A M E R I C A N J O B S P R O J E C T

The California Offshore Wind Project:

A Vision for Industry Growth

FEBRUARY 2019

AMERICAN JOBS PROJECT

A Letter from the

American Jobs Project

California is ready for a new vision and bold leadership. We are faced with dire and complex challenges that include eliminating poverty and averting a climate crisis. To solve these challenges, state leaders must embrace new ideas, industries, and policies to create the economic and environmental future we deserve.

Offshore wind can be California's next legacy—a new industry, built from the ground up, that invites shared prosperity, spurs innovation, and respects our natural treasures.

Although California typically leads on climate and renewable energy issues, we are late to the game on offshore wind. Offshore wind has already taken off in Europe, Asia, and now the United States. Governors from New York, Massachusetts, New Jersey, and others are competing for this new market—setting offshore wind targets, creating new programs, and recruiting firms to their state.

While not first, California can still lead, especially in the deployment of floating offshore wind turbines on the Pacific Coast. We have Silicon Valley in our backyard; more venture capital than any other state; a diverse workforce, the brightest minds in the technology, engineering, and environmental communities; and one of the strongest wind resources in the nation. Because offshore wind is ready to be deployed and firms want to invest in our state, it is time to seize this opportunity.

To be clear, creating an offshore wind industry in California will require significant time and investment. It is unlike any industry we have seen, as it calls for collaboration between an unprecedented number of agencies and stakeholders across the federal, state, and local levels. Infrastructure investments and innovations will be needed to retool and revitalize ports and build new transmission lines. Tradeoffs will inevitably be made: What are the environmental concerns with offshore wind development? How will offshore wind impact competing uses of ocean resources?

If the climate and economic benefits justify the investments in offshore wind, then California's leaders will have other critical questions. How can California become a leading hub for offshore wind deployment? What values do we want this industry to reflect? How will we build an inclusive economy that creates opportunities for all Californians?

This report analyzes the potential economic benefits of a California offshore wind industry and provides state and local leaders with high-level strategies to facilitate innovation, help businesses grow, and develop the workforce. The American Jobs Project empowers state and local leaders to build prosperous and equitable renewable energy economies that will transform our nation's energy future.

About Us

The American Jobs Project

The American Jobs Project is a nonprofit, nonpartisan, think-and-do tank focused on creating good-paying jobs in advanced energy and manufacturing through a bottom-up, data-driven, 360° economic development approach. Our experts tailor best practice strategies for bolstering advanced energy and manufacturing, identify assets across the value chain, estimate an industry's job-supporting potential, and support stakeholder-led initiatives by communicating ideas and analyses. Through engagement with a broad cross-section of stakeholders, we develop a shared vision of effective strategies to leverage the unique competitive advantages offered by each state and generate positive economic impacts.

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Schatz Energy Research Center, Humboldt State University

The Schatz Energy Research Center at Humboldt State University is working to establish clean energy technologies in our society. The Center, which was established in 1989, specializes in renewable energy, energy efficiency, and clean transportation systems. The work carried out by their team of over forty team members, including faculty, professional staff, and students, involves research and development, technology demonstration, project development, energy systems analysis, and education and training. In addition, they perform feasibility studies, resource assessments, and energy planning studies.

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Pacific Ocean Energy Trust

Pacific Ocean Energy Trust (POET) is a 501(c)(3) organization committed to the responsible development of marine renewable energy in the Pacific Region. Growing out of the Oregon Wave Energy Trust, POET brings ten years of experience working on issues relating to marine renewable energy development, with a special emphasis on policy and regulatory matters, better understanding of environmental effects of marine renewables, and stakeholder engagement. POET supports the development of all types of marine renewable technologies including offshore wind, tidal, and wave energy.

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BVG Associates

BVG Associates is an independent consultancy with a global outlook, specializing in the technology, industrialization, and economics of wind and marine energy generation systems. They are driven by a desire to make a real difference in the global renewable energy industry, delivering insight that comes from over 140 years of staff experience. Their team has the best objective knowledge of the market and supply chain for offshore wind, wave, and tidal energy. Their significant client base spans government, enabling bodies, investors, developers, turbine manufacturers, and other companies across the supply chain.

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Acknowledgments

This report would not be possible without the support of The JPB Foundation, Incite Labs, and the California Institute for Energy and Environment at University of California, Berkeley.

This report was a collaborative effort based on insight from dozens of interviews and extensive literature reviews. Mary Collins was the lead author and director of research. Leah Daoud was the supporting author and lead researcher. Mike Blanch, Alun Roberts, and Andy Geissbuehler from BVG Associates led economic analysis, which was informed by Arne Olson, Kush Patel, and Sanderson Hull at Energy + Environmental Economics (E3). Mat Squillante led graphic design. Supporting researchers and fact checkers were Tiffany Wong, Santos Vazquez, Christopher Eldred, Madeleine Valdez, and Max Neumeyer. Our partners on this report, Arne Jacobson and Mark Severy of the Schatz Energy Research Center at Humboldt State University and Jason Busch from the Pacific Ocean Energy Trust, provided expert guidance and input. We thank our reviewers and collaborators who generously provided feedback on the report: Robert Collier (UC Berkeley Center for Labor Research and Education), Suzanne Tegen (Center for the New Energy Economy at Colorado State University), Sandy Aylesworth (Natural Resources Defense Council), Tyler Studds (EDPR North America), Steve Black (Steve Black Strategies), Larry Oetker (Humboldt Bay Harbor, Recreation and Conservation District), Jana Ganion (Blue Lake Rancheria), and Sage Welch (Sunstone Strategies).

We extend our sincere gratitude to the many individuals from businesses, government, nonprofits, utilities, and universities for meeting with us, exploring ideas, participating in working groups, collaborating on the report, and sharing their vision for the future.

We also thank the following individuals and organizations—in addition to those who respectfully choose to remain anonymous—for offering their insight and perspectives on this work.

Sandy Aylesworth – *Natural Resources Defense Council*

Kevin Banister – *Principle Power*

Lori Biondini – *Redwood Coast Energy Authority*

Steve Black – *Steve Black Strategies*

Mike Blanch – *BVG Associates*

Jason Busch – *Pacific Ocean Energy Trust*

Kevin Christensen – *Service Employees International Union, United Service Workers West*

Robert Collier – *UC Berkeley Center for Labor Research and Education*

Cheryl Cox – *California Public Utilities Commission*

Kim Delfino – *Defenders of Wildlife*

Jordan Diamond – *Center for Law, Energy & the Environment at Berkeley Law*

Sarah Friedman – *Sierra Club*

Jana Ganion – *Blue Lake Rancheria*

Andy Geissbuehler – *BVG Associates*

Bruno Geschier – *Ideol*

Bruce Gibson – *San Luis Obispo County Board of Supervisors*

Sara Guiltinan – *Bureau of Ocean Energy Management*

Steve Hamilton – *California Polytechnic State University, San Luis Obispo*

Kate Huckelbridge – *California Coastal Commission*

Sanderson Hull – *E3*

Arne Jacobson – *Schatz Energy Research Center at Humboldt State University*

Tony Jimenez – *National Renewable Energy Laboratory*

David Keyser – *National Renewable Energy Laboratory*

Jim Lanard – *Magellan Wind*

Greg Murphy – *Blue Economy Strategies*

Walter Musial – *National Renewable Energy Laboratory*

Larry Oetker – *Humboldt Bay Harbor, Recreation and Conservation District*

Kush Patel, *E3*

Aaron Porter – *Mott MacDonald*

Chris Potter – *California Ocean Protection Council*

Neal Rickner – *Makani*

Alun Roberts – *BVG Associates*

Ben Ruttenberg – *California Polytechnic State University, San Luis Obispo*

Tim Schott – *California Association of Port Authorities*

Mark Severy – *Schatz Energy Research Center at Humboldt State University*

Nancy Stephenson – *Redwood Coast Energy Authority*

Tyler Studds – *EDPR North America*

Necy Sumait – *Bureau of Ocean Energy Management*

Suzanne Tegen – *Center for the New Energy Economy at Colorado State University*

Ross Tyler – *Business Network for Offshore Wind*

Ryan Wiser – *Lawrence Berkeley National Laboratory*

Andy Wunder – *Environmental Entrepreneurs*

EXECUTIVE SUMMARY

California's offshore wind resources represent a significant opportunity to improve grid reliability, achieve clean energy and climate goals, and grow a new industry with a values-driven framework. If California pursues cluster-based strategies to achieve 18 GW of offshore wind, the state could support over 17,500 full-time equivalent jobs in 2045.

EXECUTIVE SUMMARY

The wheels are in motion for California's offshore wind industry. At the start of 2019, the first phases of the federal leasing process are underway—potentially leading to a lease for offshore wind as early as 2020—and domestic and international firms are eyeing California's market and creating strategic partnerships. Two entities, the Redwood Coast Energy Authority (RCEA) and Castle Wind, have proposed projects off the coast of Humboldt County and San Luis Obispo County, respectively.

Developer interest is warranted: With 112 GW of technical offshore wind resource potential along its coastline—enough to supply about 1.5 times the state's annual electric energy use—California has the eighth-highest resource potential in the United States. As the state moves toward a zero-carbon electricity mix in 2045, offshore wind can provide value to the grid by balancing solar generation. Floating offshore wind technology, which is better suited for California due to its deep waters, is relatively new but has demonstrated impressive capacity factors. Scientists project that California's floating offshore wind turbines could reach capacity factors of over 70 percent, in other words, generating 70 percent of their maximum theoretical output. This capacity factor is two to three times that of solar, nearly twice that of land-based wind, and even greater than that of coal.

In addition to grid reliability, offshore wind offers a number of other benefits to Californians, including the opportunity to develop a new industry from the ground up. We estimate that if California were to install 18 GW of offshore wind capacity by 2045, the state could support over 17,500 jobs in the offshore wind industry, related downstream industries, and surrounding economy in that year. However, the state will need to guide industry growth with a cluster-based approach: creating market certainty, training workers, and facilitating connections in its innovation ecosystem, among other strategies. Working hand in glove with key federal stakeholders such as the U.S. Navy will be needed to create win-win solutions for less restrictive maritime development.

Through extensive research and over forty interviews with stakeholders and experts in California, the authors assessed the current challenges and opportunities for offshore wind development. The report:

- Summarizes offshore wind activities in California to date
- Presents the benefits of offshore wind in California
- Outlines cluster-based strategies for economic development and current competitive advantages
- Details development scenarios for offshore wind industry growth from 2019 to 2045 and associated economic impacts
- Suggests policy recommendations to pursue and investigate offshore wind in a holistic manner

SUMMARY OF RECOMMENDATIONS

The report culminates in high-level recommendations for California's leaders based on best practices in the United States and abroad. We recommend that the state bring a systems-level approach to offshore wind development that sets a broad vision for industry growth and considers near- and long-term industry needs and opportunities. While each recommendation can be viewed as a stand-alone option, the recommendations are intended to be complementary and would be more powerful if adopted as a package.

Policy 1: Appoint a California Offshore Wind Czar
Growing California's offshore wind industry will require comprehensive logistics and holistic planning efforts across the state, federal, and international levels. The governor should consider appointing a California Offshore Wind Czar to create and lead a vision for growth that aligns with the values of Californians and to serve as the primary point of contact for California's strategic offshore wind efforts. The Czar could be responsible for coordinating activities among state agencies, fostering community programs, advocating for policy and procedural changes in the federal leasing process, building international relationships for knowledge exchange, and capturing domestic and foreign direct investment opportunities.

Policy 2: Set a Market Acceleration Target and Establish a Comprehensive Approach to Studies
Currently, California has limited resources dedicated to sustainably building offshore wind projects and ensuring industry growth aligns with state values and leads to lower energy costs for ratepayers. By developing a state vision spurred by a market acceleration target, California leaders could prioritize areas of research that establish industry development guidelines and frameworks, survey potential impacts on coastal ecosystems, consider innovative financing mechanisms, and streamline project development, among other topics.

Policy 3: Establish a Phased Approach to Offshore Wind Workforce Development
California boasts robust workforce training infrastructure that it can leverage to build a skilled and ready offshore wind workforce. Near-term activities could map workforce planning, convene stakeholder groups on best practice strategies, and target professionals interested in working in the offshore wind industry. Long-term efforts could help build a diverse and inclusive workforce, formalize partnerships between industry and training providers, and ensure investments in offshore wind safety training, operations and maintenance (O&M), monitoring and verification, and technology research and development.

Policy 4: Align Innovation and Access to Capital Policies with Industry Needs
Offshore wind innovation is key to lowering energy costs, increasing grid integration, opening up new markets, protecting marine ecosystems, and improving working conditions. California leaders could facilitate offshore wind research, collaboration, knowledge exchange, and business development through joint industry projects, multidisciplinary academic programs, industry/university partnerships, business accelerators, and access to capital mechanisms that help companies overcome barriers to market entry.

Policy 5: Upgrade Ports and Establish Port Innovation Districts
Globally, ports are the nucleus of offshore wind development, often serving as hubs for the assembly, staging, fabrication, and construction of turbine components and long-term O&M activities. As California cultivates its offshore wind industry, continued port planning and upgrades will be critical to support evolving industry operations. State activities could focus on upgrading key ports to catalyze early-stage projects, building port innovation districts, and prioritizing local community benefits in port revitalization efforts.

CALIFORNIA'S OPPORTUNITY IN OFFSHORE WIND

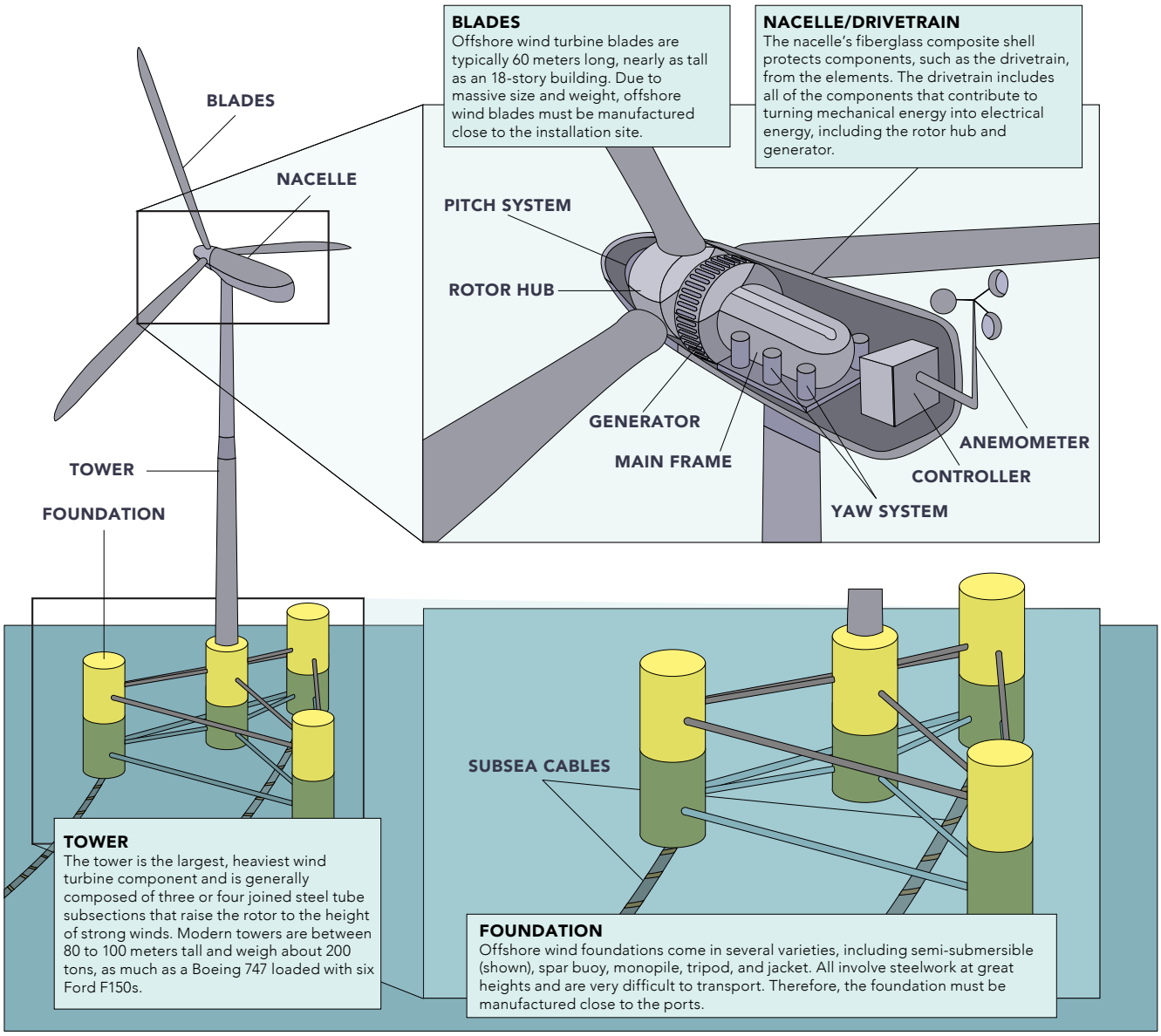
California is well positioned to capitalize on rising market demand for offshore wind given the state's strong, consistent coastal winds, supportive policies, and increasing need for a balanced grid.

WHAT IS OFFSHORE WIND?

Offshore wind turbines are similar to the land-based turbines located in California, except they are deployed at sea and several times larger. Current offshore wind turbine models—like the one depicted on page 44—are taller than the Washington Monument and have blades as long as a football field. Offshore wind turbines typically have higher power output than those onshore due to larger turbine size and faster, more consistent winds off the coast. Although offshore wind technology is new to California, it has been around for almost thirty years. The first offshore wind farm was installed in Denmark in 1991, and Europe now has over 18 GW of installed capacity off its coast. In December 2016, the first U.S. offshore wind farm—a 30 MW project in Rhode Island—was installed. More than 4 GW of East Coast projects have since progressed to permitting phases, reflecting how quickly the offshore wind industry is taking off in the United States.

Until a few years ago, the only commercially available offshore wind turbines had to be anchored to the seabed via a fixed-bottom platform. This restricted development of offshore wind farms to shallow waters up to fifty meters deep, such as offshore wind projects in Europe and the recent Block Island Wind Farm in Rhode Island. Due to the state's deep waters, California is further behind East Coast states in developing offshore wind. However, new types of foundations that can support installation at greater depths have resulted in a surge of interest in California-based projects. Now, floating foundations—which were traditionally used in the oil and gas industry—are becoming commercially viable for offshore wind. The three major types of floating foundations are semi-submersible, spar-buoy, and tension leg platform. Semi-submersible platforms have been deployed in Portugal by Emeryville-based developer Principle Power and the spar buoy platform was used in Equinor's Hywind Scotland project. In its first three months of production, Hywind Scotland achieved a 65 percent capacity factor, indicating the wind farm generated 65 percent of its maximum theoretical output. In contrast, offshore wind turbines with fixed-bottom foundations typically reach a capacity factor of 45 to 60 percent. Motivated by these early signs of success, companies around the world are developing new types of floating foundations and continuously working to cut costs and increase efficiency.

Anatomy of an Offshore Wind Turbine



Recent Offshore Wind Developments in California

California's offshore wind resource potential is 1.5 times the state's annual electricity use. Dialogue on offshore wind development in California was kickstarted in December 2016 by Trident Wind's unsolicited federal lease request for a Morro Bay project (*see timeline on page 14*). In 2018, Trident Winds partnered with EnBW to create Castle Wind, pledging to create jobs and bring economic benefits to Morro Bay and the surrounding community. Interest from developers has continued to blossom: Another lease request was submitted by the Redwood Coast Energy Authority together with a consortium that includes Principle Power, EDPR Offshore North America, and Aker Solutions for a wind farm off the coast of Eureka. Because wind farms will be installed in federal waters but interconnection and affiliated activities are under state jurisdiction, the offshore wind planning process requires a joint effort between the state and federal government. In response to the lease requests, the federal Bureau

of Ocean Energy Management (BOEM) published a Call for Information and Nominations on October 19, 2018. The Call officially solicits nominations from companies interested in offshore wind leases in three proposed areas along the California coast (*see California Offshore Wind Value Chain on page 25*). Following the public comment period ending on January 28, 2019, BOEM will begin the process of refining the wind energy areas and conducting environmental assessments. BOEM could initiate the formal leasing process as early as 2020.

The U.S. Department of Defense (DOD) is an important stakeholder in the offshore wind planning process in California, and representatives from several DOD departments have participated on the BOEM/California Intergovernmental Renewable Energy Task Force. In 2017, the U.S. Navy issued an initial mission compatibility assessment, evaluating the compatibility of potential offshore wind development with existing and proposed military operations off California's coast. In 2018, the assessment was updated, further restricting offshore wind projects on the central and southern coasts. The DOD is collaborating with industry and government representatives to identify possible areas where offshore wind development may be compatible with defense activities. Because currently restricted areas are close to regions with high electricity demand and access to some of California's most viable transmission infrastructure, these ongoing efforts are critical to the future of offshore wind development in California.

Why Develop Offshore Wind in California?

Offshore wind can provide several advantages to California. These benefits include the opportunity to fortify the state's international leadership on climate change, improve grid stability and operational efficiency, tap into rapidly decreasing costs and growing demand for the technology, harness the state's vast renewable energy resources, and transition workers from legacy industries into good-paying jobs in offshore wind.

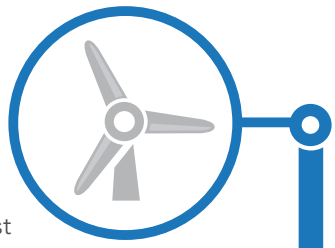
Opportunity to Demonstrate International Leadership on Climate Change

California has positioned itself as an international leader on climate change by establishing cap and trade, convening global climate leaders, and setting a 100 percent zero-carbon electricity goal. Although California is known for its forward-looking clean energy policies, the state must do more to grow in-state renewable energy generation and maintain a leadership position on the global stage. According to the Intergovernmental Panel on Climate Change (IPCC), averting a climate crisis will require a "rapid and far-reaching" transformation in modern civilization. The 2018 IPCC report concluded that current efforts to reduce greenhouse gas emissions will not stop global temperatures from rising to catastrophic levels, with a global climate crisis starting as early as 2040. Likewise, the Fourth National Climate Assessment released in November 2018 urges swift action on climate change "to avoid substantial damages to the U.S. economy, environment, and human health and well-being over the coming decades." The United States and other nations are being called to critically evaluate their policies on issues such as energy generation, land use, building construction, and transportation to reduce global net human-caused CO2 emissions by 45 percent from 2010 levels by 2030. California has an opportunity to surpass its past climate leadership by embracing new, forward-looking ideas that help meet these commitments early.

Offshore wind is an effective solution to reduce emissions and reliance on fossil fuels in the power sector: It can help the state meet its zero-carbon electricity goals by diversifying the clean energy portfolio and mitigating the impacts of climate change on California's vibrant ecosystems. Planned U.S. offshore wind projects show large potential for avoided carbon emissions. For instance, the Skipjack offshore wind farm in Maryland—comparable in size to the proposed Humboldt County project but with distinctions in project design and market characteristics—will avoid 364,000 metric tons of CO2 each year or the equivalent of emissions from 80,000 passenger vehicles. By leveraging the opportunity of offshore wind, California can ramp up its efforts to combat this urgent challenge and continue to cement its international climate leadership.

Offshore Wind Milestones in California

2016



- Trident Winds submits an unsolicited lease request for a 650 MW floating offshore wind project off the coast of Morro Bay.
- BOEM and the State of California create the BOEM/California Intergovernmental Renewable Energy Task Force, which is led by the CEC and OPC.
- 1st Task Force Meeting

2017

- The Task Force launches the California Offshore Wind Energy Gateway, which contains over 600 data sets.
- The U.S. Navy issues its first maritime use restrictions, which evaluate the compatibility of offshore wind with current and proposed military activities off California's coast.

2018

- The U.S. Navy issues its second maritime use restrictions, which further restrict offshore wind activities along the central and southern coasts.
- The RCEA and its partners submit an unsolicited lease request for a 100-150 MW wind farm off the coast of Eureka.
- 2nd Task Force Meeting
- BOEM publishes a Call for Information and Nominations (Call) to initiate the competitive planning and leasing process for offshore wind deployment.
- The City of Morro Bay approves a Community Benefits Agreement (CBA) with Castle Wind (Trident Winds and EnBW North America), requiring the developer to allocate $250,000 for the rights to the grid connection at the Morro Bay substation and to support regional workforce development.

2019

- End of public comment period
- Upcoming steps: On the federal level, BOEM will conduct Area Identification to delineate Wind Energy Areas (WEA). The areas identified will be subject to environmental analysis, and the leasing processes could begin as early as 2020.

Opportunity to Improve Grid Stability

California passed SB 100 in 2018, requiring 60 percent of its electricity to be generated from renewables by 2030 and 100 percent from carbon-free energy sources by 2045. This laudable goal is not without its challenges: As California integrates more intermittent renewable sources and retires old power plants, state regulators must continue to balance fluctuating electricity supply and demand, prevent blackouts, and reduce fossil fuel dependence. There is also a long-standing debate in the state on how best to satisfy the Renewable Portfolio Standard with in-state and out-of-state resources. Growing California's in-state renewable energy generation is critical to pave the way for a secure energy future, offering another reason why offshore wind uniquely matches the state's grid stability needs.

Winds off the coast of California are steady and generally blow throughout the day, offering the potential of consistent electricity generation. Offshore wind power will be an increasingly valuable grid asset given the upcoming decommissioning of resources like the Diablo Canyon nuclear plant, which produces about 9 percent of in-state generated electricity each year and powers 1.7 million homes. Offshore wind, which is often sited in proximity to population centers, can also provide valuable transmission congestion relief by repurposing existing interconnection points such as Diablo Canyon.

Offshore wind resources also speed up during the late afternoon and early evening, complementing the state's large installed solar capacity. California's high solar penetration has resulted in curtailment of clean energy and the need for other resources to supply energy when the sun sets. The evening ramp—when people are returning from work and using more electricity—is typically met by natural gas plants either powering back on or ramping up generation, causing local air pollution. Because coastal winds pick up later in the day, offshore wind turbines can deliver higher power output during peak demand periods and serve as a cleaner alternative to meet energy needs.

Furthermore, offshore wind's high capacity factor means it yields more energy per unit of installed capacity. For instance, the Hywind floating offshore wind farm demonstrated a capacity factor of 65 percent, which is two to three times that of solar, nearly twice that of land-based wind, and even greater than that of coal. In fact, NREL scientists predict that California offshore wind turbines may reach capacity factors of over 70 percent. Offshore wind can help the California Independent System Operator (CAISO) and the California Public Utilities Commission (CPUC) integrate a diverse resource mix that allows for a more effective balance of supply and demand, thereby supporting a more stable grid.

Opportunity to Capitalize on Growing Demand and Falling Costs for Offshore Wind

Demand for offshore wind is soaring both at home and abroad. Globally, the offshore wind industry is projected to continue growing 25 percent each year until 2022. In 2017, installations increased 95 percent over the prior year, with an additional 4.3 GW installed worldwide. At 18.5 GW of installed capacity, Europe has captured the vast majority of the offshore wind market growth. However, the United States has experienced a recent and dramatic increase in project development: There are at least twenty-eight offshore wind projects in the U.S. pipeline, amounting to almost 24 GW of potential installed capacity. Five Atlantic states made commitments to build more than 21 GW of offshore wind, enough to power about 8 million homes. While the East Coast has begun to mobilize investment in fixed-bottom offshore wind turbines, the West Coast has an opportunity to become the U.S. hub for floating offshore wind and capitalize on rapidly declining costs.

According to a 2018 study from Lawrence Berkeley National Laboratory, the market value of electricity generated by offshore wind could soon surpass its levelized cost of energy (LCOE) in several states along the Atlantic coast. The LCOE for floating offshore wind could reach $89 per MWh by 2030, a 39 percent decrease from a 2017 reference project

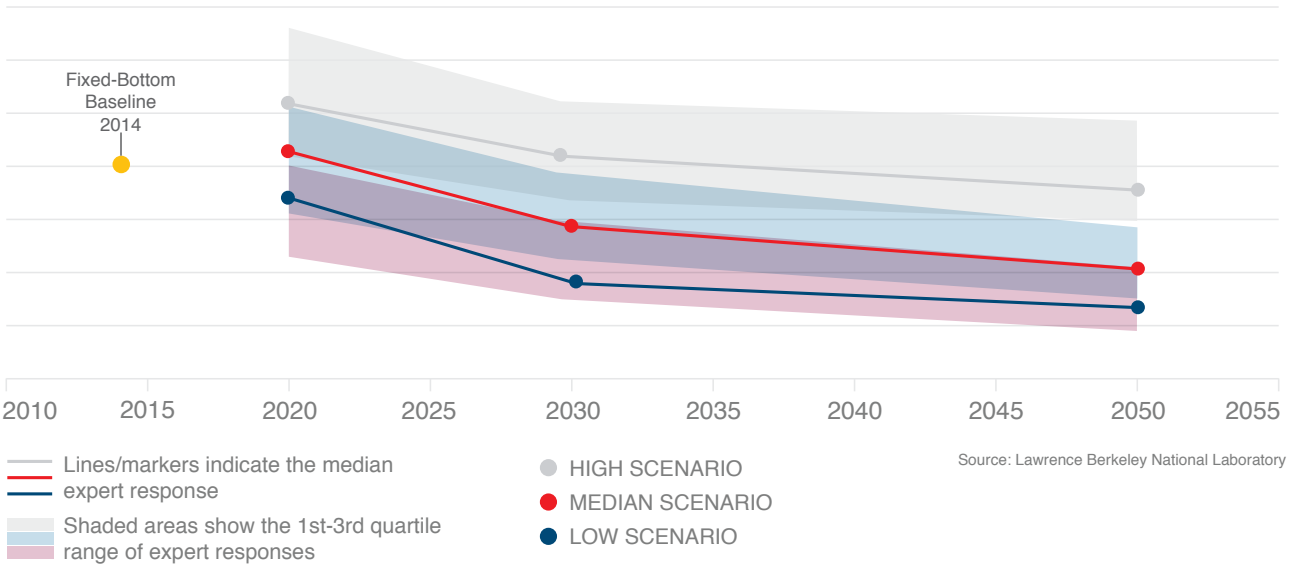
Oil and Gas Investments in Offshore Wind: Oil and gas giants around the world are investing heavily in offshore wind. Equinor plans to invest over $11 billion in offshore wind projects in the United States, Poland, and Great Britain. A consortium led by Royal Dutch Shell secured financing for a $1.5 billion offshore wind project in the North Sea. Ørsted, formerly known as Dong Energy, invested $510 million in U.S. offshore wind development.

LCOE of $146 per MWh. Longer-term projections indicate that the LCOE could decrease by as much as 53 percent by 2050 from a 2014 offshore baseline of $169 per MWh (*see figure below*). Notably, Equinor, one of the leading offshore wind developers, expects the costs of its upcoming offshore wind projects to fall between $46 to $69 per MWh by 2030, which is lower than the current $73 per MWh price of onshore wind in the United Kingdom. As technology innovation leads to higher capacity factors, the cost of floating offshore wind is expected to continue to fall and could even reach cost parity with fixed-bottom offshore wind by 2030.

Offshore wind is not merely overcoming once prohibitive capital costs: It is projected to bring a new surge in investment and employment to many of the country's working harbors. Every dollar invested in the construction of a 352 MW wind farm off the coast of New Jersey is expected to generate $1.83, resulting in a total in-state economic benefit of over $700 million.

Estimated Change in Levelized Cost of Energy (LCOE) for Floating Offshore Wind Projects

The LCOE for floating offshore wind could decrease by as much as 53% by 2050.



Note: In this study, experts were asked to provide probabilistic estimates for three future scenarios: a low LCOE scenario (10th percentile), a median LCOE scenario (50th percentile), and a high LCOE scenario (90th percentile).

Opportunity to Harness Natural Resource Potential

California's long coast features wind speeds that range from above the lower threshold for offshore wind generation to faster than the national average. Along California's central coast, average annual wind speeds reach seven to eight meters per second, and in parts of Northern California, they regularly reach ten meters per second. Moreover, California's unique ocean topography makes floating offshore wind turbines a natural choice for the state. Almost 95 percent of California's available offshore wind resources can be found in waters that exceed a depth of sixty meters, which cannot support turbines with fixed-bottom foundations. As such, floating offshore wind turbines are a natural choice for deployment in California.

Overall, there are 112 GW of technical offshore wind resource potential along the California coastline, approximately 1.5 times the state's annual electric energy use. Technical potential excludes legally protected areas, such as ecological preserves, marine sanctuaries, and critical habitats and is a representation of the overall resources that could become commercially viable. California has the eighth-highest net technical offshore wind resource potential in the United States, exceeding that of New York and New Jersey, two states that have already made significant investments in the technology.

Opportunity to Transition Workers in Legacy Industries

California policymakers and decision-making bodies can set rules and objectives for the offshore wind industry before it arrives—an unparalleled opportunity to ensure that we value workers, distribute wealth, and respect our natural landscape. As we consider this opportunity, legacy industries such as oil, gas, and nuclear are coming to a close. In 2018, Governor Brown blocked the construction of new oil and gas pipelines, preventing offshore drilling in federal waters along California's coast. Diablo Canyon, the state's last nuclear facility, will be decommissioned in 2025, displacing about 1,500 workers. For many of these workers, offshore wind may be a natural transition. Oil and gas workers can transfer skills in areas such as post-design fabrication, installation, risk management, and safety procedures. The nuclear workforce includes electricians that could participate in offshore wind installation and grid connection, among other roles. California also employs over 8,000 dockworkers in shipbuilding and ship repair and has a sizeable workforce in related industries such as land-based wind and aerospace. Moreover, California is home to several large capacity ports that could support offshore wind deployment with moderate investments, and full-scale offshore wind industry growth could be catalyzed by associated industries such as marine steel fabrication and composite materials manufacturing. Expertise from these industries and others could be leveraged for the offshore wind industry.

Opportunity to Support Good-Paying Jobs

As California welcomes a new state administration, policymakers have an opportunity to take action that will help secure a sustainable economic and environmental future. The offshore wind industry offers a diverse array of employment opportunities that caters to different education and experience levels at every phase of development. For example, the industry could employ lawyers to negotiate legal contracts and bids, metal workers to manufacture foundation components, sales representatives to facilitate the sale of manufactured parts, environmental specialists to ensure that project development is minimally invasive towards California's vibrant coastal ecosystem, and engineers to conduct regular operations and maintenance. In addition to supporting a wide array of jobs, offshore wind represents an excellent opportunity for California to build an inclusive economy that offers accessible, fair-wage jobs to its residents. (*See Job Opportunities in Offshore Wind on page 18.*) California is committed to achieving carbon-neutral power generation by 2045, and offshore wind could help meet that goal through locally generated electricity that maximizes the direct and indirect economic impacts for the local workforce. By leveraging forward-thinking strategies to develop 18 GW of offshore wind capacity by 2045, California could support more than 17,500 jobs in the development, installation, and operation of its wind farms. (*See Appendix A for jobs modeling methodology.*)

Stakeholder Perspectives: California's First Offshore Wind Farm. Many environmental advocates, industry leaders, academics, and other relevant stakeholders agree that offshore wind can help reach the state's renewable energy targets and mitigate climate change. However, opposing perspectives exist regarding California's early development and how the first project(s) should look. Some stakeholders maintain that California should start relatively small in order to assess the environmental impacts of floating turbines on the California Current Ecosystem (CCE) while others push for more large-scale projects to decrease cost per unit of output. As the offshore wind planning process moves forward, California policymakers and decision-making bodies should meaningfully consider potential short- and long-term impacts to sensitive environmental habitats, historical and cultural landscapes, and the commercial fishing industry and other existing maritime activities.

PHASES OF DEVELOPMENT

Development & Project Management | Manufacturing & Construction | Installation & Commissioning | Operations & Maintenance

The four phases of offshore wind development offer a variety of job opportunities that cater to different education and experience levels in California.

JOB OPPORTUNITIES IN OFFSHORE WIND

Electrical Engineers

Design and develop electrical equipment.

Typical Entry-Level Requirements:
Bachelor's degree

Wage: $53.31

Environmental Scientists & Specialists

Protect the environment by working with industry and advising policymakers.

Typical Entry-Level Requirements:
Bachelor's degree

Wage: $39.27

Welders, Cutters, Solderers & Brazers

Join or cut metal parts using hand-held or remotely-controlled equipment.

Typical Entry-Level Requirements:
High-school diploma or equivalent with technical and on-the-job training

Wage: $19.88

Lawyers

Provide advice and representation on legal issues and procedures.

Typical Entry-Level Requirements:
Doctoral or professional degree

Wage: $71.95

Construction Laborers

Perform physical labor on construction sites.

Typical Entry-Level Requirements:
On-the-job training

Wage: $19.80

Sales Representatives

Sell wholesale and manufactured products.

Typical Entry-Level Requirements:
Bachelor's degree

Wage: $36.65

Note: Actual wages in California's offshore wind industry may be higher than listed here. Clean energy industries typically offer wages higher than the national median, and large-scale projects often leverage project labor agreements that ensure living-wage jobs and training through state-certified apprenticeship programs.

OFFSHORE WIND CLUSTER DEVELOPMENT

There are five foundational building blocks for clusters: the innovation ecosystem, access to capital, workforce development, local market, and value chain. California has many assets that can be aligned with cluster-based development, including its unmatched access to capital and growing value chain.

The Benefits of Cluster-Based Development

If California's leaders want to reap the most benefits from offshore wind market growth, they should work to build a strong economic cluster for industry growth. Clusters are regionally situated groups of interconnected companies and institutions that are engaged in a particular industry and supported by repeated exchanges of information and resources. In today's competitive globalized economy, businesses are more likely to thrive in regions that cultivate the building blocks of cluster development: a rich

HOW DOES AN ECONOMIC CLUSTER WORK?

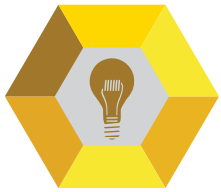
innovation ecosystem, fertile ground for capital investment, a highly skilled workforce, clear policy signals, and a robust value chain. In fact, clusters enable businesses to leverage a trained workforce, a close network of suppliers, and a wealth of resources to overcome size limitations, improve productivity, and increase operational efficiency.

Studies have shown that wages are higher in industry clusters, with one study concluding that workers typically receive wages that are 6 percent higher than those of workers employed in the same industry but outside a cluster. In industries that are dependent on manufacturing, such as offshore wind, clusters have been shown to expand access to talent and boost economic activity. By leveraging an environment of coordination and cooperation, clusters can offer workers fair wages and simultaneously stimulate innovation and economic development.

California has leveraged the building blocks of cluster-based development to establish world-class, innovation-driven industry clusters such as Silicon Valley, Napa Valley, and Hollywood. The state has an opportunity to replicate these successes by tapping into emerging renewable energy technologies such as floating offshore wind.

California can capitalize on its strengths in offshore wind by strategically building an economic cluster, which will require a comprehensive action plan and designated leaders to coordinate stakeholder efforts and translate them into meaningful economic growth. Virtually every successful cluster—both domestically and internationally—was developed through deliberate policy, a clear strategy, and strong leadership. In 2010, turbine manufacturer Vestas opened its North American manufacturing base in Colorado, citing the state's strong commitment to workforce training and other cluster-based strategies for industry growth. More recently, policymakers and stakeholders in states such as Massachusetts, New York, and Virginia are working together to streamline permitting and siting procedures, fund workforce development initiatives, and support infrastructure upgrades at ports and on roadways. California could leverage cluster-based development to become a regional offshore wind leader: The state already boasts many engaged leaders and coordinating bodies, and targeting cluster gaps can help catalyze development and create an environment where businesses and workers can thrive.

The following visual guides break down the key assets for a robust cluster. This section will use these guides to illustrate California's strengths in each foundational building block and showcase significant resources for the offshore wind industry.



Innovation Ecosystem

Innovation is essential for business and industry competitiveness, and a strong knowledge hub can be a beacon for talent and investment. The innovation ecosystem supports fundamental research across universities and labs, fosters an entrepreneurial culture that seeks to advance and disrupt industries, and brings ideas to market.

Access to Capital

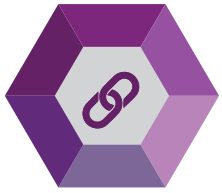
Access to investors or competitively priced non-dilutive capital can be the difference between success and failure for a new or expanding business. It is also important for consistent access to capital across development from the seed and early/growth stages to the late stage. An active investment environment can attract more entrepreneurs and investors to the state.

Workforce Development

Trained and skilled workers are fundamental to industry success, and strategic workforce development can support talent recruitment and retention. Workforce development requires collaboration across schools, businesses, labor unions, and government offices to integrate STEM education, foster industry-ready skills via apprenticeships and career-integrated curriculum, enable stackable credentials that offer multiple entries and exits, and provide resources that match skills to available jobs.

Local Market

Creating a local market for products sends a market signal to businesses that encourages investment in new facilities and employees. High local demand can attract a local company base that could then expand to regional, national, and global markets. Clear utility and business regulatory environments coupled with resources for project development and end-user adoption can create a strong local market.



Value Chain

An industry value chain is composed of an array of companies engaged in the manufacturing, sale, marketing, and distribution of technologies. It also includes organizations that represent business interests across platforms. While a supply chain is composed of the entities and processes involved in production and distribution, a value chain is composed of all the activities used to create a competitive advantage. This base provides a solid foundation from which to attract more companies and customers.

Examples of State Assets to Support Offshore Wind Development

INNOVATION ECOSYSTEM. California has an extensive network of public labs and world-class research institutions that can be used to foster technological innovation in the offshore wind industry.

- **Lawrence Berkeley National Laboratory (Berkeley Lab):** Berkeley Lab has an estimated national economic impact of $1.6 billion per year and has created approximately 5,600 jobs in the San Francisco Bay Area. In 2018, Berkeley Lab completed a national survey of individuals living nearby wind power projects, reporting that only 8% of respondents held a negative attitude towards the projects.
- **Lawrence Livermore National Laboratory (LLNL):** LLNL supports over 6,500 jobs and has helped to create more than 100 companies. The lab has pioneered innovation in wind power for over two decades due to expertise in turbine and wind plant operations, atmospheric sciences, weather forecasting, and more.
- **Stanford Precourt Institute for Energy:** Stanford's scientists are researching methods of maximizing efficiency in turbine design and reducing the overall costs of wind energy.
- **BlueTech Incubator (BTI):** In 2017, the City of San Diego awarded The Maritime Alliance (TMA) $50,000 to open an incubator for water- and ocean-based technologies. Today, San Diego is home to the nation's largest BlueTech cluster, generating an annual economic impact of roughly $14 billion.
- **Scripps Institution of Oceanography**
- **Sandia National Laboratory**

ACCESS TO CAPITAL. California can maintain its clean energy leadership by mobilizing venture capital, loan programs, and investment programs to attract foreign firms and support homegrown businesses in the offshore wind industry.

- **California Capital Access Program (CalCAP) for Small Business:** CalCAP is a loan loss reserve program that encourages banks and other financial institutions to provide loans for small business startups and expansions.
- **Opportunity Fund Northern California:** Opportunity Fund is California's largest microlending program. In 2015, it provided $37 million in loans to more than 1,500 small business entrepreneurs.
- **Cleantech Open (CTO):** CTO has supported over 1,200 early-stage clean energy entrepreneurs through its annual business accelerator. The program has helped its alumni raise $1.2 billion and create more than 3,000 jobs in clean energy.
- **California Clean Energy Fund (CalCEF):** CalCEF is a San Francisco-based seed- and early-stage venture capital fund focused on clean energy innovation.
- **California Sustainable Energy Entrepreneur Development Initiative (CalSEED):** CalSEED awards up to $600,000 in grant funds to entrepreneurs with promising clean energy concepts and provides them with mentorship and professional development services.
- **Small Business Loan Guarantee Program (SBLGP):** SBLGP has connected small-business owners in low- to moderate-income communities with over 30,000 loans.
- **Investor's Circle (IC):** Based out of San Francisco, IC is one of the nation's largest angel investment groups and has facilitated over $200 million in investments in over 330 ventures that address social, environmental, and economic challenges.
- Over half of U.S. venture capital investment went to California from 2013 through 2015, totaling over $78 billion.

WORKFORCE DEVELOPMENT. California has a number of educational and job-training programs that could ensure a sufficient pipeline of workers for the offshore wind industry.

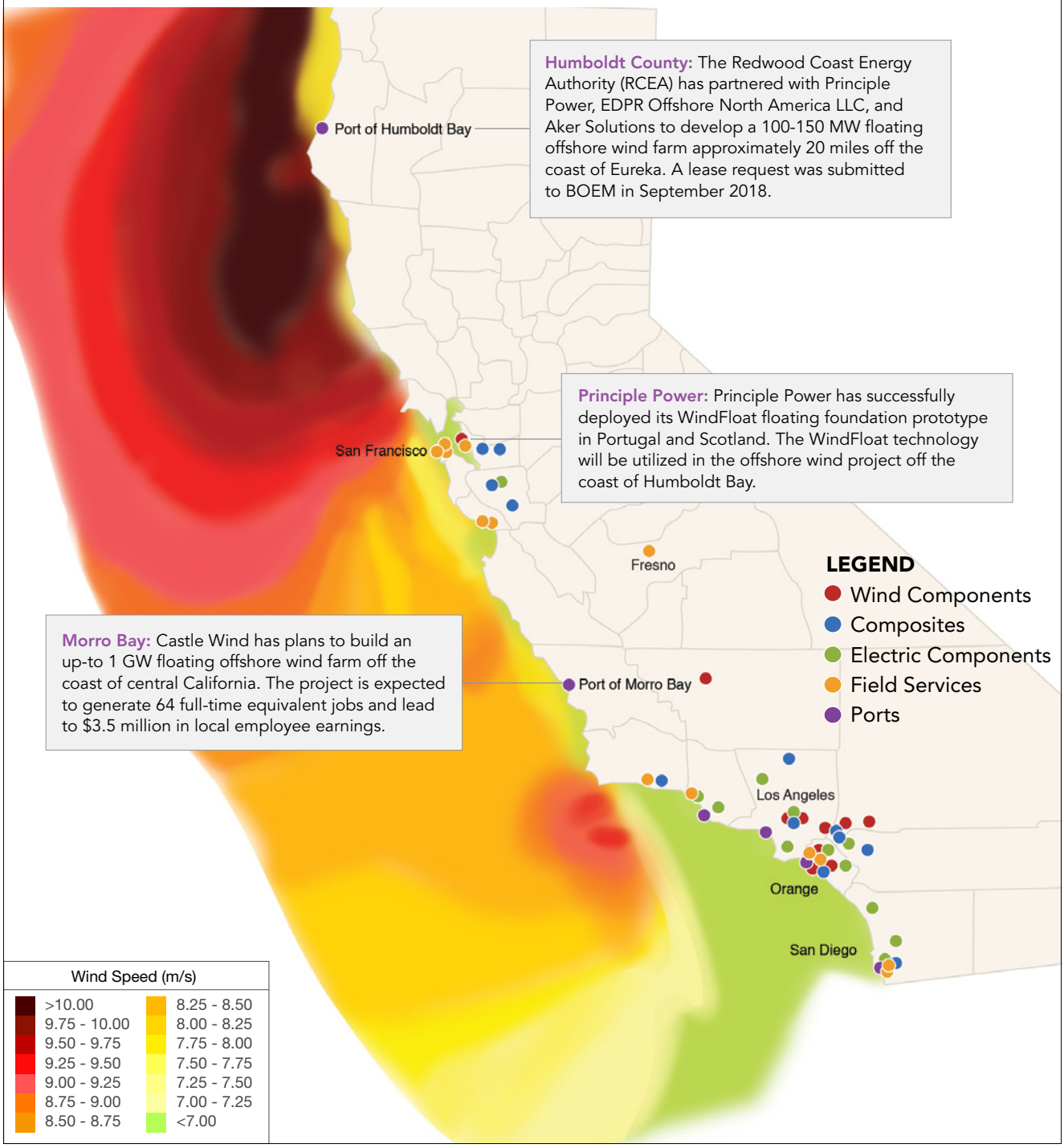
- **Environmental Resource Engineering Program (ERE) at Humboldt State University (HSU):** HSU's ERE program equips students with skills in the design and operation of renewable energy technologies such as wind and solar.
- **CSU Maritime Academy** is the only degree-granting maritime academy on the West Coast. A team from the academy won the 2018 U.S. Department of Energy's Collegiate Wind Competition.
  - **Marine Safety and Security Center (MSSC):** CSU Maritime operates the MSSC, which provides comprehensive safety and security planning and response and mitigation training for maritime activities.
- **Power Systems and Sustainable Energy Program at Santa Clara University:** The program offers curriculum that features wind energy, awarding graduates certificates in renewable energy and master's degrees in power systems and sustainable energy.
- **Renewable Energy and Communication Tower Technician Program:** Airstreams Renewables, Inc. offers safety and technical lessons to prepare students for entry-level positions in the wind industry. Airstreams is a vocational training provider whose curriculum has been used as a model for college and other educational programs around the U.S.
- **Alternative Energy Technology Certificate at Rio Hondo College:** The certificate prepares students for employment as an Alternative Energy Technician, with special emphasis in the installation of wind and solar power systems.
- **Apprenticeship Programs:** As of January 2019, California was home to over 600 active apprenticeship programs, including Advanced Manufacturing & Transportation Apprenticeships of California (AMTAC) and California Advanced Manufacturing Apprenticeship Collaborative (CAMAC).

LOCAL MARKET. California could leverage its state and local policies to support offshore wind deployment by allowing homegrown companies to easily enter the local market and offering clear guidelines that attract manufacturers and key firms to the state.

- **Memoranda of Understanding (MOU):** In 2017, the State of California and Scotland signed an MOU on climate change, which considered how the two governments could share data and expertise on offshore wind development. In 2018, the California Energy Commission (CEC) established an MOU with Denmark.
- **Renewable Portfolio Standard (RPS):** By 2045, public utilities will be required to procure 100% of their electricity from eligible clean energy sources, which include offshore wind. Notably, offshore wind energy generation correlates with peak times for power demand in California and can help support a more stable grid.
- **California Competes Tax Credit (CCTC):** CCTC provides up to $180 million in tax credits to mobilize in-state small business growth and support companies that are expanding operations into California.
- **California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA):** As a key feature of California's Green Bank, CAEATFA helps to finance projects that develop renewable energy, increase energy efficiency, and reduce carbon emissions through the support of loans, loan guarantees, and bonds.
- **Manufacturing and Research & Development Equipment Tax Exemption**

VALUE CHAIN. California has the beginning of a strong value chain for offshore wind based on its advanced energy manufacturing network and ports that can be retooled to accommodate the industry. California's strong, consistent wind resources have prompted interest from international developers.

CALIFORNIA'S OFFSHORE WIND VALUE CHAIN



CALIFORNIA OFFSHORE WIND DEVELOPMENT SCENARIOS: 2019 TO 2045

Our offshore wind industry growth scenarios demonstrate how strategic policy planning can amplify the economic benefits of offshore wind.

California Offshore Wind Development Scenarios: 2019 to 2045

Long-term forecasts are valuable to show the possibility and significance of potential scenarios, enabling policymakers to consider appropriate time horizons for action. In California, demonstrating various growth scenarios is especially relevant and timely given BOEM's recent Call for Nominations (*see Offshore Wind Milestones on page 14*), which initiates the federal planning process. Burgeoning interest in the California offshore wind market could translate to local economic growth, but such outcomes are highly dependent on state and federal policies.

Two California offshore wind growth scenarios, each with three phases from 2019 to 2045, are presented along with their associated economic impacts (*see following page*). Both scenarios—Status Quo Policy and Strategic Growth Policy—are based on global market projections, interviews with industry leaders, electrification trends, and 2045 resource mix projections from E3. The main difference between these scenarios is the level of policy intervention. For this analysis, we assume no expansion of CAISO and that California's electric supply (not including the Energy Imbalance Market) comes from in-state resources. We anticipate the California market will initially focus on floating offshore wind demonstration projects and then see robust build-out of commercial floating projects, with the potential for development of emerging technologies such as airborne offshore wind (*see Appendix B*).

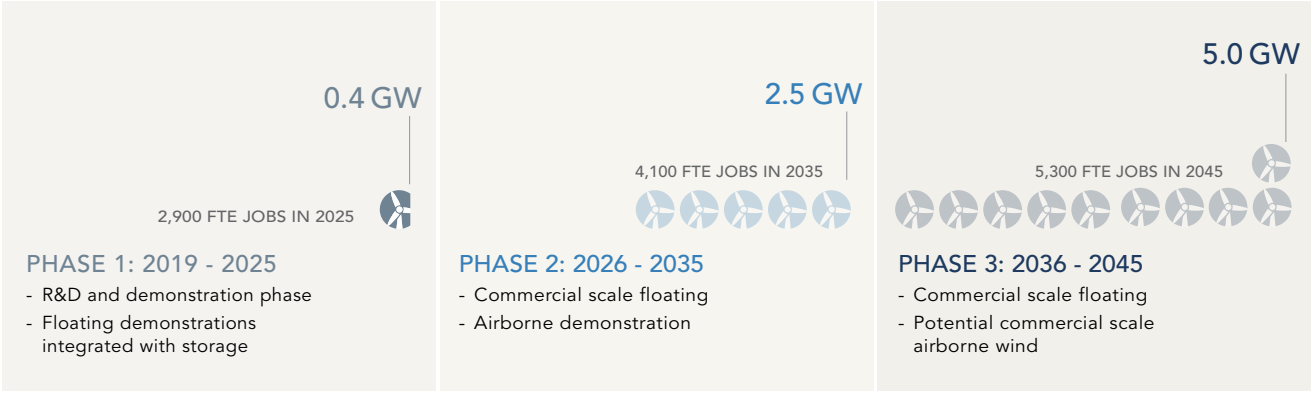
The Status Quo Policy Scenario demonstrates 5 GW of installed capacity in California by 2045. It assumes a future with status quo local, state, and federal policy. For instance, with respect to the local level, it assumes continued local support from areas such as Humboldt County and San Luis Obispo County. Regarding state policy, it assumes continued engagement by the California/BOEM Intergovernmental Task Force but no California market acceleration target or holistic economic development strategy for offshore wind. On the federal side, we assume continued support from BOEM but prohibitive maritime use restrictions by the U.S. Department of Defense (DOD), which will severely limit development close to areas with the highest electric demand. This is not a worst-case scenario of no development, but rather what can be accomplished with the current circumstances.

The Strategic Growth Policy Scenario demonstrates 18 GW of installed capacity by 2045. It assumes additional state policies aimed toward growth targets and a significantly less restrictive maritime use stance from the DOD. For instance, local port innovation districts would be established to foster clustering of offshore wind activities (*see Policy 5*). On the state level, California would adopt a market acceleration target and pursue a cluster-based strategy for development (*see Policy 2*). Federally, we assume that the DOD would open areas for development and that BOEM and DOE will increase expenditures on offshore wind. This analysis builds from a 2016 analysis by the National Renewable Energy Laboratory and takes into account additional in-state activity, rapid market growth, and further offshore wind cost reductions.

Estimated employment impacts for California are presented as full-time equivalent (FTE) jobs in a given year. We present annual FTE jobs for the last year of each phase of development. Phase 1 spans from 2019 through 2025, Phase 2 spans from 2026 through 2035, and Phase 3 spans from 2036 through 2045. The types of jobs represented include direct jobs such as construction, maintenance, and manufacturing of turbine components as well as indirect jobs from downstream services. Induced jobs, such as a new lunch counter opening at a busy offshore wind port, are also included.

The two scenarios demonstrate how policy certainty drives economic trends. For example, Phase 1 has the same installed capacity for each scenario (0.4 GW), but the Strategic Growth Policy Scenario has more jobs because more workers are preparing for the larger next round of projects. California-based manufacturing for components such as blades, anchors, and moorings will only occur in the presence of market certainty, which is accounted for in Phases 2 and 3 of the Strategic Growth Policy Scenario. More details and key assumptions regarding economic impact methodology is located in Appendix A.

STATUS QUO POLICY SCENARIO: 5 GW BY 2045



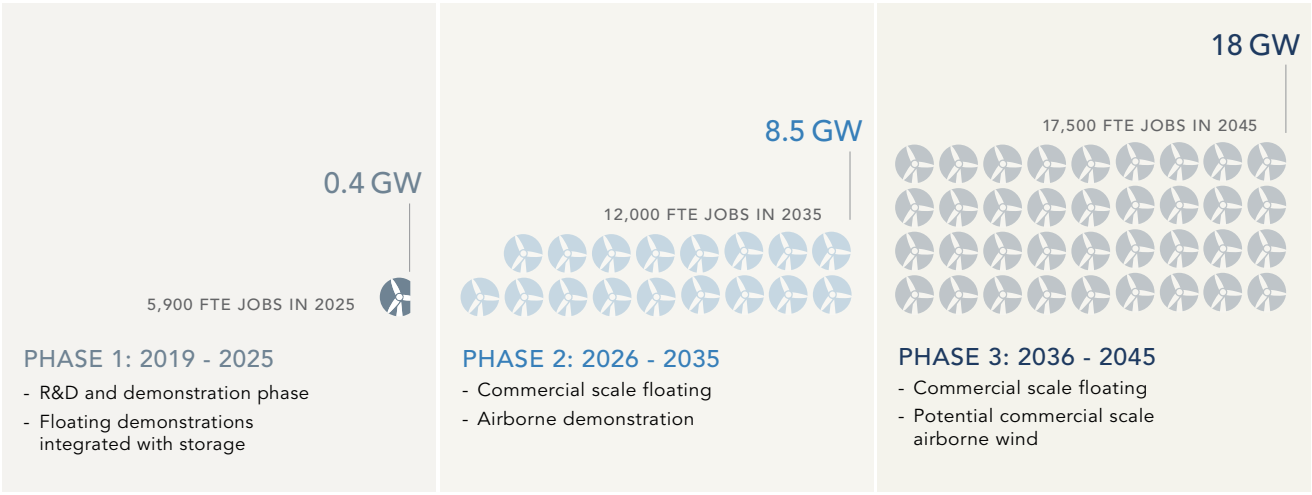
PHASE 1: 2019 - 2025
- R&D and demonstration phase
- Floating demonstrations integrated with storage

PHASE 2: 2026 - 2035
- Commercial scale floating
- Airborne demonstration

PHASE 3: 2036 - 2045
- Commercial scale floating
- Potential commercial scale airborne wind

ASSUMPTIONS
- Navy only allows North Coast development during Phase 1. Heavy restrictions on Central and South Coast in Phase 2.
- Market competition, scale, and supply chain buildout drive costs down.
- CA seeks diverse, in-state resource mix for 2045 target.
- Status quo local, state, and federal policy.

STRATEGIC GROWTH POLICY SCENARIO: 18 GW BY 2045



PHASE 1: 2019 - 2025
- R&D and demonstration phase
- Floating demonstrations integrated with storage

PHASE 2: 2026 - 2035
- Commercial scale floating
- Airborne demonstration

PHASE 3: 2036 - 2045
- Commercial scale floating
- Potential commercial scale airborne wind

ASSUMPTIONS
- State market acceleration target and cluster-based development.
- Navy allows development in areas along the entire coast.
- Market competition, scale, and supply chain buildout drive costs down.
- CA seeks diverse, in-state resource mix for 2045 target.

Our analysis is a high-level vision of likely scenarios using available data, and it intends to serve as a foundation for dialogue and future research in the state. Additional research can further refine and update assumptions, divide growth trends between the Central and North Coast, project energy production in each scenario, and model areas taken up by offshore wind farms, among other topics.

POLICY RECOMMENDATIONS

State and local leaders should take a long-term view of offshore wind development and ensure actions strategically align with the phases of industry growth. Forward-thinking policies, programs, and ideas to train workers, establish clear market signals, and ignite innovation are intended to serve as stepping stones to discussion and collaboration.

POLICY RECOMMENDATIONS

California's leaders can capitalize on the state's competitive strengths and demonstrate their commitment to offshore wind by enacting smart, forward-thinking policies and implementing non-legislative solutions. Whether taken as a whole or as piecemeal solutions, the following recommendations could attract private investment, stimulate the state's economy, and create good-paying jobs for Californians that have been left behind by other industries.

AMERICAN JOBS PROJECT

Policy 1: Appoint a California Offshore Wind Czar

California policymakers and decision-making bodies can set regulations and objectives for the offshore wind industry early—before turbines are in the water. Early direction on the development framework is an unparalleled opportunity to ensure more distribution of economic benefits, facilitate robust protections for marine and shoreline ecosystems and existing economies, incorporate California's expertise throughout the industry, and deploy best practice strategies for workforce training and re-training.

As a hybrid of the traditional marine services and energy industries, offshore wind requires comprehensive logistics, and new, holistic, and streamlined planning and regulatory efforts that will most optimally be underway before the industry develops or at least before construction begins.

To date, the California Energy Commission (CEC) has demonstrated strong leadership throughout the state's nascent offshore wind planning process (*see call-out box*). However, the state must consider additional elements such as economic development and environmental permitting issues to guide and grow the industry, some of which may be outside of the CEC's purview.

As the new state administration takes office in 2019, California has an opportunity to develop a forward-looking offshore wind action plan that ensures industry growth is consistent with local values and is minimally invasive to California's vibrant coastal ecosystem and economies. To accomplish this,

Offshore Wind Leadership at the California Energy Commission: The California Energy Commission (CEC) has played an instrumental role in the offshore wind planning process. CEC-led activities include close coordination with the federal Bureau of Ocean Energy Management, brokering information- and data-sharing agreements with Scotland and Denmark, leading a California delegation to visit the Hywind Scotland project, and conducting approximately eighty outreach meetings with California stakeholders. The California Ocean Protection Council (OPC) is also playing a leadership role in the planning process by representing marine protection concerns and conducting a process to elucidate the offshore wind permitting process.

California's governor could appoint an Offshore Wind Czar to take action on the state, federal, and international levels to create a vision for growth that aligns with the values of Californians. An ideal candidate would be familiar with various aspects of the industry, able to navigate different settings, and well-respected by California stakeholders.

The responsibilities of this position could be designed to evolve alongside the offshore wind industry as needed. For instance, in the early phases of development, the California Offshore Wind Czar could work with a small staff and use minimal state funds to develop initiatives that complement existing CEC and OPC efforts. As the industry grows, the Czar could shift to a more prominent role and be a key point of contact.

State

At the state level, the California Offshore Wind Czar could be responsible for coordinating among public and private stakeholders, complementing or supplementing the CEC's efforts. Protecting California's cherished and world-renowned Large Marine Ecosystem is an essential component of the state's statutory and public trust commitments to Californians. Marine protection is also essential to sustainable economic development as the state's fishermen and over 400,000 people employed in the coastal tourism and recreation business depend on a healthy ocean and iconic vistas to support the state's $44 billion ocean economy. Offshore wind projects will be subject to assessment from a multitude of state agencies including the California Coastal Commission and OPC (*see call-out box*). Like the New York Renewable Energy Czar, the California Offshore Wind Czar could clarify the responsibilities of these agencies and help address challenges of agency overlap and fragmentation (*see case study*). In addition to coordinating among these agencies, the Czar could support outreach with various stakeholder groups and decision-making bodies, such as tribes, labor unions, fishing communities, and environmental groups. The Czar could provide counsel on the development of studies during early phases of industry growth and later oversee the development of studies in partnership with relevant agencies as the Office of the Czar grows (*see Policy 2*).

AMERICAN JOBS PROJECT

At the onset of the industry, the Czar could leverage private and philanthropic funds—spending minimal taxpayer dollars—to develop creative programs that plant the seeds of an economic cluster. The sample early-phase programs below meaningfully engage stakeholders, proactively cultivate public acceptance, and establish connections in the innovation ecosystem.

- **Appoint a California Fisheries Liaison**. The need for early engagement and feedback from fishermen has been noted by U.S. Senators Warren, Markey, Whitehouse, and Reed as a means to identify local fisheries, mitigate spatial conflicts, and preserve the economic viability of the fishing industry. The California Offshore Wind Czar could appoint a Fisheries Liaison to serve as the point of contact between the state and representatives of the regional fishing community such as the Pacific Coast Federation of Fishermen's Associations (PCFFA). Traditionally, Fisheries Liaisons are appointed on behalf of a leaseholder, occurring later in the federal leasing process. For instance, Vineyard Wind appointed a Fisheries Liaison to lead outreach to members of the fishing industry on Cape Cod, the Islands, the South Coast, Rhode Island, and along the greater East Coast. With an extensive background in fisheries science, the Fisheries Liaison is well suited to address concerns that the fishing community has raised about the effect of offshore wind development on their industry. California could adapt the position to impartially solicit feedback and incorporate concerns from the fishing community earlier on in the planning process.
- **Establish a Blended Funds for the Arts, Education, and Culture**. The Office of the Czar could establish and oversee a public art fund financed by the private sector, philanthropic foundations, and other sources as available. The fund could provide grants for community education programs in areas where offshore wind may develop. Among other ideas, the fund could support murals that reflect offshore wind in a positive light and increase public awareness, as has been done in the conservation community.
- **Develop an Offshore Wind Tourism Program.** Just as lighthouses have become popular tourist destinations, offshore wind has the potential to attract curious visitors. Notably, Block Island Wind Farm has become a successful tourist attraction in Rhode Island, with tours charging sightseers up to $100 each. Moreover, recent surveys by the University of Delaware show that only one in ten beachgoers feel their experience will be diminished by the sight of offshore wind turbines. The California Office of Tourism could develop a

Offshore Wind's Regulatory Pathway in California: A Snapshot of Decision-Making Bodies and Various Interested Groups

- Bureau of Ocean Energy Management (BOEM)
- Bureau of Safety and Environmental Enforcement (BSEE)
- California Coastal Commission
- California Department of Conservation
- California Department of Fish and Wildlife
- California Department of Parks and Recreation
- California Energy Commission (CEC)
- California Independent System Operator (CAISO)
- California Ocean Protection Council (OPC)
- California Public Utilities Commission (CPUC)
- California State Lands Commission
- California Workforce Development Board (CWDB)
- Governor's Office of Planning and Research (OPR)
- Humboldt Bay Harbor, Recreation and Conservation District
- Labor Unions
- National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management
- National Park Service
- NOAA Fisheries
- NOAA Office of National Marine Sanctuaries
- Pacific Coast Federation of Fishermen's Associations (PCFFA)
- Port Authorities
- Redwood Coast Energy Authority (RCEA)
- San Luis Obispo County
- Tribal Governments
- U.S. Department of Defense (DOD)
- U.S. Department of Energy (DOE)
- U.S. Environmental Protection Agency (EPA)
- U.S. Fish and Wildlife Service

local tourism program that is modeled after Rhode Island's success, cultivating public curiosity and creating a positive association with offshore wind.

- **Sponsor an Offshore Wind Hackathon or Pitch Competition.** Working in partnership with universities, incubators, and the investment community, the state could identify critical challenges for offshore wind development and solicit technology solutions through a pitch competition (*see Policy 4*).

Federal

Because offshore wind farms will be located in federally-designated waters more than three miles offshore, much of the offshore wind planning process is guided by the Bureau of Ocean Energy Management (BOEM), with input from other relevant agencies such as the National Oceanic and Atmospheric Administration (NOAA). The California Offshore Wind Czar could collaborate with relevant federal agencies to establish offshore wind policies that align with the common interests of California and U.S. federal authorities such as the White House, Congressional Armed Services Committees, Department of Energy, and BOEM. By joining efforts with federal agencies, the Czar could:

- **Partner with the U.S. Department of Defense (DOD) to Meet Shared Objectives**. The military is important for California's economy and U.S. national security. With the state hosting dense concentrations of naval activities, the DOD represents a significant stakeholder in the offshore wind development process. In February 2018, the U.S. Navy updated its maritime use restrictions map with no development zones throughout the southern coast and in the Diablo Canyon-Morro Bay region where projects are currently proposed.

  Given that the Navy's use restrictions changed dramatically from 2017 to 2018 and may continue to evolve over time, state government officials and congressional representatives must engage with the White House, DOD, and Navy to find common ground. Projections indicate the Asia-Pacific region's offshore wind capacity will increase twenty-fold over the next eight years—reaching 43 GW by 2027—with especially fast growth in China, Taiwan, Japan, and South Korea. This means the U.S. military will need to prepare itself to operate in a new maritime paradigm. As diplomatic talks continue between the DOD and California officials, the California Office of Planning and Research should consider updating the California Advisory Handbook for Community and Military Compatibility Planning to include maritime spatial planning guidance for developers and military officials.

- **Enable Federally Recognized Tribes to Qualify as Federal Agencies for the Purpose of Offshore Wind Research Lease Applications**. Current BOEM guidelines state that "research leases are reserved solely for states or federal agencies conducting renewable energy research activities on the [Outer Continental Shelf]." Many tribal governments within California have demonstrated leadership in renewable energy deployment and research. California stakeholders argue that tribes should qualify as federal agencies or rank alongside federal agencies and states, making them eligible to apply for and hold federal research leases. This change will allow tribes to play a leadership role in offshore wind R&D and benefit economically from offshore wind growth.

- **Consider Multiple Factors in the BOEM Leasing Process**. Competitive BOEM lease auctions may implement sealed bidding, ascending bidding, or a combination of both; all three auction formats look solely at monetary factors. In some instances, BOEM may deploy multiple-factor bidding to account for additional criteria such as public benefits. However, the lack of transparency on exactly how nonmonetary variables are identified and weighed in the BOEM leasing process raises concerns for California stakeholders who want to emphasize factors such as environmental consideration and community engagement. International variations may be useful for comparison, such as the Japanese bidding system, which assigns different weights for each variable based on key policy objectives.

International

Local developers in California all have European partners, which will ensure broad industry knowledge is leveraged across the state's earliest projects. However, these European partners may not bring the perspective of European regulators or economic development agencies, which may limit the technical feasibility and economic impact of U.S. projects. The California Offshore Wind Czar

can ensure that international best practices are garnered from strategic partnerships while seeking new opportunities for foreign direct investment and industry collaboration. To establish partnerships and promote California on an international stage, the Czar could:

- **Leverage existing agreements and seek additional avenues for information sharing**. Formal partnerships have been established between California and the Danish and Scottish governments. However, initial discussions with partners have been limited due to a lack of resources. More dedicated staff time at the CEC and/or Office of the Czar could result in quarterly roundtables that establish desired learning outcomes and next steps for participants. Additional partnerships with Pacific Rim nations leading on offshore wind such as Taiwan, China, and Japan could also be established.
- **Establish ties with cluster networks and promote foreign direct investment (FDI) opportunities**. The Offshore Wind Czar could establish formal ties with cluster networks such as the European Clusters for Offshore Wind Servicing (ECOWindS) and Wind Europe to learn about economic development strategies to grow an offshore wind cluster (*see case study*). The state can also promote targeted FDI programs to incentivize growth across sectors within the offshore wind value chain. FDI can help foster a thriving offshore wind cluster in California by promoting the role of anchor companies, which are well-connected organizations that can help attract their suppliers to the state.

Case Study: New York State's "Energy Czar"

In 2014, Governor Cuomo launched New York's statewide clean energy strategy, Reforming the Energy Vision (REV), which instituted a 50 percent renewable portfolio standard (RPS), a 40 percent reduction in greenhouse gas emissions, and an increase of 600 trillion British thermal units (Btus) of statewide energy efficiency. In 2018, Governor Cuomo issued solicitations for 2.4 GW of offshore wind by 2030, requiring project labor agreements to ensure living-wage jobs for workers in the offshore wind industry, and in 2019, the Governor proposed increasing the offshore wind target to 9 GW by 2035. Recognizing the need for an organized strategy to help facilitate these goals, Governor Cuomo appointed Richard Kauffman as the chair of energy and finance for New York. Known as the "energy czar," Mr. Kauffman is tasked with coordinating activities at the Department of Public Service, New York State Research and Development Authority (NYSERDA), New York Power Authority (NYPA), and Long Island Power Authority (LIPA). As New York's most senior energy official, Mr. Kauffman is responsible for developing and advancing the Governor's plan to transform the state's entire energy portfolio, from R&D to market development. Under Mr. Kauffman's tenure, New York launched a $5 billion clean energy fund that is expected to support over $39 billion in customer bill savings by 2026.

Case Study: Offshore Wind Analyst at WindEurope

WindEurope is an active wind energy industry association that represents over 450 members in over 40 countries, including major supply chain companies, research institutions, electricity providers, and financial services firms. In 2018, WindEurope hired an offshore wind analyst, whose duties include establishing an offshore wind advocacy network across Europe, coordinating task forces and workshops on fixed-bottom and floating offshore wind, developing policy recommendations, advising association members on development operations, and conducting outreach to stakeholders. Priority was given to candidates with experience in the energy sector, and desired skills included experience in organizing multi-stakeholder groups and a master's degree in engineering, science, environment, or energy. Other desired skills included knowledge of current offshore wind operations in Europe, understanding of European Union legislative procedures, and ability to network with high-level parties. As the California market develops, positions like these will facilitate industry growth.

Policy 2: Set a Market Acceleration Target and Establish a Comprehensive Approach to Offshore Wind Studies

Offshore wind in California is an achievable yet complex puzzle. To ensure that offshore wind develops in a way that respects our treasured marine ecosystem and maximizes benefits to the economy, we must go beyond the reactive, piecemeal studies required by the federal leasing process. Given that the state does not have a stance on offshore wind, entities like OPC, CEC, and other state representatives have limited time and resources dedicated to offshore wind. The state also lacks an informed perspective on current research and what research is necessary to advance the sector. For instance, the outputs from one study are sometimes needed as an input for the next, as in the case of detailed wind resource assessments translating into power production curves. In other instances, resources may not be fully leveraged, as in the case of the California Offshore Wind Energy Gateway. Moreover, we may not be asking the essential questions needed for equitable development (e.g., How will economic benefits from this new industry reach communities in need?).

California should consider establishing a vision for offshore wind and, through the Office of the Czar (or other appropriate entities), overseeing related studies to track what environmental and sociological research is in the queue from the various state, federal, and philanthropic funding streams. Oversight of studies must not stifle academic or industry competition, but instead promote goals including (1) leveraging state, federal, foundation, and private-sector funding for studies; (2) creating efficiency in the rollout of research; (3) improving current resources to ensure siting decisions are well-informed; (4) addressing industry growth in a holistic, environmentally-responsible, and forward-looking manner; and (5) incorporating new technologies throughout the planning and development cycle.

The Office of the Offshore Wind Czar could prioritize preliminary studies that consider the following topics:

Market Acceleration Target. *Should California set a market acceleration target of 4 GW, as states in the Northeast have done to stimulate the market?*

- California has traditionally taken a technology-neutral approach to developing the state's energy resource portfolio. Yet with energy storage—a similarly emerging technology that also provides numerous grid benefits—the state established a procurement target that mandates investor-owned utilities (IOUs) to procure energy storage. As with the energy storage procurement target, a market acceleration target for offshore wind could seek to achieve similar goals: procuring viable and cost-effective technology, driving the market without negatively impacting ratepayers, and reducing transmission congestion. Not only did the mandate spur investment in storage, IOUs exceeded the mandate and the costs of storage continue to fall precipitously. California should consider setting an ambitious offshore wind target that competes with the procurement goals established by numerous East Coast states, sending a market signal and enabling the state to plan in a proactive, holistic, and values-driven manner.

Early Development. *How should the first projects be developed and studied in the state?*

- Some stakeholders prefer developing larger projects to decrease costs and mitigate climate change. Other stakeholders advocate for the development of smaller projects at the onset of the industry to study impacts on marine ecosystems. California policymakers should work with the offshore wind sector and stakeholders to develop a shared set of development criteria and assess various scenarios for early-stage development. Guidance from state leadership will be necessary to find the balance between ensuring economical projects that attract interest from private developers and minimize cost to ratepayers while alleviating the concerns of impacted stakeholders.

Value of Offshore Wind. *How do we measure and communicate the full value of offshore wind to a zero-carbon electric system?*

- Offshore wind is a unique resource that provides numerous potential benefits to the grid. Relative to land-based wind, coastal winds blow more consistently, and output from offshore wind farms would increase in the late afternoon when solar resources come offline. Better offshore wind resources combined with larger and highly

efficient turbines mean a capacity factor that is greater than that of onshore wind, is almost twice as high as that of solar, and even exceeds that of coal plants. Offshore wind can also alleviate transmission constraints, which can often happen in populated coastal regions. Currently, the market does not compensate developers for grid reliability traits such as voltage support, frequency response, and flexible capacity. State agencies could study how renewable resources, including offshore wind, are monetized in the market as it relates to grid system value and develop a new way of representing the full value of offshore wind in a zero-carbon electric system.

Impact to Coastal Ecosystems. *Will floating offshore wind development threaten coastal and marine ecosystems?*

- California is home to one of the richest and most biodiverse marine ecosystems in the world, with treasured and endangered species such as blue whales, short-tailed albatrosses, and leatherback sea turtles that migrate and feed in California's waters. Although the California Offshore Wind Energy Gateway has hundreds of data sets, there is still not a comprehensive spatial analysis for environmental sensitivity, which would inform appropriate offshore wind development locations. California should also ensure up-to-date baseline data on the presence of key species including bottom-dwelling fish, marine mammals, and migratory seabirds. Using more comprehensive analyses and up-to-date data sets, developers can adjust installation cycles and protocols, as well as innovate to incorporate underwater drones, remote and automated sensing, and artificial intelligence to survey marine life. Rather than wait until the Site Assessment Plan stage of the BOEM leasing process, the state could initiate geophysical and geotechnical assessments, sediment substrate analysis for anchoring and mooring, and population assessments of marine mammals, seabirds, fish, and sea turtles as well as benthic assessment to identify appropriate areas for development before sites are put up for lease.

Role of Community Choice Aggregators (CCAs) and Corporate/Municipal Power Purchase Agreements (PPAs). *Can the offshore wind industry rely on early-stage procurement from CCAs or contracting directly with municipal utilities and large energy users?*

- Offshore wind is not yet considered a supply-side resource in California's integrated resource planning (IRP) process. As the state advances studies to qualify this resource to be procured by IOUs, other means of procurement could be explored. CCAs have demonstrated that communities have a willingness to pay for locally produced renewable energy and could be a means to procure offshore wind at early stages of development, but more analysis should be performed to assess this opportunity. Given CCAs are not regulated in the same manner as IOUs (e.g., rates are not decoupled), could they establish

strategic partnerships to invest in offshore wind related infrastructure such as ports? Could CCAs employ novel mechanisms to invest in projects, as has been proposed as "Community Empowerment" in Massachusetts? Could CCAs even partner with each other to share the costs and benefits of offshore wind? How will the inability to recover costs from departing customers and concerns regarding creditworthiness be considered?

In September 2018, the Redwood Coast Energy Authority (a CCA) submitted a federal lease application with partners Principal Power Inc., EDPR Offshore North America, and Aker Solutions for a 100-150 MW offshore wind project off the Humboldt County coast.

- PPAs with large corporate offtakers have been a means of procuring onshore wind for municipal utilities and large energy users and could be similarly used for offshore wind. In 2017, Google, Facebook, Apple, and Bay Area Rapid Transit procured nearly 1 GW of wind power through virtual and physical PPAs, direct ownership, and Renewable Energy Certificate (REC) purchases. New PPA variations, like Microsoft's volume firming agreement that smooths variable price fluctuations via a third-party insurer, should also be considered in the context of offshore wind development through private-sector offtake.
- Municipal utilities have also procured large quantities of onshore wind. For instance, the Los Angeles Department of Water and Power has acquired almost 1 GW of wind power. California municipal utilities with annual load forecasts under 700 GWh are not required to submit IRP plans to the CEC. Assessments and surveys of large energy users and municipal utilities with willingness to pay for offshore wind could spur industry growth.

Streamlined Permitting Processes. *Can we create a permitting toolkit that will remove red tape in the permitting process while still protecting our natural treasures?*

- Offshore wind siting and permitting is a complex process involving local, state, and federal layers. Eliminating uncertainty in permitting timelines can increase investor confidence and increase efficiency for stakeholders. As California develops offshore wind, how can state policymakers find ways to reduce regulatory burdens and remove duplicate processes while still protecting our natural resources and addressing public concerns? Many countries and U.S. states have adopted "one stop" permitting systems, selecting one agency to coordinate with all other affiliated state and local agencies and have ultimate authority over the project.

Transmission. *Can California engage the private sector to invest in offshore wind transmission, and can we consider innovative ways to support the grid in regions where transmission infrastructure is needed?*

- Grid interconnection is a critical component to industry success. In the central coast, interconnection will be less costly due to plants such as Diablo Canyon coming offline. However, in Humboldt County, transmission capacity is limited and potentially costly upgrades will be needed. In addition to understanding the costs and benefits of required transmission investments, state policymakers should consider broader and longer term approaches to offshore wind transmission that align with CAISO and CPUC long-term planning processes.

Proposed Offshore Wind Transmission Networks:
In 2018, private developer Anbaric proposed offshore transmission highways along the east coast. In 2010, Google announced plans to invest $5 billion in a 6 GW, 350-mile offshore wind transmission system that would act as a backbone for developers, analogous to Texas' Competitive Renewable Energy Zone (CREZ) transmission upgrades to support land-based wind investment.

- Energy storage is increasingly used in tandem with offshore wind to support grid integration. In Massachusetts, developers Eversource and Ørsted are partnering with NEC Energy Solutions to connect 55 MW of storage on the 800 MW Bay State Wind project. The Hywind floating offshore wind farm in Scotland will pilot a 1 MWh lithium-ion battery system called Batwind. Energy storage is an enabling asset for grid reliability, and California IOUs are required to procure 1.3 GW of storage by 2020. As California policymakers consider integrating offshore wind into the grid, experts

should consider how energy storage could play a role in the emerging offshore wind market and increase the potential for variations in project financing.

Innovations in Offshore Wind Finance. *Are there novel approaches to financing offshore wind projects and reducing project risk?*

- Third-party solar leasing, property assessed clean energy (PACE) financing, energy-as-a-service models, and renewable asset-backed securities are just some of the innovations in renewable financing over the past decade. Offshore wind in Europe is typically debt-financed, while U.S. land-based wind financing is based on sponsor and tax equity as well as debt capital. The phaseout and cessation of the federal tax incentive for wind projects have already reduced the tax equity investment mechanism that has been central to the success of land-based wind projects for the past decade. In addition to the variations between U.S. and European capital markets, offshore wind is hard to finance due to longer lead times and perceived project risk. As a laboratory for democracy where local ideas have spawned widely-adopted programs (e.g., PACE), California should consider innovative approaches to offshore wind finance that increase investor confidence, decrease risk, lower the cost of capital, and leverage local assets to spur the offshore wind industry. Research could assess innovative capital structures and ways that the state could reduce costs and risk (e.g., low cost interconnection guarantees for developers, streamlined permitting, standardization, insurance, compliance, etc.).

Economic Development. *How can California leverage private and public capital to support offshore wind economic development?*

- Offshore wind could bring much-needed economic benefits to local communities across California, including some areas of Humboldt County where poverty rates have reached nearly 36 percent. However, in order for economic benefits to reach those in need, investments in critical infrastructure (e.g., ports and roads) will be required. Policymakers should consider novel ways to maximize public dollars and encourage private investment. Local funding mechanisms, such as tax abatement deals with developers or tax increment financing, could be explored as means to support port upgrades. Additionally, policymakers could support investments in Opportunity Zones, such as regions of Humboldt County and San Luis Obispo County, and other low-income areas primed for private investment driven economic development.
- California can investigate ways to strengthen the value chain, such as a revolving loan fund for offshore wind manufacturing facility upgrades, an anchor company tax credit to encourage recruitment and co-location of firms, or a grant program to help small businesses enter the offshore wind market.
- As the offshore wind industry evolves, California could also consider novel and emerging investment schemes for economic development, such as the multi-asset renewal fund (MARF). A MARF is a hybrid alternative investment that strategically bundles asset classes comprising an industry cluster to attract investment, leverage public-sector funds, and distribute impacts across an industry.

Policy 3: Establish a Phased Approach to Offshore Wind Workforce Development

California is in the early stages of the offshore wind planning process, but the in-state offshore wind industry could support more than 17,500 jobs by 2045. With approximately 78 percent of European wind power companies reporting challenges in recruiting qualified staff, California has an opportunity to meet the needs of industry and workers. The state has the right infrastructure to make the offshore wind industry a reality: active labor unions, apprenticeships, training programs, technical high schools, and colleges and universities that rank some of the best in the nation. Policymakers, industry leaders, unions, and colleges should consider workforce development strategies that align with the phases of project development.

Early-to-Mid Workforce Considerations:

California could take short-term action to assess workforce development goals, identify workforce gaps, and educate higher-skill professionals necessary for early planning processes.

- **Continue Workforce Analysis.** Current studies are underway to provide more detailed assessments about potential job gains and opportunities to employ marginalized communities through the offshore wind industry. Such work could be built upon to identify detailed workforce gaps, as New York State has done in preparation for the industry. These studies can be utilized to inform stakeholder convenings and help establish workforce planning

Phases of Offshore Wind Development

Developing and operationalizing an offshore wind farm will require a diverse technical workforce that spans across 74 occupations.

Development & Project Management

In the early stages of development, the offshore wind industry may rely on scientists, engineers, lawyers, and government representatives to conduct the following activities:

- Identify potential offshore wind sites;
- Conduct environmental assessment;
- Establish project feasibility; and
- Authorize siting and permitting.

Manufacturing & Construction

During this phase, the design and construction of wind turbine components may require representatives from the following professions:

- Engineers (e.g., electrical, mechanical, environmental, research, subsea structure design)
- Welders, Cutters, Solderers & Brazers
- Plant Managers
- Sales Representatives
- Lawyers
- Administrative Professionals
- Marketing & Communications Professionals

Installation & Commissioning

In this phase, wind turbine components are transported to pre-selected offshore sites, assembled, and connected to the electrical grid. This stage could require the following professions:

- Electricians
- Carpenters
- Ironworkers
- Industrial Project Managers
- Vessel Crews
- Crane Operators
- Subsea Trenching & Cable Installation Contractors
- Health & Safety Specialists

Operations & Maintenance

By the fourth stage of development, turbines must be regularly inspected and repaired, and environmental impact data must be collected. This stage is likely to involve the following professions:

- Vessel Crews
- Engineers
- Logisticians
- Crane Operators
- Environmental Scientists & Specialists

goals, which could include engaging underserved communities, retraining workers, balancing supply of labor with demand for workers, and ensuring job quality.

- **Facilitate Stakeholder Roundtables**. To ensure that state workforce goals address community concerns, California could convene its labor unions, workforce development boards, state agencies, universities, industry, and environmental justice organizations to discuss opportunities and the future of offshore wind development. The purpose of these working groups would be to identify opportunities and barriers, share best practice strategies, and anticipate the needs of workers and employers during various deployment timelines.

- **Educate High-Skilled Workers**. Early stages of development rely on high-skilled professionals in law, marine science, engineering, and economics. But many professionals are unfamiliar with the unique considerations of offshore wind. California institutions could consider creating a series of seminars for professionals interested in offshore wind, much like the 2018 Offshore Wind Skills Academy at the University of Delaware. The academy was created in partnership with the Danish Energy and Climate Academy (ECA), with classes taught by three instructors with over fifty-five staff years of wind experience, and is targeted to professionals from traditional energy sectors, manufacturing companies, regulators, and consultants. Recruiting women and people of color during early-stage trainings like this will ensure thought leaders in California's offshore wind industry reflect the state's diverse population.

Mid-to-Late Workforce Considerations:

As the California offshore wind industry moves into construction, installation, and operations and maintenance, the need for technical skills will increase. Unionized workers will make up a large portion of the workforce, with activity centered around the ports.

- **Build a Diverse and Inclusive Workforce**. In California, average hourly wages for Black and Latino workers range between $7-12 lower than hourly wages for white and Asian workers. As the state grows its offshore wind industry, policymakers could help reverse this trend by leveraging workforce development strategies that encourage equitable distribution of the industry's economic benefits. Workforce grants could require outreach to and recruitment of communities facing employment barriers, as modeled by Maryland's Offshore Wind Workforce Development Grant Program. With $800,000 allocated for training centers in 2019, the program requires eligible centers to provide training needed for mid-term development, such as welding, metal fabrication, and electrical work. Discrimination against non-English speakers can be avoided by including multiple languages in apprenticeship programs and other mid-to-late workforce training programs.

Veterans and Offshore Wind. The wind industry offers employment to veterans and servicemembers at a rate that is 72 percent higher than the national average. Nearly two million veterans reside in California.

- **Establish a Partnership for Workforce Development**. The California Workforce Development Board could partner with universities, community and technical colleges, and offshore wind industry leaders to finance, design, and develop training programs. Since numerous European offshore wind firms have expressed a desire to expand operations into California and have a vested interest in supporting the development of a trained and ready workforce, California could leverage these relationships to fund workforce development activities. These efforts could be modeled after Vineyard Wind's commitment to actively seek local talent to fill job openings in Massachusetts and invest in curriculum development and offshore wind training and mentoring programs to position the state as an offshore wind leader. Training programs will be developed in partnership with community colleges, vocational schools, manufacturers, labor unions, and other organizations such as the Fishing Partnership Support Services.

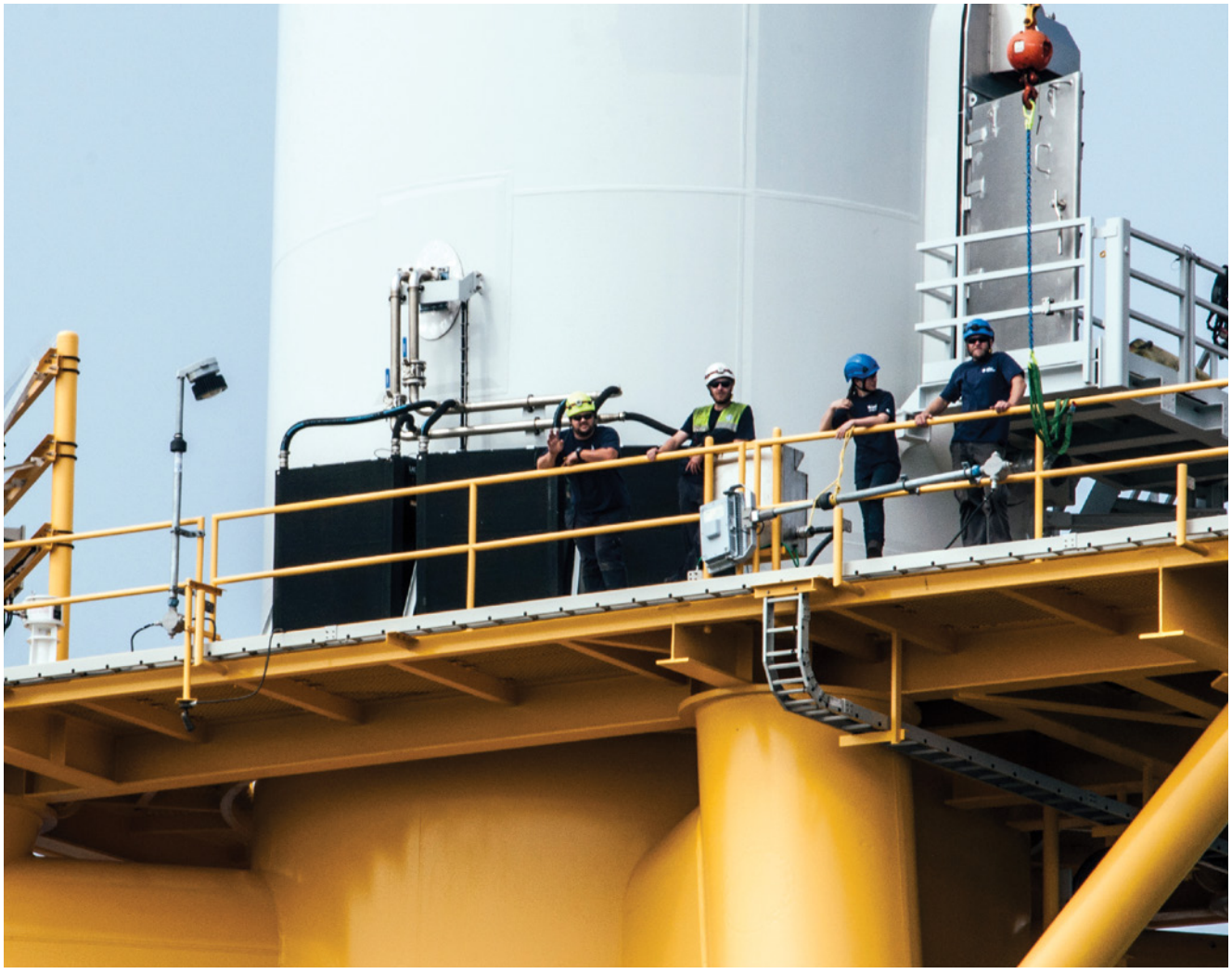
- **Invest in Offshore Wind Safety Training**. As offshore wind turbines become larger and installation processes become more complex, working offshore in a marine environment can also become increasingly challenging and hazardous.

Offshore weather conditions can be harsh and change quickly, which could increase risks to workers throughout the phases of offshore wind development. To meet the specific safety and training needs of the offshore wind industry (*see call-out box*), California could build a West Coast training facility that offers hands-on instruction in realistic settings. With the support of public and private investment, the training could cover key safety areas identified by the Global Wind Organization (GWO) such as first aid, fire awareness, working at heights, and sea survival. California could model this center after BEI Maritime, which will be the first offshore wind safety training facility in Virginia. The facility will feature a large-scale indoor pool and equipment to simulate moving from a boat to a tower, escaping from an overturned supply vessel, conducting rescues, and transferring tools.

Outside the main facility, trainees will learn firefighting skills and how to evacuate from a submerged helicopter.

Offshore Wind Safety Skills

- Advanced Rescue
- Fire Safety
- First Aid
- Marine Safety Training
- Meteorology
- Health & Safety Laws
- Sea Survival
- U.S. Coast Guard Protocols



Policy 4: Align Innovation and Access to Capital Policies with Industry Needs

California's nascent offshore wind industry will grow and evolve over the coming decades, and will undoubtedly be influenced by our strong culture of innovation and unmatched access to capital. The state government, either through the Office of the Offshore Wind Czar, CEC, or OPC, could encourage the development of new technologies that protect marine ecosystems and decrease costs, among other objectives. Encouraging the cross-pollination of ideas from different fields, leveraging local universities and national labs, continuing industry and environmental needs assessments, facilitating access to capital for local innovators, and establishing public-private test beds should be considered as the industry evolves.

Opportunity for Innovation in Offshore Wind: California's offshore wind industry has unique needs such as deep water depths and diverse marine ecosystems. These characteristics can provide market value for emerging technologies such as underwater remote-sensing technologies for cable inspections, turbine inspection drones, artificial intelligence systems to map marine ecosystems, and immersive technical and safety training through virtual reality.

National Offshore Wind Research and Development Consortium: In June 2018, the U.S. Department of Energy granted the New York Energy Research and Development Authority an $18.5 million grant to lead the National Offshore Wind Research and Development Consortium. The Consortium's goal is to reduce cost and risk while maximizing the economic benefits of offshore wind. Its independent board of directors is comprised of developers, lab/utility representatives, and research advisory groups, and its approach is guided by a national research strategy, project solicitations, and stakeholder engagement. In November 2018, the Consortium released its technical challenge areas (a precursor to solicitations) related to offshore wind plant technology advancement. Notably, mooring of floating structures is one of the first topics outlined by the Consortium. California has joined the Consortium, signifying an opportunity to leverage federal research dollars and partnerships to solve shared challenges.

Early-Term Development: Starting from when the first leases are issued until the construction of the first projects, offshore wind innovation goals include assessing industry and environmental needs, communicating market opportunity to cleantech investors, and engaging the interest of academics and entrepreneurs.

- **Conduct Industry and Environmental Technology Needs Assessment**. The CEC, OPC, advocates, and industry players have begun to identify challenges or opportunities for the offshore wind industry that may have technological solutions. Hosting a formal roundtable with an expanded group of local, state, federal, and international stakeholders to conduct a technology needs assessment can inform early stages of innovation by providing market signals to entrepreneurs and investors.
- **Co-Sponsor a Hackathon and Pitch Competition**. Governments, businesses, and institutions have used hackathons and competitions to creatively engage citizens to create new products, solve problems in a variety of fields, and stimulate the economy. For example, the UC San Diego Entrepreneur Challenge offers a $100,000 prize to encourage innovation in the biomedical field. In DOE's annual Cleantech UP Collegiate Competition, student teams compete for prize money while receiving business development and commercialization training from major research universities. In 2014, Maryland led its first civic hackathon, DataBay Reclaim the Bay Innovation Challenge, where eighty participants competed to develop and pitch innovative, data-driven solutions to solve Chesapeake Bay's pollution problem. California state officials can partner with universities, national labs, and industry to design, fund, and co-host a hackathon or pitch competition, which can be informed by the technology needs assessment. Large, multinational firms involved in the offshore wind industry or local cleantech investors may have a willingness to invest in such a competition.

Mid-Term Development: At this point, developers have secured a lease or potentially a power purchase agreement, and a pipeline of projects are in the queue. More investors seek opportunities in the California market and would be likely to provide in-kind support for joint industry projects.

- **Initiate Joint Industry Projects**. Given the unique nature of the offshore wind industry on the West Coast, a coordinated research body that advances R&D would be extremely valuable. Joint industry projects such the Floating Wind JIP Collaborative established in 2016 between partners such as Shell, Ørsted, EnBW, E.ON, Iberdrola, and Carbon Trust is a model that leverages private-sector resources to solve common industry challenges. A Joint Industry Project led by DNV GL similarly aims to establish a cost structure for the development process and standardize floating turbine certification processes. A joint industry project could be established in California to solve West Coast-specific industry challenges, potentially receiving state and/or federal funding.

- **Establish an Offshore Wind Accelerator for Local Entrepreneurs**. California has more startups and significantly greater levels of capital invested than other states. In 2016, accelerators invested over $47 million in California's 863 startup ventures compared to $17 million invested in New York. During mid-term development, international investor confidence in California's offshore wind market will increase, and academics and innovators will have greater understanding of industry needs. Through partnerships with universities, national labs, industry, and investors, California can establish an accelerator for offshore wind-related technologies that provide critical, industry-specific resources to startups. At the onset of the offshore wind accelerator, California could provide small grants through the CEC or through a general fund.

- **Consider State-Leveraged Mechanisms to Increase Access to Capital for Growing Businesses**. During mid-term development, there will be an increased willingness to invest in the California offshore wind market by global firms. However, at this stage, local investors may be less familiar with the technology and its market potential, and offshore wind entrepreneurs will be faced with significant capital barriers. As California considers access to capital for emerging businesses, various capital needs should be taken into account. Some firms require dilutive and non-dilutive funding to commercialize a new technology, while other small and medium-sized businesses are retooling operations for offshore wind and need assistance to overcome barriers to market entry. California policymakers could consider short-term mechanisms to encourage investment in new, homegrown offshore wind technologies, such as a temporary exemption to the capital gains tax, an offshore wind fund of funds, technology-specific R&D tax credits, or a combination of loans and grants. Patient working capital loans could be provided to small businesses at low interest rates to help fund capital investments or workforce training. Grants could be awarded to businesses for bidding costs, administrative expenses, or facility upgrades, as the Maryland Offshore Wind Business Development Grant has done.

Late-Term Development: At this stage, projects are installed in California waters, and additional installations are planned. The pipeline of projects spurs development of local manufacturing facilities, initiating another wave of R&D focused on offshore wind manufacturing. California has established itself as a global hub for offshore wind R&D and entrepreneurship analogous to Silicon Valley. The size of offshore wind turbines continues to grow, stimulating the need for larger test beds in the United States.

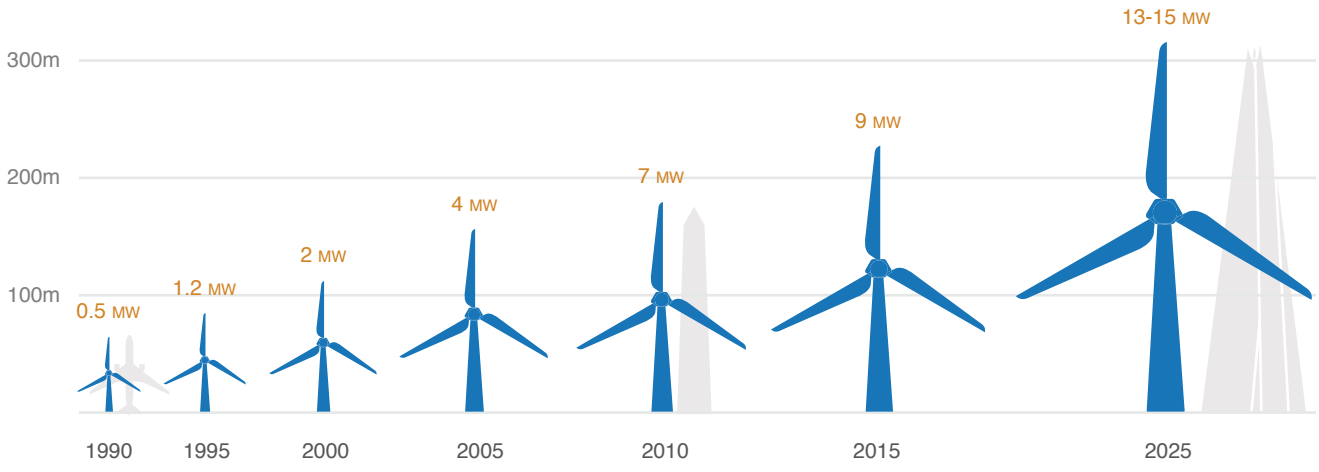
- **Provide Innovation Vouchers to Local Manufacturers**. As the offshore wind industry becomes established and there is a clear pipeline of projects, local offshore wind manufacturing will bloom, subsequently decreasing costly reliance on Asian imports. An increased need for innovation in manufacturing will emerge, particularly for smaller Tier 2, 3, and 4 suppliers that seek to incorporate new materials and processes in manufacturing operations. California policymakers could consider supplying smaller manufacturers with innovation vouchers, which would allow manufacturers to "purchase" services from national labs to help develop new materials or manufacturing processes. Modeled off of state funded programs in New Mexico and Tennessee, the innovation vouchers could enable smaller

suppliers to connect with academics, tap into R&D centers around the country (e.g., Clemson and New York), or connect with global research efforts.

- **Create a Multidisciplinary Academic Research Program**. Offshore wind requires systems thinking and multidisciplinary collaboration, but private entities are typically unwilling to fund longer-term, complex, and multidisciplinary research efforts. Therefore, academics and thought leaders from policy, economics, social sciences, civil and electrical engineering, geophysics, biology, and data science (to name a few) will need sustained support to bolster the state's vision for development. State, federal, and private research investments could be pooled at an academic institution committed to a transdisciplinary approach to developing the offshore wind industry. Arizona State University's School of Sustainability is a model for transdisciplinary research and education; the model has been replicated at University of Michigan and could provide guidance to establish a transdisciplinary offshore wind institute in California.

- **Propose Additional Test Beds**. Turbines will continue to grow in size and the state's grid system will evolve. Facilities designed to test large-scale systems, such as Clemson's 15 MW test rig, will become inadequate for next-generation generator testing. As national test bed needs evolve, California could propose establishing facilities to test the reliability of large generators and their impact on grid integration. Additionally, ocean test beds for in situ monitoring of foundations, substructures, and underwater ecosystems will be valuable during later-phase development. Test beds would likely be sponsored by the federal government and require private and state investments.

Evolution of Wind Turbine Heights and Output



As the size of wind turbines continues to grow, so will the need for R&D.

Source: Various, Bloomberg New Energy Finance

Policy 5: Upgrade Ports and Establish Port Innovation Districts

If California seeks to achieve large-scale development of offshore wind, the state must make investments in its port and harbor facilities to support the assembly, staging, fabrication, and construction of turbine components. Globally, ports are the nucleus of offshore wind development and play a unique role in the cost reduction and efficiency of offshore wind projects. In this fast-growing industry, ports are required to facilitate ever-larger turbine components, bigger vessels, and an increased number of activities that span the entire life-cycle of an offshore wind project, from assembly and operations and maintenance (O&M) to decommissioning. Wind turbine capacity will increase beyond 10 MW and rotor diameters will reach sizes over 650 feet by the early 2020s; therefore offshore wind ports will need to have adequate capacity to support the handling of these components. Because they are increasingly becoming sites for industry resources such as manufacturing warehouses, testing facilities, and training centers, ports are a natural focal point for offshore wind knowledge, labor, and capital.

California's ports are the largest on the West Coast and provide the state a competitive advantage due to assets such as access to deep water and available space for new facilities. However, continued port planning and upgrades will be required to support the evolving needs of the offshore wind industry. As offshore wind technology becomes more advanced and turbine components become larger, California will need to address logistical challenges through a multi-pronged, years-long effort that targets several components of port operations including material handling capacity, innovation, safety training, and workforce development. This effort will require port officials and state and local leaders to work together to identify port needs and assess possible funding mechanisms. It will also demand regular underwater excavation service from the U.S. Army Corp of Engineers to maintain the federal navigation channel and improve navigation channel depths, a process known as dredging. Many ports will require navigational aids such as physical and electronic buoys and regular surveys of navigation routes to ensure safe passage. Investing funds to increase load-bearing capacity and provide other site improvements at port and harbor facilities could have a ripple effect across other sectors, leading to economic revitalization in communities along California's coast. In fact, upgrades to a single U.S. port for offshore wind readiness could generate 6,000 full-time equivalent jobs and add $449 million to the state's gross domestic product. Such investments are needed to modernize port districts, attract other innovative industries, and allow ports to be competitive in the twenty-first century economy.

Steps to Mobilize Offshore Wind Readiness at California's Ports

1. Conduct holistic assessment of regional port infrastructure and capabilities, initiate outreach to relevant stakeholders, and monitor progress at other U.S. offshore wind ports
2. Engage with industry leaders to ensure that the timeline for port upgrades aligns with opportunities for offshore wind development
3. Secure public and private investment to complete port upgrades
4. Establish manufacturing network and ramp up offshore wind activity at ports

Upgrade Ports to Mobilize Offshore Wind Activity

BOEM has received two unsolicited lease requests from the Redwood Coast Energy Authority (RCEA) and Castle Wind for sites off the coast of Humboldt County and San Luis Obispo County, respectively. In these areas of high-potential development, ports are the focal point of activity and will require funds for capacity upgrades. The Port of Humboldt Bay is the only deep water port north of San Francisco that can facilitate access to wind speeds above ten meters per second and has hundreds of acres of vacant industrial space to support dockside turbine assembly, making the Port a strategic advantage for California's offshore wind industry. Access has improved due to roadwork on Highway 299, but the Port will require quayside

upgrades and continued dredging to support the assembly and towing of offshore wind components. Although the Port of Morro Bay has limited capacity to support the staging and transportation of heavy turbine components, the Port is similarly well located to facilitate offshore wind development on the central coast of California. In addition to capacity upgrades, enabling firms in the value chain to co-locate in close proximity to these ports can streamline offshore wind activity and innovation, as seen in the impact of recent investments at the Port of Taichung (*see case study*).

Establish Port Innovation Districts

Not only is proximity to the port a key consideration for business, but proximity to research and innovation is a key factor in where offshore wind firms locate. Innovation districts are geographic areas where anchor institutions and companies cluster, connecting with startups, incubators, and accelerators. Proximity between these entities has been shown to be a large driver in innovation, especially between networks of manufacturers, logistics firms, customers, and researchers—all key players in the offshore wind value chain. Innovation districts perform well when associated with unique infrastructure such as ports. Other factors that promote successful innovation districts include on-site university research programs, incubators that provide facilities and support for startups, anchor company facilities, common areas, and flexible office space. For example, the Schatz Energy Research Center is closely located to the Port of Humboldt Bay and could provide the area with a competitive advantage for offshore wind development. Examples of successful innovation districts include the newly established Rotterdam Smart Manufacturing Innovation District at the Port of Rotterdam (*see case study*).

Engage Local Communities in Port Revitalization Efforts

California is home to eleven major ports that are dotted along the state's diverse coastline. In addition to their role in creating jobs and transporting goods, ports could partner with communities to offer workforce development and maritime safety training programs, protect the environment, and coordinate long-term planning efforts in a way that maximizes benefits to the local economy. California's ports could ensure that community members have the first opportunity to find employment by offering access to training towers to simulate offshore wind conditions and training in skills such as maritime welding and safety and environmental response. These initiatives could be modeled after programs at the Port of New Bedford and the Waterfront Protection Pier at the Massachusetts Maritime Academy. California also has an opportunity to empower its local communities to have a voice in how offshore wind develops within their districts. The state could solicit information and ideas from developers and qualified locals alike to identify necessary port upgrades and appropriate financing mechanisms (*see New Jersey case study*).

Case Study: Growing an Industry Cluster at the Port of Taichung

By 2025, the Taiwanese government is projected to invest $260 million on port infrastructure upgrades that will support a 5.5 GW offshore wind procurement goal. In 2017, the Taiwan International Ports Corporation (TIPC) identified the Port of Taichung as the optimal port to facilitate offshore wind deployment in Taiwan and serve as the largest offshore wind port in Southeast Asia. TIPC has designated 247 acres of land surrounding the port for an industrial park for wind components, an investment of $92 million. This venture is aimed at attracting domestic and international offshore wind firms to expand their operations onto Taiwanese soil, and has successfully captured investment from COWI, a Danish engineering consulting firm. COWI is developing thirty-two jacket foundations that will enable installed turbines in Taiwan to withstand waves that are over sixty-five feet high. TIPC also has plans to develop offshore wind power maintenance and safety training courses to cultivate a pipeline of skilled, local workers who can staff firms that have co-located at the Port of Taichung. By enabling offshore wind companies to set up operations near the Port of Taichung, Taiwan has become the ideal hub for offshore wind development in the region.

Case Study: Establishing an Innovation District at the Port of Rotterdam

The Rotterdam Innovation District (RID) is a burgeoning entrepreneurial hub located at the Port of Rotterdam. RID was established by the port and city of Rotterdam in 2015 as a response to a Dutch policy assessment that identified the need for more spending on innovation. Industrial buildings of former shipyards and abandoned waterfronts were redeveloped to form RID. RID includes an experimental living and working space for innovators in cleantech and medical clusters, a startup accelerator, prototyping facilities, and an investment fund for port-related innovations. Universities and research centers such as Albeda College, Rotterdam University of Applied Sciences, Delft University of Technology, and Yes!Delft have co-located at RID. If mid-sized manufacturers want to locate at RID, they must engage with researchers and students and use the space actively for production.

Case Study: Empowering Local Communities in New Jersey

In 2018, the New Jersey Economic Development Authority (NJEDA) issued a Request for Ideas (RFI) to solicit information on implementing infrastructure upgrades and supply chain programs to support offshore wind development at port facilities. The purpose of the RFI was to collect ideas from offshore wind developers, industrial real estate developers, port operators, port authorities, other development agencies, and local governments that could provide insight on specific port infrastructure requirements and financing and support needs across New Jersey. Notably, the RFI asked respondents to answer questions on the role that state agencies should play in port development, such as:

- What types of public-private partnerships or industry collaborations could be formed to support the development of port infrastructure?
- What best in-class approaches or tools should NJEDA or the state government establish?
- What forms of non-financial support could state agencies utilize to facilitate port upgrades (e.g., permitting support and stakeholder engagement)?
- What types of investments in port infrastructure could the state reasonably expect from private stakeholders (e.g., anchor tenancy at ports, support on port design and development, direct investment into port infrastructure)?
- What complementary industries and port uses should be assessed with offshore wind to de-risk any investments?

The data collected from the RFI may be used to develop an offshore wind financing and development strategy for specific New Jersey ports, with a goal to lower the levelized cost of energy (LCOE) for offshore wind.

Call to Action

As California welcomes a new state administration, policymakers and stakeholders will need to think critically about paving the way for a resilient economic, environmental, and energy future. This will require bold leadership to guide the transition towards a stable energy system that creates opportunities for workers and businesses while preserving the state's cherished environmental values. Offshore wind represents an opportunity for California to achieve this future, potentially supporting more than 17,500 jobs in 2045 while helping the state be at the forefront of the fight against climate change.

The offshore wind industry is nascent in California; therefore, the state stands to benefit from a coordinated, stakeholder-driven development approach that begins with thorough data collection and environmental analyses. Offshore wind is unlike any industry we have seen as it necessitates collaboration between an unprecedented number of agencies and stakeholders at the federal, state, and local levels. The industry will also require funds to retool and revitalize ports, build new transmission lines, and support workforce development.

Despite the upfront challenges, the stakes of inaction are high. If California takes a back seat to offshore wind development, the state will lose the opportunity to guide and grow the industry with a values-driven framework and leverage offshore wind as a tool to balance the grid and maintain its climate leadership. If we do not create a vision for this new industry, we may repeat the mistakes of past development: threatened vital ecosystems and a workforce that does not reflect our population.

Growing the Offshore Wind Cluster, Growing Jobs

- Appoint a California Offshore Wind Czar
- Set a Market Acceleration Target and Establish a Comprehensive Approach to Offshore Wind Studies
- Establish a Phased Approach to Offshore Wind Workforce Development
- Align Innovation and Access to Capital Policies with Industry Needs
- Upgrade Ports and Establish Port Innovation Districts

In California, we recommend a cluster-based approach that fosters the building blocks of industry growth, such as workforce training and clear market signals. The recommendations in this report are complementary and intended to help California drive technological advances, explore innovating project financing models, equip workers with needed skills, and grow demand for offshore wind. They include short-term actions to jumpstart the industry (e.g., provide offshore wind seminars for energy professionals, study the value of offshore wind, and co-host an offshore wind technology pitch competition) as well as long-term actions for when the industry is underway (e.g., provide innovation vouchers for manufacturers). Because the timeline for offshore wind development is long, policymakers and stakeholders should consider appropriate time horizons for action.

California's leaders can draw from dozens of innovative strategies that city, county, and state governments across the country and abroad have implemented in order to create job opportunities in the advanced energy industry. Examples of these best practices and a fully cited version of this report can be found on the American Jobs Project website at http://americanjobsproject.us/. Furthermore, the American Jobs Project can continue to serve as a partner to California by organizing working groups and conducting deeper analyses, such as identifying value chain gaps, exploring policy strategies, and evaluating the state's comparative advantage in other advanced industries.

When a state succeeds in building an economic cluster, the benefits are felt throughout the state: a more resilient state economy, a skilled twenty-first century workforce that is trained for the jobs of tomorrow, a firm base of young people optimistic about job opportunities close to home, and a rich hub for innovation and collaboration.

Appendix A: Job Estimates and Economic Impact Methodology

The American Jobs Project believes the key to job creation lies in local action. Our job estimates are intended to start a conversation about how state and local leaders can work together to set goals and evaluate potential economic impacts.

The American Jobs Project and BVG Associates (BVGA) worked together to create realistic technology scenarios based on research and interviews with local partners. BVGA performed the economic analysis, employing a proprietary methodology that was created in partnership with Steve Westbrook from the University of the Highlands and Islands. This methodology is based on specific offshore wind industry and supply chain data and is informed by BVGA's extensive experience in this industry; therefore, it is more accurate than conventional economic impact methodologies.

We suggest that offshore wind can serve as a major vehicle for state economic growth, create quality jobs for Californians, and help the state achieve carbon-neutral power generation by 2045. If California can develop 18 GW of installed offshore wind capacity by 2045 and strengthen its supply chain to serve local projects, the state's offshore wind industry could support more than 17,500 California jobs in 2045.

Definitions

Job-Year: A full-time equivalent job or any combination of work that is equal to a full-time job over one year. For example, two people working half-time for a full year would equal one job-year.

Direct Jobs: Jobs created or sustained by project developers or their main contractors in the target state industry.

Indirect Jobs: Jobs created or sustained due to demand from developers or contractors for equipment, materials, and services for the target state industry.

Induced Jobs: Jobs created or sustained due to increased local spending by developers or contractors in the target state industry and their suppliers. For example, induced jobs could be created at a local sandwich shop due to increased spending by offshore wind workers.

Multiplier Effect: Refers to when the economic impact generated is larger than the initial investment due to cascading spending from the target state industry to its supplying industries and workforce to products and services in the local economy.

Modeling Approach

We model economic impacts across two offshore wind deployment scenarios derived by industry experts and based on existing projections. Each scenario is divided into three phases: Phase 1 spans from 2019 through 2025, Phase 2 spans from 2026 through 2035, and Phase 3 spans from 2036 through 2045. The first scenario (Status Quo Policy) assumes 5 GW of installed offshore wind capacity by 2045. This scenario reflects the possibility of major use conflicts with military testing, training, and operations centers along the central and southern California coast, which will require the construction of new transmission infrastructure on the northern coast. The second scenario (Strategic Growth Policy) assumes 18 GW of installed capacity by 2045. This second scenario is an update to the 2016 analysis by the National Renewable Energy Laboratory (NREL); it projects greater installed capacity on an accelerated timeline to account for increased activity in the regional offshore wind industry. In the last two years, multiple developers have expressed interest in the California market and floating offshore wind costs are now projected to be significantly lower than they were assumed to be in the NREL reports. Refer to

California Offshore Wind Development Scenarios: 2019 to 2045 on pages 27-28 for more assumptions and distinctions between Status Quo Policy and Strategic Growth Policy Scenarios.

Our analysis assumes the California market will initially focus on floating offshore wind demonstration projects and then see robust build-out of commercial-scale floating projects, with the potential for growth of airborne offshore wind (*see Appendix B*).

Evolution of Offshore Wind Technology in California

2019-2025	R&D and demonstration projects Floating demonstration projects integrated with storage
2026-2035	Commercial-scale floating projects Airborne demonstration projects
2036-2045	Commercial-scale floating projects Potential commercial-scale airborne projects

To calculate economic impacts, we first mapped which offshore wind components and services could be supplied by the California supply chain for each phase of each scenario. Potential supply chain activities spanned twenty categories from project development to decommissioning (*see sidebar*). The mapped supply chain impacts for each activity informed annual estimates of direct jobs (supported by project developers and their main contractors) and indirect jobs (supported by their supply chains) for each scenario. Indirect jobs were distinguished between 'specific' indirect jobs (those involved in delivering specialist components and services) and 'general' indirect jobs (those involved in providing the types of services that all companies use). The job estimates for each activity were based on data gathered from European offshore wind projects, which BVG Associates has analysed in detail. Induced job creation (from the recirculation of workers' salaries) was calculated by using multipliers derived from representative industries in California, based on the assumption that personal spending patterns are unlikely to vary between industrial sectors.

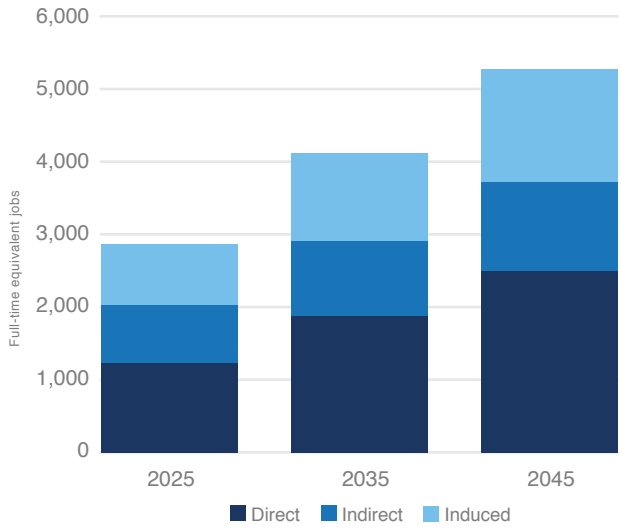
Job estimates are calculated as the average number of full-time equivalent jobs that the state can sustain in the last year of each phase of development. Additionally, job losses in industries that compete with those in our analysis are not evaluated. Models do not perfectly predict behavior, so job estimates could vary based on the reality of what projects actually progress, what is purchased locally, and foreign and domestic competition. The estimates presented in this report demonstrate that economic outcomes will be highly dependent on increased market certainty and sustained local action towards developing the offshore wind industry in California.

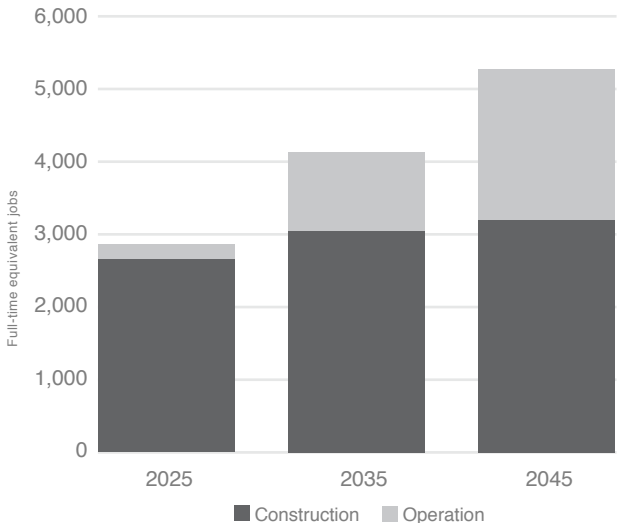
Supply Chain Activities

- **Project development and management**
- **Manufacturing**
  - Nacelle, hub, and assembly
  - Blades
  - Tower
  - Foundation supply
  - Array cable supply
  - Export cable supply
  - Onshore and offshore substation supply
  - Operational infrastructure
- **Installation**
  - Turbine installation
  - Foundation installation
  - Array cable installation
  - Export cable installation
  - Other installation
- **Operation, maintenance, and service**
  - Wind farm operation
  - Turbine maintenance and service
  - Foundation maintenance and service
  - Subsea cable maintenance and service
  - Substation maintenance and service
- **Decommissioning**

STATUS QUO POLICY SCENARIO: 5 GW IN 2045

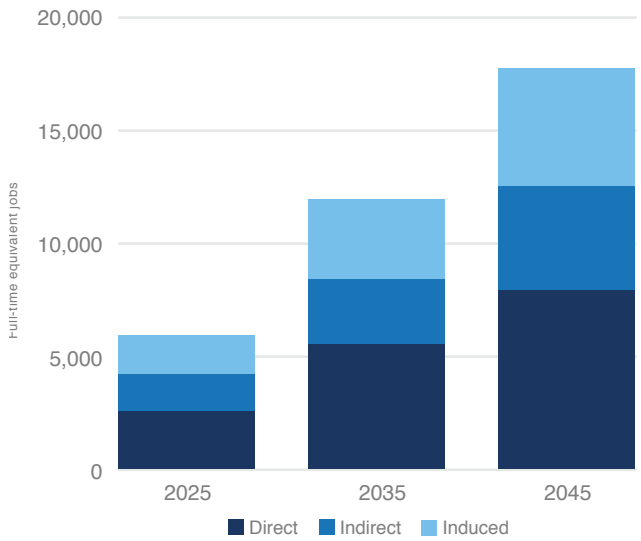
The Status Quo policy scenario reflects a reality with major use conflicts with military testing, training, and operations centers along the central and southern California coast. Therefore, local demand fails to reach levels that drive in-state manufacturing of turbine components. The majority of supply chain elements, with the exception of select elements such as substation platforms, are imported from Asia. This scenario has a greater percentage of construction jobs as compared to the Strategic Growth Policy Scenario.

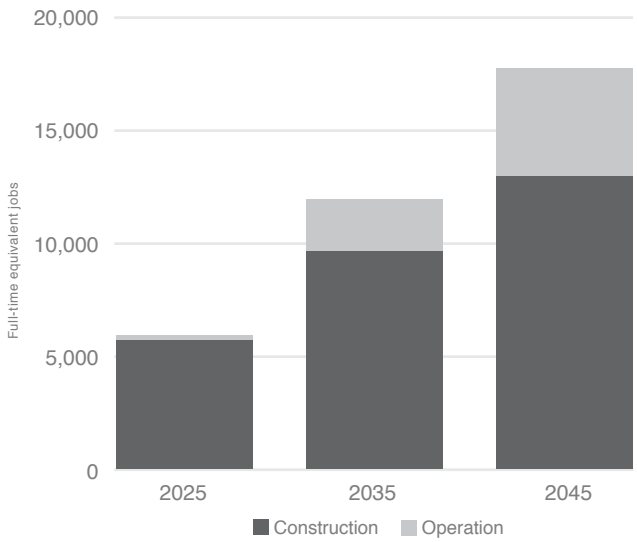




STRATEGIC GROWTH POLICY SCENARIO: 18 GW IN 2045

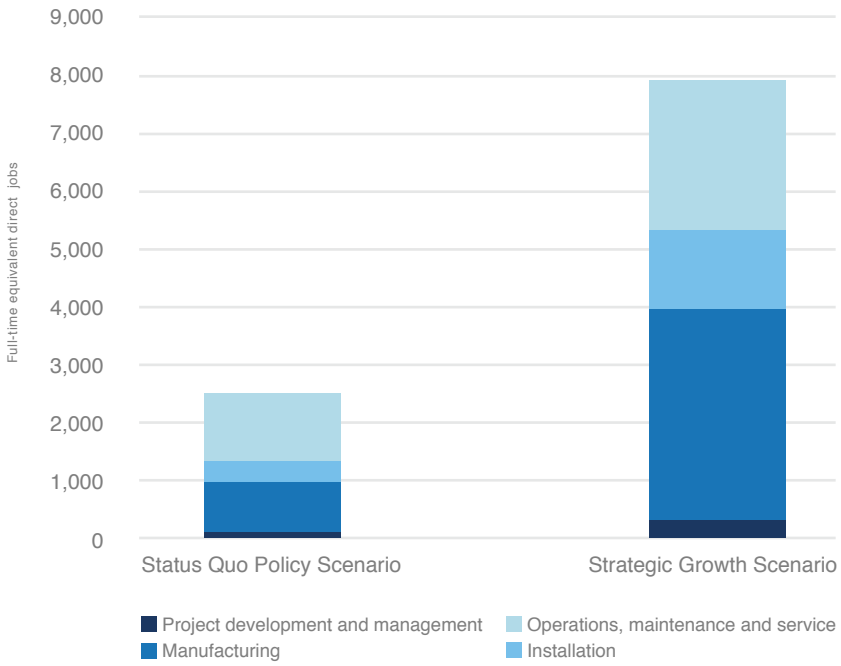
The increased market certainty in the Strategic Growth Policy Scenario results in a greater diversity and quantity of jobs. In Phases 2 and 3, there is enough offshore wind demand to justify local manufacturing of components such as blades, moorings, and anchors. This scenario projects a greater proportion of jobs in operations and maintenance than the Status Quo Policy Scenario.

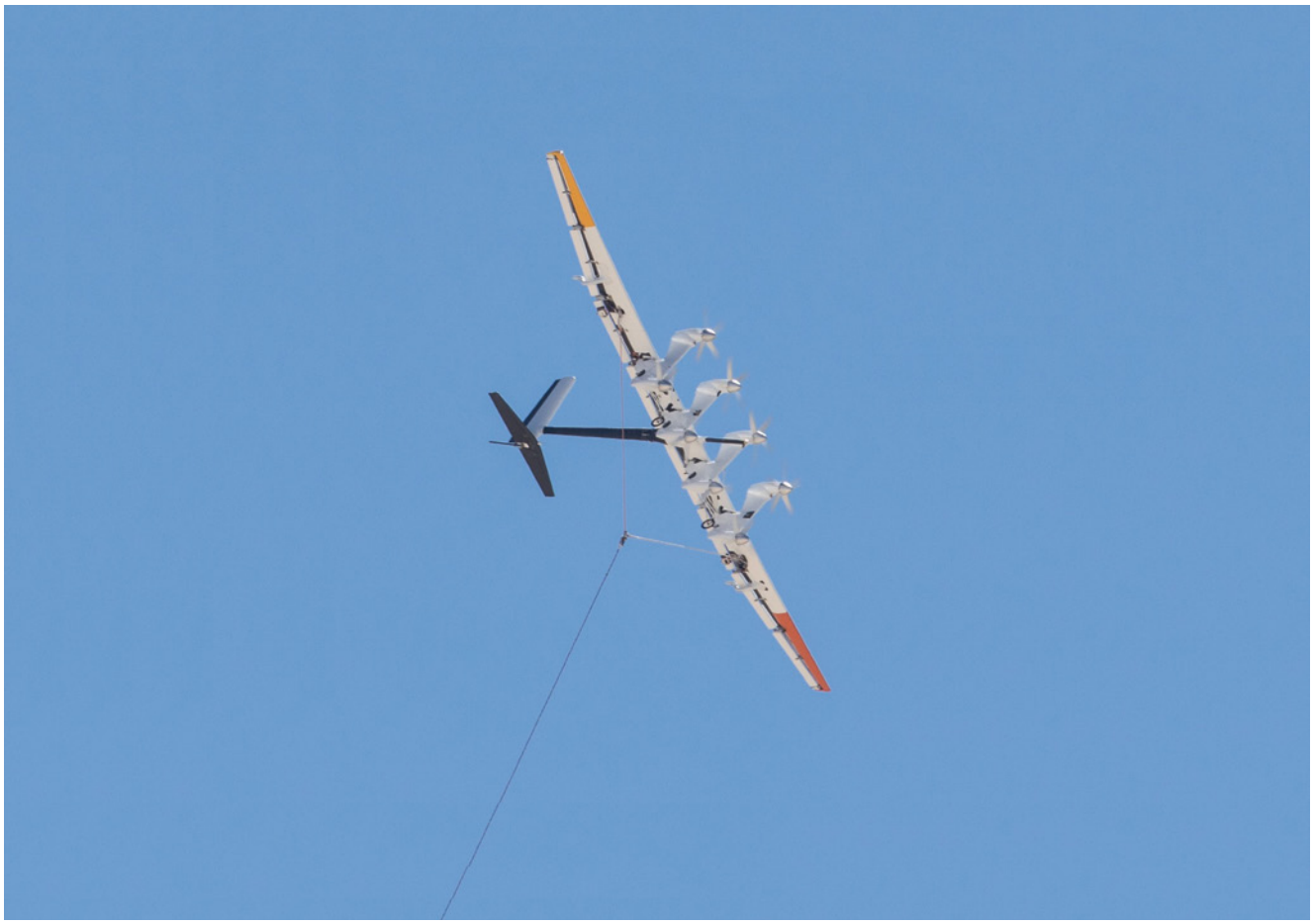




2045 DIRECT JOBS BREAKDOWN

To further illustrate that economic outcomes are highly dependent on market certainty and sustained local action,the direct jobs breakdown for each scenario are presented below. Note that there are more project development and manufacturing jobs in the Strategic Growth Policy Scenario, which could be outsourced without sufficient demand.





Appendix B: Technology Spotlight: Airborne Wind

Because energy resource diversification is critical for California to achieve carbon-neutral power generation by 2045, California should meaningfully consider other innovative technologies to meet growing electricity demand in the state, such as airborne wind. Airborne wind harnesses wind energy by deploying flying blades or wings that are mounted with an onboard generator or tethered to a generator on the ground. The global airborne wind energy market has attracted approximately $200 million in investments from respected companies such as Google, E.ON, and Shell, and is projected to grow significantly over the coming years. One of the leading airborne wind developers is Alameda-based firm and Alphabet subsidiary Makani.

The company has developed an aerodynamic, carbon fiber-reinforced wing that spans eighty-five feet and is mounted with eight spinning rotors that harness wind energy and then transfer up to 600 kW of power to the grid via a tether to the ground. Makani conducted its first commercial-scale power-generating flights at a California test site in December 2016 and began initial testing operations on Hawaii Island in June 2018.

The Makani energy kite system has many technical advantages. It is 90 percent lighter than a conventional wind turbine of a similar power rating, allowing the system to unlock wind energy resources in areas like deep water offshore that are not economically viable for existing technologies. Compared to a conventional wind turbine, the kite can be easily transported and installed, suggesting that technology deployment will be unlikely to require costly upgrades to port infrastructure. The design of Makani's system means that wind farms can exist in new places, increasing the overall percentage of energy that comes from the wind. California's policymakers should consider taking action to support airborne wind and other innovative technologies in our own backyard, such as clarifying and streamlining siting and permitting processes.

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FEBRUARY 2019

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