TRIAL RUN FOR CALIFORNIA'S OFFSHORE WIND WORKFORCE

Lessons Learned From the CADEMO High Road Training Partnership | July 5, 2023

HIGH ROAD
TRAINING PARTNERSHIP

This report was written pursuant to a High Road Training Partnership (HRTP) grant from the California Workforce Development Board (CWDB). The California Offshore Wind HRTP is funded through California Climate Investments, a statewide initiative with cap and trade funding to reduce greenhouse gas emissions, strengthen the economy, and improve public health and the environment – particularly in disadvantaged communities.

Contributors:

- **HRTP Program Liaison:** Rafael Aguilera, California Workforce Development Board
- **HRTP Grant Administrator:** Michael Specchierla, San Luis Obispo County Office of Education & SLO Partners
- **HRTP project coordinator and lead author of report:** Robert Collier, Floventis Energy. **Report co-authors:** David Vallee and Miriam Noonan, Floventis Energy; Stephanie Tsai, consultant. **Copy editor:** Deborah Meacham. **Designer:** Toben Dilworth.
- **The Economic and Employment Impact of Floating Offshore Wind Projects in California's Central Coast:** Cyrus Ramezani, Ph.D., and Mahdi Rastad, Ph.D., Cal Poly San Luis Obispo Orfalea College of Business.

Acknowledgments: Special thanks for support in this HRTP to the following individuals: Jeremy Smith, State Building and Construction Trades Council of California; Joshua Medrano and Martin Rodriguez, Tri-Counties Building and Construction Trades Council; Nancy Rader, California Wind Energy Association (CalWEA); Marina Secchitano, Inlandboatmen's Union of the Pacific; Sean Farley, International Longshore & Warehouse Union; and Benjamin Ruttenberg, Cal Poly Center for Coastal Marine Sciences.

Cover photo credit: ABB

Recommended citation: Collier, Robert, David Vallee, Miriam Noonan, and Stephanie Tsai, "Trial Run for California's Offshore Wind Workforce: Lessons Learned From the CADEMO High Road Training Partnership." California Workforce Development Board, July 5, 2023. www.offshorewindhrtp.slocoe.org.

TRIAL RUN FOR CALIFORNIA'S OFFSHORE WIND WORKFORCE

Lessons Learned From the CADEMO High Road Training Partnership | July 5, 2023

PHOTO: shutterstock

TABLE OF CONTENTS

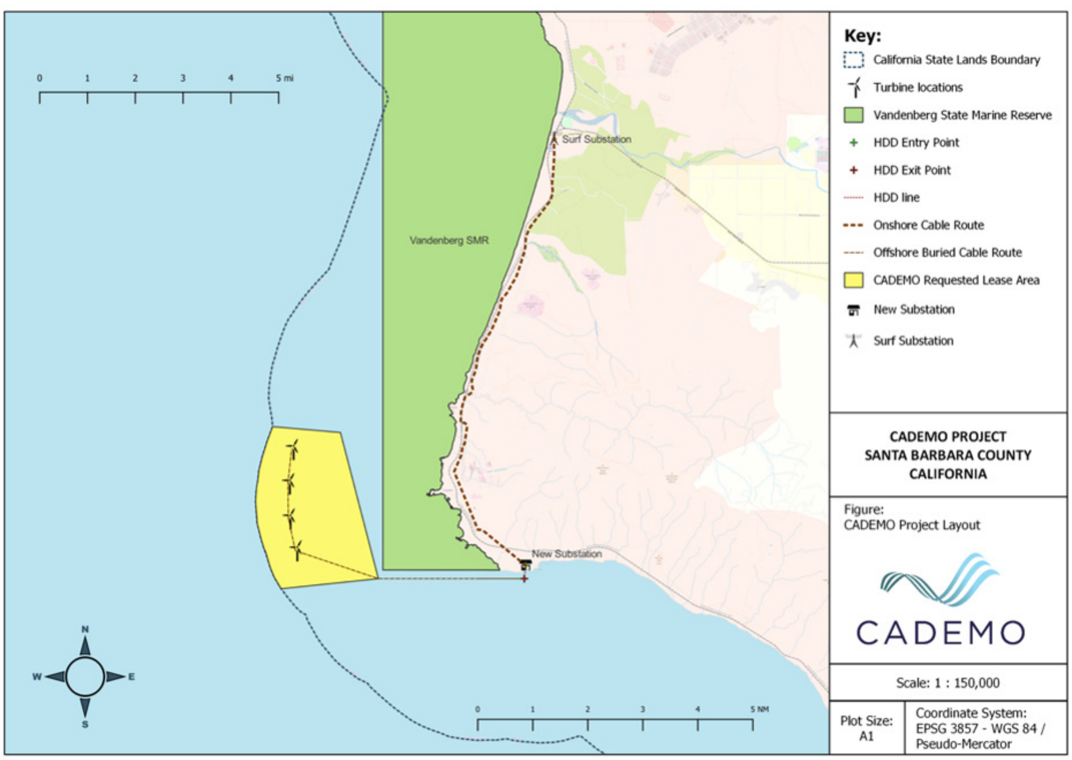
EXECUTIVE SUMMARY

Offshore wind power generation appears on the verge of becoming a major growth industry in California. With hundreds of enormous turbines to be installed off the state's Central and North Coasts, economic benefits are projected to be high.[1] But these expectations are untested, based largely on desktop research.

This report takes an empirical approach instead, examining the potential economic and workforce benefits and trade-offs of one offshore wind project, CADEMO, which is likely to be the state's first in operation. The report was prepared by participants in the Offshore Wind High Road Training Partnership (HRTP) program, funded by the California Workforce Development Board. This HRTP, which is ongoing through early 2024, uses CADEMO to test the "high road" concept of labor-management cooperation, job creation, and community benefits – all amid the tough market competition of a nascent industry.

While this report does include an economic impact analysis using desktop models, its primary focus is on the practical requirements for CADEMO's supply chain and workforce. The report is, in effect, the result of a collaborative effort in industrial planning among the HRTP partners: CADEMO's owner and developer, Floventis Energy; the state's building and construction trades unions; electrical union IBEW 1245; California Polytechnic State University, San Luis Obispo (Cal Poly); the San Luis Obispo County Office of Education; and SLO Partners.

CADEMO is a demonstration project with four full-size, 15 MW turbines floating in state waters off the coast of Vandenberg Space Force Base in northern Santa Barbara County. Because CADEMO is expected to be operational in late 2027, years before the first commercial-scale projects planned in federal waters, it offers a test case of the workforce impacts and planning choices for the industry and government policymakers prior to the installation of hundreds of turbines farther offshore.



SOURCE: Floventis

PHOTO: Mammoet

Lessons Learned: Labor Relations

The first of many lessons learned from this HRTP is simply that labor-management cooperation can be effective – but also hard to create. Floventis and the unions spent two years negotiating a project labor agreement (PLA), wrestling with the complexities of industrial cooperation and shared risk in a new industry with little existing supply chain. The resulting PLA, signed in November 2022, is intended to serve as a template for the state's offshore wind industry as it expands in future years. The industrial expertise of these counterparties comes from naturally different perspectives but has jointly served to clarify the path forward on many key issues, including port facilities, supply chain, and workforce training.

The PLA's initial signatories included the State Building and Construction Trades Council and IBEW 1245 and subsequently expanded to include other unions. It covers all construction-related work, plus all transmission and substation installation, to be carried out in California onshore and offshore by CADEMO contractors and subcontractors. The PLA does not alter the customary jurisdiction of non-construction unions, such as the marine trades and the International Longshore and Warehouse Union (ILWU), which will be included in the project through their existing relationships with CADEMO contractors and subcontractors.

By including the relevant unions from the start, Floventis earns several win-win benefits: removing the risk of last-minute uncertainty in contract negotiations; ensuring a stable and well-trained workforce through the existing apprentice system and related programs; and gaining the support of influential union allies to partner in outreach to state and local policymakers.

Lessons Learned: Ports and Jobs

For CADEMO and the initial projects in federal waters, the turbine components themselves – towers, nacelles, and blades – must be manufactured out of state because attracting such a capital-intensive industry to California will take a decade or more. But the logistical requirements of the construction, assembly, final integration and deployment of floating offshore platforms mean that these operations should be conducted in California. As a result, our HRTP analysis, in tandem with CADEMO's supply chain planning, began with the search for suitable ports.

Our initial outreach with port officials up and down the California coast found that the options for creating new facilities or upgrading existing port facilities to a sufficient standard were few and far between. In particular, it must be said directly from the start to avoid raising false hopes: Despite initial public discussions in the Central Coast region about a possible new mega-port facility sited in the immediate area where CADEMO and other offshore wind projects could create thousands of local jobs, we found such a scenario to be highly unlikely. The only port locations where construction, assembly, and final integration of the floating platforms might be feasible are located elsewhere in the state. As a result, offshore wind job creation in the Central Coast region will be relatively modest.

After much technical dialogue with port officials, CADEMO plans to construct its platforms at the Port of San Francisco, if the facilities there can be upgraded in a suitable timeframe, with final turbine integration at Port of Los Angeles. In the unlikely event that no California port facility becomes available in time to construct the platforms, the project would be obliged to import these from out of state and conduct final turbine integration them at Los Angeles.

Jobs creation from offshore wind in the Central Coast will take place through the local construction of electrical transmission infrastructure, as well as long-term operations and maintenance activities. In this latter O&M phase, an existing, local port facility such as Morro Bay or Port San Luis could serve, perhaps with small-scale infrastructure upgrades, for the docking of repair crew transfer boats. A related option for O&M servicing possibly could be the use of helicopter-based crews from a local airport such as Santa Maria. But as with other offshore wind projects on the Central Coast, CADEMO's primary jobs impact – like that of the much larger projects in the federal Morro Bay lease area – will take place at major port facilities outside of the immediate region.

MAP: Floventis

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
	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**

Overall Economic Impact of a Morro Bay Project

Project Phase	Impact Categories	Jobs (FTE)	Earnings ($ Millions)	Output ($ Millions)	GDP ($ Millions)
Construction	Onsite	272	27	27	27
	Supply Chain	9,753	885.2	2,593	1,165.3
	Induced	3,177	185.7	631.3	381.2
	Total	**13,202**	**1,097.2**	**3,251.2**	**1,573.5**
Operations (Annual)	Onsite	100	9	9	9
	Supply Chain	394	33.6	126.2	57.9
	Induced	190	12	37.9	22.9
	Total	**684**	**54.6**	**173.1**	**89.8**

SOURCE: Cal Poly

The tables above, explained in **Chapter 3** and more fully in the Cal Poly report in the **Appendix**, show the projected economic impact from CADEMO and from a hypothesized model for one of the three gigawatt-scale projects in the federal Morro Bay leasing zone. The latter are not yet in the development stage, so their capital and operating expenses were estimated. In both categories, the “onsite” jobs – that is, those in Santa Barbara and San Luis Obispo Counties – will be modest in comparison to the jobs created in other phases. For methodological reasons, it is impossible to determine with precision the geographic locations of each category listed, but it is safe to say that the San Francisco Bay Area and the Los Angeles-Long Beach area will inevitably be the big winners for CADEMO and the Morro Bay projects.

Nonetheless, Floventis is working with Central Coast partners, leading with the Santa Ynez Band of Chumash Indians, to create community benefits agreements that include targeted hiring and environmental cooperation.

Lessons Learned: Supply Chain

Our research has found that the California jobs potential of manufacturing turbine components for offshore wind projects is slim, at least for CADEMO and the initial projects in federal waters, while the potential for construction and assembly of floating platforms is significant.

Of the many platform models currently available in the offshore wind industry's global marketplace, Floventis has not yet chosen which will be used for CADEMO. For the purposes of this HRTP, it has closely analyzed two models: a steel tension-leg platform and a concrete barge. With regard to the former, California lacks any fabricators for the huge rolled steel pieces that will be needed, so these pieces would likely be imported and then welded together at a U.S. port. The latter requires large concrete forms that could readily be made with locally produced concrete at San Francisco. For both, the Bay Area's large and highly skilled construction workforce would easily suffice to fill project needs.

For CADEMO as well as all projects in federal waters, the most difficult needs for supply chain and workforce are in the marine sector: the launch of floating platforms from wharf into water, final turbine integration, and anchor and cable laying. These are challenging not primarily because skilled workers are hard to find, but because legally compliant vessels themselves will be scarce and may need to be sourced from abroad. Difficulties are likely to arise with the Jones Act (requiring U.S.-flagged vessels) and California's newly strengthened offshore emissions standards. These dilemmas urgently require the attention of state and federal government agencies in cooperation with the offshore wind industry.

Lessons Learned: Workforce Training

For all construction work in the project, the PLA will provide access to California's highly effective system of state-certified joint union-employer apprenticeship programs. These programs are flexible and can be adapted with new modules tailored to the demands of the project. They are expected to resolve all workforce needs for the land-based phases of CADEMO and larger-scale offshore wind projects.

Floventis also expects to access the well-developed employer-union training programs in marine services and port terminal operations through its contractors' and subcontractors' relationships with marine services unions and the ILWU.

Our analysis found that CADEMO's key workforce training gaps derive directly from supply chain gaps – i.e., for the vessels launching the platforms, integrating the turbines, and laying the anchors and cables. West Coast marine contractors currently lack semi-submersible barges, jack-up wind turbine integration vessels, and vessels for laying anchors and cables. CADEMO's PLA stipulates that on board the U.S.-flagged vessels, all construction-related workers will need to be members of PLA signatory unions for the applicable craft categories. On foreign-flagged vessels, 50 percent of construction-related workers must be PLA signatory union members. For these and other U.S. offshore workers, additional training will be needed.

California educational institutions and labor unions would be well advised to partner in creating offshore training programs, especially for the long-term operations and maintenance phases of offshore wind farms. A relevant example of such a program, which deserves consideration in California, is at Bristol Community College in New Bedford, Massachusetts, which offers associate degree programs in various offshore wind technology specializations, augmented with Global Wind Organization safety certificates.

Floventis also has identified potential opportunities for future offshore wind projects to partner with the offshore and onshore oil industry amid the region's transition from fossil fuels to renewable energy. These areas of collaboration could include offshore logistical assets, port facilities, and workforce retraining and upskilling. These opportunities deserve attention from industry and government officials in the coming years.

PHOTO: Shutterstock

Conclusion

The final success or failure of this HRTP will be seen only when CADEMO is built and operating. The "high road" model for California's offshore wind industry must be proven as part of a viable business strategy amid tough economic competition in the electricity marketplace. The green jobs that count are those created in California, not elsewhere. The job training that helps workers and communities is centered on the state-certified apprenticeship system, not in isolation from it. These challenges can be surmounted, but success is not guaranteed.

The key to achieving all these goals is early, proactive cooperation. By partnering sooner rather than later, the state's labor unions, offshore wind companies, and educational institutions can ensure that this new industry will contribute to the state's clean energy goals while providing equitable economic benefits for Californians.

CHAPTER 1. CHALLENGES FOR CALIFORNIA OFFSHORE WIND: HIGH ROAD OR LOW ROAD?

As numerous studies have analyzed, the floating offshore wind industry offers enormous potential, not only to help California attain its goal of 100 percent clean energy by 2045, but to be a driver of equity and good jobs.[2] More than any other renewable energy sector, offshore wind relies on heavy industry, large-scale logistics, and port development – all of which lend themselves to "high road" outcomes of middle-class wages, union representation, and community benefits. In short, the sector is a test case of the state's tenet that green jobs should be good jobs.[3]

In response to this potential, California has set ambitious offshore wind-capacity planning goals of 2-5 GW by 2030 and 25 GW by 2045. The state has partnered with the Biden administration on related initiatives, including the Federal-State Offshore Wind Implementation Partnership, which intends to spur creation of a domestic supply chain and skilled workforce.[4] Under California's AB 525, signed into law in 2021, the California Energy Commission is conducting a series of planning studies for the sector.[5]

Public expectations for the offshore wind industry have been set high. Less attention, however, has been given to the hard realities facing the sector, which depends on bold government action to develop ports, improve transmission networks, enable viable power purchase agreements, and mitigate stakeholder disputes. Furthermore, the offshore wind industry is highly globalized and competitive, with fully established supply chains in Europe, East Asia, and elsewhere that could induce California developers to opt for imported products and services.

This report examines the potential economic and workforce benefits of California offshore wind from a practical perspective, focusing on the state's first offshore wind project, CADEMO, in state waters off Vandenberg Space Force Base in northern Santa Barbara County.[6] This project comprises four 15 MW floating turbines and is being developed by Floventis, a joint venture between offshore wind developer Cierco and offshore energy infrastructure firm SBM Offshore. Because CADEMO is expected to be operational in late 2027, years before the commercial-scale projects planned in federal waters, it offers a practical test case of the workforce impacts and planning choices for the industry and government policymakers alike.

High Road Training Partnerships

This report contains a partial summary of research and analysis carried out through the Offshore Wind High Road Training Partnership (HRTP), funded by the California Workforce Development Board. This HRTP is one of two dozen such state-supported initiatives in a wide range of industries. The state's overall HRTP program, launched in 2018, provides support for model industry partnership strategies between "high road" employers and labor, with the intent of incorporating economic and social equity into the state's climate transition. Most of these HRTPs are centered on worker training programs in existing, mature industries. In contrast, the Offshore Wind HRTP takes advantage of a historically unique moment in a California industry that is still being born.

HIGH ROAD
TRAINING PARTNERSHIP

By centering its analysis on CADEMO, this report adopts an empirical approach through planning and industrial engagement, not desktop analysis. It provides practical, hard-won lessons from CADEMO's own labor negotiations, supply chain development, port facility engineering, stakeholder outreach, and workforce training planning with industrial partners.

Like the HRTP itself, this report focuses on offshore wind's blue-collar and technical workforce, not on its managerial and professional positions. While there are meaningful opportunities for management and professionals engaged in offshore wind production, these positions are less numerous and have training needs and processes that do not rely on public policies for guidance and support.

International Context: The Role of Demonstration Projects

As mentioned above, the overall opportunities and challenges of the California offshore wind sector have been widely analyzed in numerous reports from government, academic, and NGO sources. This report will not repeat that information. However, it is important to note the role played by demonstration projects in the offshore wind industry globally, starting with fixed-bottom projects. Since the first fixed-bottom offshore wind project off Sweden in the late 1980s, the industry's growth in Europe has relied, step after step, on pilot projects of progressively greater size and technological complexity.

For its part, the floating offshore wind sector, which has no commercial projects globally to date, also has begun to leapfrog forward with pilot projects. Examples to date include Hywind (30 MW) and Kincardine (50 MW) in Scotland, Wind Float Atlantic (25 MW) off Portugal, and Provence Grand Large (25 MW) in southern France. The UK is following up on Hywind and Kincardine with progressively larger floating projects, next including Erebus (100 MW) and Floventis's Llyr 1 and 2 (200 MW total) off Wales, leading subsequently to larger projects.

Development of the floating sector in Asia is spearheaded by China. The world's offshore wind leader installed a 5.5 MW floating demonstration project, Yangxi Shapa III, off Guangdong Province in 2022. China is building several more demonstration projects, including the CNOOC Deep Sea (7.25 MW) and the CSSC Fu Yao (6.2 MW), both expected to be operational in 2023.[7] China's next stage will be a pre-commercial 200 MW floating project off Hainan Island by 2025, followed quickly by multi-gigawatt projects.

In these locations around the world, demonstration projects do far more than allow turbine and platform manufacturers to prove their technological and commercial readiness. These projects serve site-specific purposes tailored to each region's particular needs. At each site, demonstration projects have goals similar to those of CADEMO: evaluating environmental impacts and mitigation measures in the region's unique ecosystem; creating a local supply chain; developing port facilities; developing support from a wide variety of stakeholders; and deconflicting regulatory challenges.

As the challenges vary by location, the findings and solutions will be different for CADEMO compared to those in Europe, Asia, and elsewhere. This HRTP is an integral part of that exploratory analytical process. By focusing specifically on supply chain, ports, labor, and workforce in California's unique conditions, this HRTP will help reduce costs, decrease project risk, and increase public support for California offshore wind in the years to come.

Key Assumptions

In this report, we analyze the abovementioned topics as they have emerged in preparations to build and operate CADEMO. Underlying our analysis are several key assumptions.

Geographic scope. Because the vast majority of economic activity resulting from offshore wind development occurs at the ports where the projects are built and assembled, it is crucial to acknowledge which ports any given project will use. The same is true for CADEMO. The analysis in this report is based on findings by the CADEMO team's intensive investigation of port facilities, which included repeated visits to ports throughout the state and in-depth dialogue with port officials from 2021 to the present. These findings were supported by recent studies of potential port options on the Central Coast conducted by Moffatt & Nichol for the California State Lands Commission and by Mott MacDonald for REACH.[8] Our research showed that there is no feasible option on the Central Coast for offshore wind construction, assembly, final turbine integration, and staging of the offshore installation – at least for CADEMO and most likely for future projects, as well. However, the Central Coast region does offer several realistic options for much smaller-scale port facilities for operations and maintenance of the project once it is installed and starts generating power.

Although this HRTP is geographically focused on the Central Coast, the CADEMO project's economic benefits – like those of the commercial-scale projects in the federal Morro Bay zone – will primarily be created outside the region. The only parts of the project to be conducted within the Central Coast counties of Santa Barbara and San Luis Obispo County are likely to be the land-based transmission installation and the ongoing operations and maintenance activities after the wind farm has been commissioned. Despite the high hopes of some Central Coast residents for a massive economic windfall from offshore wind, these counties are likely to see more modest revenues from such projects.

This HRTP report does not analyze the offshore wind situation of California's North Coast. However, we should note that, in contrast to the broad dispersion of economic benefits for Central Coast projects, those on the North Coast are likely to have a tighter geographic concentration. A specialized offshore wind port facility is being planned for Humboldt Bay, which seems likely to serve as the primary hub for both construction/assembly and final turbine integration for North Coast projects, although the Port of San Francisco could play a supporting role for platform construction.

Ports. Availability of suitable port facilities is a key variable for all offshore wind projects in California, and CADEMO is no exception. Floventis's preferred case is to construct and assemble its floating platforms at the Port of San Francisco, and the company and the port have had extensive dialogue and site visits in relation to this scenario. At the time of this writing, the company and the port are jointly planning for CADEMO to use San Francisco facilities for this purpose, and the port is conducting an engineering feasibility study to determine needs for infrastructure upgrades. The results of that feasibility study will determine whether the Port of San Francisco facilities will be ready in time for CADEMO's use.

At this time, it is unclear when the planned new Port of Humboldt Bay facilities will be completed.

If a suitable California port facility is not available on a timely basis, the project's fallback is to import the platforms from shipyards in East Asia. This default option is neither desired nor being actively planned by Floventis, but it illustrates a dilemma shared with all other California offshore wind projects: the state's lack of specialized port infrastructure, including high weight-bearing capacity wharves with extensive acreage, and the offshore wind industry's dependence on state and federal action to create such facilities. Shipyards and marine construction companies in South Korea, Taiwan, and Indonesia have well-demonstrated, state-supported capacity to build and deploy projects of large scope and complexity at low cost and with fast turnaround, and California should see them as strong competitors for the state's green jobs.

In all cases, Floventis is planning to conduct its final turbine integration – in which the turbine towers, nacelles, and blades are lifted into place atop the floating platforms – in the Port of Los Angeles.

Labor contracts. Floventis is planning to use union labor for the project's construction, assembly, installation, and maintenance work in California. This commitment is codified in CADEMO's Project Labor Agreement, Maintenance Agreement, and Outside Line Agreement, which were signed by Floventis, the State Building and Construction Trades Council of California (SBCTC), and IBEW 1245 in November 2022,[9] followed by the Southwest Mountain States Carpenters in May 2023. The negotiation of this PLA was a core part of the Offshore Wind HRTP, and it demonstrates the willingness of Floventis and unions to form a strong alliance in support of social equity in offshore wind over the short, medium, and long terms. Other unions that are not currently signatories to these agreements, including the International Longshore and Warehouse Union (ILWU) and marine services unions, are expected to participate in CADEMO in accordance with their customary areas of jurisdiction. The unions have stated they anticipate this PLA will become the template for all future offshore wind projects in California.

The incorporation of union labor in all blue-collar parts of CADEMO takes advantage of California's existing framework for workforce training, community benefits, and targeted hiring, as explained in **Chapter 4**. It also increases the economic activity generated by the project due to the use of higher union wage scales.

Supply chain. The negotiation of CADEMO's PLA was a complex two-year process in which both the company and the unions learned valuable lessons. One of these lessons was a truism that is often not fully examined in public policy discourse: the only high-road green California jobs are those that actually take place in California rather than elsewhere. A detailed understanding of the potential supply chain, with the overall intention of maximizing in-state rather than imported inputs and activities, is needed to identify high-road workforce outcomes. The most robust PLA and the most well-planned workforce training programs will be worth little if the floating platforms are built and assembled elsewhere and if the offshore marine services work is done entirely by foreign crews.

For that reason, this HRTP report has incorporated in-depth applied research by Floventis and its industry partners SBM Offshore, Deme Offshore, and Saitec Offshore Technologies, as well as Xodus consultancy. This multi-sided research examines the available options for sourcing, constructing, assembling, and installing this logistically and technically complex project, the likes of which has never been attempted on the U.S. West Coast. Far from being a desktop exercise, this unique research expertise has pinpointed specific links in the supply chain that are the most challenging and others that are the most promising – and what to do about each.

These challenges were recognized in the Bureau of Offshore Wind Management (BOEM) December 2022 auction, in which developers received bid credits in return for promises to create in-state supply chains for their projects.[10] In the coming years, as developers plan how to carry out those commitments, they are likely to face challenges similar to those experienced by CADEMO – and therefore the information in this report is likely to prove particularly relevant.

Project schedule and costs. All economic and workforce impacts for CADEMO are necessarily dependent on the project's internal timeline and budget, which will be impacted by several variables, including the permit process by state and federal regulatory agencies, the decisions on transmission by the state grid operator, the project's levelized cost of energy, and other state and federal policies for supporting offshore wind. While some of these details are proprietary, Floventis expects the project will be constructed and assembled in 2026 and 2027, with final turbine integration and deployment at sea in late 2027.

PHOTO: GE Wind

CHAPTER 2. IDENTIFYING AND LOCALIZING THE SUPPLY CHAIN

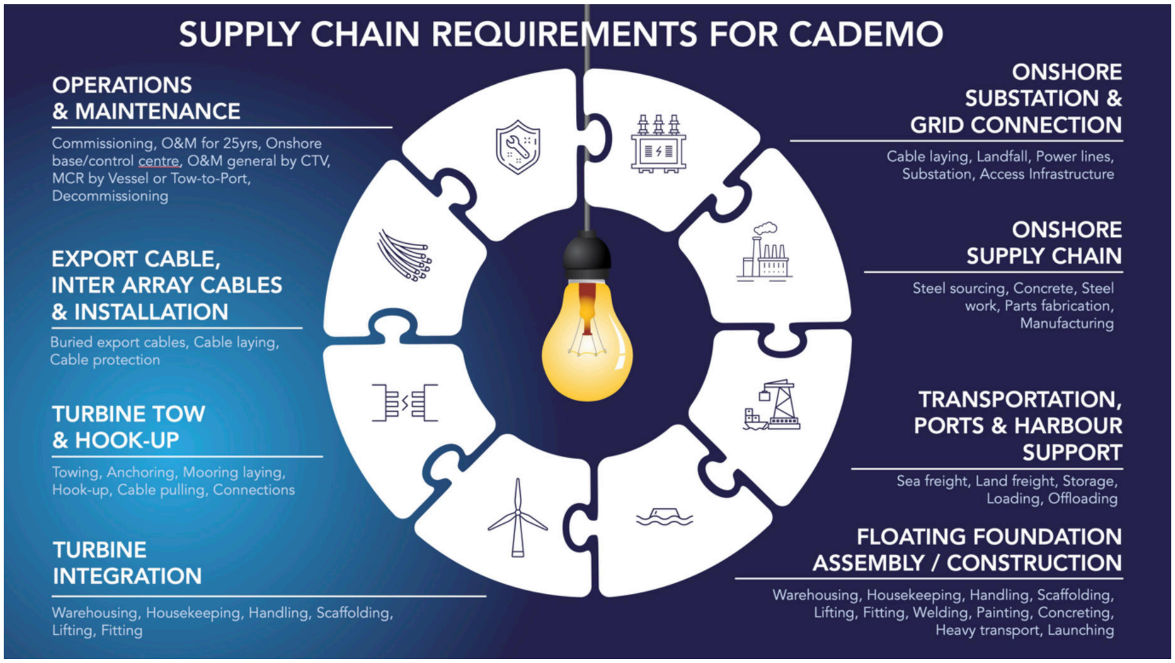
The supply chain requirements for the construction, operation, maintenance, and decommissioning of floating offshore wind projects overlap significantly with those for fixed-bottom offshore wind. Turbines, transmission cables, and substation equipment for the former all are comparable with current standards for the latter. These existing supply chains are mature, albeit with significant growth required to support the additional capacity expected in coming decades.

However, when it comes to port infrastructure requirements, floating offshore wind is far more demanding than fixed-bottom, as recent studies have noted.[11] Fixed-bottom wind typically requires a relatively small amount of wharf laydown space to store components, while many of the larger pieces (towers, nacelles, blades) are brought directly to the offshore wind farm site via barges and assembled there atop the fixed-bottom platform with a jack-up crane vessel that is standing erect in shallow water. In contrast, the floating sector needs to undertake the entire assembly process at a wharf because the seabed below floating offshore wind projects is too deep for jack-ups to touch bottom.

As the following analysis makes clear, the availability of suitable port facilities– or lack thereof – is a key determinant of supply chain development, both for CADEMO and any other project during the decades to come. California currently lacks any suitable port infrastructure for either the construction of floating platforms or their final integration with turbines (i.e., towers, nacelles, and blades). This reality underlines an unprecedented logistical challenge facing California policymakers: how, where, and when to create suitable facilities with the capacity to handle such enormous platforms – each roughly the size of a football field and weighing 5,000 to 15,000 tons – or support the world's tallest and most powerful cranes in the final integration phase.

As **Figure 2.1** shows, most links in the offshore wind supply chain depend on port facilities.

Figure 2.1: Main elements of CADEMO supply chain



SOURCE: Floventis

Sourcing Inputs: Manufacturing vs. Construction

In any analysis of employment creation in the supply chain, it is essential to avoid confusion about the definition of terms. In much public policy discourse about offshore wind, the term "manufacturing" is often used without distinction between what is actually manufactured – that is, elaborated with machinery by industrial methods – and what is constructed or assembled with manufactured inputs and/or raw materials. CADEMO has found that for the California offshore wind sector, the difference between these terms is significant.

The information presented in this chapter indicates that the California jobs potential of manufacturing for offshore wind projects is slim, at least in the short and medium term, while the potential for construction and assembly is substantial.

This information is a combination of analysis undertaken by Floventis and its supply chain partners, along with publicly available data. For CADEMO, the amount of local content expected from the California supply chain is listed in **Table 2.1**.

Table 2.1: Estimated California local content for CADEMO

Categories	In-state capital goods content	In-state labor content
Nacelles	0-10%	0-10%
Blades	0-10%	0-10%
Towers	0-10%	0-10%
Turbine integration	N/A	80%
Floating platforms (steel)	20-30%	50-70%
Floating platforms (concrete)	60-80%	90-100%
Mooring systems	10-20%	70%
Subsea cables	0-10%	70%
Onshore transmission	80-100%	100%
Offshore operations	N/A	30-50%
Project development (Incl management, engineering, and other project costs)	N/A	60-80%
O&M - Offshore maintenance	N/A	60-80%
O&M - Operation, management & admin	N/A	80-100%
Decommissioning	N/A	60-80%

SOURCE: Floventis

Tables 2.2 through **2.7** indicate production processes and potential suppliers and contractors. They are intended for explanatory purposes and should not be considered exhaustive. Failure to mention any relevant process or company is inadvertent. CADEMO has not yet selected its suppliers and contractors for the project.

All contractors and subcontractors will be required to sign the CADEMO Project Labor Agreement, Maintenance Agreement, and Outside Line Agreement, which cover all construction-related and transmission work on land and offshore in California.[12] As mentioned in **Chapter 1**, these labor agreements do not impinge upon the customary jurisdiction of non-construction unions in non-construction work, such as the longshoring and marine trades.

Floating platforms

Platform construction is relatively straightforward construction work, using the same equipment and workforce skills as California's existing construction industry. Major civil works and infrastructure contractors in the state are expected to be fully qualified to conduct the onshore portion of this work.

Different platforms can be built using steel, concrete, or even in a hybrid configuration. In the case of steel, operations will consist of plate cutting, bending, rolling, welding, and applying an anti-corrosion coating. Concrete structures require a large set-down and quay area to build the platform by continuously pouring concrete into formwork molds. The use of prefabricated concrete sections that only need to be assembled may reduce the size of wharf area required.

Conveniently for CADEMO, concrete is available from the CEMEX and Central ready-mix concrete plants at San Francisco's Pier 92, directly adjacent to the Pier 96 backlands area, where a batch plant would be installed. Other components of concrete platforms, such as the steel heave plate and steel tower transition piece, would be prefabricated offsite and probably out of state.[13]

PHOTO: ABB

Because there is no primary steel production in California and no in-state foundries have the capacity for making large tubular steel pieces, it is likely that all major steel components for CADEMO and future projects in federal waters will have to be imported, likely from East Asia, and then assembled in California. The in-state supply chain is estimated to have 57 companies manufacturing smaller-scall steel products, including rolling and drawing of purchased steel, as well as steel pipe and tube manufacturing. It also is likely that smaller cast and/or machined parts required for the project can be made by these in-state foundries.

Turbines

California does not have the manufacturing capacity to produce the major turbine components – nacelles, blades, and towers – and is not projected to develop such a capacity until years after the CADEMO project's completion. For the U.S. offshore wind industry overall, this manufacturing sector is highly capital intensive, technologically advanced, and globally competitive. Its major European and U.S. manufacturers, such as Vestas, Siemens Gamesa, and GE, are not expected to make the huge investments to create California manufacturing facilities until and unless state and federal policymakers commit to a multi-decade, large-scale sequence of offshore wind project development in California and other West Coast states.

The transportation of turbine components to the Port of Los Angeles must be done by ship. Doing so via road or rail is impossible because 15 MW nacelles weigh around 500 tons and measure 30 feet across,[14] the blades are expected to measure 375 feet each, and the towers will measure up to 500 feet, in two or three sections each. At the Port of Los Angeles, it is anticipated that these components will be stored on floating barges in wet storage areas alongside the floating platforms until the integration process begins.

Nacelles

There are three major nacelle manufacturers with confirmed manufacturing capacity in the United States, but none in California. To date, these companies have supplied only the U.S. onshore wind industry, with capacity ratings much smaller than the 15 MW size needed for CADEMO and other California offshore wind projects. It seems unlikely that any in-state nacelle manufacturers will be available at that size in time for deployment on CADEMO.

Blades

There are four major companies with confirmed manufacturing capacity in the United States, but none in California, and none currently makes blades as large as those needed for CADEMO. However, Siemens Gamesa has announced it will build a factory for 15 MW blades for offshore wind farms in Portsmouth, Virginia. These facilities are expected to be operational by the mid-2020s, possibly in time to supply CADEMO, although output is likely to be backordered for years by the multi-gigawatt, fixed-bottom offshore wind projects that will be in construction along the East Coast at that time.

Towers

Because offshore wind turbines are so much bigger than onshore turbines, the offshore towers must be considerably larger, approximately 400-450 feet tall, and therefore cannot be transported by road or rail. For this reason, none of the nation's existing inland manufacturers will suffice for California. A tower manufacturing plant specifically for offshore wind is planned at the Port of Albany, New York, although its construction is facing major delays,[15] and once operational, its production is expected to be backordered for many years.

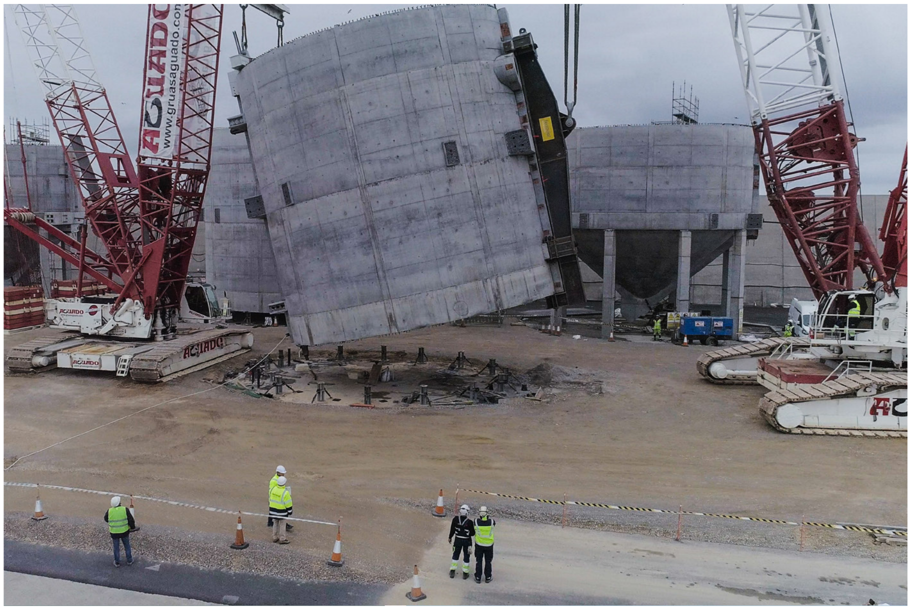
Phases of the Supply Chain

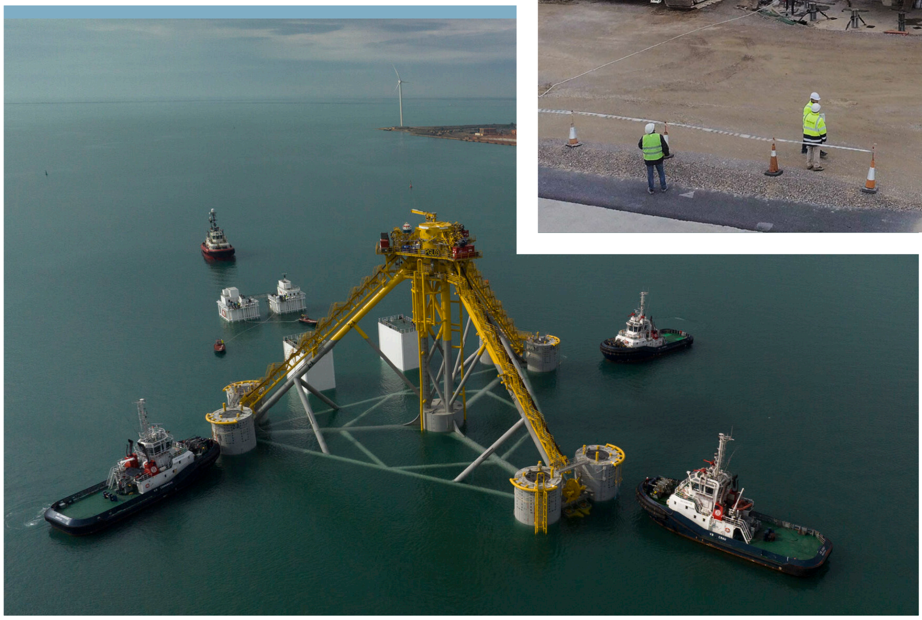
Platform design

Of the dozens of competing platform designs currently available in the offshore wind industry marketplace, Floventis has not yet selected which it will use for CADEMO, but expects to make its final decision in early 2024. For the purposes of this report, Floventis has chosen designs from two suppliers: a steel tension-leg platform by SBM Offshore and a concrete barge by Saitec. This report's analysis is specific to those two companies' models. However, their assembly requirements appear similar to those of other companies' steel and concrete designs, and thus, the analysis here will be applicable to the eventual winners in the platform design race and to California's offshore wind industry in the years to come.[16]

The SBM floating tension-leg platform design[17] is modular, enabling components such as the steel tubular braces to be prefabricated and transported to the Port of San Francisco. These pieces would be assembled in stages at the port and welded to the central column to form the complete floating platform.

The Saitec SATH barge platform[18] is constructed of reinforced concrete in a layout similar to a catamaran. Its construction complexity is similar to conventional uses of concrete for large infrastructure projects such as bridges. The horizontal twin hulls in the SATH design would be constructed in sections from concrete, cast vertically onsite at a batch plant installed in the Pier 96 backlands area. These sections would then be rotated horizontally for combining into a complete hull. As discussed below, concrete is readily available from local suppliers, including the CEMEX and Central ready-mix concrete plants, both located directly adjacent to Pier 96. Other components of the Saitec platform, such as the steel heave plate and steel tower transition piece, would be prefabricated offsite – most likely outside California – and transported by vessel to San Francisco.





PHOTOS: SBM Offshore (left), Saitec (right)

Floating platform assembly and construction

CADEMO's project planning process has evaluated several scenarios for assembly and construction of the floating platforms.

Default scenario. Import platforms: This option, while least favored, is the fallback if fabrication and assembly within California turn out to be infeasible, i.e., if suitable port infrastructure capacity is not developed to meet the project requirements within the project timeframe. In this case, the floating platforms would be constructed in East Asian ports and delivered by ocean-going, semi-submersible barges to the Port of Los Angeles for integration with the wind turbines at that site.

Preferred scenario. Construct platforms in California. Floventis has identified the Port of San Francisco's Pier 96 as the preferred location for construction, assembly, and launching of CADEMO's floating platforms. As of this writing, in May 2023, the port was moving forward with a plan to modify Pier 96, a long-unused container terminal, as a multi-purpose facility. This plan would enable Pier 96 to serve several functions: production of floating platforms for CADEMO; production of platforms for offshore wind projects in federal waters; and use as the city's emergency aid site in case of a major earthquake. While the timeline of these infrastructure upgrades has not yet been finalized, it is the port's hope and expectation that the facility will be improved to a sufficient standard to meet CADEMO's construction needs on the appropriate timeline. A secondary option, not analyzed for this report, is to build the platforms at the Port of Humboldt Bay, which has an undefined timeline for its plan to become a major offshore wind facility.

In the preferred scenario, Pier 96 and its backlands area will be used for modular construction and assembly of the project's four platforms. The platforms will then be launched into the bay and towed to the Port of Los Angeles for final turbine integration.

Table 2.2: Lead San Francisco-area contractors for platform construction

Company	Role	Description	Origin	Unions
Manson	General contractor	General construction	Bay Area	Building Trades
Kiewit	General contractor	General construction	Bay Area	Building Trades
CS Marine	General contractor	General construction	Bay Area	Building Trades
Bechtel	General contractor	General construction	Los Angeles Area	Building Trades
Bragg Companies	General contractor or subcontractor	Cranes and rigging	Los Angeles Area	Building Trades
Cemex	Subcontractor	Concrete	San Francisco	Teamsters
Central Concrete	Subcontractor	Concrete	San Francisco	Teamsters

SOURCE: Floventis

Marine Activities: Final Integration, Installation, and Operations

Platform design

Once a floating platform is assembled, it will be placed onto a separate, specialized semi-submersible vessel docked alongside the pier. This vessel will then move out to deeper water within San Francisco Bay, submerge partially, and release the platform to float off into the water. As discussed below in the section on the Jones Act, this semi-submersible vessel is likely to be foreign flagged, with a mixed foreign and U.S. crew.

Three large tugs will tow each platform to the Port of Los Angeles for integration with the turbine. The tugs will return to San Francisco to transport each platform in a serial process. These tugs are expected to be based in California, with local crews.

Turbine importation

As mentioned previously, CADEMO expects to import the major turbine components – tubular steel towers, nacelles and blades – from Europe, Asia, and/or the U.S. East Coast. These components will be delivered by non-California vessels directly to the Port of Los Angeles for the final turbine integration. The turbine components will either be stored on barges in the harbor or on land at the port. Except for the shore-based harbor tugs that guide these vessels into port, no California crews are likely to be involved in this stage.

Final turbine integration

Prior to the start of integration, all four floating platforms will be towed to the Port of Los Angeles and anchored in a "wet storage" area close to the jack-up vessel.

CADEMO's turbine integration is projected to occur in a water area of the port. This stage is unlikely to be carried out with a dock-based crane due to the lack of a suitable wharf facility with the necessary qualifications: high weight-bearing capacity at the wharf apron, deep-water access, and no bridges to seaward. Instead, the turbine integration will likely be conducted with a heavy-lift wind turbine installation vessel. These vessels have large heavy-lift cranes and jack themselves up out of the water atop stilt-like legs standing on the harbor bottom. They are commonly used to assemble and install fixed-bottom offshore wind projects, but for California, they make a suitable substitute for the largest wharf-based ring cranes.

Because of the high hook height required – roughly 650 feet – it is expected that fewer than 20 such ships will exist at that time on the global market outside of China.[19] The only such U.S.-flagged crane vessel that is expected to exist at the time of CADEMO construction is Dominion Energy's *Charybdis*, currently under construction at a cost of $500 million and projected to be launched in late 2023.[20] These jack-up vessels typically have rental fees of hundreds of thousands of dollars per day, including transit to and from their originating location, which could be the U.S. East Coast, East Asia, or Europe. These vessels will likely be in high demand because of the glut of offshore wind projects in those regions, so they must be contracted years in advance.

The jack-up cranes and other specialized vessels, such as the cable-laying ships, typically come with permanent live-aboard crews, most of whom have highly specialized skills that are customized to the needs of the vessel. For this reason, these contractors' capacity – and need – to add California-based workers in the tight living and working spaces on board will be limited. Nevertheless, as mentioned previously, CADEMO has committed under its PLA that for construction-related crew positions on any foreign-flagged ships used in the project, one American trade union worker will be hired for each foreign worker. This arrangement excludes vessel employees who perform specialized non-construction work.

Table 2.3: Lead Los Angeles-area contractors for final turbine integration

Company	Role	Description	Origin	Unions
Turbine OEMs	Supervision	Technical/managerial	TBD	None
Deme	Lead offshore contractor	Jack-up crane vessel	Belgium	California unions TBD
Boskalls	Lead offshore contractor	Jack-up crane vessel	Netherlands	
Foss	Subcontractor	Tug/barge	Bay Area, LA-Long Beach	IBU
Crowley	Subcontractor	Tug/barge	Bay Area, LA-Long Beach	SIU
Manson	Subcontractor	Tug/barge	Bay Area, LA-Long Beach	IBU
Pasha	Subcontractor	Breakbulk terminal & stevedoring	Bay Area, LA-Long Beach	ILWU

SOURCE: Floventis

*For foreign specialist vessels, boat crews will be foreign, and 50 percent of construction-related workers on board will be from California building trades.

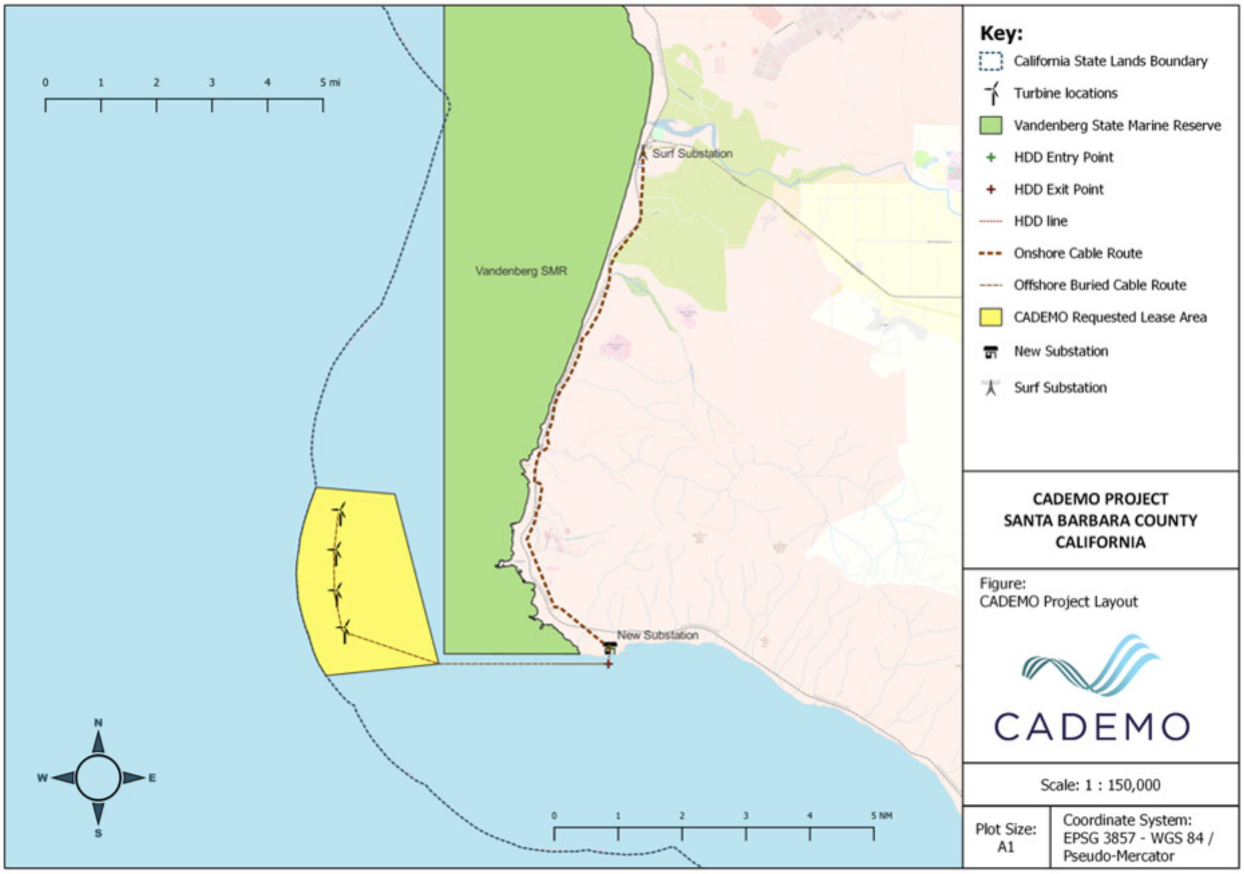
Once fully integrated, the turbines will be towed to CADEMO's project site in state waters off Vandenberg Space Force Base for hook-up to mooring lines and inter-array cables, which will have been pre-installed, as described below. The tugs used at this stage are expected to be based in California, with local crews.

Offshore and onshore transmission

The offshore inter-array transmission cable is a single string of dynamic cables connecting the four turbines and leading to an export cable buried about five feet under the seabed, looping southward and then east to a landing point south of Point Arguello near Vandenberg Dock. These cables will be installed by specialized vessels, as described in the Jones Act section, below.

Horizontal directional drilling will be required as the export cable burrows ashore and surfaces about 100 yards west of the dock, within the Vandenberg Space Force Base. A new electrical substation will be built at the landing point from which a new 70kV transmission cable line will be built 11 miles north to the existing Surf substation for connection to the California Independent System Operator (CAISO) power grid, as illustrated in **Figure 2.2**.

Figure 2.2: Transmission route from turbines to onshore grid



CREDIT: Floventis

The construction of land-based transmission consists of several segments: from the Vandenberg Dock to the new Surf substation; construction of this substation; and construction of the new 70kV lines to the point of interconnection with the CAISO grid. All of this work will be done under the terms of the CADEMO PLA and Outside Line Agreement, which reserves covered work to contractors that are signatories to the NECA California Outside Line Construction Agreement.[21]

Table 2.4: California contractors for offshore and onshore transmission lines

Company	Role	Description	Origin	Unions*
Deme	Lead offshore contractor	Specialist vessels	Belgium	Foreign crew & California unions TBD
Prysmian Group	Subcontractor	Offshore cable laying	Italy	Foreign crew & California unions TBD
Foss	Subcontractor	Tug/barge	Various California	IBU
CS Marine	Subcontractor	Offshore cables, ROV work	Vallejo	Pile Drivers
Western Line Constructors Chapter (see list) **	Subcontractor	Onshore transmission & substations	Various California	IBEW 1245

SOURCE: Floventis

* For foreign specialist vessels, boat crews will be foreign, and 50 percent of construction-related workers on board will be from California building trades.

** Western Line Constructors Chapter, "Membership Directory" (NECA, n.d.).

Mooring cable systems

Mooring and anchor manufacturers exist in California but are focused on other markets. The type and size of components manufactured in California are insufficient to serve for floating offshore wind.

Like the turbine components, the mooring lines and anchors are expected to be imported to California by non-California ships and crews. However, mooring lines and anchors are easier to ship, handle, and store than the turbine components. At the Port of Los Angeles and/or Port of San Francisco, existing breakbulk terminal facilities are expected to readily load, unload, and store the mooring lines and anchors on dock and/or barges using California-based and -crewed vessels.

The anchors will be installed using a variety of vessels and methods that depend on the anchor design selected. This stage may require a heavy anchor handling tug, most likely mobilized from the Gulf of Mexico, along with a supporting tug from California, or it might merely need a California-based barge. In either case, a remotely operated subsea robot, an ROV, may be used to screw, suction, or drag the anchor into the seabed. The mooring cables will be installed with a similar variety of U.S.-based vessels.

Table 2.5: California contractors for stevedoring and storage of anchors and cables

Company	Role	Description	Origin	Unions
Pasha	Terminal operator and/or subcontractor	Breakbulk stevedoring & terminals	San Francisco and Los Angeles	ILWU

SOURCE: Floventis

The laying of the offshore mooring cables and anchors will be executed by specialized vessels, probably the same contractors as the transmission cable laying operations, described earlier. The Gulf of Mexico offshore oil industry has many qualified U.S. marine services contractors for this work, although their vessels are not believed to comply with California's Tier 4 emissions requirements, described in the Jones Act section below. Deme estimates that approximately three to five California union workers can be added to each vessel crew. CADEMO has not yet verified whether this would comply with the PLA's requirement of 50-percent domestic workers on board, although it seems likely.

Table 2.6: California contractors for installation of anchors and mooring cables

Company	Role	Description	Origin	Unions*
Deme	Lead offshore contractor	All specialist vessels	Belgium	California unions TBD
Crowley	Lead offshore contractor or subcontractor	Specialist	Various Calif	Inlandboatmen, SIU
Boskalis	Subcontractor	Mooring cables, anchor laying	Netherlands	Foreign crew & California unions TBD
2H Offshore	Subcontractor	Mooring cables, anchor laying	U.S. Gulf of Mexico	California unions TBD
Manson	Subcontractor	Mooring cables, anchor laying	Various Calif	California unions TBD
Longitude 123	Subcontractor	Mooring cables, anchor laying	Various Calif	California unions TBD
Local tug and barge companies	Subcontractor	Support tugs and barges	Various Calif	Inlandboatmen, SIU

SOURCE: Floventis

*For foreign specialist vessels, boat crews will be foreign, and 50 percent of construction-related workers on board will be from California building trades.

Offshore installation and commissioning

U.S.-crewed tow boats will tow the fully integrated platforms to the CADEMO site off the coast of Vandenberg. Once there, specialized crews from the turbine manufacturers will connect the platforms to the mooring and transmission cables, install monitoring equipment and program software, conduct technical checks, and commission the project for operations.

Table 2.7: Lead contractors for installation and commissioning

Company	Role	Description	Origin	Unions*
OEMs	Supervision	Commissioning	N/A	N/A
Deme	EPCI, all phases	Tug/barge, specialist	Belgium	Foreign & 50% California union
Foss	Subcontractor (installation)	Tug/barge, specialist	All California	IBU, MMP
Crowley	EPCI, all phases	Tug/barge, specialist	All California	IBU, SIU, MMP

SOURCE: Floventis

*For foreign specialist vessels, boat crews will be foreign, and 50 percent of construction-related workers on board will be from California building trades.

Offshore operations and maintenance

During the phase of operations and maintenance over the project's expected 25-year lifespan, a crew transfer vessel will bring personnel to the site for maintenance tasks. Because of the nature of this work – in which the vessel must safely deliver crews to the turbines amid often-heavy seas and dangerous conditions – such a vessel is likely to be purpose-built in the United States. It is also possible that some of this O&M work may be done via helicopter from a local airport such as Santa Maria.

CADEMO's PLA includes a Maintenance Agreement for heavy repairs. It is expected that day-to-day maintenance will be conducted by employees of the wind farm's operating company. CADEMO has not yet thoroughly researched the available firms for this phase.

Jones Act and Emissions Controls

The supply chains for CADEMO and all other offshore wind projects in California will be impacted at several crucial points by two factors: the Jones Act and emissions controls.

The Jones Act requires any vessel transporting cargo between U.S. ports or between any two points in U.S. waters to be built and flagged in the United States and crewed by U.S. nationals. Since it became law in 1920, the Jones Act has limited the actions of offshore contractors but has proved durable because it also is believed to support the employment of Americans in the marine sector.

The U.S. shipbuilding industry is relatively small by global standards, much smaller than those of shipbuilding giants China, South Korea, and Japan. The process of birthing a

U.S.-flagged offshore wind fleet will be slow, especially on the West Coast. But broadly put, U.S. Customs and Border Protection (CBP) has provided enough flexibility in its enforcement of the law to enable the offshore oil and gas sector to use foreign-flagged specialist vessels whenever truly necessary – that is, whenever a U.S.-flagged ship is unavailable for those purposes.[22]

Recently, uncertainty has been growing about how the law and its enforcement may impact the offshore wind sector.[23] Legislation has been introduced in Congress that could dramatically cut back on the loopholes available for using foreign-flagged specialist vessels for tasks that no U.S. vessels can perform.

For CADEMO, the Jones Act has several specific implications that may also be relevant to the California offshore wind industry in later years, as well:

Jones Act challenges

- **Jack-up vessel for final turbine integration**. As mentioned above, it is expected there will be only one U.S.-flagged vessel with sufficient capacity at the time of CADEMO construction, and that ship is likely to be difficult to contract because of the high number of offshore wind projects on the East Coast at that time. However, because CADEMO will use such a vessel only in one location at the Port of Los Angeles and the vessel will not be transporting merchandise from one point to another in U.S. waters, it is expected that CADEMO will be able to use a foreign-flagged jack-up vessel in compliance with the Jones Act.

- **Cable-laying vessel.** In the past, CBP has allowed foreign-flagged ships to do this work. For example, the Trans-Bay Cable project in San Francisco Bay was carried out in 2009 by an Italian flagged ship, Prysmian Group's *Giulio Verne*, under contract to Manson Construction. The foreign crew was placed under temporary California union membership under Manson's PLA. CADEMO expects to be able to use a foreign vessel, although this arrangement will need to be clarified with CBP.

- **Anchor-laying vessel.** Anchor laying will require a Jones Act-compliant heavy anchor handling tug with at least 200 tons bollard pull. These vessels are not available on the West Coast and will need to be sourced from the Gulf of Mexico.

- **Semi-submersible barge for launching platforms.** For California floating wind projects, a key challenge is how to move the mammoth floating platforms, which can weigh 10,000 tons or more, from their construction site on the wharf into the water. CADEMO's plan, which is likely to be used by other offshore wind developers, is to transfer the platform via a self-propelled modular transporter (SPMT) from the wharf onto a semi-submersible barge docked at the wharf. The barge then moves away into deeper waters and sinks partially to allow the platform to float off. This stage might be interpreted as moving merchandise – the platform – from one point to another in U.S. waters or merely from a land point to a water point. It is likely that the CBP will need to clarify this matter for both CADEMO and the future California offshore wind industry.

In addition to these Jones Act constraints, the availability of suitable tugs, cable-laying vessels, and other motorized barges will be limited by the state's increasingly strict regulations for marine emissions.[25] The California Air Resources Board's adoption of the U.S. Environmental Protection Agency's Tier 4 emissions standards, phasing in from 2023 onward, will bar the use of all large ocean-going tugs currently in service on the West Coast and the Gulf of Mexico. Marine service companies contacted by CADEMO have said they do not yet have plans to purchase and deploy Tier 4 vessels of sufficient size and capacity for California offshore wind projects. This challenge, like the Jones Act issues, will need to be addressed by state and federal policymakers in coordination with the offshore wind and marine services industries.

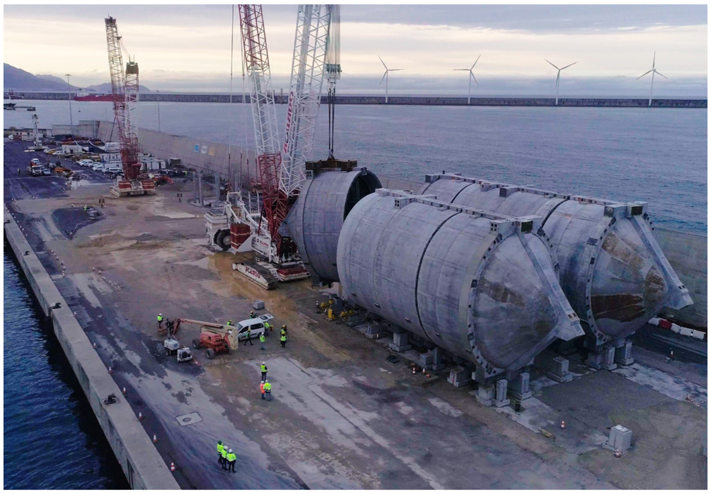


PHOTO: Saitec

CHAPTER 3. ECONOMIC IMPACTS: WHERE, WHEN, AND HOW

As explained in **Chapter 1**, the dominant factor in determining the economic impact of California offshore wind projects is the siting of their floating platforms' construction. The platforms are roughly the size of a football field and can be extremely labor-intensive to build. California will capture their production and the resulting economic value if it can develop sufficient port facilities as well as a supply chain that is competitive with global competitors.

Other major components, including towers, nacelles, and blades, are roughly similar in scope and complexity to commercial airplane manufacturing and more capital and technology intensive than the platforms. Turbine components are produced by a small pool of original equipment manufacturers. Production of turbine components in California will be unlikely for years to come, at least until manufacturers such as Vestas, Siemens, GE, or Nordex can be persuaded that the West Coast market will justify investments totaling billions of dollars to build local factories.

Unlike the empirical focus of the rest of this report, this chapter discusses the economic impact analysis from the California Polytechnic State University, San Luis Obispo (Cal Poly), contained in the **Appendix**.

As previewed in **Chapter 1**, Cal Poly's analysis assumes that no new large port facility will be built on the Central Coast for integration within the next decade or more. Such a facility has been advocated by some local supporters to compensate for economic loss caused by the eventual closure of the Diablo Canyon nuclear power plant, which at the time of this writing appears likely to be postponed to at least 2030. Such a mega-port could not be built within the CADEMO timeline, and in any case, its construction might face intense local opposition because of its environmental impacts.[26]

We do, however, expect the Central Coast will provide a smaller-scale port facility for the operations and maintenance phase. This facility is expected to be located at Morro Bay, Port San Luis, or even Port Hueneme and would essentially comprise a dock for a crew transfer boat and a nearby storage warehouse, which could be augmented by helicopter services based at the Santa Maria airport. However, none of the location options has been fully investigated, and Central Coast opinion leaders and stakeholders will need to decide which has sufficient community support. Phase 2 of this HRTP, which extends through March 2024, will include further outreach to local stakeholders about port options.

The bulk of Central Coast economic impact will be generated by local construction of transmission facilities and an onshore electrical substation and ongoing operations and maintenance activities over CADEMO's expected 25-year lifespan.

The Cal Poly report provides granularity that contributes significantly to other recently published reports on the economic impacts of California offshore wind, including those released by the National Renewable Energy Laboratory, California Energy Commission, Mott MacDonald, and E2.[27] The tables below summarize Cal Poly's findings on the economic impact of two projects.

PHOTO: SBM Offshore (top), Saitec (bottom)

Table 3.1.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
	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 3.1.b: Overall Economic Impact of a Morro Bay Project

Project Phase	Impact Categories	Jobs (FTE)	Earnings ($ Millions)	Output ($ Millions)	GDP ($ Millions)
Construction	Onsite	272	27	27	27
	Supply Chain	9,753	885.2	2,593	1,165.3
	Induced	3,177	185.7	631.3	381.2
	Total	**13,202**	**1,097.2**	**3,251.2**	**1,573.5**
Operations (Annual)	Onsite	100	9	9	9
	Supply Chain	394	33.6	126.2	57.9
	Induced	190	12	37.9	22.9
	Total	**684**	**54.6**	**173.1**	**89.8**

SOURCE: Cal Poly

Key findings from the Cal Poly report include the following:

- The CADEMO project is expected to directly employ a total of 697 full-time-equivalent (FTE) jobs in California (onsite and supply chain) during the project's three- to five-year development and construction timeline.[28]

- CADEMO's onsite jobs – that is, those in Santa Barbara and San Luis Obispo Counties – will be modest in comparison to the jobs created in the supply chain category, most of which comprise platform construction.

- The "Construction" calculations are based on CADEMO's expected total capital expenditure budget of $338 million. The "Operations" numbers are based on the assumption of $3 million for in-state annual operating expenses. These figures do not include development expenditures, engineering and management costs, or major repairs and replacement.

As with any economic impact analysis, the assumptions used in the modeling determine the results. For CADEMO, as well as for all other California offshore wind projects, the geographical dispersion and extent of benefits depend on policy decisions by state and federal government agencies and on market conditions.

In addition, several methodological clarifications should be noted:

- The JEDI modeling system used in the report does not allow sufficient disaggregation of the regional impacts – in other words, how much of the total impact would be in the Central Coast region and how would be much centered on the two port locations of San Francisco and Los Angeles for platform construction and turbine integration, respectively.

- The analysis is premised on CADEMO's preferred case of in-state platform construction. No analysis was conducted for the default case of imported platforms.

- Because fabricated steel components are likely to be imported, the economic impact of steel platforms would probably be less than the concrete designs. Cal Poly used an average for its study.

- The available California databases do not appear to adequately incorporate union wage scales.

- The Standard Occupational Classification System (SOC) used in this modeling does not define several key job categories, such as concrete pouring and mold construction, dockworkers, deckhands, deckhand engineers, or able seaman. The closest alternatives were used.

- This analysis does not include impact of infrastructure upgrades at the Port of San Francisco, which are outside the scope of the CADEMO project, although they will support the project.

- The Morro Bay project in **Table 3.1.b** represents a hypothesized modeling of one of the three 1 GW projects in the federal Morro Bay leasing zone, comprising 66 floating turbines. At the time of this writing, none of the three auction winners had yet finalized its BOEM lease, so this modeling uses generic assumptions and inputs.

It is also worth noting that Floventis is working with the Santa Ynez Band of Chumash Indians to create a community benefits agreement that will include targeted hiring for tribal and community members as well as initiatives for environmental cooperation and co-management using tribal traditional knowledge. These details were under negotiation at the time of this writing. Floventis expects to engage directly with community groups around the ports of San Francisco and Los Angeles as well as at the project's eventual Central Coast location for operations and maintenance to discuss local hiring and community benefits.

In addition, still to be discussed and determined are potential benefits to Vandenberg Space Force Base, including electricity supply and other joint energy initiatives.

CHAPTER 4. WORKFORCE SKILLS AND TRAINING

The analysis in this chapter is derived from CADEMO's empirical planning process for the project's workforce needs, rather than from prescriptive policy formulations. Unlike much recent workforce training research about California offshore wind, the focus here is demand driven rather than supply driven – in other words, it examines only the jobs to be created directly by the project's own supply chain, as described in **Chapter 2**.

Other recent strategies have focused on ways to proactively create a supply of trained workers before any given project's detailed construction plans are finalized. For example, BOEM's rules for the December 2022 offshore wind auction provided substantial bid credits for companies that provide workforce training.[29] Those rules stipulate that such training must take place years before the wind farms are actually built, and any given company's programs must not funnel their graduates exclusively to jobs in the company's own wind farm. A comprehensive analysis of offshore wind workforce needs published in 2022 by the National Renewable Energy Laboratory, "U.S. Offshore Wind Workforce Assessment," identifies several key training gaps that should be filled well in advance, including port terminal crews, vessel construction crews, and turbine technicians.[30]

While recognizing the importance of this previous research, CADEMO's planning process has taken note of California's success with a different model, one that is driven by direct cooperation between employers and unions: the state-certified apprenticeship system. As described in "Putting California on the High Road: A Jobs and Climate Action Plan For 2030," a report prepared by the UC Berkeley Labor Center for the California Workforce Development Board, the state's apprenticeship system has been uniquely successful because it trains workers only for actual jobs for which they will be hired upon graduation.[31]

Our analysis for CADEMO, which we believe will be broadly applicable to future commercial-scale offshore wind farms in California, identifies no significant training gaps in the construction, port terminals, and marine services phases. The project's contractors and subcontractors, in cooperation with their respective trade unions, are likely to successfully apply and adapt the existing systems of training and apprenticeship programs to address those workforce needs.

Our analysis did identify training gaps for the phases of offshore installation and operations and maintenance. Contractors in those sectors say they will need to upskill those workers through specialized programs that have been created on the East Coast and should be adapted to California. The primary challenge, however, is to ensure that the supply chain and, therefore, the jobs are located to the maximum extent in California rather than elsewhere.

CADEMO's Sectoral Needs

This chapter analyzes the jobs that directly result from the CADEMO project and that will be performed by California residents, as summarized in **Table 4.1**.

PHOTO: Jacques Tarnero

Table 4.1: CADEMO project jobs, associated unions, and training programs

Sector	Main types of work	Primary unions	Assist crafts	Training programs
Onshore transmission, substation, and grid connection	Horizontal/directional drilling, transmission lines, substation construction	IBEW 1245		Existing IBEW apprenticeships
Manufacturing supply chain	Manufacturing components, subcomponents	TBD		TBD
Transport, port and harbor support	Tugboat crews, longshore loading and unloading, temporary storage on wharfs, trucking	Inlandboatmen, SIU, ILWU, Teamsters		Existing marine and ILWU training programs
Floating platform construction and assembly	Welding, steel and concrete work, lifting, fitting, heavy transport	Operating Engineers, Ironworkers, Cement Masons, Carpenters, ILWU	Teamsters, Laborers	Existing building trades apprenticeship programs; existing ILWU training
Wind turbine integration	Lifting, fitting by foreign crews and/or local construction workers	Operating Engineers, Millwrights, Ironworkers, ILWU		Existing building trades apprenticeship programs; existing ILWU trainin
Tow & hook-up	Towing, anchoring, mooring laying, hook-up, cable pulling, connections	Inlandboatmen, SIU		Existing marine and ILWU training programs
Cable laying and anchor installation	Laying of mooring and transmission cables, setting of anchors for floating platforms	Inlandboatmen, SIU, IBEW 1245, ILWU, Operating Engineers, Divers		Existing IBEW and Operating Engineers apprenticeship programs and marine services unions' training, plus specialized programs
Operations and Maintenance	Commissioning, operations and maintenance, onshore control center, major repairs and component replacement, decommissioning	IBEW 1245, Inlandboatmen, SIU, ILWU		Specialized training programs needed via unions and/or community colleges

SOURCE: Floventis

Among the project phases that will involve construction, we anticipate that the building of the onshore substation, grid connections, and floating foundations will consist of the types of work that California's existing skilled and trained construction workers are already well equipped for and accustomed to performing.

Building and commissioning the CADEMO substation and transmission lines on land will not require new skills or training. Northern Santa Barbara County, where this work will take place, already has a skilled supply of utility workers, and CADEMO's PLA includes an Outside Line Agreement with utility union IBEW 1245 covering all land and offshore transmission cable and substation installation work.[32]

For the floating platforms, assuming the preferred scenario described in **Chapter 2**, the construction and assembly will take place at the Port of San Francisco, and the platforms will then be towed to the Port of Los Angeles for integration with the towers and turbines. In this case, the floating foundations will be built by local contractors and construction crews. As stated in **Chapter 2**, the platform construction process is expected to be roughly comparable in terms of labor skills and processes to those of major land-based civil works and infrastructure projects. For this reason, platform construction is not expected to require new skills or training programs beyond those already available in the existing California workforce.

The phase of laying the transmission cables, mooring cables, and anchors is likely to involve specialized boats and workforces, some of which may need to be foreign-flagged boats, supported by U.S.-flagged tugs and barges. Floventis's PLA commitment to use at least 50-percent U.S. union members on any foreign boats will need to be finessed with its offshore contractors, but Floventis's initial discussions with several major service providers in this sector have indicated that this labor split is expected to be feasible.

Similarly, in the phases of turbine integration, tow and hook-up, and final commissioning, the near-term timing of the CADEMO project means that the work may have to be performed in part by foreign contractors and work crews, with a complement of U.S. marine services workers.

California Unions' Apprenticeship System

The building trades unions have a well-established system of workforce training through the state-certified apprenticeship model, which is well recognized across North America and has been in practice for more than 100 years. In California, apprenticeships in construction and other industries are approved by the Division of Apprenticeship Standards under the Department of Industrial Relations, which administers and enforces state apprenticeship laws and standards, including those pertaining to wages, hours, working conditions, skills, and certifications.[33] As of February 2023, there were approximately 60,000 registered apprentices in the construction trades in California, a total of roughly 425,000 union construction workers under the umbrella of the State Building and Construction Trades of California (SBCTC), and roughly 60,000 workers under the United Brotherhood of Carpenters.

The SBCTC comprises 14 unions, each of which specializes in a set of crafts or trades:

- International Brotherhood of Boilermakers;
- International Union of Bricklayers and Allied Craftworkers;
- International Brotherhood of Electrical Workers (IBEW);
- International Union of Elevator Constructors;
- International Association of Heat and Frost Insulators and Allied Workers;
- International Association of Bridge, Structural, Ornamental and Reinforcing Iron Workers;
- Laborers' International Union of North America;
- International Union of Operating Engineers;
- International Union of Painters and Allied Trades;
- Operative Plasterers' and Cement Masons' International Association;
- United Union of Roofers, Waterproofers, and Allied Workers;
- Sheet Metal Workers' International Association;
- International Brotherhood of Teamsters; and
- United Association of Plumbers and Fitters.

The United Brotherhood of Carpenters (UBC) is unaffiliated with the SBCTC and includes several unions with apprenticeship programs: the Carpenters, Millwrights, and Pile Drivers and Divers.

As noted above, the IBEW's construction union locals are designated as "inside wire" locals, which means they represent electricians who work on non-utility construction projects. The IBEW umbrella also includes non-construction "outside line" locals representing workers in electrical utilities, such as PG&E, Southern

California Edison, and San Diego Gas & Electric. The labor contracts for these locals, such as IBEW 1245, are nominally separate from those of the SBCTC but typically are joined in a package, as exemplified in CADEMO's PLA documents. In that package, the PLA and Maintenance Agreement are with the SBCTC, covering all construction-related work on the project in California. The Outside Line Agreement is with IBEW 1245, covering all installation of onshore and offshore transmission lines and substations.

These unions' state-certified apprenticeship training programs are formal, structured programs that are jointly administered and led by contractors and unions. The unions and employers work in collaboration with each other through joint labor-management committees made up of equal representation from each party. Committee members work together to make collective decisions and run the apprenticeship training programs.

Joint labor-management committees develop the training curricula and requirements for each apprenticeship based on industry standards and needs, as well as occupational health and safety requirements. Every apprenticeship includes a combination of classroom instruction and training on the job. Apprentices gain hands-on experience by performing their trade on actual construction sites, under the supervision and mentorship of more experienced workers who have previously completed their apprenticeship training.

Apprenticeship is known as an "earn while you learn" model because trainees are paid from the beginning through the end of their time in an apprenticeship program, and they receive progressive wage increases as they advance. Apprenticeship programs are funded through contracts negotiated between unions and employers, i.e., the PLAs. A percentage of each worker's wages paid through a union construction contract is deposited into a training fund for the joint labor-management committee to utilize. The amount varies by trade and contract, as well as geographic location. Through this model, apprentices are paid for their time and work, and the training is funded by and overseen by both labor and management.

Table 4.2 below provides data on prevailing wages for both first-period apprentices and journey (non-apprentice) workers in four building trades.

Table 4.2: **CADEMO project jobs, associated unions, and training programs**

	Ironworker		Laborer		Operating Engineer		IBEW Outside LIne		IBEW Inside Wire	
	Apprentice	Journey	Apprentice	Journey	Apprentice	Journey	Apprentice	Journey	Apprentice	Journey
Basic Hourly	$25.19	$50.38	$22.75	$38.95	$28.34	$57.55	$38.64	$64.40	$33.80	$84.50
Health & Welfare	$5.50	$10.20	$9.60	$9.60	$13.38	$13.38	$8.00	$8.00	$18.33	$18.33
Pension		$12.32		$13.86	$9.18	$10.78	$12.71	$12.33	$1.01	$20.52
Training	$0.72	$0.72	$0.50	$0.50	$2.12	$1.12	$0.19	$0.32	$1.09	$1.08
Vacation / Holiday	$6.00	$6.00	$0.91	$3.05	$5.37	$5.87				
Other	$0.35	$5.57	$0.30	$0.30	$1.58	$1.58	$0.42	$0.70	$0.63	$0.38
Total Hourly	$37.76	$85.19	$34.06	$66.26	$59.97	$90.28	$59.96	$88.38	$54.86	$124.81

SOURCE: California Department of Industrial Relations, "General Prevailing Wage Determinations" (n.d.).

Apprenticeships in the building and construction trades take an average of three to five years to complete. Working in construction is physically demanding and involves strict schedules and long hours, and many apprenticeships require physical fitness tests. Most programs also require a high school diploma, GED, or equivalent, as well as a valid driver's license. Upon completion of an apprenticeship, a worker graduates to journey level with an industry-recognized credential, valid nationwide, along with opportunities to continue learning, training, advancing, and earning more, as well as health and retirement benefits and membership in their trade union.

Each of the construction trade unions has multiple apprenticeship programs or career tracks for various specializations within the trade. For example, within the Ironworkers union, there are different apprenticeship programs for Bridge, Structural, Ornamental, and Reinforcing Ironworker; Field Reinforcing Ironworker; Field Structural Ironworker; and others. Within the Operating Engineers, there are apprenticeships for Construction Equipment Operator; Crane Operator; Dredge Operator; Grade Checker; Heavy Duty Repair; Mobile Concrete Pumps Operator; Mobile Vertical and/or Horizontal Drilling Machine Operator; Plant Equipment Operator; Rock, Sand and Gravel Operator; and others. The programs' duration ranges from two to four years or more.

Apprenticeship training centers' facilities and locations vary by trade, as each union has its own training needs based on the nature of the work and the various job types and specializations within it. For example, within the Operating Engineers, construction equipment operators must learn and practice their trade on actual construction equipment, so their training facilities require a large amount of physical space and expensive equipment and vehicles.

Pre-Apprenticeship Programs

While most construction apprenticeships have relatively few prerequisites, they can be challenging to comprehend and navigate, and many apprenticeship programs are competitive. Pre-apprenticeship offers an opportunity to learn about and prepare for apprenticeships and careers in the trades. Building trades unions in California use the Multi-Craft Core Curriculum (MC3), an introductory-level course designed by North America's Building Trades Unions (NABTU) to help individuals gain the technical and soft skills needed to enter and succeed in a construction apprenticeship. The MC3 is approved by the unions that are part of NABTU and is used throughout the United States, and all MC3 pre-apprenticeship programs are authorized through their local building trades council.

Pre-apprenticeships teach participants about the different trades and career pathways, the fundamentals of construction work, including hands-on training, as well as soft skills and professional development. These free programs provide introductions and connections to the unions and contractors, as well as preparation and assistance with exams, interviews, and placements into apprenticeships. Many of them also include access to tutoring or remedial math and reading education, mental health services, financial assistance, removal of employment barriers, and other supportive services.

Pre-apprenticeship programs help increase participants' likelihoods of entering and successfully completing building trades apprenticeships. They provide a more accessible and inclusive pathway into the apprenticeship system and construction careers, particularly for individuals who have faced barriers to employment, such as low-income people of color, women, veterans, individuals who have experienced homelessness, and those with criminal records. Many programs are operated by community-based organizations through partnerships with their local building trades council, with support from employers, state and local workforce development boards, educational institutions, and other entities. These partnerships enable pre-apprenticeship programs to offer specialized resources and support beyond a training curriculum.

As of May 2023, there were 77 MC3 pre-apprenticeship programs currently in operation throughout California in a variety of iterations and settings, including within high schools and the prison system. Through its High Road Construction Careers (HRCC) program, the California Workforce Development Board (CWDB) supports 28 of these programs.[34] The CWDB is investing in the pre-apprenticeship model as an accessible, inclusive pathway to stable middle-class careers. The HRCC program provides funding and technical support to help foster partnerships among local trades councils, workforce boards, community colleges, and community-based organizations with the goal of creating structured pathways to state-certified apprenticeships in the building and construction trades.

Our analysis has found that the existing construction workforces in the Bay Area and Los Angeles have more than adequate skills to deliver the phases of the project at the Port of San Francisco and the Port of Los Angeles.

Other Job Training Programs

Longshore work

The longshore worker hiring hierarchy is as follows, from most to least seniority: Class A longshore workers; Class B longshore workers; Identified casual workers; and Temporary unidentified casual workers. Virtually all Class A and Class B longshore workers are ILWU members, while casual workers are not members of the union. The workers are employed directly by the port terminal operating companies. These companies, in turn, are members of the Pacific Maritime Association (PMA), which has a master contract with the ILWU for all West Coast ports.[35] Joint ILWU-PMA training facilities for longshore workers, clerks, and casuals are located in each region along the West Coast, including Los Angeles and Oakland. These programs function in a similar manner to the construction unions' apprenticeships, on a paid "earn as you learn" basis. CADEMO expects to contract its port services in San Francisco and Los Angeles with a terminal operator that belongs to the PMA and thus provides ILWU-affiliated workforce and training programs.

Marine services

California's tug and tow industry has a robust worker training program that will adequately serve the needs of CADEMO and California's other offshore wind projects. The Inlandboatmen Union (IBU) represents boat workers, such as deckhands, deckhand engineers, and able seaman on tugs and barges, who are involved with ship-assist work, marine construction, and fuel-barge transfer work, as well as other marine sectors such as ferries and tour boats. Workers are required to receive and maintain Coast Guard-certified training and credentials. The IBU's two-year apprenticeship program, based in San Pedro, provides entry-level skills and knowledge through 3,000 hours of on-the-job "sea time" training, plus 420 hours of classroom instruction and training. Another key module for maritime workers is the week-long Standards of Training, Certification, and Watchkeeping certification, which covers safety issues, personal survival, first aid/CPR for mariners, firefighting science, and hands-on firefighting. These training programs will be sufficient to cover CADEMO's tug and tow needs at the ports and for ocean towing between ports.

Anchor and cable laying

As discussed in **Chapter 2**, West Coast marine contractors do not currently have any semi-submersible barges, jack-up wind turbine integration vessels, or vessels suitable for anchor and cable laying. These vessels will need to be sourced from elsewhere in the United States or globally. CADEMO's PLA stipulates that on board U.S.-flagged vessels, all construction-related workers in the applicable craft categories will need to be members of the PLA signatory unions, while for foreign-flagged vessels that are used in compliance with the Jones Act, at least 50 percent of workers must be California union members. It is expected that these Californians will need to undergo marine safety training (see below), while the more specialized technical tasks may be relegated to the foreign crews that travel permanently with their boats. The application of these details will be ironed out in dialogue with the offshore contractors themselves.

In addition, Pile Drivers and Divers Union, under the United Brotherhood of Carpenters, is planning to initiate a training program for operating subsea Remote Operated Vehicle (ROV) robots. This training program will be important for developing California-based skills to perform those tasks.[36]

Specialized Programs

There are no officially adopted offshore wind energy industry training standards in the United States, but organizations are working to align existing U.S. standards and training requirements with worldwide standards and to develop and certify programs and facilities to support standards such as the Global Wind Organization (GWO) Basic Safety and Sea Survival Training.

The most advanced U.S. training program is at Bristol Community College in New Bedford, Massachusetts. The college's National Offshore Wind Institute is the only U.S. training provider with associate degree programs in offshore wind power technology, augmented with GWO certificates.[37] These programs train students as fully proficient technicians in all aspects of offshore turbine operations and maintenance. Non-degree programs with modules in topics such as mechanical, electrical, and hydraulics are also offered. Massachusetts Maritime Academy at Buzzards Bay, in cooperation with the industrial safety training company RelyOn Nutec, offers non-degree training such as the GWO safety training modules mentioned above.[38]

Similar programs will be needed in California. On the North Coast, the College of the Redwoods, Cal Poly Humboldt, and the Yurok Tribe took initial steps toward this goal in February 2023 by signing a Memorandum of Understanding to leverage wind developers' bid credit commitments in the BOEM auction to raise funds to create a training center.[39] They have recently created a new HRTP to develop training programs for the region's offshore wind projects. A similar program could be created at educational institutions on the Central Coast.

Another area of training will need to be developed for environmental monitoring and mitigation projects in the CADEMO ocean area during both the permitting and operations phases. These projects will seek to measure environmental impacts of the turbines on fish, marine mammals, sea turtles, and birds and to help create mitigation techniques for these impacts for CADEMO and the big offshore wind farms in federal waters. While these projects have not yet been designed, they likely will involve considerable use of Remotely Operated Vehicle (ROV), Autonomous Underwater Vehicle (AUV), and Artificial Intelligence (AI) technologies – and thus a highly skilled workforce. At this time of writing, Floventis was in dialogue with Cal Poly Humboldt, Cal Poly San Luis Obispo, and Oregon State University to propose creation of a center for ocean-based workforce training and research for the offshore wind industry in California and the region.

Project Labor Agreements and Targeted Hire

Project labor agreements help generate a stable, predictable demand for highly skilled construction workers. In recent decades, almost all of California's utility-scale renewable generation projects have been built under PLAs.[40] These binding agreements between construction project owners or developers, contractors, and construction unions spell out the terms and conditions for all construction work on a project, including timelines and schedules, wages and benefits, health and safety guidelines, grievance and dispute resolution, and many other aspects. As explained in the following section in relation to CADEMO's labor contracts, PLAs are master agreements only covering construction and transmission work and do not include other sectors, such as marine trades and dockworkers.

Typically, PLAs specify the utilization of apprentices, provided that they are directly supervised by journey-level (fully trained) workers. Publicly funded projects in California require an overall ratio of one apprentice for every five journey workers, although the actual ratio and numbers vary by trade. The same ratios are not required in the private sector, but they are viewed as successful models for large construction projects and are expected to be used at CADEMO and other offshore wind projects in the state. In this way, PLAs provide a predictable pipeline of work for both advanced journey-level and apprentice construction workers.

An important aspect of PLAs is that they can include targeted hire goals or requirements. Targeted hire is a key tool for increasing diversity, equity, and inclusion in the construction workforce. A PLA can set goals or requirements for hiring a certain number or percentage of workers who match a specified set of identities, communities, or backgrounds. Some examples of target populations are women, tribal members, residents of zip codes near the project location that have high rates of unemployment or underemployment, and veterans. To support a targeted hire goal or requirement, a PLA can also require or provide resources for outreach, recruitment, and partnerships with local organizations in a community. For example, a PLA can specify and direct funds to local project partners that include local MC3 pre-apprenticeship programs and community-based organizations that have specialized experience and trusted relationships working with the target population.

CADEMO's Labor Agreements

As mentioned in **Chapter 1**, in November 2022 Floventis, the State Building and Construction Trades Council, and IBEW 1245 signed a four-part series of documents that embraces and codifies the "high road" concept for management-labor relations in the offshore wind industry. These documents comprised a Memorandum of Understanding, Project Labor Agreement, Maintenance Agreement, and Outside Line Agreement. In May 2023, the Southwest Mountain States Regional Council of Carpenters also signed the documents, which are referred to collectively in this report as the project's PLA.

Under these agreements, CADEMO will require all its contractors and subcontractors to also sign the PLA, thus employing members of the signatory unions for traditionally covered craft work in all construction and transmission phases of the project taking place within California. This agreement will not affect the traditional jurisdiction of the ILWU over longshore work at the ports, which will be covered by the port terminal operators' ILWU contract through the Pacific Maritime Association, as mentioned above. Nor does it affect the traditional jurisdiction of marine trades unions, such as Inlandboatmen, Seafarers International Union (SIU), and

Masters, Mates and Pilots (MMP), for the crewing of boat and barge services, which will be covered by the existing labor contracts of CADEMO's contractors and subcontractors in those sectors.

Community Benefits Agreements

As part of its HRTP, Floventis is negotiating community benefits agreements, including targeted hiring and pre-apprenticeships, with local stakeholders. Leading in this dialogue is the Santa Ynez Band of Chumash Indians, the federally recognized tribe on whose ancestral waters and lands the CADEMO project will be located. Floventis is establishing a partnership with the Santa Ynez Chumash that both sides hope will serve as a cooperative model for ecologically and culturally respectful development in California's offshore wind industry for years to come.

Retraining of Oil Industry Workers

In Central and Southern California, the advent of the offshore wind industry offers significant potential to partner with another historic phase in California's clean energy transition – the decommissioning of offshore oil platforms.[41] A total of 23 oil platforms exist in federal waters and four in state waters. As of this writing, at least eight platforms were shut in and are expected to be decommissioned and removed in the 2020s, with at least an equal number for the 2030s.[42] This multi-billion-dollar process will pose unprecedented planning challenges for the industry, as well as local, state, and federal government agencies.

In short, this process demonstrates the two sides of the coin for California's offshore energy transition – on one side, removing the old fossil fuel infrastructure, and on the other, bringing in the new renewable energy. All of it is large scale, expensive, and logistically challenging, and it requires skilled industrial workforces.

The process of oil decommissioning will call for marine industrial assets that are not dissimilar to those of installing offshore wind. Six of California's platforms are in water depth exceeding 500 feet, which is the current world record for offshore oil decommissioning. This process will pose extreme logistical difficulties for extracting the huge structures from the water, disassembling them, and sending the pieces to shore facilities for recycling and disposal. All told, the decommissioning program will require the world's largest heavy-lift crane vessels, extensive port facilities, and a highly skilled workforce for deconstruction, marine services, and breakbulk stevedoring, all amid strict environmental compliance requirements and close public scrutiny.[43] There is an intriguing possibility for engaging offshore oil industry workers in both processes, possibly with joint training programs and rehiring of existing workforce.

Over the past two years, Floventis has carried out in-depth dialogue with the offshore oil industry about the potential for sharing major logistics assets, including heavy-lift vessels and port facilities, to facilitate both processes. The company also has discussed these matters in detail with relevant state officials, who have expressed interest in facilitating cooperation between the offshore oil industry and the offshore wind industry in this regard.

However, the oil decommissioning program is currently proceeding at an uncertain pace, with possible regulatory and legal challenges ahead. The challenge of synchronizing the contracting schedules of CADEMO and oil platform decommissioning, as well as the environmental review requirements, have made it unfeasible for joint work to take place. The timing and feasibility of such cooperation may improve in future years, however, and appears a promising option that industry and state government should pursue.

Similar potential may exist for the transition of the region's land-based oil industry. For example, the closure of the Phillips 66 oil refinery and its planned removal might enable the retraining and rehiring of those workers for work in offshore wind.[44] This opportunity has not yet been explored in depth.

PHOTO: Jacques Tarnero

CHAPTER 5. LESSONS LEARNED AND NEXT STEPS

This HRTP has been an iterative learning process, with a robust exchange of information and perspectives among partners. Here is a summary of some of the lessons learned, plus a few guiding concepts for the next phase of the HRTP program, which extends until April 2024.

Ports and Jobs

- The offshore wind industry is highly competitive and globalized, and California cannot take in-state production for granted. Suitable port facilities must be provided, so that the green jobs from offshore wind can be California jobs.
- The manufacturing of turbine components – towers, nacelles, and blades – is unlikely to be established in California anytime soon. The state should focus its attention on platform construction and final turbine integration, along with marine services.
- The Central Coast is highly unlikely to host a large new port complex for offshore wind, and proposals for any such development will prove controversial. The region should start actively planning for the more feasible outcome of creating one or more small operations and maintenance facilities. Public support for even this reduced outcome is not guaranteed and will require considerable community dialogue and resolution of local concerns. Phase 2 of this HRTP will include further outreach to local stakeholders about O&M port options.

Supply Chain

- In public discourse, confusion between the terms "manufacturing" and "construction" has blurred the distinction between the benefits California can reasonably expect to capture and those that are much less likely. The potential for in-state manufacturing of offshore wind turbine components is slim, at least in the short and medium terms, while the potential for major benefits from construction and assembly of floating platforms is significant.
- The state lacks fabricators for the huge rolled steel components that will be needed for steel floating platforms, so these pieces will likely be imported and then welded together at California docks.
- Concrete barge platforms could readily be made with concrete produced at San Francisco's two large local producers, which is an in-state advantage for concrete-based platform designs.
- For CADEMO and the big federal projects alike, the most complex supply chain needs are in the marine phase: the launching of platforms from wharf into the water; the final turbine integration; and the anchor and cable laying. These stages are challenging not primarily because skilled workers are scarce (except in Humboldt), but because legally compliant vessels themselves will be hard to find and may need to be sourced from abroad.
- Difficulties are likely to arise with the Jones Act (requiring U.S.-flagged vessels) and with California's newly strengthened Tier 4 offshore emissions standards. These dilemmas urgently need the attention of state and federal government agencies in cooperation with the offshore wind industry.

Labor

- By including all the relevant unions from the start, Floventis earned several win-win benefits: removing the risk of supply chain limitations that could be caused by last-minute labor negotiations, ensuring a stable and well-trained workforce and gaining the support of influential union allies to partner in negotiations with state and local policymakers.
- Labor contract negotiations are difficult. It took two years for CADEMO's PLA to be finalized. Many aspects provoked significant concern among the counterparties during the negotiations, especially regarding the impacts on contractors and subcontractors, legal risks, political vulnerability, inter-union jurisdiction,

PHOTO: Jacques Tarnero

in-state versus out-of-state work, and more. The final agreements were hard won for both sides. Offshore wind developers and state policymakers should recognize the need to start labor negotiations at the beginning of the project development process, not the end.

- CADEMO's PLA documents provide a template for the rest of the industry. The union signatories to these documents are unlikely to be willing to substantively re-negotiate the terms for other wind developers, and offshore wind companies are equally unlikely to want to cede terms to the unions. The second phase of our HRTP offers multiple opportunities to share information about the negotiating process and the PLA terms with the state's offshore wind industry, especially the five federal auction winners.

- The role of other non-signatory labor unions needs to be recognized appropriately. In particular, non-construction unions such as the ILWU and the marine trades must have their traditional jurisdictions recognized and not overstepped.

Workforce Training

- The large and highly skilled construction workforce in the San Francisco Bay Area and the Los Angeles-Long Beach area will easily suffice to fill the construction and assembly needs at the ports for CADEMO and larger commercial-scale projects. However, this HRTP did not analyze the Humboldt workforce situation, which may have significant gaps that projects in that area will need to address.

- The key workforce gaps derive directly from supply chain gaps in the marine sector for the vessels engaging in launching the platforms, integrating the turbines, and laying the anchors and cables. The second phase of our PLA will address this sector.

- CADEMO's PLA will provide access to California's well-honed, highly effective system of state-certified joint union-employer apprenticeship programs in the construction sector. These programs will be able to adapt readily to fill any specialized needs for the project. Other developers' PLAs will serve the same function.

- CADEMO also expects to access well-developed employer-union training programs in the marine services and in port terminal operations through its contractors' and subcontractors' relationships with marine unions and the ILWU.

- California educational institutions and labor unions have a significant opportunity to partner to create offshore training programs, especially for the operations and maintenance phases of offshore wind farms. One model that deserves attention is at Bristol Community College in New Bedford, Massachusetts, which offers associate degree programs in various offshore wind technology specializations. Our HRTP will work with Central Coast stakeholders and the new Humboldt HRTP to help develop opportunities for such partnerships.

- California's most effective tool to ensure equitable hiring and an inclusive workforce is the state-certified apprenticeship system, which in turn is enabled by PLAs. When paired with pre-apprenticeship programs tied to targeted-hiring programs and community workforce agreements, this system will be a driver of equity and inclusion for the offshore wind industry.

Endnotes

1 Matt Shields and et al., "A Supply Chain Road Map for Offshore Wind Energy in the United States" (National Renewable Energy Laboratory, January 2023); Paul Deaver and Jim Bartridge, "Preliminary Assessment of Economic Benefits of Offshore Wind: : Related to Seaport Investments and Workforce Development" (California Energy Commission, February 24, 2023); Robert Collier et al., "California Offshore Wind: Workforce Impacts and Grid Integration" (UC Berkeley Center for Labor Research and Education, September 2019); E2, "California's Offshore Wind Opportunity: Creating Jobs by Developing a New Clean Energy Resource, and Capitalizing on Robust Job Creation Potential," February 2023; Mott MacDonald, "Central Coast Emerging Industries Waterfront Siting and Infrastructure Study" (REACH, December 2022); Guidehouse, "California Supply Chain Needs Summary" (California Energy Commission, May 2, 2022).

2 Ibid.

3 Carol Zabin et al., "Putting California on the High Road: A Jobs and Climate Action Plan For 2030" (UC Berkeley Center for Labor Research and Education, for the California Workforce Development Board, September 3, 2020).

4 Office of the Governor, "California Joins White House Partnership on Offshore Wind Energy," February 22, 2023.

5 California Energy Commission, "AB 525 Reports: Offshore Renewable Energy," n.d.

6 Cierco US Corp., "CADEMO Offshore Wind Demonstration Project," n.d; California State Lands Commission, "Applications for Offshore Wind Energy Development in State Waters," n.d.

7 Barry van Wyk, "Far out: Offshore Floating Wind Power Is Taking off in China," China Project, December 27, 2022.

8 Moffatt & Nichol, "Alternative Port Assessment to Support Offshore Wind" (California State Lands Commission, January 31, 2023); Mott MacDonald, "Central Coast Emerging Industries Waterfront Siting and Infrastructure Study" (REACH, December 2022).

9 "CADEMO's Project Labor Agreement with Building Trades," November 29, 2022.

10 Bureau of Ocean Energy Management, "Final Sale Notice: Pacific Wind Lease Sale 1 for Commercial Leasing for Wind Power on the Outer Continental Shelf in California," October 21, 2022.

11 Guidehouse, "California Supply Chain Needs Summary"; U.S. Department of Energy, "DOE Launches Prize to Accelerate Domestic Supply Chains for Floating Offshore Wind Energy," September 12, 2022; Shields and et al., "A Supply Chain Road Map for Offshore Wind Energy in the United States."

12 "CADEMO's Project Labor Agreement with Building Trades."

13 A heave plate is a structural component of a floating structure whose primary purpose is to increase damping and add mass in heave or pitch direction.

14 Adnan Durakovic, "15 MW Siemens Gamesa Turbines for US Offshore Wind Farm," Offshore Wind, May 26, 2020.

15 Rick Karlin, "Overruns, Delays Plague Port of Albany Wind Tower Project," Albany Times Union, February 28, 2023.

16 U.S. Department of Energy, "DOE Launches Prize to Accelerate Domestic Supply Chains for Floating Offshore Wind Energy," September 12, 2022,

17 SBM Offshore, "Float4Wind: The Next Generation of Tension Leg Platform Technology," 2022.

18 Saitec Offshore Technologies, "SATH Technology," accessed November 11, 2020.

19 "US Offshore Wind Developers Exposed to 'Tight' Vessel Outlook" (Reuters, February 23, 2022).

20 Dominion Energy, "Dominion Energy Continues Development of First Jones Act Compliant Offshore Wind Turbine Installation Vessel," December 16, 2020.

21 "California Outside Line Construction Agreement," June 1, 2022.

22 "U.S. Customs Agency Issues Guidance on Jones Act Compliance in Connection with Offshore Wind Projects," National Law Review, June 1, 2022.

23 Mike Schuler, "House Bill Would Close Jones Act Letter Ruling Loopholes," GCaptain, December 15, 2022.

24 Prysmian Group, "Giulio Verne," n.d.

25 California Air Resources Board, "CARB Passes Amendments to Commercial Harbor Craft Regulation," March 24, 2022.

26 Mackenzie Shuman, "Massive Port Infrastructure Needed in SLO County to Support Offshore Wind, New Study Shows," San Luis Obispo Tribune, December 15, 2022.

27 Shields and et al., "A Supply Chain Road Map for Offshore Wind Energy in the United States"; Deaver and Bartridge, "Preliminary Assessment of Economic Benefits of Offshore Wind: : Related to Seaport Investments and Workforce Development"; E2, "California's Offshore Wind Opportunity: Creating Jobs by Developing a New Clean Energy Resource, and Capitalizing on Robust Job Creation Potential"; Mott MacDonald, "Central Coast Emerging Industries Waterfront Siting and Infrastructure Study."

28 Note this is an annualized figure. One job for three years would equate to 3 FTE.

29 Bureau of Ocean Energy Management, "Pacific Wind Lease Sale 1 (PACW-1) for Commercial Leasing for Wind Power on the Outer Continental Shelf in California - Final Sale Notice (FSN)," October 5, 2022.

30 Jeremy Stefek and et al., "U.S. Offshore Wind Workforce Assessment" (National Renewable Energy Laboratory, October 2022).

31 Carol Zabin et al., "Putting California on the High Road: A Jobs and Climate Action Plan For 2030" (UC Berkeley Center for Labor Research and Education, September 3, 2020).

32 "California Outside Line Construction Agreement" (June 1, 2022).

33 California Department of Industrial Relations, "Division of Apprenticeship Standards" (n.d.).

34 California Workforce Development Board, "High Road Construction Careers" (n.d.).

35 Pacific Maritime Association, "Contract Documents" (n.d.); Edwin Lopez, "ILWU, PMA Reach Tentative Deal on 'Certain Key Issues,'" Supply Chain Dive (April 21, 2023).

36 UBC Pile Drivers and Divers, "Offshore Wind" (n.d.).

37 Bristol Community College, "National Offshore Wind Institute" (n.d.).

38 Massachusetts Maritime Academy, "US Offshore Wind Training" (n.d.).

39 Cal Poly Humboldt, "Offshore Wind Workforce to Be Trained by Cal Poly Humboldt, Yurok Tribe, and College of the Redwoods" (February 16, 2023).

40 Zabin et al., "Putting California on the High Road: A Jobs and Climate Action Plan For 2030."

41 Bureau of Ocean Energy Management, "Pacific Oil and Gas Decommissioning Activities" (n.d.).

42 John Bridge Smith & Robert Clark Byrd, "Update on the Challenges to Offshore Facility Decommissioning on the California Coast" (Offshore Technology Conference, Houston, Texas, May 1, 2023).

43 California Department of Fish and Wildlife et al., "Joint Comments on Draft Programmatic Environmental Impact Statement (PEIS) for Oil and Gas Decommissioning Activities" (September 27, 2021).

44 County of San Luis Obispo, "Phillips 66 Santa Maria Refinery Demolition and Remediation Project" (n.d.).

PHOTO: ABB

APPENDIX

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

Cyrus Ramezani, Ph.D.
cramezan@calpoly.edu

Mahdi Rastad, Ph.D.
mrastad@calpoly.edu

CAL POLY
Orfalea College *of* Business

01 April 2023

This report is prepared as part of the "High Road to Offshore Wind Energy" grant to the San Luis Obispo County Office of Education by the California Workforce Development Board- High Road Training Partnership.

Contents

List of Tables

List of Figures

Acknowledgments

This research was funded as part of the "High Road to Offshore Wind Energy" grant to the San Luis Obispo County Office of Education by the California Workforce Development Board- High Road Training Partnership. The authors gratefully acknowledge industry stakeholders, including the Cierco/CADEMO staff for their input. Any reference, discussion, or analysis of an entity or company, or its product or service in this report is not an endorsement or advertisement for the company, nor is it in any way intended as a criticism of the entity or company. Such examples are offered for illustrative and discussion purposes only. Finally, the opinions and conclusions expressed herein are those of the authors and do not necessarily represent those of the HRTP, CADEMO staff, 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 onshore, 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

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

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.

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 the Scope of the Study

Jose Vega-Lozano ©Equinor

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.

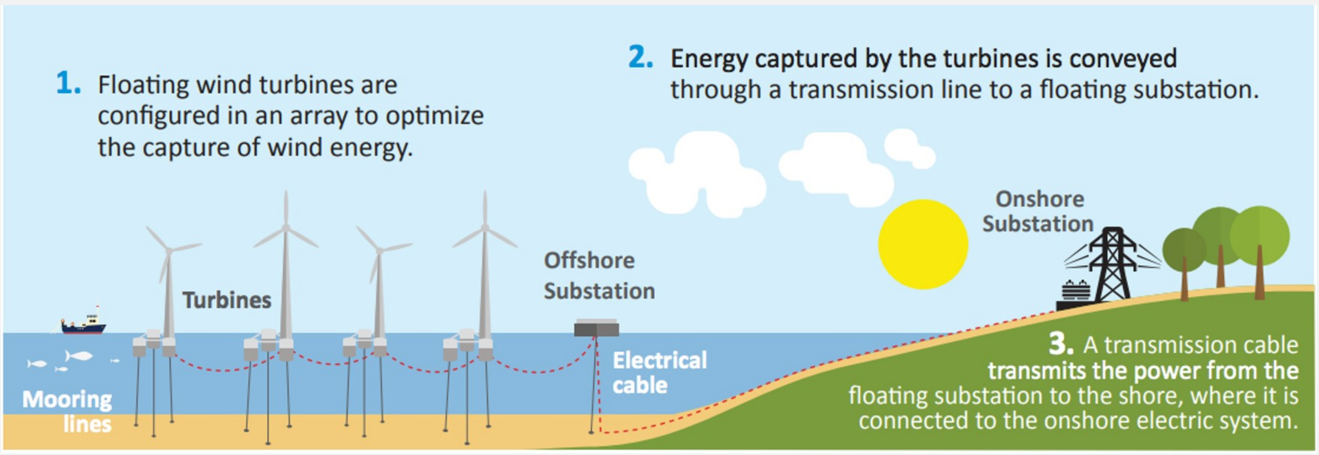
2.1 Background on Floating Offshore Wind

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)

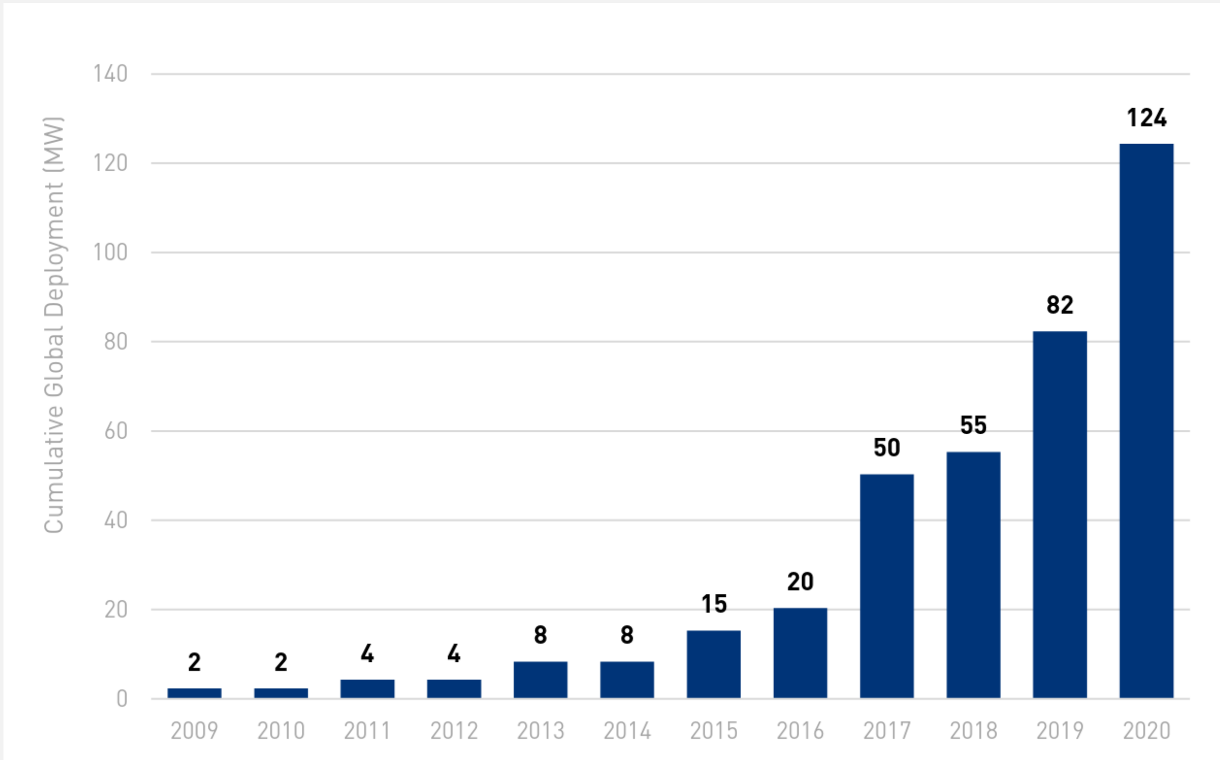
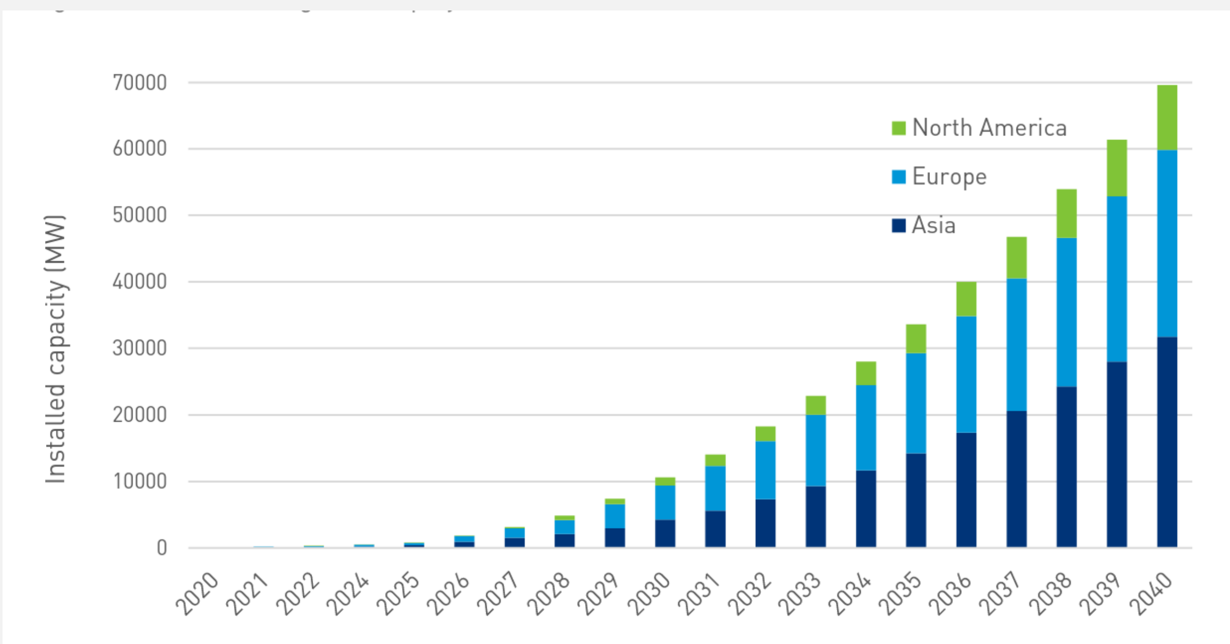


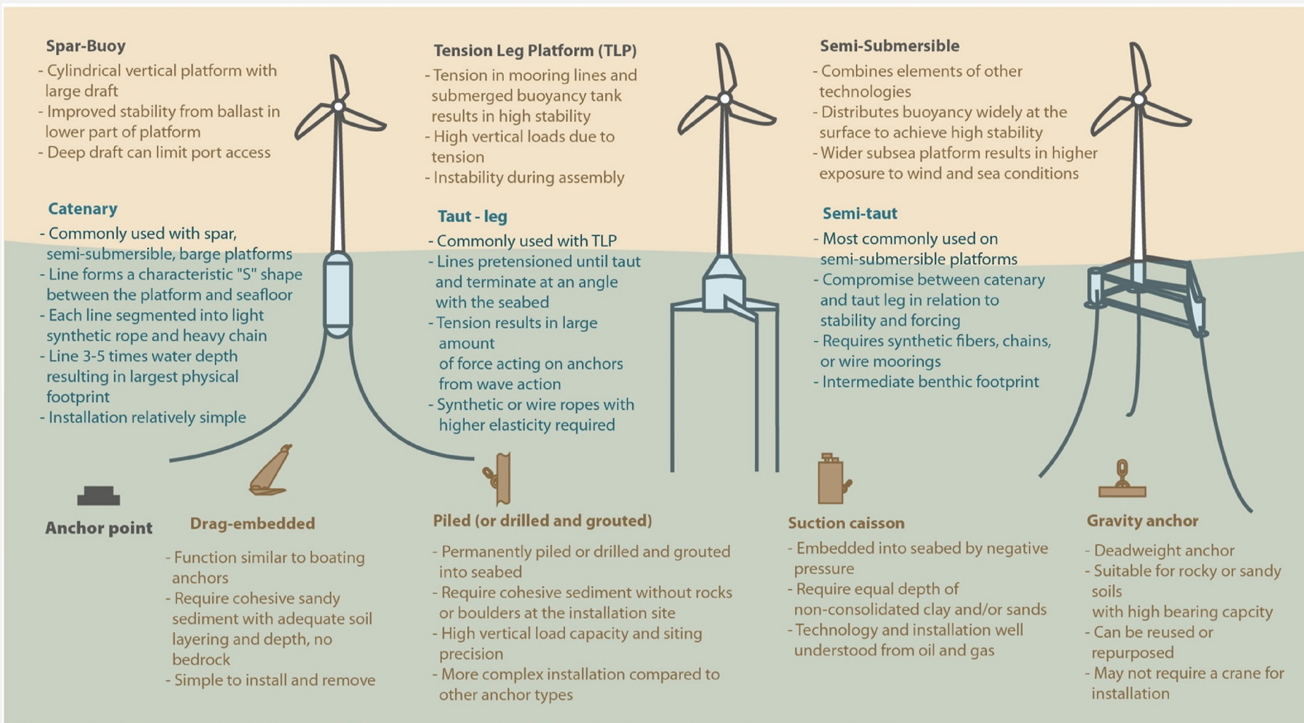
Figure I.2B: Expected Global FOSW Deployment



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



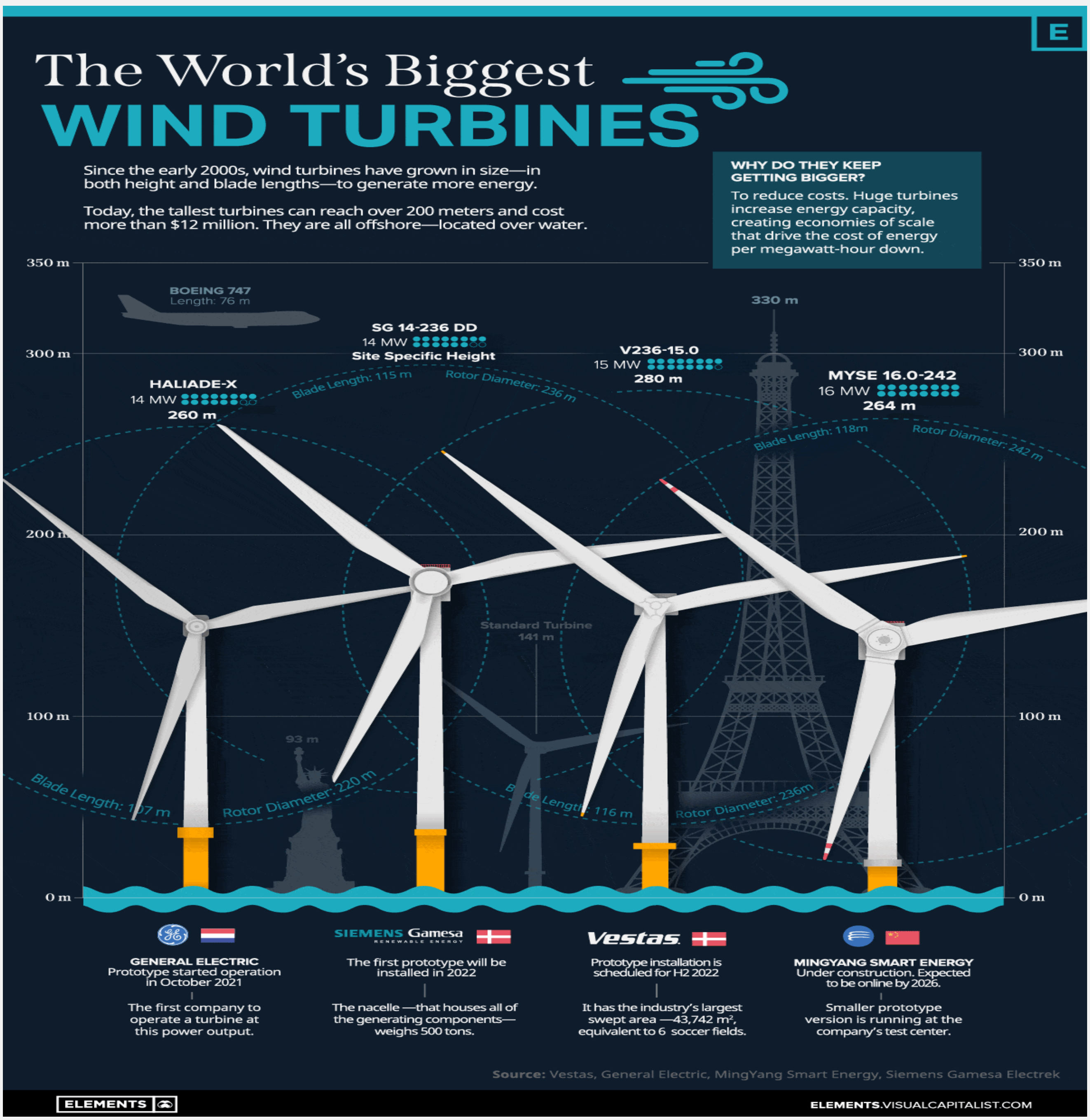
Source: Maxwell, et al. 2022

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.

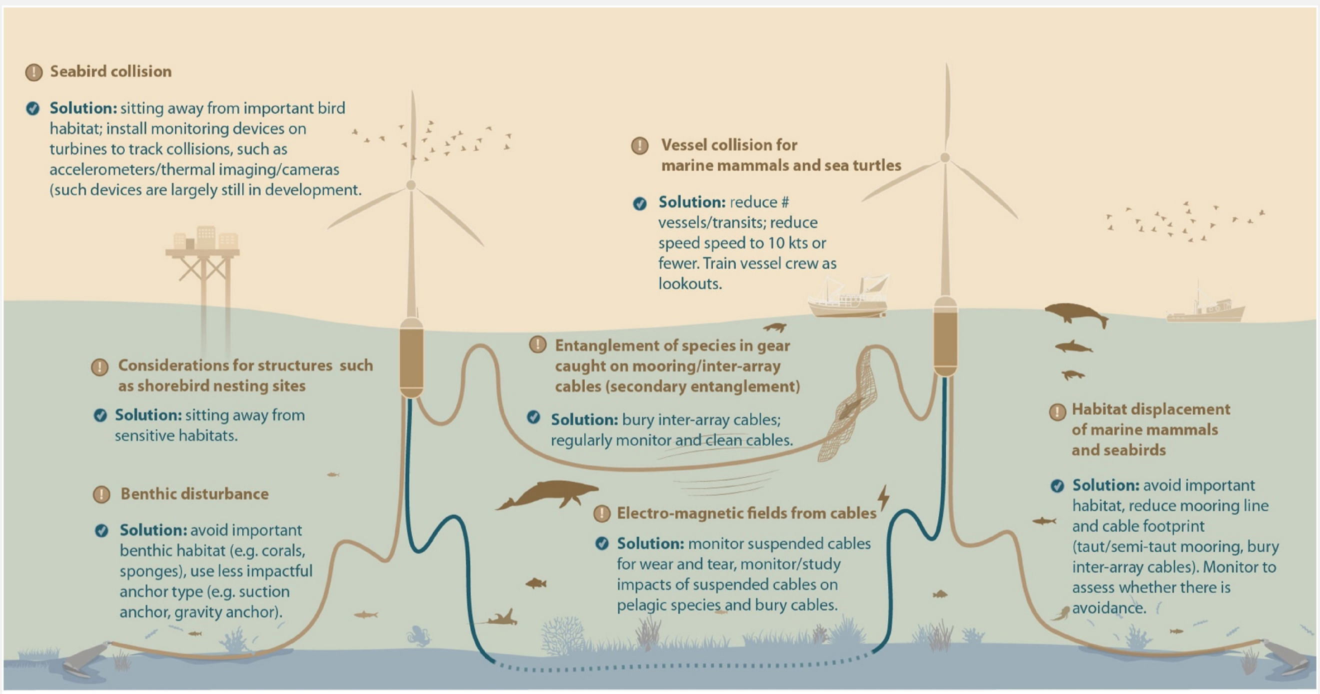
The largest cost saving for FOSW projects is expected to come from growth in the size of turbines. As Figure I.4 shows, turbine capacity has increased significantly in recent years. In this study we assume that 15 MW turbines will be used for both CADEMO and the commercial scale Morro Bay projects.

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 and Employment Impact of FOSW

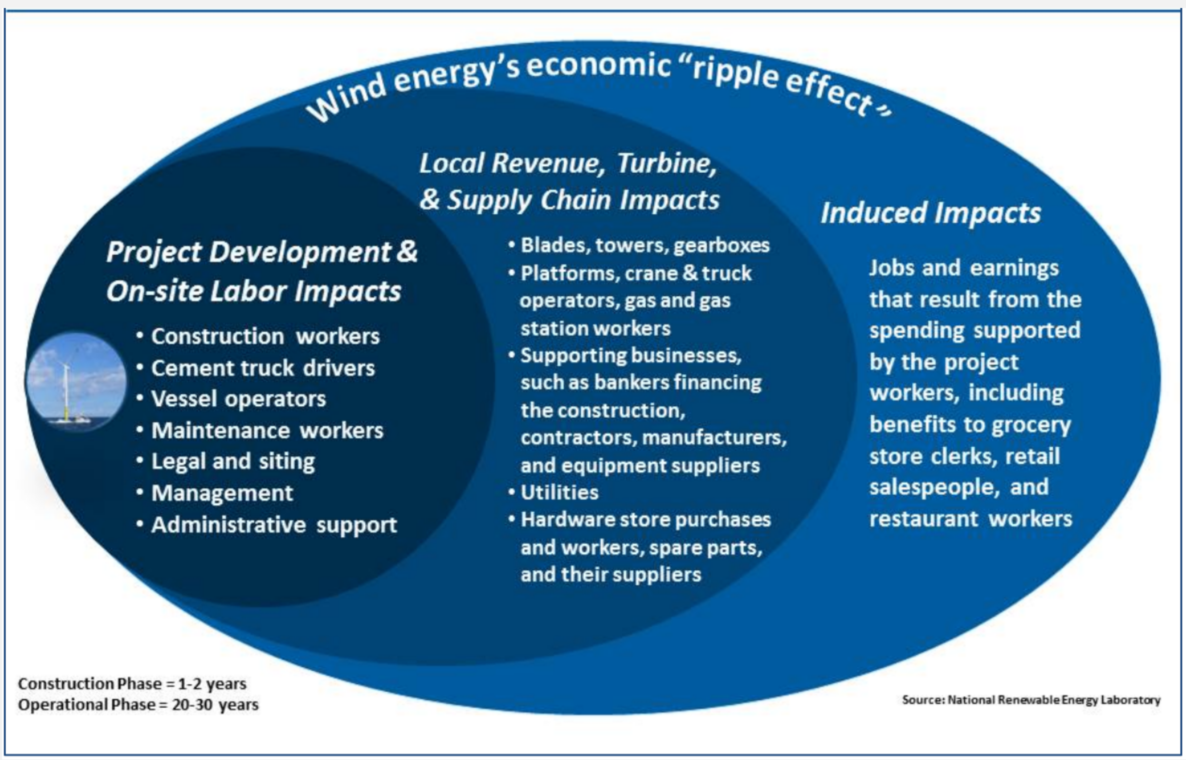
The TetraSpar Demonstrator Project ApS. / ©Stiesdal.

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:

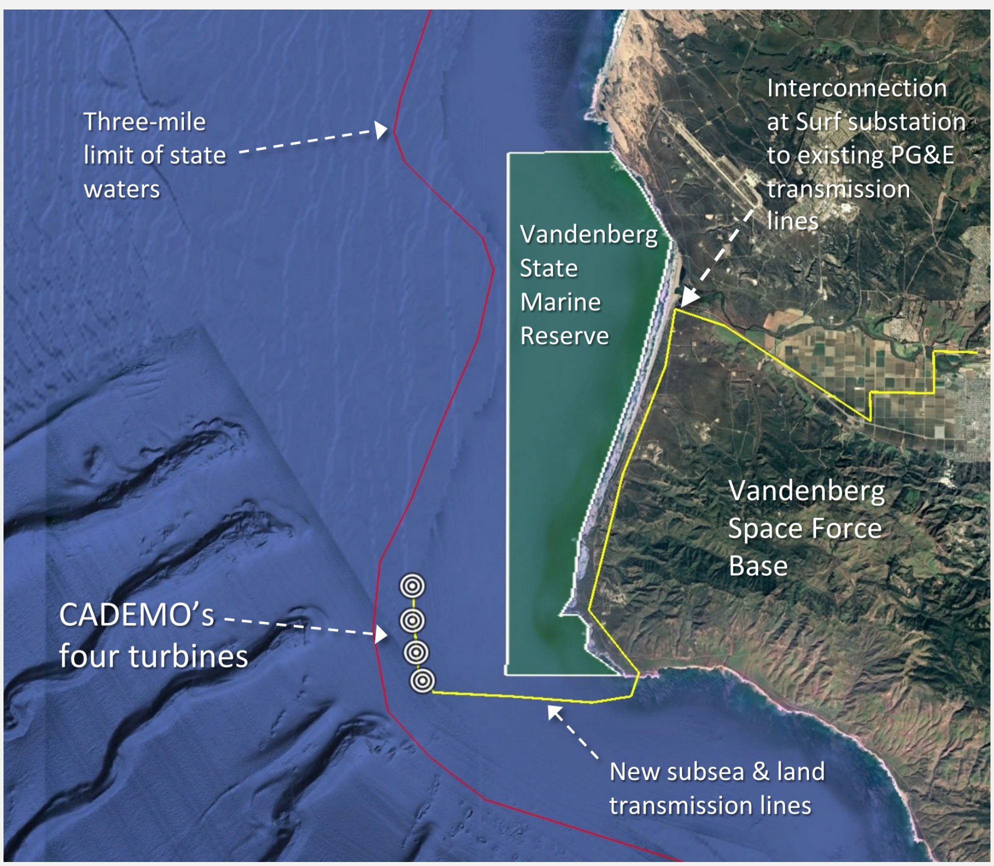
- **Construction** period results are inherently short-term. Jobs are defined as full-time equivalents (FTE), or 2,080-hour units of labor. One construction period job equates to one full-time job for one year. Equipment manufacturing jobs, for example building turbine towers, are included in construction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

Figure E.2: CADEMO's Geographic Location

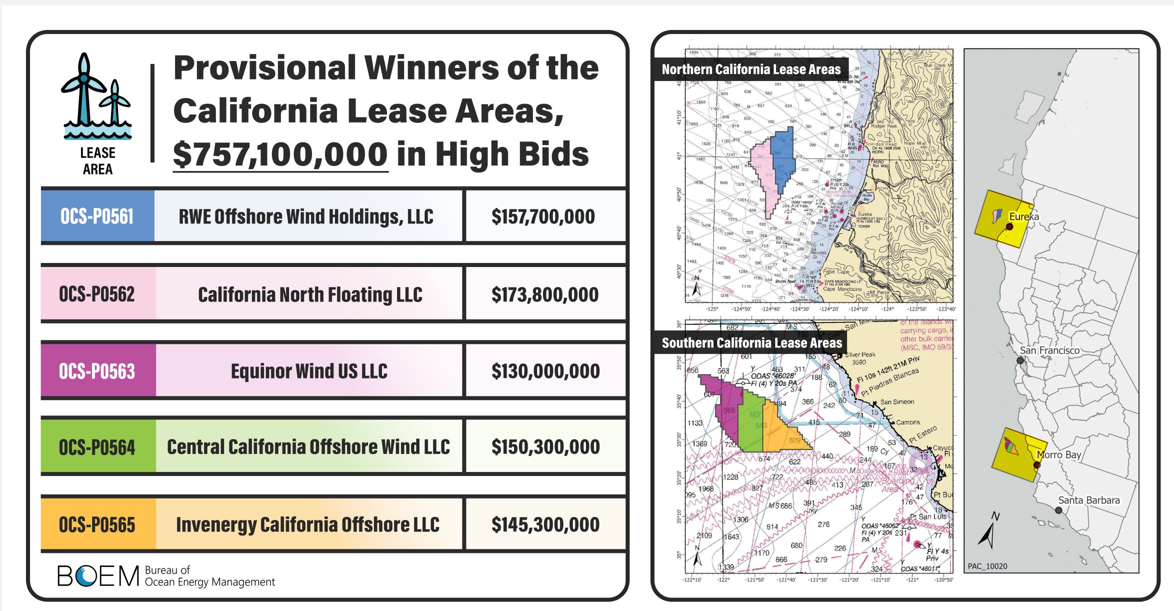


Source: The CADEMO Project, https://cademo.net/the-project/

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]

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**

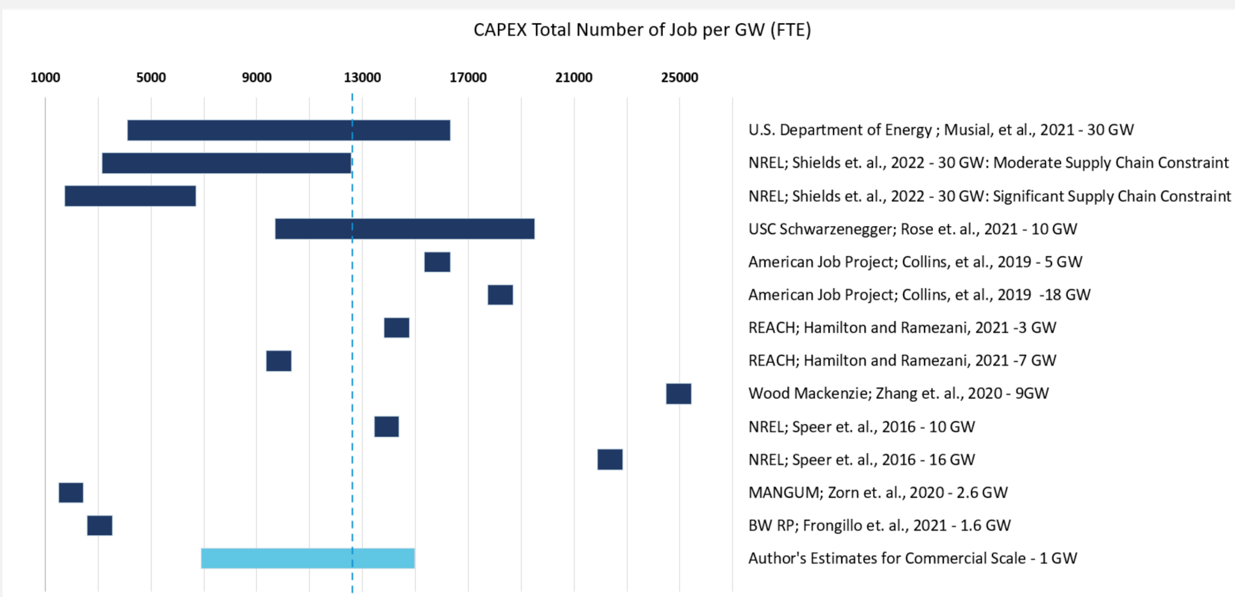
Operations and Maintenance (Annual, Ongoing)				
Scenario		**C1**	**C2**	**C3**
Jobs (FTE)	Onsite	128	100	100
	Supply Chain	157	394	394
	Induced	113	190	190
	Total	**398**	**684**	**684**
Earnings ($ Millions)	Onsite	11.3	9.0	9.0
	Supply Chain	11.6	33.6	33.6
	Induced	7.7	12.0	12.0
	Total	**30.5**	**54.6**	**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%**

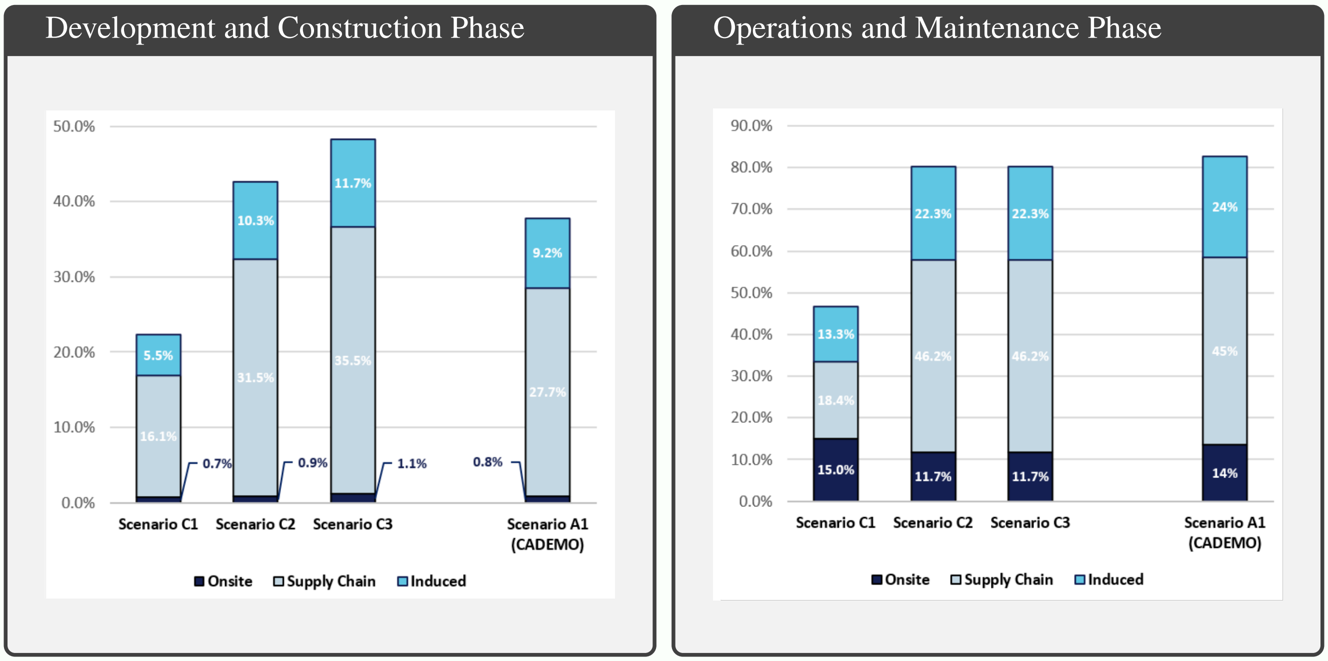
Scenario	C1	C2	C3
Operations and Maintenance (Annual, Ongoing)	Jobs FTE	Jobs FTE	Jobs FTE
Technicians and Management	129	100	100
Supply Chain/Support Services	157	394	394
Induced	113	190	190
Total	**399**	**684**	**684**
California's Share of Global Jobs Created	**46.7%**	**80.2%**	**80.2%**

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 Projects in California

The TetraSpar Demonstrator Project ApS. / ©Stiesdal.

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.

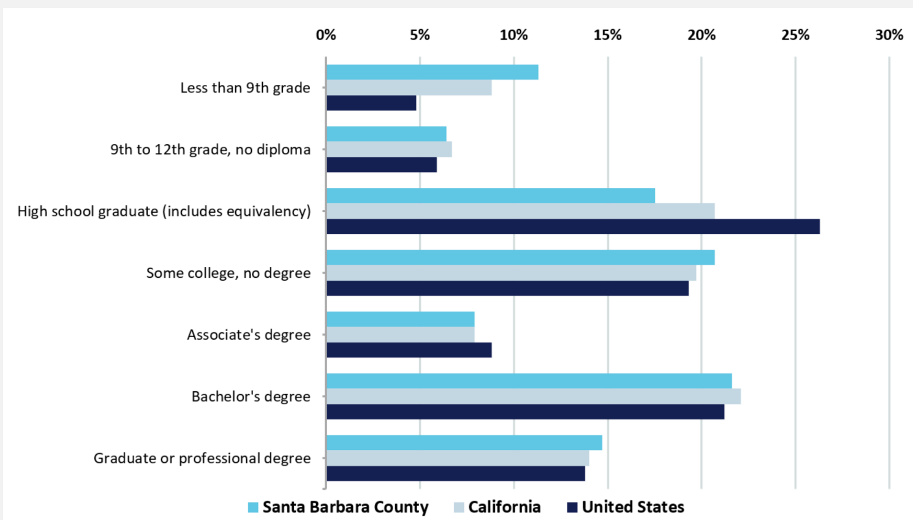
Table SB.4: Educational Attainment in Santa Barbara County for Population 25 Years and Over

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.

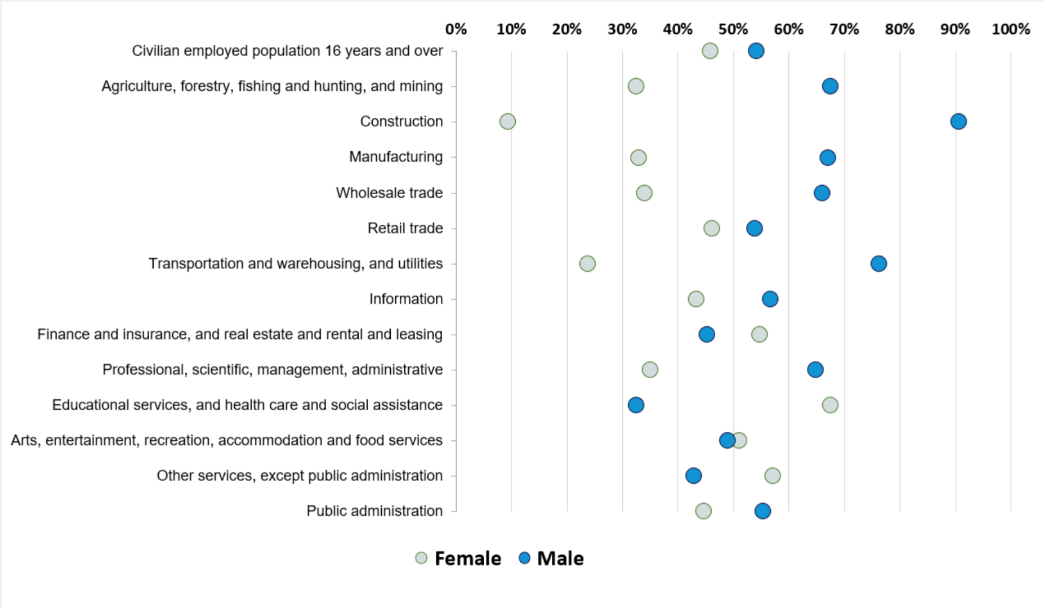
Figure SB.1: Educational Attainment, 2021



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.

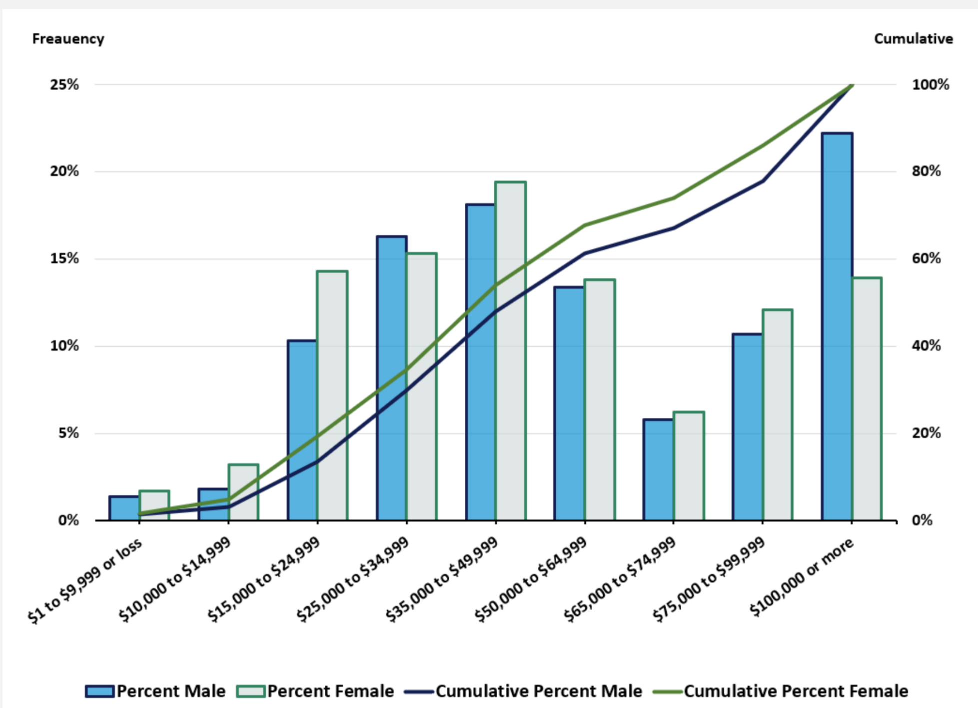
Figure SB.2: Composition of Jobs in Santa Barbara County by Industry and Gender



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.

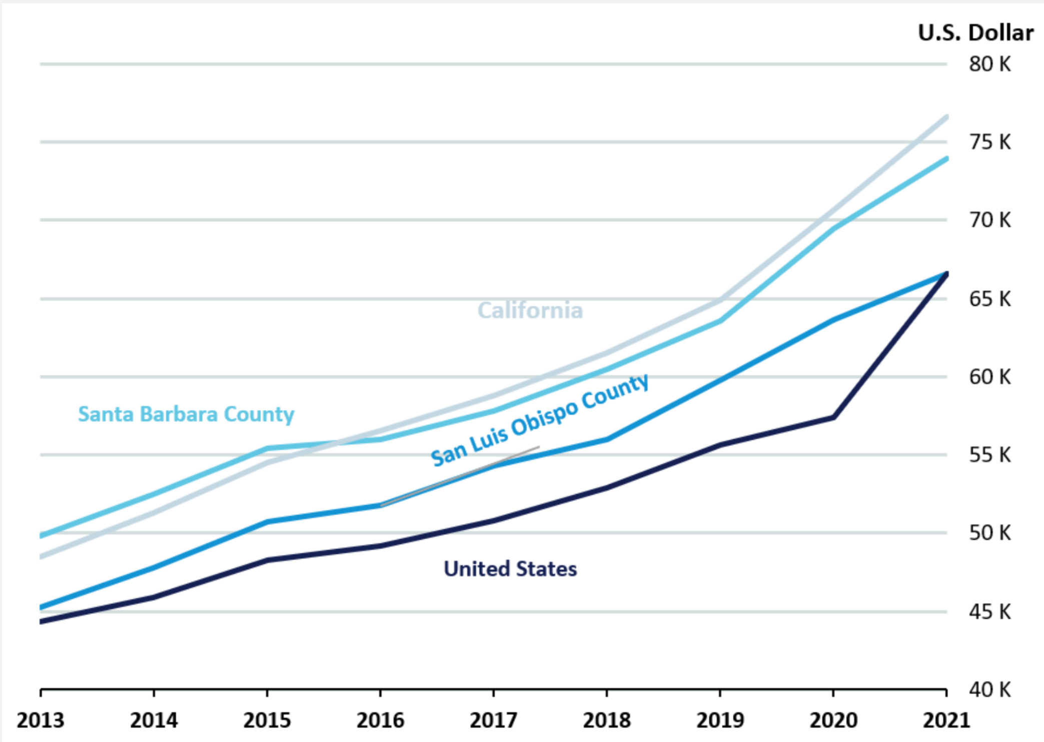
Figure SB.3: Wages Distribution by Gender in Santa Barbara County, 2020



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

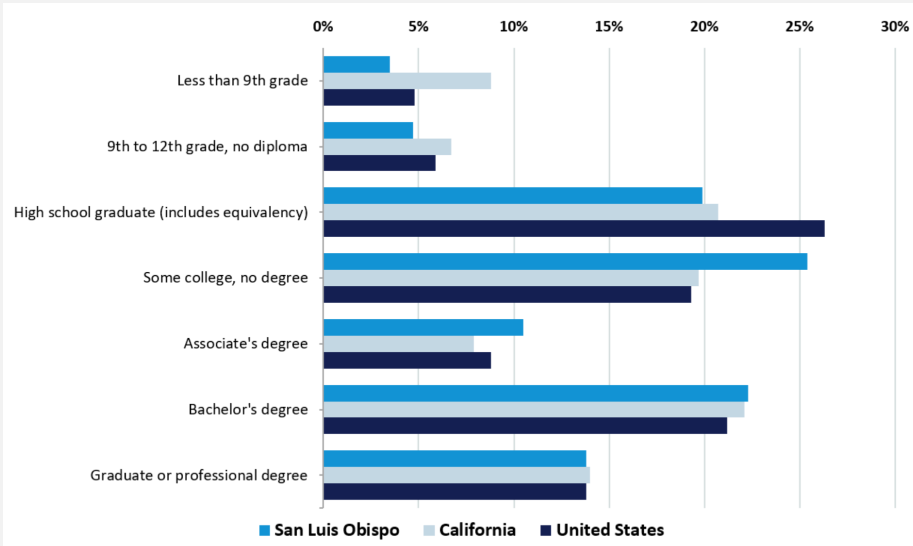
Population 25 years and over	2016 (%)	2018 (%)	2020 (%)
Less than 9th grade	4.4	4.1	3.5
9th to 12th grade, no diploma	5.5	5.0	4.7
High school graduate	19.4	19.8	19.9
Some college, no degree	26.7	25.9	25.4
Associate degree	10.0	10.5	10.5
Bachelor's degree	21.7	21.4	22.3
Graduate or professional degree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

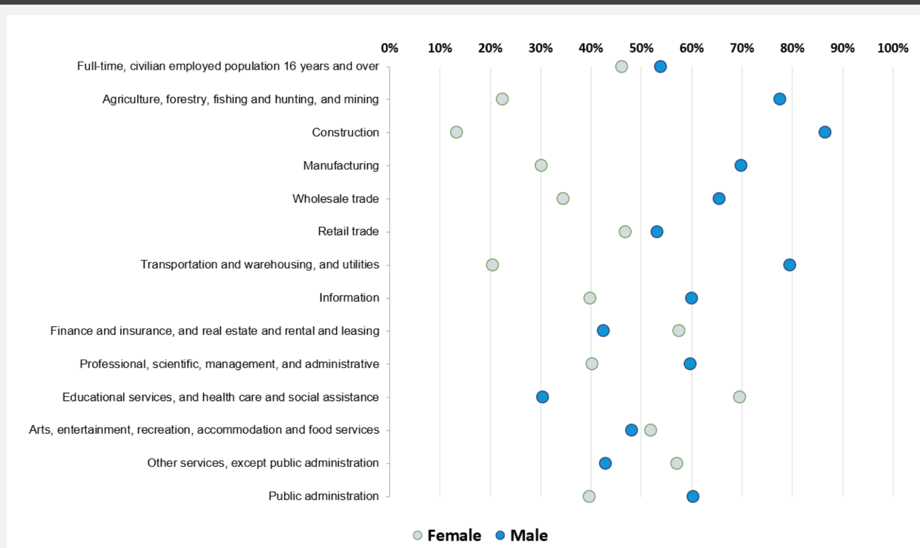
Figure SL.1: Educational Attainment, 2021



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.

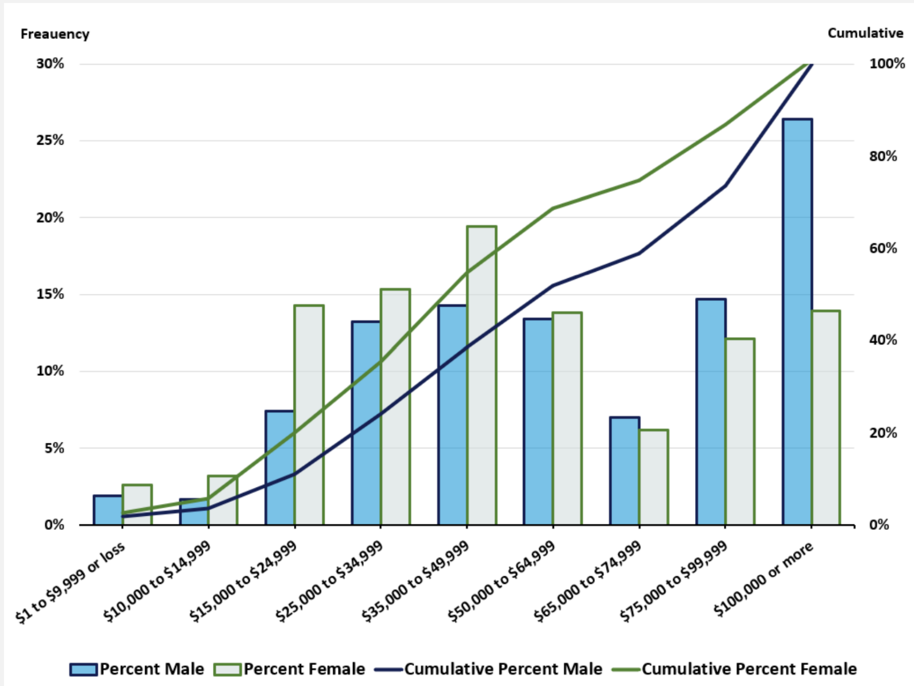
Figure SL.2: Composition of Jobs in San Luis Obispo County by Industry and Gender



Source: U.S. Census Bureau

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).

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



Source: U.S. Census Bureau

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

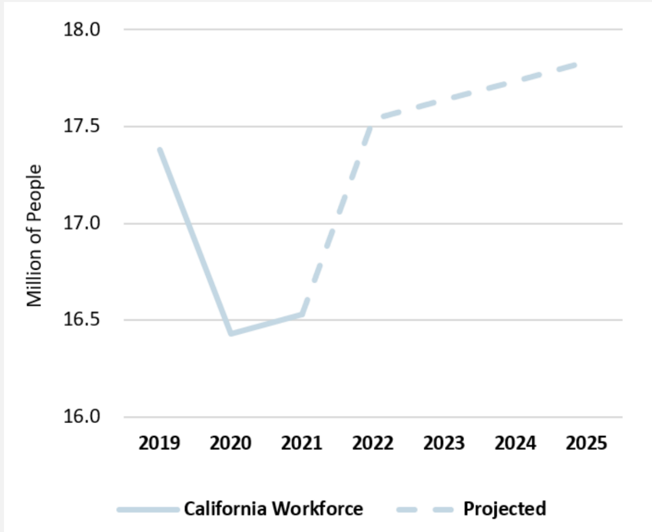
Income	Total	Percent (%)
Less than $10,000	715,644	5.3
$10,000 to $14,999	469,896	3.5
$15,000 to $24,999	808,568	6.0
$25,000 to $34,999	829,411	6.2
$35,000 to $49,999	1,206,545	9.0
$50,000 to $74,999	1,974,452	14.7
$75,000 to $99,999	1,639,647	12.2
$100,000 to $149,999	2,359,723	17.6
$150,000 to $199,999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

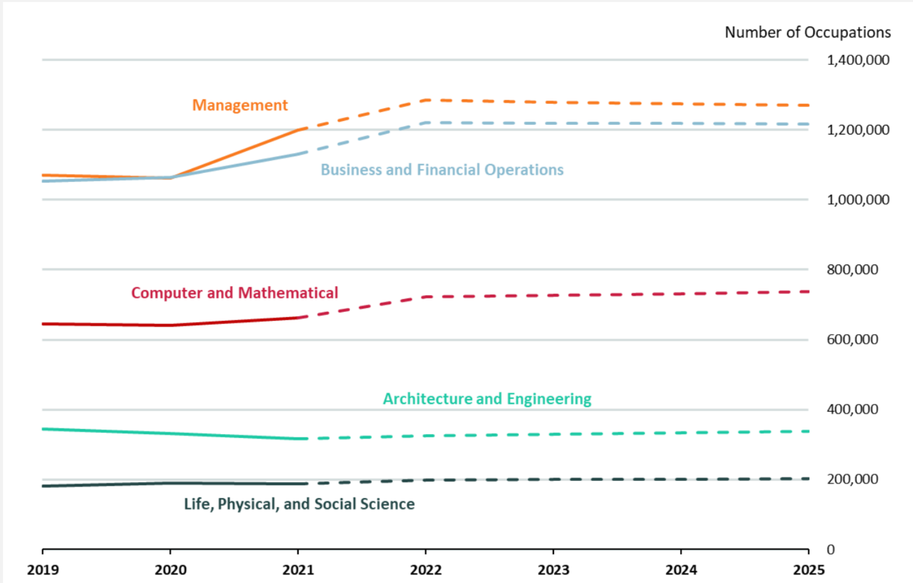
4. Administrative and Construction Occupations

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



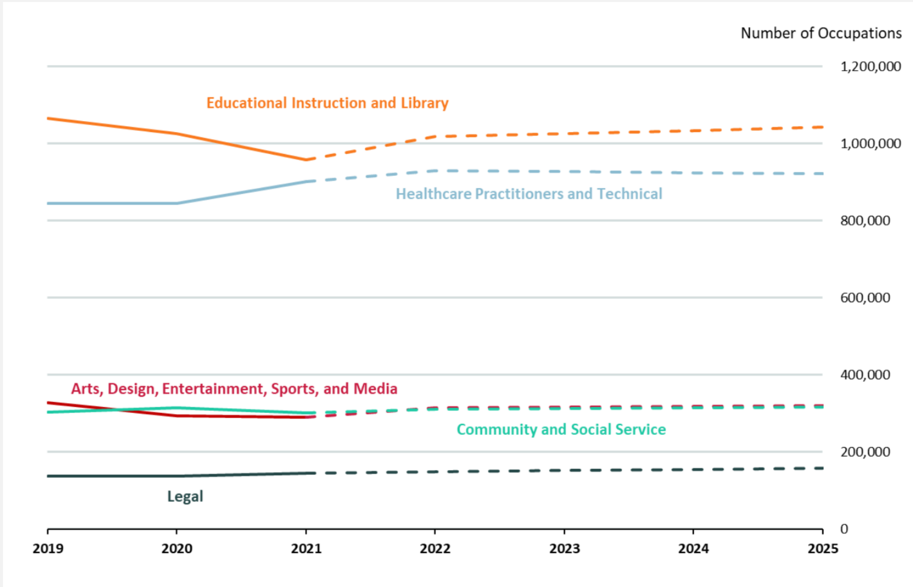
Source: U.S. Bureau of Labor Statistics (BLS) and JobsEQ

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.

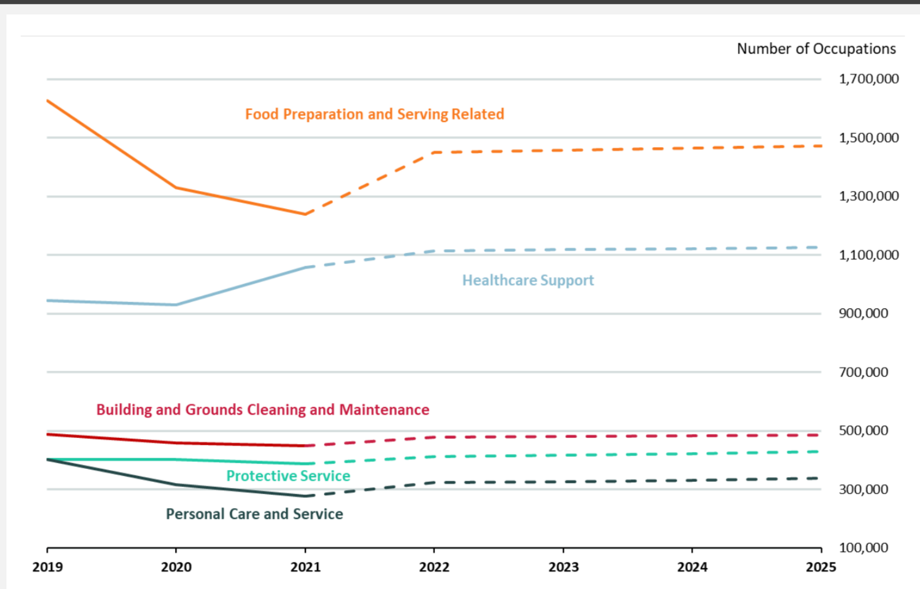
Figure CA.3: Employment in Community Service Occupations



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.

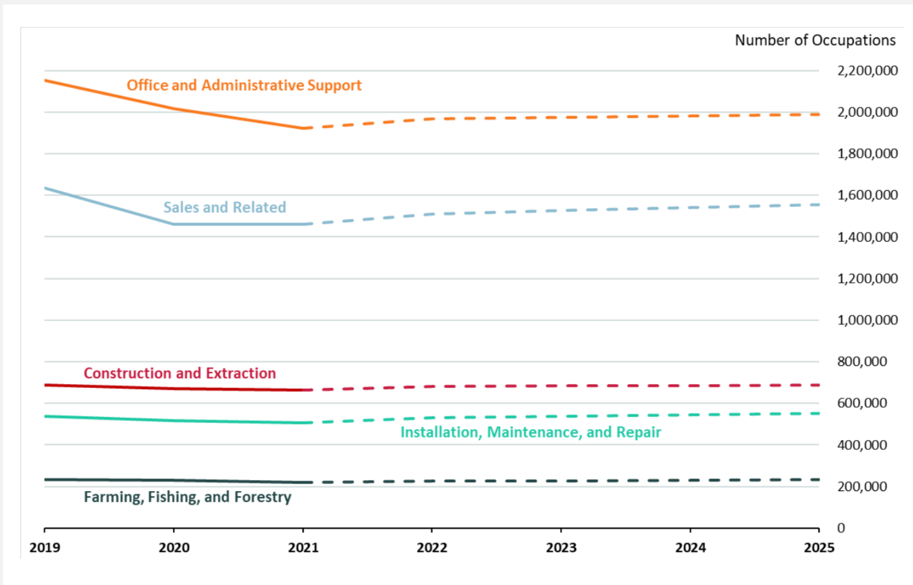
Figure CA.4: Employment in Food and Wellness Occupations



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.

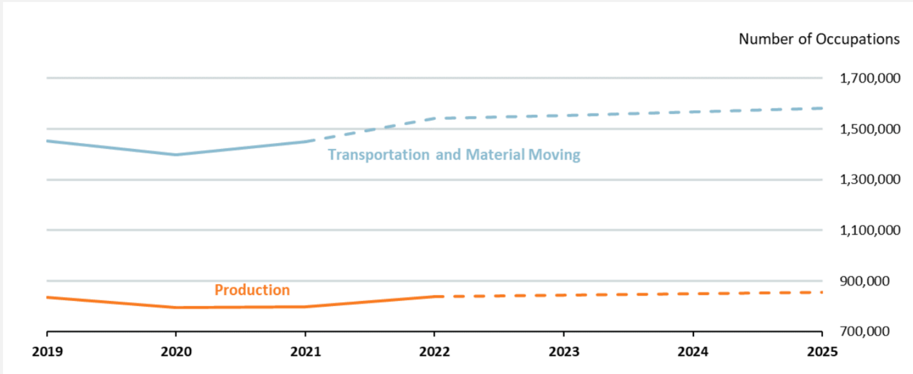
Figure CA.5: Employment in Administrative and Construction Occupations



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 Floating Offshore Wind Labor Gap in California by Key Occupations

The TetraSpar Demonstrator Project ApS. / ©Stiesdal.

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 Demand	Unemployed	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 Conclusions

The TetraSpar Demonstrator Project ApS. / ©Stiesdal.

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.

8. Additional References

1. *The California Offshore Wind Project: A Vision for Industry Growth*, American Jobs Project. 2019.

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.

8. *Offshore wind market report: 2022 edition*, Musial, W., Spitsen, P., Beiter, P., Duffy, P., Marquis, M., Cooperman, A., Hammond, R. and Shields, M., S department of energy, energy efficiency & renewable energy Tech. rep. Office of Energy Efficiency & Renewable Energy, 2022.

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

Ole Jørgen Bratland ©Equinor

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


ShS OS2

PHOTO: Saitec