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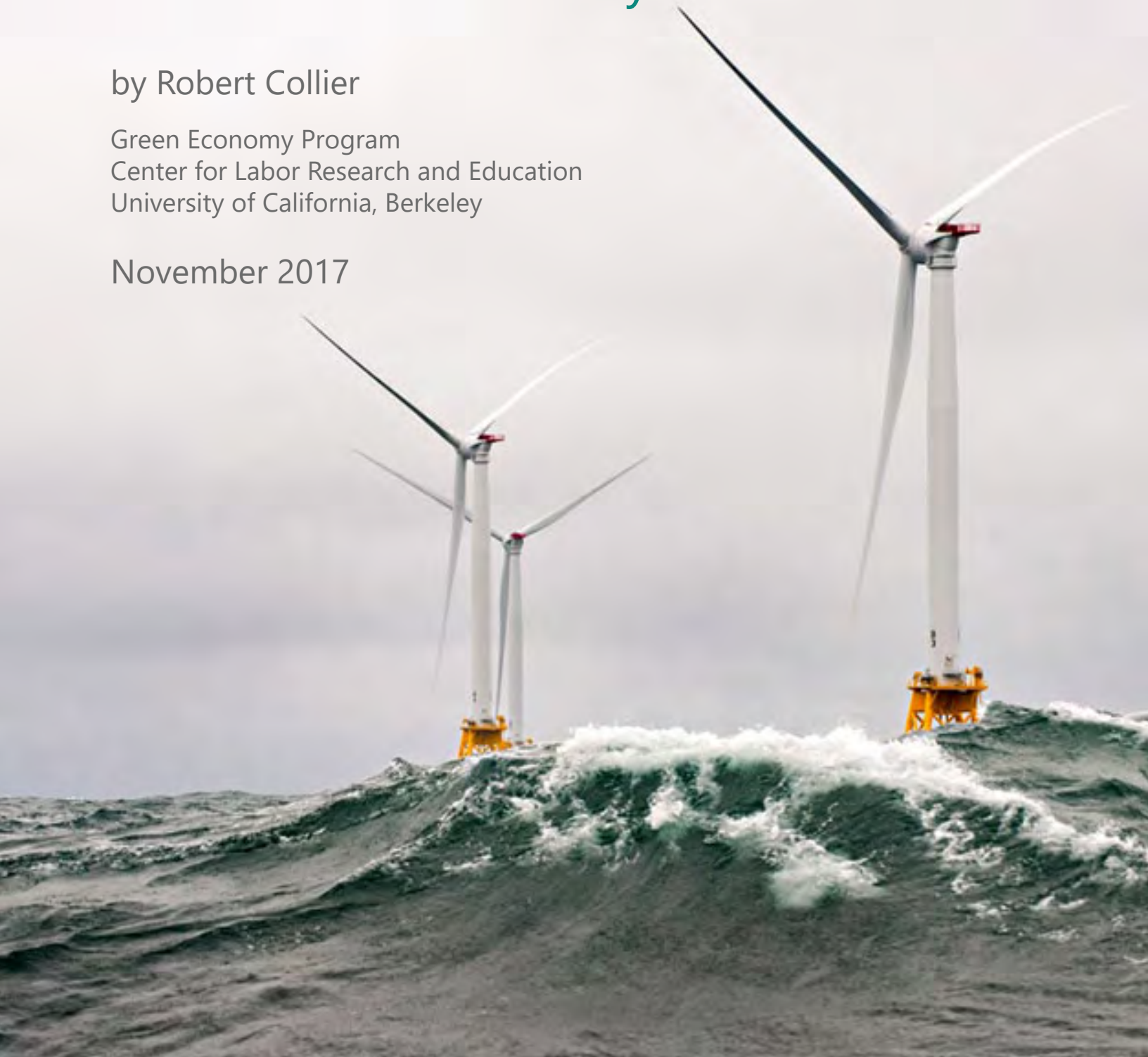
# High Road for Deep Water

## Policy Options for a California Offshore Wind Industry

by Robert Collier

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Center for Labor Research and Education  
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## ACKNOWLEDGMENTS

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Cover photo: Block Island Wind Farm, Rhode Island; credit: U.S. Department of Energy, <https://www.flickr.com/photos/departmentofenergy/37158627656/>

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A turbine being “mated” with its underwater substructure prior to being installed at Hywind Scotland, the world’s first commercial floating offshore wind farm, which began operations in October 2017. Photo: Statoil

## EXECUTIVE SUMMARY

As California accelerates its transition to a low-carbon future, one of its challenges is to choose “high-road” policies that not only cut emissions but spur broad-based growth, create quality jobs, and benefit communities. The state and federal governments have recently launched a planning process for one emerging clean energy source with significant high-road potential: offshore wind.

This report analyzes the policy actions needed for offshore wind power to become an important component of California’s energy mix and an economic catalyst. These steps would entail an unusual degree of long-term coordination and commitment by government and industry. Yet such an effort appears to merit serious consideration because of the sector’s potential to create high-wage employment and help balance the state’s power grid at electricity rates competitive with those of similar sources.

California state agencies already provide direct and indirect subsidies to other, much-touted technologies of the future such as battery storage and advanced biofuels. By placing strategic bets on competing clean energy alternatives, these subsidies stimulate a multi-sided development race that will strengthen the state’s climate policy options in the years to come. Offshore wind carries the same inherent risk as the other technologies in this race: the lack of certainty that they will cut their currently-high costs enough to become fully competitive. But offshore wind also has a unique vulnerability that doubles as economic potential: its physical scale and logistical complexity.

Because the ocean floor along California's coast slopes steeply downward into deep waters, offshore wind turbines must be on floating platforms, instead of being fixed to the ocean floor in shallow waters like those along the East Coast and much of Europe. The floating turbines expected for California will be huge, with heights reaching as much as 700 feet, meaning that each floating turbine is effectively a giant half-ship, half-airplane, with complex manufacturing, logistical, and maintenance needs.<sup>1</sup> These needs, in turn, require an extensive supply chain. Ensuring that this supply chain takes root in California rather than in Asia or Europe would require major upgrades to California's infrastructure for ports, transportation, and transmission. The payoff would be creation of a new economic sector that – to a greater or lesser extent, depending on policy decisions – could provide family-supporting wages, health and retirement benefits, and career training opportunities, including for workers from disadvantaged communities.

A necessary factor in developing this supply chain is investor confidence. In-state production of the full range of wind farm components is possible if state and federal planners send clear signals to wind developers that, if they build this manufacturing capacity in California, their investments will find steady markets through a long-term series of offshore projects. Without such signals, it is likely that much of the supply chain would be outsourced, with fewer economic benefits for Californians.

For these reasons, California's offshore wind is a case study of the challenges and opportunities inherent in a 21st-century industrial policy for the clean energy transition. An entirely new industry is being envisioned, potentially involving major infrastructure requirements and long-term power resource planning. Success will depend on policy decisions and market signals that are only just now beginning to be evaluated by government and non-government stakeholders.

A central finding of this report is that California's offshore wind planning efforts will soon need to broaden their scope. Since early 2016, the state and federal governments have commissioned research, conducted stakeholder outreach, and mapped out the labyrinth of state, federal, and local permitting. This is important groundwork, much of which involves potential environmental concerns that are outside the purview of this report.<sup>2</sup> But because there are so few U.S. precedents for high-road economic planning, additional attention will be needed to identify and design the appropriate policy tools.

This report analyzes the potential economic and environmental benefits of a California offshore wind industry, the types of policy decisions and public investments needed to maximize this potential, and the not-insignificant challenges that lay ahead. Research for this report included interviews with a wide variety of stakeholders, ranging from those outside the current planning effort such as labor union leaders in California, Massachusetts, and Rhode Island, to policy insiders such as California state officials, wind industry executives, and representatives of environmental organizations. The report's findings are summarized below.

## ROLE OF OFFSHORE WIND IN CALIFORNIA'S LOW-CARBON TRANSITION

- **In-state grid balancing:** Offshore wind would bridge the daily late-afternoon gap between fast-vanishing solar output and rising residential electricity consumption, thus reducing the state's need to import wind power from Wyoming or other out-of-state sources. In doing so, it could allow California to develop additional solar power without destabilizing the grid. As an in-state energy source rather than an out-of-state import, offshore wind would be under the purview of the state's own regulators as well as federal agencies, thus allowing California policymakers to ensure compliance with state policies and interests.<sup>3</sup>

- **Economic feasibility:** Until only a year or two ago, offshore wind seemed far too expensive to ever be able to compete with California's other sources of renewable power. But recent technological innovations have sent offshore wind costs plummeting, suggesting that by the mid-2020s, floating wind farms will be close enough to price parity with land-based renewables that they could play a large, complementary role in California's power mix.<sup>4</sup>

## HIGH-ROAD STRATEGIES

- **Jobs potential:** An April 2016 analysis (Speer et al.) by the National Renewable Energy Laboratory (NREL) of development scenarios for California offshore wind concluded that an economically feasible build-out of 16 GW would create steadily increasing employment totaling an annual average of 13,620 full-time jobs in construction, installation, and manufacturing by 2040-2050, and 4,330 full-time, long-term jobs in operations and maintenance, plus thousands more service-sector jobs in the broader economy.<sup>5</sup> If the construction and installation contracts were governed by project labor agreements, and if manufacturers and wind farm owners could be encouraged to adopt similar arrangements, the offshore wind sector as a whole could act as catalyst of a high-road industrial workforce strategy statewide.
- **Manufacturing supply chain:** California's first offshore wind project or two are likely to be done with imported turbines and other parts. But if state policymakers send clear signals that a multi-year sequence of many contracts is in the offing, private manufacturers and investors are more likely to build factories and other facilities in California for turbines, blades, towers, and foundations. This, in turn, could lower costs and make the electricity produced more competitive with other power sources.
- **Port infrastructure:** A full supply chain presupposes the availability of suitable port facilities for manufacturing and assembly. Two alternatives appear potentially viable: either a multi-site approach, with different functions carried out at a variety of ports, or a single multi-use hub at Eureka, where the Port of Humboldt Bay has vast expanses of vacant industrial land at a deep-water harbor but also has major challenges for highway and rail transport as well as grid interconnection. Either solution would require considerable additional research and planning.
- **Transition for PG&E nuclear workforce:** California's initial offshore wind farms are likely to be either in waters near the Diablo Canyon nuclear plant, whose reactors are slated to close in 2024 and 2025, or offshore Humboldt and Del Norte counties, near a long-closed nuclear plant that is currently undergoing its decommissioning process. In either case, the result could be retraining and re-employment for some of the nuclear plant workers.

## STATE POLICY SUPPORT

A recurring theme from interviews with policymakers and other stakeholders, both outside and inside California, is that the state and federal governments need to send unambiguous signals to wind companies and investors that offshore wind can play a significant role in California's energy markets. These actions would not entail unconditional support for offshore wind. But by enabling further exploration of its high-road potential, they would complement the state's strategic backing for other emerging technologies. A logical sequence of policy actions would include the following:

- **2017-18, Air Resources Board:** Inclusion of offshore wind as a potential supply of renewable energy in its Scoping Plan, which provides non-binding, strategic guidance about resource planning.

- **2017-18, Public Utilities Commission:** Guidance to utilities – especially PG&E but also Community Choice providers – to include offshore wind in their Integrated Resource Plans for 2030.
- **2018-19, Bureau of Ocean Energy Management:** Decision on size and scope of the initial project(s) – most likely a relatively small pilot of 30-50 MW.
- **2018-19, Legislature and/or Public Utilities Commission:** Legislation and/or rulemaking authorizing utilities to purchase power from the initial offshore wind farm(s) with full cost recovery.
- **2019-25+, State and local elected officials:** Coordination with labor advocates and wind companies to encourage project labor agreements, community benefits agreements, and other measures to ensure favorable outcomes for workers and communities.
- **2021-25+, Legislature and/or Public Utilities Commission:** Legislation and/or rulemaking authorizing subsequent offshore wind projects and providing support to upgrade electric transmission capacity, port facilities, and rail connections.

These steps would not be easy to execute. They would require the kind of coordinated industrial planning that has been rare in the United States in recent decades. Nevertheless, if California is to transition to renewable energy via the economic high road, policymakers and stakeholders should give serious consideration to offshore wind.



## BACKGROUND: OFFSHORE WIND AS INDUSTRIAL POLICY

In the initial period after President Trump's inauguration, there was much speculation that he might oppose offshore wind development, as he did during the election campaign.<sup>6</sup> But in March, Interior Secretary Ryan Zinke signaled explicit support for offshore wind, praising a federal auction of wind development rights for 122,000 acres in the Atlantic Ocean off North Carolina:

"Renewable energy, like offshore wind, is one tool in the all-of-the-above energy toolbox that will help power America with domestic energy, securing energy independence, and bolstering the economy. This is a big win for collaborative efforts with state, local, and private sector partners."<sup>7</sup>

Zinke's stance gave a green light to a planning effort started under the Obama administration by the Bureau of Ocean Energy Management (BOEM), which the Interior Department oversees, and the California Energy Commission (CEC). The two agencies formed a task force that has held one formal meeting, several conferences and workshops, and dozens of outreach meetings with coastal communities. Outreach efforts have deliberately cast a wide net, including environmental groups, the U.S. military, the Central Coast fishing industry, tribes, wind companies, scientists, and local governments.<sup>8, 9</sup> (Regarding Native American involvement, see Appendix A.) Labor unions have not yet been included.



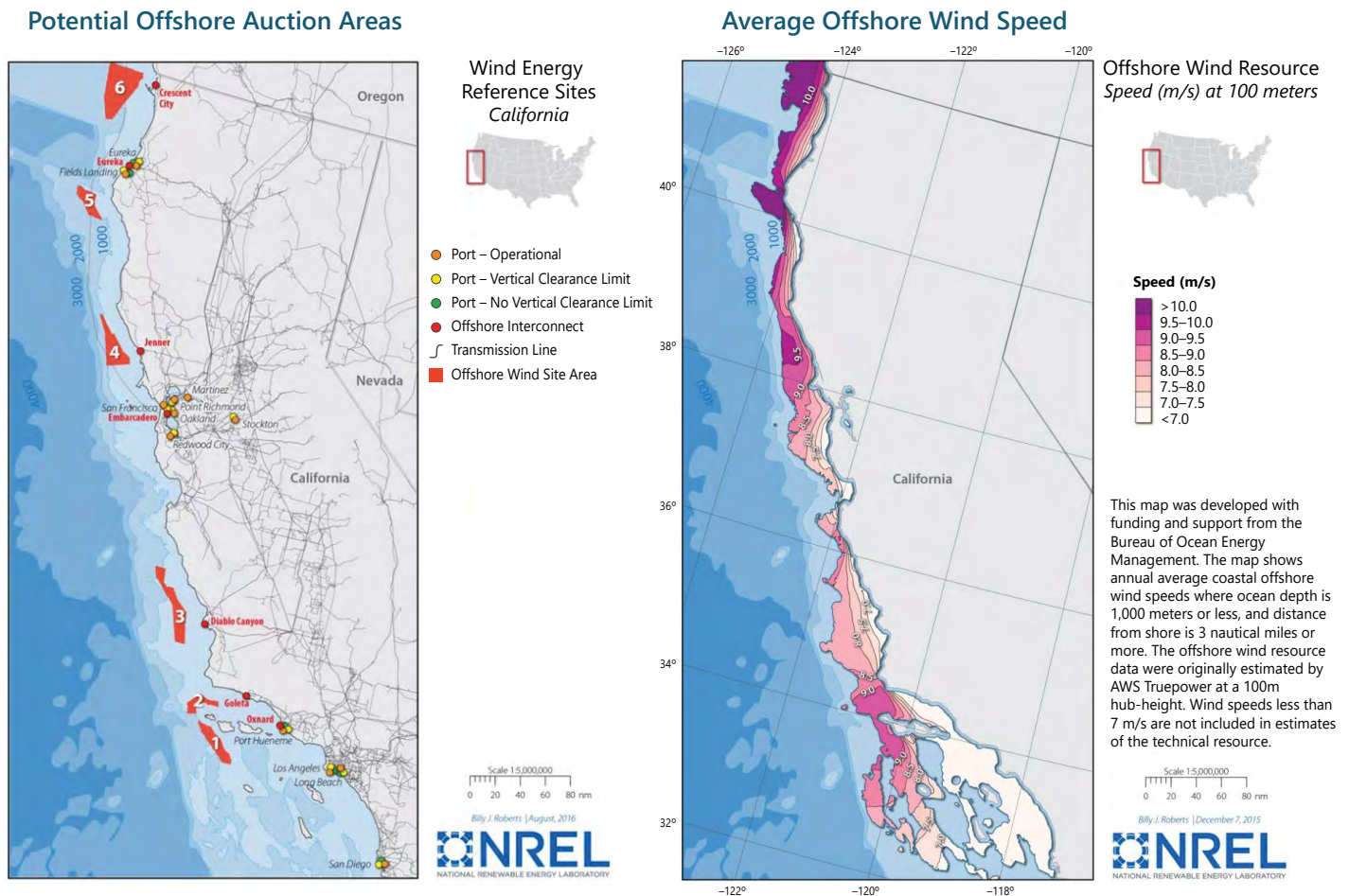
Turbine assembly at port in Norway prior to being towed to Hywind Scotland, the world's first floating offshore wind farm. Photo: Statoil

Sometime in early 2018, BOEM is expected to choose one or more specific California offshore areas for wind development, as shown in Exhibit 1. This will be followed by months of public hearings and possible revision of the areas, followed by an auction of wind development rights in the designated areas, and then years of federal, state, and regional environmental reviews and permits. The first large-scale deployment of turbines is envisioned for the mid-2020s, although a smaller-scale pilot project might come earlier.

While offshore wind has become a mature industry in Europe, operating more than 3,500 turbines and directly or indirectly employing about 75,000 people,<sup>10</sup> it is still in its infancy in the United States. As of the writing of this report in October 2017, one project had been completed in Rhode Island waters, another was slated to start construction next year nearby off New York State's Long Island, and more projects were planned for Massachusetts, New York, Maryland, North Carolina, and Ohio.

In all these locations, offshore wind turbines are fixed to the ocean floor in shallow waters that stretch far offshore. For California, however, the situation is necessarily different. Because of environmentalist concerns, wind farms must be at least 15-20 miles from the coast to avoid impacts on coastal views

Exhibit 1



Note: NREL designated the six zones as "reference" but did not formally suggest them as auction sites. BOEM will choose the auction site(s) after consultation with California state agencies, to be followed by public comment and review.

Source: Musial, Beiter, Tegen and Smith, 2016

and avian flyways, yet the steep drop-off of the Continental Shelf means that those locations are in water hundreds or thousands of feet deep. For these reasons, California's offshore turbines must be floating rather than fixed-bottom.

Floating turbines are mounted on platforms that are, in effect, stationary ships. The platforms' design is adapted directly from the oil industry, which has decades of experience with deep-water rigs in the Gulf of Mexico and elsewhere. Stabilized by submerged or partially submerged watertight hulls, the platforms are tethered by long mooring lines to the ocean floor.<sup>11</sup> Because wind farms are intentionally located in high-wind areas, the turbines must have specially designed software to adjust the blades' pitch to wind strength and direction, thus controlling the g-forces on turbine structures to balance them and keep them upright. Prototype floating turbines have been installed in Europe, Maine, and Japan, while the first commercial floating wind farm, a 30 MW project off the coast of Scotland, began operations in October 2017.<sup>12</sup> Other projects are underway off France, Portugal, and Japan.<sup>13</sup> All in all, they represent huge technological advances, but further improvements in engineering design and manufacturing efficiency are needed to lower production costs.

Offshore wind also is a test case of best practices in industrial policy planning.<sup>14</sup> In Europe, several national governments, the European Commission, and government-owned energy firms such as Norway's Statoil are playing an active role in laying the building blocks for a vertically integrated industry for floating offshore wind. In doing so, European planners are leveraging a local supply chain that builds on the region's already existing manufacturing base for fixed-bottom offshore wind.<sup>15</sup> Successful examples of wind manufacturing ports include Bremerhaven in Germany, Esbjerg in Denmark, and Hull and Sheerness in England.<sup>16</sup> In Japan, the government's New Energy and Industrial Technology Development Organization (NEDO) is undertaking a major effort to create a locally based, fully integrated offshore wind industry, even though no commercial offshore wind farms have yet become operational in Japanese waters.<sup>17</sup>

In China, the central and provincial governments have worked successfully for the past 15 years to build a wind manufacturing sector from scratch.<sup>18</sup> The world's largest wind turbine manufacturer is now a Chinese firm, Xinjiang Goldwind.<sup>19</sup>

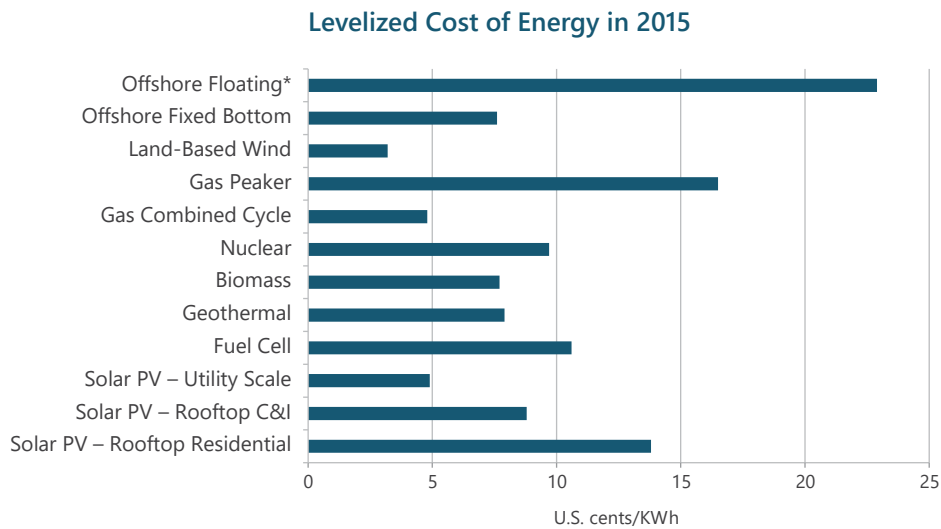
In the United States, by contrast, there is broad political aversion to government-led planning, so policymakers have less experience than those of many other nations in industrial policy, "green" or otherwise. For that reason, the evolution of California's offshore wind industry will be instructive for future analyses of government and stakeholder strategies to advance and deploy clean energy technologies.<sup>20</sup>

## ROLE OF OFFSHORE WIND IN CALIFORNIA'S LOW-CARBON TRANSITION

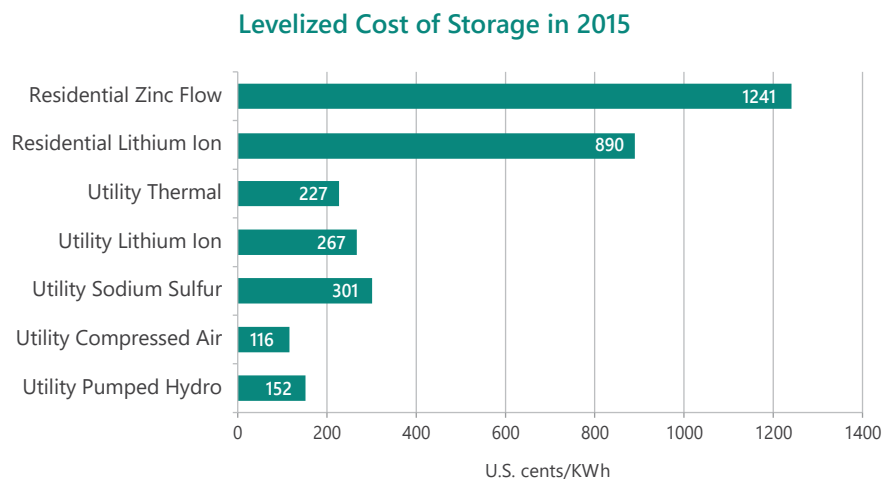
### Economic Feasibility

For many years, offshore wind was considered a mere pipe dream for California. Costs in European fixed-bottom wind farms were extremely high and initial development of the industry was only made possible through extensive government subsidies. Even recently, California policymakers believed floating offshore wind could never come close to competing with fast-dropping prices for onshore wind and solar.

Exhibit 2



\* Source for offshore floating: Mone et al. 2015; source for all others: Lazard 2016a



Source: Lazard 2016b

The outlook for floating wind seemed gloomy as recently as 2015, the date of the most recently published comparative cost data. Exhibit 2 shows offshore wind had significantly higher levelized costs (i.e., including lifetime capital and operating expenses) than other low-carbon sources of power, yet far lower costs than the energy storage technologies that have attracted so much attention recently from policymakers, the media, and investors.<sup>21</sup>

As a sign of this problem, an Oregon offshore test project was canceled in 2016 by the developer, Principle Power, after the state legislature dropped a bill that would have allowed local utilities to purchase the project’s electricity and pass the extra costs to ratepayers.<sup>22</sup> The project had received close to \$10 million in federal grants and had the promise of \$40 million more. But because the project was small, intended to test technical viability while requiring subsidies, it would have created few jobs and had only modest political support, said Dominique Roddier, Chief Technical Officer of Principle Power, an Emeryville-headquartered firm. “Why the Oregon project didn’t continue is because it was

a one-off," he said. "It was hard at the government level to justify anything based on those three turbines. But if we do a commercial project selling 300, 400, 500 MW, instead of a demonstration project selling 20 MW, that will change the political calculation."<sup>23</sup>

Since 2016, however, the situation has changed markedly. Offshore wind has had its own technological revolution, with multiple engineering breakthroughs.<sup>24</sup> Costs have plummeted, and dozens of new fixed-bottom wind farms are in the works from the North Sea to the Atlantic Ocean, several of which will not require any government subsidies.<sup>25</sup> For example, a 600 MW fixed-bottom wind farm contract at Kriegers Flak, in the Baltic Sea between Denmark, Sweden, and Germany, was won in November 2016 by the Swedish firm Vattenfall at an unsubsidized bid of only 5.9 U.S. cents per kWh,<sup>26</sup> less than one-third the average cost cited in Exhibit 2. More information is in Appendix B.

Another wild card that could alter the competitiveness of offshore wind occurred in late September 2017, when the U.S. International Trade Commission issued a ruling authorizing punitive tariffs on foreign-made solar cells and panels.<sup>27</sup> A final decision in the case by President Trump is expected between November and January. Solar industry leaders and elected officials have warned that any decision to impose new tariffs could make solar energy less competitive vis-à-vis other electricity sources, including wind power.<sup>28</sup>

Because of all these trends, Exhibit 2 serves more as a historical benchmark than as a realistic indication of where costs will be when floating wind farms are first deployed off the California coast in the mid 2020s. California state officials will need to pay close attention to these developments as they impact the ability of offshore wind to serve as a cost-competitive component of the state's renewable energy mix.

## In-State Solution to Grid Balancing

The rapid growth of solar power generation appears to be aggravating the duck curve – the daily challenge of balancing the electricity grid as solar output rises rapidly in midday then vanishes completely in evening, while power consumption rises gradually to its evening peak. As a sign of this imbalance, statewide curtailment (i.e., the short-term over-production of energy, in which grid regulators at the California Independent System Operator (CAISO) must order generators to shut down immediately) reached a record 8 GWh in April 2017.<sup>29</sup> CAISO has predicted maximum hourly curtailments of over 13,000 MWh by 2024, nearly half of springtime peak demand.<sup>30</sup> As of October 17, 2017, CAISO reported that a total of 345 GWh had been curtailed in the year to date.<sup>31</sup> This over-generation was aggravated by higher-than-average hydroelectric generation, indicating that the duck curve may be unlikely to cause serious grid instability over the short and medium terms. Yet it could become unsustainable in the long term,<sup>32</sup> when the state's share of renewable power pushes past its current goal of 50 percent by 2030. Significantly, that timeframe overlaps with the projected deployment of California's first large-scale offshore wind projects in the mid 2020s onward.

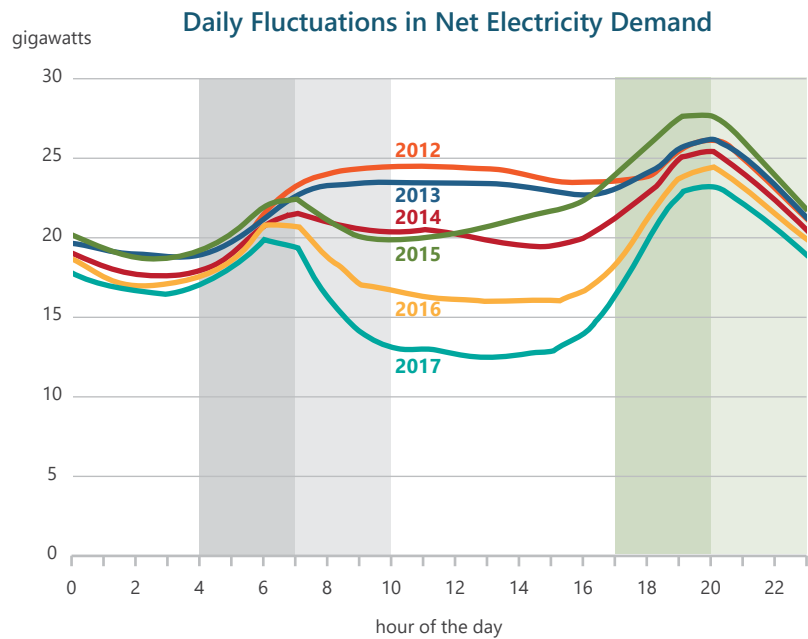
The hourly generation profile of offshore wind could help address this grid balancing problem, as shown in Exhibit 3. Two reports issued in 2016 by the federal Energy and Interior Departments (Gilman et al.) and by NREL (Musial, Beiter, Tegen and Smith) noted that Pacific coast winds generally blow 24 hours per day with few lulls, peaking during late afternoon and early evening, unlike California's land-based wind (which peaks later at night) and solar power, which disappears at sundown.<sup>33, 34</sup> Ocean winds off Central and Southern California tend to reach their daily peak about an hour later than those for Northern California, but all sites show a tendency to peak between 5 pm and 7 pm.

“The capacity factor for offshore wind is quite high,” said Karen Douglas, commissioner of the California Energy Commission and the lead state official on offshore wind planning efforts.<sup>35</sup> “Because generation from offshore wind would peak in the late afternoon and evening, it would be a helpful addition to the overall energy system.”

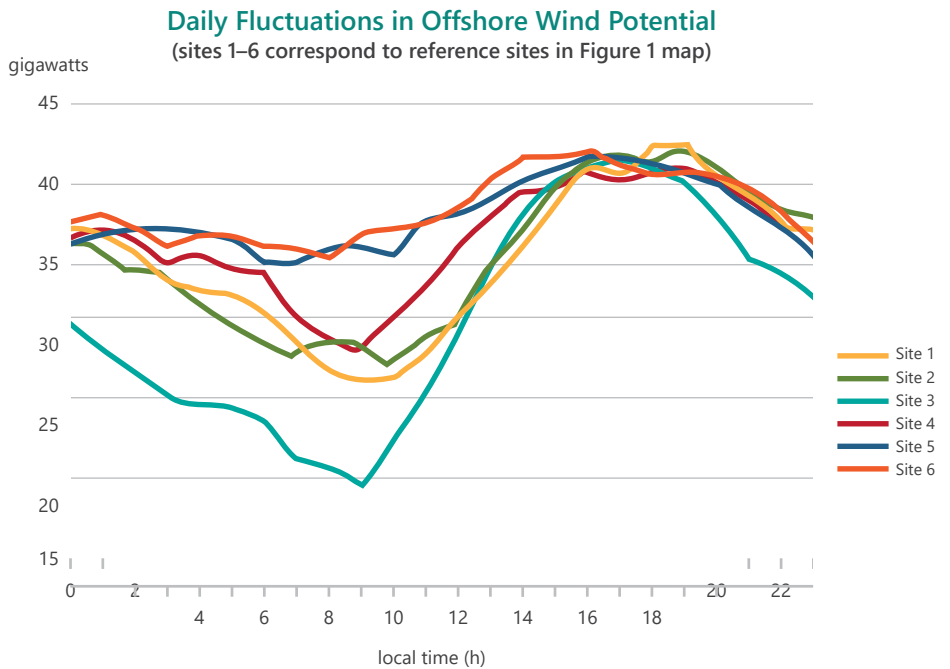
However, similar benefits might be provided by land-based wind power from Wyoming and New Mexico, which is expected to continue to have lower costs than offshore wind. It is not the intent of this report to assess the benefits and drawbacks of the various proposals for grid regionalization,<sup>36</sup> which would open the door to large-scale imports of wind power, but to point out that offshore wind could be at least a partial solution to California’s balancing needs.

The 2016 NREL report concluded that a build-out of California’s six most likely offshore wind farm zones would have a total potential capacity of 16.2 GW.<sup>37</sup> This would be roughly equivalent to one-third of the state’s average summertime daily power consumption, according to CAISO data.<sup>38</sup> For comparison purposes, total installed capacity of in-state renewable resources was 20.7 GW as of June 2017.<sup>39</sup>

Exhibit 3



Source: U.S. Energy Information Administration, July 24, 2017



Source: Musial, Beiter, Tegen and Smith, 2016

# HIGH-ROAD STRATEGIES

## Jobs Potential

A close analysis of the potential for high-road employment in offshore wind must tease apart the available data to understand the jobs and workforce potential of alternative ways to develop offshore wind. This task starts with an NREL report (Speer, Keyser and Tegen, 2016) that calculated economic impact from feasible development scenarios for California. NREL estimated that a large yet feasible build-out of 16 GW of capacity in six sites off the Southern, Central, and Northern California coast would produce as many as 13,620 average annual construction jobs and 4,330 long-term operations jobs before 2050.<sup>40</sup> See Exhibit 4 below.

It is important to note that the analysis below does not include the category of induced employment, which comprises thousands of additional jobs, largely in the service sector, that would be created by the ripple effect of spending by households earning income from wind projects and the supply chain.<sup>41</sup> This analysis focuses only on those jobs that might be responsive to high-road industrial policies and thus produce quality outcomes for workers and their communities.<sup>42</sup>

Exhibit 4:

NREL Estimates of Average Annual Jobs in California Offshore Wind

Scenario	Phase	2020-30	2030-40	2040-50
10 GW build-out	Construction: on-site	100	280	860
	Construction: supply chain	550	1,670	4,940
	Total construction	650	1,950	5,800
	Operations: on-site	80	270	780
	Operations: supply chain	200	560	1,450
	Total operations	280	830	2,230
16 GW build-out	Construction: on-site	260	1,130	2,340
	Construction: supply chain	1,350	5,490	11,280
	Total construction	1,610	7,750	13,620
	Operations: on-site	130	530	1,270
	Operations: supply chain	370	1,130	3,060
	Total operations	500	1,660	4,330

*Note: The construction phase jobs are average per year over each decade, while operations phase jobs are for individual years 2030, 2040, and 2050, not decades, and are ongoing and assumed to last for 25 years.*

*Source: Speer, Keyser and Tegen, 2016*

In each of these scenarios, more than three-quarters of jobs are in the supply chain. The study assumed that because of California's large and diverse economy, the share of in-state content for construction and operations by 2035 would grow to slightly over one-third in the 10 GW build-out scenario, and to slightly over one-half in the 16 GW scenario. See Exhibit 5 below.

Exhibit 5:

NREL Estimates of Local Content in Offshore Wind Supply Chain

Scenario	Phase	2025	2035-2050
10 GW build-out	Construction	16%	35%
	Operations	18%	38%
16 GW build-out	Construction	18%	54%
	Operations	26%	52%

Source: Speer, Keyser and Tegen, 2016

The study assumed the continuation of current federal-state planning efforts but did not include any major state initiatives to accelerate development of the supply chain and infrastructure or to expand workforce training.<sup>43</sup> The study’s authors made no attempt to predict potential policies in this regard, noting: “The levels of local content are uncertain ... in a large part owing to uncertainties around the requirements for specialized ports and labor skills.” Although supply chain modeling necessarily includes many variables, some of NREL’s data suggests that local content might be larger than projected if state policies were broadened in scope.

For example, the study assumed that the construction of the floating turbine substructures (the hull-like structures below water level) would have a maximum of 55 percent locally manufactured content, with the remainder supplied by Texas- and Louisiana-based manufacturers of offshore oil rigs. But if California shipyards could retool for this purpose, additional jobs could be created.

More upside potential could come in installation and construction jobs. Both of the study’s scenarios assumed that because of a lack of specialized workforce training, California workers would comprise at most 65 percent of the labor for wind farm installation and interconnection to the grid, with out-of-state technicians imported on a regular basis to do the remaining work. But if the state, wind industry, and construction trades unions were to collaborate proactively through state-certified apprenticeship programs to fill any skill gaps, the state’s share of construction jobs in offshore wind could increase. There is precedent for this: California’s apprenticeship programs have been leaders in developing new training modules and certifications for advanced lighting controls and other cutting-edge clean energy technologies.<sup>44</sup>

Overall, it seems likely that a significant proportion of offshore wind employment might be well-paying union jobs, as shown by the nation’s first commercial offshore wind farm, in Rhode Island. That fixed-bottom project, which became operational in late 2016, has five turbines generating a total of 30 MW. Much of this power serves the community of Block Island, which previously lacked a connection to the mainland grid and relied on diesel generators. Despite its relatively small size, the project provided about 300 annual full-time equivalent jobs for two years under a project labor agreement (PLA) negotiated by the developer, Deepwater Wind, with the Rhode Island Building and Construction Trades Council. As is common for major construction projects in the region, the Block Island PLA required prevailing wage rates, health and pension benefits, and joint employer-labor contributions for apprenticeship programs.<sup>45</sup> The PLA employed members of IBEW Local 99 (inside wiremen), UA Local 51, New England Carpenters Local 94 (mostly pile drivers and divers), laborers, elevator constructors, ironworkers, cement masons, operating engineers, International Longshoremens’ Association, and ILWU.





“There are good jobs in offshore wind – the kind of jobs we want,” said Michael Sabitoni, the Trades Council’s president.<sup>46</sup> “They can’t be built without us, and we’ve got to make sure we’re in from the beginning. These are large projects, and they give a chance for our members to increase their skills, and they connect with some of our apprenticeship programs.”

Although its 300 jobs in construction and installation were a significant boost to the local economy, the Block Island project created few jobs in the manufacturing supply chain precisely because it was the nation’s first commercial-scale offshore wind project. The turbine, tower, and blades were imported from Europe while the foundation was built in Louisiana by a firm specializing in offshore oil rigs. Even the “jack-up” ship for attaching the turbines to the sea floor was brought over from Denmark, with elaborate arrangements to allow for utilization of a foreign-flagged vessel under the Jones Act, which normally prohibits such use in U.S. waters.<sup>47, 48</sup>

With more fixed-bottom offshore wind projects in the planning pipeline along the East Coast from Massachusetts to North Carolina, as well as in Lake Erie off Ohio, employment prospects for the unionized, skilled construction trades

are promising. Since completing their work on Block Island, Sabitoni and Deepwater have signed a similar PLA for a larger wind project in New York waters.<sup>49</sup>

In California, most of the jobs generated would be construction-related, so they would likely follow the state’s well-established path of quality employment in utility-scale power projects. A significant body of research has shown that California has leveraged its low-carbon transformation to support and sustain middle-class jobs in large-scale renewable energy projects.<sup>50</sup> The primary policy driving this job creation has been the Renewables Portfolio Standard, first authorized in 2002, expanded in 2008 to a goal of 33 percent by 2020, and expanded again in 2016 to a goal of 50 percent by 2030. Most new large-scale renewable energy projects built during the past decade have been governed by collectively-bargained PLAs, which provide good wages, benefits, and pathways into state-certified apprenticeship programs for underserved communities.<sup>51</sup>

As noted below, however, recent labor trends in the manufacturing sector are less promising than those of construction projects governed by PLAs, so policymakers and stakeholders would need to work proactively to ensure good outcomes for wind turbine manufacturing workers.

## Manufacturing Supply Chain

The establishment of a California-based offshore wind supply chain is an important factor in maximizing economic competitiveness. This effect was summarized in a 2016 NREL report (Beiter et al.) that projected a continued rapid reduction in future costs for offshore wind projects nationwide but said this reduction would be contingent on “sufficient domestic deployment” of the supply chain.<sup>52</sup>

This need for physical proximity of supply derives from sheer logistics. The latest models of fixed-bottom offshore wind turbines are significantly larger than those in land-based wind farms, and that gap is projected to grow, including for floating offshore turbines. Many industry observers expect that in the mid-2020s, both fixed-bottom and floating turbines will have as much as 12-15 MW generating capacity each and will exceed 700 feet high, with subsurface structures as much as 250 feet below water. As a result, many of their component parts will be too large to be transported by truck or rail from domestic U.S. turbine manufacturers, all of which serve the land-based wind industry and nearly all of which are located inland, far from deep-water ports. The costs of long-distance ocean transit will be significant, although the degree to which those costs would affect the bottom line is debated within the industry.<sup>53</sup>

“The supply chain for wind tech is mostly in Europe, but if we could get to scale, driving costs down, building a supply chain that’s California based, with not everything necessarily built in California but a large part of it, that’s part of getting costs down,” said Douglas.<sup>54</sup>

Wind manufacturers concur that proximity is a market advantage, and top executives of major firms have been actively scouting the California market. “Without a local supply chain, the economics would be more challenging,” said Jason Folsom, who heads offshore wind in the Americas region for Siemens-Gamesa, the world’s biggest offshore wind turbine manufacturer.<sup>55</sup> Folsom attended several California offshore wind planning meetings in 2016 and 2017, and his firm’s turbine factories in Europe are considered likely competitors for California’s initial, import-driven contracts.

All those interviewed for this report said that in California, like the East Coast, the first offshore wind project or two are likely to be built with major components imported from abroad, with smaller machine components manufactured domestically. For example, the foundations for California projects might be manufactured in China, South Korea, or Japan, and the turbines would be built in European countries – all nations that are deliberately building offshore wind manufacturing capacity – with the final assembly in California ports. More information about existing California manufacturers for the land-based wind industry is in Appendix C.

The greater challenge, however, is what happens after the initial projects. If state policymakers send clear signals to support a multi-year sequence of many contracts, large manufacturers would be likely to build factories in California capable of producing turbines, blades, towers, and foundations, thus driving down costs of the power produced to levels more closely competitive with on-shore renewable power sources.

In East Asia and Europe, governments and wind turbine manufacturers have worked aggressively in recent years to develop full supply chains for offshore wind, along with significant capacity for technological innovation. In European offshore wind ports, the factories and other facilities for turbines, blades, towers, and foundations are grouped in large, high-tech clusters of advanced manufacturing akin to those in the passenger airliner industry.<sup>56</sup> Creation of a significant supply chain within California might require similar clustering and would be a complex process, but it would be more likely to occur if policymakers explicitly adopt it as a priority.



A prototype wind turbine blade is prepared for tests at Massachusetts Wind Technology Testing Center in Charlestown, MA.  
Photo: Massachusetts Clean Energy Center

On the East Coast, several states have taken steps that reflect their willingness to engage in the industrial planning process.<sup>57</sup> Massachusetts has made an early effort to set itself up as an offshore wind manufacturing hub, building a blade testing facility in Charlestown that was funded with \$24.7 million in federal stimulus money, \$18.2 million from the state government, and \$2 million from NREL. Massachusetts also invested \$113 million in state funds to create a dedicated marine terminal at New Bedford for wind turbine assembly.<sup>58</sup>

Rhode Island has taken similar steps, spending \$50 million of state funds and \$22.3 million in federal funds at an abandoned Navy base at Quonset Point to set up a port and manufacturing hub for offshore wind.

In Maryland, state officials said earlier this year that the state would attempt to leverage its defense and robotics industry to establish a supply chain hub for offshore wind at the Port of Baltimore. "Offshore wind is Maryland's 'Space Race'," declared Mary Beth Tung, director of the Maryland Energy Administration.<sup>59</sup>

Even more important are the policy signals to developers that they will be able to sell their electricity into the grid: Massachusetts has set a goal of 1.6 GW of offshore wind by 2027, New York has committed to develop 2.4 GW by 2030,<sup>60</sup> and Maryland has a Renewables Portfolio Standard of 25 percent by 2020, including 2.5 percent from offshore wind.<sup>61</sup>

Unlike the energy construction sector, in which PLAs are common, the manufacturing sector has a mixed record of producing quality, family-supporting jobs. As shown in Appendix C, most of California's firms that manufacture products for the land-based wind farms are non-union, and all the major wind manufacturing plants elsewhere nationwide are non-union.<sup>62</sup> The state's aerospace manufacturing industry, in which well-paying labor contracts were common, has collapsed since the early 1990s, with unions remaining only at a handful of firms.<sup>63, 64</sup> Progress in ensuring good outcomes for manufacturing workers has been made recently in the electric bus industry, such as the community benefits agreement in Los Angeles signed by BYD Motors.<sup>65</sup> In that case, the company signed a union contract paying living wages, created pre-apprenticeship and training programs, and committed to hire 40 percent of its workforce from disadvantaged communities. The agreement was a successful example of a policy model for "inclusive public procurement" proposed by Jobs to Move America, a nonprofit policy group that negotiated the deal with BYD.<sup>66</sup> However, the model relies on legal and economic tools that apply to contracts between manufacturers and government agencies but not to contracts between manufacturers and other private companies, such as utilities.

How transferable these tools may be to wind manufacturing is an open question. Given the offshore wind industry's need for state and local government support, it seems possible that policymakers and stakeholders could exert sufficient pressure on wind manufacturers to elicit similar outcomes. This hypothesis is untested to date.

## Port Infrastructure

The jobs jackpot for offshore wind is at the ports – especially if they can serve as hubs for multiple functions in the supply chain, including manufacturing, assembly, transportation and final installation, as well as long-term operations and maintenance. Finding enough suitable land for these purposes will be a difficult task, one that has not yet been fully examined by state decision-makers.

Many smaller turbine components can be transported by land, which means that they are likely to be supplied by a wide range of industrial parts manufacturers in California and nationwide. But the huge size of offshore turbines means that some components are so large that they must be transported by water. For example, the blades and tower sections must be manufactured directly at one or more ports, then either used for final assembly at the same location or transported directly via water to a separate assembly location. In any case, the assembly site must have protected waters – and, just as crucially, no bridges obstructing passage for the 700-foot-high turbines as they are towed out fully erect to the wind farm site.

A 2016 study commissioned by BOEM about California ports' suitability for offshore wind noted that considerable dockside real estate will be needed for several functions: manufacturing, fabrication, assembly, and operations/maintenance.<sup>67</sup> These facilities could be sited in several different ports, or all in one central location. The study identified several California ports as adequately suited for all functions, although it noted that land availability could be a sticking point. Port Hueneme, a medium-size port near Oxnard, was given highest grades, while San Diego and Long Beach also were cited as good fits.<sup>68</sup>

As it turns out, none of the most-recommended ports have any room for manufacturing, according to Kristin Decas, who is CEO of Port Hueneme and also serves as president of the California Association of Port Authorities.

"I don't think ports want to see manufacturing plants on their facility," Decas said.<sup>69</sup> "Even though these ports like Los Angeles and Long Beach are really, really big, if you go there, they have major congestion challenges." Decas said that while Port Hueneme or nearby ports would be willing to host

the small fleets that repair and maintain the wind farms, hers and other Southern California ports might not be able to rent prime dockside real estate for long periods to serve as assembly points. “We want to move your stuff, sure, but we wouldn’t want to build it,” she said. “We do throughput, we’re not a closet.”

The BOEM study of ports suggested that an alternative option might be for the major turbine sections to be manufactured at several different California ports with bridge clearance restrictions, such as those in Alameda, Vallejo, Richmond, or Stockton, then assembled at a port that is closer to the project and has no bridges blocking access to the open ocean.

In the 2000s, Decas served as director of the Port of New Bedford, Massachusetts, where she helped re-invent the crumbling, depressed port as a future hub for the region’s offshore wind industry, which at that time was in a gestation phase similar to the one California is experiencing now. The effort bore fruit after her departure, when three major wind firms agreed in 2016 to use the New Bedford terminal for assembly and staging of their upcoming projects along the Northeast coast.<sup>70</sup>

Decas suggested that California’s best shot at a joint manufacturing and assembly location is a port even more down on its luck than New Bedford – Humboldt Bay. That port has vast expanses of abandoned industrial land at the sites of pulp and lumber mills that shut down in past decades and threw hundreds of union employees out of work. Port officials and local politicians have tried unsuccessfully to reinvent the port, and even have touted its suitability as an offshore wind center.<sup>71</sup> For more information about Humboldt Bay, see Appendix D.

A turbine being assembled prior to being towed to the world’s first commercial floating wind farm, Hywind Scotland, which began operations in October 2017. Photo: Statoil



## Transmission Infrastructure

For California, another complicating factor for offshore wind farms is their interconnection to the state's electric grid. This task will be relatively easy and inexpensive if the initial projects are built off the Santa Barbara County and San Luis Obispo County coast (zones 1, 2, and 3 in Exhibit 1), as had been widely expected until recently. Wind farms in this area could easily connect with the 2 GW transmission line at Diablo Canyon nuclear power plant, which is planned for closure in 2025, or the 600 MW interconnection at Morro Bay Power Plant, which closed in 2014.

However, those zones overlap with the Point Mugu Sea Range, a military testing area that covers 36,000 square miles of coastal waters from Los Angeles to San Simeon.<sup>72</sup> The U.S. Navy, which shares use of those waters with commercial shipping and fishing, has objected to the siting of wind farms in zones 1, 2, and 3.<sup>73</sup> As of the writing of this report, BOEM had postponed its planned July 2017 announcement of auction zones, and BOEM and the CEC were in discussions with the Navy about its concerns.

If southern zones are passed up because of Navy objections, the fall-back options would be zones 4, 5, and 6, off Sonoma, Humboldt, and Del Norte counties, which do not face military opposition. These areas have higher average wind speeds than farther south and thus greater energy generation potential. However, the Sonoma coast has no significant grid interconnection or ports. The Eureka area is currently served by two PG&E long-distance transmission lines totaling 70 MW that import power from the state grid. The area itself could absorb the output of a pilot project generating roughly 30 MW, and reversal of the PG&E transmission lines could provide enough demand for a somewhat larger installation to supply Eureka and export a limited amount of power to the state grid.

However, any extended build-out of the wind potential in those northern zones would require an expansion of land-based transmission capacity to allow significant export of power to the grid. The costs and feasibility of building a high-voltage transmission line to the grid have not been adequately studied. Such an analysis, when undertaken, should place the Northern California options in their proper context: in comparison with the costs and policy implications of the proposals to import power from other Western states via the construction of new, long-distance transmission lines, and with the incremental cost of grid modernization at extremely high levels of distributed energy.<sup>74, 75</sup>

## Transition for PG&E Nuclear Workforce

Whether the initial projects go south or north, in either case they could benefit from the availability of a sizable nuclear industry workforce. As mentioned above, if the initial auction areas go off Southern and Central California, the projects would interconnect with PG&E's grid at either Diablo Canyon or Morro Bay. The result could be retraining and re-employment opportunities for some of Diablo Canyon's employees, including its 471 members of IBEW 1245. Opportunities for electricians could be in marine cable installation and maintenance, interconnection to the grid, and turbine manufacturing.

Alternatively, if BOEM picks offshore Humboldt and Del Norte counties for its initial wind farm auction sites, that choice could give retraining and re-employment options for the 250 people currently employed on PG&E's decommissioning of its Humboldt Bay nuclear power plant, of whom approximately 75 are union members.<sup>76, 77</sup> That plant ceased operations in 1976 but is only now undergoing its decommissioning process, a \$679 million project that is slated to conclude in 2020.<sup>78</sup>

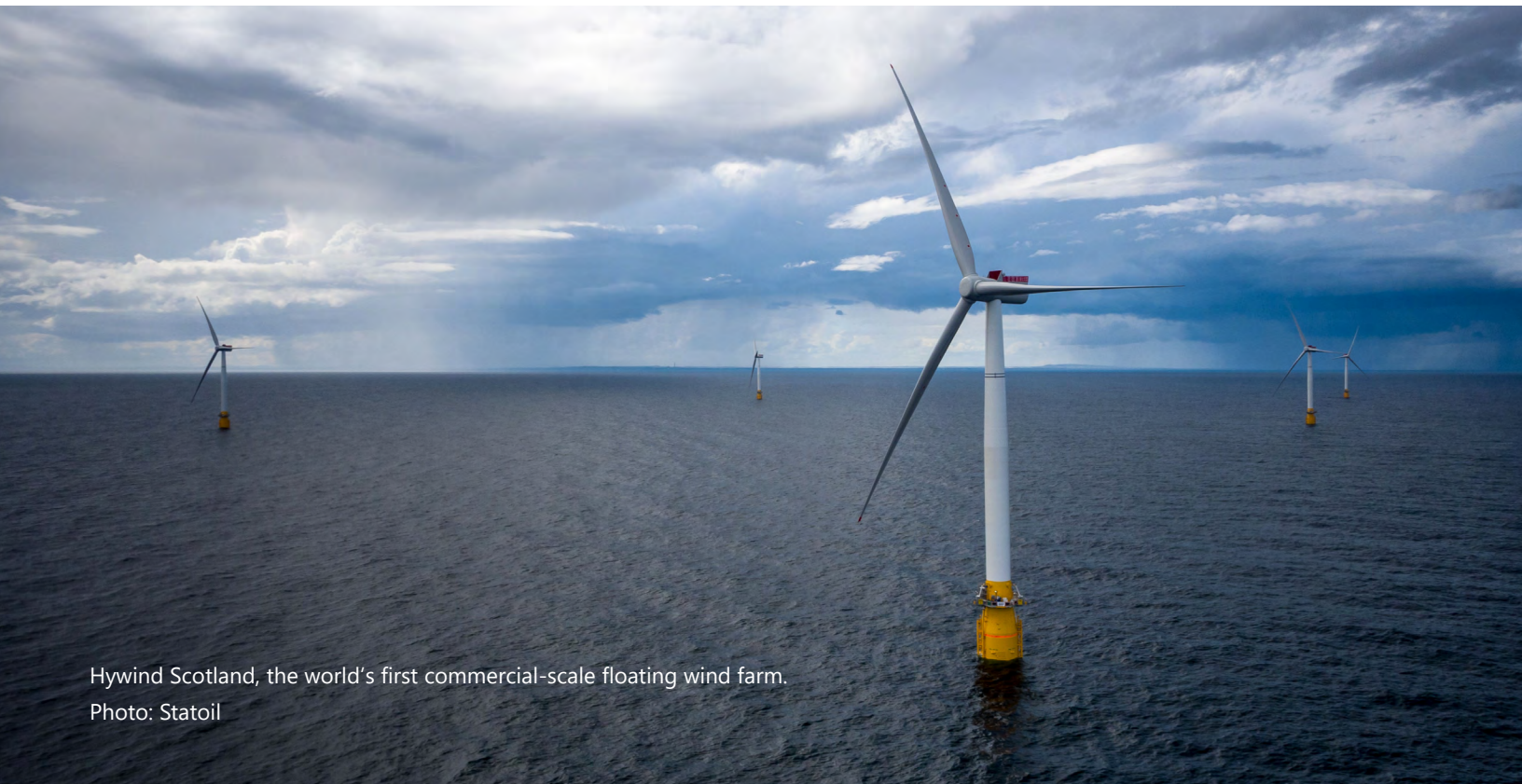
## STATE POLICY SUPPORT

### Market Signals

Offshore wind has a chicken-or-the-egg problem: manufacturers are unlikely to invest hundreds of millions of dollars to build factories for turbines, blades, towers, and floating platforms unless their market has a high degree of certainty – in other words, unless a large series of wind farm contracts is available and the electricity can be sold profitably to utilities or other large electricity users. But they might not be able to compete against other low-carbon power sources unless they have local manufacturing capacity. Which comes first?

“The first project or two will be done with fabrication of imported turbines, towers, and foundations, using temporary facilities,” said Liz Burdock, Executive Director of the Business Network for Offshore Wind, an industry group advocating the creation of U.S. offshore wind supply chains on the East and West Coasts.<sup>79</sup> She noted that the initial project might be only a handful of turbines with less than 50 MW total capacity, intended to test technical, economic, and environmental performance. The downside of a relatively small project is that it would be more dependent on direct or indirect subsidies. The upside, however, is that it could give additional proof of viability to powerful stakeholders whose approval will be crucial to get the industry moving – the financiers and energy giants that will need to invest large sums, the state agencies such as the Coastal Commission, Ocean Protection Council, and Lands Commission that will need to give regulatory approval, and the judges who would rule on any legal challenges under the California Environmental Quality Act or the National Environmental Policy Act.

If the state decides to bet on offshore wind, Burdock said, it will need to send a clear signal of long-term market demand for offshore power. “The manufacturers, if they see a multi-gigawatt offtake in California, they will set up production facilities. And that’s not just the Siemens, the GEs, and Vestas, but the OEMs (original equipment manufacturers) all down the supply chain, the medium and smaller companies that will create a large share of the overall industry employment.”<sup>80</sup>



Hywind Scotland, the world’s first commercial-scale floating wind farm.

Photo: Statoil

Executives of major companies express similar views. Jason Folsom at Siemens said that in order for his firm to decide to set up large factories in California, it would need a solid “pipeline,” i.e., the likelihood of power purchased by utilities, of roughly 4-6 GW during the initial years. This amount is equivalent to eight times the initial wind farm envisioned for Pacific waters off Morro Bay. “We would need a clear signal that there would be project permitting and offtake for the power for a significant number of years,” Folsom said.<sup>81</sup>

Bruce Hamilton, a director in the energy practice at Navigant, an industry research and consulting firm, said market expectations might vary: “The pipeline estimate of 2-6 GW is pretty consistent with our research, perhaps on the low side. We asked a major wind turbine generator vendor what size of offshore wind market in the Northeast would be needed in order to justify building a full-scale factory, and they said that the current 3.5 GW in the 10-year pipeline (i.e., 300-400 MW/year) is not enough. They need more like 500-700 MW/year, for a total of 5-7 GW. However, there could be lower level (single-component) suppliers that could build smaller factories at lower market levels. They could build even sooner if their factory can also serve other industries such as onshore wind.”<sup>82</sup>

## Existing Precedents

The state has many policies that give direction and strategic support to clean energy industries:

- **Integrated Resource Planning:** As authorized under SB 350,<sup>83</sup> the IRP process directs all “load-serving entities” (investor-owned and public utilities) to create a plan for acquiring additional renewables to meet state goals and to include those costs in their rates, and to submit them for review by the CPUC and California Energy Commission.<sup>84</sup> This gives regulators significant discretion in choosing which energy resources to prioritize. The CPUC issued a proposed guidance for the IRPs in May 2017, and the initial IRPs must be submitted in first quarter 2018, with updates submitted in subsequent years.
- **Storage mandates:** Under the California Energy Storage Roadmap,<sup>85</sup> an interagency plan developed in 2014 by the CPUC, California Energy Commission, and CAISO, the state’s investor-owned utilities must acquire significant amounts of energy storage, with costs absorbed into electricity rates. State law embodied in AB 2514 (Skinner, 2014) required utilities to procure 1,325 MW of storage by 2020, and AB 2868 (Gatto, 2016) authorized an additional 500 MW of behind-the-meter storage.<sup>86</sup>
- **Storage subsidies:** The Self-Generation Incentive Program<sup>87</sup> provides \$448 million of incentives for 2017-2019 for energy storage. It includes \$391 million for medium-scale and large-scale storage projects (10 kW or bigger) and \$57 million for smaller, residential storage projects.
- **Advanced biofuels:** Since 2011, the California Energy Commission has given 14 grants totaling \$28.7 million to projects that develop new technologies and infrastructure for biomethane and biodiesel.<sup>88</sup>
- **Residential solar subsidy:** The Net Metering program provides a major subsidy to customers with PV solar systems, requiring the utilities to purchase rooftop solar power at retail rather than wholesale rates.
- **Diablo Canyon:** As discussed previously, the joint proposal by PG&E, environmental groups, and labor unions for shutting down the Diablo Canyon nuclear plant provides for replacing that plant’s 2 GW output with zero-carbon power and allowing cost recovery via ratepayers in PG&E’s upcoming IRP.<sup>89</sup>



- **Electric vehicles:** The state is currently allowing the three investor-owned utilities to charge ratepayers \$1 billion for construction of electric vehicle charging infrastructure.
- **Tesla Gigafactory:** In 2014, Gov. Jerry Brown reportedly offered Tesla about \$500 million in incentives to locate its planned battery manufacturing plant in California, but lost the bidding war to Nevada.<sup>90</sup>

“There are many ways these market signals can be sent – by the utilities, the CPUC, the Legislature,” said Joao Metelo, CEO of Principle Power. “What’s important is there need to be targets that give developers and financiers enough confidence that the wind farms’ power can be sold into the grid.”<sup>91</sup>

Successful advocacy for these policy signals is likely to require an unusual degree of cooperation in the clean energy industry. However, the interests of California’s offshore wind developers may diverge from those of its onshore wind companies. Nancy Rader, executive director of the California Wind Energy Association, which represents land-based wind firms, said her members are heavily involved in out-of-state, land-based projects but are not involved in offshore wind. She added that her members are actively lobbying California authorities to reduce regulatory barriers to imports of land-based wind power from Wyoming and New Mexico.

Rader said that while the outlook for California’s onshore wind industry is gloomy in the short term, it could improve later to become a competitor to offshore wind. Echoing other industry analysts, she said that while land-based wind farms could boost their output by replacing decades-old turbines with larger, more efficient models, California utilities have already met their renewables goals for the year 2020 and will not need significant amounts of new renewable energy sources until later in the decade – about the same time as offshore wind starts deployment.<sup>92, 93</sup>

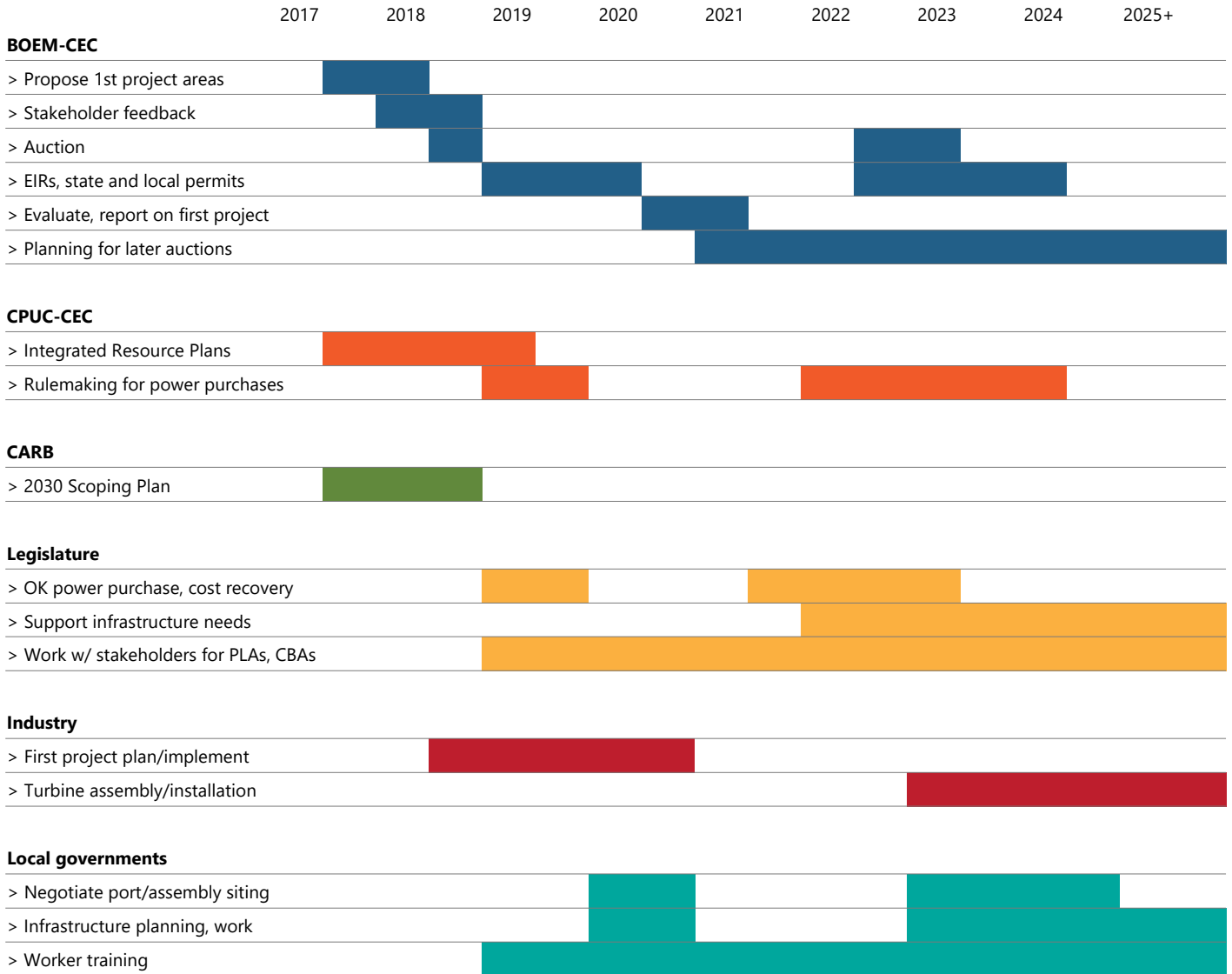
## Policy Options for a Full Supply Chain

Here is a summary of the principal action steps recommended by many stakeholders to maximize the potential of an integrated supply chain. Dates and details are approximate. See Exhibit 6 timeline.

- **2017-18:** CPUC guidance to utilities – including Community Choice electricity providers – to include offshore wind in their Integrated Resource Plans (IRPs) for 2030. Detailed procurement commitments are not needed, but general commitment to explore the feasibility of offshore wind would be a useful placeholder and overall market signal.
- **2017-18:** Inclusion by California Air Resources Board of offshore wind in its final Scoping Plan. This plan does not provide firm, statutory commitments but does serve as strategic policy guidance for legislators, manufacturers, and investors.
- **2018-19:** Decision by BOEM, in dialogue with CEC and wind developers, about size and scope of the initial project – most likely a pilot of 30-50 MW.
- **2018-19:** Legislation and/or CPUC rulemaking to authorize investor-owned utilities and/or Community Choice providers to purchase power from the initial project and to allow costs to be recovered.
- **2019 onward:** Coordination between state and local elected officials, labor advocates and wind companies to support project labor agreements, community benefits agreements (CBAs), and other measures to ensure family-supporting wages, full benefits, and apprenticeship programs with employment pathways for underserved communities.
- **2021-25 onward:** Reports to Legislature by CPUC and CEC about results of initial project(s). If results are promising, legislation will be needed for subsequent projects to allow further cost recovery until price competitiveness is established, and to support a supply chain strategy and infrastructure needs (port/rail/transmission).

Exhibit 6:

## High-Road Planning Timeline



Acronyms: BOEM: U.S. Bureau of Ocean Energy Management. CEC: California Energy Commission. CPUC: California Public Utilities Commission. CARB: California Air Resources Board.

Source: Author's interviews and research

## CONCLUSION

Offshore wind in California is a Rubik's Cube of policymaking. Existing technologies for renewable power and other paths of less resistance might seem like more expedient choices. But if California is to move to 100 percent renewables in the coming decades, while simultaneously generating good jobs for a diverse workforce and spawning community benefits, offshore wind is one option that deserves close analysis.

This study has found that offshore wind could have multiple positive impacts:

- It would help balance California's grid, allowing for increased integration of electricity from distributed and other solar energy projects.
- As an in-state resource rather than an out-of-state import, it would be subject to the decisions of the state's own regulators and legislators, thus ensuring compliance with California policies and interests.
- It could help generate thousands of well-paying jobs in advanced manufacturing, construction, engineering, and maritime services in California.
- It could provide retraining and re-employment for nuclear workers at Diablo Canyon or Humboldt Bay.

As this study has also discussed, floating offshore wind has potential barriers to implementation:

- It is a new, evolving technology that will require a fast and sustained pace of development – and continued financing – to reach market and policy readiness. Like the so-called “valley of death” that is common in tech industry launches, its gap between innovation and market viability will be challenging to bridge.
- Infrastructure needs are considerable. Transmission, port, and rail facilities may need expensive upgrades.
- Multi-stakeholder economic planning is a difficult juggling process, and even more so for the long term.

In sum, offshore wind poses a major test of industrial planning for California. It requires the sort of multi-stakeholder, long-term collaborative effort that is relatively common in Europe and East Asia but not yet in the United States. Nevertheless, California has a hard-won reputation for proving its critics wrong and moving forward successfully on renewable energy and carbon reduction. This track record suggests that offshore wind merits serious and sustained consideration by policymakers in the months and years to come.

## APPENDIX A – Tribal Concerns

To date, the primary environmental justice concerns that have surfaced before the California offshore wind task force have come from Native American tribal groups. Some environmental organizations and a San Luis Obispo-area group, the Northern Chumash Tribal Council, have proposed federal designation of 10,000 square miles off Morro Bay to become the Chumash National Heritage Marine Sanctuary.<sup>94</sup> The exact effects of sanctuary status on wind farm development is a matter of much speculation among stakeholders, with some saying it would bar all offshore wind development and others saying it might not, or might ban wind farms only in some areas. “It remains to be determined exactly what effect sanctuary designation would have on offshore wind,” said Thomas Gates, the California Energy Commission’s tribal liaison. “We just don’t know that yet.”<sup>95</sup>

The Northern Chumash Tribal Council does not have federal recognition as a tribal group, unlike a rival group, the Santa Ynez Band of Chumash Indians, which enjoys federal status and has opposed the marine sanctuary proposal. Another non-federally recognized Chumash group, the Salinan Tribe, has not endorsed the sanctuary either.<sup>96</sup> In any case, the chances of the sanctuary proposal being approved seem slim under the Trump administration. Nevertheless, the existence of Native concerns will remain politically relevant for California state policymakers and stakeholders.

The California Energy Commission’s work with the tribes derives from a 2011 executive order by Gov. Jerry Brown directing state agencies to engage in effective consultation with tribal groups in regard to development projects that might affect their interests.<sup>97</sup>

## APPENDIX B – Offshore Wind’s Cost Competitiveness

A 2016 study by NREL (Musial, Beiter, Tegen and Smith) predicted that the levelized cost of electricity (LCOE) for the sites most likely to be developed will decrease from approximately 18.5 cents per KWh in 2015 to approximately 10 cents per KWh by 2030.<sup>98</sup> Yet technology advances are coming so fast that the NREL study’s authors said their calculations might be too conservative. While the recently-finished Block Island Wind Farm project (which is fixed-bottom) has a power purchase agreement with National Grid (the main Rhode Island utility) set at 24 cents per KWh, that contract was signed with the utility in 2009, at a time when offshore wind prices were much higher than now. The NREL study noted that recent European offshore fixed-bottom wind farm costs have dropped by more than one-half since 2010, such as at Vattenfall’s Kriegers Flak project, a 600 MW wind farm in the Baltic Sea between Denmark, Sweden, and Germany.<sup>99</sup> In November, the company won the auction with a bid of 4.9 U.S. cents per KWh, 20 percent below its estimate of only two months previously and 41 percent below its original 2012 estimate.

Other projects have seen similar reductions, NREL noted: “Fixed-bottom offshore wind project costs are decreasing more rapidly than anticipated by many industry cost models, including the cost-reduction pathway estimated by this analysis. .... The extent that these lower costs can be sustained and passed on to floating technology is not evaluated.”<sup>100</sup>

The U.S. Energy Information Administration’s 2017 annual study of LCOE for all energy sources did not include an estimate for floating offshore wind, in contrast to previous years’ studies, perhaps because cost had recently become such a moving target.<sup>101</sup>

A 2015 study by the British government’s Energy Technologies Institute predicted that floating offshore wind will have an LCOE of 10.9 U.S. cents per KWh by 2025.<sup>102</sup>

In March 2017, a report by the International Energy Agency noted that for Europe’s large offshore wind industry, costs had dropped much faster than expected:

The industry has already exceeded its 2025 cost target (€80/MWh, incl. grid connection) 8 years ahead of schedule. ... The level of cost reduction achieved to date is a major success story for the offshore wind industry, a sign of the sector’s maturity and proving that it is on track to become a low-cost and mainstream energy technology.<sup>103</sup>

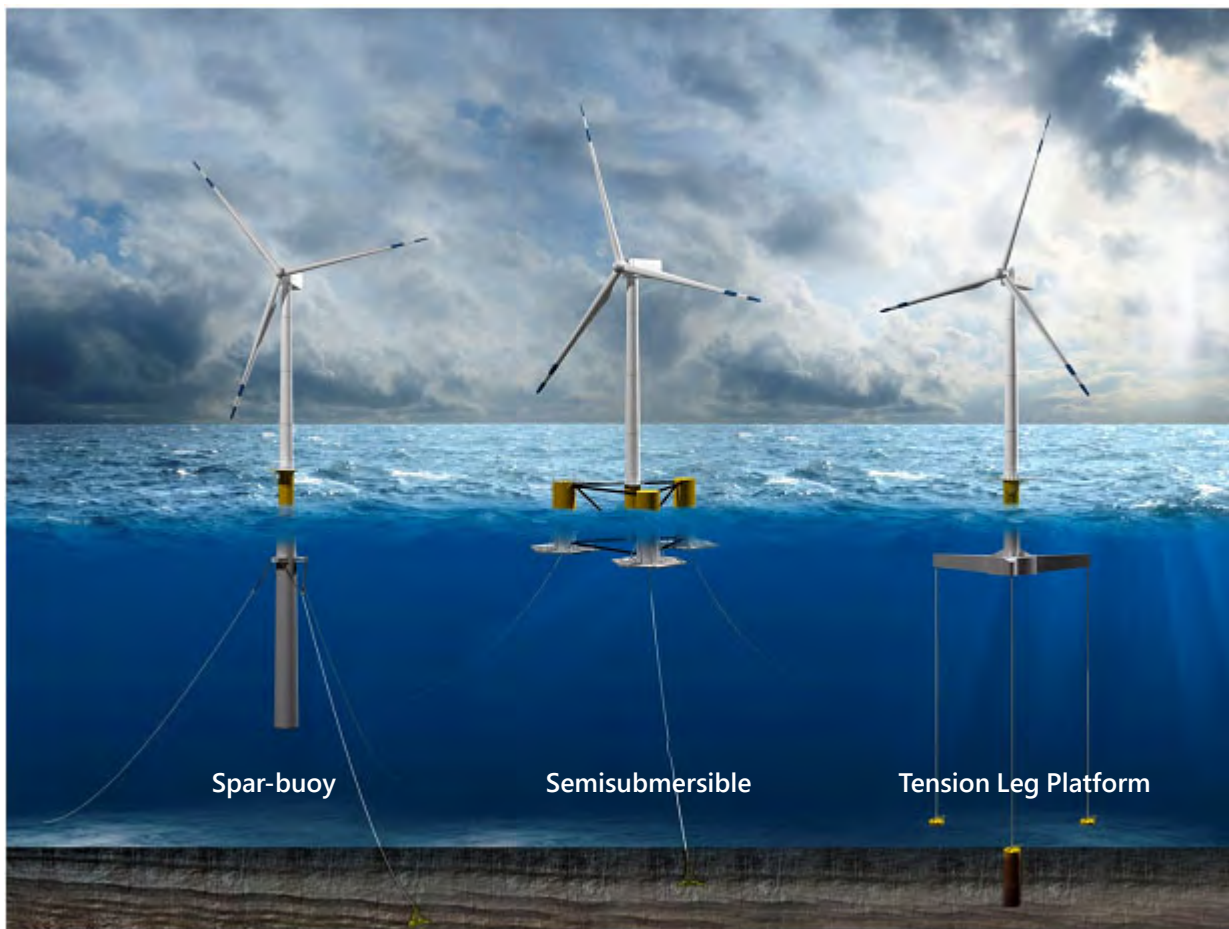
Offshore wind developers’ bullish viewpoint was summarized by Aaron Smith, Strategic Planning Manager of Principle Power, in May 2017:

The big challenge is that the data behind these studies is now a bit out of date with the industry moving to competitive tenders and much larger turbines much more quickly than anticipated by the study authors only one year ago. For example, the biggest turbine that NREL assumes in its study of California is 10 MW with Commercial Operations Date (COD) in 2027. However, the recent tenders in Germany are based on 13-15 MW turbines with COD in 2024. In addition, cost of finance (WACC) has fallen from ~8-10 percent to 3-5 percent for some of these recent tenders, with massive implications for LCOE. ... It will take some time for California to build supply chain and maturity to hit these same levels, but, even at a premium over

Europe, our cost expectations are far lower than they were just one year ago due to the confluence of accelerated technology development, supply chain efficiencies, and increased bankability.<sup>104</sup>

The world's first commercial floating wind farm, Statoil's Hywind project off Scotland, began operations in October 2017 at a price of 6.4 U.S. cents per KWh and with government subsidies of 18.5 U.S. cents per KWh, for a total of 24.9 cents per KWh. The project combines 30 MW wind capacity with battery storage of a capacity of 1 MWh. In a statement on the first day of operations, Statoil said it expects to reduce the cost of floating wind power to a range of 4.7 to 7.1 U.S. cents per KWh by 2030.<sup>105</sup>

### Principal Design Options for Floating Wind Turbines



Source: Musial, Beiter, Tegen and Smith, 2016

## APPENDIX C - Manufacturers of Land-Based Wind Components in California

According to Peter Kelley, vice president for public affairs of the American Wind Energy Association (AWEA), the industry's trade group, about 60 percent of all equipment in U.S. wind farms were manufactured domestically.<sup>106</sup> The only parts of a wind turbine that have no U.S.-based supplier are the generators, all of which are made in Europe or Asia. Major wind equipment suppliers such as GE, Siemens, and Vestas have manufacturing facilities in South Carolina, Iowa and Kansas, and Colorado, respectively, all of which are non-union. The only unionized wind manufacturers are those that supply smaller portions of the turbine, and in many cases these firms make a wide variety of products for many industries, not just for wind, according to Kelley.

A recent AWEA study estimated that California's land-based wind industry causes a total annual employment of 3,100 people. This includes the manufacturing supply chain for out-of-state wind projects, and it also includes induced jobs, i.e. those created in the California service sector by the personal spending of manufacturing workers. It is unclear how many of the firms listed below work full-time on wind-related products rather than simply supplying products for many industries.

Company	Product Classification	Union (if any)	Facility City
ABB Inc.	Electrical drivetrain, control systems, electrical protection, hydraulic systems, converters, lightning protection, yaw and pitch systems, and grid connection solutions		Santa Clara
AOC LLC	Materials polyester resin, gel coat, composite coatings		Perris
Atmospheric Systems Corp.	Electrical SODARs sensors		Valencia
Bal Seal Engineering	Electrical generation seals and connectors, generator components		Foothill Ranch
Barksdale Control Products	Power transmission hydraulics, switches and control systems, switches hydraulics		Vernon
DEX	Electrical converters, control boards, electronic components		Camarillo
GS Manufacturing	Materials resins and adhesives used in the fabrication process of fiberglass/composite.		Costa Mesa
Halus Power Systems	Distributed wind turbines		San Leandro
Interplastic Corp	Gearbox sales and service, composite coatings	Teamsters Local 29	Hawthorne
Lift-It	Equipment construction		Los Angeles
Maxwell Technologies	Electrical ultracapacitor cells and modules, power converters		San Diego
PowerWorks	Distributed wind turbines		Tracy
RLH Industries	Electrical fiber optic communication		Orange

Source: American Wind Energy Association, AWEA U.S. Wind Industry Map website, <http://gis.awea.org/arcgisportal/apps/webappviewer/index.html?id=eed1ec3b624742f8b18280e6aa73e8ec>

## APPENDIX D – Port of Humboldt Bay

California has several options for siting a supply chain, but all are complicated by the fact that under current floating wind technologies, the final assembly must be done in protected waters at a port, then towed directly out to the final operations site. Because offshore turbines by the mid-2020s could be at least 700 feet high, no bridges can stand in the way. One option is for different sites to be used for manufacturing, then final assembly at a separate location.

Ideally, however, one site would be used for integrated manufacturing and assembly, as with major European offshore wind hubs such as Cuxhaven in Germany and Grimsby in northern England.<sup>108</sup> California's only viable site for manufacturing as well as assembly is the Port of Humboldt Bay, which has vast expanses of vacant industrial land but would need upgrading of its dock and transportation infrastructure.

When interviewed, Jack Crider, executive director of the Humboldt Bay Harbor District, was enthusiastic. "This would be a good location," he said.<sup>109</sup> "It's hard to find that much open property for reasonable cost anywhere else. Prices here are still extremely cheap for California."

However, Crider readily admitted that any attempt to use his port for manufacturing would need to address the limited ground transportation options.<sup>110</sup> Highway links to the outside world are mediocre, and the state-owned North Coast Railroad Authority (NCRA) line to Ukiah was shut down in 1998 after flooding washed out part of the line. The region's elected officials, business leaders and labor unions have been seeking support to rebuild the rail line, but without success.<sup>111</sup> A consultant's analysis for the Humboldt Bay Harbor District in 2013 estimated that the project could cost \$600 million.<sup>112</sup> Rebuilding the line through the environmentally sensitive Eel River Canyon would also require an environmental impact report under the California Environmental Quality Act (CEQA), a potentially formidable challenge.<sup>113</sup>

A U.S. Environmental Protection Agency worker looks from the roof of an abandoned pulp mill toward the Port of Humboldt Bay, which has the largest amount of unused land with deep water access and suitability for wind manufacturing and assembly of any West Coast port. Photo: U.S. EPA





Crider said that if state policymakers wanted Humboldt Bay to become a wind manufacturing hub, legislation might be needed to provide support for rebuilding the rail line.

The dock facilities are also in need of major upgrades. Piers have not been significantly modernized in decades, their weight-bearing capacity is low, and they would require rebuilding.<sup>114</sup>

The region lacks a large industrial workforce, with the previous employees of long-shuttered pulp and lumber mills now either retired or dispersed. But as discussed in this report, the decommissioning of the Humboldt Bay nuclear power plant offers the potential for retraining and rehiring the approximately 250 highly skilled workers employed in that project, which is scheduled to finish in 2020.

Yet another challenge for Humboldt Bay is the fact that transmission to the California and Oregon grids from the Eureka area (the PG&E system) and Crescent City (the PacificCorp system) is too limited to support utility-scale offshore wind development without construction of major new power lines, which could add significant cost and delays. The Humboldt Bay area is served by two transmission lines with a total of 70 MW capacity. As mentioned previously, any major build-out of offshore wind would require a costly expansion of land-based transmission capacity. The details and feasibility of such a project have not been studied adequately.



Decommissioning of Principle Power's 2 MW prototype floating turbine after five years of operation in the Atlantic Ocean. Porto de Sines, Portugal, July 2016. Photo: Principle Power

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<sup>84</sup> Existing law states that the CPUC and Energy Commission have authority to review the IRPs of Community Choice providers and determine whether they are found to be non-compliant with the requirements of SB 350 (2016) and SB 618 (2017). See California Public Utilities Commission, Integrated Resource Plan and Long Term Procurement Plan (IRP-LTPP) webpage, <http://www.cpuc.ca.gov/irp/>. However, Community Choice advocacy groups have suggested that the CPUC and Energy Commission do not have authority to reject a non-compliant Community Choice IRP and that only the governing board of each Community Choice provider has the power to do so. See, for example, California Community Choice Association (CalCCA), “Re: CalCCA Informal CCA *En Banc* Hearing Comments,” submission to CPUC, February 23, 2017, p. 6, [http://www.cpuc.ca.gov/uploadedFiles/CPUC\\_Public\\_Website/Content/Utilities\\_and\\_Industries/Energy/Energy\\_Programs/Costs\\_and\\_Rates/CCA\\_and\\_Direct\\_Access/CalCCA%20Informal%20CCA%20En%20Banc%20Hearing%20Comments.Final.docx.pdf](http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Costs_and_Rates/CCA_and_Direct_Access/CalCCA%20Informal%20CCA%20En%20Banc%20Hearing%20Comments.Final.docx.pdf).

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<sup>92</sup> Interview with author, February 10, 2017.

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