THE ECONOMIC AND EMPLOYMENT IMPACT OF FLOATING OFFSHORE WIND PROJECTS IN CALIFORNIA'S CENTRAL COAST

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Finally, the opinions and conclusions expressed herein are those of the authors and do not necessarily represent those of the HRTP, CADEMO, or the San Luis Obispo Office of Education. Special thanks to Aaron Helvig and Amin Rahmati for providing able research assistance and help with tabulating results, and Noah Bultman for assistance in gathering data and related information. Any errors or omissions are the sole responsibility of the authors. Please direct comments and suggestions to Cyrus Ramezani (cramezan@calpoly.edu) and Mahdi Rastad (mrastad@calpoly.edu).

1 Executive Summary

1. Executive Summary

The floating offshore wind (FOSW) industry represents a major opportunity to provide clean energy, utilizing abundant wind resources in California's Central Coast, while promoting significant job growth and economic development throughout the state. In this study, we undertake an Economic Impact Analysis (EIA) of two FOSW projects in this region. The first is CADEMO, a small-scale pilot plant near the Vandenberg Space Force Base. We then undertake a similar study for a commercial scale project in the Morro Bay region. Our analysis provides estimates of direct, supply chain, and induced impact of these projects in terms of jobs created and economic output in California. Finally, we conduct a complimentary study of the gap in available labor to meet the anticipated labor demand for both projects in California and the counties of San Luis Obispo and Santa Barbara.

CADEMO's FOSW project, consists of four 15 MW turbines (60 MW) and is expected to be operational in 2027.[1] This pilot project will be built in California state waters near Vandenberg Space Force Base. The construction, installation, and operations-maintenance of CADEMO will utilize existing California ports facilities and maritime resources. Moreover, the power generated will also use existing onshore transmission lines. As detailed below, CADEMO is an important demonstration project that will generate critical data in advance of large-scale commercial developments, including on-site scientific studies of the potential environmental impacts, testing and deployment of new technologies, and an assessment of local infrastructure and workforce needs.[2] The lessons gained from this pilot project will likely result in the development of "best practices" that are critical to creation of California's offshore wind industry.

The completion of the first offshore wind energy lease auction in California – three parcels off the coast in Morro Bay and two in Humboldt – represents a pivotal moment for offshore wind in the United States, as these leases represent the first commercial scale projects that will utilize floating foundations in deep waters. The leased areas are expected to generate an estimated 4.6 GW of energy, placing California on track to potentially become a global leader in FOSW industry. Each Morro Bay parcel is expected to generate nearly 1 GW of energy.

To assess the economic impact of commercial scale FOSW development in California, we study a hypothetical project constructed in Morro Bay. We assume that this FOSW facility will consist of sixty-six 15 MW turbines (990 MW) and will become operational within in 2030-32 period. As with the CADEMO, we assume the project will use the existing onshore electrical grid, and the construction, installation, and operations-maintenance will utilize existing California ports facilities and maritime resources.[3] The rationale for these assumptions is detailed in the body of this report.

Table 1 (panels A & B) reports the result of an Economic Impact Analysis (EIA) for the CADEMO and the commercial scale Morro Bay projects, including estimate of the number of jobs created, labor's earnings, total output, and the increase in California's GDP. These figures are for the entire construction phase (3-5 years) and the annual operations period (25 years). Construction jobs are those resulting from the initial capital expenditures, including on-site labor and professional services; supply chain impacts are due to purchases from supporting industries; and induced impacts are local expenditures from those receiving earnings from the first two categories.

The EIA is based on the data provided by CADEMO project's staff. It includes capital expenditures, and estimates of employment by labor types (construction workers, electricians, welders, etc.) for the on-shore, offshore, and transmission components of the project. Similar data for the commercial scale Morro Bay project is independently collected by the authors from existing FOSW studies. The report provides EIA under a number of assumptions, detailed below, regarding capital expenditures and local content of FOSW components for each project.

Table 1.A: Overall Economic Impact of the CADEMO Project

Project Phase	Impact Categories	Jobs (FTE)	Earnings ($ Millions)	Output ($ Millions)	GDP ($ Millions)
Construction	Onsite	20	2.0	2.0	2.0
	Supply Chain	677	66.1	156.6	84.7
	Induced	225	13.1	44.7	27.0
	Total	**922**	**81.2**	**203.4**	**113.7**
Operations (Annual)	Onsite	4	0.4	0.4	0.4
	Supply Chain	12	1.1	3.9	1.8
	Induced	7	0.4	1.3	0.8
	Total	**23**	**2.0**	**5.6**	**3.1**

Table 1.B: Overall Economic Impact of the Morro Bay Project

Project Phase	Impact Categories	Jobs (FTE)	Earnings ($ Millions)	Output ($ Millions)	GDP ($ Millions)
Construction	Onsite	272	27.0	27.0	27.0
	Supply Chain	9753	885.2	2593.0	1165.3
	Induced	3177	185.7	631.3	381.2
	Total	**13202**	**1097.9**	**3251.2**	**1573.5**
Operations (Annual)	Onsite	100	9.0	9.0	9.0
	Supply Chain	394	33.6	126.2	57.9
	Induced	190	12.0	37.9	22.9
	Total	**684**	**54.6**	**173.1**	**89.8**

This report also presents estimates of jobs created by each project and the existing labor supply that can support the development of FOSW, by occupations types (SOC codes) for California, Santa Barbara, and San Luis Obispo Counties. The labor supply gap estimates provide critical information for the development of educational and skill training programs to meet California's clean energy goals. Table 2 (panels

A & B) provides a list of key occupations ranked by number of jobs created by each project. We show that the SLO and SB counties together may be able to partially support the labor needs of the CADEMO project, particularly for white-collar occupations such as management and engineering (except for industrial engineers). However, there will remain a significant workforce gap for blue-collar jobs, requiring CAMDEO to look beyond the SB and SLO labor markets.

We also develop detailed JEDI models for a variety of commercial scale FOSW projects near Morro Bay. We find that a 1 GW FOSW project will generate nearly 24K FTE jobs during its construction phase (6 years) and about 600 annual jobs during its operations phase (25 years). Roughly 50% of the construction and over 80% of the operations jobs will be local. The occupational categories with the largest workforce demand are similar to the CADEMO project. However, the California labor market is only capable of partially meeting the demand for specialized workers created by commercial scale FOSW projects. The bottleneck occupation categories will be production, especially in the metal/steel industry, wind turbine service technicians, and engineering and transportation workers. Absent robust and comprehensive educational and skill training programs, California's FOSW industry will have to import trained workers from other states, while simultaneously developing a local workforce.

Table 2.A: Top Occupation Needs for the CADEMO Project

Rank	SOC Code	Occupation
1	49-9080	Wind Turbine Service Technicians
2	49-9090	Miscellaneous Installation, Maintenance, and Repair Workers
3	11-1020	General and Operations Managers
4	51-2040	Structural Metal Fabricators and Fitters
5	17-2110	Industrial Engineers, Including Health and Safety
6	43-6010	Secretaries and Administrative Assistants
7	51-8090	Miscellaneous Plant and System Operators
8	51-4050	Metal Furnace Operators, Tenders, Pourers, and Casters
9	51-4010	Computer Control Programmers and Operators
10	53-5020	Ship and Boat Captains and Operators
11	51-4120	Welding, Soldering, and Brazing Workers

While in the short run, timely development of commercial scale projects will face a significant labor shortage, workers can be recruited from other counties or states. Our analysis shows that other California Metropolitan Statistical Areas (MSAs), for example Bakersfield, offer a strong labor market for recruiting needed workers in key occupations, including wind turbine service technicians and miscellaneous plant and system operators. In contrast, no MSA region in California has excess workers for engine and other machine assemblers, metal furnace operators, or related occupations. In those cases, the industry will have to rely on other states' labor markets.

Table 2.B: Top Occupation Needs for the Morro Bay Project

Rank	SOC Code	Occupation
1	49-9080	Wind Turbine Service Technicians
2	51-2040	Structural Metal Fabricators and Fitters
3	11-1020	General and Operations Managers
4	49-9090	Miscellaneous Installation, Maintenance, and Repair Workers
5	51-4050	Metal Furnace Operators, Tenders, Pourers, and Casters
6	51-4010	Computer Control Programmers and Operators
7	17-2110	Industrial Engineers, Including Health and Safety
8	51-4120	Welding, Soldering, and Brazing Workers
9	53-5020	Ship and Boat Captains and Operators
10	51-2030	Engine and Other Machine Assemblers
11	51-1010	First-Line Supervisors of Production and Operating Workers

Tables 2.A and 2.B above identify several occupations that will be particularly in short supply. Over the long-term, to close the FOSW skill gap, California must provide incentives to create and expand specific occupational training programs. As this study demonstrates, the educational attainment for FOSW occupations with the highest worker shortages is typically below college level, except for industrial and related engineering fields.

Our findings indicate that high schools, union apprenticeship programs, vocational training facilities and junior colleges (Cuesta, Allan Hancock, Santa Barbara City), should focus on enhancing the workforce that supports the on-site and supply chain occupations. On the other hand, local universities – Cal Poly and UCSB – should focus on training environmental scientists, engineers, computer programmers, and business professionals to support highly specialized occupations.

To conclude, our analysis suggests that the success of California's FOSW industry hinges upon targeted investments in key elements of (1) the supply chain, (2) infrastructure and ports, and (3) human capital and vocational training programs. Examples of targeted investments include development of the metal/steel industry to support the FOSW supply chain; the construction of specialized port facilities near the Central Coast to support installation, operation and maintenance of FOSW projects; investment in critical infrastructure, including the electrical grid, to accelerate deployment and adoption of new technologies; and most importantly, investments in educational and occupational training programs to build and maintain a viable FOSW labor force. Meeting California's floating offshore wind milestones will be challenging, but it can be done with coordinated efforts, investments in both physical and human capital, and effective collaboration among the stakeholders.

2 Introduction and Scope of the Study

2. Introduction and the Scope of the Study

The floating offshore wind (FOSW) industry represents a major opportunity to provide clean energy, utilizing abundant wind resources in California's Central Coast, while promoting significant job growth and economic development throughout the state. In this study, which was funded by the California Workforce Development Board- High Road Training Partnership (HRTP), we conduct a detailed Economic Impact Analysis (EIA) of two FOSW projects in this region. The first, CADEMO, is a small-scale pilot near the Vandenberg Space Force Base (VSFB). The second, a commercial scale project in the Morro Bay region.

In this section we provide general background on FOSW and discuss the scope of our study. Details of each project, several potential development scenarios, and specifics of the EIA models associated with each scenario is presented in section (3). We then presents the results of our analysis, including estimates of direct, supply chain, and induced impact of each project in terms of increased economic output and jobs created in California.

For purposes of economic policy analysis, it is important to understand the impact of FOSW projects in terms of jobs created by different occupations and to assess the current availability and employment of that type of workforce in counties near the FOSW and the State of California. For example, given the estimated demand for construction jobs associated with CADEMO in Santa Barbara County, it is critical to know the number of available construction workers in the county (both employed and unemployed) and within the state under each potential development scenarios, i.e., the existing labor gap.

In section (4) we present the details of a complimentary study of the gap in available labor supply – in California and the Counties of San Luis Obispo and Santa Barbara – to satisfy the anticipated increase in labor demand for each project under alternative development scenarios. Our findings are organized into five broad occupation categories: business and STEM, community service, food and wellness, administrative and construction, and transportation and production occupations. Before turning to the discussion of our findings, it will be helpful to provide a brief overview of FOSW technology.

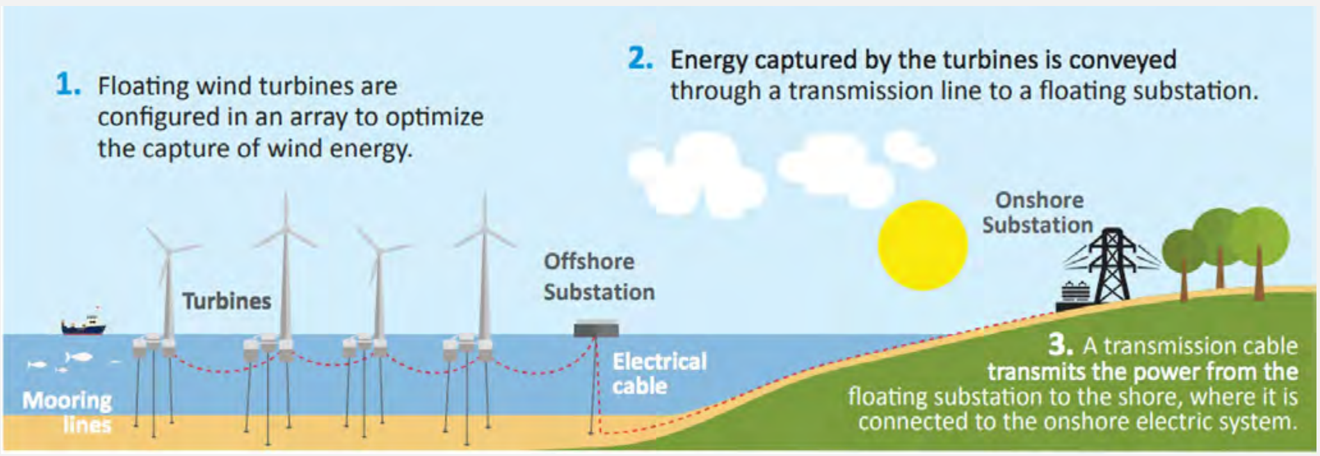
2.1 Background on Floating Offshore Wind

Floating Offshore Wind is a new technology.[4] Floating wind projects are highly complex, requiring a deep understanding of the technology, including electrical interfaces, and manufacturing inter-dependencies, such as coordination in procurement, fabrication, assembly, wind turbine integration, offshore installation, and commissioning phases.

Figure I.1 provides a visual presentation of the components of FOSW energy generation along with a basic framework to understand the inputs and outputs for EIA models. In particular, a project's direct impact occurs at the offshore site, and the supply chain impacts arise from manufacturing the necessary hardware, including turbines, foundations, mooring system, offshore substation, and electrical connecting cables. The development of maritime services (i.e., installation ships and tugs, and port facilities), new onshore substations, and enhancements to the grid that delivers the energy to consumers and businesses will also enhance the supply chain impact.

While floating offshore wind technology is relatively new, it is fast evolving and quickly becoming a more cost-effective source of energy. The industry is expected to reach a high degree of maturation as the number of manufacturers and developers, as well as planned and commissioned projects, expand globally. It is also universally expected that because of scale economies in construction and manufacturing, as well as turbine size, the costs of electricity produced by FOSW will decline, particularly as new commercial scale projects are brought online.[5]

Figure I.1: Floating Offshore Wind Components



Source: Bureau of Ocean Management (BOEM)

The FOSW industry, however, has a relatively short track record. The first demonstration project – a single turbine – was installed in 2009 in Norway (2.3 MW).[6] The first commercial scale FOSW project, the Hywind Scotland, started production in 2017 (30 MW). The world's third and fourth floating wind projects are Windfloat Atlantic (2020) and Kinckadine (2021). These projects generate 30 MW and 50 MW of power, respectively. Finally, the largest floating wind project, Hywind Tampen in Norway (95 MW), has just began production.[7] To date, approximately 200 MW of floating wind projects have been installed, mostly in Europe. Figure I.2 shows the cumulative deployment of FOSW since installation of the first turbine in 2009.

The acceleration of FOSW projects should continue as many countries have big long-term ambitions for this technology. For example, France has announced plans for 20 GW and Scotland plans 17 GW, in the next two decades. Asia is also particularly active in FOSW projects and South Korea, Japan, China, Taiwan, and the Philippines plan large projects. Finally, the Biden administration announced plans for 15 GW by 2035, and in December 2022, the first Pacific lease sale was announced for Morro Bay and Humbolt counties, a total area with the potential of nearly 5 GW power generation. As Figure I.2B shows, FOSW is expected to account for more than 20% of all offshore projects globally installed by 2040.

At the current time, the FOSW turbines are identical to those used in fixed-bottom offshore wind projects. The essential difference between the two technologies is the foundation. There are 4 main types of FOSW foundations; Spar, Tension Leg Platform, Semi-Submersible, and barge.[8] All foundation maybe made from concrete or steel, the choice depending on the site, the scale, the technical capacity of the operators/contractors, and most importantly local manufacturing, construction, supply chain capacity, and the availability of required skilled labor force.

Figure I.2A: Cumulative global deployment of floating offshore wind (2009-2020)

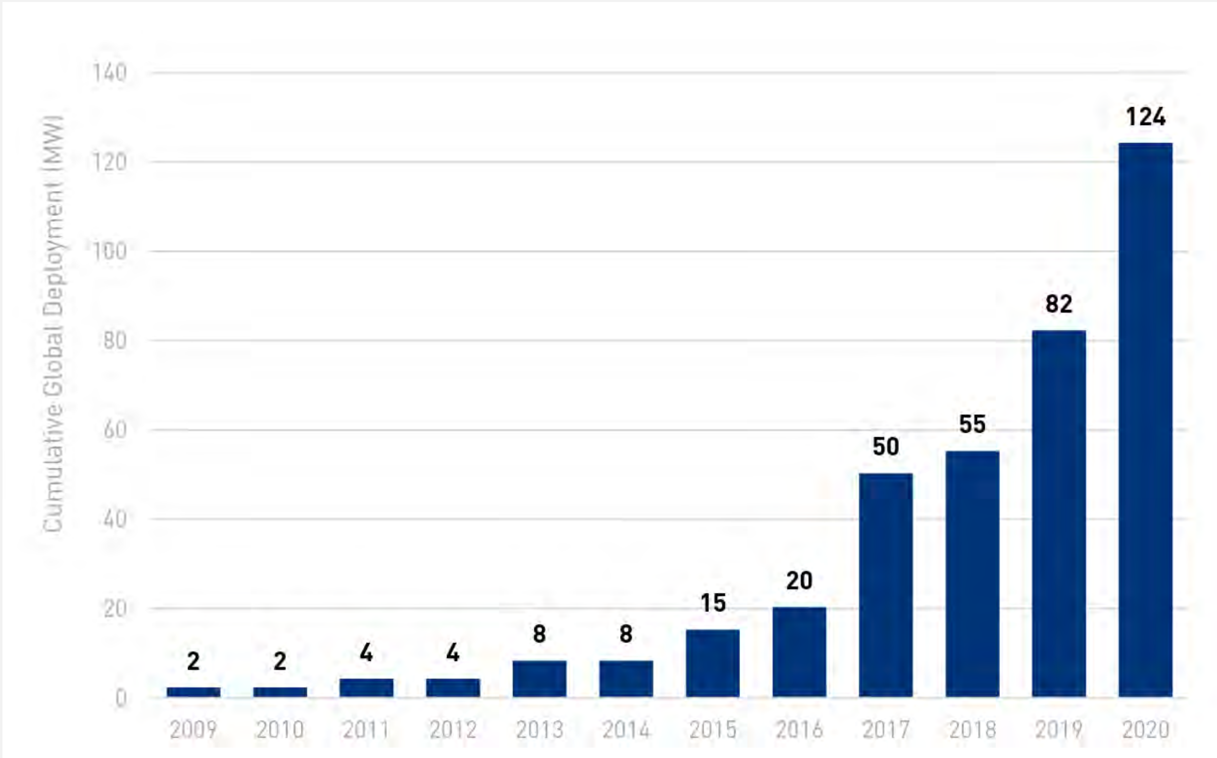
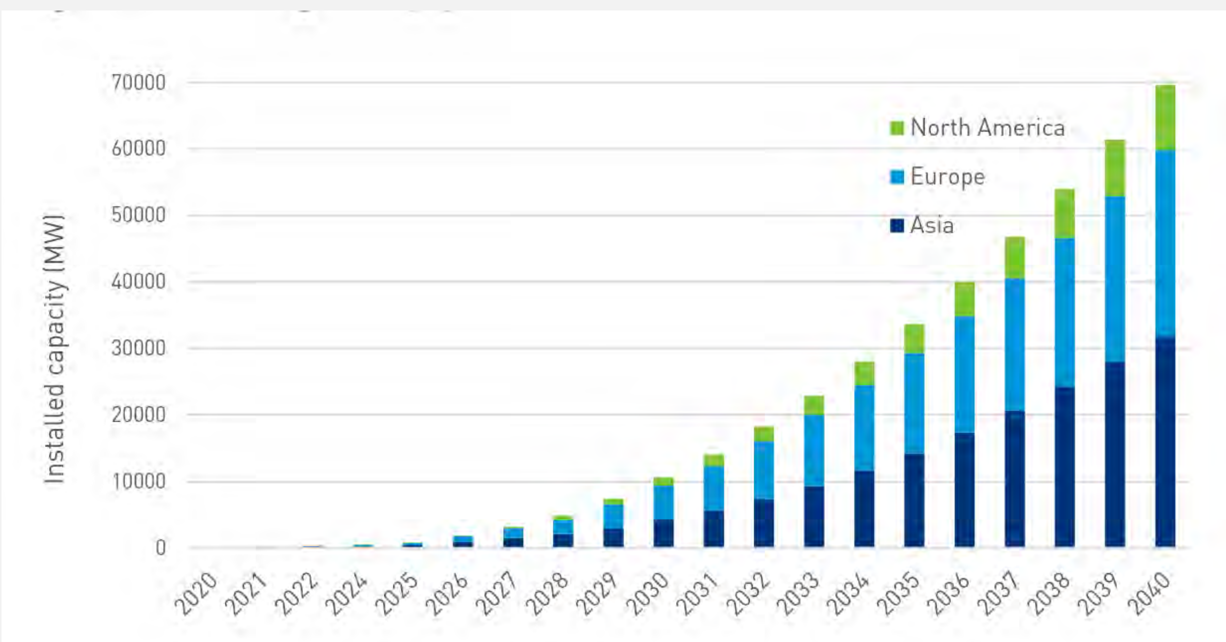


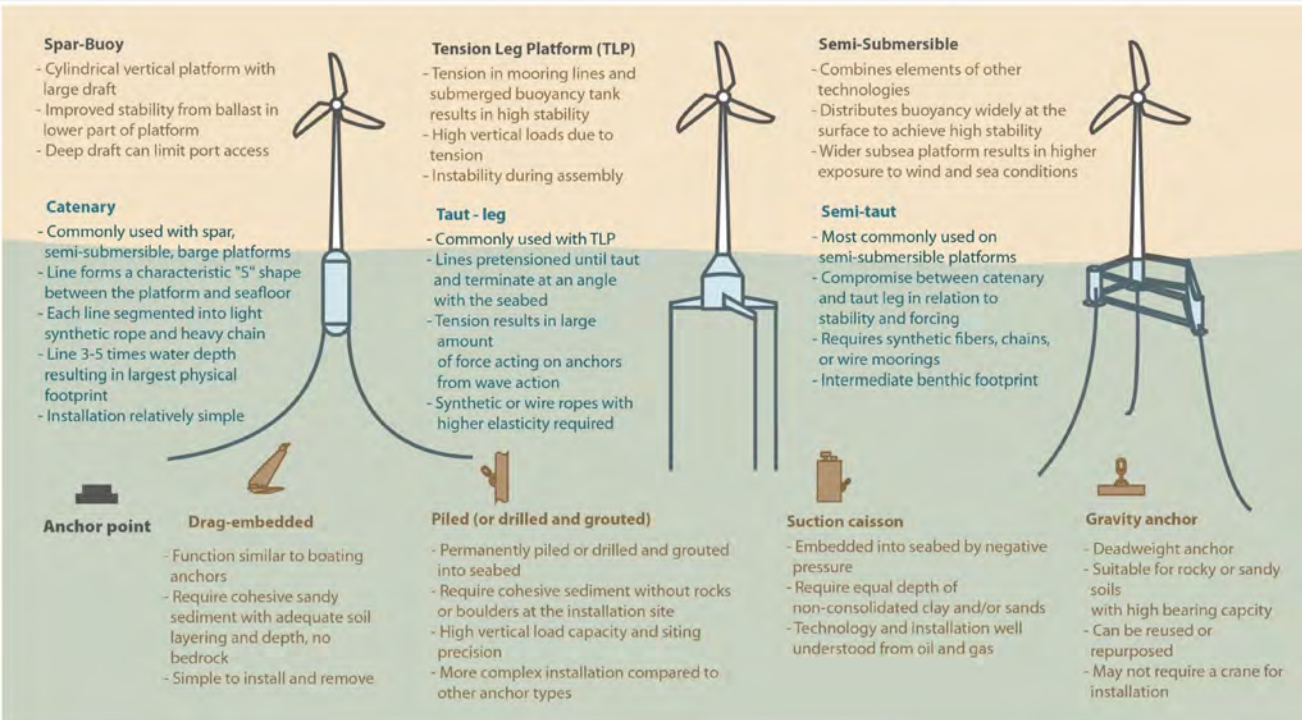
Figure I.2B: Expected Global FOSW Deployment



Source: GWEC (2022)

Figure I.3 presents details of each type of floating structure and its advanatges and limitations.[9] Overall, the semi-submersible foundation is the most popular technology is use. This technology is suitable for rocky and sandy soils, and can be reused and repurposed. For this study, we assumes semi-submersible foundations will be used for both the CADEMO and Morro Bay projects.[10] However, CADEMO has not yet made its final decision for the platforms technology to be used for its turbines, and is also considering using a concrete barge design. Likewise, Morro Bay project developers are expected to consider a variety of platforms designs. These choices could change the jobs composition resulting from these projects.

Figure I.3: Floating Foundation Technology



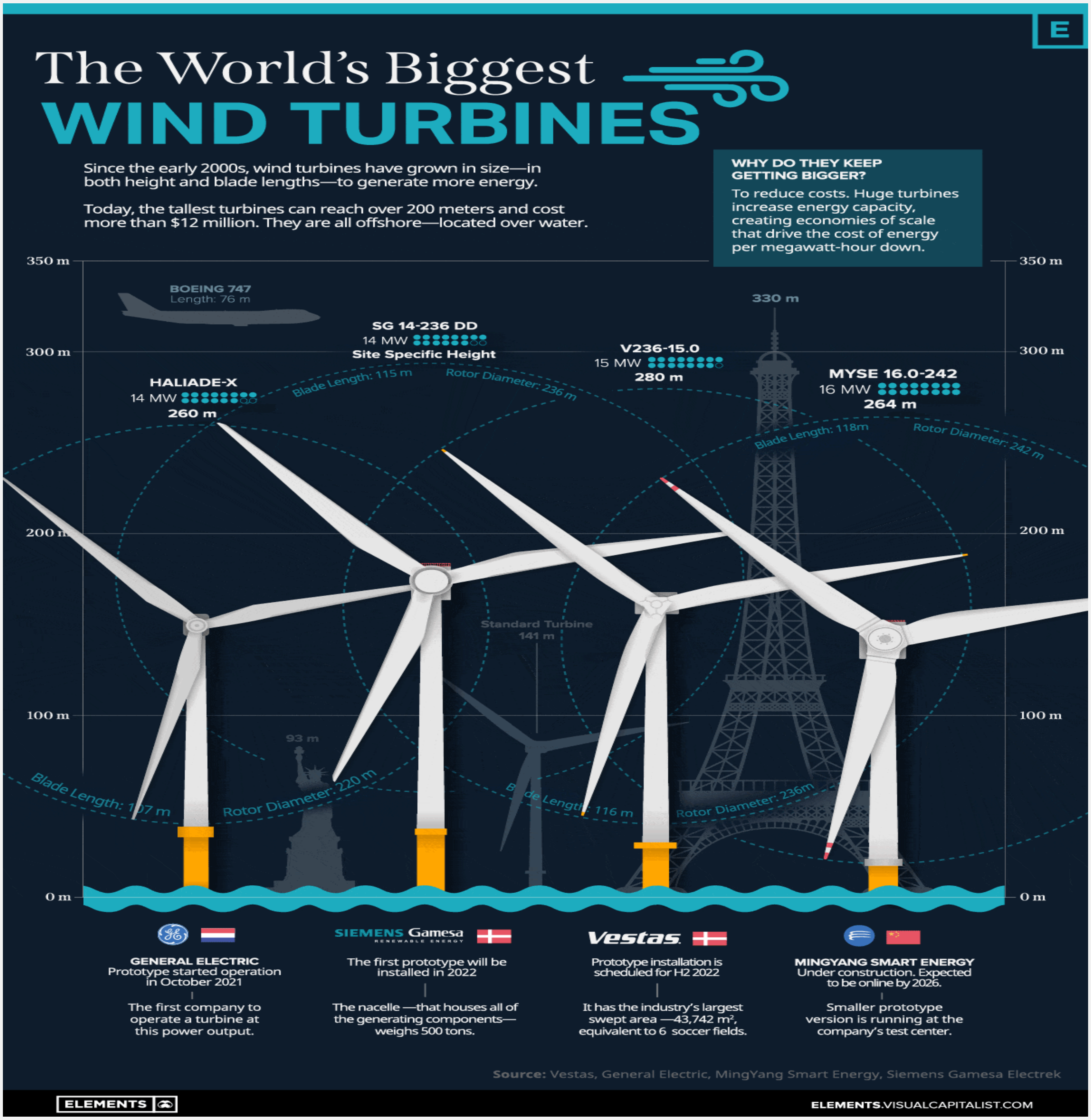
Source: Maxwell, et al. 2022

An important advantage of FOSW concerns the construction of the wind turbine and its foundation at a port, with specialized assembly and construction facilities, rather than at sea. FOSW turbine and its foundation are assembled in a protected wind port and towed to their final site, requiring simpler vessels. Therefore, relative to fixed-bottom structures that require ocean installation, FOSW is less risky and is expected to be more cost-effective.[11] However, there exist few California ports that can fulfill the needs for importation, manufacturing, or assembly of FOSW turbines. A number of ongoing studies have identified promising ports and potential site for the assembly and delivery of offshore wind turbines. However, it appears that construction of the appropriate ports and infrastructure is costly and many years away from becoming a reality.[12]

A recent study by Hamilton et al. (2021) considers the potential for a specialized assembly and staging port on California's Central Coast. The authors discuss how a specialized port facility could be instrumental for assembly and installation, operations and maintenance (O&M), as well as future decommissioning activities. This study suggests that, on an interim basis, manufacturing of some FOSW components, such as the turbines and foundations, could occur in the Asia Pacific region, where the industry is more advanced and cost-effective. The specialized ports, therefore, represent an intermediate opportunity for initiating the development of a local manufacturing industry and supply chain, while advancing employment and regional economic growth. Given this background, our analysis does not include the construction of a port, i.e., we assume the hypothetical commercial scale project will replicate CADEMO's strategy by utilizing the existing California ports' facilities and maritime resources.

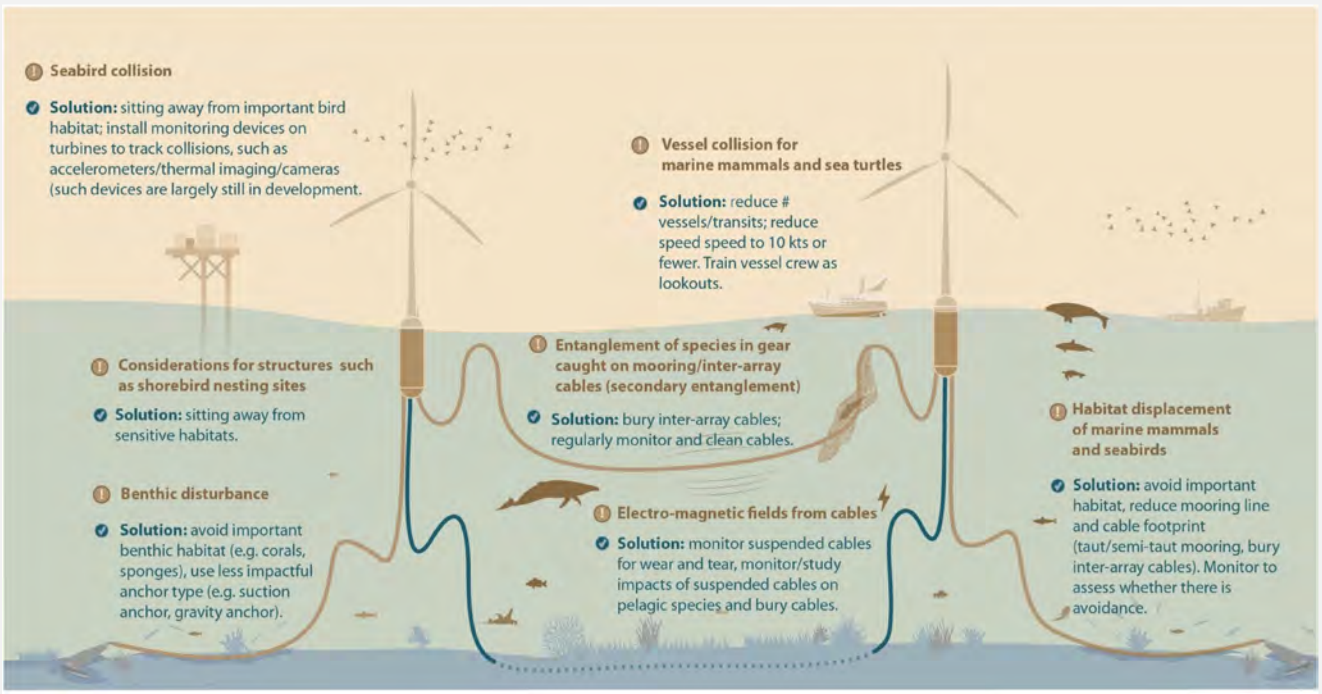
The largest cost saving for FOSW projects is expected to come from growth in the size of turbines. As Figure I.4 shows, turbine capacity has increased significantly in recent years. In this study we assume that 15 MW turbines will be used for both CADEMO and the commercial scale Morro Bay projects.

Figure I.4: Growing FOSW Turbines



Like all heavy infrastructure projects, FOSW will impact the environment. Figure I.5 summarizes the potential environmental impacts of FOSW projects. However, since the industry is in its infancy, there is relatively little data on actual environmental impacts of large-scale projects. Floating turbines are expected to have lower environment impacts, since during the construction phase there is no foundation installed on the ground (no hydraulic hammers and surface installation disturbances). However, during their operational phase, the risks of species entanglement in gear, caught on mooring /inter-array cables or drifting fishing nets may be significant. Moreover, the incidence of bird collisions for FOSW is expected to be similar or lower than fixed-bottom turbines. It is important to note that the EIA models presented below contain no estimates of environmental costs or benefits associated with FOSW.

Figure I.5: Environmental impact of FOSW projects



Source: Maxwell, et al. 2022

The completion of the first offshore wind energy lease auction in California – three parcels off the coast in Morro Bay and two in Humboldt – represents a pivotal moment for offshore wind in the United States, as these leases represent the first commercial scale projects that will utilize floating foundations in deep waters.[13] The leased areas are expected to generate an estimated 4.6 GW of energy, placing California on track to potentially become a global leader in the FOSW industry.[14]

However, the provisional auction winners must complete a series of site characterization and survey activities, submit a Site Assessment Plan and a Construction and Operations Plan to BOEM for review, and conduct project-specific environmental impact analyses. They are also required to engage with federal and local government agencies, tribal communities, the fishing industry, labor unions, environmental justice groups, and environmental advocates. According to BOEM's own estimation, the timeline to complete these steps before construction could commence may be 7 to 8 years.[15] On the other hand, there are strong state and federal legislative pressure and incentive programs that aim to streamline the environmental and permitting process, and keep development plans on track.[16] Moreover, the California auctions provided significant incentives to invest in local communities and supply chain development, which are also expected to accelerate progress.[17]

Earlier this year, the Biden administration established a goal of deploying 15 GW of FOSW capacity by 2035.[18] In August, the California Energy Commission, adopted planning goals for 2 to 5 GW FOSW by 2030 and 25 GW by 2045.[19] The completion of California auctions is an important step in meeting the federal and state goals. The energy produced in the auctioned parcels could satisfy the state's 2030 goal, and contribute to the 2045 goal. However, to play a significant role in meeting the state and federal goals, California's FOSW projects must overcome a number of challenges, most importantly:

- Manage the inherent risks of developing a new technology in deep waters[20]
- Develop and train a robust FOSW workforce and expand state's transmission infrastructure[21]
- Construct appropriate ports and infrastructure[22]
- Reduce shortage of FOSW components and specialized ships, including Jones Act compliant vessels[23]
- Alleviate logistical and supply chain constraints, including congestion in California ports.[24]
- Resolve uncertainty about buyers for the energy generated and the details of purchasing power agreements[25]
- Develop strategies to manage inflation and rising input costs, including labor, raw materials, manufactured goods, and energy[26]
- Manage rising interest rates and higher costs of equity and debt financing[27]

These factor have adversely impacted the progress of all green energy projects, particularly FOSW in 2022.[28] The CADEMO pilot project will serve as a "learn as you go" experiment in overcoming these challenges. However, transitioning from the CADEMO project to the development of several commercial-scale projects, across multiple parcels, may face new and unforeseen challenges. For example, capital expenditures per MW are expected to fall as commercial-scale projects are brought online, but that expectation may not be realized, unless inflation and interest rates return to their historical lows.

The recently awarded California auctions have created the opportunity to deliver commercial scale offshore wind energy, a major leap for California's nonexistent FOSW industry. Delivering this capacity will require seamless development of industrialized supply chains to produce and install hundreds of large turbines over the course of a few years. Commercial scale projects create the opportunity to invest in new facilities, expanded existing ones, work with many suppliers to optimize design and production, and address bottlenecks in the fabrication, assembly, and installation phases. Success will require significant coordination and cooperation among the public and private sector entities, representing a monumental task for California industry and government.

The economic impact analysis presented in the next section assumes there will be efficient and timely collaboration among developers, manufacturers, and supply chain service provider so that development time is minimized and execution risks are optimally managed. It is also assumed that both projects posses acceptable purchase power agreements, and neither will benefit from participation in the "Infrastructure Investment and Jobs Act" or the "Inflation Reduction Act".[29] Finally, we presume that policymakers will create the conditions for long-term and sustainable growth of California's floating wind industry.

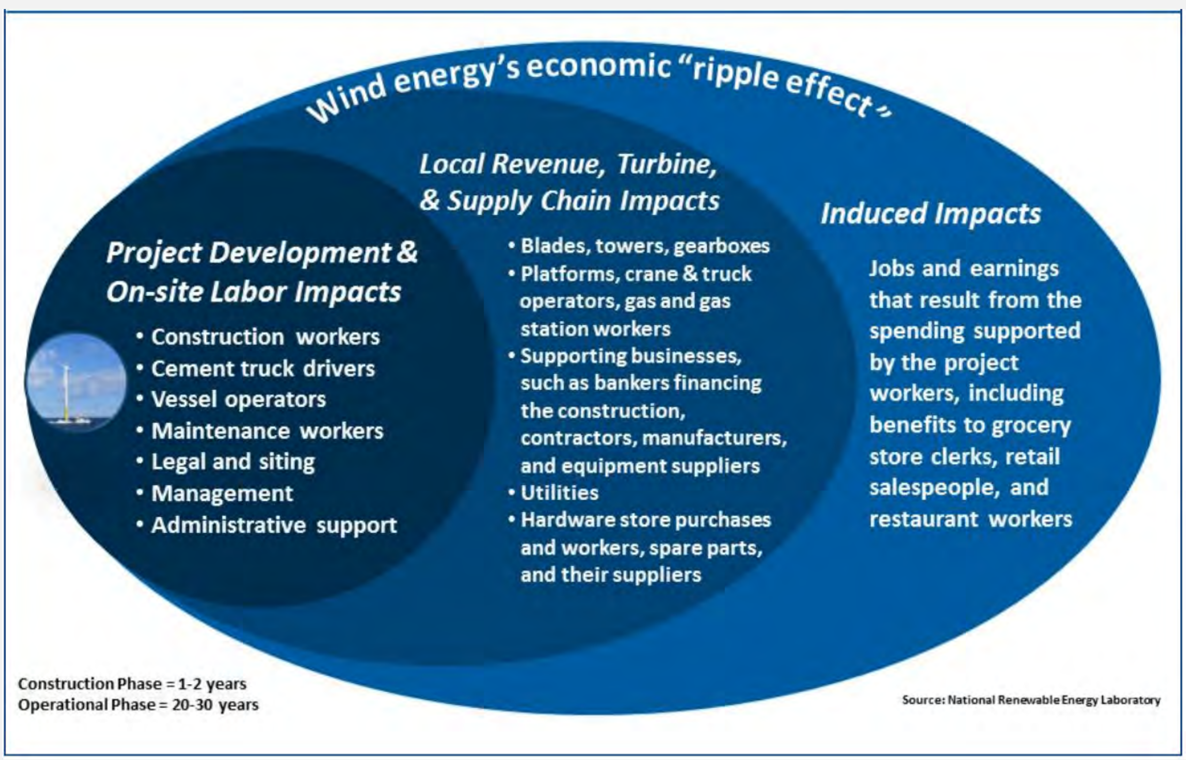
3 Economic impact of FOSW

3. Economic and Employment Impact of FOSW

It is standard practice to use “Economic Impact Assessment” (EIA) models to estimate the economic and employment impact of FOSW projects. EIA models takes on-site economic activity as input and project the current and future impact on earnings and employment in a region. It is important that the EIA model provides projections of the expected labor demand by specific occupations in the local markets, so that skill training and educational programs can be scaled to meet the FOSW’s workforce needs. To assess the economic benefits of FOSW developments, we utilize the widely recognized *Jobs and Economic Development Impact* (“JEDI”) model, which was developed by the National Renewable Energy Laboratory (“NREL”).

Figure E.1 provides a schematic overview of a generic FOSW project and its overall earnings and employment impacts as projected by JEDI. The figure shows three types of economic activities resulting from FOSW developments: “direct impact” results from the capital and development expenditures, and employment at the project site. The “supply chain impacts” include employment and capital expenditures on manufactured components and procurement of other supply chain services. Finally the “induced impact” from the purchases resulting from the expenditure of the earnings generated by the on-site and supply chain effects, including expenditures of earnings generated during operations and maintenance (O&M) phase of the project.

Figure E.1: JEDI model economic ripple effect (FOSW)



JEDI is an Excel-based model that projects the economic impacts of constructing and operating a FOSW project, at the local level. JEDI relies on the widely recognized input-output economic multipliers.

These multipliers are derived from IMPLAN, which includes state level data. IMPLAN is based on input-output tables, employment and wage data, inter-regional trade flows, and personal expenditures.[30]

The inputs to the FOSW-JEDI model include technical characteristics of the project, including capacity, number of turbines, distance from shore, water depth, and specific capital expenditures associated with the construction and operations phases of the project. JEDI projections can be based either on default inputs, derived by NREL from interviews with industry experts and project developers, or the user supplied data. JEDI also requires several categories of expenditures and their "local content," which is the fraction of each expenditure item entering the local economy, in this case the state of California.

JEDI provides estimates of potential activity resulting from a specific project, rather than a precise forecast. In addition, JEDI results presuppose that the project is financially viable and can be justified independent of its economic development value. Importantly, results generated by JEDI models are gross (not net) results. JEDI does not account for potential increases or decreases in electricity rates resulting from investments in new infrastructure, or the possibility that a project may displace economic activity elsewhere.

Given the project-specific inputs, JEDI provides estimates of job creation, earnings, and output for the region. JEDI's output, which is grouped by the construction and operation phases, provides the basis to address questions regarding the impacts of FOSW projects. JEDI's outputs are defined as follows:

- **Jobs:** Additional jobs resulting from the increased FOSW spending.
- **Earnings:** The additional earnings (wages and employer paid benefits) associated with the additional jobs.
- **Output:** Additional output, i.e, the sum value of all goods and services at all stages of development, including raw material and finished goods.
- **Value Added:** The difference between output and the cost of intermediate inputs.
- **GDP:** The addition to sum total of value added for all enterprises.

Outputs are categorized into direct, supply chain, and induced economic impacts:

- **Direct** results are defined as on-site labor and professional services. These are the impacts from dollars spent on labor by companies engaged in on-site development and construction, maintenance-operations of the FOSW plant, and transmission to the grid. These results include only labor (materials are excluded). Enterprises that fall into this category include project developers, environmental and permitting consultants, road builders, concrete-pouring companies, construction companies, tower erection crews, crane operators, and O&M personnel.
- **Supply chain** impacts result from the increase in direct on-site demand for goods and services, which in turn increase demand for components, equipment, and supply chain services. Companies in this group include all original equipment and replacement parts manufacturers, construction material suppliers, legal and business professionals, and financial analysts.

- **Induced** effects are driven by the local expenditures of earnings received by the first two categories. These are often associated with increased purchases at local restaurants, entertainment venues, retail establishments, and broad services such as health and childcare.

JEDI model results are presented for two different time periods:

- **Construction** period results are inherently short-term. Jobs are defined as full-time equivalents (FTE), or 2,080-hour units of labor. One construction period job equates to one full-time job for one year. Equipment manufacturing jobs, for example building turbine towers, are included in construction period jobs. All employment related to project construction is reported in FTE.

- **Operation** period results are long-term, accruing throughout the operating life of the facility, and are reported as annual FTE jobs.

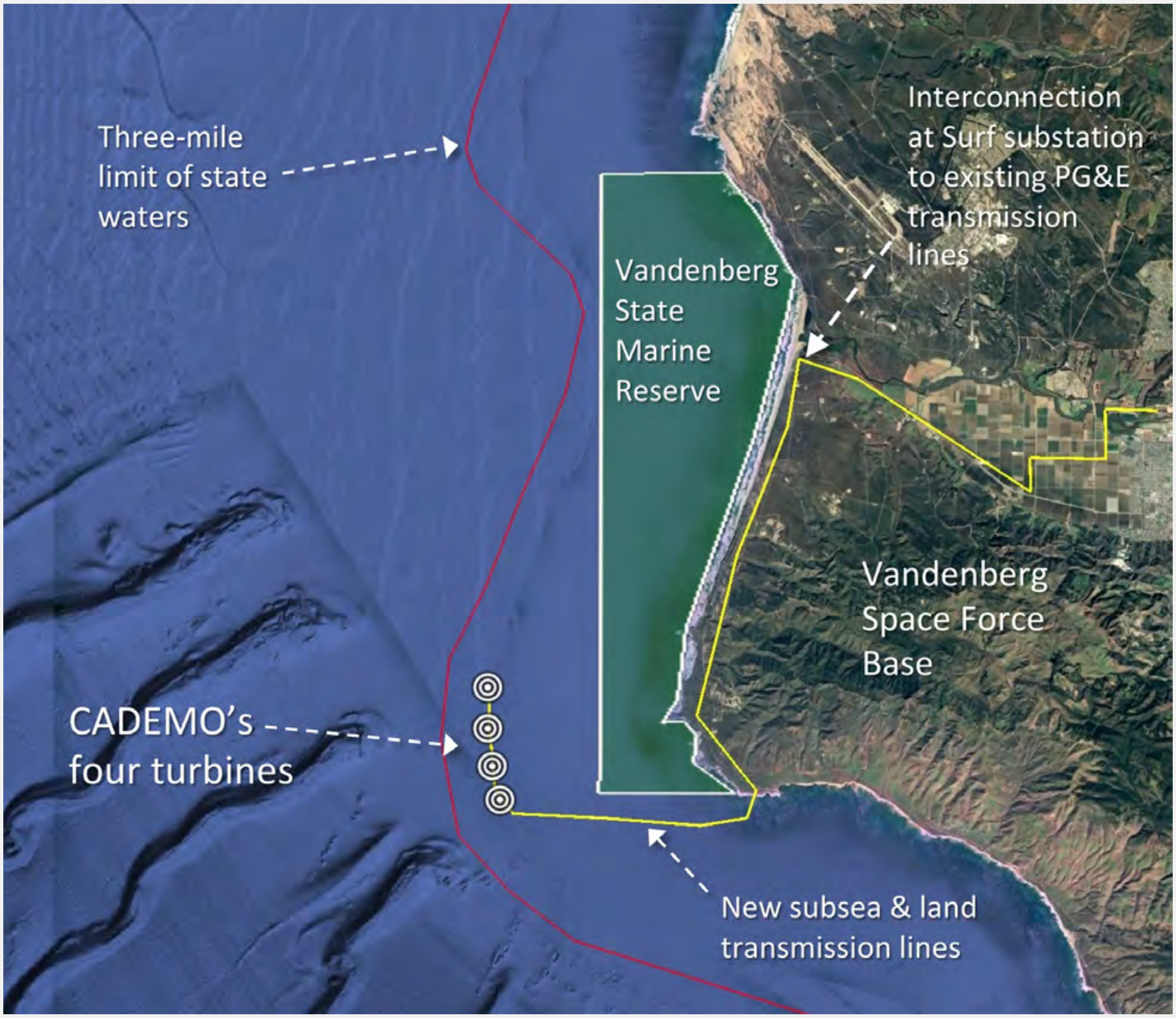
3.1 Project Descriptions and Technical Data

This analysis provides economic impact assessment results for the proposed construction and operation of two FOSW projects in the Central Coast of California. The first, the **CADEMO** project, will be located approximately 2.8 miles from the Vandenberg Space Force Base (VSFB) in Santa Barbara County. CADEMO includes up to 60 MWs of generating capacity with four 15 MW per turbines, all of which will be located within state waters. New submarine and land transmission lines will connect to an onshore substation and the existing electric grid. Figure E.2 provides additional details.[31]

The Vandenberg Space Force Base (VSFB), is located halfway between San Francisco and Los Angeles. It is bordered by the Pacific Ocean, the Santa Ynez Mountains, and the ranches of northern Santa Barbara County.[32]

The **CADEMO** project is expected to play an important role in the development of commercial scale FOSW projects in California, and contribute to the local and state economy by creating new jobs. The construction and operations of CADEMO will help launch California's offshore wind industry.[33]

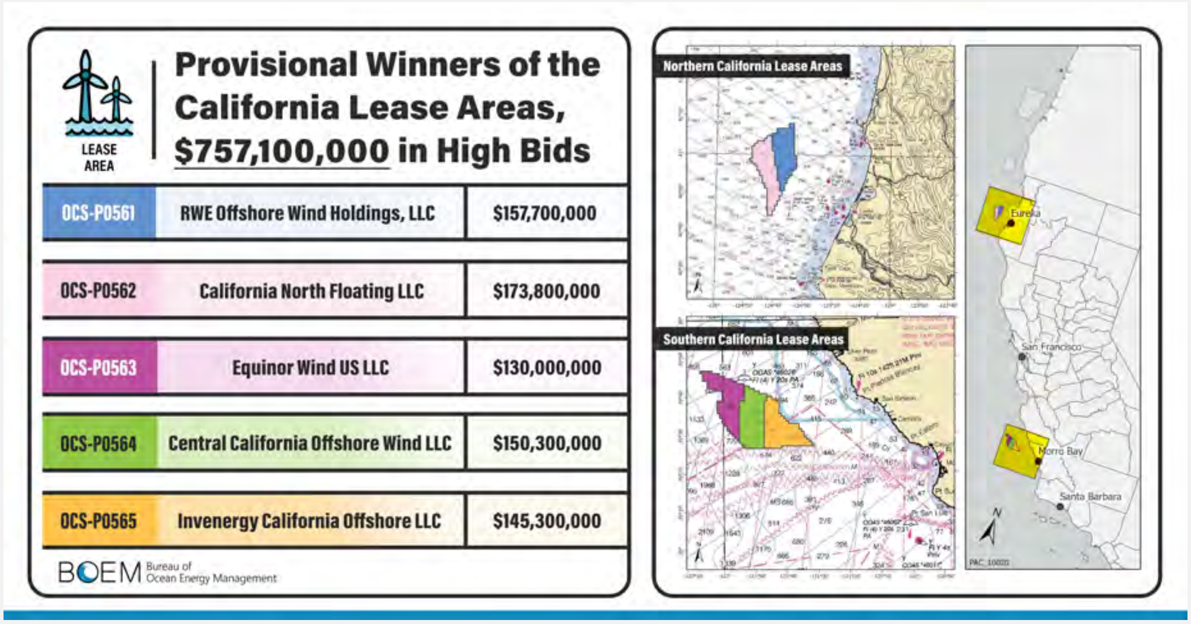
Figure E.2: CADEMO's Geographic Location



Source: The CADEMO Project, https://cademo.net/the-project/

The **Commercial Scale** Morrow Bay plant is a hypothetical project to be constructed on the recently auctioned parcel, area OCS-P0563 in Figure E.3 below. It will be located approximately 30 miles from the coastline in San Luis Obispo County. The hypothetical project will generate up to 990 MWs, using 66 turbines with capacity of 15 MW each, all of which will be located within federal waters. It is assumed that inter-array and export cables, offshore substation(s) and new submarine transmission lines will connect to the existing electric grid in Morro Bay.[34] It is also assumed that semi-submersible foundations will be used for both the CADEMO and Morro Bay projects, though as of this writing, the developers have not finalized this decision.

Figure E.3: California FOSW Call Areas



JEDI requires three basic input data categories:

1. Capital and development expenditures, and operations & maintenance (O&M) costs. Appendix A presents these costs for both projects under different development scenarios.

2. Project technical data, including plan characteristics, turbine design, site characteristics, substructure design, electric infrastructure, port characteristics, and vessel deployment. Appendix B presents detailed technical information for each projects.

3. Local Content: JEDI requires detailed estimates of project expenditures and the share of each individual expenditure line item that is procured locally. These data must be developed for both the construction and operations phases of the plant life cycle.[35]

Except for the basic technical data, JEDI provides default values for capital and development expenditures along with operations and maintenance (O&M) costs for projects off the California coast. In this study, we also obtain input data from two additional sources. The CADEMO project staff provided technical specifications, costs, employment, and expected local content data for their pilot project. Similar data were collected from prior studies and applied to both CADEMO and commercial scale Morro Bay project.

While JEDI Offshore Wind Model provides default input estimates for California, we propose a number of alternative scenarios using parameters values supplied by CADEMO staff and prior FOSW studies. The resulting scenarios are useful for understanding the implications of different assumptions, particularly with respect to potential demand for local workforce. Both JEDI's default and our proposed alternatives are presented in Appendix C and discussed in the next section.

3.2 Alternative Development Scenarios

To obtained estimates of the economic impact of these projects, we consider a number of possible scenarios that are reflective of potential variations in costs and geographic sourcing of each project's inputs. In particular, the proposed scenarios rely on different estimates of capital expenditures (CAPEX), operation and maintenance costs (OPEX), and local content of turbines, floating substructure, and other components.[36]

CAPEX include costs related to the development phase, components and installation process, all of which are site dependent (distance to shore and water depth), various financial expenses and insurance, and general management costs. Major components include turbines and substructures, mooring and all the electrical and connecting cables (submarine cabling, onshore and offshore substations). CAPEX also includes development expenditures (DEVEX), such as the environmental surveys and permitting, project management and development services. CAPEX are mostly incurred prior to operation of the FOSW project and vary with the size of the project.

The turbine costs consists of rotor (blades, hub, etc.), nacelle (turbine components housing cover), and tower. The nacelle accounts for a large share of the turbine cost, followed by the rotor and tower. Because floating substructures are new and have not been used in large-scale projects, it is difficult to obtain an accurate estimate of their costs. For similar reasons, estimates of mooring costs in deep waters are highly uncertain. Grid integration costs, which include connection and inter-array cables, generally rise with distance to shore. Finally, transportation and installation costs for semi-submersible foundations are expected to be lower than other types of floaters and fixed bottom structures. It is important to note that JEDI's default values likely constitute a good estimate of CAPEX costs for California.

Operation and maintenance costs (OPEX) are a significant share of the total costs in FOSW projects. The fixed portion of these costs include replacement and repair of components, O&M workforce wages, and expenditures for equipment and port services. The variable component includes expenses associated with routine inspections and travel to turbines.[37] OPEX are expected to decline for large projects due to scale economies. However, because large-scale FOSW projects have not been yet developed, an accurate estimation of O&M costs is difficult. It is important to note that JEDI's default values likely constitute an accurate estimate of OPEX for California.

We consider two combinations of CAPEX-OPEX estimates and local content outcomes: First is the pilot project cost estimates provided by CADEMO staff, in combination with two local content parameters. Second, the JEDI's default CAPEX-OPEX estimates for California, in combination with the same two local content parameters. Table E.1 provides a summary of these scenarios. The local content parameters, supplied by CADEMO staff, serve as a lower bound under the assumption of pre-industrialization of FOSW in California. The second set of local content parameters, estimated by the authors, serve as a hypothetical upper bound after industrialization of FOSW inside California in the future.

Table E.1: CADEMO CAPEX-OPEX Estimates and Alternative Local Content Scenarios	
Scenario	**CAPEX-OPEX and Local Content Combinations**
A1: Base	CADEMO's costs estimates in conjunction with CADEMO supplied local content.
A2: High	CADEMO's costs estimates in conjunction with Authors' hypothetical local content estimates.
B1: Base	JEDI's default costs in conjunction with CADEMO supplied local content estimates.
B2: High	JEDI's default costs and the Authors' hypothetical local content estimates.

We utilize JEDI's cost estimates for the commercial scale Morro Bay project. However, we consider three potential levels of local content outcomes. In the short term the California FOSW industry is constrained and unable to fully participate in components manufacturing. Consequently, the supply chain impact is likely to be small. Over the next decade, however, it is expected that significant investments in manufacturing, infrastructure, and workforce will lead to higher California content. Over the long term, the California FOSW industry is expected to fully mature and reach its maximum potential. We obtain estimates of the short-, intermediate-, and long-term local content outcomes from prior studies (see Appendix C). Table E.2 summarizes these scenarios.

Table E.2: Commercial Scale Cost and Local Content Scenarios	
	Local Content Scenario
C1: Low	Implies that a small fraction of component production, construction work, and supply chain services is provided by California's FOSW industry. The main activities undertaken are assembly of imported materials, and transportation/installation activities, which utilize local workforce. This local content level corresponds to short-term development phase of California's FOSW industry.
C2: Mid	Refers to intermediate local content provisioning based on estimates from prior studies. This local content level is associated with development of California's FOSW industry over a decade.
C3: High	Refers to upper bound of local content provisioning, obtained from prior studies. This local content level would be representative of a mature California FOSW industry.

3.3 JEDI Model Aggregate Output

In this section we present JEDI's outputs for FOSW projects in California. The primary source for critical inputs are CADEMO and prior FOSW studies. In cases where inputs are unavailable, we use the JEDI default values or utilize a range of estimates from prior studies. In the remainder of this section, we first present the overall economic impacts in terms of increase in aggregate employment, earnings, output and GDP for CADEMO and the Commercial scale projects.

Note that the "Onsite" figures represent the direct impact resulting from on-site employment and capital expenditure. The "Supply Chain" figures correspond to equipment, manufacturing, and service purchases that support the on-site developments. Finally, the "Induced" figures results from increased spending of household earnings from the project's on-site development and supply chain businesses.

Tables E.3 and E.4 present the JEDI's summary output for each project under different cost structures and local content scenarios, as discussed earlier. The output shows a summary of the overall potential economic benefits in California, including local jobs created (detailed in the next section), labor earnings ($M), which encompass the additional wages and employer paid benefits associated with the additional jobs created; gross output ($M), which is the sum value of all goods and services at all stages of production resulting from a project; and GDP ($M), which is the sum of value added by all local enterprises participating in the development of a project.[38] Construction jobs are reported as job-years since employment may spread over a multi-year period. Job-years are defined as FTE jobs multiplied by the number of years.[39] Operations jobs are reported as annual FTE jobs over the operating period.

Table E.3 shows that, depending on the scenario, the CADEMO project will result in the range of 922-1511 total job-years during the construction phase (assumed to be 3 years), and 23-42 jobs in the operations phase. The increase in total earnings is estimated to be $81.2-140.2 million in the construction phase and $2.0-3.3 million per year in the operations phase. The total value of project output is $203.4-344.1 million during the construction phase and $5.6-10.5 million per year during the operations phase. Finally, the increase in total GDP is estimated to fall within the range of $113.7-188.3 million during the construction phase and $3.1-5.4 million per year during the operations phase.

The results in Table E.3 suggest that the economic impact of the pilot project is lowest under the CADEMO supplied CAPEX-OPEX and Local Content estimates (scenario A1) and highest under the JEDI default parameters values (scenario B1). For the construction phase, relative to CADEMO provided parameters, JEDI defaults suggest 64% higher jobs, 74% higher earning, 69% higher output, and 66% higher GDP during the construction phase. Similarly, for operations phase, JEDI defaults indicate 83% more jobs, 65% higher earning, 87% higher output, and 74% higher GDP. Clearly, scenario A1 represents the most conservative and scenario B1 is the most optimistic projection.

Table E.4 presents similar results for the Commercial scale project. Based on the JEDI analysis, the project is expected to account for a total of 6,900-14,956 job-years in the construction phase and 398-684 jobs on an annual basis during the operations phase. The estimated increase in total earnings is $571.2-1,231.9 million in the construction phase and $30.5-54.6 million per year in the operations phase. The estimated increase in total output is $1,713.4-3,712.6 million during the construction phase and $89.4-

173.1 million per year during the operations phase. Finally, the total increase in GDP is estimated to be in the range of $838.8-1,797.1 million during the construction phase and $48.4-89.8 million per year during the operations phase.

Table E.3: Economic Impact of CADEMO, Four CAPEX-Local Content Scenarios

Construction					
Scenario		A1	A2	B1	B1
Jobs (FTE)	Onsite	20	30	31	41
	Supply Chain	677	830	892	1084
	Induced	225	278	321	386
	Total	**922**	**1138**	**1244**	**1511**
Earnings ($ Millions)	Onsite	2.0	3.0	2.0	3.0
	Supply Chain	66.1	78.6	98.5	114.6
	Induced	13.1	16.3	18.7	22.6
	Total	**81.2**	**97.9**	**119.2**	**140.2**
Output ($ Millions)	Onsite	2.0	3.0	2.0	3.0
	Supply Chain	156.6	204.9	206.1	264.3
	Induced	44.7	55.3	63.8	76.8
	Total	**203.4**	**263.2**	**271.9**	**344.1**
GDP ($ Millions)	Onsite	2.0	3.0	2.0	3.0
	Supply Chain	84.7	105.4	113.9	138.9
	Induced	27.0	33.4	38.5	46.4
	Total	**113.7**	**141.8**	**154.5**	**188.3**

Operations and Maintenance (Annual, Ongoing)					
Scenario		A1	A2	B1	B1
Jobs (FTE)	Onsite	4	4	7	7
	Supply Chain	12	12	23	23
	Induced	7	7	12	12
	Total	**23**	**23**	**42**	**42**
Earnings ($ Millions)	Onsite	0.4	0.4	0.5	0.5
	Supply Chain	1.1	1.1	2.0	2.0
	Induced	0.4	0.4	0.7	0.7
	Total	**2.0**	**2.0**	**3.3**	**3.3**
Output ($ Millions)	Onsite	0.4	0.4	0.5	0.5
	Supply Chain	3.9	3.9	7.6	7.6
	Induced	1.3	1.3	2.3	2.3
	Total	**5.6**	**5.6**	**10.5**	**10.5**
GDP ($ Millions)	Onsite	0.4	0.4	0.5	0.5
	Supply Chain	1.8	1.8	3.5	3.5
	Induced	0.8	0.8	1.4	1.4
	Total	**3.1**	**3.1**	**5.4**	**5.4**

Table E.4 also shows that as California's FOSW industry matures, and the local content rises, the economic impact of the commercial scale project in terms of jobs, earnings, output, and GDP more than doubles.

Table E.4: Economic Impact of Commercial Scale, Three Local Content Scenarios

Construction				
Scenario		C1	C2	C3
Jobs (FTE)	Onsite	214	272	353
	Supply Chain	4,998	9,753	10,991
	Induced	1688	3177	3612
	Total	**6,900**	**13,202**	**14,956**
Earnings ($ Millions)	Onsite	21.2	27.0	35.0
	Supply Chain	450.6	885.2	985.2
	Induced	99.4	185.7	211.7
	Total	**571.2**	**1097.9**	**1231.9**
Output ($ Millions)	Onsite	21.2	27.0	35.0
	Supply Chain	1356.7	2593.0	2959.9
	Induced	335.5	631.3	717.7
	Total	**1713.4**	**3251.2**	**3712.6**
GDP ($ Millions)	Onsite	21.2	27.0	35.0
	Supply Chain	615.0	1165.3	1328.7
	Induced	202.6	381.2	433.4
	Total	**838.8**	**1573.5**	**1797.1**

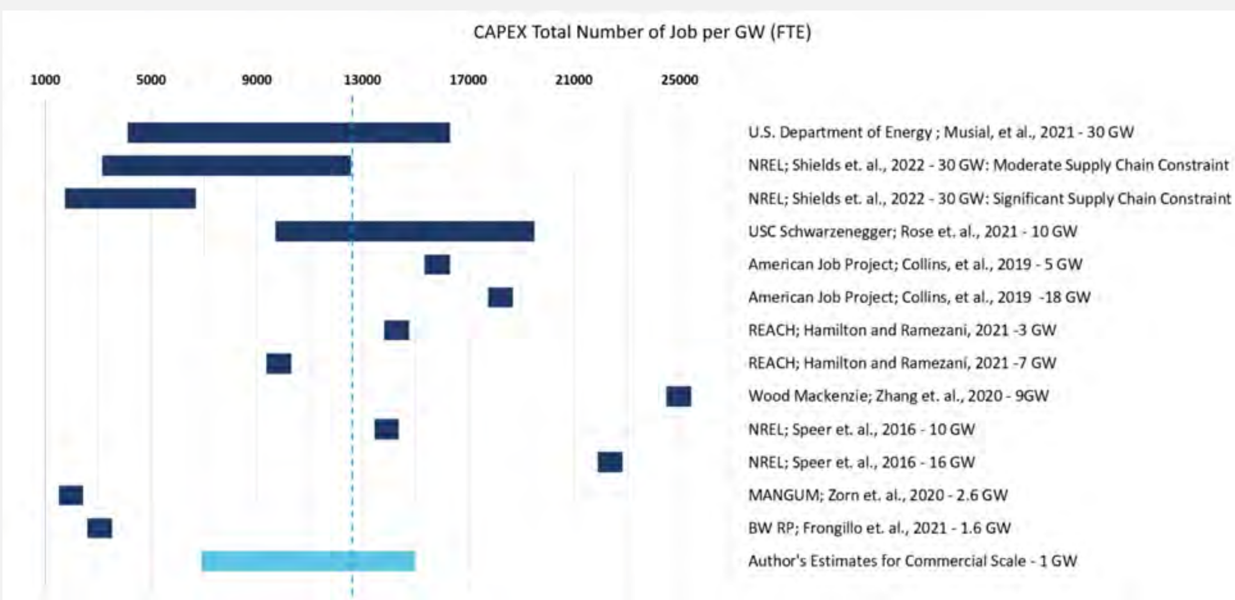
Operations and Maintenance (Annual, Ongoing)				
Scenario		C1	C2	C3
Jobs (FTE)	Onsite	128	100	100
	Supply Chain	157	394	394
	Induced	113	190	190
	Total	**398**	**684**	**684**
Earnings ($ Millions)	Onsite	11.3	9.0	9.0
	Supply Chain	11.6	33.6	33.6
	Induced	7.7	12.0	12.0
	Total	**30.5**	**54.6**	**54.6**
Output ($ Millions)	Onsite	11.3	9.0	9.0
	Supply Chain	55.6	126.2	126.2
	Induced	22.5	37.9	37.9
	Total	**89.4**	**173.1**	**173.1**
GDP ($ Millions)	Onsite	11.3	9.0	9.0
	Supply Chain	23.5	57.9	57.9
	Induced	13.6	22.9	22.9
	Total	**48.4**	**89.8**	**89.8**

3.4 JEDI's Employment Impacts

In this section we present the estimated employment impacts of CADEMO and the Commercial scale projects, during the construction and the operations phases and under the local content scenarios noted earlier. Our discussion will not include the "induced" jobs, which are typically associated with increased business at local restaurants, entertainment and retail establishments, as well as other professional services such child and health care. While these types of jobs are typically a third of jobs created, there is general agreement that the supply of this type of labor is not as critical for the development of FOSW projects. Moreover, the focus of skill training and educational efforts will likely be on programs that directly support the construction and operation phases of FOSW projects.

Before discussing our findings, it will be instructive to provide a comparison of the employment impact of large-scale FOSW projects on a per GW basis. Figure E.4 provides such comparison, showing a wide range of projected jobs creation during the construction phase. First, note that the range of estimates from our analysis is similar, though mostly below the median (dash vertical line) of all reported estimates. Moreover, our estimated range includes values in most prior studies. Finally, the extreme values in our estimated range are significantly lower than outliers reported in most studies listed in Figure E.4.[40] Together these findings suggests that our jobs estimates are very reasonable, i.e., neither over-optimistic nor too conservative.

Figure E.4: Comparison of Employment Impact of Commercial Scale Projects per GW



Returning to specific results, Tables E.5 and E.6 present a breakdown of employment estimates by types of activities during the construction and operation phases for each project. The tables demonstrate the impact of rising capital expenditures and increased local content of construction and operations activities. Again, the upper bound on employment creation is attained under scenario B2 (high CAPEX and

Local Content) for CADEMO and C3 (high Local Content) for the Commercial scale project.

The row labeled "California's Share of Global Jobs Created" reports the fraction of the total employment created by a given project filled in California, as estimated by JEDI. Note that under all the potential scenarios, less than 50% of jobs associated with each project will be in California. This is reflective of several factors. First, because of technological advantages and competitive production costs, some components may not be locally produced. Second, it may be advantageous to import certain components to speed up development and revenue generation of a project.

Table E.5: Employment Impact of CADEMO, CAPEX-Local Content Scenarios

Scenario		A1	A2	B1	B2
Construction		Jobs FTE	Jobs FTE	Jobs FTE	Jobs FTE
Installation Activities (Onsite)	Foundation	1	3	1	4
	Scour Protection	2	2	3	3
	Turbine	17	17	26	26
	Array and Export Cabling	0	4	1	4
	Other	0	4	1	4
	Subtotal	**20**	**30**	**32**	**41**
Component Manufacturing and Supply Chain/ Support Services	Nacelle	0	36	0	36
	Blades	0	40	0	40
	Tower	0	20	0	20
	Foundation	170	188	170	188
	Array & Export Cables	0	3	0	17
	Substation	0	3	0	17
	Onshore Transmission	32	36	98	110
	Ports and Staging	78	81	78	81
	Installation, Development, and Other	397	424	546	575
	Subtotal	**677**	**831**	**892**	**1084**
Induced		225	278	321	386
Total		**922**	**1139**	**1245**	**1511**
California's Share of Global Jobs Created		**37.8%**	**46.7%**	**34.3%**	**41.6%**

Scenario	A1	A2	B1	B2
Operations and Maintenance (Annual, Ongoing)	Jobs FTE	Jobs FTE	Jobs FTE	Jobs FTE
Technicians and Management	4	4	7	7
Supply Chain/Support Services	12	12	23	23
Induced	7	7	12	12
Total	**23**	**23**	**42**	**42**
California's Share of Global Jobs Created	**82.6%**	**82.6%**	**80.3%**	**80.3%**

Table E.5 above demonstrates that under low CAPEX and Local Content (scenario A1), the employment impact of certain activities is nearly zero. These include export cables, nacelle, blades, tower, and substation, which will likely all be imported. Indeed, as we would expect, most jobs will be associated with installation, foundation, onshore transmission, and ports and staging activities. Table E.6 shows similar results for the Commercial scale project. These findings also show that as the industry transitions to larger scale projects, i.e., the FOSW industry matures, local jobs in every category of construction, component manufacturing, and supply chain/support service will expand.

Table E.6: Employment Impact of Commercial, Local Content Scenarios

Scenario		C1	C2	C3
Construction		Jobs FTE	Jobs FTE	Jobs FTE
Installation Activities (Onsite)	Foundation	39	10	59
	Scour Protection	0	62	62
	Turbine	139	195	195
	Array and Export Cabling	31	4	32
	Other	5	1	5
	Subtotal	**214**	**272**	**353**
Component Manufacturing and Supply Chain/ Support Services	Nacelle	0	600	600
	Blades	654	175	654
	Tower	327	66	327
	Foundation	1599	4748	4748
	Array & Export Cables	0	171	281
	Substation	0	171	281
	Onshore Transmission	992	893	893
	Ports and Staging	375	1173	1217
	Installation,Development, and Other	1051	1756	1989
	Subtotal	**4998**	**9753**	**10990**
Induced		1688	3177	3612
Total		**6900**	**13202**	**14955**
California's Share of Global Jobs Created		**22.3%**	**42.6%**	**48.3%**

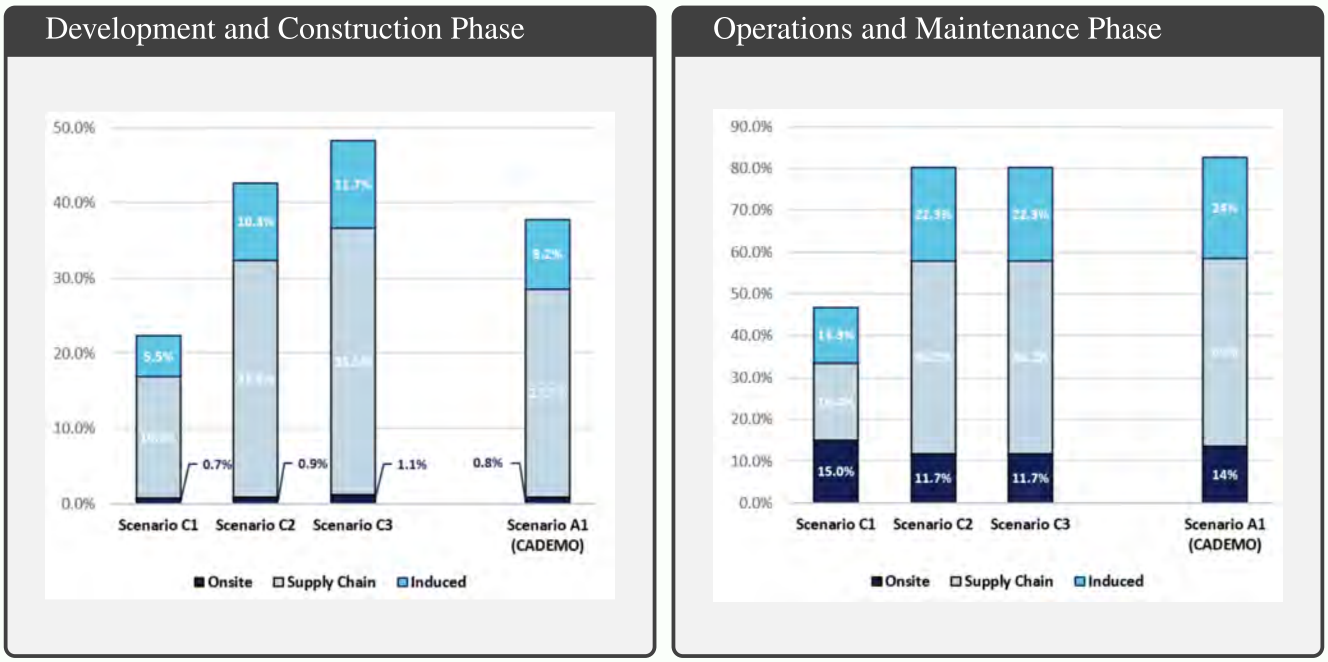
Scenario	C1	C2	C3
Operations and Maintenance (Annual, Ongoing)	Jobs FTE	Jobs FTE	Jobs FTE
Technicians and Management	129	100	100
Supply Chain/Support Services	157	394	394
Induced	113	190	190
Total	**399**	**684**	**684**
California's Share of Global Jobs Created	**46.7%**	**80.2%**	**80.2%**

Turning to the operations and maintenance in Tables E.5 and E.6, we note that with the exception of the low local content case (C1), California's share of global jobs will be generally over 80%. Again, these results are in line with those for the construction phase, as much of O&M activity must rely on the local labor supply.

Figure E.5 presents California's share of global jobs created by the commercial scale and CADEMO projects under our proposed scenarios. The figure also shows global shares for both construction and operations and maintenance phases of each project. The results demonstrate that as local content increases, on-site and supply chain jobs expand the most. On the other hand, global shares of operations and maintenance jobs quickly reaches its maximum and remains constant.

Finally, standard EIA models often report an employment multiplier, defined as the ratio of a project's total employment to direct jobs at a project's site.[41] However, application of this concept to JEDI output is problematic since it is difficult to categorize the employment associated with component manufacturing and supply chain/support service into direct and indirect jobs. For example, onshore transmission, ports and staging, and other installations jobs could also be considered as "direct" jobs. There is no clear consensus in the literature regarding the correct method to calculate employment multipliers in JEDI models. For this reason, we refrain from calculating employment multipliers for the CADEMO and Commercial scale projects.

Figure E.5: California's Share of Global Jobs by Development Scenarios



4 Labor Market Implications of FOSW Project Supply Chain

4. Labor Market Implications of FOSW Projects in California

This section will provide a general overview of the economic and demographic characteristics of Santa Barbara (SB) and San Luis Obispo (SLO) counties, and the State of California. We provide detailed information for these counties because of their proximity to the proposed FOSW projects. We expect that over time, these counties could become the primary source of skilled labor for the construction, operation, and maintenance of the proposed FOSW projects. As we demonstrate, the two counties have very similar economic profiles, share significant commercial relationships and have strong business ties. The primary sources for county and state level data for our analysis are the Census Bureau, the Bureau of Labor Statistics, and JobsEQ, a private provider of demographic, industry, and employment data.

4.1 Santa Barbara County

Table SB.1 summarizes the population estimates for each city in Santa Barbara County over the past decade. The total population of the county was estimated to be 445,164 as of January 1, 2022. The largest city in the county is Santa Maria with a population of 109,910. Lompoc is the third largest city and has a population of 43,845. Because of their close vicinity to the CADEMO project, workers in these cities are likely to fill some of the created jobs, particularly the induced and support job categories, such as social services, hospitality, food service, and health care.

Table SB.1: Population Estimates for Cities in Santa Barbara County

City	2012	2017	2022
Buellton	4,867	5,125	5,055
Carpinteria	13,052	13,485	12,963
Goleta	29,928	31,384	32,591
Guadalupe	7,102	7,257	8,544
Lompoc	42,981	43,885	43,845
Santa Barbara	89,474	92,663	86,591
Santa Maria	100,504	105,786	109,910
Solvang	5,284	5,621	5,709
Balance Of County	**135,145**	**141,968**	**139,956**
Incorporated	293,192	305,206	305,208
County Total	**428,337**	**447,174**	**445,164**

Source: State of California, Department of Finance

Age distribution is an important factor to consider when determining the available labor supply for FOSW projects. Table SB.2 compares the various age groups at the SB county, state, and national levels.

People between the ages of 18 and 64, which is the primary age range for labor force, comprise 62.4% of the population in SB county, slightly higher than state and national levels. This is a positive aspect of the county's labor supply that could prove beneficial to both FOSW projects.

Table SB.2: Age Distribution in Santa Barbara County

Persons by Age	Santa Barbara (%)	California (%)	United States (%)
Under 5 years	5.7	6.0	5.8
Under 18 years	22.4	22.3	22.4
18 to 64 years	62.4	61.7	61.2
65 years and over	15.2	16.0	16.3

Source: U.S. Census Bureau

Table SB.3 expands on Table SB.2 by highlighting another positive aspect of the SB labor supply. It compares labor force participation rates for smaller age ranges between 2016 and 2020. The age range spanning from 25 to 54 years shows the highest participation rate with each group coming in at over 80%. Furthermore, there is a general increasing trend in the labor force participation for individuals between 25 and 34, and 75 and older.

Table SB.3: Labor Force Participation in Santa Barbara County by Age Group

Age	2016 (%)	2018 (%)	2020 (%)
16 to 19 years	35.8	37.8	36.3
20 to 24 years	70.8	70.4	70.6
25 to 29 years	82.5	83.7	85.2
30 to 34 years	83.6	83.4	85.1
35 to 44 years	82.3	82.4	82.2
45 to 54 years	81.1	82.7	82.6
55 to 59 years	72.9	74.0	73.6
60 to 64 years	62.4	64.1	63.7
65 to 74 years	32.9	32.7	31.9
75 years and over	8.5	8.4	10.6

Source: U.S. Census Bureau

Another important demographic factor to consider is the educational attainment of local communities. Many of the FOSW project jobs require a highly educated labor force. Table SB.4 shows a positive trend in SB's labor force from 2016 to 2020. Individuals 25 years and older are earning associate, baccalaureate, and graduate or professional degrees at increasing rates.

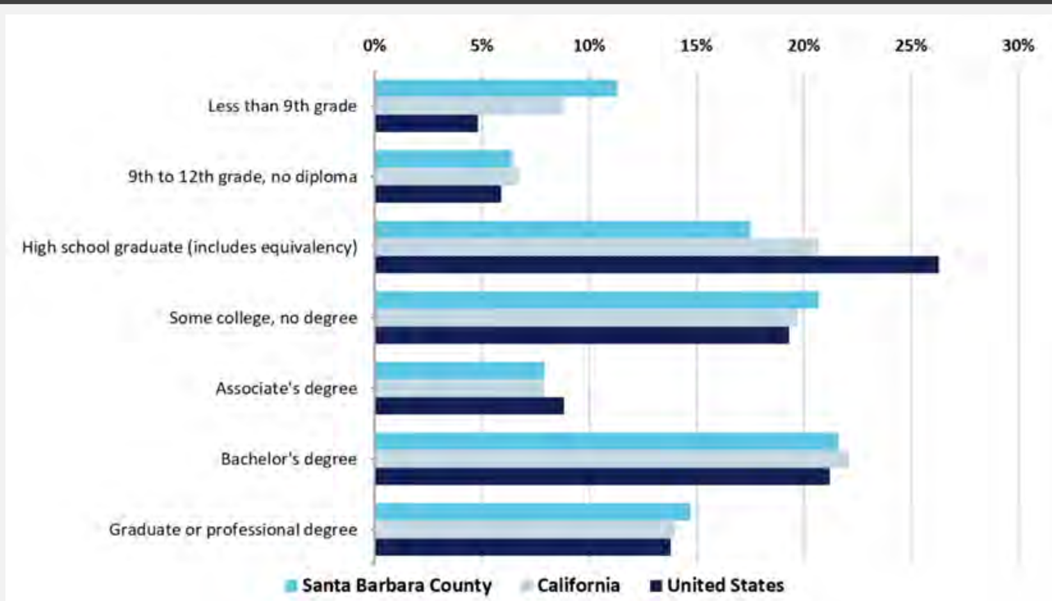
Table SB.4: Educational Attainment in Santa Barbara County for Population 25 Years and Over

Population 25 years and over	2016 (%)	2018 (%)	2020 (%)
Less than 9th grade	12.5	12.2	11.7
9th to 12th grade, no diploma	7.4	6.8	6.4
High school graduate	17.9	17.9	16.9
Some college, no degree	22.1	21.5	21.6
Associate degree	7.8	7.7	8.3
Bachelor's degree	19.2	20.0	20.8
Graduate or professional degree	13.1	13.8	14.1

Source: U.S. Census Bureau

Relatedly, Figure SB.1 provides data on educational attainment of SB residents. As of 2021, about 35% of county residents have a high school diploma or less, down 3% from 2016. Overall, SB county has similar educational attainment rates when compared to California and slightly better rates of individuals with baccalaureate and graduate degrees than the national average. One category in which SB is clearly below the national and state levels is high school graduates.

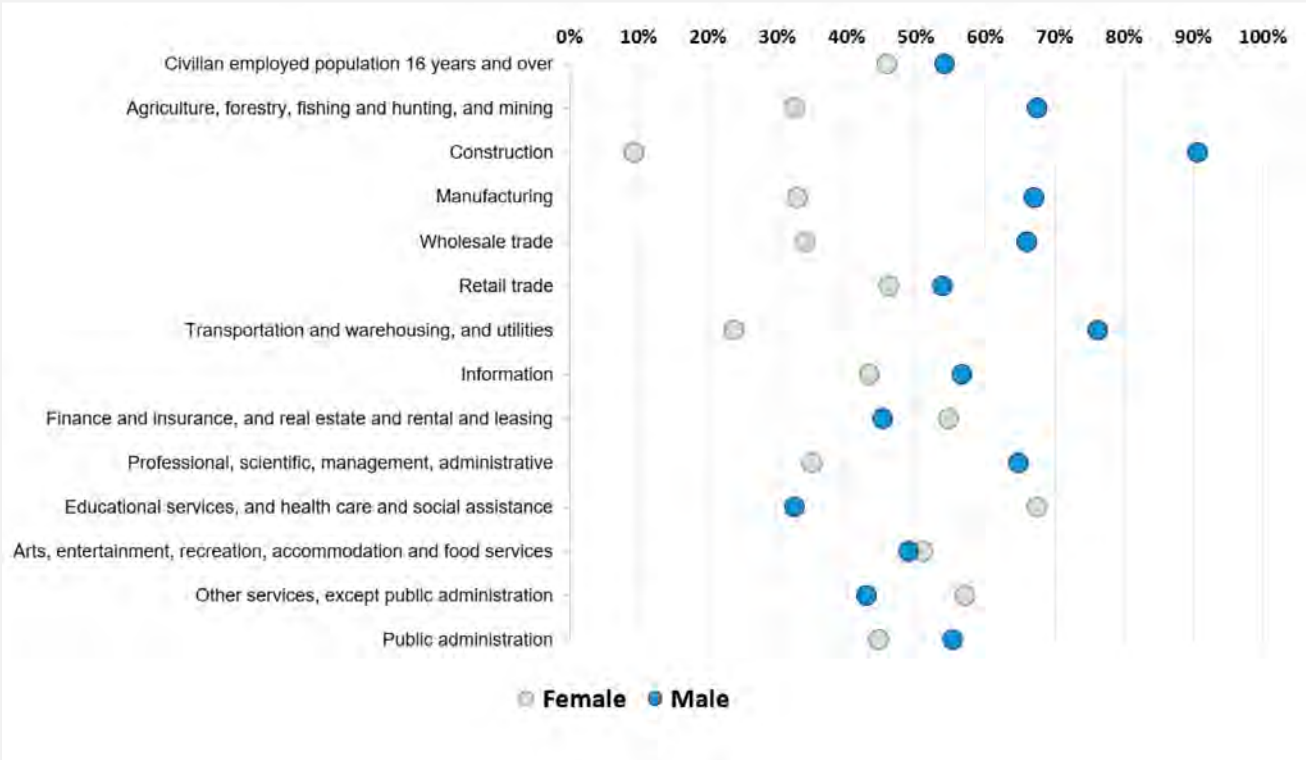
Figure SB.1: Educational Attainment, 2021



Source: U.S. Census Bureau

Turning to gender diversity of the labor force, Figure SB.2 shows the composition of jobs held in SB county by men and women. In general, males comprise the majority of most industries. FOSW projects will draw heavily from construction, transportation, warehousing, and utilities industries. However, professional, scientific, management and administrative jobs are more gender diverse.

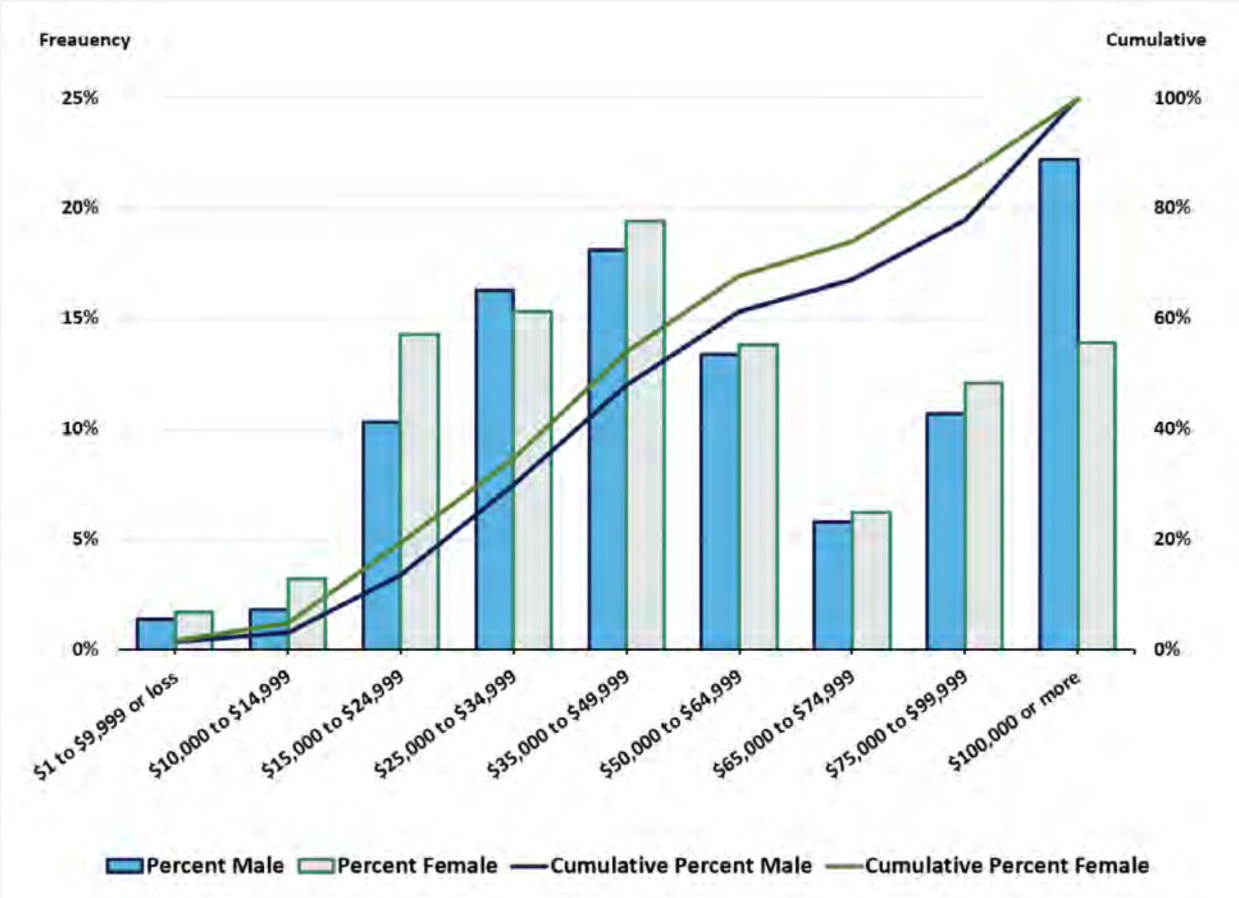
Figure SB.2: Composition of Jobs in Santa Barbara County by Industry and Gender



Source: U.S. Census Bureau

Similarly, workforce gender imbalance carries implications for wages in the labor market. Figure SB.3 presents a breakdown of county wages at various income levels by gender. Unlike mid-income jobs in which men and women are almost equally distributed, in high pay jobs (above $100,000) the share of men is significantly higher whereas in low pay jobs (below $25,000) the share of women is higher.

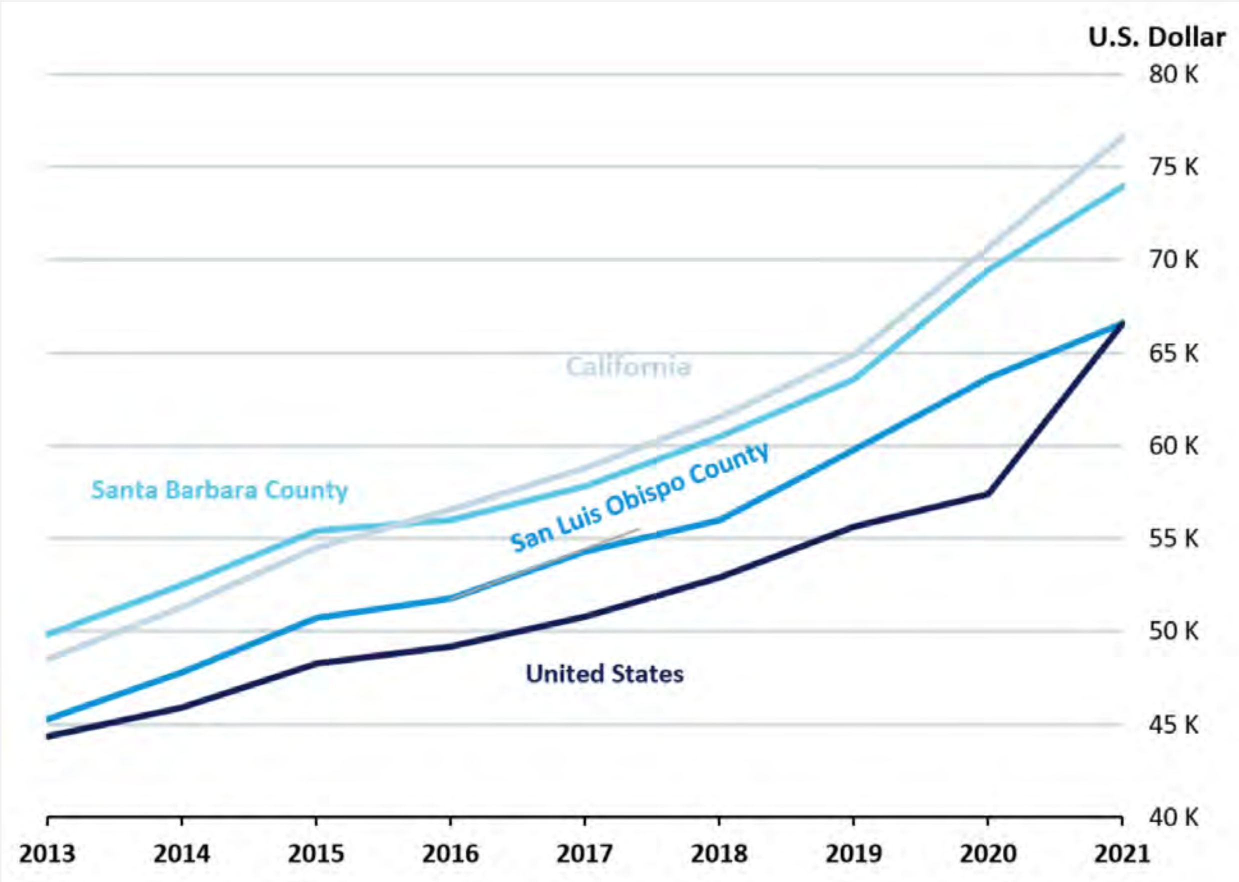
Figure SB.3: Wages Distribution by Gender in Santa Barbara County, 2020



Source: U.S. Census Bureau

Turning to the economy of SB county, Figure SB.4 shows that in 2020 the county had an average per capita personal income of about $68,000, slightly below California but above the national average. Since 2013, the gap between the county and the United States has grown from about $5,000 to over $10,000 as of 2020. California and SB county alike demonstrate a faster per capita personal income growth than the United States. This suggests there will be a strong local demand for offshore wind electricity in the future. At the same time, it implies that the local labor supply might be more expensive too.

Figure SB.4: Per Capita Personal Income



Source: U.S. Bureau of Economic Analysis

Finally, SB county is home to top universities and colleges, like UCSB, SB City College, and Allan Hancock College, which generate a highly educated workforce ready to enter the labor market. FOSW projects offer a multitude of long-term, high paying careers which could help retain these workers within the county, contributing to its economy and the fiscal health of the state.

4.2 San Luis Obispo County

Table SL.1 contains population estimates for SLO county and its major cities over the last decade. The total county population, as of January 1, 2022, is estimated to be 280,721. In this period, SLO county population has on average grown by about 3.2% and provides a potential local labor supply for FOSW projects.

Table SL.1: Population Estimates for Cities in San Luis Obispo County

City	2012	2017	2022
Arroyo Grande	17,344	17,828	18,294
Atascadero	28,572	30,379	30,480
El Paso De Robles	30,286	31,249	31,176
Grover Beach	13,197	13,465	12,707
Morro Bay	10,281	10,392	10,466
Pismo Beach	7,721	8,282	7,981
San Luis Obispo	45,346	46,270	47,653
Balance Of County	**119,186**	**120,496**	**121,964**
Incorporated	152,747	157,865	158,757
County Total	**271,933**	**278,361**	**280,721**

Source: State of California, Department of Finance

As shown in Table SL.2, age distribution in SLO county is quite different from California and the United States: the share of younger population is lower while the share of older population is higher. However, compared to California and the United States, it has a similar proportion of working age adults, 18 to 64 years old.

Table SL.2: Age Distribution in San Luis Obispo County

Persons by Age	San Luis Obispo (%)	California (%)	United States (%)
Under 5 years	4.3	6.0	5.8
Under 18 years	17.5	22.3	22.4
18 to 64 years	61.1	61.7	61.2
65 years and over	21.4	16.0	16.3

Source: U.S. Census Bureau

The older population of San Luis Obispo, does have an impact on potential labor supply. As Table SL.3 provides, across each year and age range, SLO county tends to have lower labor force participation compared to SB county. Meanwhile, except for one age group, over the past five years labor force participation has increased for the working age groups between 16 and 54.

Table SL.3: Labor Force Participation in San Luis Obispo County by Age Group

Age	2016 (%)	2018 (%)	2020 (%)
16 to 19 years	33.7	34.0	34.9
20 to 24 years	66.7	65.5	69.7
25 to 29 years	82.2	82.9	84.4
30 to 34 years	83.0	82.2	80.0
35 to 44 years	81.6	81.7	84.0
45 to 54 years	80.0	79.2	79.5
55 to 59 years	72.5	72.6	72.4
60 to 64 years	52.2	52.3	55.1
65 to 74 years	25.6	25.4	26.8
75 years and over	6.0	6.9	6.4

Source: U.S. Census Bureau

SLO county's educational attainment is even better than that of SB county. Since 2016, while individuals 25 and older have been earning associate, baccalaureate, and graduate or professional degrees at increasing rates, the share of people with a high school degree or higher is more than that of SB county. Again, FOSW projects can benefit from the highly educated local labor supply in the county.

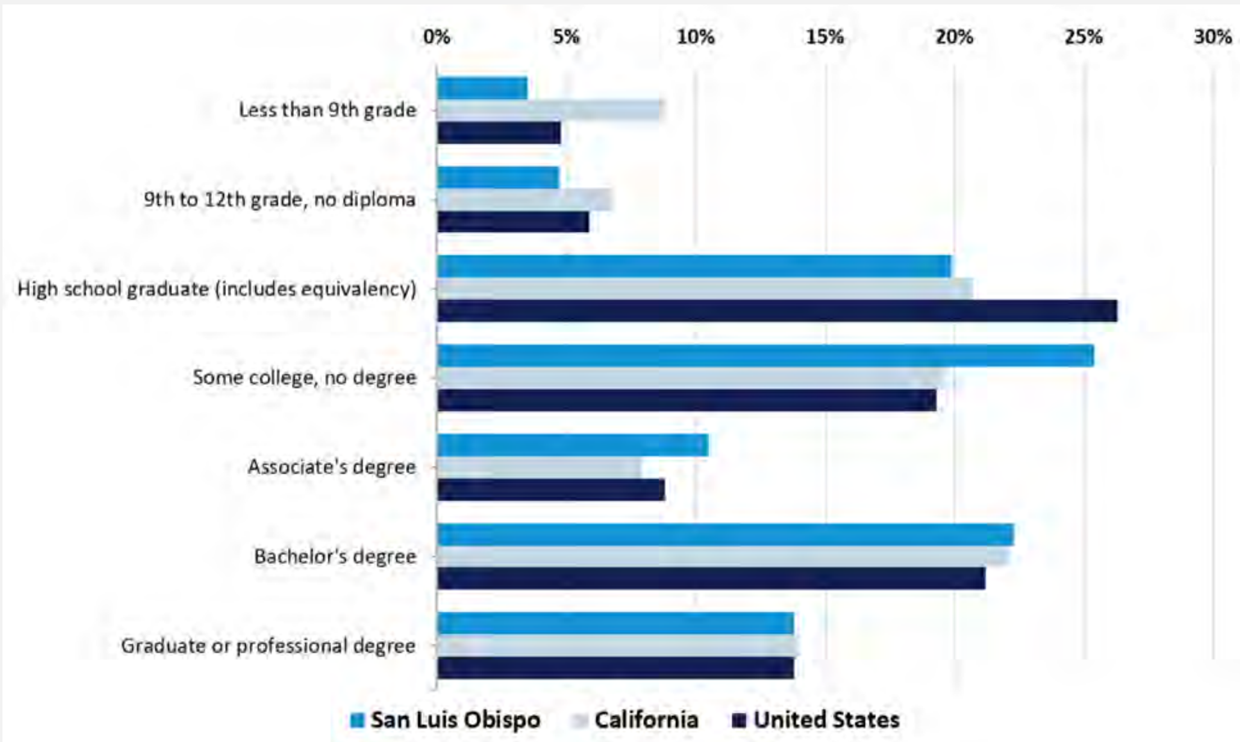
Table SL.4: Educational Attainment in San Luis Obispo for Population 25 Years and Over

Population 25 years and over	2016 (%)	2018 (%)	2020 (%)
Less than 9th grade	4.4	4.1	3.5
9th to 12th grade, no diploma	5.5	5.0	4.7
High school graduate	19.4	19.8	19.9
Some college, no degree	26.7	25.9	25.4
Associate degree	10.0	10.5	10.5
Bachelor's degree	21.7	21.4	22.3
Graduate or professional degree	12.4	13.2	13.8

Source: U.S. Census Bureau

Figure SL.1 provides a comparison of the educational attainment levels in SLO county, California and the United States. It is clear that SLO county dominates both California and the United States at all levels of higher education. For example, as of 2021, around 26% of the county's population have some college education compared to less than 20% at national or state levels. This is important to FOSW projects, as it enhances the industry's prospects to rely on the local labor force. Similar to SB county, one category in which SLO is clearly below the national and state levels is high school graduates.

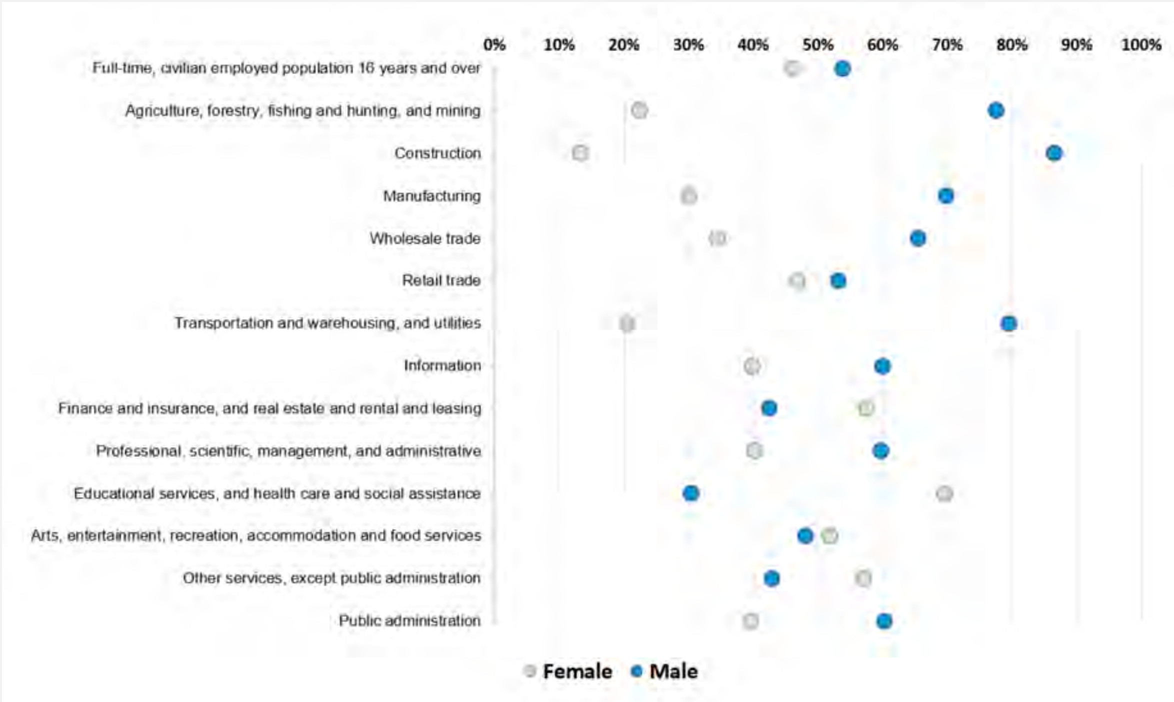
Figure SL.1: Educational Attainment, 2021



Source: U.S. Census Bureau

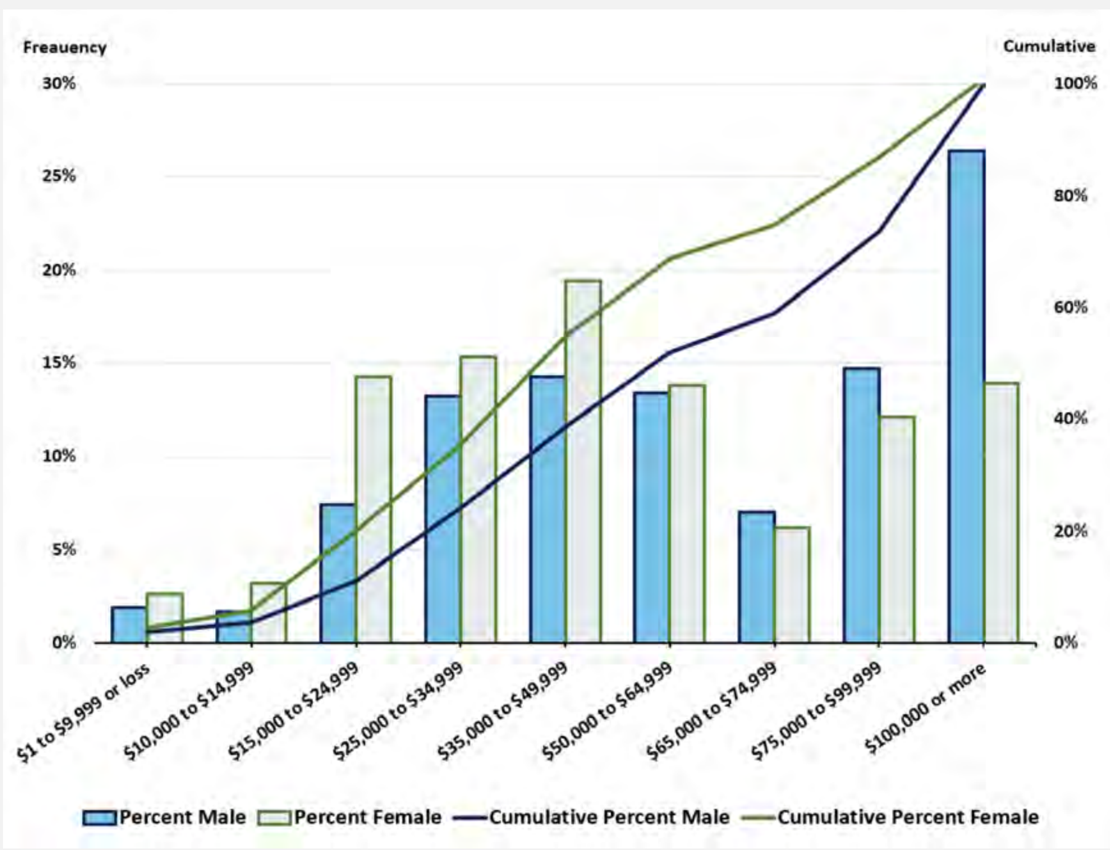
As for the gender diversity of the SLO labor force, Figure SL.2 provides a breakdown of the composition of jobs in the county. Like SB county, most blue-collar occupations, particularly construction and transportation, are male dominated, while top white-collar occupations, such as professional, scientific, management and administrative categories, are more gender diverse. In addition, support occupations such as educational, health care, social services, finance, insurance, and real estate are female dominated.

Figure SL.2: Composition of Jobs in San Luis Obispo County by Industry and Gender



Source: U.S. Census Bureau

Figure SL.3: Wages Distribution by Gender in San Luis Obispo County, 2020



Source: U.S. Census Bureau

Again the gender imbalance in the SLO workforce has important implications for wages. Figure SL.3 shows the breakdown of various wage ranges by gender in SLO county. As in SB county, female employees hold a larger proportion of the lower and middle wage groups while male employees hold high paying jobs (above $75,000).

The SLO county economy had an average per capita personal income of $45,257 in 2013, just over the national level but below the state and SB levels. As shown in Figure SL.3, this difference has grown to nearly $5,000, with SLO county residents earning an average of $62,342 in 2021. While the SLO personal income has been growing at a rate similar to that of the national level, California still outpaced the county's growth.

Finally, both SB and SLO counties are home to large universities (UCSB and Cal Poly), and junior colleges (SB City, Cuesta, Allan Hancock) which generate highly educated workers ready to enter the workforce. FOSW projects offer a multitude of long-term, high paying careers which would help retain these workers within the county, contributing to the economy and fiscal health of these counties and the State of California.

4.3 California

Due to projected labor market shortages in both SB and SLO counties, especially in wind-related occupations, the FOSW projects in California's Central Coast will likely draw workers from outside these counties. As Table CA.1 shows, with a total population of nearly 40 million, California has no shortage of working-age residents.

Table CA.1: California Population by Age, 2021

Age	Total	Male (%)	Female (%)
Under 14 years	7,216,595	18.9	18.0
15 to 19 years	2,579,680	6.7	6.4
20 to 24 years	2,531,692	6.6	6.3
25 to 29 years	2,825,980	7.4	7.0
30 to 34 years	3,001,889	7.9	7.4
35 to 39 years	2,792,703	7.4	6.9
40 to 44 years	2,621,983	6.8	6.6
45 to 49 years	2,430,082	6.2	6.2
50 to 54 years	2,498,846	6.4	6.3
55 to 59 years	2,446,661	6.2	6.3
60 to 64 years	2,327,199	5.8	6.0
65 to 69 years	1,952,796	4.7	5.3
70 to 74 years	1,616,408	3.9	4.4
75 years and over	2,395,322	5.1	7.1
Total	**39,237,836**	**100**	**100**

Source: U.S. Census Bureau

As Table CA.2 shows, California has some of the highest household incomes in the United States, with 43.1% of households earning more than $100,000 per year. While higher household incomes may support higher clean electricity prices, FOSW projects will have to offer competitive wages for California's skilled workers, resulting in higher costs.

As previously observed in Figures SB.1, and SL.1, the two Central Coast counties have similar rates of educational attainment in higher education. With a larger overall population to draw from, FOSW projects should expect to fill employment gaps especially in occupations that require at least high school level training with California's large population of educated workers across many age groups.

The gender diversity pattern of the labor force for California is fairly similar to the two counties (Figures SL.2 and SB.2), with male dominated blue-collar industries, and white collar and support categories being more gender diverse.

Table CA.2: California Household Income, 2021

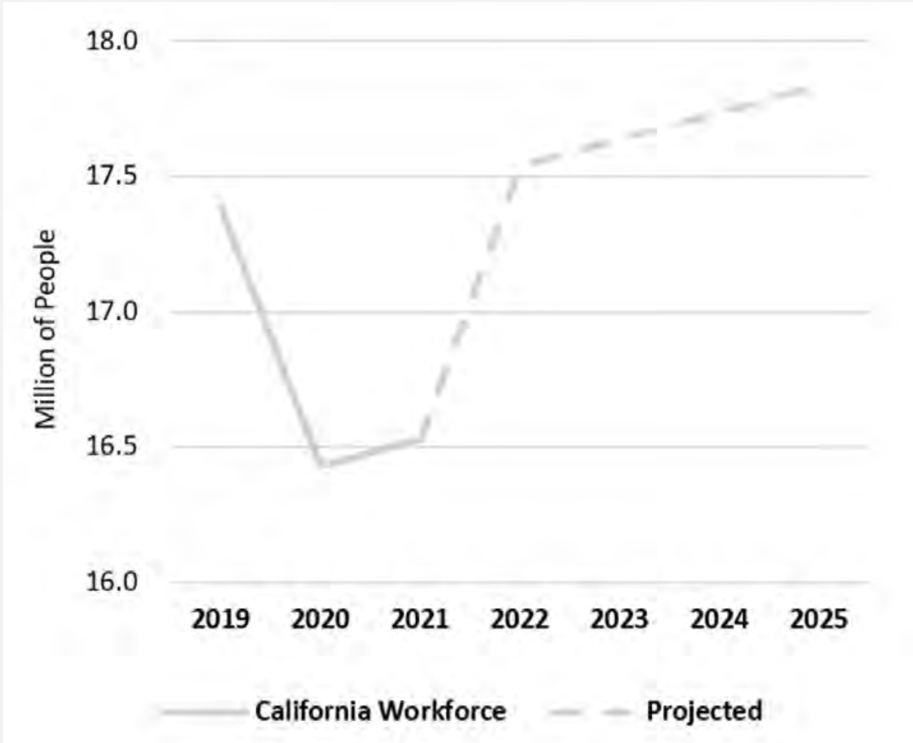
Income	Total	Percent (%)
Less than $10,000	715,644	5.3
$10,000 to $14,999	469,896	3.5
$15,000 to $24,999	808,568	6.0
$25,000 to $34,999	829,411	6.2
$35,000 to $49,999	1,206,545	9.0
$50,000 to $74,999	1,974,452	14.7
$75,000 to $99,999	1,639,647	12.2
$100,000 to $149,999	2,359,723	17.6
$150,000 to $199,999	1,343,134	10.0
$200,000 or more	2,082,043	15.5

Source: U.S. Census Bureau

Taking a closer look at California labor market, we consider past and projected labor market trends for different occupations based on the Standard Occupational Classification system (SOC). Labor market data is obtained from the Bureau of Labor Statistics (BLS), whereas projected labor data is collected from JobsEQ.

For the overall California workforce, JobsEQ projects a growth rate of 0.7% in 2023 and 2025. This translates into an additional 800K employees, over the next two years as illustrated in Figure CA.1. Although pandemic skewed labor supply heavily at both national and state levels, the California workforce had fully recovered to its pre-pandemic level by 2022. This growing California workforce is expected to meet the labor needs of the state's FOSW industry.

Figure CA.1: California Workforce



Source: U.S. Bureau of Labor Statistics (BLS) and JobsEQ

To study general labor trends in different occupation groups in California, the size of the workforce is aggregated from 6-digit SOC categories into 1-digit level. This resulted in 5 occupational groupings as follows:

1. Business and STEM occupations

2. Community Service Occupations

3. Food and Wellness Occupations

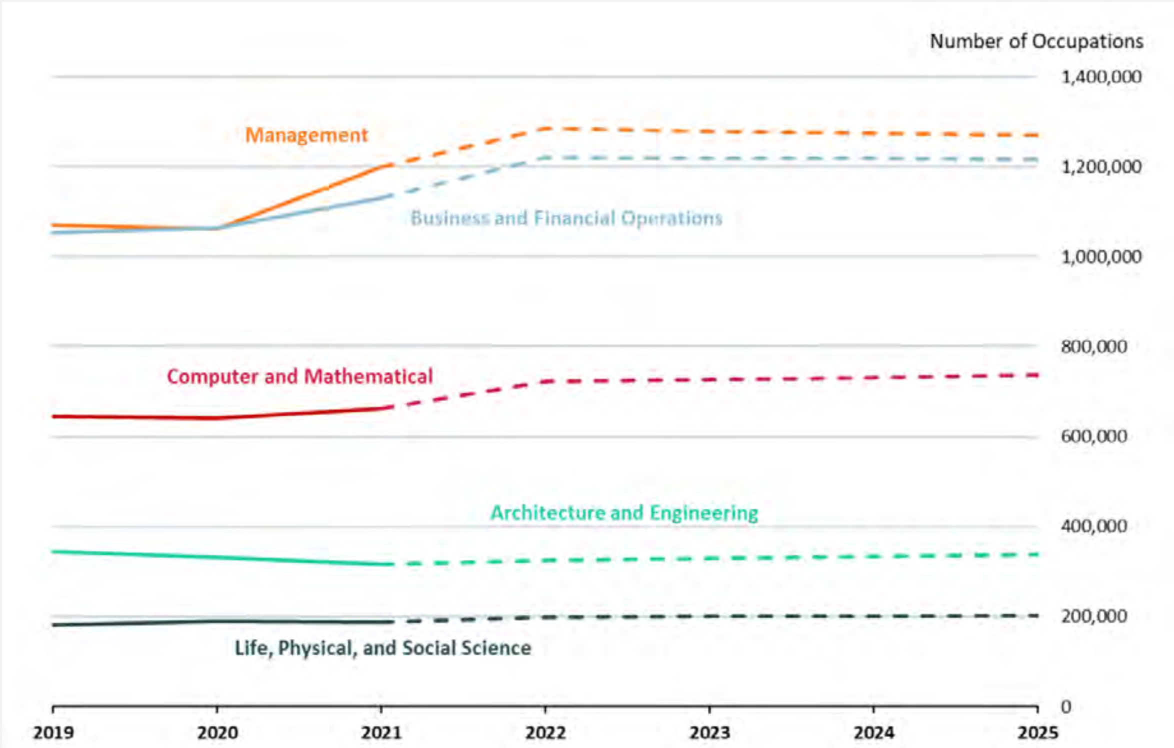
4. Administrative and Construction Occupations

5. Transportation and Production Occupations

In the remainder of this section, the focus will be on groups 1, 4, and 5, as these are critical to the FOSW industry.

Business and STEM Occupations have been the fastest growing among all 5 categories with an average annualized growth rate of 4.4% between 2019 and 2022. This rate is expected to slow down to 0.1% annual growth rate between 2022 and 2025. This category includes white-collar subcategories such as management, business and financial operations, computer and mathematical, architecture, engineering and life, physical, and social services. As Figure CA.2 shows, there is significant variation in the growth rate among these subcategories during this period, with management occupations growing at 6.3%, while architecture and engineering has declined at a 1.9% rate annually.

Figure CA.2: Employment in Business and STEM occupations



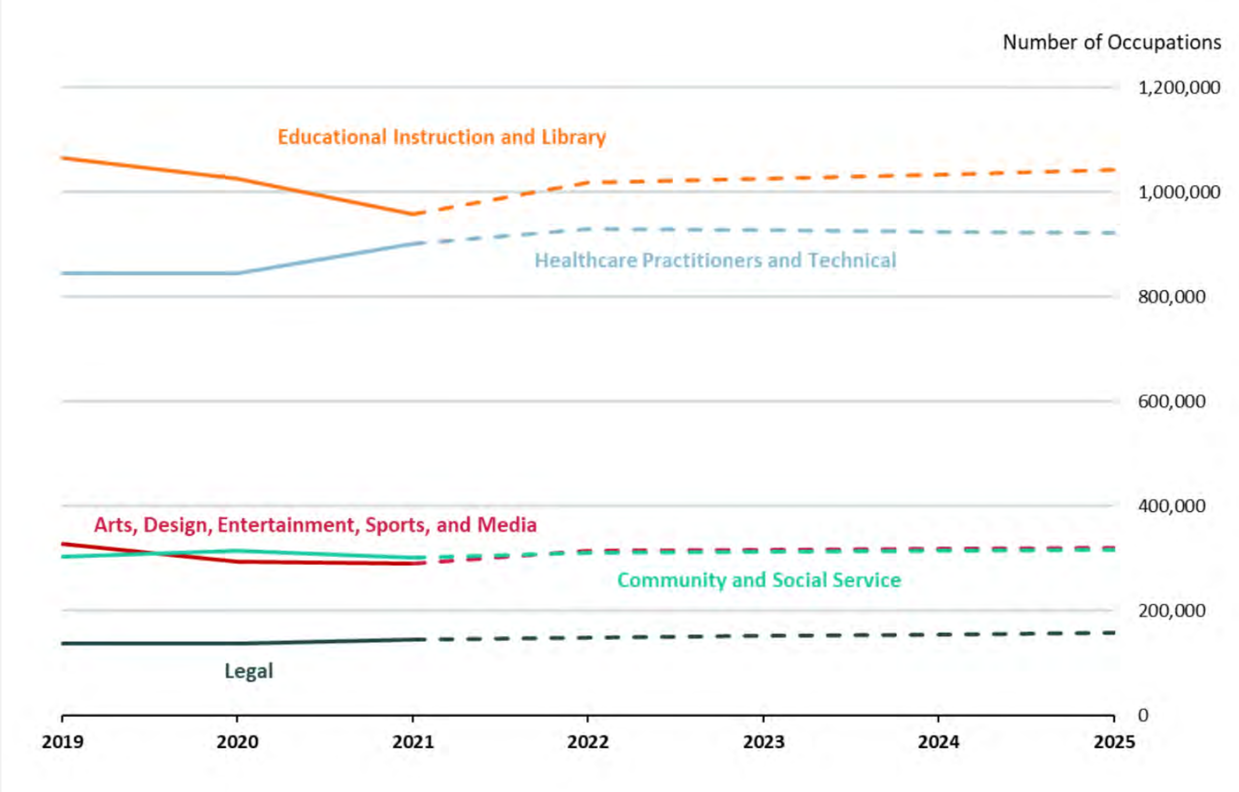
Source: U.S. Bureau of Labor Statistics (BLS) and JobsEQ

The shrinkage in engineering occupations can potentially create a challenge for the state's FOSW industry. This suggest a critical need for expanding engineering and STEM training programs. On the other hand, the healthy growth rate over the past three years in management and business occupations is good news for the industry, although it is expected to flatten out in near future.

Community Service Occupations have experienced a wide range of growth rates in its subcategories over the past three years, from -1.5% for educational instruction and library to 3.3% for health care practitioners and technical occupations, as illustrated in Figure CA.3. Overall, the category has been growing 0.50% per year and is expected to continue at that pace over the next three years.

Although there are no direct offshore wind jobs in this category, it provides support jobs for the new employees in the industry and therefore may require additional training especially in the educational and healthcare categories to support the growing workforce in the offshore wind industry.

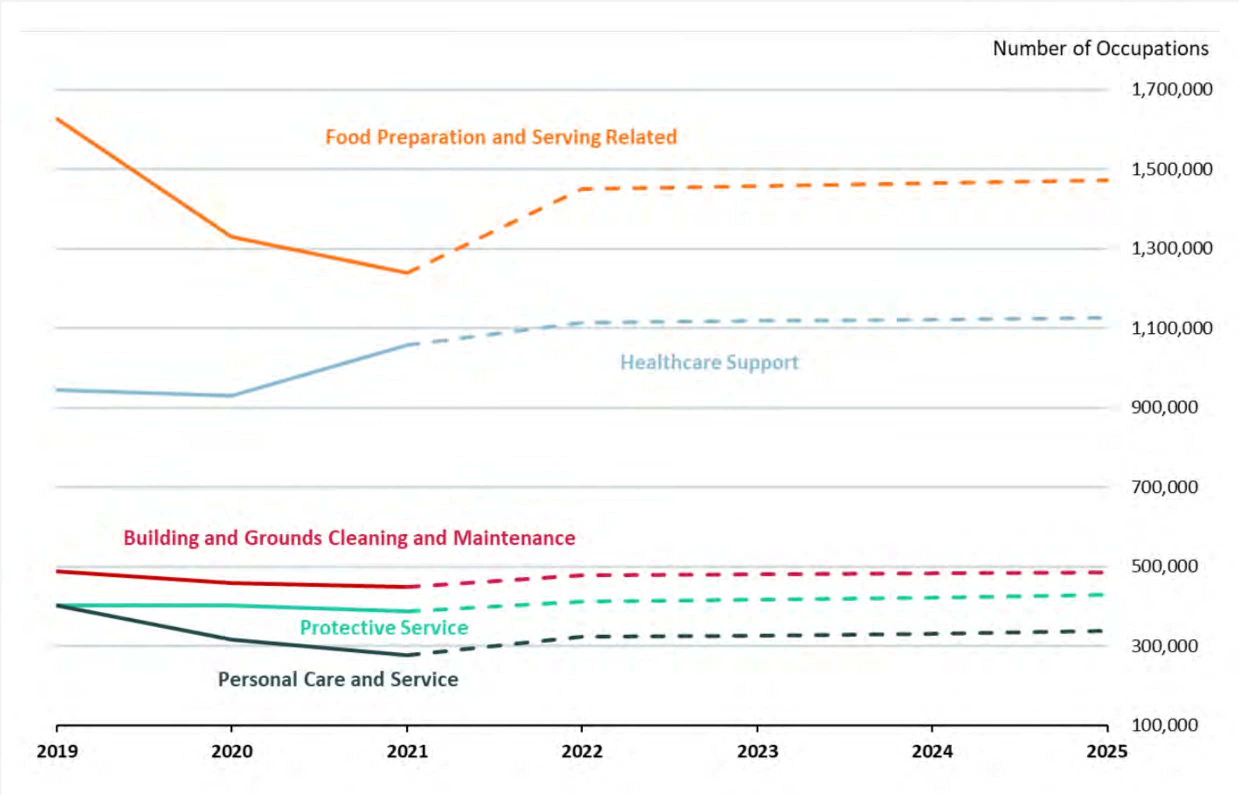
Figure CA.3: Employment in Community Service Occupations



Source: U.S. Bureau of Labor Statistics (BLS) and JobsEQ

Food and Wellness Occupations in California have been shrinking over the past years at 0.8% per year but are expected to rebound with a 0.7% annual growth rate over the next three years as shown in Figure CA.4. This category was heavily impacted by the pandemic as it includes service worker and personal care occupations that shrank by 3.8% and 7.1%, respectively. These categories still have not returned to their 2019 highs. Like community services, this category also provides support to the offshore wind workforce and therefore requires planning and training to keep up with the pace of FOSW growth.

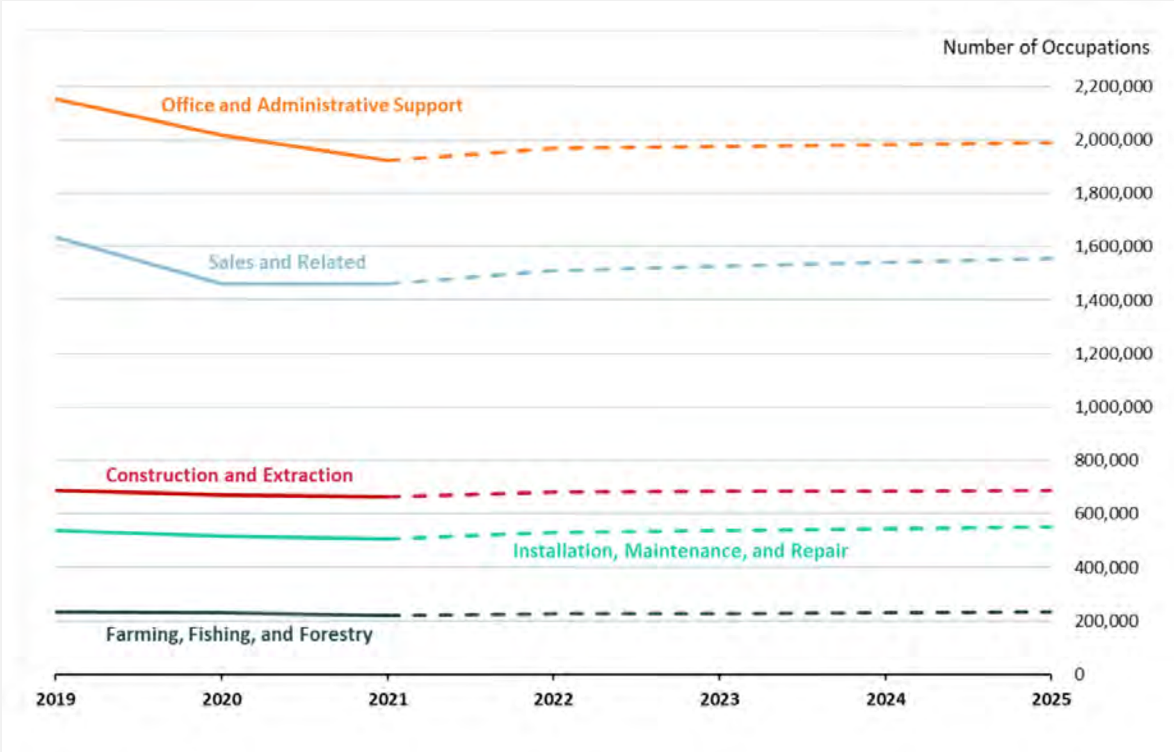
Figure CA.4: Employment in Food and Wellness Occupations



Source: U.S. Bureau of Labor Statistics (BLS) and JobsEQ

Administrative and Construction Occupations have experienced the largest decline (see Figure CA.5). This category experienced an annualized growth rate of –2.2% between 2019 and 2022. All subcategories shrank in this period, notably Office and Administrative (-3.0%) and construction and extraction (-0.4%). In particular, the decline in construction and extraction, and installation, maintenance and repair occupations are of serious consequence to the FOSW industry, given that both categories include occupations such as Wind Turbine Service Technicians. This shortfall requires urgent attention by the policy makers, along with extensive planning to train and educate this category of workers.

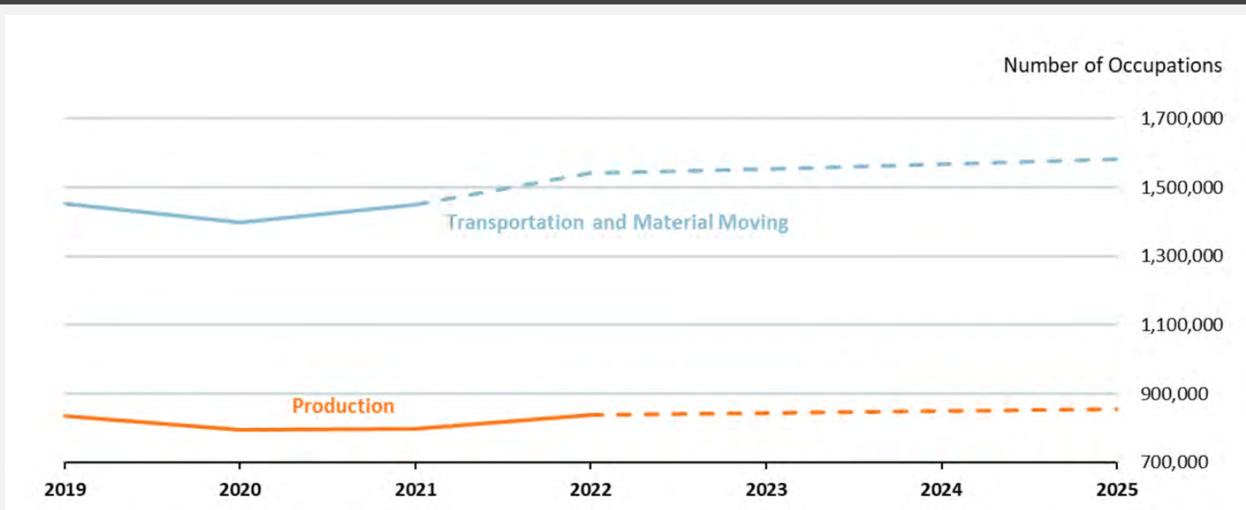
Figure CA.5: Employment in Administrative and Construction Occupations



Source: U.S. Bureau of Labor Statistics (BLS) and JobsEQ

Transportation and Production Occupations have been the second fastest growing category over the past years with a 1.3% annual growth rate and are expected to continue growing at the slower pace of 0.8% over the next three years (See Figure CA.6). Specifically, transportation and material moving occupations experienced an annual growth rate of 1.3%, while production workforce grew 0.1%. Both are expected to continue growing at 0.9% and 0.7%, respectively. This is good news for FOSW industry.

Figure CA.6: Employment in Transportation and Production Occupations



Source: U.S. Bureau of Labor Statistics (BLS) and JobsEQ

5

5. Floating Offshore Wind Labor Gap in California by Key Occupations

As the results in section 3 show, JEDI provides estimate of employment created by broad job categories, for example “Installation Activities - Foundation” (see tables E.5 and E.6). However, for the purpose of policy analysis, it is important to assess the demand for labor, in terms of specific occupations, that are particularly critical to FOSW developments, such as welders, concrete layers, electrical engineers, etc. Unfortunately, it is not possible to decompose the JEDI’s broad job categories into specific occupations. However, based on our own analysis of prior studies, we are able to identify key FOSW occupations and subsequently assess the availability of critical worker types in the vicinity of CADEMO and the commercial scale Morro Bay developments. Our estimated supply in conjunction with the number of unemployed for each occupation provides a picture of the labor gap and its severity for each location. This information will be essential to the design and delivery of educational and vocational training programs.

Table CA.3 presents data on the available supply and the number of unemployed workers for the top 30 offshore wind occupations in SB, SLO, and California. Starting with SB, the table shows that while the county has a large supply of blue-collar workers, its labor market is very tight across most other occupations, particularly for jobs related to the FOSW industry. Focusing on the number of unemployed (in parentheses), Miscellaneous Assemblers and Fabricators (SOC 51-4050), Industrial Truck and Tractor Operators (53-7050), Inspectors and Testers, etc (51-9060) have the highest number of unemployed, while Hoist and Winch Operators (53-7040), Ship Engineers (53-5030) and Wind Turbine Service Technicians (49-9080) have no unemployed workers.

Turning to SLO county, Table CA.3 shows similar results; Miscellaneous Assemblers and Fabricators (51-4050), Industrial Truck and Tractor Operators (53-7050), and Civil Engineers (17-2050) are the occupations with available workers, and Metal Furnace Operators (51-4050), Hoist and Winch Operators (53-7040), and Ship Engineers (53-5030) have no unemployed workers.

We can next consider the SB and SLO counties’ combined labor supply. As shown earlier, the two counties have similar economic profiles and share strong business ties, suggesting that FOSW projects can potentially recruit workers from both areas. Table CA.3 shows that the combined workforce for the two counties is unlikely to solve the problem of a FOSW labor shortage, despite the size of the areas’ blue-collar workforce. Clearly, in the short-term, FOSW projects will have to rely on the California workforce, and possibly beyond.

Table CA.3 also presents the data on California’s FOSW related occupations. Interestingly, the labor shortages pattern in California is nearly identical to that of SB and SLO counties. However, at the state level, there are many more available workers and the labor market is not as constrained.

To summarize, the lack of “local” skilled workers will present a significant challenge to the Central Coast FOSW development over the short- and intermediate-terms. Over the longer term, however, SB and SLO counties, and the State of California could overcome these challenges but must invest in skill training programs. Such efforts must deliver a consistent supply of FOSW specific workers who can build, operate and maintain projects that will enable California to reach its FSOW goals.

Table CA.3: California's Workforce Supply and Labor Gap by Top FOSW Occupations

SOC	Occupation	Santa Barbara	San Luis Obispo	Sum of SLO and SB	California
11-1020	General and Operations Managers	3382 (61)	2022 (34)	5404 (95)	323635 (7817)
11-3020	Computer and Information Systems Managers	876 (9)	336 (3)	1212 (12)	93952 (1177)
11-3030	Financial Managers	958 (13)	492 (6)	1450 (19)	101403 (1793)
11-3070	Transportation, Storage, and Distribution Managers	198 (4)	109 (3)	307 (7)	23831 (744)
13-1040	Compliance Officers	432 (5)	254 (3)	686 (8)	42559 (784)
17-2050	Civil Engineers	653 (13)	398 (7)	1051 (20)	44718 (1207)
17-2070	Electrical and Electronics Engineers	582 (4)	226 (1)	808 (5)	49697 (402)
17-2110	Industrial Engineers, Including Health and Safety	287 (1)	116 (0)	403 (1)	26129 (137)
17-3020	Engineering Technicians, Except Drafters	623 (14)	250 (7)	873 (21)	49428 (1383)
17-3030	Surveying and Mapping Technicians	69 (1)	43 (0)	112 (1)	4886 (54)
43-6010	Secretaries and Administrative Assistants	4350 (89)	2452 (52)	6802 (141)	385914 (11476)
47-5040	Mining Machine Operators	26 (0)	6 (0)	32 (0)	722 (44)
49-2090	Miscellaneous Electrical and Electronic- -Equipment Mechanics, Installers, and Repairers	212 (7)	168 (5)	380 (12)	25730 (1007)
49-9040	Industrial Machinery Installation, Repair, and Maintenance Workers	384 (4)	231 (3)	615 (7)	34666 (590)
49-9080	Wind Turbine Service Technicians	8 (0)	11 (0)	19 (0)	1010 (43)
49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	472 (11)	337 (6)	809 (17)	43023 (1315)
51-1010	First-Line Supervisors of Production and Operating Workers	527 (6)	387 (4)	914 (10)	54797 (887)
51-2030	Engine and Other Machine Assemblers	15 (0)	8 (0)	23 (0)	1468 (60)
51-2040	Structural Metal Fabricators and Fitters	35 (0)	25 (0)	60 (0)	5070 (61)
51-2090	Miscellaneous Assemblers and Fabricators	1653 (85)	504 (24)	2157 (109)	137782 (9423)
51-4020	Forming Machine Setters, Operators, and Tenders, Metal and Plastic	58 (0)	29 (0)	87 (0)	6714 (104)
51-4050	Metal Furnace Operators, Tenders, Pourers, and Casters	11 (1)	1 (0)	12 (1)	958 (100)
51-4120	Welding, Soldering, and Brazing Workers	393 (14)	239 (7)	632 (21)	38831 (1939)
51-8090	Miscellaneous Plant and System Operators	44 (1)	53 (1)	97 (2)	6503 (189)
51-9060	Inspectors, Testers, Sorters, Samplers, and Weighers	724 (18)	302 (8)	1026 (26)	66205 (2269)
51-9120	Painting Workers	162 (5)	89 (2)	251 (7)	17004 (830)
51-9162	Computer Numerically Controlled Tool Programmers	239 (9)	92 (4)	331 (13)	19430 (947)
53-5020	Ship and Boat Captains and Operators	32 (1)	19 (0)	51 (1)	3698 (98)
53-5030	Ship Engineers	4 (0)	2 (0)	6 (0)	799 (49)
53-7040	Hoist and Winch Operators	2 (0)	1 (0)	3 (0)	292 (7)
53-7050	Industrial Truck and Tractor Operators	1138 (45)	427 (15)	1565 (60)	125160 (7952)
	Total	**18549 (421)**	**9629 (195)**	**28178 (616)**	**1736014 (54888)**

Source: JobsEQ, (Number of unemployed appear in parentheses)

5.1 Location Quotients and Wages

Two measures, availability of workers and prevailing wages, are critical determinants of FOSW development decisions. These related metrics provide insight on the concentration and cost of workers in different regions across California. Concentration is measured by Location Quotient (LQ), which is defined as "the ratio of talent concentration in a defined geography to that of the national average". For example, if a region's LQ for "mechanical engineers" is 2.0, it indicates that its concentration of that occupational category is twice that of the U.S. as a whole.

Table CA.4 presents the LQs and annual wages for key FOSW occupations in SB, SLO, and the State of California. Starting with SB, the LQ varies from 0.22 for Engine and Other Machine Assemblers, to 1.41 for Civil Engineers. Engineering occupations (SOC 17), have the highest LQ and production occupations (SOC 51) have the lowest LQ. Similarly, for SLO, Civil Engineers (SOC 17) has the highest and Forming, etc (SOC 51) the lowest LQ. To summarize, the LQ data indicates that FOSW projects on the Central Coast can rely on SB and SLO counties to supply white-collar workers, particularly in the engineering and management fields, but will have to import blue-collar workers for many other job categories.

Turning to the State of California, the highest LQ in California is for management and business (SOC codes 11 and 13) and engineering occupations (SOC 17). There are a number of other occupations with high LQs, which is reflective of California's diverse and strong economy. There are also several occupations with low LQ, including construction and extraction occupations (SOC 47) and production occupations (SOC 51). Overall, it is clear that while California is a rich source of workers for white-collar occupations such as engineering, management and business, its supply of blue-collar workers, including production, construction and extraction, are below national levels. The later will present significant challenges to the development of FOSW projects, requiring concerted efforts to recruit and train workers for occupations with low LQ.

Considering annual salaries in Table CA.4, we find similar wage rates in SB, SLO, and California. White-collar occupations, such as management and engineering, provide the highest and blue-collar occupations, such as production and construction, offer the lowest compensation. The only exception among white-collar jobs is office and administrative support (SOC 43), which is among the lowest paying jobs. Likewise, transportation and material moving occupations (SOC 53) are the only exception among blue-collar jobs, offering higher wages.

California's wage picture can be highlighted by the dramatic difference between the salaries of white-collar and blue-collar jobs (almost half). This gap, combined with the higher cost of living, particularly in SB and SLO, drastically reduce the affordability of residing near coastal California. The cost of living in California is 39% higher than the national average. Housing is 102% higher than the national average, while utilities are 22% higher.[42] Given these high costs, skill training programs, while necessary will not be sufficient to draw workers to FOSW jobs. To attract a sufficient quantity of blue-collar workers, the FOSW industry will have to offer higher salaries and benefits, as well as affordable housing, particularly in California's coastal communities.

Table CA.4: Location Quotients (LQ) and Mean Wage for Wind Farm Occupations

SOC	Occupation	Location Quotient (LQ)			Wage (U.S. Dollar)		
		SB	SLO	CA	SB	SLO	CA
11-1020	General and Operations Managers	0.72	0.78	0.85	123,400	116,100	136,500
11-3020	Computer and Information Systems Managers	1.13	0.78	1.48	179,100	168,800	198,400
11-3030	Financial Managers	0.91	0.84	1.17	159,300	141,800	171,300
11-3070	Transportation, Storage, and Distribution Managers	0.87	0.86	1.27	113,400	109,900	114,200
13-1040	Compliance Officers	0.86	0.92	1.04	84,200	80,400	89,800
17-2050	Civil Engineers	1.41	1.55	1.18	113,300	111,100	114,900
17-2070	Electrical and Electronics Engineers	1.30	0.91	1.36	132,300	110,100	134,200
17-2110	Industrial Engineers, Including Health and Safety	0.59	0.43	0.66	116,100	110,500	115,100
17-3020	Engineering Technicians, Except Drafters	1.06	0.77	1.03	74,700	71,000	75,400
17-3030	Surveying and Mapping Technicians	0.78	0.89	0.68	79,300	69,200	77,700
43-6010	Secretaries and Administrative Assistants	0.88	0.89	0.95	51,900	51,000	55,900
47-5040	Mining Machine Operators	0.68	0.27	0.24	61,800	63,700	63,200
49-2090	Miscellaneous Electrical and Electronic- -Equipment Mechanics, Installers, and Repairers	0.59	0.85	0.88	65,500	73,600	69,600
49-9040	Industrial Machinery Installation, Repair, and Maintenance Workers	0.53	0.57	0.59	66,300	74,500	69,400
49-9080	Wind Turbine Service Technicians	0.42	1.03	0.64	67,200	68,000	69,200
49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	0.87	1.12	0.97	46,900	46,000	50,100
51-1010	First-Line Supervisors of Production and Operating Workers	0.54	0.71	0.69	72,100	73,000	75,000
51-2030	Engine and Other Machine Assemblers	0.22	0.19	0.26	49,300	50,000	51,300
51-2040	Structural Metal Fabricators and Fitters	0.37	0.48	0.66	48,900	49,600	50,400
51-2090	Miscellaneous Assemblers and Fabricators	0.79	0.43	0.81	37,500	39,900	42,000
51-4020	Forming Machine Setters, Operators, and Tenders, Metal and Plastic	0.31	0.08	0.34	47,900	49,200	49,000
51-4050	Metal Furnace Operators, Tenders, Pourers, and Casters	0.57	0.63	0.69	53,800	53,600	55,600
51-4120	Welding, Soldering, and Brazing Workers	0.34	0.75	0.62	75,200	93,000	92,200
51-8090	Miscellaneous Plant and System Operators	0.84	0.63	0.94	50,300	51,200	50,500
51-9060	Inspectors, Testers, Sorters, Samplers, and Weighers	0.65	0.64	0.83	52,800	53,800	50,900
51-9120	Painting Workers	0.82	0.57	0.81	54,500	53,600	56,500
51-9162	Computer Numerically Controlled Tool Programmers	0.37	0.33	0.53	43,900	43,900	45,900
53-5020	Ship and Boat Captains and Operators	0.52	0.54	0.73	103,800	103,300	108,900
53-5030	Ship Engineers	0.29	0.21	0.73	109,200	109,400	113,200
53-7040	Hoist and Winch Operators	0.42	0.47	0.65	72,500	72,700	74,900
53-7050	Industrial Truck and Tractor Operators	0.93	0.63	1.25	43,100	45,500	46,100

Source: JobsEQ

5.2 Floating Offshore Wind Labor Demand by Occupations

In this section, we estimate the labor demand for a FOSW project using a novel method that draws on the European offshore wind experience. We adopt the economic model developed by BVG Associates and integrate it with the JEDI model.[43] Our methodology breaks down the CAPEX and OPEX phases of the project into sub-phases as illustrated in Table CA.5 below. The BVG model estimates the share of the top 12 occupations for each of the sub-elements at 6-digit SOC classifications. For example, it indicates that the composition of the labor force building the towers will be 19% Metal Furnace Operators, 19% Structural Metal Fabricators, 8% First-Line Supervisors, 6% Welding, and so on.

We then decompose the JEDI output using the BVG's shares to arrive at our estimate of the aggregate demand across each SOC code for the development (DEVEX), construction (CAPEX), and operation (OPEX) phases of the project. An important caveat is that this methodology is based on the fixed-bottom offshore wind. Although the differences in these technologies, in term of both CAPEX and OPEX, can skew our estimates, we believe our results are still very informative and quite useful at this time. It will become possible to obtain more accurate estimate once projects like CADEMO are developed and experience with FOSW accumulates in California.

Table CA.5: Offshore Wind Supply Chain Elements

Phase	Element	Subelement
Capital Expenditures (CAPEX)	Project development and management	Project development and management
	Turbine supply	Nacelle, rotor and assembly Blades Tower
	Balance of plant	Foundation Array Cables Export cables Substation supply and operational infrastructure
	Installation and commissioning	Turbine Foundation Subsea cable Other installation
Operational Expenditures (OPEX)	Operation, maintenance and service	Wind farm operation Turbine maintenance and service Foundation maintenance and service Subsea cable maintenance and service Substation maintenance and service

Source: BVG Associates

5.2.1 Labor Demand: the CADEMO Project

Using the decomposition method noted above, we estimate the number of workers (FTE basis at 6-digit SOC) needed during the construction and operations phases of the CADEMO project. More specifically, as Table C.6 shows, we convert the JEDI's jobs output (FTEs) to annual demand by occupation by SOC. We then calculate the "labor gap" relative to the "Max Demand" column, which is the highest labor need during the project construction phase.

Table CA.6: Number of Jobs Required by Occupation groups for CADEMO

SOC	Occupation	Max Demand	2022	2023	2024	2025	2026	Total (FTE)
49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	44	0	0	44	44	22	110
51-2040	Structural Metal Fabricators and Fitters	15	0	0	15	15	7	37
11-1020	General and Operations Managers	12	1	7	12	9	4	33
17-2110	Industrial Engineers, Including Health and Safety	11	0	2	11	10	5	28
51-9162	Computer Numerically Controlled Tool Programmers	11	0	0	11	11	5	27
51-4050	Metal Furnace Operators, Tenders, Pourers, and Casters	10	0	0	10	10	5	25
51-4120	Welding, Soldering, and Brazing Workers	10	0	0	10	10	5	25
49-9080	Wind Turbine Service Technicians	9	0	0	9	9	5	23
43-6010	Secretaries and Administrative Assistants	7	1	3	7	6	3	20
51-8090	Miscellaneous Plant and System Operators	7	0	0	7	7	4	18
11-3020	Computer and Information Systems Managers	5	0	0	5	5	2	12
17-2070	Electrical and Electronics Engineers	4	1	3	4	3	1	12
49-2090	Miscellaneous Electrical and Electronic Equipment Mechanics,	4	0	1	4	4	2	11
53-5020	Ship and Boat Captains and Operators	4	0	0	4	4	2	10
51-1010	First-Line Supervisors of Production and Operating Workers	4	0	0	4	4	2	10
17-3020	Engineering Technicians, Except Drafters	3	0	0	3	3	2	8
53-5030	Ship Engineers	3	0	0	3	3	2	8
17-2050	Civil Engineers	3	0	2	3	2	1	8
17-3030	Surveying and Mapping Technicians	3	0	0	3	3	1	7
13-1040	Compliance Officers	3	0	0	3	3	1	7
47-5040	Mining Machine Operators	3	0	0	3	3	1	7
11-3030	Financial Managers	3	1	3	2	1	0	7
49-9040	Industrial Machinery Installation, Repair, and Maintenance Workers	2	0	0	2	2	1	5
53-7040	Hoist and Winch Operators	2	0	0	2	2	1	5
11-3070	Transportation, Storage, and Distribution Managers	2	0	0	2	2	1	5
	Others	86	8	32	86	71	32	229
	Total		**12**	**53**	**269**	**246**	**117**	**697**

Source: Authors' Estimates

Note that CADEMO's development and construction phases require five years, with development spanning 2022-24, construction commencing in 2024 and ending in 2026. and operations starting in 2026 and continuing over 25 years, at which point the turbines will likely be decommissioned. As expected, the construction phase will require the largest numbers of construction, installation, and engineering professionals. Our labor decomposition in Table CA.6 demonstrates that the top required occupations during the construction phase include Installation, Maintenance, and Repair (SOC 49), Production (SOC 51), Architecture and Engineering (SOC 17), and Management (SOC 11). Table CA.7 presents similar estimates for the operation phase, again on annual FTE basis. As expected, turbine service technicians constitute the largest occupation category.

Table CA.7: Number of annual jobs CADEMO Operating Demands

SOC	Occupation	Number of Jobs (Annual)
49-9080	Wind Turbine Service Technicians	7
11-1020	General and Operations Managers	1
53-5020	Ship and Boat Captains and Operators	1
17-2110	Industrial Engineers, Including Health and Safety	1
	Others	6
	Total	**16**

Source: Authors' Estimates

5.2.2 Labor Demand: Commercial Scale Morro Bay Projects

We use the procedure described above to estimate the number of required workers (by occupation) for two commercial scale projects near Morro Bay – 1.5 and 3.0 GW capacity. These estimates account for potential gains from scale economies due the expansion of the FOSW supply chain and manufacturing in California. Table CA.8 presents our estimates for selected SOC categories, based on JEDI's scenario C2 (Mid Local Content case) output. Note that the maximum number of employees is reached in 2029, suggesting a short time frame (6 years) before major labor market bottlenecks could materialize. The labor shortage situation will be most severe for wind turbine technicians, as this category is the largest portion of operations jobs.

Table CA.8: 1.5 GW Construction and Development Phase

SOC	Occupation	Max Demand	2025	2026	2027	2028	2029	2030	Total (FTE)
51-2040	Structural Metal Fabricators and Fitters	671	0	0	168	420	671	420	1679
51-9162	Computer Numerically Controlled Tool Programmers	486	0	0	121	304	486	304	1215
49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	463	0	0	116	289	463	289	1157
51-4050	Metal Furnace Operators, Tenders, Pourers, and Casters	443	0	0	111	277	443	277	1108
51-4120	Welding, Soldering, and Brazing Workers	411	0	0	103	257	411	257	1028
51-1010	First-Line Supervisors of Production and Operating Workers	202	0	0	50	126	202	126	504
11-1020	General and Operations Managers	132	6	18	54	96	132	82	388
51-2030	Engine and Other Machine Assemblers	142	0	0	35	89	142	89	355
17-2110	Industrial Engineers, Including Health and Safety	134	2	5	39	88	134	84	352
47-5040	Mining Machine Operators	116	0	0	29	72	116	72	289
49-9080	Wind Turbine Service Technicians	88	0	0	22	55	88	55	220
13-1040	Compliance Officers	88	0	0	22	55	88	55	220
43-6010	Secretaries and Administrative Assistants	75	3	8	28	53	75	47	214
53-7040	Hoist and Winch Operators	85	0	0	21	53	85	53	212
51-8090	Miscellaneous Plant and System Operators	81	0	0	20	51	81	51	203
11-3070	Transportation, Storage, and Distribution Managers	79	0	0	20	50	79	50	199
51-9060	Inspectors, Testers, Sorters, Samplers, and Weighers	66	0	0	16	41	66	41	164
51-9120	Painting Workers	65	0	0	16	41	65	41	163
53-7050	Industrial Truck and Tractor Operators	59	0	0	15	37	59	37	148
11-3020	Computer and Information Systems Managers	49	0	0	12	31	49	31	123
53-5020	Ship and Boat Captains and Operators	45	0	0	11	28	45	28	112
51-2090	Miscellaneous Assemblers and Fabricators	40	0	0	10	25	40	25	100
17-3020	Engineering Technicians, Except Drafters	40	0	0	10	25	40	25	100
49-2090	Miscellaneous Electrical and Electronic Equipment Mechanics, Installers, and Repairers	36	1	2	12	24	36	23	98
51-4020	Forming Machine Setters, Operators, and Tenders, Metal and Plastic	35	0	0	9	22	35	22	88
	Others	1483	88	281	709	1131	1483	906	4598
	Total		**100**	**314**	**1779**	**3740**	**5614**	**3490**	**15037**

Source: Authors' Estimates

Again, development and construction are assumed to take 6-years (2025-30). The development phase spans 2025-30, while construction spans 2027-30. The later stages of construction will require large numbers of blue-collar workers. As shown in Table CA.8, the top 2-digit SOC occupation groups are Production (SOC 51), Installation, Maintenance, and Repair (SOC 49), Management (SOC 11), and Architecture and Engineering (SOC 17). Turning to the operations phase, Table CA.9 shows that the largest occupations will be Installation, Maintenance, and Repair Occupations (SOC 49), Management (SOC 11), and Production (SOC 51).

Table CA.9: 1.5GW Commercial Operating Demand

SOC	Occupation	Number of Jobs (Annual)
49-9080	Wind Turbine Service Technicians	321
11-1020	General and Operations Managers	43
53-5020	Ship and Boat Captains and Operators	29
17-2110	Industrial Engineers, Including Health and Safety	24
51-2030	Engine and Other Machine Assemblers	19
43-6010	Secretaries and Administrative Assistants	17
51-8090	Miscellaneous Plant and System Operators	17
11-3020	Computer and Information Systems Managers	16
13-1040	Compliance Officers	14
17-3020	Engineering Technicians, Except Drafters	13
	Others	228
	Total	**741**

Source: Authors' Estimates

5.2.3 Labor Gap Analysis

The last step in this analysis is to assess the gap between supply and demand of labor by key occupations. We follow the methodology proposed in the NYSERDA study. Specifically, labor or "workforce gap" will be defined as the difference between demand and supply of workers, normalized by the supply, i.e., the relative percentage shortfall for each occupational category (6-digit SOC).[44] For our analysis, the supply of workers for each occupation is taken from Table CA.3. We then use the "Max Demand" from tables CA.6 and CA.8, as the upper bound in demand and the development of potential labor market bottlenecks. Following the NYSERDA study, we can identify three levels of workforce gap severity:

Severe	Demand exceeds supply and this gap exceeds the size of the existing workforce
Moderate	Demand exceeds supply but the gap is smaller than the existing workforce
Mild	Supply exceeds demand

We conduct the Labor Gap Analysis for the CADEMO Project at the county and state level, and for the two hypothetical commercial scale projects at the state level only. Tables CA.10 through CA.12 present our workforce gap analysis, where occupations are sorted, in descending order, by labor gap severity. This analysis identifies occupations that could present the greatest challenge to the development of FOSW projects. Accordingly, results reported in the tables below can guide strategies to enhance new and existing educational and skill training programs.

Starting with results for the CADEMO project in Table CA.10, we find 9 occupations with moderate gap, 11 with mild gap, and none with severe gap at the county level. Overall, the two counties can partially support the labor needs of CADEMO, particularly for white-collar occupations. However, when it comes to blue-collar jobs, CAMDEO must look beyond the local labor market and focus its recruiting strategy on other counties or even outside California.

The last column in Table CA.10 lists the typical educational background required by each occupation. Focusing on the occupations experiencing a moderate labor gap, it is clear that high schools, apprenticeship and post-secondary training programs can play an indispensable role in alleviating CADEMO's workforce shortage problems in SB and SLO counties. At the state level, however, CADEMO will face little problem meeting its labor needs.

Labor gap analysis for the two hypothetical commercial scale projects (1.5 and 3.0 GW) are presented in tables CA.11 and CA.12 respectively. The estimated labor demand for the 3 GW plant is assumed to be double the 1.5 GW, which can be justified by the linearity embedded in the JEDI model.[45]

The results in tables CA.11 and CA.12 present an interesting picture in terms of binding labor constraints the FOSW industry is likely to face in California. For example, scaling up to 3 GW will lead to a larger set of occupations with moderate labor gap, notably engineering and transportation jobs. Overall, it appears California's labor market is capable of partially supporting FOSW industry's labor demand. However, some occupations will remain a challenge, especially in the metal/steel industry, wind turbine service technicians, and engineering and transportation.

Table CA.10: CADEMO Santa Barbara and San Luis Obispo Labor Gap Analysis

SOC	Occupation	Max Demand	Unemployed	Employed	Gap (%)	Typical Education
51-4050	Metal Furnace Operators, Tenders, Pourers, and Casters	10	1	12	74.0	High School Diploma
49-9080	Wind Turbine Service Technicians	12	0	19	61.4	Post-secondary Training or Associate's
53-5030	Ship Engineers	3	0	6	55.1	Post-secondary Training or Associate's
51-2040	Structural Metal Fabricators and Fitters	15	0	60	24.3	Apprenticeship/Postsecondary Training
53-5020	Ship and Boat Captains and Operators	4	1	51	5.9	Apprenticeship/Postsecondary Training
51-8090	Miscellaneous Plant and System Operators	7	2	97	5.5	Apprenticeship/Postsecondary Training
49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	44	17	809	3.3	High School Diploma Apprenticeship/Postsecondary Training
17-2110	Industrial Engineers, Including Health and Safety	11	1	403	2.5	Bachelor's Degree
17-3030	Surveying and Mapping Technicians	3	1	112	1.7	Apprenticeship/Postsecondary Training
17-2070	Electrical and Electronics Engineers	4	5	808	-0.2	Bachelor's Degree / Master's Degree
11-3020	Computer and Information Systems--Managers	5	12	1212	-0.6	Bachelor's Degree
51-1010	First-Line Supervisors of Production and Operating Workers	4	10	914	-0.7	High School Diploma
51-9160	Computer Numerically Controlled Tool Operators and Programmers	11	13	331	-0.7	Apprenticeship/Postsecondary Training
11-3030	Financial Managers	3	19	1450	-1.1	Bachelor's Degree / Master's Degree
11-1020	General and Operations Managers	12	95	5404	-1.5	Bachelor's Degree / Master's Degree
17-2050	Civil Engineers	3	20	1051	-1.6	Bachelor's Degree
51-4120	Welding, Soldering, and Brazing Workers	10	21	632	-1.8	Apprenticeship/Postsecondary Training
43-6010	Secretaries and Administrative Assistants	7	141	6802	-2.0	Post-secondary Training or Associate's Bachelor's Degree
17-3020	Engineering Technicians, Except Drafters	3	21	873	-2.0	Apprenticeship/Postsecondary Training or Associate's Bachelor's Degree
49-2090	Miscellaneous Electrical and Electronic Equipment Mechanics, Installers, and Repairers	4	12	380	-2.1	Apprenticeship/Postsecondary Training or Associate's

Source: Authors' Estimates

Table CA.11: 1.5 GW Commercial Labor Gap Analysis

SOC	Occupation	Max Deman	Unemploye	Employed	Gap (%)	Typical Education
51-4050	Metal Furnace Operators, Tenders, Pourers, and Casters	443	100	958	35.8	High School Diploma
49-9080	Wind Turbine Service Technicians	376	43	1010	32.9	Post-secondary Training or Associate's
53-7040	Hoist and Winch Operators	85	7	292	26.9	Apprenticeship/Postsecondary Training
51-2040	Structural Metal Fabricators and Fitters	671	61	5070	12.0	Apprenticeship/Postsecondary Training
47-5040	Mining Machine Operators	116	44	722	10.0	Apprenticeship/Postsecondary Training
51-2030	Engine and Other Machine Assemblers	142	60	1468	5.6	High School Diploma
17-2110	Industrial Engineers, Including Health and Safety	134	137	26129	0.0	Bachelor's Degree
17-3030	Surveying and Mapping Technicians	33	54	4886	-0.4	Apprenticeship/Postsecondary Training
17-2070	Electrical and Electronics Engineers	24	402	49697	-0.8	Bachelor's Degree / Master's Degree
51-4020	Forming Machine Setters, Operators, and Tenders, Metal and Plastic	35	104	6714	-1.0	High School Diploma Apprenticeship/Postsecondary Training
53-5020	Ship and Boat Captains and Operators	57	98	3698	-1.1	Apprenticeship/Postsecondary Training
11-3020	Computer and Information Systems Managers	49	1177	93952	-1.2	Bachelor's Degree
51-1010	First-Line Supervisors of Production and Operating Workers	202	887	54797	-1.3	High School Diploma
49-9040	Industrial Machinery Installation, Repair, and Maintenance Workers	28	590	34666	-1.6	Apprenticeship/Postsecondary Training
13-1040	Compliance Officers	88	784	42559	-1.6	Bachelor's Degree
51-8090	Miscellaneous Plant and System Operators	81	189	6503	-1.7	Apprenticeship/Postsecondary Training
53-5030	Ship Engineers	35	49	799	-1.8	Post-secondary Training or Associate's
49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	463	1315	43023	-2.0	High School Diploma Apprenticeship/Postsecondary Training
51-9160	Computer Numerically Controlled Tool Operators and Programmers	486	947	19430	-2.4	Apprenticeship/Postsecondary Training
11-1020	General and Operations Managers	132	7817	323635	-2.4	Bachelor's Degree / Master's Degree
17-2050	Civil Engineers	26	1207	44718	-2.6	Bachelor's Degree
17-3020	Engineering Technicians, Except Drafters	40	1383	49428	-2.7	Apprenticeship/Postsecondary Training or Associate's Bachelor's Degree
11-3070	Transportation, Storage, and Distribution Managers	79	744	23831	-2.8	Bachelor's Degree
43-6010	Secretaries and Administrative Assistants	75	11476	385914	-3.0	Post-secondary Training or Associate's Bachelor's Degree
51-9060	Inspectors, Testers, Sorters, Samplers, and Weighers	66	2269	66205	-3.3	Apprenticeship/Postsecondary Training
49-2090	Miscellaneous Electrical and Electronic--Equipment Mechanics, Installers, and Repairers	36	1007	25730	-3.8	Apprenticeship/Postsecondary Training or Associate's
51-4120	Welding, Soldering, and Brazing Workers	411	1939	38831	-3.9	Apprenticeship/Postsecondary Training
51-9120	Painting Workers	65	830	17004	-4.5	High School Diploma
53-7050	Industrial Truck and Tractor Operators	59	7952	125160	-6.3	Apprenticeship/Postsecondary Training
51-2090	Miscellaneous Assemblers and Fabricators	40	9423	137782	-6.8	High School Diploma Apprenticeship/Postsecondary Training

Source: Authors' Estimates

Table CA.12: 3 GW Commercial Labor Gap Analysis

SOC	Occupation	Max Deman	Unemploye	Employed	Gap (%)	Typical Education
51-4050	Metal Furnace Operators, Tenders, Pourers, and Casters	887	100	958	82.1	High School Diploma
49-9080	Wind Turbine Service Technicians	751	43	1010	70.1	Post-secondary Training or Associate's
53-7040	Hoist and Winch Operators	171	7	292	56.1	Apprenticeship/Postsecondary Training
47-5040	Mining Machine Operators	232	44	722	26.0	Apprenticeship/Postsecondary Training
51-2040	Structural Metal Fabricators and Fitters	1343	61	5070	25.3	Apprenticeship/Postsecondary Training
51-2030	Engine and Other Machine Assemblers	284	60	1468	15.3	High School Diploma
53-5030	Ship Engineers	69	49	799	2.5	Post-secondary Training or Associate's
17-2110	Industrial Engineers, Including Health and Safety	269	137	26129	0.5	Bachelor's Degree
53-5020	Ship and Boat Captains and Operators	114	98	3698	0.4	Apprenticeship/Postsecondary Training
17-3030	Surveying and Mapping Technicians	65	54	4886	0.2	Apprenticeship/Postsecondary Training
51-9160	Computer Numerically Controlled Tool Operators and Programmers	972	947	19430	0.1	Apprenticeship/Postsecondary Training
51-8090	Miscellaneous Plant and System Operators	162	189	6503	-0.4	Apprenticeship/Postsecondary Training
51-4020	Forming Machine Setters, Operators, and Tenders, Metal and Plastic	70	104	6714	-0.5	High School Diploma Apprenticeship/Postsecondary Training
17-2070	Electrical and Electronics Engineers	49	402	49697	-0.7	Bachelor's Degree / Master's Degree
51-1010	First-Line Supervisors of Production and Operating Workers	403	887	54797	-0.9	High School Diploma
49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	926	1315	43023	-0.9	High School Diploma Apprenticeship/Postsecondary Training
11-3020	Computer and Information Systems Managers	98	1177	93952	-1.1	Bachelor's Degree
13-1040	Compliance Officers	176	784	42559	-1.4	Bachelor's Degree
49-9040	Industrial Machinery Installation, Repair, and Maintenance Workers	56	590	34666	-1.5	Apprenticeship/Postsecondary Training
11-1020	General and Operations Managers	263	7817	323635	-2.3	Bachelor's Degree / Master's Degree
11-3070	Transportation, Storage, and Distribution Managers	159	744	23831	-2.5	Bachelor's Degree
17-2050	Civil Engineers	52	1207	44718	-2.6	Bachelor's Degree
17-3020	Engineering Technicians, Except Drafters	79	1383	49428	-2.6	Apprenticeship/Postsecondary Training or Associate's Bachelor's Degree
51-4120	Welding, Soldering, and Brazing Workers	822	1939	38831	-2.9	Apprenticeship/Postsecondary Training
43-6010	Secretaries and Administrative Assistants	149	11476	385914	-2.9	Post-secondary Training or Associate's Bachelor's Degree
51-9060	Inspectors, Testers, Sorters, Samplers, and Weighers	131	2269	66205	-3.2	Apprenticeship/Postsecondary Training
49-2090	Miscellaneous Electrical and Electronic--Equipment Mechanics, Installers, and Repairers	72	1007	25730	-3.6	Apprenticeship/Postsecondary Training or Associate's
51-9120	Painting Workers	130	830	17004	-4.1	High School Diploma
53-7050	Industrial Truck and Tractor Operators	117	7952	125160	-6.3	Apprenticeship/Postsecondary Training
51-2090	Miscellaneous Assemblers and Fabricators	80	9423	137782	-6.8	High School Diploma Apprenticeship/Postsecondary Training

Source: Authors' Estimates

5.2.4 Wind Workforce in California Metropolitan Statistical Areas (MSA):

In this section we provide a list of Metropolitan Statistical Areas (MSA) with sizable labor markets that could partially alleviate Central Coast's labor shortages, particularly for occupations with moderate workforce gap.[46] Over the short term, these regions can become the target for recruiting specific workers, while new workers are trained. The occupations in Table CA.13 are listed in descending severity for the combined SB and SLO counties.

The data in Table CA.13 suggests specific regions for recruiting workers to close the workforce gap in SB and SLO counties. These include Bakersfield for Wind Turbine Service Technicians and Miscellaneous Plant and System Operators, and El Centro for Mining Machine Operators. However, several occupation categories – e.g., SOC 51-2030 and 51-4050 – require the industry to recruit outside the state, particularly from areas with high LQ where the concentration of needed skills is above the national average. Over the longer term, California must strategically develop educational and skill training programs that optimally serve the needs of the state's floating offshore wind industry, and help California and the nation meet their stated green energy objectives.

Table CA.13: MSAs with Largest Concentrations of Wind Farm Workers

Occupations from Commercial Projects								
SOC	Occupation	Gap	MSA 1	LQ 1	MSA 2	LQ 2	MSA 3	LQ 3
17-2110	Industrial Engineers, Including Health and Safety	Moderate	San Jose-Sunnyvale -Santa Clara	1.48	San Diego-Carlsbad	0.85	Oxnard-Thousand Oaks-Ventura	0.71
17-3030	Surveying and Mapping Technicians	Moderate	San Francisco-Oakland-Hayward	0.94	San Diego-Carlsbad	0.83	Santa Rosa	0.72
47-5040	Mining Machine Operators	Moderate	El Centro	7.22	Bakersfield	2.27	Redding	1.5
49-9080	Wind Turbine Service Technicians	Moderate	Bakersfield	3.85	Vallejo-Fairfield	2.3	Riverside-San Bernardino-Ontario	1.07
49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	Moderate	Santa Rosa	1.22	Vallejo-Fairfield	1.21	Riverside-San Bernardino-Ontario	1.17
51-2030	Engine and Other Machine Assemblers	Moderate	San Diego-Carlsbad	0.43	Los Angeles-Long Beach-Anaheim	0.29	San Jose-Sunnyvale-Santa Clara	0.27
51-2040	Structural Metal Fabricators and Fitters	Moderate	Los Angeles-Long Beach-Anaheim	1.44	San Francisco-Oakland-Hayward	1.06	Riverside-San Bernardino-Ontario	0.97
51-4050	Metal Furnace Operators, Tenders, Pourers, and Casters	Moderate	Riverside-San Bernardino-Ontario	0.77	Fresno	0.6	Oxnard-Thousand Oaks-Ventura	0.47
51-8090	Miscellaneous Plant and System Operators	Moderate	Bakersfield	1.58	Vallejo-Fairfield	1.41	San Francisco-Oakland-Hayward	0.92
51-9160	Computer Numerically Controlled Tool Operators and Programmers	Moderate	Oxnard-Thousand Oaks-Ventura	1.48	San Jose-Sunnyvale -Santa Clara	1.4	Los Angeles-Long Beach-Anaheim	0.98
53-5020	Ship and Boat Captains and Operators	Moderate	Los Angeles-Long Beach-Anaheim	1.21	San Francisco-Oakland-Hayward	0.95	San Diego-Carlsbad	0.69
53-5030	Ship Engineers	Moderate	Los Angeles-Long Beach-Anaheim	1.24	San Francisco-Oakland-Hayward	1.11	Vallejo-Fairfield	0.48
53-7040	Hoist and Winch Operators	Moderate	Riverside-San Bernardino-Ontario	1.1	Los Angeles-Long Beach-Anaheim	0.62	San Francisco-Oakland-Hayward	0.47

Source: U.S. Bureau of Labor Statistics

6 Summary and conclusion

6. Summary and Conclusions

California has set ambitious goals for the development of FOSW energy: up to 5 GW by 2030 and 25 GW by 2045. These goals are in line with the Biden Administration's target of 30 GW of FOSW by 2030. The transition to clean energy sources, particularly the expansion of the FOSW industry, is expected to bring new jobs and investments to California, while helping the nation significantly reduce greenhouse gas emissions. California's Central Coast is expected to play a key role in this transition, with the Morro Bay Wind Energy Area (WEA) aiming for 3 GW by 2030, expandable up to 5 GW in the future. Moreover, the development of the Diablo Canyon WEA can bring an additional 1.0 GW capacity in the future.

In this study, we conduct an Economic Impact Analysis (EIA) of two FOSW projects in Central Coast. The first is CADEMO, a small-scale pilot project near the Vandenberg Space Force Base. The second is a hypothetical commercial scale project in Morro Bay WEA. Our analysis provides estimates of direct, supply chain, and induced impact of these projects in terms of jobs created and economic output. We also conduct a complimentary study of the labor gap to meet the anticipated worker demand for both projects in California and the Counties of San Luis Obispo and Santa Barbara.

A first step in the development of California's offshore wind energy is the CADEMO demonstration project near the Vandenberg Space Force Base. CADEMO's 60 MW capacity is roughly equivalent to average electricity demand by 60K homes. CADEMO is estimated to require a total CAPEX of $338 million, and an annual OPEX of $4 million over its 25-year life span.[47] The cumulative GDP impact of CADEMO is estimated to be $113.7 million during 5 years of development and construction, and $3.1 million per year during its 25 years of operation. Similarly, the cumulative output and earnings impacts are estimated to be $203.4 and $81.2 million respectively during the development and construction period and $5.6, and $2.0 million per year during the operation period.

The CADEMO project is expected to generate a total of 1840 FTE jobs during the development and construction period, of which 697 FTE are likely to be local.[48] Moreover, it will generate 20 annual jobs for the operation and maintenance, of which 16 will be local. This project is also expected to create a total of 225 FTE induced jobs during its construction and 7 annual induced local jobs over its life span. In total, the CADEMO project is expected to create 922 FTE local jobs during the construction phase and 23 annual local jobs during the operation period.

Installation, Maintenance, and Repair (SOC 49), Production (SOC 51), and Architecture and Engineering (SOC 17) appear to be the largest occupational categories needed for CADEMO project. We show that the SLO and SB counties together may be able to partially support the labor needs of the CADEMO project, particularly for white-collar occupations such as management and engineering (except for industrial engineers). However, there will remain a significant workforce gap for blue-collar jobs, such as wind turbine service technicians, installation, maintenance, repair, metal/steel production, transportation and moving occupations, requiring CAMDEO to look beyond the SB and SLO labor markets.

We also developed detailed JEDI models for a variety of commercial scale FOSW projects near Morro Bay. We found that a 1 GW FOSW project will generate nearly 24K FTE jobs during its construction phase (6 years) and about 600 annual jobs during its operations phase (25 years). Roughly 50% of the construction and over 80% of the operations jobs will be local.[49] The occupation categories with largest workforce demand are similar to the CADEMO project. However, the California labor market is only capable to partially meet the demand for specialized workers created by commercial scale FOSW projects. The bottleneck occupation categories will be production, especially in the metal/steel industry, wind turbine service technicians, and engineering and transportation workers. Absent robust and comprehensive educational and skill training programs, California's FOSW industry will have to import trained labor from other states, while simultaneously investing in the developing of a local workforce.

While in the short-run, timely development of commercial scale projects will face significant labor shortage, workers can be recruited from other counties or states. Our analysis shows that other California Metropolitan Statistical Areas (MSA), for example Bakersfield, offer a strong labor market for recruiting needed workers in key occupations, including wind turbine service technicians and miscellaneous plant and system operators. In contrast, no California MSA has excess workers for engine and other machine assemblers, or metal furnace operators, tenders, etc. In those cases, the industry will have to rely on other states' labor supply in the short term, and on California's workforce development programs over the long-term.

We identify several occupations that will be short supply. Junior colleges, high schools, unions, and vocational training programs should focus on key occupations, including metal furnace operators; wind turbine service technicians, hoist and winch operators, mining machine operators, structural metal fabricators and fitters, and engine and other machine assemblers. Local universities should focus on training ship engineers, industrial engineers, including health and safety ship and boat captains and operators, surveying and mapping technicians, and computer numerically controlled tool operators and programmers.

Over the long-term, to close the FOSW skill gap, California must provide incentives to create and expand specific occupational training programs. As we demonstrated, the educational attainment for the key bottleneck occupations is typically below college level, i.e., apprenticeship training, post-secondary training, or high school diploma. The only exception is industrial and related engineering fields, which require a bachelor's degree.

To conclude, our analysis suggests that the success of California's FOSW industry hinges upon targeted investments in key elements of (1) the supply chain, (2) infrastructure and ports, and (3) human capital and vocational training programs. Examples of targeted investments include, the development of metal/steel industry to support the FOSW supply chain, the construction of specialized port facilities near the Central Coast to support installation and O&M of FOSW projects, investment in critical infrastructure, including the electrical grid, to accelerate deployment and adoption of new technologies, and most importantly, investments in educational and occupational training programs to build and maintain a viable FOSW labor force. Meeting California's floating offshore wind milestones will be challenging, but it can be done with coordinated efforts, investments in both physical and human capital, and effective collaboration among the stakeholders.

7. Notes

1. The CADEMO project is detailed here: https://cademo.net/.
2. See "Benefits of a pilot," https://cademo.net/benefits-of-a-pilot/
3. For the most recent assessment of the prospect to construct port facilities to serve the FOSW industry see "2023 Alternative Port Assessment to Support Offshore Wind," California State Land Commission, https://www.slc.ca.gov/content-types/commission-releases-alternative-port-assessment-to-support-offshore-wind-2/
4. See Wiki information: https://en.wikipedia.org/wiki/Floating_wind_turbine.
5. Musial, et al., Offshore Wind Market Report: 2022 Edition
6. See "World's first floating wind turbine opens in Norway", https://phys.org/news/2009-09-world-turbine-norway.html.
7. Hywind Tampen uses eleven 8.6 MW turbines operating at the depth of 853 to 984 feet, and 87 miles from coast. See "First turbine installed at world's largest floating offshore wind farm – which will power oil and gas," https://electrek.co/2022/06/07/first-turbine-installed-at-worlds-largest-floating-offshore-wind-farm-which-will-power-oil-and-gas/
8. The advantages and disadvantages of each foundations are discussed in GWEC, Report 2022 – Floating Offshore Wind – A global opportunity, https://gwec.net/wp-content/uploads/2022/03/GWEC-Report-Floating-Offshore-Wind-A-Global-Opportunity.pdf.
9. Note that barge and semi-submersible foundations are similar technologies.
10. According to Global Wind Energy Council (GWEC), 67% of floating offshore wind turbines in the market use a semi-submersible floater, https://gwec.net/wp-content/uploads/2022/03/GWEC-Report-Floating-Offshore-Wind-A-Global-Opportunity.pdf.
11. On the other hand, an important limitation of FOSW, particularly in deeper waters, is the need for costly inter-array dynamic cables and transmission lines.
12. See "Central Coast Emerging Industries Waterfront Siting + Infrastructure Study," https://reachcentralcoast.org/wp-content/uploads/Waterfront-Infrastructure-Report-121522.pdf.Chapter 2 in California Energy Commission 2003 report, entitled "Preliminary Assessment of Economic Benefits of Offshore Wind," highlights economic forces effecting port developments in California, https://www.offshorewindca.org/reports.
13. See formal DOE announcement: https://doi.gov/pressreleases/biden-harris-administration-announces-winners-california-offshore-wind-energy-auction.
14. For information about California's FOSW Industry see: https://www.offshorewindca.org/. Each Morro Bay parcel is expected to generate nearly 1 GW of energy.
15. See BOEM presentation entitled "Informational Hearing on Offshore Wind Development": https://documents.coastal.ca.gov/assets/slideshow/Th7a-9-2021-presentationslides.pdf.
16. For example California's Assembly Bill 525 (https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB525), and Department of Energies "Floating Offshore Wind Shot," https://www.energy.gov/eere/wind/floating-offshore-wind-shot.

17. For information regarding the details of the auctions and embedded incentives programs, see: https://www.powerinfotoday.com/wind-energy/757m-raised-at-maiden-offshore-wind-auction-in-california/.

18. See "FACT SHEET: Biden-Harris Administration Announces New Actions to Expand U.S. Offshore Wind Energy," https://www.whitehouse.gov/briefing-room/statements-releases/2022/09/15/fact-sheet-biden-harris-administration-announces-new-actions-to-expand-u-s-offshore-wind-energy/.

19. See "CEC Adopts Historic California Offshore Wind Goals, Enough to Power Upwards of 25 Million Homes," https://www.energy.ca.gov/filebrowser/download/4361.

20. See "Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs," https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Pacific-Region/Studies/BOEM-2016-074.pdf.

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

22. See "Alternative Port Assessment to Support Offshore Wind," https://static1.squarespace.com/static/5d87dc688ef6c t/63f65bf9f8062927a8139650/1677089788112/Alternative-Port-Assessment-To-Support-Offshore-Wind-Final.pdf

23. See "OFFSHORE WIND ENERGY: Planned Projects May Lead to Construction of New Vessels in the U.S., but Industry Has Made Few Decisions amid Uncertainties," United States Government Accountability Office, GAO-21-153, December 2020.

24. See "A Supply Chain Road Map for Offshore Wind Energy in the United States," https://static1.squarespace.com/static/5d87dc688ef6cb38a6767f97/t/63f65c1ee9bccf313f3bf11e/1677089826037/Supply+Chain+Roadmap.pdf.

25. See "Power Purchase Agreement Checklist for State and Local Governments," https://www.nrel.gov/docs/fy10osti/46668.pdf.

26. See "Green Energy Is Stuck at a Financial Red Light," *Wall Street Journal, 31 March 2023.*

27. Investors in FOSW developments include renewable energy developers, utilities, green investments, pension funds, and oil-gas companies. These participants take part in different phases of FOSW development, depending upon the risk-reward opportunities associated with each development phase. For additional details see "Financing Offshore Wind," World Forum Offshore Wind, https://wfo-global.org/wp-content/uploads/2022/09/WFO_FinancingOffshoreWind_2022.pdf.

28. "Supply-chain constraints, inflation and market uncertainty contributed to the nearly 17% decline in capacity additions last year compared to 2021's results." See Global Wind Energy Council, Global Wind Report 2023, https://gwec.net/globalwindreport2023/.

29. For details of these laws see, "UPDATED FACT SHEET: Bipartisan Infrastructure Investment and Jobs Act," https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/02/updated-fact-sheet-bipartisan-infrastructure-investment-and-jobs-act/ and "Offshore Wind Provisions in the Inflation Reduction Act," https://crsreports.congress.gov/product/pdf/IN/IN11980.

30. IMPLAN contains county, state, and federal economic statistics which are specialized by region and that can be used to measure the effect of a change in economic activity on a region's economy. Input-output tables are compiled at the national level by the Bureau of Economic Analysis at the Department of Commerce. State and county specific input-output tables are derived by

adjusting the national tables.

31. See "The CADEMO Project," https://cademo.net/the-project/.

32. VSFB is home to the *30th Space Wing*, which manages the Department of Defense's space and missile testing base, with a mission of placing satellites into polar orbit using expendable and reusable rocket boosters. For a brief history of VSFB see https://www.vandenberg.spaceforce.mil/About-Us/Fact-Sheets/Display/Article/338341/history-office/.

33. For additional information about the CADEMO project see https://cademo.net/

34. See "Morro Bay Wind Energy Area: Development of an Environmental Assessment," https://www.boem.gov/renewable-energy/state-activities/morro-bay-wind-energy-area

35. Throughout this report, local content refers to the percentage of expenditures that will occur in the State of California.

36. The EIA estimates in this report exclude decommissioning of turbines and substructures. There is great uncertainty concerning the decommissioning costs, as no FOSW project has reached this phase.

37. FOSW turbines installed on semi-submersible foundations can be towed to port facilities for repairs and maintenance, offering a cost advantage over fixed-bottom structures.

38. Value added is the sum of earnings from capital and labor or the difference between total gross output and the cost of intermediate inputs. It is comprised of payments made to workers, proprietary and property income, supply chain business taxes, and taxes on production and imports and net of any subsidies.

39. Some construction and operation jobs may last for only a portion of a year, while others may last over multiple years.

40. We find similar increases in employment for the O&M phase of a commercial scale project.

41. Under this definition, an employment multiplier of 3 indicates that the creation of 1 direct new job is expected to support 2 additional jobs in the local economy, for a total impact of 3 new jobs.

42. Source: C2ER: The Council for Community and Economic Research, https://www.c2er.org/.

43. BVG Associates Limited, 2019, U.S. Job Creation in Offshore Wind: A Report for the Roadmap Project for Multi-State Cooperation on Offshore Wind. https://tethys.pnnl.gov/publications/us-job-creation-offshore-wind-report-roadmap-project-multi-state-cooperation-offshore.

44. Similar versions of this definition have been used in other labor gap studies, including the New York State Energy Research and Development Authority (NYSERDA), 2022, New York State Offshore Wind Workforce Gap Analysis, Prepared by BW Research Partnership: https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/Offshore-Wind/New-York-State-Workforce-Gap-Analysis-2022.pdf.

45. From NREL website: "Results are based on the assumption that all industrial inputs and factors of production are used in fixed proportions and respond perfectly elastically. This means that the impacts will typically be linear — that is, directly proportional to the size of the project without respect to economies of scale." https://www.nrel.gov/analysis/jedi/limitations.html.

46. The data for this section is adopted from Bureau of Labor Statistics database on Metropolitan and Non-metropolitan Area Occupational Employment and Wages. This database provides estimates on local employment for all 6-digit SOCs that have 30 or more people employed. Metropolitan Statistical Areas (MSA) are geographical regions with a relatively high population density at its core and close economic ties throughout the area. California has 29 MSA's including Santa Maria-Santa Barbara

and San Luis Obispo-Paso Robles-Arroyo Grande. In order to evaluate potential areas to recruit to close the projected gaps, we collected data on the top three MSAs with the highest Labor Quotients (LQ's) for each of the offshore wind occupations with moderate gap.

47. The CAPEX estimate includes $82 million for turbine components, $157 million for balance of system costs and $99 million in soft costs. The OPEX estimate includes $2 million for maintenance and $2 million for operation costs. Of these figures, CADEMO is expected to spend $94 million of its CAPEX and $3 million of its OPEX locally in California. Local spending on CAPEX, which mainly covers the balance of systems includes substructures and foundations costs, development and assessment costs, port and staging with a focus on assembly, engineering and management costs. At this stage local spending does not include supply chain costs associated with of turbine components production given that they are imported.

48. Of 697 FTE local jobs, 87 FTE jobs relates to DEVEX between 2022 and 2025, and 610 FTE jobs are related to CAPEX between 2024 and 2026, with a peak of 281 annual jobs in 2024-2025 period.

49. Local jobs created during the CAPEX period includes 272 FTE jobs on-site, 9,753 FTE jobs related to local supply chain and support services and 3,177 FTE induced jobs.

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2. *Coastal Infrastructure Co-Benefits Linked to Offshore Wind Development,*, M. Severy, Z. Alva, G. Chapman, M. Cheli, T. Garcia, C. Ortega, N. Salas, A. Younes, J. Zoellick, & A. Jacobson (Eds.), 2020.

3. *California North Coast Offshore Wind Studies*, Schatz Energy Research Center, 2020, http://schatzcenter.org/pubs/2020-OSW-R11.pdf.

4. *Economic Impact of Offshore Wind Farm Development on the Central Coast of California*, Hamilton, S., Ramezani, C., Almancen, C., and Stephan, B., 2021, https://reachcentralcoast.org/wp-content/uploads/Economic_Value_OSW_REACH.pdf.

5. *Floating Offshore Wind in California: Gross Potential for Jobs and Economic Impacts for Two Future Scenarios*, Speer, B., D. Keyser, and S. Tegen., National Renewable Energy Laboratory 2016.

6. *Economic Impact Analysis of Offshore Wind Development in California*, Wei, D., Rose, A., and Einbinder, A., Draft Report to American Wind Energy Association (AWEA), Offshore Wind California (OWC), and The Energy Foundation, 2021.

7. *Economic Impact Study of New Offshore Wind Lease Auctions by BOEM*, Zhang, F., Cohen, M., and Barr, A., Report by Wood Mackenzie Power & Renewables, 2020, https://www.noia.org/wpcontent/uploads/2020/08/Offshore-wind-economic-impact-analysis-white-paper-final-1.pdf.

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9. *New York State Offshore Wind Workforce Gap Analysis*, 2022, https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/Offshore-Wind/New-York-State-Workforce-Gap-Analysis-2022.pdf.

10. *Potential Impact Of The Development Of The Offshore Wind Energy Industry On Hampton Roads And Virginia*, 2020, https://hamptonroadsalliance.com/wp-content/uploads/2020/09/Offshore-Wind-Economic-Impact-Report-092820.pdf.

11. *The Demand for a Domestic Offshore Wind Energy Supply Chain,* Shields, M., Marsh, R., Stefek, J., Oteri, F., Gould, R., Rouxel, N., Diaz, K., Molinero, J., Moser, A., Malvik, C. and Tirone, S., (No. NREL/TP-5000-81602), National Renewable Energy Lab, Golden, CO, 2022.

12. *Floating Offshore Wind – a Global Opportunity,* Global Wind Energy Council. 2022.

13. *Potential impacts of floating wind turbine technology for marine species and habitats,* Maxwell, S. M., Kershaw, F., Locke, C. C., & Conners, M. G., Journal of Environmental Management, Volume 307, 2022.

14. *The Demand for a Domestic Offshore Wind Energy Supply Chain,* Shields, M., Marsh, R., Stefek, J., Oteri, F., Gould, R., Rouxel, N., Diaz, K., Molinero, J., Moser, A., Malvik, C. and Tirone, S., (No. NREL/TP-5000-81602), National Renewable Energy Lab, Golden, CO, 2022.

Appendix

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9. Appendix A: Projects' Cost Structure and Earnings Under Alternative Scenarios

Table A.1: Cost Structure Under Alternative Scenarios

A: CADEMO's Cost Structure by CAPEX-OPEX and Local Content Scenario

Scenarios for CADEMO Project	A1	A2	B1	B2
OPEX/CAPEX Parameters	Adjusted by CADEMO		Model Defaults	
Local Content	Base	High	Base	High
Nameplate Capacity (MW)	60.0	60.0	60.0	60.0
Number of Turbines	4.0	4.0	4.0	4.0
Construction Summary				
Project Cost ($/kW)	5905.3	5905.3	8380.5	8380.5
Total Cost ($ million)	354.3	354.3	502.8	502.8
Total Local Expenditures ($ Million)	130.4	154.0	166.7	194.5
Overall Construction Local Content	36.8%	43.5%	33.1%	38.7%
O&M Summary				
Operating Cost ($/kW)	62.5	62.5	119.1	119.1
Annual Cost ($ million)	3.8	3.8	7.1	7.1
Total Local Expenditures ($ million)	3.0	3.0	5.7	5.7
Overall O&M Local Content	80.7%	80.7%	79.5%	79.5%

B: Commercial Scale Cost Structure by Local Content Scenarios

Scenarios for Commercial Scale	C1	C2	C3
OPEX/CAPEX Parameters	Model Defaults		
Local Content	Low	Mid	High
Nameplate Capacity (MW)	990.0	990.0	990.0
Number of Turbines	66.0	66.0	66.0
Construction Summary			
Project Cost ($/kW)	4422.6	4422.6	4422.6
Total Cost ($ million)	4378.4	4378.4	4378.4
Total Local Expenditures ($ million)	951.7	1776.2	2041.2
Overall Construction Local Content	21.7%	40.6%	46.6%
O&M Summary			
Operating Cost ($/kW)	120.9	120.9	120.9
Annual Cost ($ million)	119.7	119.7	119.7
Total Local Expenditures ($ million)	48.8	93.7	93.7
Overall O&M Local Content	40.8%	78.3%	78.3%

Table A.2: CADEMO's Earnings Impact Under Alternative Scenarios

Scenario		A1	A2	B1	B2
Construction		Earnings ($ Millions)	Earnings ($ Millions)	Earnings ($ Millions)	Earnings ($ Millions)
Installation Activities (Onsite)	Foundation	0.1	0.3	0.1	0.3
	Scour Protection	0.2	0.2	0.2	0.2
	Turbine	1.7	1.7	1.7	1.7
	Array and Export Cabling	0.0	0.4	0.0	0.4
	Other	0.0	0.4	0.0	0.4
	Subtotal	**2.0**	**3.0**	**2.0**	**3.0**
Component Manufacturing and Supply Chain/ Support Services	Nacelle	0.0	3.2	0.0	3.2
	Blades	0.0	3.1	0.0	3.1
	Tower	0.0	1.8	0.0	1.8
	Foundation	15.9	17.5	15.9	17.5
	Array & Export Cables	0.0	0.2	0.0	1.6
	Substation	0.0	0.2	0.0	1.6
	Onshore Transmission	3.0	3.3	9.2	10.3
	Ports and Staging	5.2	5.4	5.2	5.4
	Installation, Development and Other	41.9	43.7	68.2	70.0
	Subtotal	**66.1**	**78.6**	**98.5**	**114.6**
Induced		13.1	16.3	18.7	22.6
Total		**81.2**	**97.9**	**119.2**	**140.2**
California's Share of Global Earnings		**39.2%**	**47.3%**	**37.1%**	**43.7%**

Scenario	A1	A2	B1	B2
Operations and Maintenance (Annual, Ongoing)	Earnings ($ Millions)	Earnings ($ Millions)	Earnings ($ Millions)	Earnings ($ Millions)
Technicians and Management	0.4	0.4	0.5	0.5
Supply Chain/Support Services	1.1	1.1	2.0	2.0
Induced	0.4	0.4	0.7	0.7
Total	**2.0**	**2.0**	**3.3**	**3.3**
California's Share of Global Earnings	**83.8%**	**83.8%**	**81.3%**	**81.3%**

Table A.3: Earnings Impact of Commercial Scale Under Alternative Scenarios

Scenario		C1	C2	C3
Construction		Earnings ($ Millions)	Earnings ($ Millions)	Earnings ($ Millions)
Installation Activities (Onsite)	Foundation	3.9	1.0	5.8
	Scour Protection	0.0	6.3	6.3
	Turbine	13.8	19.4	19.4
	Array and Export Cabling	3.1	0.3	3.1
	Other	0.4	0.0	0.4
	Subtotal	**21.2**	**27.0**	**35.0**
Component Manufacturing and Supply Chain/ Support Services	Nacelle	0.0	53.0	53.0
	Blades	50.4	13.2	50.4
	Tower	30.1	6.0	30.1
	Foundation	147.9	437.3	437.3
	Array & Export Cables	0.0	16.0	26.3
	Substation	0.0	16.0	26.3
	Onshore Transmission	92.7	83.5	83.5
	Ports and Staging	25.2	78.7	81.7
	Installation, Development, and Other	104.4	181.4	196.6
	Subtotal	**450.6**	**885.2**	**985.2**
Induced		99.4	185.7	211.7
Total		**571.2**	**1097.9**	**1231.9**
California's Share of Global Earnings		**22.2%**	**42.7%**	**47.9%**

Scenario	C1	C2	C3
Operations and Maintenance (Annual, Ongoing)	Earnings ($ Millions)	Earnings ($ Millions)	Earnings ($ Millions)
Technicians and Management	11.3	9.0	9.0
Supply Chain/Support Services	11.6	33.6	33.6
Induced	7.7	12.0	12.0
Total	**30.5**	**54.6**	**54.6**
California's Share of Global Earnings	**45.5%**	**81.3%**	**81.3%**

10. Appendix B: JEDI Technical Inputs

Table B.1: JEDI Technical Inputs for Cademo and Commercial Scale Projects

Category	Units	Input Value for CADEMO	Input Value for Morro Bay
PROJECT PAREMETERS			
Economic Analysis Area	State	California	California
Year Construction Starts	Year	2024	2027
Money Value (Dollar Year)	Year	2023	2023
PLANT CHARACTERISTICS			
Plant Capacity	MW	60	990
Number of Turbines		4	66
Array Layout		Grid	Grid
Row Spacing	# rotor diameters	7	7
Turbine Spacing	# rotor diameters	7	7
TURBINE DESIGN			
Turbine Selector		15 MW	15 MW
SITE CHARACTERISTICS			
Site Depth	meters	70	1080
Mean Windspeed	meters/second	8.4	8.4
Distance: Port to Site	kilometers	440	440
Distance: Site to Offshore Substation	kilometers	4.5	2
Distance: Offshore Substation to Landfal	kilometers	5	40
Distance: Landfall to Interconnection	kilometers	10	10
Landfall Trench Length	kilometers	3	3
SUBSTRUCTURE DESIGN			
Substructure Type		Semisubmersible	Semisubmersible
Foundation Type		Floating	Floating
Scour Protection	$/tonne	40	40
ELECTRICAL INFRASTRUCTURE			
Export Cable Selector		XLPE 1000m 220kV	XLPE 1000m 220kV
Redundant Export Cable		0	0
Additional Export Cable Length	%	0.00%	0.00%
Array Cable Selector		XLPE 185mm 66kV	XLPE 185mm 66kV
Second Array Cable Selector		None	None
Additional Array Cable Length	%	0.00%	0.00%
# Offshore Substations		1	1
PORT CHARACTERISTICS			
Port Rate	$/month	$2,000,000	$2,000,000
# Cranes		1	1
VESSEL DEPLOYMENT			
Floating Installation Support Vessel	# vessels	1	1
	day rate	$100,000	$100,000
Floating Installation Towing Vessel	# vessels	1	1
	day rate	$30,000	$30,000
	# Towing Groups	1	1
Offshore Substation Installation Floating Heavy Lift Vessel	# vessels	1	1
	day rate	$500,000	$500,000
Offshore Substation Installation Floating Barge Vessel	# vessels	1	1
	day rate	$120,000	$120,000
Cabling Installation Array Cable Installation Vessel	# vessels	1	1
	day rate	$120,000	$120,000
Cabling Installation Export Cable Installation Vessel	# vessels	1	1
	day rate	$120,000	$120,000

11. Appendix C: Local Content Assumptions by Component for Each Scenario

Table C.1: JEDI Local Content Input Under Alternative Scenarios

Scenarios	A1/B1	A2/B2	C1	C2	C3
Estimated by	CADEMO	Authors	CA Energy Commission	CADEMO	Authors
Local Content	% Base	% High	% Low	% Mid	% High
Turbine Component Costs					
Nacelle/Drivetrain					
Materials	0	10	0	10	10
Labor	0	30	0	30	30
Blades	0	0	0	0	0
Materials	0	50	50	10	50
Labor	0	50	50	30	50
Towers	0	0	0	0	0
Materials	0	50	50	10	50
Labor	0	50	50	50	50
Other/Miscellaneous	0	0	0	0	0
Balance of System Costs					
Substructure and Foundation					
Monopile	0	0	0	0	0
Monopile Materials	0	0	0	0	0
Monopile Labor	0	0	0	0	0
Scour Protection	0	0	0	0	0
Scouring Protection Materials	0	0	0	0	0
Scouring Protection Labor	0	0	0	0	0
Spar	0	0	0	0	0
Spar Materials	0	0	0	0	0
Spar Labor	0	0	0	0	0
Semisubmersible	50	50	20	50	50
Semisubmersible Materials	0	0	0	0	0
Semisubmersible Labor	0	0	0	0	0
Mooring System	15	80	20	80	80
Mooring System Materials	0	0	0	0	0
Mooring Systems Labor	0	0	0	0	0
Electrical Infrastructure Components					
Array Cable System	0	30	0	30	30
Materials	0	0	0	0	0
Labor	0	0	0	0	0
Export Cable System	0	20	0	5	20
Materials	0	0	0	0	0
Labor	0	0	0	0	0
Offshore Substation	80	40	0	10	40
Materials	0	0	0	0	0
Labor	0	0	0	0	0

Table C.1 (Cont): JEDI Local Content Input Under Alternative Scenarios

Scenarios	A1/B1	A2/B2	C1	C2	C3
Balance of System Costs					
Assembly and Installation					
Foundation					
Vessel	5	30	20	5	30
Labor	5	30	20	5	30
Mooring System	0	0	0	0	0
Vessel	70	70	0	70	70
Labor	70	70	0	70	70
Turbine	0	0	0	0	0
Vessel	70	70	50	70	70
Labor	70	70	50	70	70
Array Cable	0	0	0	0	0
Vessel	5	50	50	5	50
Labor	5	50	50	5	50
Export Cable	0	0	0	0	0
Vessel	5	50	50	5	50
Labor	5	50	50	5	50
Offshore Substation	0	0	0	0	0
Vessel	5	50	50	5	50
Labor	5	50	50	5	50
Scour Protection	0	0	0	0	0
Vessel	5	5	0	5	5
Labor	5	5	0	5	5
Ports and Staging					
Foundation	70	70	20	70	70
Mooring System	80	85	0	80	85
Turbine	80	85	50	80	85
Array Cable	80	85	50	80	85
Export Cable	80	85	50	80	85
Offshore Substation	80	85	50	80	85
Scour Protection	80	85	0	80	85
Development and Other Project Costs					
Site Auction Price	80	85	0	80	85
BOEM Review	90	85	0	90	85
Construction Operations Plan	80	85	50	80	85
Design Install Plan	80	85	50	80	85
Site Assessment Plan	80	85	50	80	85
Site Assessment Activities	100	100	50	100	100
Onshore Transmission	80	90	100	90	90
Engineering and Management					
Construction Operations	80	80	50	80	80

Table C.1 (Cont): JEDI Local Content Input Under Alternative Scenarios

Scenarios	A1/B1	A2/B2	C1	C2	C3
Estimated by	CADEMO	Authors	CA Energy Commission	CADEMO	Authors
Local Content	% Base	% High	% Low	% Mid	% High
Total OPEX					
Maintenance					
Offshore Maintenance					
Technicians (Labor)	75	75	100	75	75
Spare Parts	75	75	50	75	75
Vessels	75	75	50	75	75
Onshore Electric Maintenance	75	75	50	75	75
Operations					
Operation, Management and General Administration	90	90	100	90	90
Operating Facilities	90	90	21	90	90
Environmental, Health, and Safety Monitoring	90	90	100	90	90
Insurance	90	90	0	90	90
Annual Leases and Fees	90	90	0	90	90
Soft Costs					
Commissioning	0	0	50	0	0
Construction Finance	0	0	0	0	0
Construction Insurance	0	0	0	0	0
Contingency	10	10	0	10	10
Decommissioning	70	70	50	70	70
Other/Miscellaneous	0	0	50	0	0

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