Las Positas Community College District - OSHA Training Institute Education Center	Community College	OSHA 5410: OSHA Standards for Maritime	N	OSHA Maritime	On-the-Job Training	Pleasanton	Bay Area
Hacienda La Puente Adult Education	Community Adult School	Electrician	N	Electrician	Certificate	La Puente	Southern California
Huntington Park Adult School	Community Adult School	Electrician/1: Fundamentals	N	Electrician	On-the-Job Training	Bell	Southern California
College of the Redwoods	Community College	A.S CADD/CAM Design & Manufacturing	N	Manufacturing	Associate Degree	Eureka	North Coast
College of the Redwoods	Community College	A.S Drafting & 3D Modeling	N	Drafting Technology	Associate Degree	Eureka	North Coast
College of the Redwoods	Community College	A.S Manufacturing Technology	N	Manufacturing	Associate Degree	Eureka	North Coast
College of the Redwoods	Community College	A.S. Welding Technology	N	Welding	Associate Degree	Eureka	North Coast
College of the Redwoods	Community College	Certificate of Achievement CADD/CAM Design & Manufacturing	N	Manufacturing	Certificate	Eureka	North Coast
College of the Redwoods	Community College	Certificate of Achievement Drafting & 3D Modeling	N	Drafting Technology	Certificate	Eureka	North Coast
College of the Redwoods	Community College	Certificate of Achievement in Manufacturing Technology	N	Manufacturing	Certificate	Eureka	North Coast
College of the Redwoods	Community College	Certificate of Achievement Welding Technology	N	Welding	Certificate	Eureka	North Coast

Org Name	Provider Type	Program Name	Apprenticeship? Y/N	Training Focus	Educational Outcomes	City	Region
College of the Redwoods	Community College	Certificate of Recognition Electric Arc & Oxyacetylene Welding	N	Welding	Certificate	Eureka	North Coast
College of the Redwoods	Community College	Certificate of Recognition General Welding	N	Welding	Certificate	Eureka	North Coast
College of the Redwoods	Community College	Certificate of Recognition MIG & TIG Welding	N	Welding	Certificate	Eureka	North Coast
Huntington Park Adult School	Community Adult School	Electrician/2: Wiring and Codes	N	Electrician	On-the-Job Training	Bell	Southern California
IEC/AAI dba UEI College - Gardena	Private Training Center	Electrician Technician Training Program	N	Electrician	On-the-Job Training	Gardena	Southern California
Hacienda La Puente Adult Education	Community Adult School	Combination Welder	N	Welding	Certificate	La Puente	Southern California
Inland Empire Electrical Training Center	Training Center	Journeyman Certifications	N	Electrician	Certification	San Bernardino	Central Coast
Harbor Occupational Center	Community Adult School	Forklift	N	Forklift	On-the-Job Training	San Pedro	Southern California
Harbor Occupational Center	Community Adult School	Gas Tungsten Arc Welding	N	Welding	On-the-Job Training	San Pedro	Southern California
Harbor Occupational Center	Community Adult School	Welding 1-3/UPGRADE	N	Welding	On-the-Job Training	San Pedro	Southern California
Harbor Occupational Center	Community Adult School	Welding 2-3/Upgrade	N	Welding	On-the-Job Training	San Pedro	Southern California
Harbor Occupational Center	Community Adult School	Welding/1	N	Welding	On-the-Job Training	San Pedro	Southern California
HPTC - Pearce Renewables (GWO Training Provider)	Private Company	GWO Training	N	GWO Safety	On-the-Job Training	Tehachapi	Southern California
Huntington Park Adult School	Community Adult School	Apprenticeship Multi-Craft Core Curriculum	Y	Construction	On-the-Job Training	Bell	Southern California
Los Angeles Technology Center	Community Adult School	Electrician 1 - Fundamentals	N	Electrician	On-the-Job Training	Los Angeles	Southern California

Org Name	Provider Type	Program Name	Apprenticeship? Y/N	Training Focus	Educational Outcomes	City	Region
Los Angeles Technology Center	Community Adult School	Electrician 2 - Wiring & Codes	N	Electrician	On-the-Job Training	Los Angeles	Southern California
Huntington Park Adult School	Community Adult School	Welding/1	N	Welding	On-the-Job Training	Bell	Southern California
Huntington Park Adult School	Community Adult School	Welding/2	N	Welding	On-the-Job Training	Bell	Southern California
Huntington Park Adult School	Community Adult School	Welding/3	N	Welding	On-the-Job Training	Bell	Southern California
Huntington Park Adult School	Community Adult School	Welding/Certification Upgrade	N	Welding	On-the-Job Training	Bell	Southern California
Los Angeles Technology Center	Community Adult School	Electrician 3 - Wiring Techniques	N	Electrician	On-the-Job Training	Los Angeles	Southern California
Manteca Adult School	Community Adult School	Electrical Wiring - Module 3	N	Electrician	Certificate	Manteca	Central Coast
Manteca Adult School	Community Adult School	Electricity Fundamentals - Module 1	N	Electrician	Certificate	Manteca	Central Coast
Manteca Adult School	Community Adult School	Electricity Fundamentals - Module 2	N	Electrician	Certificate	Manteca	Central Coast
Maxine Waters Employment Prep Center	Community Adult School	Electric Motor Controls	N	Electrician	On-the-Job Training	Los Angeles	Southern California
Maxine Waters Employment Prep Center	Community Adult School	Electrician 1 - Fundamentals	N	Electrician	On-the-Job Training	Los Angeles	Southern California
Maxine Waters Employment Prep Center	Community Adult School	Electrician 2 - Wiring & Codes	N	Electrician	On-the-Job Training	Los Angeles	Southern California
IEC/AAI dba UEI College - Gardena	Private Training Center	Welding Training Program	N	Welding	On-the-Job Training	Gardena	Southern California
Maxine Waters Employment Prep Center	Community Adult School	Electrician 3 - Wiring Techniques	N	Electrician	On-the-Job Training	Los Angeles	Southern California
Maxine Waters Employment Prep Center	Community Adult School	Electrician 4 - Industrial	N	Electrician	On-the-Job Training	Los Angeles	Southern California
INTERNATIONAL ASSOCIATION OF BRIDGE, STRUCTURAL, ORNAMENTAL	Union	Ironworker (field) Apprenticeship	Y	Ironworking	On-the-Job Training	La Palma	Central Coast

Org Name	Provider Type	Program Name	Apprenticeship? Y/N	Training Focus	Educational Outcomes	City	Region
AND REINFORCING IRON WORKERS							
INTERNATIONAL ASSOCIATION OF BRIDGE, STRUCTURAL, ORNAMENTAL AND REINFORCING IRON WORKERS	Union	Ironworker (field) Apprenticeship	Y	Ironworking	On-the-Job Training	San Diego	Southern California
INTERNATIONAL ASSOCIATION OF BRIDGE, STRUCTURAL, ORNAMENTAL AND REINFORCING IRON WORKERS	Union	Ironworker (field) Apprenticeship	Y	Ironworking	On-the-Job Training	Sacramento	Bay Area
INTERNATIONAL ASSOCIATION OF BRIDGE, STRUCTURAL, ORNAMENTAL AND REINFORCING IRON WORKERS	Union	Ironworker (field) Apprenticeship	Y	Ironworking	On-the-Job Training	San Francisco	Bay Area
International Association of Sheet Metal, Air, Rail, and Transportation Workers (SMART)	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	Ventura	Southern California
International Association of Sheet Metal, Air, Rail, and Transportation Workers (SMART)	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	Bakersfield	Central Coast
International Association of Sheet Metal, Air, Rail, and Transportation Workers (SMART)	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	Modesto	Bay Area
Ironworkers Local 229	Union	Ironworker Apprenticeship	Y	Ironworking	On-the-Job Training	San Diego	Southern California
Ironworkers Local 377	Union	Ironworker (field) Apprenticeship	Y	Ironworking	On-the-Job Training	Benicia	Bay Area
Ironworkers Local 378	Union	Ironworking Apprenticeship Program	Y	Ironworking	On-the-Job Training	Benicia	Bay Area
Ironworkers Local 433	Union	Ironworking Apprenticeship Program	Y	Ironworking	On-the-Job Training	La Palma	Southern California

Org Name	Provider Type	Program Name	Apprenticeship? Y/N	Training Focus	Educational Outcomes	City	Region
IUOE Local 12 - International Union of Operating Engineers	Union	Operating Engineer Apprenticeship	Y	Operating Engineer	On-the-Job Training	Whittier	Southern California
IUOE Local 12 - International Union of Operating Engineers	Union	Operating Engineer Apprenticeship	Y	Operating Engineer	On-the-Job Training	Devore	Southern California
IUOE Local 12 - International Union of Operating Engineers	Union	Operating Engineer Apprenticeship	Y	Operating Engineer	On-the-Job Training	Valley Center	Southern California
IUOE Local 12 - International Union of Operating Engineers	Union	Operating Engineer Apprenticeship	Y	Operating Engineer	On-the-Job Training	Camarillo Airport	Central Coast
IUOE Local 12 - International Union of Operating Engineers	Union	Operating Engineer Apprenticeship	Y	Operating Engineer	On-the-Job Training	Bakersfield	Central Coast
IUOE Local 12 - International Union of Operating Engineers	Union	Operating Engineer Apprenticeship	Y	Operating Engineer	On-the-Job Training	San Luis Obispo	Central Coast
Laborers Local 1184	Union	Laborer Apprenticeship	Y	Laborer	On-the-Job Training	Riverside	Southern California
Laborers Local 1309	Union	Laborer Apprenticeship	Y	Laborer	On-the-Job Training	Lakewood	Southern California
Laborers Local 300	Union	Laborer Apprenticeship	Y	Laborer	On-the-Job Training	Los Angeles	Southern California
Laborers Local 652	Union	Laborer Apprenticeship	Y	Laborer	On-the-Job Training	Santa Ana	Southern California
Laborers Local 89	Union	Laborer Apprenticeship	Y	Laborer	On-the-Job Training	San Marcos	Southern California
Local 104 - Alameda & Contra Costa Counties JATC	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	Livermore	Bay Area
Local 104 - Fresno JATC	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	Fresno	Central Coast
Local 104 - Modesto Area Sheet Metal Joint Apprenticeship Training Committee	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	Modesto	Bay Area
Local 104 - Monterey & San Benito Counties JATC	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	Castroville	Central Coast
Local 104 - Sacramento Area Training Center	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	Mather	Bay Area
Local 104 - San Francisco County JATC, North Bay	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	Fairfield	Bay Area

Org Name	Provider Type	Program Name	Apprenticeship? Y/N	Training Focus	Educational Outcomes	City	Region
JATC, San Mateo County JATC							
Local 104 - Santa Clara County JATC	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	San Jose	Bay Area
Local 104 - Tri Counties Sheet Metal Workers' JATC	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	Ventura	Southern California
Local 206 - International Association of Sheet Metal, Air, Rail, and Transportation Workers (SMART)	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	San Diego	Southern California
Local 3 - California Joint Apprenticeship Training Center	Union	Operating Engineer Apprenticeship	Y	Operating Engineer	On-the-Job Training	Alameda	Bay Area
Local 3 - Technical Engineers Apprenticeship Training Program	Union	Operating Engineer Apprenticeship	Y	Operating Engineer	On-the-Job Training	Sloughhouse	Bay Area
Local 34 - Pile Drivers	Union	Piledrivers Apprenticeship	Y	Piledriver	On-the-Job Training	Oakland	Bay Area
Local 39 - International Union of Operating Engineers	Union	Operating Engineer Apprenticeship	Y	Operating Engineer	On-the-Job Training	Sacramento	Bay Area
Local 501 - International Union of Operating Engineers	Union	Operating Engineer Apprenticeship	Y	Operating Engineer	On-the-Job Training	Los Angeles	Southern California
Los Angeles Technology Center	Community Adult School	Construction Essentials	N	Construction	On-the-Job Training	Los Angeles	Southern California
Los Angeles Technology Center	Community Adult School	Construction Work 1	N	Construction	On-the-Job Training	Los Angeles	Southern California
Los Angeles Technology Center	Community Adult School	Construction Work 2	N	Construction	On-the-Job Training	Los Angeles	Southern California
Los Angeles Technology Center	Community Adult School	Construction Work 3	N	Construction	On-the-Job Training	Los Angeles	Southern California
Sacramento Electrical Training Center	Training Center	Journeyman Certifications	N	Electrician	Certification	Sacramento	Bay Area
San Francisco JATC	Training Center	Journeyman Certifications	N	Electrician	Certification	San Francisco	Bay Area
San Mateo Count JATC	Training Center	Journeyman Certifications	N	Electrician	Certification	San Carlos	Bay Area

Org Name	Provider Type	Program Name	Apprenticeship? Y/N	Training Focus	Educational Outcomes	City	Region
Manteca Adult School	Community Adult School	Basic Welding	N	Welding	On-the-Job Training	Manteca	Central Coast
College of San Mateo	Community College	Electrical Technology: Inside Wireman	Y	Electrician	Associate Degree	San Mateo	Bay Area
College of San Mateo	Community College	Electrical Technology: Inside Wireman	Y	Electrician	Certificate	San Mateo	Bay Area
ELECTRICAL TRAINING INSTITUTE	Private Training Center	Inside Wireman (Electrical) Apprenticeship Program	Y	Electrician	On-the-Job Training	San Diego	Southern California
Manteca Adult School	Community Adult School	Forklift Certification Series	N	Forklift	Certificate	Manteca	Central Coast
Manteca Adult School	Community Adult School	Structural Welding	N	Welding	On-the-Job Training	Manteca	Central Coast
Electrical Training Institute of Southern California	Training Center	Electrician Apprenticeship	Y	Electrician	On-the-Job Training	Commerce	Southern California
IBEW 11	Union	Electrician Apprenticeship	Y	Electrician	On-the-Job Training	Pasadena	Southern California
IBEW 302	Union	Electrician Apprenticeship	Y	Electrician	On-the-Job Training	Martinez	Bay Area
IBEW 40	Union	Electrician Apprenticeship	Y	Electrician	On-the-Job Training	North Hollywood	Southern California
IBEW 551	Union	Electrician Apprenticeship	Y	Electrician	On-the-Job Training	Santa Rosa	Bay Area
Maxine Waters Employment Prep Center	Community Adult School	Welding 1	N	Welding	On-the-Job Training	Los Angeles	Southern California
Maxine Waters Employment Prep Center	Community Adult School	Welding 2	N	Welding	On-the-Job Training	Los Angeles	Southern California
Maxine Waters Employment Prep Center	Community Adult School	Welding 3	N	Welding	On-the-Job Training	Los Angeles	Southern California
Mt. San Antonio College	Community College	A.S Manufacturing Technology	N	Manufacturing	Associates Degree	Walnut	Southern California
Mt. San Antonio College	Community College	A.S. Welding Technology	N	Welding	Associate Degree	Walnut	Southern California
Mt. San Antonio College	Community College	Electronic Assembly and Fabrication Certificate	N	Manufacturing	Certificate	Walnut	Southern California

Org Name	Provider Type	Program Name	Apprenticeship? Y/N	Training Focus	Educational Outcomes	City	Region
Mt. San Antonio College	Community College	Gas Tungsten Arc Welding	N	Welding	Certificate	Walnut	Southern California
Mt. San Antonio College	Community College	Manufacturing Foundation	N	Manufacturing	Certificate	Walnut	Southern California
Mt. San Antonio College	Community College	Welder - Licensed	N	Welding	Certificate	Walnut	Southern California
Newport Coast Maritime Academy	Training Center	Basic Cruising Course	N	Maritime	Certificate	Newport Beach	Southern California
Newport Coast Maritime Academy	Training Center	Coastal Cruising Course	N	Maritime	Certificate	Newport Beach	Southern California
Newport Coast Maritime Academy	Training Center	Electronic Navigation Course	N	Maritime	Certificate	Newport Beach	Southern California
Newport Coast Maritime Academy	Training Center	Night Operations Course	N	Maritime	Certificate	Newport Beach	Southern California
Newport Coast Maritime Academy	Training Center	Vessel Maintenance Course	N	Maritime	Certificate	Newport Beach	Southern California
Northern California Laborers Training Center	Training Center	Laborer Apprenticeship	Y	Construction	On-the-Job Training	San Ramon	Bay Area
IBEW 595	Union	Electrician Apprenticeship	Y	Electrician	On-the-Job Training	Dublin	Bay Area
Plumbers, Pipe, and Refrigeration Fitters Local Union 442	Union	Piping Apprenticeship	Y	Plumbing	On-the-Job Training	Modesto	Bay Area
IBEW 952	Union	Electrician Apprenticeship	Y	Electrician	On-the-Job Training	Ventura	Central Coast
Inland Empire Electrical Training Center	Training Center	Electrician Apprenticeship	Y	Electrician	On-the-Job Training	San Bernardino	Central Coast
Orange County Electrical Training Institute	Training Center	Electrician Apprenticeship	Y	Electrician	On-the-Job Training	Santa Ana	Southern California
Redwood Empire Electrical Training Center	Training Center	Electrician Apprenticeship	Y	Electrician	On-the-Job Training	Santa Rosa	Southern California
Sacramento Electrical Training Center	Training Center	Inside Wireman Electrical Apprenticeship	Y	Electrician	On-the-Job Training	Sacramento	Bay Area
San Joaquin Delta College	Community College	Industrial Technology Program	Y	Manufacturing	Certificate	Stockton	Central Coast

Org Name	Provider Type	Program Name	Apprenticeship? Y/N	Training Focus	Educational Outcomes	City	Region
San Joaquin Delta College	Community College	Welding Technology Program	N	Welding	Certificate	Stockton	Central Coast
San Francisco JATC	Training Center	Inside Wireman Electrical Apprenticeship	Y	Electrician	On-the-Job Training	San Francisco	Bay Area
San Joaquin/Calaveras Counties Joint Electrical Apprenticeship	Union	Electrical Apprenticeship	Y	Electrician	On-the-Job Training	Stockton	Central Coast
San Mateo Count JATC	Training Center	Electrician Apprenticeship	Y	Electrician	On-the-Job Training	San Carlos	Bay Area
Solano-Napa Counties JATC	Training Center	Inside/Commercial Wireman	Y	Electrician	On-the-Job Training	Napa	Bay Area
Southern California Sheet Metal JATC	Union	Sheet Metal Worker Apprenticeship	Y	Sheet Metal	On-the-Job Training	City of Industry	Central Coast
Training Resources Maritime Institute	Technical School	Confined Space Training	N	Maritime	On-the-Job Training	San Diego	Southern California
Training Resources Maritime Institute	Technical School	GWO Advanced Rescue Training	N	Maritime	On-the-Job Training	San Diego	Southern California
Training Resources Maritime Institute	Technical School	GWO Basic Technical Training	N	Maritime	On-the-Job Training	San Diego	Southern California
Training Resources Maritime Institute	Technical School	GWO Basic Technical Training with Installation Module	N	Maritime	On-the-Job Training	San Diego	Southern California
Training Resources Maritime Institute	Technical School	GWO Basic Technical Training with Sea Survival	N	Maritime	On-the-Job Training	San Diego	Southern California
UA Local 38 Plumbers & Pipefitters	Union	Plumbing Apprenticeship	Y	Plumbing	On-the-Job Training	San Francisco	Bay Area
UC San Diego - OSHA Training Institute Education Center	Public University	OSHA 5410: Occupation Safety and Health Standards for the Maritime Industry	N	OSHA Maritime	On-the-Job Training	La Jolla	Southern California

Appendix H: Port Development Workforce Needs by Detailed Occupation

Only occupations that have at least 10 jobs projected in 2030 are listedlisted in this table.

SOC	Occupation	Total Port Jobs, 2030 (High Scenario)
47-2061	Construction Laborers	1,041
47-2111	Electricians	1,038
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	664
47-2031	Carpenters	565
47-2152	Plumbers, Pipefitters, and Steamfitters	466
11-9021	Construction Managers	409
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	351
13-1082	Project Management Specialists	324
43-9061	Office Clerks, General	297
47-2051	Cement Masons and Concrete Finishers	268
47-2073	Operating Engineers and Other Construction Equipment Operators	265
47-2141	Painters, Construction and Maintenance	245
11-1021	General and Operations Managers	240
17-2051	Civil Engineers	175
13-1051	Cost Estimators	163
43-3031	Bookkeeping, Accounting, and Auditing Clerks	150
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	142
53-3032	Heavy and Tractor-Trailer Truck Drivers	133
47-2211	Sheet Metal Workers	100
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	95
47-2221	Structural Iron and Steel Workers	73
13-2011	Accountants and Auditors	72
51-4121	Welders, Cutters, Solderers, and Brazers	71
47-3013	Helpers--Electricians	69
11-9199	Managers, All Other	67
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	59
43-1011	First-Line Supervisors of Office and Administrative Support Workers	58
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	57
49-2022	Telecommunications Equipment Installers and Repairers, Except Line Installers	55

SOC	Occupation	Total Port Jobs, 2030 (High Scenario)
47-2231	Solar Photovoltaic Installers	55
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	49
49-2098	Security and Fire Alarm Systems Installers	47
13-1199	Business Operations Specialists, All Other	47
47-2081	Drywall and Ceiling Tile Installers	47
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	45
17-3011	Architectural and Civil Drafters	41
49-9098	Helpers--Installation, Maintenance, and Repair Workers	39
49-9052	Telecommunications Line Installers and Repairers	38
47-4031	Fence Erectors	37
17-1011	Architects, Except Landscape and Naval	37
47-2121	Glaziers	35
47-2151	Pipelayers	34
17-2071	Electrical Engineers	33
11-9041	Architectural and Engineering Managers	33
37-3011	Landscaping and Groundskeeping Workers	32
49-9071	Maintenance and Repair Workers, General	31
11-3031	Financial Managers	30
49-9099	Installation, Maintenance, and Repair Workers, All Other	27
17-2141	Mechanical Engineers	27
19-5011	Occupational Health and Safety Specialists	27
53-7021	Crane and Tower Operators	26
47-2071	Paving, Surfacing, and Tamping Equipment Operators	25
43-6011	Executive Secretaries and Executive Administrative Assistants	24
13-1071	Human Resources Specialists	24
43-5061	Production, Planning, and Expediting Clerks	24
47-3019	Helpers, Construction Trades, All Other	23
13-1161	Market Research Analysts and Marketing Specialists	23
47-4011	Construction and Building Inspectors	23
13-1023	Purchasing Agents, Except Wholesale, Retail, and Farm Products	22
15-1252	Software Developers	22
43-5032	Dispatchers, Except Police, Fire, and Ambulance	21
43-4051	Customer Service Representatives	21
47-2044	Tile and Stone Setters	21
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	20
47-3012	Helpers--Carpenters	19

SOC	Occupation	Total Port Jobs, 2030 (High Scenario)
43-3051	Payroll and Timekeeping Clerks	19
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	19
53-3033	Light Truck Drivers	19
47-2171	Reinforcing Iron and Rebar Workers	18
53-7065	Stockers and Order Fillers	18
47-2161	Plasterers and Stucco Masons	18
49-9044	Millwrights	17
17-2199	Engineers, All Other	17
43-4171	Receptionists and Information Clerks	17
47-5023	Earth Drillers, Except Oil and Gas	16
47-4099	Construction and Related Workers, All Other	16
47-2072	Pile Driver Operators	16
47-5022	Excavating and Loading Machine and Dragline Operators, Surface Mining	16
17-1022	Surveyors	15
11-2022	Sales Managers	14
11-3012	Administrative Services Managers	14
11-1011	Chief Executives	14
43-3021	Billing and Posting Clerks	14
47-2011	Boilermakers	14
47-3014	Helpers--Painters, Paperhangers, Plasterers, and Stucco Masons	13
17-3022	Civil Engineering Technologists and Technicians	13
53-7051	Industrial Truck and Tractor Operators	13
49-2097	Audiovisual Equipment Installers and Repairers	12
47-2021	Brick masons and Block masons	12
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	12
43-5071	Shipping, Receiving, and Inventory Clerks	12
17-3023	Electrical and Electronic Engineering Technologists and Technicians	11
47-2181	Roofers	11
15-1232	Computer User Support Specialists	10
49-9051	Electrical Power-Line Installers and Repairers	10
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	10
15-1299	Computer Occupations, All Other	10
17-3012	Electrical and Electronics Drafters	10

Appendix I: Current Workforce Supply by Detailed Occupation and Region

SOC	Occupation	Bay Area - Total Jobs, 2022 Q4	Bay Area - Location Quotient	North Coast - Total Jobs, 2022 Q4	North Coast - Location Quotient	Central Coast - Total Jobs, 2022 Q4	Central Coast - Location Quotient	Southern California - Total Jobs, 2022 Q4	Southern California - Location Quotient
15-1252	Software Developers	75,912	2.13	269	0.47	3,210	0.82	32,549	0.94
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	57,253	0.98	654	0.69	5,234	0.82	75,914	1.34
11-1021	General and Operations Managers	56,548	0.89	713	0.69	5,493	0.78	53,031	0.86
43-9061	Office Clerks, General	50,878	0.92	849	0.95	5,570	0.91	49,911	0.93
53-7065	Stockers and Order Fillers	43,977	0.88	780	0.96	4,673	0.85	44,823	0.92
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	38,987	0.85	634	0.85	4,386	0.87	48,910	1.10
43-4051	Customer Service Representatives	38,227	0.66	467	0.50	3,487	0.55	38,089	0.68
13-1199	Business Operations Specialists, All Other	37,527	1.53	541	1.36	3,627	1.34	30,691	1.29
43-3031	Bookkeeping, Accounting, and Auditing Clerks	33,935	0.98	494	0.88	3,698	0.96	34,778	1.03
53-3032	Heavy and Tractor-Trailer Truck Drivers	33,627	0.78	503	0.72	3,623	0.76	41,226	0.99
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	33,189	0.81	585	0.88	3,587	0.80	32,509	0.82
13-2011	Accountants and Auditors	31,291	1.06	383	0.80	2,889	0.88	29,828	1.04
43-1011	First-Line Supervisors of Office and Administrative Support Workers	28,912	0.95	439	0.89	2,839	0.85	27,868	0.95
41-3091	Sales Representatives of Services, Except Advertising,	27,274	1.25	192	0.54	1,885	0.78	19,932	0.94

SOC	Occupation	Bay Area - Total Jobs, 2022 Q4	Bay Area - Location Quotient	North Coast - Total Jobs, 2022 Q4	North Coast - Location Quotient	Central Coast - Total Jobs, 2022 Q4	Central Coast - Location Quotient	Southern California - Total Jobs, 2022 Q4	Southern California - Location Quotient
	Insurance, Financial Services, and Travel								
33-9032	Security Guards	26,762	1.20	219	0.61	2,078	0.85	35,526	1.64
53-3033	Light Truck Drivers	24,675	1.10	307	0.85	2,295	0.93	28,378	1.31
49-9071	Maintenance and Repair Workers, General	24,519	0.79	446	0.88	2,904	0.84	25,717	0.85
15-1299	Computer Occupations, All Other	24,094	2.66	136	0.92	1,439	1.44	12,199	1.39
13-1161	Market Research Analysts and Marketing Specialists	23,597	1.44	172	0.65	1,563	0.87	17,716	1.12
47-2061	Construction Laborers	22,415	0.83	484	1.11	3,123	1.05	20,173	0.77
13-1082	Project Management Specialists	21,820	1.22	234	0.81	1,672	0.85	15,617	0.90
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	21,423	0.80	242	0.56	2,862	0.97	33,498	1.29
53-7051	Industrial Truck and Tractor Operators	20,450	1.23	176	0.65	1,589	0.86	18,981	1.17
47-2031	Carpenters	19,966	1.07	354	1.17	2,312	1.12	17,341	0.96
11-3031	Financial Managers	19,797	1.38	215	0.92	1,553	0.98	16,473	1.18
23-1011	Lawyers	18,859	1.14	227	0.85	1,638	0.90	16,925	1.05
11-9199	Managers, All Other	18,661	1.56	249	1.29	1,724	1.31	14,504	1.25
37-3011	Landscaping and Groundskeeping Workers	18,276	0.78	412	1.09	3,524	1.37	17,750	0.78
11-2022	Sales Managers	17,835	1.85	142	0.91	1,414	1.33	15,404	1.65
15-1232	Computer User Support Specialists	17,496	1.27	111	0.50	898	0.59	9,635	0.72
13-1071	Human Resources Specialists	16,262	1.02	185	0.71	1,402	0.80	15,697	1.01

SOC	Occupation	Bay Area - Total Jobs, 2022 Q4	Bay Area - Location Quotient	North Coast - Total Jobs, 2022 Q4	North Coast - Location Quotient	Central Coast - Total Jobs, 2022 Q4	Central Coast - Location Quotient	Southern California - Total Jobs, 2022 Q4	Southern California - Location Quotient
43-4171	Receptionists and Information Clerks	15,182	0.72	226	0.66	1,696	0.73	14,528	0.71
43-5071	Shipping, Receiving, and Inventory Clerks	14,624	0.89	173	0.64	1,634	0.90	18,869	1.18
47-2111	Electricians	13,760	0.93	135	0.56	1,257	0.77	12,084	0.84
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	13,336	0.87	242	0.98	1,631	0.96	11,224	0.75
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	12,661	1.00	160	0.78	1,185	0.85	14,358	1.17
43-6011	Executive Secretaries and Executive Administrative Assistants	10,896	1.09	173	1.07	976	0.89	9,112	0.94
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	10,759	0.93	88	0.47	1,150	0.90	14,356	1.27
15-1253	Software Quality Assurance Analysts and Testers	10,634	2.17	37	0.47	457	0.84	4,623	0.97
43-3021	Billing and Posting Clerks	9,398	1.05	116	0.80	908	0.92	9,172	1.05
11-9021	Construction Managers	9,034	0.98	219	1.47	1,046	1.03	7,869	0.88
43-5061	Production, Planning, and Expediting Clerks	8,360	1.08	83	0.67	809	0.95	9,623	1.28
47-2152	Plumbers, Pipefitters, and Steamfitters	8,265	0.86	121	0.77	1,001	0.94	7,263	0.78
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	8,137	1.39	29	0.31	510	0.79	6,141	1.08

SOC	Occupation	Bay Area - Total Jobs, 2022 Q4	Bay Area - Location Quotient	North Coast - Total Jobs, 2022 Q4	North Coast - Location Quotient	Central Coast - Total Jobs, 2022 Q4	Central Coast - Location Quotient	Southern California - Total Jobs, 2022 Q4	Southern California - Location Quotient
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	7,948	0.73	138	0.78	951	0.79	8,152	0.77
47-2141	Painters, Construction and Maintenance	7,892	1.10	110	0.94	976	1.23	7,011	1.00
17-2051	Civil Engineers	7,838	1.24	146	1.43	991	1.43	6,346	1.04
11-9041	Architectural and Engineering Managers	7,346	1.89	40	0.63	648	1.51	5,700	1.51
23-2011	Paralegals and Legal Assistants	7,050	1.01	61	0.54	506	0.66	6,735	0.99
13-1023	Purchasing Agents, Except Wholesale, Retail, and Farm Products	6,880	1.06	76	0.72	715	0.99	6,992	1.11
11-1011	Chief Executives	6,766	1.26	160	1.84	852	1.44	5,113	0.98
17-2141	Mechanical Engineers	6,440	1.09	31	0.32	653	1.00	5,983	1.04
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	6,353	0.79	94	0.72	781	0.88	6,175	0.79
11-3012	Administrative Services Managers	6,153	1.34	91	1.22	551	1.09	4,926	1.11
27-3031	Public Relations Specialists	5,818	1.07	88	0.99	448	0.74	4,676	0.88
43-5032	Dispatchers, Except Police, Fire, and Ambulance	5,730	1.36	46	0.68	371	0.80	4,957	1.21
41-9099	Sales and Related Workers, All Other	5,698	1.13	108	1.32	576	1.04	5,957	1.22
17-2071	Electrical Engineers	5,661	1.46	29	0.47	518	1.21	4,614	1.22
17-2199	Engineers, All Other	5,651	1.70	37	0.69	495	1.35	4,750	1.47
51-4121	Welders, Cutters, Solderers, and Brazers	5,438	0.63	47	0.34	836	0.87	6,440	0.76

SOC	Occupation	Bay Area - Total Jobs, 2022 Q4	Bay Area - Location Quotient	North Coast - Total Jobs, 2022 Q4	North Coast - Location Quotient	Central Coast - Total Jobs, 2022 Q4	Central Coast - Location Quotient	Southern California - Total Jobs, 2022 Q4	Southern California - Location Quotient
47-2073	Operating Engineers and Other Construction Equipment Operators	5,301	0.63	141	1.04	818	0.88	4,230	0.52
13-1081	Logisticians	4,657	1.18	33	0.51	441	1.02	5,123	1.34
13-1051	Cost Estimators	4,544	1.05	62	0.89	522	1.10	4,284	1.02
17-2112	Industrial Engineers	4,484	0.73	18	0.18	413	0.61	5,004	0.84
15-2051	Data Scientists	4,447	1.98	20	0.56	205	0.82	2,142	0.98
11-3051	Industrial Production Managers	4,439	1.08	41	0.61	529	1.16	5,312	1.33
51-4041	Machinists	4,409	0.63	22	0.20	893	1.16	8,057	1.19
11-3071	Transportation, Storage, and Distribution Managers	4,204	1.35	41	0.82	385	1.12	4,764	1.58
51-9199	Production Workers, All Other	4,195	0.96	53	0.74	545	1.13	6,281	1.48
47-2081	Drywall and Ceiling Tile Installers	4,142	1.74	37	0.96	468	1.78	4,190	1.81
17-1011	Architects, Except Landscape and Naval	4,115	1.61	32	0.77	371	1.32	2,932	1.18
17-3023	Electrical and Electronic Engineering Technologists and Technicians	3,921	1.90	16	0.49	334	1.47	2,795	1.40
49-9099	Installation, Maintenance, and Repair Workers, All Other	3,876	1.03	65	1.07	515	1.24	4,598	1.26
35-2012	Cooks, Institution and Cafeteria	3,795	0.46	82	0.61	432	0.48	3,928	0.49
19-1029	Biological Scientists, All Other	3,708	3.82	20	1.27	215	2.01	1,066	1.13
49-2022	Telecommunications Equipment Installers and	3,492	0.99	31	0.55	295	0.76	2,773	0.81

SOC	Occupation	Bay Area - Total Jobs, 2022 Q4	Bay Area - Location Quotient	North Coast - Total Jobs, 2022 Q4	North Coast - Location Quotient	Central Coast - Total Jobs, 2022 Q4	Central Coast - Location Quotient	Southern California - Total Jobs, 2022 Q4	Southern California - Location Quotient
	Repairers, Except Line Installers								
47-2051	Cement Masons and Concrete Finishers	3,370	0.87	49	0.78	479	1.12	3,294	0.87
43-3051	Payroll and Timekeeping Clerks	3,319	1.06	48	0.94	354	1.02	3,499	1.15
47-2181	Roofers	3,114	0.98	95	1.85	399	1.14	2,712	0.88
53-7081	Refuse and Recyclable Material Collectors	3,077	1.06	68	1.45	348	1.08	2,926	1.04
17-3011	Architectural and Civil Drafters	2,922	1.37	22	0.63	273	1.16	2,256	1.09
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	2,607	0.83	31	0.62	317	0.91	3,683	1.21
47-4011	Construction and Building Inspectors	2,581	1.00	57	1.35	310	1.08	2,012	0.80
11-3013	Facilities Managers	2,571	1.19	41	1.17	266	1.11	2,375	1.13
19-4099	Life, Physical, and Social Science Technicians, All Other	2,313	1.76	25	1.16	166	1.14	1,425	1.12
19-5011	Occupational Health and Safety Specialists	2,231	1.02	35	0.99	249	1.04	1,970	0.93
53-2011	Airline Pilots, Copilots, and Flight Engineers	2,133	1.19	4	0.14	52	0.26	5,051	2.90
49-3011	Aircraft Mechanics and Service Technicians	2,102	0.74	12	0.27	205	0.65	5,173	1.87
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	2,071	0.66	45	0.88	291	0.85	2,432	0.80
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	2,066	1.40	15	0.61	184	1.13	1,778	1.24

SOC	Occupation	Bay Area - Total Jobs, 2022 Q4	Bay Area - Location Quotient	North Coast - Total Jobs, 2022 Q4	North Coast - Location Quotient	Central Coast - Total Jobs, 2022 Q4	Central Coast - Location Quotient	Southern California - Total Jobs, 2022 Q4	Southern California - Location Quotient
49-2098	Security and Fire Alarm Systems Installers	2,053	1.23	23	0.86	154	0.84	1,571	0.97
47-2211	Sheet Metal Workers	2,033	0.77	27	0.62	270	0.92	2,102	0.82
49-9052	Telecommunications Line Installers and Repairers	1,969	0.97	18	0.55	192	0.86	1,535	0.78
11-3061	Purchasing Managers	1,567	1.08	17	0.70	160	1.00	1,530	1.08
49-9098	Helpers--Installation, Maintenance, and Repair Workers	1,516	0.82	26	0.87	180	0.89	1,498	0.84
47-2044	Tile and Stone Setters	1,342	1.14	15	0.80	157	1.21	1,284	1.13
47-2161	Plasterers and Stucco Masons	1,299	2.36	10	1.16	153	2.51	1,191	2.22
47-2221	Structural Iron and Steel Workers	1,204	0.85	13	0.58	147	0.94	1,207	0.88
49-9051	Electrical Power-Line Installers and Repairers	1,140	0.45	22	0.54	201	0.71	977	0.39
17-1022	Surveyors	1,137	1.13	11	0.70	109	0.98	843	0.86
17-3022	Civil Engineering Technologists and Technicians	1,117	0.88	32	1.53	150	1.06	826	0.67
11-3131	Training and Development Managers	1,115	1.44	11	0.88	91	1.07	818	1.09
17-2081	Environmental Engineers	1,020	1.15	16	1.12	111	1.13	788	0.91
13-2054	Financial Risk Specialists	1,013	0.87	10	0.52	69	0.54	794	0.71
47-2121	Glaziers	915	0.84	9	0.52	122	1.02	972	0.92
47-2231	Solar Photovoltaic Installers	843	2.05	6	0.94	75	1.64	685	1.71
19-4071	Forest and Conservation Technicians	799	1.26	29	2.82	172	2.47	483	0.79
47-2021	Brick masons and Block masons	784	0.59	8	0.36	95	0.65	677	0.53

SOC	Occupation	Bay Area - Total Jobs, 2022 Q4	Bay Area - Location Quotient	North Coast - Total Jobs, 2022 Q4	North Coast - Location Quotient	Central Coast - Total Jobs, 2022 Q4	Central Coast - Location Quotient	Southern California - Total Jobs, 2022 Q4	Southern California - Location Quotient
51-4193	Plating Machine Setters, Operators, and Tenders, Metal and Plastic	747	1.09	5	0.42	125	1.65	1,678	2.52
47-2071	Paving, Surfacing, and Tamping Equipment Operators	745	0.77	23	1.50	115	1.08	609	0.65
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	742	0.26	5	0.10	80	0.26	959	0.35
47-3013	Helpers--Electricians	731	0.49	6	0.25	61	0.37	594	0.41
17-3026	Industrial Engineering Technologists and Technicians	712	0.56	3	0.13	68	0.49	653	0.53
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	683	0.69	9	0.58	84	0.77	596	0.62
53-5021	Captains, Mates, and Pilots of Water Vessels	668	0.86	11	0.88	61	0.72	1,608	2.14
53-7021	Crane and Tower Operators	657	0.72	11	0.77	86	0.85	957	1.08
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	653	0.74	15	1.06	80	0.83	722	0.85
47-3012	Helpers--Carpenters	637	1.10	8	0.86	68	1.06	503	0.90
47-4099	Construction and Related Workers, All Other	627	1.00	11	1.05	77	1.11	580	0.96
17-3012	Electrical and Electronics Drafters	625	1.39	4	0.51	60	1.21	458	1.05
19-2042	Geoscientists, Except Hydrologists and Geographers	599	1.21	7	0.85	69	1.27	439	0.92
47-3019	Helpers, Construction Trades, All Other	572	1.00	7	0.75	68	1.08	529	0.95

SOC	Occupation	Bay Area - Total Jobs, 2022 Q4	Bay Area - Location Quotient	North Coast - Total Jobs, 2022 Q4	North Coast - Location Quotient	Central Coast - Total Jobs, 2022 Q4	Central Coast - Location Quotient	Southern California - Total Jobs, 2022 Q4	Southern California - Location Quotient
49-9044	Millwrights	565	0.70	14	1.07	40	0.46	467	0.60
17-2041	Chemical Engineers	520	1.05	5	0.57	62	1.13	357	0.74
47-2151	Pipelayers	520	0.73	12	1.03	80	1.02	398	0.58
53-5011	Sailors and Marine Oilers	520	0.86	8	0.81	41	0.61	1,256	2.14
53-2022	Airfield Operations Specialists	515	1.85	6	1.31	57	1.85	1,035	3.83
47-4031	Fence Erectors	496	0.92	9	1.02	95	1.58	431	0.82
17-2131	Materials Engineers	484	1.09	3	0.37	47	0.95	557	1.29
19-5012	Occupational Health and Safety Technicians	484	1.10	7	0.98	47	0.96	428	1.01
53-6051	Transportation Inspectors	432	0.78	9	1.02	49	0.79	695	1.28
49-2097	Audiovisual Equipment Installers and Repairers	419	0.79	5	0.55	46	0.78	435	0.84
47-3014	Helpers--Painters, Paperhangers, Plasterers, and Stucco Masons	389	1.98	3	0.93	45	2.07	311	1.63
47-4021	Elevator and Escalator Installers and Repairers	385	0.82	2	0.24	19	0.36	374	0.82
17-3019	Drafters, All Other	354	1.10	4	0.69	40	1.12	379	1.21
47-5022	Excavating and Loading Machine and Dragline Operators, Surface Mining	350	0.46	7	0.53	63	0.74	274	0.37
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	336	1.38	1	0.33	33	1.23	259	1.09
47-2171	Reinforcing Iron and Rebar Workers	334	0.78	4	0.53	46	0.99	357	0.86
19-1023	Zoologists and Wildlife Biologists	270	0.81	9	1.59	27	0.73	111	0.34
19-2021	Atmospheric and Space Scientists	268	1.54	1	0.44	11	0.58	63	0.37

SOC	Occupation	Bay Area - Total Jobs, 2022 Q4	Bay Area - Location Quotient	North Coast - Total Jobs, 2022 Q4	North Coast - Location Quotient	Central Coast - Total Jobs, 2022 Q4	Central Coast - Location Quotient	Southern California - Total Jobs, 2022 Q4	Southern California - Location Quotient
19-3091	Anthropologists and Archeologists	255	1.62	3	1.09	21	1.22	165	1.08
51-8099	Plant and System Operators, All Other	251	0.83	3	0.69	30	0.90	243	0.83
51-8013	Power Plant Operators	241	0.41	10	1.08	46	0.72	339	0.60
47-5023	Earth Drillers, Except Oil and Gas	230	0.68	3	0.54	38	1.03	190	0.58
49-9096	Riggers	216	0.57	3	0.49	31	0.74	270	0.74
49-9081	Wind Turbine Service Technicians	187	0.71	1	0.23	14	0.49	113	0.45
47-2011	Boilermakers	185	0.62	3	0.57	27	0.81	170	0.59
17-3028	Calibration Technologists and Technicians	175	0.97	1	0.32	14	0.71	174	1.00
19-4043	Geological Technicians, Except Hydrologic Technicians	175	0.83	1	0.44	19	0.81	168	0.82
53-5031	Ship Engineers	172	0.95	2	0.66	9	0.46	354	2.00
47-2072	Pile Driver Operators	162	1.75	3	1.81	17	1.67	144	1.60
53-6032	Aircraft Service Attendants	135	0.47	1	0.16	15	0.47	289	1.04
53-7072	Pump Operators, Except Wellhead Pumpers	131	0.51	2	0.45	22	0.77	156	0.63
19-2043	Hydrologists	126	1.00	3	1.53	16	1.12	86	0.70
11-9161	Emergency Management Directors	104	0.55	5	1.55	18	0.88	77	0.42
19-1011	Animal Scientists	96	1.29	2	1.57	8	0.99	45	0.62
49-9092	Commercial Divers	64	0.82	1	0.61	7	0.77	73	0.96
17-2121	Marine Engineers and Naval Architects	54	0.31	4	1.45	6	0.34	41	0.25
53-7041	Hoist and Winch Operators	41	0.56	3	2.55	4	0.52	64	0.89

Appendix J: Source Data Tables for Figures

Table J.1. Annual and cumulative installed OSW capacity in California. (Figure 2.1.)

Installed Capacity	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Annual Installed Capacity	0	1000	1000	1000	1250	1250	1250	1500	1500	1500	1500	1750	1750	1750	1750	1750	1750	1750
Cumulative Installed Capacity	0	1000	2000	3000	4250	5500	6750	8250	9750	11250	12750	14500	16250	18000	19750	21500	23250	25000

Table J.2. Comparison of workforce requirements by project area under the High (top) scenario. (Figure 2.3.)

Project Area	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Project Development	0	502	502	753	1004	798	1049	1152	1049	1152	1152	1197	1726	1292	1726	1440	1874	1726	1154	1154	444	444	0	0
Wind Turbine Supply	0	0	0	0	0	0	0	565	565	1065	1065	1065	1565	1065	1565	1565	1565	1565	1565	1565	1565	1565	0	0
Balance of Plant Supply	0	0	0	0	0	0	0	234	234	234	234	468	1033	1094	1328	1328	1328	1328	1328	1328	1328	468	0	0
Installation & Commissioning	0	0	0	0	216	216	360	634	317	526	533	425	735	634	425	742	634	843	634	742	742	627	627	0
Operations & Maintenance	0	0	0	0	0	0	592	592	888	1184	1184	1480	2072	2072	2368	2664	2960	3256	3256	3256	3256	3256	3256	3256

Table J.3. Comparison of workforce requirements by project area under the Medium (middle) scenario. (Figure 2.3.)

Project Area	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Project Development	0	502	502	753	1004	798	1049	1152	1049	1152	1152	1197	1726	1292	1726	1440	1874	1726	1154	1154	444	444	0	0
Wind Turbine Supply	0	0	0	0	0	0	0	351	351	351	351	351	351	351	351	351	351	351	351	351	351	351	0	0
Balance of Plant Supply	0	0	0	0	0	0	0	234	234	234	234	234	799	799	799	799	799	799	799	799	799	234	0	0
Installation & Commissioning	0	0	0	0	216	216	360	634	317	526	533	425	735	634	425	742	634	843	634	742	742	627	627	0
Operations & Maintenance	0	0	0	0	0	0	592	592	888	1184	1184	1480	2072	2072	2368	2664	2960	3256	3256	3256	3256	3256	3256	3256

Table J.4. Comparison of workforce requirements by project area under the Baseline (bottom) scenario. (Figure 2.3.)

Project Area	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Project Development	0	502	502	753	1004	798	1049	1152	1049	1152	1152	1197	1551	1152	1551	1300	1699	1551	1049	1049	444	444	0	0
Wind Turbine Supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Balance of Plant Supply	0	0	0	0	0	0	0	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	0	0
Installation & Commissioning	0	0	0	0	216	216	360	634	317	526	533	425	735	634	425	742	634	843	634	742	742	627	627	0
Operations & Maintenance	0	0	0	0	0	0	592	592	888	1184	1184	1480	2072	2072	2368	2664	2960	3256	3256	3256	3256	3256	3256	3256

Table J.5. Comparison of workforce requirements by training level for a readily available workforce under the High (top) scenario. (Figure 2.4.)

Training Level	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Skilled trade-Standard	0	0	0	0	44	44	251	481	500	727	723	863	1344	1208	1417	1571	1643	1780	1722	1744	1729	1539	1123	979
Trades-person	0	0	0	0	0	0	102	228	252	377	359	434	715	648	770	830	872	932	914	914	914	787	516	462
Support Staff	0	56	56	84	118	118	153	158	160	165	171	201	236	183	244	224	282	259	203	206	150	141	55	55
Non-skilled Labor	0	10	10	15	122	112	238	596	534	835	884	939	1488	1300	1559	1705	1706	1806	1743	1794	1779	1406	676	517

Table J.6. Comparison of workforce requirements by training level for a readily available workforce under the Medium (middle) scenario. (Figure 2.4.)

Training Level	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Skilled trade-Standard	0	0	0	0	44	44	251	451	470	607	603	670	1061	1030	1076	1230	1302	1439	1381	1403	1388	1256	1123	979
Trades-person	0	0	0	0	0	0	102	208	232	292	274	316	532	514	538	598	640	700	682	682	682	604	516	462
Support Staff	0	56	56	84	118	118	153	156	158	163	169	199	234	181	242	222	280	257	201	204	148	139	55	55
Non-skilled Labor	0	10	10	15	122	112	238	528	466	571	620	611	964	957	956	1102	1103	1203	1140	1191	1176	882	676	517

Table J.7. Comparison of workforce requirements by training level for a readily available workforce under the Baseline (bottom) scenario. (Figure 2.4.)

Training Level	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Skilled trade-Standard	0	0	0	0	44	44	251	382	401	538	534	601	853	827	868	1027	1094	1231	1183	1205	1205	1187	1123	979
Trades-person	0	0	0	0	0	0	102	138	162	222	204	246	366	348	372	432	474	534	516	516	516	534	516	462
Support Staff	0	56	56	84	118	118	153	156	158	163	169	199	234	181	242	222	280	257	201	204	148	139	55	55
Non-skilled Labor	0	10	10	15	122	112	238	357	295	400	449	440	599	592	591	737	738	838	775	826	811	711	676	517

Table J.8. Comparison of workforce requirements by training level for a highly skilled workforce under the High (top) scenario. (Figure 2.5.)

Training Level	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Manager	0	66	66	99	140	138	222	314	295	370	351	405	580	459	559	569	644	652	557	561	491	464	224	143
Skilled Trade-Specialist	0	16	16	24	44	28	184	364	388	569	556	639	953	827	992	1078	1143	1231	1190	1196	1172	1116	768	693
Engineer	0	184	184	276	404	384	540	634	611	702	715	813	1209	1038	1282	1240	1443	1412	1167	1185	934	745	377	308
Scientist	0	126	126	189	252	130	195	258	195	258	256	197	355	282	351	284	355	355	215	215	10	12	6	0
University Degree	0	44	44	66	96	60	116	144	118	158	153	144	251	212	238	238	273	291	226	230	156	150	138	99

Table J.9. Comparison of workforce requirements by training level for a highly skilled workforce under the Medium (middle) scenario. (Figure 2.5.)

Training Level	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Manager	0	66	66	99	140	138	222	285	266	307	288	328	469	380	432	442	517	525	430	434	364	353	224	143
Skilled Trade-Specialist	0	16	16	24	44	28	184	319	343	439	426	475	704	677	723	809	874	962	921	927	903	867	768	693
Engineer	0	184	184	276	404	384	540	614	591	652	665	747	1113	915	1113	1071	1274	1243	998	1016	765	649	377	308
Scientist	0	126	126	189	252	130	195	258	195	258	256	197	355	282	351	284	355	355	215	215	10	12	6	0
University Degree	0	44	44	66	96	60	116	144	118	158	153	144	251	212	238	238	273	291	226	230	156	150	138	99

Table J.10. Comparison of workforce requirements by training level for a highly skilled workforce under the Baseline (bottom) scenario. (Figure 2.5.)

Training Level	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Manager	0	66	66	99	140	138	222	259	240	281	262	302	412	324	375	386	460	468	375	379	312	327	224	143
Skilled Trade-Specialist	0	16	16	24	44	28	184	238	262	358	345	394	580	553	599	685	750	838	797	803	779	786	768	693
Engineer	0	184	184	276	404	384	540	600	577	638	651	733	919	740	919	896	1080	1049	842	860	666	635	377	308
Scientist	0	126	126	189	252	130	195	258	195	258	256	197	325	258	321	260	325	325	197	197	10	12	6	0
University Degree	0	44	44	66	96	60	116	144	118	158	153	144	224	189	211	215	246	264	207	211	149	150	138	99

Table J.11. Number of workers required in the year with maximum workforce demand for each job role across the high, medium, and baseline scenarios. (Figure 2.6.)

Scenario	Crane operator	Heavy equipment operator	Ironworker	Laborer	Machinist	Onshore engineer	Offshore engineer	Production operative	Protective coating technician	Rigger	Scaffolder	Welder
High Scenario	175	269	287	625	222	637	338	315	396	317	127	450
Medium Scenario	142	187	138	475	145	458	338	125	221	225	91	248
Baseline Scenario	112	147	78	360	84	345	338	5	177	186	66	156

Table J.12. Number of apprentices required in each year for the baseline, medium, and high scenarios. (Figure 2.7.)

Scenario	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
High Scenario	0	10	10	15	20	10	93	153	163	253	241	263	563	514	580	614	646	685	663	663	648	480	333	297
Medium Scenario	0	10	10	15	20	10	93	140	150	194	182	204	458	441	461	495	527	566	544	544	529	375	333	297
Baseline Scenario	0	10	10	15	20	10	93	98	108	152	140	162	250	233	253	287	319	358	336	336	321	333	333	297

Table J.13. Approximate number of workers requiring GWO training in each year for the baseline, medium and high scenarios. (Figure2.8.)

Scenario	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
High Scenario	0	14	14	21	44	30	143	199	211	303	300	339	503	461	523	589	634	699	666	674	653	636	563	506
Medium Scenario	0	14	14	21	44	30	143	184	196	268	265	296	440	422	456	522	567	632	599	607	586	573	563	506
Baseline Scenario	0	14	14	21	44	30	143	176	188	260	257	288	424	406	440	506	551	616	583	591	570	565	563	506

Table J.14. Approximate number of workers requiring offshore safety training in each year. (Figure 2.9.)

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Number of Workers	0	178	178	267	356	178	846	1008	1029	1444	1336	1465	2295	2098	2297	2534	2841	3167	2881	2881	2614	2722	2722	2398

Table J.15. Industry employment outputs for statewide port upgrades. (Figure 3.1.)

Industry	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Construction	4,507	9,276	9,276	9,276	9,276	5,428	4,589	4,589	4,589	3,183
Professional Services	281	532	532	532	532	281	240	240	240	166
Transportation & Warehousing	0	0	0	0	0	0	0	0	0	0
Other Supply Chain	0	0	0	0	0	0	0	0	0	0
Direct Employment	**4,788**	**9,808**	**9,808**	**9,808**	**9,808**	**5,709**	**4,829**	**4,829**	**4,829**	**3,349**

Table J.16. Employment outputs for port upgrades by region. (Figure 3.2.)

Region	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
North Coast	3,239	3,294	3,294	3,294	3,294	29	0	0	0	0
Bay Area	1,549	1,572	1,572	1,572	1,572	851	0	0	0	0
Central Coast	0	113	113	113	113	0	0	0	0	0
Southern California	0	4,829	4,829	4,829	4,829	4,829	4,829	4,829	4,829	3,349
Direct Employment	**4,788**	**9,808**	**9,808**	**9,808**	**9,808**	**5,709**	**4,829**	**4,829**	**4,829**	**3,349**

Table J.17. Unemployment rate by region. (Figure 4.2.)

Region	Unemployment Rate
U.S. Average	3.9%
California Average	4.1%
North Coast	5.0%
Bay Area	5.0%
Central Coast	5.1%
Southern California	5.0%

Table J.18. Educational attainment by region (population 25 years and over). (Figure 4.3.)

Education Level	California Average	North Coast	Bay Area	Central Coast	Southern California
Less than high school	15.8%	16.0%	16.6%	13.0%	15.9%
High school or equivalency	20.4%	26.8%	26.5%	18.9%	20.4%
Some college, no degree	20.5%	25.1%	22.4%	23.7%	24.5%
Associate degree	8.0%	8.8%	8.3%	9.3%	7.6%
Bachelor's degree	21.9%	15.9%	17.4%	20.5%	20.8%
Graduate or professional degree	13.4%	7.4%	8.7%	14.5%	10.8%

Table J.19. Age range by region. (Figure 4.4.)

Age Range	California Average	North Coast	Bay Area	Central Coast	Southern California
20 to 34 years	25.0%	23.2%	24.8%	21.9%	20.5%
35 to 44 years	21.3%	20.0%	21.0%	34.9%	26.5%
45 to 54 years	13.8%	14.7%	14.0%	10.3%	16.0%
55 to 59 years	12.6%	13.0%	12.3%	7.3%	13.3%
60 years and over	6.2%	6.3%	7.0%	5.4%	6.2%

Table J.20. Percentage of population that speaks English "less than very well" by region. (Figure 4.5.)

Region	Percentage
U.S. Average	17.4%
California Average	17.2%
North Coast	7.3%
Bay Area	17.2%
Central Coast	8.5%
Southern California	14.8%

Table J.21. Total jobs in major occupational groups by region, 2022 Q3. (Figure 4.6.)

Occupational Group	North Coast	Bay Area	Central Coast	Southern California
Construction and Extraction Occupations	119,608	2,023	14,696	105,712
Production Occupations	30,042	279	4,102	42,758
Installation, Maintenance, and Repair Occupations	58,490	944	6,807	61,959
Transportation and Material Moving Occupations	201,124	2,705	19,343	238,071
Professional Service Occupations	523,179	5,114	41,935	397,688
All Other Occupations	408,820	5,705	42,630	429,233

Table J.22. Location quotients for major occupational groups by region, 2022 Q3. (Figure 4.7.)

Occupational Group	North Coast	Bay Area	Central Coast	Southern California
Construction and Extraction Occupations	0.97	1.02	1.08	0.89
Production Occupations	0.91	0.52	1.13	1.34
Installation, Maintenance, and Repair Occupations	0.96	0.95	1.01	1.04
Transportation and Material Moving Occupations	0.96	0.80	0.84	1.17
Professional Service Occupations	1.21	0.73	0.88	0.95
All Other Occupations	0.99	0.85	0.93	1.07

Table J.23. North Coast OSW workforce demand by supply chain area. (Figure 5.1.)

Training Level	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Project Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind Turbine Supply	0	0	0	0	0	0	0	0	0	0	0	0	500	500	500	500	500	500	500	500	500	500	0	0
Balance of Plant Supply	0	0	0	0	0	110	402	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	0	0
Installation and Commissioning	0	0	0	0	0	0	165	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	0
Operations and Maintenance	0	0	0	0	0	0	0	318	318	318	318	636	1272	1272	1272	1590	1908	2226	2226	2226	2226	2226	2226	2226

Table J.24. Bay Area workforce demand by OSW supply chain area. (Figure 5.2.)

Training Level	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Project Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind Turbine Supply	0	0	0	0	0	0	0	573	573	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	0	0
Balance of Plant Supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Installation and Commissioning	0	0	0	0	0	0	0	186	186	279	279	279	279	279	279	279	279	279	279	279	279	279	0	0
Operations and Maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	318	318	318	318	318	318	318	318	318	318

Table J.25. Central Coast workforce demand by OSW supply chain area. (Figure 5.3.)

Training Level	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Project Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind Turbine Supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Balance of Plant Supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Installation and Commissioning	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operations and Maintenance	0	0	0	0	0	0	0	636	636	954	954	954	954	954	954	954	954	954	954	954	954	954	954	954

Table J.26. Southern California workforce demand by OSW supply chain area. (Figure 5.4.)

Training Level	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Project Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind Turbine Supply	0	0	0	0	0	0	0	0	0	0	0	0	851	851	851	851	851	851	851	851	851	851	0	0
Balance of Plant Supply	0	0	0	0	0	0	0	0	0	0	0	330	335	335	335	335	335	335	335	335	335	335	0	0
Installation and Commissioning	0	0	0	0	0	0	0	0	0	0	0	0	200	200	200	400	400	400	400	400	400	400	400	0
Operations and Maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0