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California Energy Commission

COMMISSION REPORT

Offshore Wind Energy Development off the California Coast

Maximum Feasible Capacity and Megawatt Planning Goals for 2030 and 2045

Gavin Newsom, Governor
August 2022 | CEC-800-2022-001-REV

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ABSTRACT

This report responds to the directive set forth by Assembly Bill 525 (AB 525, Chiu, Chapter 231, Statutes of 2021). The law directs that on or before June 1, 2022, the California Energy Commission (CEC) shall "evaluate and quantify the maximum feasible capacity of offshore wind to achieve reliability, ratepayer, employment, and decarbonization benefits and shall establish megawatt offshore wind planning goals for 2030 and 2045." This report addresses these requirements. Furthermore, it discusses the potential for offshore wind energy development in federal waters off the California coast to provide a new source of electricity generation, add technology diversity to the state's renewable energy and zero-carbon resource portfolio, and help California meet its ambitious climate and energy goals.

This report is the first of four work products the CEC is directed by AB 525 to prepare. By no later than June 30, 2023, the CEC, in coordination with federal, state, and local agencies and a wide variety of stakeholders, must develop a strategic plan for offshore wind energy developments installed off the California coast in federal waters and submit it to the California Natural Resources Agency and the Legislature. The strategic plan is to be informed by interim activities and products developed by the CEC that include this report and two additional reports due on or before December 31, 2022. The two additional reports include assessing the economic benefits of offshore wind as they relate to seaport investments and workforce development needs and standards and preparing a permitting roadmap that describes time frames and milestones for a coordinated, comprehensive, and efficient permitting process for offshore wind energy facilities and associated electricity and transmission infrastructure off the California coast.

Keywords: Offshore wind energy, floating offshore wind, offshore energy, offshore development, offshore wind planning goals, decarbonization, coastal resources, maximum feasible capacity, renewable energy, reliability, transmission, infrastructure planning, wind energy, Assembly Bill 525, Senate Bill 100

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EXECUTIVE SUMMARY

On September 23, 2021, Governor Gavin Newsom signed into law Assembly Bill 525 (AB 525, Chiu, Chapter 231, Statutes of 2021), which took effect January 1, 2022. AB 525 requires the California Energy Commission (CEC), in coordination with federal, state, and local agencies and a wide variety of stakeholders, to develop a strategic plan for offshore wind energy deployment off the California coast in federal waters. The CEC must submit the strategic plan to the California Natural Resources Agency (CNRA) and the Legislature by no later than June 30, 2023. The following interim activities and products developed by the CEC will contribute to the strategic plan:

1. Evaluate and quantify the maximum feasible capacity of offshore wind to achieve reliability, ratepayer, employment, and decarbonization benefits, and establish megawatt (MW) offshore wind energy planning goals for 2030 and 2045 by no later than June 1, 2022.[1]
2. Complete and submit to CNRA and the relevant fiscal and policy committees of the Legislature a preliminary assessment of the economic benefits of offshore wind as they relate to seaport investments and workforce development needs and standards by no later than December 31, 2022.
3. Complete and submit a permitting roadmap to CNRA and the relevant fiscal and policy committees of the Legislature that describes timeframes and milestones for a coordinated, comprehensive, and efficient permitting process for offshore wind energy facilities and associated electricity and transmission infrastructure off the coast of California by no later than December 31, 2022.

This report focuses on evaluating and quantifying the maximum feasible capacity of offshore wind in federal waters off the California coast to achieve reliability, ratepayer, employment, and decarbonization benefits. Moreover, the report establishes the MW planning goals for 2030 and 2045. The proposed MW planning goals are for developing the strategic plan. AB 525 requires that the "[d]evelopment of the strategic plan shall incorporate, but not delay, progress to advance responsible development of offshore wind in other relevant policy venues" (Public Resource Code (PRC), section 25991 [a][2]) and incorporates progress toward advancing responsible development of offshore wind in other relevant policy venues and also makes clear that nothing in the provisions of the law "is intended to create a technology set-aside or mandatory minimum for any type of eligible renewable energy resource" (PRC Section 25991.7).

AB 525 further requires the CEC to consider 12 factors when establishing the MW offshore wind planning goals. As discussed in Chapter 3, the CEC assessed all 12 factors. While all

1 This report was originally proposed for consideration at a CEC Business Meeting on May 24, 2022, however, at a May 18, 2022 public workshop commenters identified newly released studies that were not considered in the development of the draft report. To evaluate these new studies and allow for additional public process around how these studies may inform the draft report, consideration of the draft report was postponed to a later date.

factors are important in establishing MW planning goals for the strategic plan, the following five factors have had greater influence on development of the MW planning goals in the draft report published on May 6, 2022:

1. The findings of the *2021 SB 100 Joint Agency Report.*
2. The need to initiate long-term transmission and infrastructure planning to facilitate delivery of offshore wind energy to Californians.
3. The need for reliable renewable energy that accommodates California's shifting peak load.
4. The generation profile of offshore wind off the California coast.
5. The potential impacts on coastal resources, fisheries, Native American and Indigenous peoples, and national defense, and strategies for addressing those potential impacts.

An additional factor that has contributed to the proposed revisions here is factor 11: any executive action from the Governor regarding offshore wind.

The first factor is the findings of the *2021 SB 100 Joint Agency Report*. The *2021 SB 100 Joint Agency Report* evaluates the challenges and opportunities of implementing SB 100. The report provides critical context for the opportunity offshore wind energy represents for California to generate carbon-free energy and diversify the state's renewable energy portfolio, especially considering the scale of the climate crisis. The 100 Percent Clean Energy Act of 2018, commonly referred to as Senate Bill 100 (De León, Chapter 312, Statutes of 2018), is a pillar of the state's clean energy policy.

SB 100 increased the state's Renewables Portfolio Standard to ensure that at least 60 percent of the state's electricity comes from eligible renewable energy resources by 2030. SB 100 also requires that eligible renewable energy resources and zero-carbon resources supply 100 percent of all retail sales of electricity to California customers and 100 percent of electricity procured to serve all state agencies by December 31, 2045. The *2021 SB 100 Joint Agency Report* found that California will need significant development of clean energy generation over the next 25 years. Energy resource computer modeling completed for the report covered a range of scenarios and technologies. Modeling of scenarios to achieve the SB 100 policy used an assumption that a maximum of 10 gigawatts GW of offshore wind is available and all 10 GW were selected by the model in the 2045 Core Scenario as well as in almost all other scenarios.

The second factor is the need to initiate long-term electricity transmission and infrastructure planning to ease delivery of offshore wind energy to Californians. The availability of existing transmission and the need to develop more transmission in specific areas affect the offshore wind MW planning goals the CEC establishes and can expect to achieve over time. The availability and need are particularly critical given that AB 525 requires the CEC to include a transmission planning chapter in the strategic plan to support the 2030 and 2045 offshore wind MW planning goals. The California Independent System Operator (California ISO) has recently completed transmission studies involving offshore wind and is conducting another study as part of the annual transmission planning process (TPP) in collaboration with the

California Public Utilities Commission (CPUC). The MW planning goals, and the forthcoming transmission chapter of the strategic plan will build on those ongoing efforts.

The North Coast wind resource is one of the best in the world with high renewable energy potential and wind speeds consistent and favorable for commercial development. But the electric system in California's North Coast region is relatively isolated from the California grid and serves primarily local community need. Additional transmission infrastructure will be needed to deliver offshore wind energy from this region to the grid. Existing transmission on the Central Coast is robust and near large load centers. Near-term electric generator retirements, such as 2,225 MW from the Diablo Canyon Nuclear Power Plant, provides an opportunity to repurpose existing infrastructure to integrate wind energy developed offshore the Central Coast. However, there is still a need to do long-term planning for the subsea infrastructure and the ability to use existing onshore infrastructure.

The third factor focuses on the need for reliable renewable energy that accommodates California's daily peak load (highest electric demand within a period of time) shifting from later in the afternoon to early evening as solar generation decreases. This shift creates a need for reliable renewable energy sources that continue to generate electricity into the evening hours.

The fourth factor, the generation profile of offshore wind, is closely related to the third. Offshore wind, like other variable-output renewable energy sources, has inherent uncertainty with the associated energy and reliability contributions.

The fifth factor is the potential impacts on coastal resources (including ocean resources and marine ecosystems), fisheries, Native American and Indigenous peoples, and national defense, and strategies for addressing those potential impacts. These impacts are the subject of past and ongoing study and stakeholder and tribal outreach and engagement. Current data and analyses show that approaches to addressing potential impacts, such as avoiding, minimizing, and managing these impacts, can affect the MW planning goals as well as the quantification of the maximum feasible capacity.

In addition to the factors described above, the proposed revisions of the planning goals are supported by factor 11, any executive action from the Governor regarding offshore wind. In a July 22, 2022 letter to the Chair of the California Air Resources Board, the Governor urged bold actions to address the urgency of the climate crisis, and outlining new targets to accelerate progress on California's 2030 climate goals and to get to climate neutrality no later than 2045. In the letter, among other requested actions, the Governor asks the CEC to establish an offshore wind planning goal of at least 20 GW by 2045 and to work with the state's federal partners to accelerate the deployment of offshore wind, noting that California is home to one of the best offshore wind resources in the world and that offshore wind can serve as a clean, domestic source of electricity that can play an important role in meeting the state's growing need for clean energy.[2] The Energy Commission factored this climate urgency and the call for at least a 20 GW goal into these proposed revisions.

AB 525 also requires the identification of suitable sea space for wind energy areas in federal waters sufficient to accommodate the offshore wind MW planning goals. CEC staff, in coordination with other federal, state, and local agencies, has assessed offshore wind since 2016. Based on this experience and existing information, CEC staff recommends that identifying suitable sea space for wind energy areas in federal waters is a condition precedent to being able to quantify the maximum feasible capacity of offshore wind to achieve reliability, ratepayer, employment, and decarbonization benefits. The considerations the CEC must make to identify suitable sea space are:

- Existing data and information on offshore wind resource potential and commercial viability.
- Existing and necessary transmission and port infrastructure.
- Protecting cultural and biological resources with the goal of prioritizing least-conflict ocean areas.

This work is underway but is not expected to be completed until after this report *Offshore Wind Energy Development off the Coast of California, Maximum Feasible Capacity and Megawatt Planning goals for 2030 and 2045,* is completed based on the sequence of activities prescribed by AB 525. The need to complete this work prevents CEC staff from quantifying the maximum feasible capacity until the strategic plan is developed and could result in refining the offshore wind MW planning goals. As discussed in Chapter 2, the CEC did evaluate studies that have assessed nearly 21.8 GW of offshore wind technical potential in federal waters off the California coast. The assessments are based on wind speed, ocean depth, bottom slope, distance to grid interconnection, and distance to existing port infrastructure that are technically suitable for current floating technologies. The nearly **21.8 GW number is a reference point** for technically *feasible* capacity that the CEC will continue to evaluate as work continues to:

- Identify sea space.
- Evaluate additional technical assessments of transmission need and grid integration strategies.
- Assess port infrastructure.
- Analyze potential impacts on coastal resources and users, fisheries, Native American and Indigenous peoples, and national defense, as required by AB 525.

The CEC staff also considered other planning initiatives for offshore wind energy generation that are already ongoing in California, including planning by non-ISO load-serving entities, publicly owned utility IRPs, and the CPUC's integrated resource planning (IRP) process and the

2 Governor Gavin Newsom, letter to Chair of the California Air Resources Board. July 22, 2022. https://www.gov.ca.gov/wp-content/uploads/2022/07/07.22.2022-Governors-Letter-to-CARB.pdf?emrc=1054d6

ISO's TPP. The AB 525 offshore wind MW planning goals serve to anchor the state's strategic planning effort called for in AB 525. The AB 525 strategic plan will be an important foundation to set up IRP, the TPP, and other energy resource planning and investment decisions as they relate to procurement of offshore wind generation and transmission. To best serve this approach, the MW planning goals should reasonably exceed current IRP and TPP assumptions and amounts of offshore wind to allow flexibility as those ongoing processes continue to inform and direct the optimal procurement for ratepayers over the coming years. The MW planning goals are not intended as a core input to IRP or TPP analysis, nor should they be seen as a "floor" or "ceiling" for offshore wind procurement in California.

To ensure public engagement, the CEC held three public workshops to inform the planning goals for AB 525. The first workshop, held March 3, 2022, focused on approaches to fulfill the statutory requirements of AB 525 in setting offshore wind energy planning goals for 2030 and 2045. The Bureau of Ocean Energy Management (BOEM) also presented on activities leading to a lease sale auction for the Humboldt and Morro Bay Wind Energy Areas. On May 18, 2022, the CEC held a second workshop to present the draft report and proposed findings and recommendations. Commenters in the May 18 workshop referenced three studies, released after the posting of the draft report, that recommend higher MW offshore wind planning goals than those in the draft report. This final workshop, held June 27, 2022, focused on these and other studies, and how they relate to the AB 525 requirements and the draft report.

The May 6, 2022 draft report proposed a preliminary planning goal of 3,000 megawatts for 2030. For completing the strategic plan, the CEC instead establishes a preliminary planning goal range of **2,000 MW–5,000 MW** (2 GW–5 GW) of offshore wind for 2030. The upper end of this range could come from a full build-out of the Morro Bay Wind Energy Area (WEA) or a combination of a partial build-out of the Morro Bay WEA and Humboldt WEA. The WEAs are areas identified by BOEM in coordination with other federal, state, local, and tribal partners that appear most suitable for commercial wind energy activities while presenting the fewest apparent environmental and user conflicts. The lower end of that range reflects an understanding that achieving a 2030 online date for any proposed offshore wind project will take a significant mobilization of effort and resources, and timely infrastructure investments, among other factors. The CEC will work with state and federal partners to identify process steps and milestones that could allow for a 2030 online date for California's first offshore wind projects.

The May draft report proposed to evaluate an additional 7,000–12,000 MW of offshore wind for 2045, establishing the total 2045 preliminary megawatt planning goals for the strategic plan at 10,000 MW to 15,000 MW (10 GW to 15 GW), and noting that technological developments and related cost reductions could support a larger megawatt planning goal of up to 20 GW between 2045 and 2050. **In light of the Governor's call to adopt a more aspirational target, and on the basis of additional studies and comment received, the CEC establishes a preliminary planning goal of 25,000 MW (25 GW) for 2045. These preliminary planning goals are designed to be potentially achievable but aspirational and are established at levels that can contribute significantly to achieving California's climate goals. These goals reflect the evaluation of the 12**

factors prescribed by AB 525, the improvements in technology referenced above, and the additional information provided to the CEC after the publication of the May draft report.

The MW planning goals will guide the development of the strategic plan for offshore wind in federal waters off the California coast under AB 525. These preliminary planning goals may be refined as part of completing the strategic plan as more information becomes available from the analysis of suitable sea space and potential impacts on coastal resources, fisheries, Native American and Indigenous people, and national defense, as well as other strategic plan topics. These planning goals are not procurement targets. Any future procurement authorization of offshore wind will have to go through all necessary resource planning, procurement, and permitting requirements.

CHAPTER 1: Background on SB 100 and Offshore Wind

California is working to reduce the pace, magnitude, and costs of climate change impacts by strengthening climate change resilience and reducing greenhouse gas emissions. With the passage of the landmark legislation, the 100 Percent Clean Energy Act of 2018 (Senate Bill [SB] 100, De León, Chapter 312, Statutes of 2018), California requires that eligible renewable energy resources and zero-carbon resources supply 100 percent of total retail sales of electricity in California to end-use customers and 100 percent of electricity procured to serve all state agencies by 2045.

SB 100 also requires that the California Energy Commission (CEC), California Air Resources Board (CARB), and the California Public Utilities Commission (CPUC) prepare a joint report every four years, evaluating the opportunities and challenges of implementing SB 100. The first report, the *2021 SB 100 Joint Agency Report*, was issued in March 2021 and finds that achieving the 2045 policy is technically feasible.[3] The report also finds California will need to roughly triple its current electric power capacity to meet the 2045 target, and a significant buildout of eligible renewable and zero-carbon energy generation will be required over the next 25 years.

In addition to renewable and zero-carbon energy goals, the state set an economywide target of reducing greenhouse gas emissions to 40 percent below 1990 levels by 2030[4] and 80 percent below by 2050.[5] The state is taking bold action to meet these greenhouse gas reduction targets. For example, California has established a loading order to prioritize meeting energy needs first with energy efficiency and demand response; second with renewable energy, including distributed generation and utility-scale; and third with a clean, conventional electricity supply. Every three years, the CEC adopts updated *Building Energy Efficiency Standards* that guide the construction of buildings to better withstand extreme weather, lower energy costs, and reduce climate and air pollution.

California has also established aggressive zero emission transportation goals, including the following:

- All new passenger vehicles sold are to be zero-emission by 2035.
- Transition all drayage trucks to be zero-emission by 2035.

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3 CEC, CPUC, and CARB. 2021. *2021 SB 100 Joint Agency Report Achieving 100 Percent Clean Electricity in California: An Initial Assessment*. Publication Number: CEC-200-2021, https://efiling.energy.ca.gov/EFiling/GetFile.aspx?tn=237167&DocumentContentId=70349.

4 Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016) (SB 32).

5 Senate Bill 100 (De León, Chapter 312, Statutes of 2018) (SB100).

- All medium and heavy-duty vehicles in California are to be zero-emission by 2045 where feasible.

Wind energy developed in federal ocean waters[6] off California's coast is poised to play an important role in diversifying the state's portfolio of resources. Offshore wind can help California achieve its 100 percent renewable and zero-carbon energy goals, as well as the electrification of other sectors, such as transportation.

Resource portfolio modeling completed for the *2021 SB 100 Joint Agency Report* included a range of scenarios and technologies. The model for the Core Scenario[7] included 145 GW of utility-scale capacity additions to achieve the SB 100 policy for 2045, including 10 GW of offshore wind. The estimated total resource cost of the Core Scenario in 2045 is $66 billion. Furthermore, the report included a scenario with no offshore wind, which had an estimated 2045 total resource cost of $67 billion. These modeling results indicate that including 10 GW of offshore wind reduced the modeled 2045 total resource costs by $1 billion.[8] **Figure 1** shows the projected new resource additions for the SB 100 Core Scenario, including 10 GW of offshore wind by 2045.

6 Federal waters extend from 3 nautical miles (nm) offshore to the edge of the Exclusive Economic Zone ending at 200 nm offshore, except within boundaries of any National Park, National Marine Sanctuary, National Wildlife Refuge (or associated systems), or National Monument.

7 The SB 100 Core Scenario is consistent with the joint agencies (CEC, CPUC, and CARB) interpretation of SB 100 and includes only commercialized technologies with publicly available cost and performance data. The Core Scenario includes retail sales and state loads, high electrification demand, and all candidate resources available.

CEC, CPUC, and CARB. 2021. 2021 SB 100 Joint Agency Report Achieving 100 Percent Clean Electricity in California: An Initial Assessment, pages 6-7,
https://efiling.energy.ca.gov/EFiling/GetFile.aspx?tn=237167&DocumentContentId=70349.

8 Ibid, pages 88–89.

Figure 1: Modeling Results from the SB 100 Joint Agency Report Core Scenario

California
Clean Electricity Resources

	Existing Resources 2019*	Projected New Resources 2030**	Projected New Resources 2045**
Solar (Utility-Scale)	12.5 GW	16.9 GW	69.4 GW
Solar (Customer)	8.0 GW	12.5 GW	28.2 GW
Storage (Battery)	0.2 GW	9.5 GW	48.8 GW
Storage (Long Duration)	3.7 GW	0.9 GW	4.0 GW
Wind (Onshore)	6.0 GW	8.2 GW	12.6 GW
Wind (Offshore)	0 GW	0 GW	10.0 GW
Geothermal	2.7 GW	0 GW	0.1 GW
Biomass	1.3 GW	0 GW	0 GW
Hydrogen Fuel Cells	0 GW	0 GW	0 GW
Hydro (Large)	12.3 GW	N/A†	N/A†
Hydro (Small)	1.8 GW	N/A†	N/A†
Nuclear	2.4 GW	N/A†	N/A†

*Includes in-state | **Includes in-state and out of state capacity | †New hydro and nuclear resources were not candidate technologies for this round of modeling and could not be selected*

Source: *2021 SB 100 Joint Agency Report* Summary, March 2021

The *2021 SB 100 Joint Agency Report* acknowledges there are additional investments and actions that would have to occur to realize 10 GW of offshore wind by 2045. While there is a significant wind resource potential off the California coast, there are challenges to developing offshore wind energy. The report states: "Among the foremost challenges are significant anticipated transmission requirements and competing coastal uses, including shipping, fishing, recreation, marine conservation, and Department of Defense activities. Together, these factors severely limit the feasible resource potential."[9] However, the report found that offshore wind energy represents an opportunity for California to generate carbon-free energy and diversify the state's renewable energy portfolio, especially considering the scale of the climate crisis.

The Offshore Wind Energy Opportunity for California

Offshore wind has been identified as an abundant domestic source of clean energy production for the United States because offshore winds tend to be strong, fast, and uniform. However, specific technologies depend on site-specific conditions and characteristics such as water depth, wind speeds, and seabed geology. Floating and fixed-bottom technologies have been

9 Ibid., page 107.

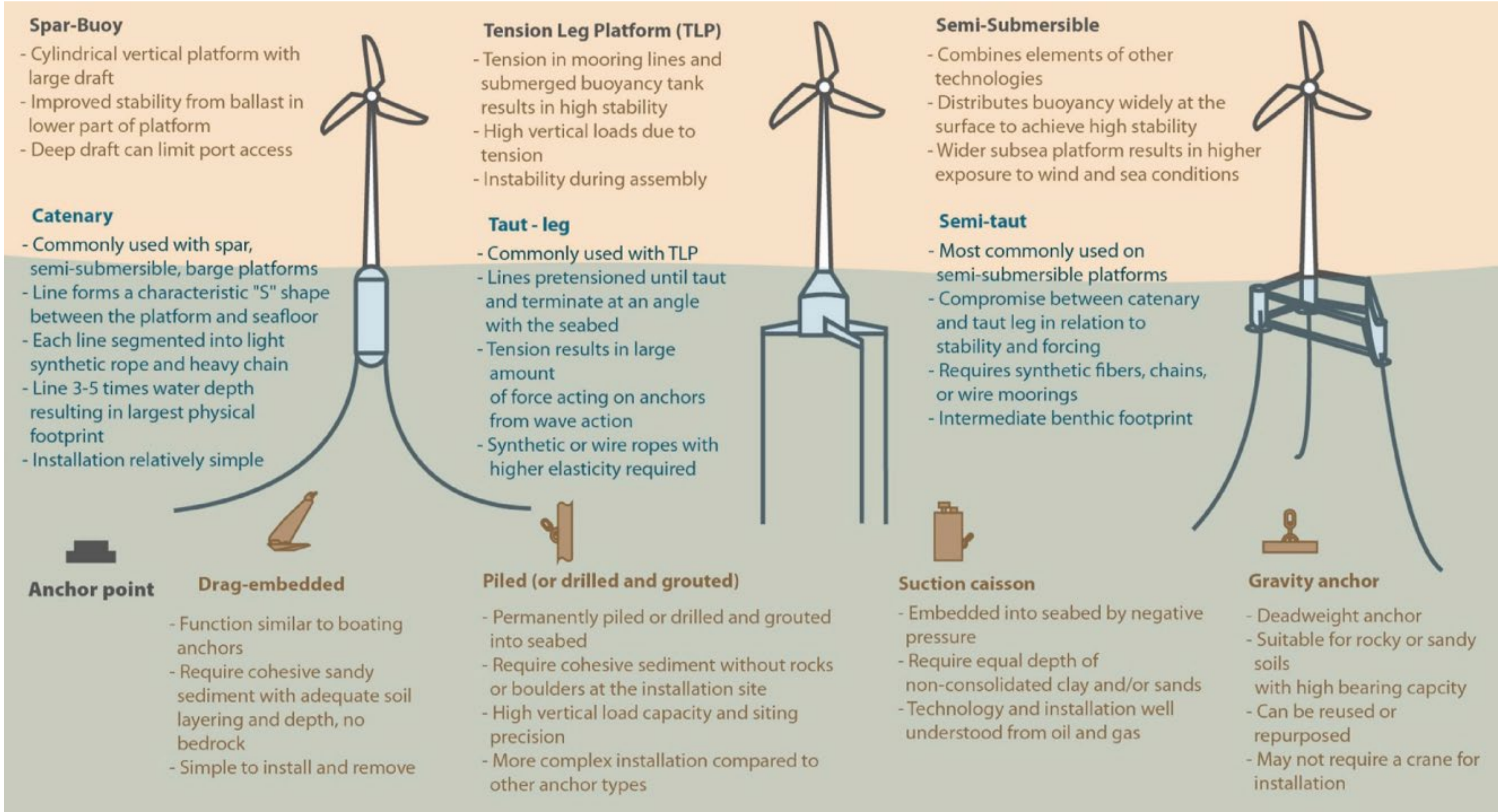
deployed internationally, and there are 50,500 MW of installed capacity of fixed-bottom projects globally, including a pipeline of additional projects under development on the U.S. East Coast, as well as 123 MW of installed capacity of floating projects globally.[10] Whether floating or fixed-bottom, offshore technologies use wind turbines that essentially operate in the same way as onshore wind technologies. Offshore wind turbines and related components are larger than those used for onshore wind energy generation, and current market data indicate they are expected to continue increasing in size.[11] For example, offshore wind turbine hub height averaged 330 feet with a capacity of 6 MW in 2016 and is expected to grow to nearly 500 feet with a capacity of 15 MW or more by 2035.[12] In addition to turbines, floating offshore wind developments will likely include midwater-suspended electrical cables linking the turbines, mooring cables, and anchors attaching the turbines to the seafloor, with an electrical cable to transport the energy from the turbines to a substation, either onshore or offshore. There is also variability among floating offshore wind technologies with regard to some of the examples of currently known platform design, mooring, and anchor configurations being pursued in deep ocean waters, as seen in **Figure 2**.

10 NREL April 7, 2022. "Offshore Wind Briefing for Oregon Department of Energy" presentation. https://www.oregon.gov/energy/energy-oregon/Documents/2022-04-05-ODOE-FOSW-Public-Meeting-PPT.pdf.

11 Optis, Mike, Alex Rybchuk, Nicola Bodini, Michael Rossol, and Walter Musial. 2020. *2020 Offshore Wind Resource Assessment for the California Pacific Outer Continental Shelf*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-77642. https://www.nrel.gov/docs/fy21osti/77642.pdf.

12 U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. August 30, 2021. "Wind Turbines: the Bigger the Better." https://www.energy.gov/eere/articles/wind-turbines-bigger-better.

Figure 2: Diagram of Mooring, Anchoring, and Floating Foundations

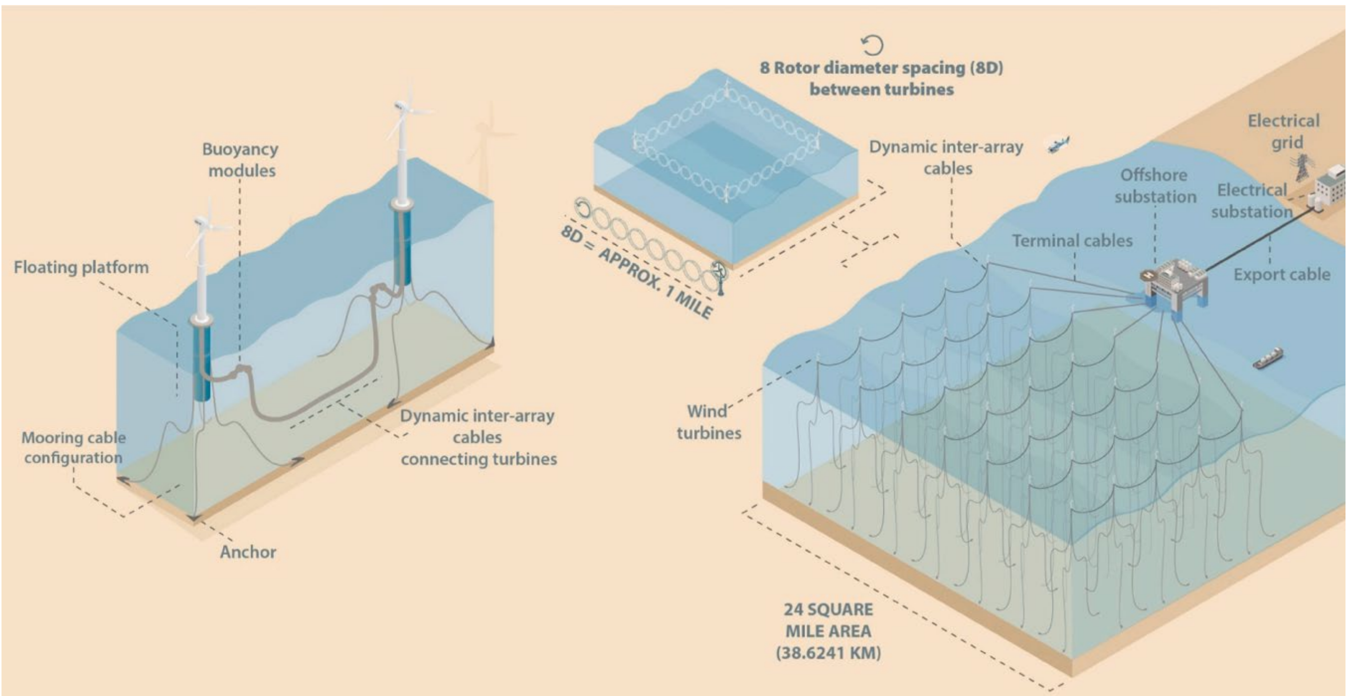


Source: Maxwell et al. 2022.[13]

13 Maxwell, Sara M., Francine Kershaw, Cameron C. Locke, Melinda G. Conners, Cyndi Dawson, Sandy Aylesworth, Rebecca Loomis, and Andrew F. Johnson. 2022. "Potential Impacts of Floating Wind Turbine Technology for Marine Species and Habitats." *Journal of Environmental Management* 307 (2022) 114577. https://doi.org/10.1016/j.jenvman.2022.114577.

To date, most offshore wind energy projects have used fixed-bottom foundations, which are more suitable for shallow waters of 60 meters (about 200 feet) or less. The deep waters of the Pacific Outer Continental Shelf off California's coast have steep drop-offs and will require offshore wind turbines installed on floating platforms to be anchored to the seabed. The schematic shown in **Figure 3** is an example of a floating offshore wind project, though no floating offshore wind projects have been developed at the scale shown in **Figure 3**. While the global floating offshore wind market is still in early stages of development, the technology is projected to quickly advance, with some estimates that the global floating offshore wind energy installed capacity could grow to more than 40 GW by 2036.[14]

Figure 3: Schematic of an Example Full-Scale Floating Wind Energy Development



Source: Image taken from California Coastal Commission CD-0001-22 April 7, 2022, hearing, Exhibit 1-3. Original source from Maxwell et al. 2022.[15]

At the national level, planning for offshore wind energy development on the Outer Continental Shelf (OCS) began to take shape starting in 2009 when the United States Department of the Interior (DOI) developed regulations for renewable energy development in the OCS. In 2011, DOI's Bureau of Ocean Energy Management (BOEM) was created and vested with authority for offshore renewable energy development in federal waters. BOEM's authority extends from 3

14 Guidehouse. May 2022. *California Supply Chain Needs Summary Report* https://efiling.energy.ca.gov/GetDocument.aspx?tn=242928&DocumentContentId=76513.

15 Maxwell, Sara M., Francine Kershaw, Cameron C. Locke, Melinda G. Conners, Cyndi Dawson, Sandy Aylesworth, Rebecca Loomis, and Andrew F. Johnson. 2022. "Potential Impacts of Floating Wind Turbine Technology for Marine Species and Habitats." *Journal of Environmental Management*, 307 (2022) 114577. https://doi.org/10.1016/j.jenvman.2022.114577.

nautical miles (nm) offshore ending at 200 nm offshore, except within boundaries of any National Park, National Marine Sanctuary, National Wildlife Refuge (or associated systems), or National Monument.

In March 2021, President Joseph Biden announced a national goal to deploy 30,000 MW (30 GW) of offshore wind capacity by 2030 to create a pathway to 110,000 MW (110 GW) of offshore wind capacity by 2050.[16] As of June 2021, there were 42 MW of installed offshore wind operating capacity in the United States.[17] Since 2013, BOEM has conducted nine competitive lease sales in the United States — all on the East Coast.[18] On the West Coast, BOEM designated three call areas[19] in 2018 off the coast of California, two of which BOEM identified as wind energy areas in 2021. In April 2022, BOEM announced a Call for Information and Nominations for two areas off the south-central and southern coast of Oregon near the northern coast of California.[20]

The three call areas in federal waters off the coast of California are the Humboldt call area on the North Coast and the Morro Bay and Diablo Canyon[21] call areas, off the Central Coast.

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16 The White House. 2021. "FACT SHEET: Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs." Last modified: March 29, 2021. https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/.

17 Musial, Walter, Paul Spitsen, Philipp Beiter, Patrick Duffy, Melinda Marquis, Aubryn Cooperman, Rob Hammond, and Matt Shields. 2021. Offshore Wind Market Report: 2021 Edition. Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. https://www.energy.gov/sites/default/files/2021-08/Offshore%20Wind%20Market%20Report%202021%20Edition_Final.pdf. The 42 MW of operating offshore wind come from two projects, the Coastal Virginia Offshore Wind Project (12 MW) and the Block Island Wind Farm (30 MW).

18 Fiscal Year 2022 Interior Budget in Brief, Bureau of Ocean Energy Management. (Since publication of the Budget Brief noting 8 lease sales, the New York Bight lease sale occurred.) https://www.doi.gov/sites/doi.gov/files/fy2022-bib-bh021.pdf.

19 "Call areas" are locations identified by BOEM for public comment to explore interest in commercial wind energy leases in the area.

20 BOEM, Oregon Activities. https://www.boem.gov/renewable-energy/state-activities/Oregon.

21 The Diablo Canyon Call Area is within the area nominated by the Northern Chumash Tribal Council to become a national marine sanctuary (Chumash National Marine Sanctuary. 2022. "About the Proposed Chumash Heritage Sanctuary." https://chumashsanctuary.org/about/). In response to this nomination, NOAA has proposed a sanctuary designation that excludes "any geographical overlap with the proposed Morro Bay Wind Energy Area for offshore wind development" (NOAA, "Proposed Designation of Chumash Heritage National Marine Sanctuary." https://sanctuaries.noaa.gov/chumash-heritage/. Accessed April 14, 2022). If the proposed sanctuary designation is approved as described by NOAA with the Diablo Canyon Call Area, under current law BOEM would not have authority to lease from within the Diablo Canyon Call Area: "BOEM lacks the authority to lease within the boundaries of National Marine Sanctuaries." (BOEM. October 18, 2018. Notice. Commercial Leasing for Wind Power Development: Outer Continental Shelf Offshore California. https://www.regulations.gov/document/BOEM-2018-0045-0001). The CEC will continue to engage with NOAA, BOEM, other stakeholders, and tribal governments during development of the AB 525 strategic plan, including identifying suitable sea space in federal ocean waters and related considerations in planning for offshore wind.

Together, these three California call areas have a potential capacity of 8.3 GW,[22] assuming 3 MW per square kilometer.[23] Based on input from California agencies, the federal Department of Defense, and other stakeholders, BOEM analyzed extended areas to the Morro Bay call area following a May 2021 agreement between the federal government and the state of California to advance areas for wind energy development offshore California. BOEM subsequently designated the Humboldt and Morro Bay wind energy areas (WEAs), with a combined potential generation capacity of 4.5 GW.

On May 26, 2022, the DOI announced proposed auction details and lease terms for offshore wind energy development in the Morro Bay and Humboldt WEAs, with a goal of holding a lease sale auction in fall of 2022. The California Proposed Sale Notice (PSN) includes information about potential areas that could be available for leasing within the two WEAs as well as proposed lease provisions, conditions, and auction details.[24] According to BOEM, the Humboldt WEA could bring up to 1.6 GW of energy to the grid,[25] and the Morro Bay WEA could bring up to 2.9 GW.[26] The map in **Figure 4** depicts the three 2018 call areas as well as the WEAs.

22 One gigawatt is enough to supply the electric demand of about 1 million average California homes. "California Energy Commission, Energy Glossary," https://www.energy.ca.gov/resources/energy-glossary.

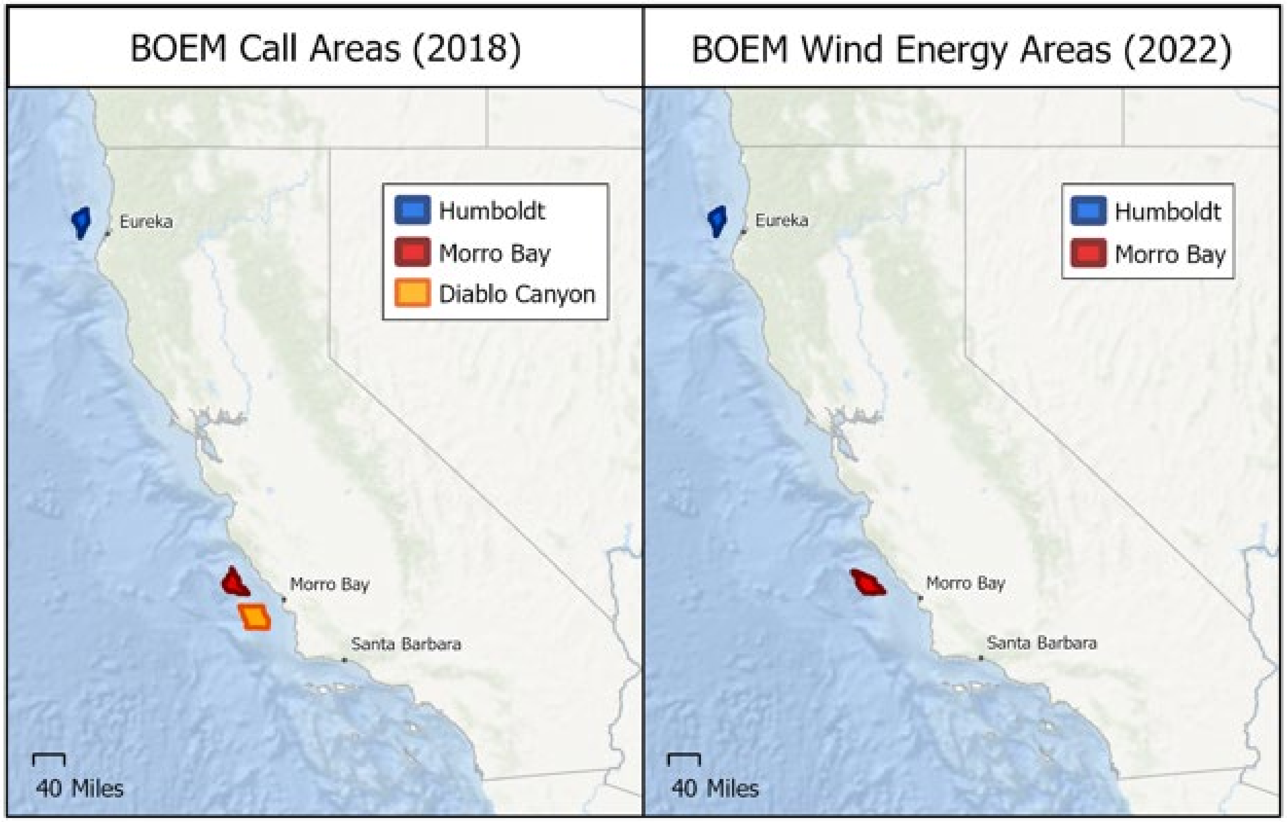
23 About 8,350 MW offshore wind modeled by the ISO (as a sensitivity in the 2021–2022 Transmission Plan) is based on three 2018 BOEM call areas, assuming 3 MW per square kilometer, as transmitted to the ISO by the CPUC in "Attachment A Modeling Assumptions for the 2021-2022 Transmission Planning Process" to Decision 21-02-008 in Rulemaking 20-05-003. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M366/K452/366452138.PDF. For further information, see page 42 of CPUC Inputs and Assumptions, 2019-2020 Integrated Resource Planning, November 2019 (https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2019-2020-irp-events-and-materials/inputs--assumptions-2019-2020-cpuc-irp_20191106.pdf) which uses calculations from Exhibit 8.2 on page 57 of https://laborcenter.berkeley.edu/pdf/2019/CA-Offshore-Wind-Workforce-Impacts-and-Grid-Integration.pdf.

24 Department of the Interior. May 31, 2022. "Pacific Wind Lease Sale 1 (PACW-1) for Commercial Leasing for Wind Power on the Outer Continental Shelf in California – Proposed Sale Notice." https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/california/2022-11537.pdf

25 Bureau of Ocean Energy Management. July 2021. "Area ID Memorandum: Humboldt Wind Energy Area." https://www.boem.gov/sites/default/files/documents//App.%20A%20Area%20ID%20Humboldt%20Memo%20Final.pdf.

26 BOEM. November 10, 2021. "Area ID Memorandum, Morro Bay WEA Final Signed." https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Area-ID-CA-Morro-Bay.pdf.

Figure 4: Offshore Wind Call Areas and Wind Energy Areas off the Coast of California



Source: California Energy Commission

California's Efforts in Offshore Wind Planning

Since 2016, the state has participated in the BOEM California Intergovernmental Renewable Energy Task Force, which is a partnership of members of state, local, and federal agencies, and tribal governments.[27] The task force examines potential wind leasing areas in federal waters and coordinates related planning and permitting processes. The California Offshore Wind Energy Gateway[28] was created in support of the task force, with publicly available geospatial information on ocean wind resources, ecological and natural resources, commercial and recreational ocean uses, and community values. The Offshore Wind Energy Gateway helps synthesize data and identify areas off California that may be suitable for offshore wind development.

Several California state agencies, as well as the ISO, are individually and collectively working to assess the potential role and opportunity offshore wind can provide for California. Along

27 BOEM. 2017. California Offshore Renewable Energy Fact Sheet. https://www.boem.gov/sites/default/files/renewable-energy-program/State-Activities/CA/BOEM-Offshore-Renewables-Factsheet--02-22-17.pdf.

28 California Offshore Wind Energy Gateway. Powered by Data Basin. https://caoffshorewind.databasin.org/.

with the CEC, they include the California Department of Fish and Wildlife, the California Ocean Protection Council, the California State Lands Commission, the California Coastal Commission, the CPUC, and the Governor's Office of Planning and Research. The agencies play an important role in California's policy framework, including implementing climate and clean energy goals and protecting and conserving coastal and ocean resources that are experiencing increasing impacts from climate change. The agencies have been working in partnership with BOEM to understand the implications of offshore wind as a potential energy resource and bring forward the best available science regarding environmental considerations and existing uses of the ocean to guide future state and BOEM decision making. These efforts include significant public outreach to stakeholders to identify and collect relevant data and information on existing ocean resources and uses.[29]

The California Coastal Commission implements the Coastal Zone Management Act (CZMA), which provides the state agency with the ability to review federal activities or permits outside the coastal zone, including offshore wind projects, that could influence California's coastal resources. In March 2022, the California Coastal Commission staff issued a recommendation conditionally concurring with BOEM's determination that leasing activities in the Humboldt offshore WEA are consistent with the CZMA.[30] In April 2022, the California Coastal Commission voted on and approved its staff's recommendation of conditional concurrence. Similarly, in April 2022, California Coastal Commission staff issued a recommendation conditionally concurring with BOEM's determination that leasing activities in the Morro Bay WEA are consistent with the CZMA. In June 2022, the California Coastal Commission voted on and approved staff's recommendation of conditional concurrence. These conditional concurrences allow additional study of offshore wind energy development in the Humboldt and Morro Bay WEAs to move forward.

The CEC's Energy Research and Development Division administers the Electric Program Investment Charge (EPIC), which funds research leading to technological advancements and scientific breakthroughs supporting California's clean energy goals, with a focus on providing ratepayer benefits, including reliability, lower costs, and safety. The CEC's EPIC has invested $8 million into floating offshore wind energy technology innovation. In August 2020, the CEC published a report to develop priority recommendations for research and development that would lead to cost-effective offshore wind projects.[31] The EPIC Interim Investment Plan 2021

29 Bureau of Ocean Energy Management/California Intergovernmental Renewable Energy Task Force. "Public Information Meetings and Outreach Efforts." https://www.boem.gov/renewable-energy/state-activities/public-information-meetings-and-outreach-efforts.

30 California Coastal Commission. March 2022. *Staff Report: Consistency Determination No: CD-0001-22* (Bureau of Ocean Energy Management, Humboldt Co.). https://documents.coastal.ca.gov/reports/2022/4/Th8a/Th8a-4-2022%20staffreport.pdf.

31 Sathe, Amul, Andrea Romano, Bruce Hamilton, Debyani Ghosh, Garrett Parzygnot (Guidehouse). 2020. *Research and Development Opportunities for Offshore Wind Energy in California*. California Energy Commission. Publication Number: CEC-500-2020-053. https://www.energy.ca.gov/sites/default/files/2021-05/CEC-500-2020-053.pdf.

and Proposed 2021–2025 Investment Plan identify research designed to accelerate the market readiness of floating offshore wind.

The CPUC's integrated resource planning (IRP) process seeks to reduce the cost of achieving GHG reductions and other policy goals by looking across load-serving entities' (LSE) boundaries and resource types to identify solutions to reliability, cost, or other concerns that might not otherwise be found without an integrated planning process. The IRP process includes capacity expansion modeling of the electricity system that provides the analytical foundation for the CPUC to require LSEs to procure new energy resources, such as renewable generation and storage resources to achieve California's goals.

Based on the CPUC's portfolio of planned resources, the ISO annually conducts analysis and, if applicable, approval of the transmission needs that would be required from these future resources. The CPUC recently adopted the 2021 Preferred System Plan (PSP), which the ISO will analyze as part of its 2022–23 TPP. This planning portfolio includes 1.7 GW of offshore wind resources by 2032. The ISO's TPP results in an annual transmission plan that is based upon the state's demand forecasts, GHG emissions reductions targets, and the CPUC's adopted portfolio of future generation and storage resources. The annual transmission plan is a key route for ensuring development of the transmission needs in California to accommodate offshore wind resources.

Assembly Bill 525

In January 2022, AB 525 became effective, setting the analytical framework for offshore wind energy development off the California coast in federal waters and tasking the CEC to move swiftly to develop a strategic plan for offshore wind development.

AB 525 requires the CEC to develop the strategic plan and submit it to the California Natural Resources Agency (CNRA) and the Legislature by no later than June 30, 2023. The CEC is to develop the strategic plan in coordination with the California Coastal Commission, Ocean Protection Council, State Lands Commission, Governor's Office of Planning and Research, Department of Fish and Wildlife, Governor's Office of Business and Economic Development, the ISO, the CPUC, and other relevant federal, state, and local agencies as needed.

AB 525 Legislative Findings

In enacting AB 525, the Legislature found and declared, among other things, that:

- If developed and deployed at scale, the development of offshore wind energy can provide economic and environmental benefits to the state and nation.
- Offshore wind energy can advance California's progress toward its statutory renewable energy and climate mandates.
- Diversity in energy resources and technologies lowers overall costs, and offshore wind can add resource and technology diversity to the state's energy portfolio.
- Offshore wind energy development presents an opportunity to attract investment capital and realize community economic and workforce development benefits in California, including the development and preservation of a skilled and trained

construction workforce to carry out projects, long-term job creation, and development of an offshore wind energy supply chain.

- Offshore wind energy can contribute to a diverse, secure, reliable, and affordable renewable energy resource portfolio to serve the electricity needs of California ratepayers and improve air quality, particularly in disadvantaged communities.
- Offshore wind should be developed in a manner that protects coastal and marine ecosystems.
- Investment in offshore wind energy development can offer career pathways and workforce training in clean energy development.

Strategic Plan

AB 525 requires that the CEC's development of the strategic plan "shall incorporate, but not delay progress to advance responsible development of offshore wind in other relevant policy venues."[32]

The strategic plan must include, at a minimum, the following five chapters:

1. Identification of sea space
2. Economic and workforce development and identification of port space and infrastructure
3. Transmission planning
4. Permitting
5. Potential impacts on coastal resources, fisheries, Native American and Indigenous peoples, and national defense, and strategies for addressing those potential impacts

Each chapter must be developed with specific content and public review process as described in section 25991 of the California Public Resources Code.

Identification of Sea Space

The CEC, in coordination with the California Coastal Commission, Department of Fish and Wildlife, Ocean Protection Council, and State Lands Commission, is required to work with stakeholders,[33] other state, local, and federal agencies, and the offshore wind energy industry to identify suitable sea space for wind energy areas in federal waters sufficient to accommodate the offshore wind MW planning goals the CEC is required to establish under AB 525.

AB 525 specifies a sequence of actions requiring that the CEC first identify the sea space identified by BOEM in its 2018 call for nominations for areas offshore the California coast and any other relevant information necessary to achieve the 2030 offshore wind MW planning goals the CEC is required to establish under AB 525. The CEC, in coordination with the

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32 California Public Resources Code, section 25991, subparagraph (a)(2).

33 The term "stakeholders," as used by AB 525, includes, but is not limited to, fisheries groups, labor unions, industry, environmental justice organizations, environmental organizations, and other ocean users. California Public Resources Code, §25991.6.

California Coastal Commission, Department of Fish and Wildlife, Ocean Protection Council, and State Lands Commission, shall next identify suitable sea space for a future phase of offshore wind leasing to accommodate the 2045 offshore wind planning goal the CEC is required to establish under AB 525.

In identifying suitable sea space, the CEC shall consider:

- Existing data and information on offshore wind resource potential and commercial viability.
- Existing and necessary transmission and port infrastructure.
- Protecting cultural and biological resources with the goal of prioritizing least-conflict ocean areas.

In addition, AB 525 requires the CEC to:

- Incorporate the information developed by the Bureau of Ocean Energy Management California Intergovernmental Renewable Energy Task Force.
- Use the California Offshore Wind Energy Gateway, or functionally equivalent publicly accessible, commission-approved internet website, to provide relevant information developed under this section to the public.
- Coordinate with the California Coastal Commission; the Department of Fish and Wildlife; the Ocean Protection Council; the State Lands Commission; stakeholders; other state, local, and federal agencies; and the offshore wind energy industry. They shall make recommendations regarding potential significant adverse environmental impacts and use conflicts, such as avoidance, minimization, monitoring, mitigation, and adaptive management, consistent with California's long-term renewable energy, greenhouse gas emission reduction, and biodiversity goals.

Economic and Workforce Development and Identification of Port Space and Infrastructure

Based on the identified sea space, the CEC, in coordination with relevant state and local agencies and representatives of key labor organizations and apprenticeship programs, must develop a plan to improve waterfront facilities that could support a range of offshore wind energy development activities. These activities include construction and staging of foundations, manufacturing of components, final assembly, and long-term operations and maintenance facilities. AB 525 directs that the strategic plan must include:

- A detailed assessment of the necessary investments in California seaports to support offshore wind energy activities, including construction, assembly, and operations and maintenance. The assessment shall consider the potential availability of land and water acreage at each seaport, including competing and current uses, infrastructure feasibility, access to deep water, bridge height restrictions, and the potential impact to natural and cultural resources, including coastal resources, fisheries, and Native American and Indigenous peoples.
- An analysis of the workforce development needs of the California offshore wind energy industry, including occupational safety requirements, the need to require the use of a

skilled and trained workforce to perform all work, and the need for the Division of Apprenticeship Standards to develop curriculum for in-person classroom and laboratory advanced safety training for workers.

- Recommendations for workforce standards for offshore wind energy facilities and associated infrastructure, including prevailing wage, skilled and trained workforce, apprenticeship, local hiring, and targeted hiring standards that ensure sustained and equitable economic development benefits.

Regarding port infrastructure, the strategic plan must:

- Emphasize and prioritize near-term actions, particularly related to port retrofits and investments and the workforce, to accommodate the probable immediate need for jobs and economic development.
- Strive for compatibility with other harbor tenants and ocean users to ensure that the local benefits related to offshore wind energy construction complement other local industries when considering port retrofits.
- Emphasize and prioritize actions that will improve port infrastructure to support land-based work for the local workforce.

Transmission Planning

The CEC, in consultation with the CPUC and ISO, must assess the transmission investments and upgrades necessary, including subsea transmission options, to support the 2030 and 2045 offshore wind MW planning goals. The assessment must include relevant cost information for subsea transmission and network upgrades, as well as the extent to which existing transmission infrastructure and available capacity could support offshore wind energy development.

Permitting Roadmap

The CEC must develop and produce a permitting roadmap that describes time frames and milestones for a coordinated, comprehensive, and efficient permitting process for offshore wind energy facilities and associated electricity and transmission infrastructure off the California coast. The roadmap must:

- Include a goal for the permitting time frame.
- Clearly define local, state, and federal agency roles, responsibilities, and decision-making authority.
- Include interfaces with federal agencies, including timing, sequence, and coordination with federal permitting agencies, and coordination between reviews under the California Environmental Quality Act and the federal National Environmental Policy Act of 1969.

The permitting roadmap must also be developed in consultation with all relevant local, state, and federal agencies, including the California Coastal Commission, the Department of Fish and Wildlife, and the State Lands Commission, interested California Native American tribes, and affected stakeholders.

Potential Impacts on Coastal Resources, Fisheries, Native American and Indigenous Peoples, and National Defense, and Strategies for Addressing Those Potential Impacts

For this chapter, the CEC, in coordination with the California Coastal Commission, the Department of Fish and Wildlife, the Ocean Protection Council, the State Lands Commission, stakeholders, other state, local, and federal agencies, and the offshore wind energy industry, shall make recommendations regarding the potential impacts on coastal resources, fisheries, Native American and Indigenous peoples, and national defense. This coalition of agencies and industry must develop strategies for addressing those potential impacts.

The strategic plan chapters will also be guided by:

1. The report to evaluate and quantify the maximum feasible capacity of offshore wind to achieve reliability, ratepayer, employment, and decarbonization benefits and establish MW planning goals for 2030 and 2045, due June 1, 2022.
2. The preliminary assessment of the economic benefits of offshore wind as they relate to seaport investments and workforce development needs and standards, due December 31, 2022.
3. The permitting roadmap that describes time frames and milestones for a coordinated, comprehensive, and efficient permitting process for offshore wind energy facilities and associated electricity and transmission infrastructure off the coast of California, due December 31, 2022.

This report addresses the first product identified in AB 525 by discussing the maximum feasible capacity of offshore wind to achieve reliability, ratepayer, employment, and decarbonization benefits and establishing MW planning goals for 2030 and 2045, taking into consideration 12 factors addressed in Chapter 3 of this report. The CEC will continue to consider additional information as it becomes available to refine the maximum feasible capacity in future offshore wind plans, including the development of the AB 525-required strategic plan due in June 2023.

To establish the MW planning goals, CEC staff considered other planning initiatives for offshore wind that are already ongoing in California, including planning by non-ISO LSEs, POU IRPs and, part of the CPUC's integrated resource planning (IRP) process and the ISO's TPP. The AB 525 offshore wind MW planning goals anchor the state's strategic planning effort called for in AB 525. The AB 525 strategic plan will be an important foundation to set up IRP, the TPP, and other energy resource planning and investment decisions as they relate to procurement of offshore wind generation and transmission. To best serve this approach, the MW planning goals should reasonably exceed current IRP and TPP offshore wind assumptions, to allow flexibility as those ongoing processes continue to direct the optimal procurement for ratepayers over the coming years. The MW planning goals are not intended as a core input to IRP or TPP analysis, nor should they be seen as a "floor" or "ceiling" for offshore wind procurement in California.

This report is based on currently available information. The preliminary MW planning goals are for developing the strategic plan, as AB 525 states that nothing in the provisions of the law "is intended to create a technology set-aside or mandatory minimum for any type of eligible renewable energy resource."[34]

34 California Public Resources Code, Section 25991.7.
https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=PRC&sectionNum=25991.7.

CHAPTER 2: Evaluation and Quantification of the Maximum Feasible Capacity of Offshore Wind to Achieve Reliability, Ratepayer, Employment, and Decarbonization Benefits

This chapter addresses the AB 525 requirements to evaluate and quantify the maximum feasible capacity of offshore wind.

Existing studies of technically feasible potential provide a starting point for evaluation, but do not indicate the maximum feasible capacity because they have not been evaluated to ensure offshore wind developments will be located in areas with suitable sea space that minimize potential impacts on coastal resources, fisheries, Native American and Indigenous people, and national defense. Further analysis is also needed to improve understanding of how the feasible capacity relates to reliability, ratepayer, employment, and decarbonization benefits.

After analyses are completed, the CEC will evaluate and quantify maximum feasible capacity of offshore wind to achieve reliability, ratepayer, employment, and decarbonization benefits. As an interim measure, this report establishes a reference point for technically feasible offshore wind energy potential based on estimates of technically feasible potential repeatedly studied through the issuance of this report.

Definition of Maximum Feasible Capacity

AB 525 directs the CEC to evaluate and quantify maximum feasible capacity but does not provide a definition for "feasible." The CEC staff looked to regulations that govern the CEC proceedings and the legislative findings of AB 525 to give meaning to the term "feasible." California Code of Regulations, Title 20, section 1201(h), defines "feasible" as "capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social, and technological factors." This definition aligns with a holistic reading of AB 525 legislative findings, which focus on evaluating how California can realize development of offshore wind at utility scale but with realistic projections of what could be achieved by 2030 and 2045, considering a broad range of specified factors. For example, in AB 525, the Legislature finds and declares, "Offshore wind should be developed in a manner that protects coastal and marine ecosystems. The State of California should use its authority under state programs and policies to ensure (1) avoidance, minimization, and mitigation of significant adverse impacts, and (2) monitoring and adaptive management for offshore wind projects and their associated infrastructure."[35] The CEC staff will approach the evaluation of maximum feasible capacity based on these provisions.

California Offshore Wind Technical Potential

The California coast has relatively strong offshore winds averaging up to 10 meters per second and large resource areas with developable depth (<1,300 meters or about 4,200 feet).[36] There have been assessments of California offshore wind technical potential in federal waters, including the National Renewable Energy Laboratory (NREL)[37] and the U.S. BOEM,[38] U.C. Berkeley,[39] the Schatz Energy Research Center,[40] and the CPUC.[41] These studies explore differing amounts of offshore wind generation technical potential with differing focuses, such as supply chain economics, technology costs, levelized cost of energy, and transmission infrastructure needs. The CPUC sourced data from a U.C. Berkeley study to use for capacity expansion modeling in its 2019–2021 IRP cycle for offshore wind potential.[42]

In 2020, NREL produced a cost study for the period between 2019 and 2032. In this study, NREL selected areas with an average wind speed of at least 7 meters per second and a water depth between 40 meters and 1,300 meters. NREL selected the following five study areas for

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35 Assembly Bill 525 (Chiu, Chapter 231, Statutes of 2021).

36 Optis, Mike, Alex Rybchuk, Nicola Bodini, Michael Rossol, and Walter Musial. 2020. *2020 Offshore Wind Resource Assessment for the California Pacific Outer Continental Shelf*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-77642. https://www.nrel.gov/docs/fy21osti/77642.pdf.

37 Ibid.

38 Bureau of Ocean Energy Management. July 2021. "Area ID Memorandum: Humboldt Wind Energy Area." https://www.boem.gov/sites/default/files/documents//App.%20A%20Area%20ID%20Humboldt%20Memo%20Final.pdf. Also see, Bureau of Ocean Energy Management. November 2021, "Area ID Memorandum: Morro Bay Wind Energy Area." https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Area-ID-CA-Morro-Bay.pdf.

39 Collier, Robert, Sanderson Hull, Oluwafemi Sawyerr, Shenshen Li, Manohar Mogadali, Dan Mullen, and Arne Olson. September 2019. *California Offshore Wind: Workforce Impacts and Grid Integration*. Center for Labor Research and Education, University of California, Berkeley. https://laborcenter.berkeley.edu/pdf/2019/CA-Offshore-Wind-Workforce-Impacts-and-Grid-Integration.pdf.

40 Severy, M., C. Ortega, C. Chamberlin, and A. Jacobson. 2020. "Wind Speed Resource and Power Generation Profile Report." In M. Severy, Z. Alva, G. Chapman, M. Cheli, T. Garcia, C. Ortega, N. Salas, A. Younes, J. Zoellick, & A. Jacobson (Eds.) *California North Coast Offshore Wind Studies.* Humboldt, CA: Schatz Energy Research Center. https://schatzcenter.org/pubs/2020-OSW-R2.pdf.

41 CPUC. February 2022. *Decision Adopting 2021 Preferred System Plan*. D.22-02-004 in Rulemaking 20-05-003. https://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=451412947. Also, CPUC, February 2022, *Modeling Assumptions for the 2022–2023 Transmission Planning Process*. Staff Report. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M451/K485/451485713.PDF.

42 CPUC. November 2019. *Inputs & Assumptions: 2019-2020 Integrated Resource Planning*. https://files.cpuc.ca.gov/energy/modeling/Inputs%20%20Assumptions%202019-2020%20CPUC%20IRP%202020-02-27.pdf.

detailed cost analysis (**Figure 5**): Morro Bay (Call Area), Diablo Canyon (Call Area), Humboldt (Call Area), Cape Mendocino, and Del Norte.[43] NREL assumed commercial offshore wind development would be technically feasible in these five study areas. The potential study areas sum to more than 21,170 MW of capacity.[44]

The study areas have been identified based on wind speed, ocean depth, bottom slope, distance to grid interconnection, and distance to existing port infrastructure and are technically suitable for current technologies. They are all identified in federal waters, within the leasing jurisdiction of BOEM, and are located outside the network of existing national marine sanctuaries. However, they have not been fully examined for existing coastal and ocean uses and potential effects on those uses. The assessments of these areas indicate that they may be feasible for wind generation from a technical perspective. Due to location, the study areas differ from one another on energy cost, transmission infrastructure, and potential impact to coastal resources and existing ocean uses.

NREL offers the following information regarding these areas:

> Del Norte and Cape Mendocino are additional areas of interest that were adopted from a recent University of California Berkeley study assessing the workforce impacts and grid integration of offshore wind in California (Collier et al. 2019). These sites were derived by Collier from an earlier NREL study (Musial et al. 2016a). This study defined site-selection criteria (e.g., for wind speed, water depth, use conflicts, access to transmission, suitable ports, and distance from shore) and identified sites that met these criteria to sustain a commercial offshore wind project. Neither Collier (2019) nor Musial (2019a) vetted these areas for offshore wind development among stakeholders. These sites should not be confused with the actual BOEM Call Areas. Neither Del Norte nor Cape Mendocino have been designated by BOEM to move forward under any formal regulatory framework.[45]

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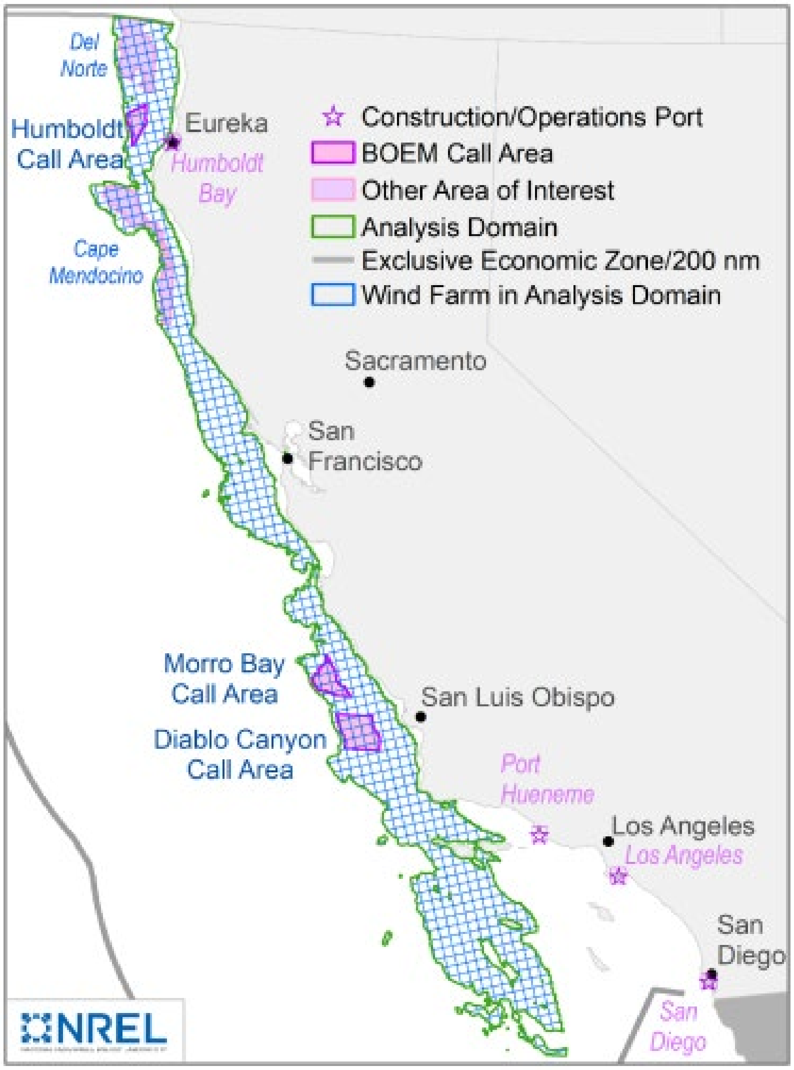
43 Beiter, Philipp, Walter Musial, Patrick Duffy, Aubryn Cooperman, Matt Shields, Donna Heimiller, and Mike Optis. 2020. *The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-77384. https://www.nrel.gov/docs/fy21osti/77384.pdf.

44 The five study areas in total include approximately 7,057 square kilometers and assumes an offshore wind turbine power density of 3 megawatts per square kilometer.

45 Beiter, Philipp, Walter Musial, Patrick Duffy, Aubryn Cooperman, Matt Shields, Donna Heimiller, and Mike Optis. 2020. *The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-77384. https://www.nrel.gov/docs/fy21osti/77384.pdf. Other studies referenced in this excerpt: Collier, Robert, Sanderson Hull, Oluwafemi Sawyerr, Shenshen Li, Manohar Mogadali, Dan Mullen, and Arne Olson. September 2019. California Offshore Wind: Workforce Impacts and Grid Integration. Center for Labor Research and Education, University of California, Berkeley. https://laborcenter.berkeley.edu/pdf/2019/CA-Offshore-Wind-Workforce-Impacts-and-Grid-Integration.pdf; Musial, Walter, Philipp Beiter, Suzanne Tegen, and Aaron Smith. December 2016a. *Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs*. NREL. Prepared under IAG No. M14PG00038; task number WFHA.1005. https://www.nrel.gov/docs/fy17osti/67414.pdf. Musial, W., P. Beiter, J. Nunemaker, D. Heimiller, J. Ahmann, and J. Busch. 2019a*. Oregon Offshore Wind Site Feasibility and Cost Study*.

Figure 5: Five Areas Studied in 2020 for Offshore Wind Technical Potential off California's Coast



Source: *The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032,* NREL, November 2020

A 2020 study by the Schatz Energy Research Center analyzed electricity generation scenarios for potential wind development in the Humboldt call area and the Cape Mendocino study area mentioned above.[46]

NREL/TP-5000-74597. National Renewable Energy Laboratory (NREL). https://www.nrel.gov/docs/fy20osti/74597.pdf.

46 Severy, M., C. Ortega, C. Chamberlin, and A. Jacobson. 2020. *Wind Speed Resource and Power Generation Profile Report*. In M. Severy, Z. Alva, G. Chapman, M. Cheli, T. Garcia, C. Ortega, N. Salas, A. Younes, J. Zoellick, and A. Jacobson (Eds.) California North Coast Offshore Wind Studies. Humboldt, CA: Schatz Energy Research Center. https://schatzcenter.org/pubs/2020-OSW-R2.pdf.

In 2021, modeling conducted for the CPUC IRP process allowed selection of offshore wind from the Humboldt, Morro Bay, and Diablo Canyon call areas. For development of the 2021 Preferred System Plan, the model did not select offshore wind capacity from the Humboldt or Diablo Canyon call areas. However, in the final busbar mapping discussed later in this chapter, 120 MW of offshore wind was relocated from the Morro Bay call area to the Humboldt call area as an "energy only" resource.[47]

In 2021, BOEM established the Humboldt wind energy area. After identifying extensions to the 2018 Morro Bay call area and conducting a call for information and nomination for these extended areas, BOEM designated the Morro Bay wind energy area.[48] The size of the Morro Bay wind energy area is larger than the 2018 Morro Bay call area that was used in the assessments described above describing technical potential. Taking this change into account brings the total from 21,170 MW to nearly 21,800 MW (21.8 GW) of offshore technical potential. In developing the wind energy areas, BOEM aimed to "balance commercial project viability with potential impacts to the human, marine, and coastal environment, including consideration of existing OCS users."[49]

The nearly 21,800 MW (21.8 GW) of studied capacity represents a reference point for technically feasible offshore wind potential based on existing studies. It does not represent the quantification of maximum feasible capacity for offshore wind. It simply represents estimated capacity of potential offshore wind capacity located in the Humboldt wind energy area, Morro Bay wind energy area, Diablo Canyon call area, and two additional areas with high wind speeds offshore Northern California. Although elements of these five areas have been repeatedly studied through 2021, additional evaluation is needed to ensure offshore wind energy developments will be located in areas with suitable sea space, whether from within these five areas or outside them, that minimize potential impacts on coastal resources, fisheries, Native American and Indigenous people, and national defense.

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47 CPUC. February 2022. Decision Adopting 2021 Preferred System Plan. D.22-02-004 in Rulemaking 20-05-003. https://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=451412947. Also, CPUC, February 2022, modeling assumptions for the 2022–2023 transmission planning process. Staff report. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M451/K485/451485713.PDF.

48 Bureau of Ocean Energy Management. July 2021. "Area ID Memorandum: Humboldt Wind Energy Area." https://www.boem.gov/sites/default/files/documents//App.%20A%20Area%20ID%20Humboldt%20Memo%20Final.pdf. Also see, Bureau of Ocean Energy Management. November 2021. "Area ID Memorandum: Morro Bay Wind Energy Area." https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Area-ID-CA-Morro-Bay.pdf.

49 For example, a summary of data, resources, and stakeholder comments informing identification of the Morro Bay wind energy area is included in Bureau of Ocean Energy Management's November 2021, "Area ID Memorandum: Morro Bay Wind Energy Area." https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Area-ID-CA-Morro-Bay.pdf.

Achieving Reliability, Ratepayer, Employment, and Decarbonization Benefits

To evaluate and quantify the feasible capacity of offshore wind off California's coast to achieve reliability, ratepayer, employment, and decarbonization benefits, the CEC staff reviewed existing publications and research. Some of the reports, studies, and sources of information include:

- Studies by NREL[50] and the U.S. Department of Energy.[51]
- Resources from the CPUC's IRP process and 2021 Preferred System Plan.[52]
- Materials from the August 27, 2020, CPUC webinar on offshore wind resource profile and technology costs,[53] as well as the December 17, 2021, CPUC Planning Workshop on the Roadmap for Offshore Wind in Integrated Resource Planning.[54]
- A study by the ISO of the CPUC's Offshore Wind Policy-Driven Sensitivity Portfolio for the 2021–22 transmission planning process.[55]
- The *2021 SB 100 Joint Agency Report.*[56]

These studies and other literature referenced in this report indicate that California has some of the best offshore wind energy resources in the world and there is a large technical potential off the state's coast. Costs for deploying floating offshore wind are expected to continue to

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50 Such as National Renewable Energy Laboratory. December 2016. *Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs*. https://www.nrel.gov/docs/fy17osti/67414.pdf; and Beiter, Philipp, Walter Musial, Patrick Duffy, Aubryn Cooperman, Matt Shields, Donna Heimiller, and Mike Optis. 2020. *The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-77384. https://www.nrel.gov/docs/fy21osti/77384.pdf;

51 Musial, Walter, Paul Spitsen, Philipp Beiter, Patrick Duffy, Melinda Marquis, Aubryn Cooperman, Rob Hammond, and Matt Shields. 2021. *Offshore Wind Market Report: 2021 Edition*. Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. https://www.energy.gov/sites/default/files/2021-08/Offshore%20Wind%20Market%20Report%202021%20Edition_Final.pdf.

52 CPUC. February 2022. Decision Adopting 2021 Preferred System Plan. D.22-02-004 in Rulemaking 20-05-003. https://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=451412947. Also, CPUC, February 2022, modeling assumptions for the 2022–2023 transmission planning process. Staff report. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M451/K485/451485713.PDF.

53 CPUC IRP Modeling Advisory Group. Webinar 5 – 8/27/2020 – Offshore Wind Resource Profile and Technology Costs. Presentation slides and webinar recording available online at https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-power-procurement/long-term-procurement-planning/2019-20-irp-events-and-materials.

54 CPUC IRP Webinar – 12/17/2021 – IRP Offshore Wind Roadmap Workshop. Presentation slides and webinar recording available online at https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-power-procurement/long-term-procurement-planning/2022-irp-cycle-events-and-materials.

55 California ISO. March 2022. *2021–2022 Transmission Plan*. http://www.caiso.com/InitiativeDocuments/ISOBoardApproved-2021-2022TransmissionPlan.pdf.

56 CEC, CPUC, and California Air Resources Board. 2021. *2021 SB 100 Joint Agency Report Achieving 100 Percent Clean Electricity in California: An Initial Assessment.* https://efiling.energy.ca.gov/EFiling/GetFile.aspx?tn=237167&DocumentContentId=70349.

decrease as floating technology becomes more mainstream throughout the world. Offshore wind can also strengthen system reliability (by increasing the average amount of renewable electricity generation available in the early evening hours as solar generation begins to decline) and help save on overall system costs as California moves to meet the SB 100 clean energy goals. Also, development of offshore wind can create thousands of new high-quality clean energy jobs in California.[57]

CEC staff noted that the CPUC IRP process is required to simplify the planning and procurement by its jurisdictional load-serving entities to meet the state's long-term decarbonization objectives reliably and at least cost to ratepayers. Accordingly, the CPUC IRP process and the partner process, the ISO's TPP, already have planners and stakeholders in California assessing the reliability, ratepayer, and decarbonization benefits of offshore wind. The methods and input data to do so can be considered part of assessing the maximum feasible capacity.

The requirement of AB 525 to also consider employment benefits goes beyond the scope of the CPUC IRP process and ISO TPP. The CEC staff discusses information sources to address this in this section.

Reliability Benefits

Moving to zero-carbon resources is critical to reducing greenhouse gas emissions and addressing the long-term impacts of climate change. Many of these sources do not operate on demand like traditional fossil-fuel generation or as baseload resource such as geothermal. They require more agile management of generation on the grid, greater coordination in the electricity market, and improved resource planning.

Offshore wind turbines are an attractive technology from a system planning perspective due to the high-capacity factor and associated generation profile that complements solar daily and seasonally. These turbines can provide more consistent output during the winter months when solar production is lower.[58] While there is a significant resource potential off the California coast, there are also considerable barriers. Among the foremost challenges are significant anticipated transmission requirements and competing coastal uses, including shipping, fishing, recreation, marine conservation, and Department of Defense activities. These topics will be addressed in the strategic plan.

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57 American Jobs Project. February 2019. *The California Offshore Wind Project: A Vision for Industry Growth*. http://americanjobsproject.us/wp/wp-content/uploads/2019/02/The-California-Offshore-Wind-Project.pdf. Additional job growth estimates are summarized and compared in Rose, A., D. Wei, and A. Einbinder. 2021. *California's Offshore Wind Electricity Opportunity*. Schwarzenegger Institute for State and Global Policy. http://schwarzeneggerinstitute.com/images/files/OSW_Report.pdf.

58 National Renewable Energy Laboratory. December 2016. *Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs*. https://www.nrel.gov/docs/fy17osti/67414.pdf.

In 2020, Schatz Energy Research Center studied the wind speed resource and power generation profiles off Humboldt Bay, California.[59] This study modeled wind development ranging from 50 MW to 1,800 MW in two locations: the 2018 BOEM Humboldt call area and a second location off Cape Mendocino. The analysis of the wind speed patterns for this study in Northern California shows that wind energy will frequently produce power at the rated capacity. The study provided information on average generation profiles, which appear fairly flat throughout the day, as well as the large seasonal variability of this wind resource. Modeling results for a hypothetical wind development scenario showed no electricity generation for 19 percent of the year (1,670 hours).

This information suggests that while offshore wind does complement solar daily and seasonally and blows more consistently over time than onshore wind, there is still significant variability that may make grid integration a challenge. Studies as part of the CPUC IRP process consider how offshore wind energy generation at specific locations fit with systemwide electrical demand, and the role of other resource types including energy storage to support the integration of offshore wind reliably.

Ratepayer Benefits

CEC staff continues to work closely with the CPUC and the ISO to evaluate offshore wind as part of California's renewable energy portfolio and as part of the portfolio of eligible renewable energy and zero-carbon resources to meet the energy goals of SB 100. The ISO's TPP, which results in an annual transmission plan, is a key route for ensuring development of the transmission needs in California to accommodate offshore wind resources. The TPP is based upon the state's demand forecasts, GHG emissions reductions targets, and a portfolio of future generation and storage resources that minimizes ratepayer costs. Integration of the CPUC IRP and the ISO TPP ensures that ratepayer costs are fully considered.

CPUC's IRP process also ensures implementation of the Senate Bill 350 (De León, Chapter 547, Statutes of 2015) requirements to ensure that load-serving entities (LSEs) meet targets that allow the electricity sector to contribute to California's economywide greenhouse gas emissions reductions goals.

The CPUC included offshore wind as a candidate resource in its integrated resource planning process for the first time as part of the 2019–2021 IRP cycle. The cycle concluded with the CPUC adopting its 2021 Preferred System Plan, which included 195 MW of offshore wind generation by 2030 and a cumulative 1.7 GW of offshore wind generation by 2032. The development of the preferred system plan involved a combination of planning by LSEs (selecting 195 MW by 2030) and capacity expansion modeling by CPUC staff (selecting the additional 1.5 GW by 2032). Partly due to "lack of available transmission in the Humboldt

59 Severy, M., C. Ortega, C. Chamberlin, and A. Jacobson. 2020. *Wind Speed Resource and Power Generation Profile Report*. In M. Severy, Z. Alva, G. Chapman, M. Cheli, T. Garcia, C. Ortega, N. Salas, A. Younes, J. Zoellick, and A. Jacobson (Eds.). California North Coast Offshore Wind Studies. Humboldt, CA: Schatz Energy Research

area"[60] and the length of time needed to build new transmission, the process to map resources to specific busbars (substations) proposed interconnecting all the offshore wind at Morro Bay. However, in response to comments from the Redwood Coast Energy Authority recommending the CPUC map "100–150 MW of offshore wind to the Humboldt area as energy only resources,"[61] the CPUC "remapped 120 MW of offshore wind to Humboldt from Morro Bay" in the busbar mapping[62] transmitted to the ISO.[63]

To develop cost input assumptions for the IRP, the CPUC worked with NREL to study the trajectory for the levelized cost of energy (LCOE) for offshore wind. A goal of this 2020 NREL cost study, *The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032,* is to "provide cost and performance data that can help state energy analysts evaluate how offshore wind can become part of California's future energy mix from a reliability, greenhouse-gas emissions, and economic perspective."[64] The CPUC IRP process can assess resources at varying levels of geographic detail. For offshore wind, the IRP process distinguishes among five zones that correspond to the study areas in the 2020 NREL cost study. Costs and performance of floating offshore wind are evaluated for those specific locations.

This 2020 NREL cost study[65] provides the following key information to help assess the maximum feasibility of offshore wind related ratepayer benefits:

- "Floating offshore wind technology, which is required for the deep waters along the California coast, is currently in a precommercial phase, with approximately 84 MW installed worldwide at the end of 2019. In Europe there are more than 292 MW of new pilot projects scheduled to be operating by the end of 2022, and the first large-scale commercial projects are already in the permitting phase in Asia and scheduled for operation in 2024. This pace of floating wind technology advancements and commercial development indicates that commercial floating arrays may be technically feasible in California's market as early as the mid-2020s."
- For offshore wind development in the five study areas with commercial operation dates between 2019 and 2032, NREL estimated the LCOE will decline by 44 percent on

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60 CPUC. February 2022. *Modeling Assumptions for the 2022–2023 Transmission Planning Process*. Staff report. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M451/K485/451485713.PDF. Page 13.

61 CPUC. February 2022. Decision Adopting 2021 Preferred System Plan. D.22-02-004 in Rulemaking 20-05-003. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M451/K412/451412947.PDF. Page 174.

62 "Busbar mapping" is the process of refining the geographically coarse portfolios produced in CPUC's IRP proceeding into plausible network modeling locations for transmission analysis in the ISO's annual TPP.

63 CPUC. February 2022. *Modeling Assumptions for the 2022-2023 Transmission Planning Process*. Staff report. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M451/K485/451485713.PDF. Page 70.

64 Beiter, Philipp, Walter Musial, Patrick Duffy, Aubryn Cooperman, Matt Shields, Donna Heimiller, and Mike Optis. 2020. *The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032.* Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-77384. https://www.nrel.gov/docs/fy21osti/77384.pdf.

65 Ibid.

average. NREL estimated the LCOE in the five study areas will reach $53/MWh–$64/MWh by 2032.

- The baseline costs for a commercial scale floating offshore wind power plant are projected to decrease because of three factors:
  - Experiential learning within the industry
  - Economies of scale realized through higher capacity turbines and larger projects
  - Impact of technological innovations

The NREL 2021 Annual Technology Baseline (ATB) for Offshore Wind,[66] which examines the future costs for three technology innovation scenarios, includes a conservative, a moderate, and an advanced technology scenario, which are outlined in **Table 1**. For developing the strategic plan, the CEC is considering the range of technology scenarios and will examine, among other sources, the moderate and advanced scenarios, which align best with the assumptions used in the state's approach to offshore wind. Under the moderate scenario, assumptions for representative technology include a 15-MW turbine mounted on a floating substructure using improved and highly tailored technology and materials. The turbine system is installed and operated using greatly enhanced port infrastructure and vessel capabilities relative to what exists today. Under the NREL advanced scenario, an 18-MW turbine would be mounted on a floating substructure using next-generation technology and materials, port infrastructure, and vessel capabilities. Efficiency gains are achieved through accelerated standardization, large economies of scale, and fiercely increased competition.

Under both scenarios, the levelized cost of energy for offshore wind generation is projected to continue to drop, primarily due to increasing capability and efficiency of the supply chain to support offshore wind and economies of turbine size and offshore generation facility scale. **Figure 6** shows the modeled levelized cost of energy based on the technology innovation scenarios in **Table 1**. The continual technology improvements over time and the sustained rate of cost reductions suggest that a high range of MW planning goals can be supported in the 2045–2050 time frame.

66 "Annual Technology Baseline, Electricity, Offshore Wind, National Renewable Energy Laboratory, 2021." https://atb.nrel.gov/electricity/2021/offshore_wind.

Table 1: Turbine Technology Details by Scenario From the NREL ATB

	Base 2019	Conservative 2030	Moderate 2030	Advanced 2030
Hub height m	100	136	150	161
Number of turbines [-]	167	84	67	56
Rotor diameter m	150	214	240	263
Specific power W/m2	340	334	332	331
Turbine rating MW	6	12	15	18

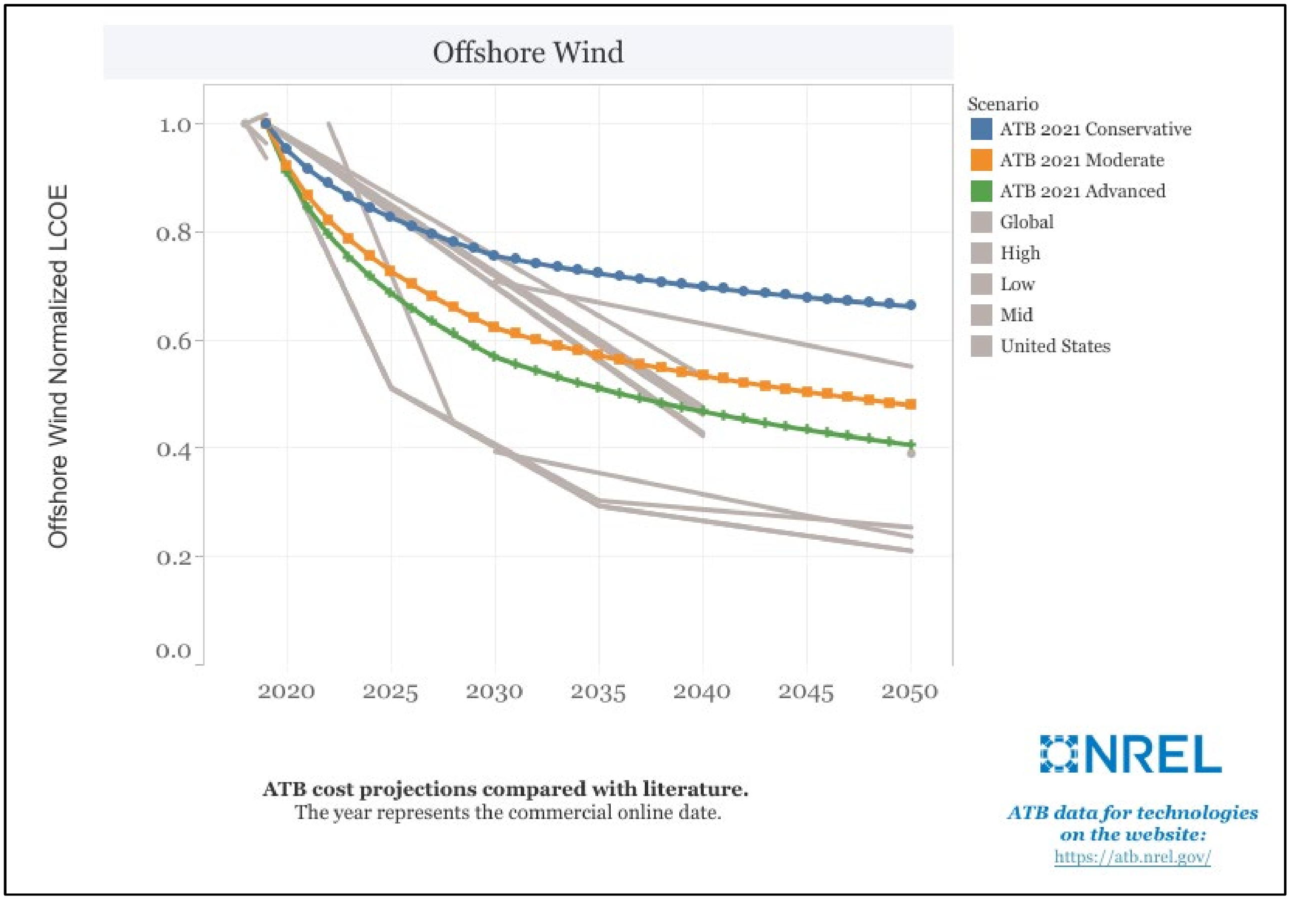
m=meter
W=watt
MW=megawatt

NREL

ATB data for technologies on the website: https://atb.nrel.gov/

Source: NREL 2021 Annual Technology Baseline (ATB) for Offshore Wind

Figure 6: Modeled LCOE Scenario Results for the NREL Scenarios Discussed Above, Compared With Literature Projections



Source: NREL 2021 Annual Technology Baseline (ATB) for Offshore Wind

The ISO TPP provides a comprehensive evaluation of the ISO transmission grid to address grid reliability requirements, identify upgrades needed to successfully meet California's policy goals, and explore projects that can bring economic benefits to consumers. The 10-year ISO transmission plan is updated annually and relies heavily on key inputs from state agencies in translating legislative policy into actionable policy-driven inputs, including the CEC's *Integrated Energy Policy Report*, demand forecast, energy planning products, and the CPUC's IRP process. The ISO studies the base case portfolio adopted by the CPUC as part of its IRP process to evaluate and potentially approve new transmission infrastructure and upgrades to the existing system that are required to meet reliability standards and minimize ratepayer costs. The ISO also examines sensitivity and policy portfolios requested by the CPUC and performs special transmission studies.

In March 2022, the ISO approved a 10-year transmission plan that identified 23 transmission projects at an estimated cost of $2.9 billion for system expansions, upgrades, and reinforcements needed for reliability and to meet the state's clean energy targets. This *2021–2022 Transmission Plan* also included an informational sensitivity study with estimates of potential overland and subsea transmission pathways off the California coast. The ISO's *2021-*

2022 Transmission Plan provides a valuable high-level overview of the transmission needs for development of 21 GW of potential offshore wind generation, including 14.4 GW from California's North Coast and 6.7 GW from California's Central Coast.[67]

Employment Benefits

In adopting AB 525, the Legislature found that offshore wind energy development presents an opportunity to attract investment capital and realize community, economic, and workforce development benefits in California.[68] Among others, these benefits include the development and preservation of a skilled and trained construction workforce to carry out projects, long-term job creation, and development of an offshore wind energy supply chain.

The largest economic benefits for California from an offshore wind industry would be realized with the development of a local supply chain where offshore wind components such as floating platforms, towers, mooring lines, and anchors could be manufactured in-state. A University of Southern California (USC) Schwarzenegger Institute for State and Global Policy study published in 2021 compared scenarios with different levels of in-state manufacturing of offshore wind farm components. The study found that scenarios with higher in-state manufacturing substantially increased projected employment and economic benefits to California from offshore wind development.[69] To encourage development of a local supply chain, a sufficient offshore wind pipeline needs to be identified to provide confidence in the market and support early investment. According to a study conducted by the U.C. Berkeley Center for Labor Research and Education, industry has identified a minimum threshold of 8 GW over a 10-year period to support manufacturing and supply chain investments. Without a minimum threshold of 8 GW over a 10-year period, manufacturers would be less likely to invest in a local supply chain, and the economic benefits would be far less significant.[70]

Based on currently available information, a minimum of 8 GW of offshore wind over the next decade should be considered for maximizing the achievable offshore wind economic benefits. As required by AB 525, a preliminary economic assessment including an analysis of the workforce development needs for a California offshore wind industry will be completed by the CEC on or before December 31, 2022. The economic assessment will provide additional insight into the employment opportunities and benefits of a robust offshore wind industry in California.

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67 California ISO. March 2022. *2021–2022 Transmission Plan*. http://www.caiso.com/InitiativeDocuments/ISOBoardApproved-2021-2022TransmissionPlan.pdf.

68 Assembly Bill 525 (Chiu, Chapter 231, Statutes of 2021).

69 Rose, A., D. Wei, and A. Einbinder. 2021. *California's Offshore Wind Electricity Opportunity*. Schwarzenegger Institute for State and Global Policy. http://schwarzeneggerinstitute.com/images/files/OSW_Report.pdf.

70 Collier, Robert, Sanderson Hull, Oluwafemi Sawyerr, Shenshen Li, Manohar Mogadali, Dan Mullen, and Arne Olson. *California Offshore Wind: Workforce Impacts and Grid Integration*. Center for Labor Research and Education, University of California, Berkeley. September 2019. https://laborcenter.berkeley.edu/pdf/2019/CA-Offshore-Wind-Workforce-Impacts-and-Grid-Integration.pdf.

Decarbonization Benefits

Meeting the state's decarbonization goals will require significant modernization of the current electric system, including diversifying the energy mix. The *SB 100 Joint Agency Report* assessed how California should approach achieving the goals established by the 100 Percent Clean Energy Act of 2018. Portfolio modeling completed for the *2021 SB 100 Joint Agency Report* included a new assumption of 10 GW of offshore wind resource potential available in the RESOLVE model by 2045. In the resulting analysis, the RESOLVE model selected all 10 GW of offshore wind for the SB 100 Core Scenario.

Similarly, the CPUC found that offshore wind has a significant place in the 2021 Preferred System Plan by 2032. It is likely that the capacity expansion modeling used to arrive at this finding selected offshore wind because of the contribution to decarbonization, as well as reliability.

Offshore wind energy has the potential to be a valuable resource as the generation profile can complement solar. On average, offshore wind continues to generate electricity as solar generation drops off in the evening.[71] In addition to being a renewable generation resource, including offshore wind in the state's energy portfolio may help California reduce the use of gas-fired power plants in the evening hours, helping reduce greenhouse gas emissions and maintain system reliability during net peak.[72] Using a capacity factor of 5.1 percent and a heat rate of 10,450 Btu/kWh,[73] a study by the USC Schwarzenegger Institute for State and Global Policy estimated that if 5 GW of gas peaking capacity can be replaced with the deployment of 10 GW of offshore wind, this scenario could result in a potential reduction of 4.73 million metric tons of carbon dioxide equivalent greenhouse gases in 2040.[74]

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71 Optis, Mike, Alex Rybchuk, Nicola Bodini, Michael Rossol, and Walter Musial. 2020. *2020 Offshore Wind Resource Assessment for the California Pacific Outer Continental Shelf*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-77642. https://www.nrel.gov/docs/fy21osti/77642.pdf.

72 California Energy Commission. May 2021. "A Peek at Net Peak." https://www.energy.ca.gov/data-reports/energy-insights/peek-net-peak.

73 Nyberg, Michael. 2020. *Thermal Efficiency of Natural Gas-Fired Generation in California: 2019 Update*. California Energy Commission. Publication Number: CEC-200-2020-003. https://efiling.energy.ca.gov/getdocument.aspx?tn=233380.

74 Rose, A., D. Wei, and A. Einbinder. 2021. *California's Offshore Wind Electricity Opportunity*. Schwarzenegger Institute for State and Global Policy. http://schwarzeneggerinstitute.com/images/files/OSW_Report.pdf.

CHAPTER 3: Megawatt Offshore Wind Planning Goals for 2030 and 2045

As discussed above, AB 525 requires the CEC, on or before June 1, 2022, to evaluate and quantify the maximum feasible capacity of offshore wind to achieve reliability, ratepayer, employment, and decarbonization benefits and establish offshore wind MW planning goals for 2030 and 2045. This chapter addresses the second requirement to establish MW planning goals for 2030 and 2045.

In establishing the MW planning goals, the CEC is required to consider:

1. The findings of the *2021 SB 100 Joint Agency Report.*
2. The need to develop a skilled and trained offshore wind workforce.
3. The potential to attract supply-chain manufacturing for offshore wind components throughout the Pacific region.
4. The need for reliable renewable energy that accommodates California's shifting peak load.
5. The generation profile of offshore wind off the California coast.
6. The need for economies of scale to reduce the costs of floating offshore wind.
7. The need to initiate long-term transmission and infrastructure planning to expedite delivery of offshore wind energy to Californians.
8. The availability of federal tax incentives for offshore wind investments.
9. The National Renewable Energy Laboratory report finding that California has 200 GW of offshore wind technical power potential.
10. The opportunity for California to participate in the federal government's intention to deploy 30,000 MW of offshore wind by 2030 and create a pathway to unlocking 110,000 MW by 2050.
11. Any executive action from the Governor regarding offshore wind.
12. Potential impacts on coastal resources, fisheries, Native American and Indigenous peoples, and national defense, and strategies for addressing those potential impacts.

During the March 3, 2022, workshop, CEC staff explained that only certain factors are likely to have greater influence on or directly influence shaping the MW planning goals than others, though all the factors are important in establishing the goals and contributing to development of the specific plan.

The factors of particular importance are as follows, and they are given greater attention in the discussion below than the remaining factors:

1. The findings of the *2021 SB 100 Joint Agency Report*
2. The need to initiate long-term transmission and infrastructure planning to expedite delivery of offshore wind energy to Californians
3. The need for reliable renewable energy that accommodates California's shifting peak load
4. The generation profile of offshore wind off the California coast
5. Potential impacts on coastal resources, fisheries, Native American and Indigenous peoples, and national defense, and strategies for addressing those potential impacts

As described in the chapter above regarding maximum feasible capacity, the offshore wind MW planning goals presented in this report have not considered potential impacts. CEC staff will consider the potential impacts described in Number 5 above during development of the strategic plan, including strategies to address those potential impacts.

Factors Considered in Establishing Offshore Wind Megawatt Planning Goals

The legislative factors for consideration in establishing the MW planning goals are discussed in this section.

Findings of the *2021 SB 100 Joint Agency Report*

As previously discussed, resource modeling completed for the *2021 SB 100 Joint Agency Report* covered a range of scenarios and technologies. In the Core Scenario, the modeling used a built-in assumption that 10 GW of offshore wind are available and were selected in the 2045 portfolio. The *SB 100 Joint Agency Report* also acknowledges that there are additional investments and actions that would have to occur to realize 10 GW of offshore wind by 2045.

The SB 100 report and modeling guide the offshore wind MW planning goals, indicating that with additional actions and investments to address challenges such as transmission and competing coastal uses, a minimum of 10 GW of offshore wind could meaningfully support reaching the SB 100 goals by 2045.

The Need to Initiate Long-Term Transmission Planning

Both the availability of existing transmission and the need to develop more transmission capacity in specific areas affect the offshore wind MW planning goals the CEC establishes and what the state can expect to achieve over time. The development of a comprehensive transmission capacity expansion plan can help establish an efficient and economic path for offshore wind transmission development to deliver offshore wind energy to Californians.

The North Coast electric system is relatively isolated from the California grid and serves primarily local community needs. Additional transmission will be needed to deliver offshore wind energy from this region to the grid, and there may be opportunities to coordinate transmission planning for offshore wind generation from California's Northern Coast and the larger Pacific Northwest.[75] Existing transmission on the South-Central Coast is robust and interconnects with the grid near large load centers. Near-term generation retirements, such as 2,225 MW from the Diablo Canyon Nuclear Power Plant, provide opportunities to repurpose existing infrastructure.[76] But there is still a need to do long-term planning for both the at-sea infrastructure and the ability to use existing onshore infrastructure. Ongoing efforts to guide transmission planning and recently completed studies were used to inform the MW planning goals and will support development of the overall strategic plan.

As discussed in Chapter 2, the CPUC's 2021 Preferred System Plan for the IRP included 1.7 GW of offshore wind generation by 2032.[77] This capacity was found by the CPUC to be the optimal amount and timing for offshore wind to come on-line, along with the other new resources needed to meet the state's emissions reduction goals reliably at least cost to ratepayers. Most of the 1.7 GW is expected to interconnect at Morro Bay, with only 120 MW expected to come from the North Coast,[78] where there is a greater potential for offshore wind electricity generation due to higher annual wind speeds. The CPUC regularly updates the IRP, and a new IRP cycle that includes refreshed inputs and assumptions for capacity expansion modeling has begun in 2022.

In March 2022, the ISO Board approved a 10-year transmission plan with significant new investment, specifically 23 transmission projects with an estimated $2.9 billion cost that will reinforce the system for reliability and help meet the state's clean energy targets. This *2021–2022 Transmission Plan* also includes a sensitivity study that provides information on the estimated costs for potential overland and subsea transmission pathways for offshore off the California coast.[79] The ISO provided a high-level discussion of 21 GW of potential offshore

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75 California Independent System Operator. March 2022. *2021–2022 Transmission Plan*. http://www.caiso.com/InitiativeDocuments/ISOBoardApproved-2021-2022TransmissionPlan.pdf. Page 30.

The CEC is initiating additional transmission studies in partnership with the State of Oregon and the Department of Defense to explore additional North Coast transmission challenges and opportunities. This study will further support development of the strategic plan. U.S. Department of Defense. August 31, 2021. "Notice of Award: Northern California & Southern Oregon Mission Compatibility and Transmission Infrastructure Assessment." Office of Local Defense Community Cooperation. https://www.energy.ca.gov/filebrowser/download/3709.

76 The ISO notes that the owners of the Diablo Canyon Power Plant retain certain deliverability retention options for repowering that can remain in effect for three years following retirement. California Independent System Operator. March 2022. *2021–2022 Transmission Plan*. http://www.caiso.com/InitiativeDocuments/ISOBoardApproved-2021-2022TransmissionPlan.pdf. Page 30.

77 CPUC. February 2022. Decision Adopting 2021 Preferred System Plan. D.22-02-004 in Rulemaking 20-05-003. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M451/K412/451412947.PDF.

78 The CPUC's 2021 Preferred System Plan includes 1.7 GW of offshore wind interconnecting at Morro Bay; however, in response to comments from the Redwood Coast Energy Authority, the CPUC remapped 120 MW of offshore wind from Morro Bay to Humboldt in the busbar mapping submitted to the ISO. CPUC. February 2022. *Modeling Assumptions for the 2022–2023 Transmission Planning Process*. Staff report. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M451/K485/451485713.PDF. Page 70.

79 California Independent System Operator. March 2022. *2021–2022 Transmission Plan.* http://www.caiso.com/InitiativeDocuments/ISOBoardApproved-2021-2022TransmissionPlan.pdf.

wind generation, including 14.4 GW from California's North Coast and 6.7 GW from California's Central Coast.[80]

For the North Coast, the ISO identified costs and benefits of three transmission projects and technologies that could be used to bring 1.6 GW south to the San Francisco Bay Area, as well as 12.8 GW of additional offshore wind that was considered as part of a long-term "outlook assessment."

For the Central Coast, the ISO identified costs of alternative technologies that could transfer offshore wind to load from the Diablo Canyon and Morro Bay areas. This analysis recognized the need for a new 500 kV substation to manage the 2.3 GW of offshore wind being modeled for a Morro Bay interconnection. The ISO also confirmed that the existing transmission system in the Central Coast area can accommodate about 5.3 GW of offshore wind, noting that the Diablo Canyon Power Plant will be retiring by the end of 2025 and that gas-fired generation at Morro Bay has already retired.

In May 2022 the ISO also published its first *20-Year Transmission Outlook*, in which the ISO explored transmission options for 10 GW of potential offshore wind development that was identified in the SB 100 starting point scenario for 2040.[81] The outlook assumes 4 GW from the North Coast offshore areas and 6 GW from the Central Coast offshore areas. This study identified three transmission technologies with the potential to combine output from several North Coast offshore wind projects.[82] This study estimated transmission costs of $5.9 billion to $8.1 billion, including: [83]

- 4 GW from North Coast offshore wind could be connected to the ISO bulk transmission grid by 2040 at a cost of $5.8 billion to $8.0 billion.
- 6 GW from the Central Coast could be connected to the ISO bulk transmission grid by 2040 at a cost of $110 million.

As requested by the CPUC, the ISO's *2021–2022 Transmission Plan* included a sensitivity analysis "to test the transmission implications if barriers were to be removed to large-scale development of OSW."[84] For 8.3 GW of offshore wind by 2031, the ISO identified four interconnection options. Including network upgrades, the cost ranged from $2.8 billion to

80 California Independent System Operator. March 2022. *2021–2022 Transmission Plan.* http://www.caiso.com/InitiativeDocuments/ISOBoardApproved-2021-2022TransmissionPlan.pdf. Page 220.

81 California Energy Commission, California Public Utilities Commission, and California Independent System Operator. September 2021. "SB 100 Starting Point for the CAISO 20-Year Transmission Outlook." https://efiling.energy.ca.gov/GetDocument.aspx?tn=239685&DocumentContentId=73101.

82 California Independent System Operator. May 2022. *20-Year Transmission Outlook.* http://www.caiso.com/InitiativeDocuments/Draft20-YearTransmissionOutlook.pdf.

83 Ibid.

84 CPUC. February 11, 2021. Decision Transferring Electric Resource Portfolios to California Independent System Operator for 2021–2022 Transmission Planning Process. Decision 21-02-008 in Rulemaking 20-05-003. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M366/K426/366426300.PDF.

nearly $6 billion. This analysis included potential North Coast and Central Coast offshore wind generation from the following offshore wind call areas:

- 1.6 GW from the Humboldt Bay area
- 2.3 GW from the Morro Bay area
- 4.4 GW from the Diablo Canyon area

Table 2 lists the five potential offshore wind areas considered by the ISO and the two BOEM WEAs in federal waters off the California coast. The authors emphasize that AB 525 requires the CEC to assess the potential impacts on national defense and strategies for addressing those potential impacts. CEC staff is aware that federal waters off of the Central Coast of California are important to the Department of Defense's (DOD) mission. During development of the strategic plan, the CEC will continue collaborating with DOD and stakeholders to identify potential opportunities for suitable sea space off the Central Coast.

In addition to ongoing work at the CPUC and the ISO, the Schatz Energy Research Center at Cal Poly Humboldt (formerly Humboldt State University) assessed infrastructure for the North Coast. The North Coast assessment evaluated project scenarios ranging from 140 MW to 480 MW by 2030. The study found that a small commercial offshore wind farm, up to 170 MW, could be developed without upgrading the transmission system by allowing some curtailment (estimated at 4 to 6 percent of the time in 2030); however, larger projects would require significant investments in transmission upgrades.[85]

85 Schatz Energy Research Center. July 2021. "Offshore Wind on California's North Coast." Presentation. CEC Docket: 21-IEPR-05, TN# 239028. https://efiling.energy.ca.gov/GetDocument.aspx?tn=239028&DocumentContentId=72461.

Table 2: Federal Offshore Wind Energy Areas and Other Areas Considered in the ISO Studies by California Offshore Region (From North to South)

Area Name	General Region	Potential Electricity Generation Capacity (GW) Considered in the ISO Studies (January 2022)[86]	Potential Capacity (GW) of BOEM Wind Energy Areas[87]
Del Norte	Northern Coast	6.6	
Humboldt	Northern Coast	1.6	1.6
Cape Mendocino	Northern Coast	6.2	
Morro Bay	Central Coast	2.3	2.9
Diablo Canyon	Central Coast	4.4	

Source: California ISO and BOEM

The CPUC IRP and the ISO TPP examine the energy resources by location and technology and identify the transmission infrastructure and infrastructure upgrades needed to achieve the state's climate and energy goals. They are designed to ensure that the energy system is developed and operated cost-effectively while ensuring system reliability. As such, the outputs from these planning processes provide key information to advise the maximum feasible capacity of offshore wind the state can expect to achieve by 2045 and MW planning goals for 2030 and 2045. The development of new transmission capacity has been identified as necessary to moving offshore wind power from the North Coast to California load centers. The IRP and TPP information discussed above do not correspond directly with the 2030- and 2045-time frames required by AB 525 for the offshore wind MW planning goals. However, the information can guide the MW planning goals as follows: for 2030, it is prudent to plan for more than the current adopted 2032 IRP amount of offshore wind of 1.7 GW, potentially up to about 5 GW, which is what can be accommodated on existing transmission. Beyond this amount appears infeasible from a transmission perspective by 2030. For 2045, there is much greater possibility of achieving some or all of the transmission upgrades examined by the ISO. This possibility suggests the CEC may consider establishing a minimum MW planning goal for 2045 ranging from 10 GW to 14.3 GW (informed by both the ISO *2021–22 Transmission Plan* and the ISO 20-year Transmission Outlook).

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86 California Independent System Operator. March 2022. *2021–2022 Transmission Plan.* http://www.caiso.com/InitiativeDocuments/ISOBoardApproved-2021-2022TransmissionPlan.pdf

87 U.S. Department of the Interior, Bureau of Ocean Energy Management. January 24, 2022. *Consistency Determination for Leasing Wind Energy Areas Offshore Humboldt County, California*. https://documents.coastal.ca.gov/assets/upcoming-projects/offshore-wind/Humboldt-CD.pdf.

U.S. Department of the Interior. November 10, 2021. "Central California Area Identification Pursuant to 30 C.F.R § 585.211(b)." https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Area-ID-CA-Morro-Bay.pdf.

Need for Renewable Energy to Accommodate California's Shifting Peak Load

On average, California's daily net-peak load is shifting to later into the evening hours when solar generation is substantially diminished or nonexistent.[88] This shift is creating a need for renewable energy sources that continue to generate electricity later into the evening hours. The profile of offshore wind on the North Coast on an average day complements solar resources. The profile for the Central Coast is similar to the North Coast, but there are differences across times of day, season, and total wind resource potential.

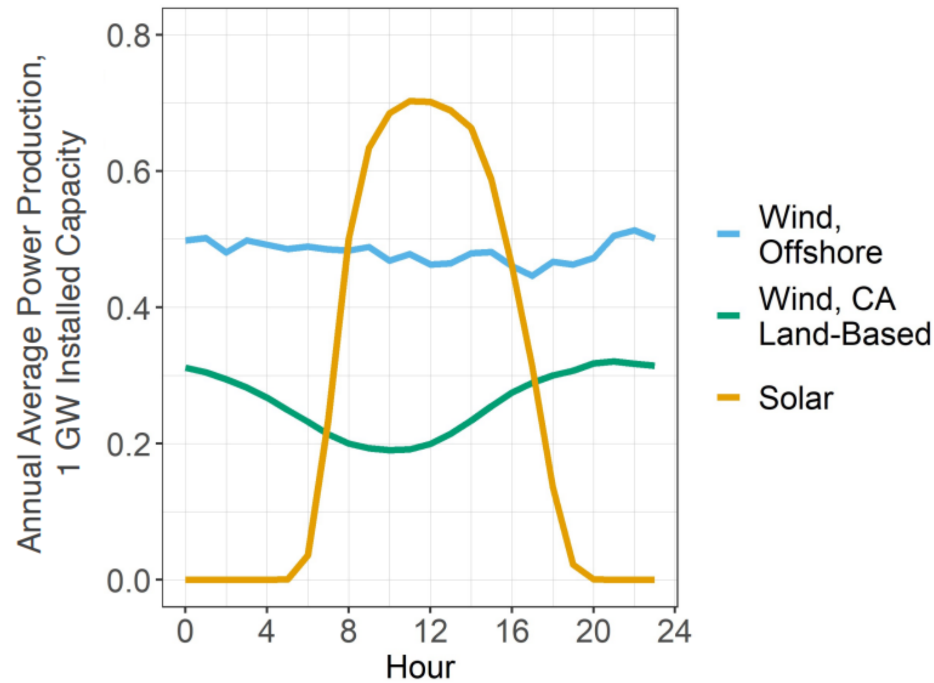
Offshore wind is an attractive technology from a system planning perspective due to the associated generation potential profile that complements solar, with higher output in the evenings, when electricity demand is high and solar production is low. Offshore wind also complements solar in the winter season and can provide more consistent output during winter months when solar production is lower. Furthermore, a recent CPUC published study, *Regional Wind Effective Load Carrying Capability Study Results for 2024*, shows offshore wind has a higher average capacity factor, with steady energy production throughout summer months, compared to land-based wind resources, which decline in total output.[89]

Figure 7 shows that the time of generation of offshore wind can be a useful complement to solar and land-based wind, generating later into the evening hours when solar generation declines.

88 Erne, David, Mark Kootstra, Tom Flynn, Christopher McLean, Angela Tanghetti, and Stephanie Bailey. 2022. *Final 2021 Integrated Energy Policy Report, Volume II: Ensuring Reliability in a Changing Climate*. California Energy Commission. Publication Number: CEC-100- 2021-001-V2. https://efiling.energy.ca.gov/GetDocument.aspx?tn=241583.

89 CPUC. June 1, 2022. *Energy Division Study for Proceeding R.21-10-002. Regional Wind Effective Load Carrying Capability Study Results for 2024*. https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M482/K148/482148586.PDF.

Figure 7: Average Annual Generation Profiles of Offshore Wind, Land-Based Wind and Solar



Source: Presentation from the Schatz Energy Research Center, July 2021[90]

The need for renewable energy to accommodate California's shifting peak load informs the MW planning goals. The CPUC IRP process discussed above considers the fit between renewable generation output and electricity demand. A significant amount of offshore wind was found by the CPUC to be optimal for ratepayers in its recently adopted 2021 Preferred System Plan. This optimal amount indicates there is a synergy between offshore wind and solar, both daily and in the winter. If there were not a synergy, the capacity expansion modeling in IRP would have not selected any offshore wind, considering that it is higher cost than solar and energy storage. To connect this factor to the MW planning goals, the CEC staff established offshore wind MW planning goals that are higher than the current adopted amount of offshore wind in the IRP. These higher planning goals allow flexibility as IRP and TPP continue to direct the optimal procurement of generation and transmission for ratepayers over the coming years. Allowing a buffer above the current adopted amount in the IRP helps prepare California to take advantage of the generation profile of offshore wind to help meet load at peak demand and helps ensure California meets its SB 100 energy goals.

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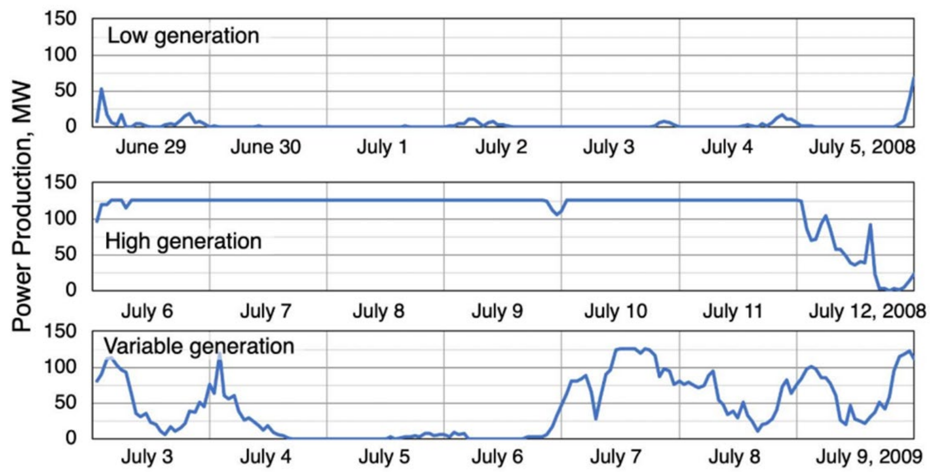
90 Schatz Energy Research Center. July 2021. "Offshore Wind on California's North Coast." Presentation. CEC Docket: 21-IEPR-05, TN# 239028.
https://efiling.energy.ca.gov/GetDocument.aspx?tn=239028&DocumentContentId=72461.

Generation Profile of Offshore Wind Off the California Coast

Offshore wind, like other variable-output renewables, has inherent uncertainty associated with projections about the related energy and reliability contributions. In 2020, the Schatz Energy Research Center studied the wind resource generation profile in the Humboldt area and found that power output from offshore wind could be distributed in two extremes, either low to no generation or times of high variability, as seen in **Figure 8**.

Figure 8: Example of Variability in Offshore Wind Power Generation Profile Scenario for the Humboldt Call Area

(Assumes 144 MW Nameplate Capacity)



Source: Schatz Energy Research Center

Regarding Morro Bay, a study modeling 100-meter wind speeds suggested wind speeds in summer months are more predictable than wind speeds in the winter.[91] Another study estimated the generation profile for potential Central California offshore wind farms, including farms in the Morro Bay call area. Hourly spatial-mean generation for Morro Bay was lowest around 10 a.m., ramping up from midmorning to about 7 p.m. The study estimated there would be no generation in the Morro Bay or Diablo Canyon call areas about 11 to 14 percent of the time, mostly due to low-wind conditions.[92]

According to a 2022 study by Abido and colleagues, adding offshore wind to California's renewable energy portfolio can reduce energy storage needs overall but is projected to have greater variability in the times of year when energy storage may be at minimum charge. On

91 Bodini, N., W. Hu, M. Optis, G. Cervone, and S. Alessandrini. 2021. "Assessing Boundary Condition and Parametric Uncertainty in Numerical-Weather-Prediction-Modeled, Long-Term Offshore Wind Speed Through Machine Learning and Analog Ensemble." *Wind Energy. Sci.*, 6(6), 1363–1377. https://doi.org/10.5194/wes-6-1363-2021.

92 Wang, Y.-H., R. K. Walter, C. White, M. D. Kehrli, and B. Ruttenberg. 2022. "Scenarios for Offshore Wind Power Production for Central California Call Areas." *Wind Energy*, 25(1), 23–33. https://doi.org/10.1002/we.2646.

average, the study concludes that winter months around sunrise will pose the most challenging time for a renewable-driven electricity grid in California.[93]

The generation profile for offshore wind energy, along with the shifting peak load factor discussed above, help guide development of the MW planning goals.

CEC and IRP energy modeling considers historical weather patterns, projected climate change, and the impact of these factors on generation and demand. Energy modeling uses this information in stochastic analysis to project expected reliability of future electricity generation portfolios. Because offshore wind involves geographies that are less studied than current generation sources in California, additional analysis will enhance understanding how offshore wind generation supports the energy system and helps meets peak load. BOEM has deployed lidar buoys with remote sensing technology in the WEAs to collect real-time wind data, and NREL continues to improve wind modeling tools to help identify optimal wind resources. As standard practice, this updated information is used in CEC energy modeling, the IRP and TPP processes and this work will also help direct the strategic plan.

Potential Impacts on Coastal Resources, Fisheries, Native American and Indigenous People, and National Defense and Strategies for Addressing Those Impacts

AB 525 requires the CEC to consider potential impacts on coastal resources (including ocean resources and marine ecosystems), fisheries, Native American and Indigenous peoples, and national defense, and strategies for addressing those impacts. Current data and analyses show that avoidance, minimization, mitigation, and adaptive management for these potential impacts can directly affect the MW planning goals. The offshore wind MW planning goals laid out in this report have not considered these potential impacts but will do so during strategic plan development.

Decisions to deploy offshore wind will result in new infrastructure in the marine environment such as floating platforms and turbines, mooring lines and anchors, and electrical cables. This new infrastructure may introduce several impacts to coastal and cultural resources and existing users. However, because the floating offshore wind market is in the early stages and the technology is rapidly advancing, additional study and analysis are needed to fully understand the degree, magnitude, and extent of potential impacts of offshore wind development on coastal resources, fisheries, Native American and Indigenous peoples, and national defense and identify effective strategies for addressing those potential impacts.

Based on existing information including a literature review and thorough extensive outreach, major themes have emerged that help identify a suite of impact concerns. From an ocean uses perspective, tribal governments have identified potential impacts to cultural landscapes and sacred sites. Fishing industry stakeholders have identified potential impacts related to restricted access to fishing grounds, impacts to fish habitat and species, and impacts to

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93 Abido, M. Y., Z. Mahmud, P. A. Sánchez-Pérez, and S. R. Kurtz. 2022. "Seasonal Challenges for a California Renewable-Energy-Driven Grid." *Science*, 25(1), 103577. https://doi.org/10.1016/j.isci.2021.103577.

specific types of fishing activities such as midwater and bottom trawl. Coastal communities have identified concerns regarding visual impacts from turbines and lighting, increased vessel traffic, and potential economic impacts to fishing and tourism dependent coastal economies. From the environmental perspective, potential impacts have been identified to pelagic and benthic fish, marine mammals, sea turtles, birds, and bats, seabed and benthic habitat, water quality, and ocean currents and upwelling.

The California Coastal Commission conditionally concurred with BOEM's consistency determination for the Humboldt WEA in April 2022 and for the Morro Bay WEA in June 2022. The California Coastal Commission's reports included similar findings. While the reports focused on analyzing the impacts associated with leasing and survey activities, they also identified potential impacts from the development and operations of offshore wind development and includes conditions that establish a framework for addressing those impacts.

The Coastal Commission's reports were produced in consultation and coordination with subject matter experts from several state and federal agencies. With the information that was able to be analyzed at the time of the reports, the California Coastal Commission found that future offshore wind development in the Humboldt and Morro Bay WEAs could adversely affect marine resources through:

- Seafloor disturbance.
- Turbine strikes.
- Increased entanglement risk.
- Marine species displacement.
- Avoidance or attraction.
- Increased ship strike risk.
- Elevated levels of underwater sound.
- Fish aggregation.
- The artificial reef effect.
- Invasive species.
- Weakened upwelling.
- Electromagnetic fields.

The reports also found that the fishing industry could potentially be impacted through exclusion and displacement from fishing grounds, increased costs and time at sea to reach new fishing grounds, loss of grounds from future fishing activity, and loss or disruption of harbor space and fishing infrastructure at ports. Finally, the reports found that offshore wind development could adversely and disproportionately impact environmental justice communities with environmental impacts associated with infrastructure development, as well as California Native American tribes that could be affected by impacts to culturally important places, species, and traditional marine fishing practices.[94] The conditions in the "consistency determinations" reflect measures and processes necessary to ensure that potential impacts described above are appropriately addressed as the leasing and development of offshore wind move forward.

As part of developing the broader strategic plan, CEC staff will coordinate with the California Coastal Commission; Department of Fish and Wildlife; Ocean Protection Council; State Lands Commission; stakeholders; other state, local, and federal agencies; the offshore wind energy industry; and California Native American tribes to identify suitable sea space for offshore wind energy. They will also make recommendations regarding environmental impacts and use conflicts, and strategies to avoid, minimize, and address significant adverse impacts consistent with California's long-term renewable energy, greenhouse gas emission reduction, and biodiversity goals.

The statutory deadline for establishing the MW planning goals and identifying maximum feasible capacity for offshore wind is before completion of the sea space evaluation, which is an important component of the broader strategic plan. Therefore, the CEC staff has not completed the sea space analysis. Through the sea space analysis, the CEC staff will continue to identify and assess impacts and strategies and use that information to guide the maximum feasible capacity and potentially refine the MW planning goals as needed.

Developing a Skilled and Trained Workforce

Having a skilled and trained workforce will be necessary to successfully deploying offshore wind in California. Investing in offshore wind energy development can offer career pathways and workforce training opportunities in clean energy.

The workforce opportunity from a robust offshore wind industry in California is significant. In a 2019 report, projections by BVG Associates for the American Jobs Project estimate that with additional state policies aimed toward advancing offshore wind and a build-out of 18 GW by 2045, California could see more than 17,000 jobs. Without additional policies supporting the growth of offshore wind, it projected a build-out of 5 GW by 2045, yielding closer to 5,000 jobs.[95]

Conducting new work initiated by the CEC, Guidehouse assessed California workforce needs for various offshore wind deployment scenarios, including 10 GW, 18 GW, and 20 GW by 2042, 2045, and 2050, respectively. Guidehouse found that most jobs needed will be in

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94 California Coastal Commission. March 2022. *Staff Report: Consistency Determination No: CD-0001-22* (Bureau of Ocean Energy Management, Humboldt Co.). https://documents.coastal.ca.gov/reports/2022/4/Th8a/Th8a-4-2022%20staffreport.pdf.

California Coastal Commission. June 2022. *Staff Report: Consistency Determination No: CD-0004-22* (Bureau of Ocean Energy Management, San Luis Obispo Co.). https://documents.coastal.ca.gov/assets/upcoming-projects/offshore-wind/W7a-6-2022-AdoptedFindings.pdf.

95 American Jobs Project. February 2019. *The California Offshore Wind Project: A Vision for Industry Growth*. http://americanjobsproject.us/wp/wp-content/uploads/2019/02/The-California-Offshore-Wind-Project.pdf.

component manufacturing and supply chain and support services, particularly for installation and development, ports and staging, onshore transmission, foundations, towers, and blades. It also concluded that the total workforce needed is roughly the same for all three scenarios.[96]

The CEC recognizes the need to start developing a trained and skilled workforce to support the deployment of offshore wind. This factor does not directly influence the establishment of the MW planning goals as the magnitude of the workforce will adjust with the MW planning goals. The need for a skilled and trained workforce will be explored further in the development of the strategic plan.

Attracting Supply Chain Manufacturing in the Pacific Region

A possible benefit of developing wind offshore in California is the economic development opportunities for California and the Pacific region from scaling-up a new industry. A report — *California Offshore Wind: Workforce Impacts and Grid Integration*, conducted by the UC Berkeley Labor Center — indicates that the largest economic development benefits of an offshore wind industry would come from having a local supply chain for manufacturing components used in project development.[97] Moreover, as offshore wind continues to develop around the world, having a local supply chain and workforce capabilities makes California, the West Coast, and the United States less vulnerable to global supply chain bottlenecks and better positioned to achieve offshore wind deployments at scale. However, offshore wind developers and the supply chain industry need to have confidence in the offshore wind pipeline to support early investments in local supply chain development.

While developing a local supply chain in California and throughout the Pacific region is necessary to maximizing the economic benefits of an offshore wind industry in California, this factor does not directly influence the establishment of the MW planning goals. Like the development of a skilled and trained workforce, the development of a local supply chain will scale from the MW planning goals. The CEC also recognizes the role the MW planning goals will play in sending market signals for early investment in the development of a local supply chain. The need for a local supply chain will be explored further in the development of the strategic plan.

The Need for Economies of Scale to Reduce Costs

In 2020, NREL published results of a study, conducted in partnership with BOEM and the CPUC, updating cost assumptions for offshore wind in California. In 2019, NREL found that the levelized cost of energy for offshore wind ranged from \$83/MWh to \$180/MWh. The latest estimates indicate costs could decrease by 44 percent on average by 2032, reaching a

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96 Guidehouse. May 2022. *California Supply Chain Needs Summary Report.* https://efiling.energy.ca.gov/GetDocument.aspx?tn=242928&DocumentContentId=76513.

97 Collier, Robert, Sanderson Hull, Oluwafemi Sawyerr, Shenshen Li, Manohar Mogadali, Dan Mullen, and Arne Olson. September 2019. *California Offshore Wind: Workforce Impacts and Grid Integration*. Center for Labor Research and Education, University of California, Berkeley. http://laborcenter.berkeley.edu/offshore-wind-workforce-grid.

levelized cost of energy in the range of $53/MWh to $64/MWh, assuming a global deployment of 8 GW by 2032. The study attributed this potential cost decline to the following factors:[98]

- Turbine upsizing, which will result in lower per-unit costs
- Economies of scale and efficiencies in manufacturing
- Technology innovations, which can reduce material use, improve performance, and improve logistic efficiencies

These cost estimates do not include the other significant investments that will be needed to construct offshore wind, such as the port facilities and transmission that will be necessary. The report states: "Continued turbine and plant upscaling, as well as an expansion of the supply chain, are needed to obtain the costs modeled in this analysis."[99]

The CEC recognizes the importance of economies of scale to reduce offshore wind development costs. While this factor did not influence the offshore wind MW planning goals as significantly as some of the factors previously discussed, it does support more ambitious offshore wind MW planning goals.

The Availability of Federal Tax Incentives

The offshore wind provision of the Business Energy Investment Tax Credit (ITC) allows a 30 percent investment tax credit that applies to capital expenditures on projects that start construction before the end of 2025.[100] A "safe harbor provision" allows projects that start construction or spend at least 5 percent of the total capital expenditure of a project by the end of 2025 and come on-line by 2035 to capture the benefit of the ITC.[101] However, the availability of federal tax incentives after 2025 is uncertain.

The CPUC's 2021 IRP Preferred System Plan includes 1.7 GW of offshore wind energy by 2032, with a key assumption being the 2025 "safe harbor" ITC deadline could be met by developers. The IRP analysis showed that if the ITC is not part of offshore wind cost assumptions, then the optimal resource portfolio does not include any offshore wind by 2032 beyond the 300 MWs included in some load-serving entities' IRPs.[102]

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98 Beiter, Philipp, Walter Musial, Patrick Duffy, Aubryn Cooperman, Matt Shields, Donna Heimiller, and Mike Optis. 2020. *The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-77384. https://www.nrel.gov/docs/fy21osti/77384.pdf.

99 Ibid.

100 "Fact Sheet: Advancing the Growth of the U.S. Wind Industry: Federal Incentives, Funding, and Partnership Opportunities." U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. https://www.energy.gov/sites/default/files/2021-07/us-wind-industry-federal-incentives-funding-partnership-opportunities-fact-sheet-v2.pdf.

101 U.S. Internal Revenue Service. 2021. "Notice 2021-05: Beginning of Construction for Sections 45 and 48; Extension of Continuity Safe Harbor for Offshore Projects and Federal Land Projects." https://www.irs.gov/pub/irs-drop/n-21-05.pdf.

102 CPUC. February 2022. Decision Adopting 2021 Preferred System Plan. D.22-02-004 in Rulemaking 20-05-003. https://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=451412947.

When combined with other key offshore wind assumptions, such as generation profile, capital and operating expenses, and financing costs, the ITC has the effect in the IRP capacity expansion modeling of reducing the implied levelized cost of energy from a range of about $60/MWh to $70/MWh to a range of $40/MWh to $50/MWh. In line with standard practice, the levelized cost of energy discussed in the NREL report and for CPUC IRP resource modeling covers generation costs and excludes the costs of major bulk transmission expansions.[103]

While some of the early offshore wind development projects may be able to take advantage of the ITC, there is considerable uncertainty about the availability of the tax credit for projects that do not meet the safe harbor provision by the end of 2025. However, the availability of the ITC for such projects is possible and is reason for establishing MW offshore wind MW planning goals higher than the current adopted amount of offshore wind in IRP.

The National Renewable Energy Laboratory Report Finding That California Has 200 Gigawatts of Offshore Wind Technical Power Potential

In early 2020, NREL updated its 2016 assessment of offshore wind potential based on a state-of-the-art wind resource data set for the Outer Continental Shelf (OCS).[104] The report found significantly higher mean wind speeds modeled in the new data set compared to other models, which showed an increase in the mean 100-m wind speed at the centroids of the Humboldt, Morro Bay, and Diablo Canyon call areas.[105] This report also applied revised input assumptions to generate new estimates of technical potential for offshore wind in California. These new estimates resulted in a finding of increased technical potential for the Pacific OCS of 201 GW. The findings of this report are most applicable to evaluating and quantifying the maximum feasible capacity of offshore wind as discussed in Chapter 2.

The Opportunity for California to Participate in the Federal Government's Offshore Wind Planning Goals

In March 2021, the DOI, the Department of Energy (DOE), and the Department of Commerce announced a shared goal to deploy 30 GWs of offshore wind in the United States by 2030 while protecting biodiversity and promoting ocean co-use. The Biden administration sees the achievement of this target as a pathway to 110 GW by 2050.[106]

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103 Beiter, Philipp, Walter Musial, Patrick Duffy, Aubryn Cooperman, Matt Shields, Donna Heimiller, and Mike Optis. 2020. *The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-77384. https://www.nrel.gov/docs/fy21osti/77384.pdf.

104 Musial, Walt, Donna Heimiller, Philipp Beiter, George Scott, and Caroline Draxl. September 2016. *2016 Offshore Wind Energy Resource Assessment for the United States*. Golden. CO: National Renewable Energy Laboratory. NREL/TP-5000-66599. https://www.nrel.gov/docs/fy16osti/66599.pdf.

105 Optis, Mike, Alex Rybchuk, Nicola Bodini, Michael Rossol, and Walter Musial. 2020. *2020 Offshore Wind Resource Assessment for the California Pacific Outer Continental Shelf*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-77642. https://www.nrel.gov/docs/fy21osti/77642.pdf

106 The White House. March 2021. "Fact Sheet: Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs." https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/.

The Biden administration and Governor Newsom announced an effort to advance areas for offshore wind off the Northern and Central Coasts of California. The Biden administration contextualizes this announcement as a part of the nationwide 2030 deployment goal. According to the 2021 Edition of the U.S. DOE *Offshore Wind Market Report*, there are eight states with existing offshore wind procurement targets totaling close to 40 GW by 2040.[107] As part of the announcement of setting a 30 GW goal, the Biden administration announced that BOEM is expecting to hold up to seven additional lease sales by 2025, including a lease sale for the Humboldt and Morro Bay wind energy areas in the fall of 2022. BOEM is also planning to review construction and operation plans representing more than 19 GW of offshore wind in the United States by 2025.[108]

A recent study by NREL developed a baseline scenario to achieve the federal deployment goal of 30 GW by 2030. The baseline scenario included 2.5 GW of offshore wind from California by 2030. The study noted that while the timeline may be ambitious and would require work in developing the technology, supply chain, and regulatory and permitting process, it may be possible given the state's support of growing an offshore wind industry.[109] This supports consideration of a 2030 offshore wind planning goal of at least 2.5 GW to contribute to the federal goal of 30 GW by 2030.

Executive Action from the Governor Regarding Offshore Wind

On July 22, 2022, Governor Gavin Newsom issued a letter to the Chair of the California Air Resources Board, outlining new targets to accelerate progress on California's 2030 climate goals and to get to climate neutrality no later than 2045. In the letter, among other requested actions, the Governor asks the CEC to establish an offshore wind planning goal of at least 20 GW by 2045 and to work with the state's federal partners to accelerate the deployment of offshore wind. The letter noted that California is home to one of the best offshore wind resources in the world and that offshore wind can serve as a clean, domestic source of electricity that can play an important role in meeting the state's growing need for clean energy.[110]

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107 U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. *Offshore Wind Market Report: 2021 Edition*. https://www.energy.gov/sites/default/files/2021-08/Offshore%20Wind%20Market%20Report%202021%20Edition_Final.pdf.

108 "Press Release: U.S. Department of the Interior, October 2021, Secretary Haaland Outlines Ambitious Offshore Wind Leasing Strategy." https://www.doi.gov/pressreleases/secretary-haaland-outlines-ambitious-offshore-wind-leasing-strategy.

109 Shields, Matt, Ruth Marsh, Jeremy Stefek, Frank Oteri, Ross Gould, Noé Rouxel, Katherine Diaz, Javier Molinero, Abigayle Moser, Courtney Malvik, and Sam Tirone. 2022. *The Demand for a Domestic Offshore Wind Energy Supply Chain*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-81602. https://www.nrel.gov/docs/fy22osti/81602.pdf.

110 Governor Gavin Newsom, letter to Chair of the California Air Resources Board. July 22, 2022. https://www.gov.ca.gov/wp-content/uploads/2022/07/07.22.2022-Governors-Letter-to-CARB.pdf?emrc=1054d6

Public Workshops on AB 525 for Establishing Offshore Wind Planning Goals

On March 3, 2022, the CEC held a public workshop on AB 525 that included discussion of CEC staff's approach toward establishing offshore wind MW planning goals. On May 6, 2022, CEC staff published a draft report and held two workshops seeking public comment. Information submitted during the May 18, 2022, public workshop recommended the CEC establish different MW offshore wind planning goals for 2030 and 2045. The information was based on studies released after the draft offshore wind report. The third and final workshop was held on June 27 and provided the public an opportunity to explore these studies and how they relate to the AB 525 requirements and the draft report. The CEC staff received public comments from several individuals and stakeholders representing the offshore wind industry, environmental organizations, labor organizations, environmental justice, fishing, tribal, and the shipping industry, among others.

In the public comments received at the March 3rd workshop, offshore wind industry stakeholders and others provided a range for suggested planning goals starting at 3 GW in 2030 and scaling to between 10 GW and 18 GW by 2045. At the May 18 and June 27 workshops, several stakeholders provided revised offshore wind planning goal recommendations of 5 GW by 2030 and 20 GW by 2045, pointing to newly released offshore wind studies that were not available at the time of the March 3 workshop or during development of the draft report. (See section on "Additional Information Considered" below.) Several stakeholder comments recommending larger planning goals emphasized the importance of the MW planning goals in sending market signals necessary to drive investment in ports, infrastructure, and supply chain development and point to how planning goals and procurement targets have driven offshore wind development on the East Coast.[111] Others commented that the planning goals should be robust enough to drive economies of scale,[112] which will be essential for reducing costs, delivering competitively priced clean power, and encouraging local industry and job development.[113]

Across all three public workshops, other commenters emphasized the importance of ensuring offshore wind growth is equitable, creating long-lasting benefits to local California

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111 RWE Renewables Americas, LLC. March 11, 2022. CEC Docket: 17-MISC-01, TN# 242270. Avangrid Renewables Comments on AB 525 Offshore Wind Goals. CEC Docket 17-MISC-01, TN#242284. American Clean Power – California. March 11, 2022. CEC Docket: 17-MISC-01, TN#242268. Joe Martens. June 26, 2022. Joe Martens Comments-California Offshore Renewable Energy Targets. CEC Docket: 17-MISC-01, TN# 243715.

112 California Wind Energy Association. March 11, 2022. California Wind Energy Association Comments on AB 525 Implementation. CEC Docket: 17-MISC-01, TN#242618.

113 Offshore Wind California. March 11, 2022. Offshore Wind California Comments on AB 525 Planning Goals. CEC Docket: 17-MISC-01, TN#242274

communities.[114] It was also indicated that local economic development should be elevated through a focus on quality jobs and local economic benefits.[115]

Environmental organizations commented that offshore wind goals should be reflective of environmental and social development and the least-cost alternative to get California to the state's economywide decarbonization goals.[116] Comments also asserted that offshore wind planning goals should be aligned with environmentally and socially responsible offshore wind development — avoiding, minimizing, or mitigating significant or adverse impacts to the environment or other ocean users.[117] Ocean users including representatives from the fishing industry raised concerns about unknown environmental, economic, and cultural impacts of developing an offshore wind industry and encouraged strong engagement and coordination while identifying suitable sea space and prioritizing least-conflict ocean areas.[118]

Additional Information Considered

CEC staff examined four new reports that were discussed at the June 27, 2022, Public Workshop. Two primary studies provide additional information to inform the MW planning goals.

The first study is the *Assessment of Offshore Wind Energy Leasing Areas for Humboldt and Morro Bay Wind Energy Areas*.[119] This study, developed for BOEM to inform the federal offshore wind lease process, delineates the number of recommended lease areas for each of the BOEM-identified WEAs. This delineation assessment was completed by examining the potential deployment of a 1 GW facility in each lease area and examined the deployment with three floating platform technologies with optimal turbine layout for each platform type. The report identifies two potential lease areas in the Humboldt WEA, with a total generation capacity of 1.5 GW to 3 GW. For the Morro Bay WEA, NREL identifies three potential lease areas with a total generation capacity between 3 GW and 5 GW. This NREL report confirms

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114 Verbal comments at March 3, 2022 workshop from Sarah Xu, Brightline Defense.

115 Natural Resources Defense Council. March 11, 2022. Natural Resources Defense Council Comments on AB 525 Offshore Wind Planning Goals. CEC Docket 17-MISC-01, TN# 242272.

116 Natural Resources Defense Council. June 28, 2022. Natural Resources Defense Council Comments – Julia De Lamare – Comments Lead Commissioner Workshop. CEC Docket 17-MISC-01, TN#243738.

117 Environmental Defense Center. March 11, 2022. Environmental Defense Center Comments. CEC Docket 17-MISC-01, TN# 242269. Natural Resources Defense Council. March 11, 2022. Natural Resources Defense Council Comments on AB 525 Offshore Wind Planning Goals. CEC Docket 17-MISC-01, TN# 242272.

118 Verbal comments from May 18, 2022, workshop from Mike Conroy, West Coast Fisheries. Stephen Scheiblauer. June 27, 2022. Stephen Scheiblauer Comments – CEC workshop on AB 525 goals. CEC Docket 17-MISC-01, TN# 243736. Pacific Merchant Shipping Association. May 23, 2022. Pacific Merchant Shipping Association Comments on AB 525 CEC Draft Report on Offshore Wind Development off the California Coast. CEC Docket 17-MISC-01, TN# 243220.

119 Cooperman, Aubryn, Patrick Duffy, Matt Hall, Ericka Lozon, Matt Shields, and Walter Musial. April 2022. *Assessment of Offshore Wind Energy Leasing Areas for Humboldt and Morro Bay Wind Energy Areas, California*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-82341. https://www.nrel.gov/docs/fy22osti/82341.pdf.

that by increasing the density of turbines deployed, developers could achieve a range of between 4.5 GW and 8 GW of total generation capacity within these two BOEM call areas. The density of turbines would depend on the type of floating platform technology and anchoring technology selected. This information suggests higher nameplate capacity goals could be achieved in other suitable areas off the California Coast.

The second is a set of studies, the *Achieving an Equitable and Reliable 85 Percent Clean Electricity System by 2030 in California* technical report and the Policy Report by Energy Innovation, Telos Energy, and GRIDLab.[120] These reports complement the 2021 Joint Agency SB 100 Report by examining system reliability for a series of portfolios with a combination of RESOLVE and production cost modeling (PLEXOS) focused on 2030. Findings indicate that California can reliably meet an 85 percent clean electricity standard by 2030 through multiple resource pathways, which are based primarily on wind and solar generation, and battery storage. As modeling assumptions, minimum buildouts of 2 GW of geothermal and 4 GW of offshore wind were used in the modeling work for 2030 and the modeling assumes that the 4 GW of offshore wind is available. CEC staff used information from this study to project an amount of offshore wind capacity for 2045. Starting with the assumption of 4 GW of offshore wind by 2030 and applying a deployment rate of 1 GW to 1.5 GW per year to support ongoing manufacturing and supply chain for offshore wind, the state could expect between 20 GW to 27 GW of capacity to be deployed by 2045.

Two other ongoing studies were also discussed at the workshop. These include a draft working paper from the University of California Berkeley Goldman School of Public Policy, *The Offshore Report: California Plummeting Offshore Wind (OSW) Costs Can Accelerate a Diverse Net-Zero Grid* and the Nature Conservancy's forthcoming study, *Power of Place West*.[121]

The Goldman School of Public Policy working paper examines a range of scenarios that have offshore wind goals for 2045 based on the NREL ATB.[122] An NREL ATB mid case of 50 GW of

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120 GridLab. May 2022. *Reliability Reaching California's Clean Electricity Targets: Stress Testing an Accelerated 2030 Clean Portfolio*. https://gridlab.org/wp-content/uploads/2022/05/GridLab_California-2030-Study-Technical-Report-5-9-22-Update1.pdf.

Energy Innovation. May 2022. *Achieving an Equitable and Reliable 85 Percent Clean Electricity System by 2030 in California*. https://energyinnovation.org/wp-content/uploads/2022/05/Achieving-An-Equitable-And-Reliable-85-Percent-Clean-Electricity-System-By-2030-In-California-1.pdf.

121 Paliwal, Umed, Nikit Abhyankar, David Wooley, Amol Phadke (2022). "The Offshore Report: California, Plummeting offshore wind costs can accelerate a diverse net-zero grid", Working Paper 1, Center for Environmental Pubic Policy, Goldman School of Public Policy, University of California, Berkeley. https://gspp.berkeley.edu/assets/uploads/page/CA_OSW_Assessment_Working_Paper_CEPP.pdf

The Nature Conservancy. June 2022. Power of Place West, forthcoming publication. CEC Docket 17-MISC-01, TN# 243738. https://efiling.energy.ca.gov/GetDocument.aspx?tn=243688&DocumentContentId=77515

122 "Annual Technology Baseline, Electricity, Offshore Wind, National Renewable Energy Laboratory, 2021." https://atb.nrel.gov/electricity/2021/offshore_wind.

offshore wind by 2045 was examined and a $30+ billion estimate for new transmission investment identified.

The Nature Conservancy's study takes a west-wide perspective on optimal resource mixes needed (including offshore wind) to collectively achieve economywide net zero by 2050. The Nature Conservancy believes this type of modeling represents a realistic picture of California's clean energy future and offers efficiency and myriad other benefits that an integrated market represents.

Both studies are in draft form and are expected to be finalized during CEC's continuing work on the AB 525 Offshore Wind Strategic Plan. CEC staff will follow the development of these studies and continue to consider the relevant information they provide to guide the SB 100 implementation process and next report.

CHAPTER 4: Conclusion

To assess the potential quantity of maximum feasible capacity of offshore wind to achieve reliability, ratepayer, employment, and decarbonization benefits and establish offshore wind MW planning goals for 2030 and 2045, CEC staff used available information as described above to evaluate considerations specified in AB 525. These considerations include floating offshore wind technologies, potential impacts, and infrastructure requirements. The statutory deadline for establishing the MW planning goals and identifying maximum feasible capacity for offshore wind is before completion of the sea space evaluation, which is needed to inform identifying maximum feasible capacity. This sea space evaluation is an important component of the broader strategic plan. As the sea space analysis is being completed, CEC staff will continue to identify and assess impacts and strategies and will use that information to inform the maximum feasible capacity and refine the MW planning goals as needed.

Offshore Wind Technical Potential

Based on existing studies described in this report, nearly 21.8 GW of offshore wind technical potential of the 201 GW of the gross resource estimate has been identified and examined for technical feasibility. This number does not represent the quantification of maximum feasible capacity of offshore wind as defined in this report and required by AB 525; it simply represents the offshore wind technical potential that has been studied to date. As discussed, the estimates of technical potential used in these studies do not account for other important factors such as competing uses or environmental considerations, which will significantly reduce the technical potential. Similarly, technological advancements or identification of new suitable areas may increase the technical potential. CEC staff will continue to examine these areas in the assessment of sea space requirements, transmission need, and potential impacts for the strategic plan. This work is necessary to evaluate and quantify the maximum feasible capacity of offshore wind to achieve reliability, ratepayer, employment, and decarbonization benefits.

Offshore Wind Megawatt Planning Goals

To establish offshore wind MW planning goals, CEC staff evaluated five factors of particular importance as described in Chapter 3 of this report. A summary of the evaluation for each of the five factors as well as additional information considered and how they guide the MW planning goals are provided below.

1. The findings of the *2021 SB 100 Joint Agency Report.*

   The *2021 SB 100 Joint Agency Report* advises the offshore wind MW planning goals, suggesting the CEC set a minimum of 10 GW for offshore wind as a planning goal for 2045. The report also concludes that offshore wind can contribute to increased resource diversity, which helps lower overall system costs.

2. The need to initiate long-term transmission and infrastructure planning to expedite delivery of offshore wind energy to Californians.

   The CPUC IRP process and the ISO TPP examine the energy resources by location and technology and identify the transmission infrastructure and infrastructure upgrades needed to achieve the state's climate and energy goals. They are designed to ensure that the energy system is developed and operated cost-effectively while ensuring system reliability.

   As such, the outputs from these planning processes provide key information to inform the maximum feasible capacity of offshore wind and MW planning goals for 2030 and 2045. The development of new transmission capacity has been identified as necessary to deliver offshore wind power from the North Coast to California load centers.

   For 2030, it is prudent to have the AB 525 strategic plan evaluate at least the current adopted 2032 IRP amount of offshore wind of 1.7 GW, potentially up to nearly 5 GW, which is what can be accommodated on existing transmission. An amount beyond this appears infeasible from a transmission perspective by 2030. For 2045, there is greater possibility of achieving some or all of the transmission upgrades examined by the ISO. This suggests the CEC may consider establishing a MW planning goal for 2045 of at least 10 GW to 14.3 GW for 2045 (informed by both the ISO *2021–2022 Transmission Plan* and the ISO *20-Year Transmission Outlook*).

3. The need for reliable renewable energy that accommodates California's shifting peak load.

   The need for renewable energy to accommodate California's shifting peak load guides the maximum feasible capacity of offshore wind and the MW planning goals. The complementary nature of offshore wind to solar, both daily and in the winter, suggests the CEC establish offshore wind MW planning goals that are reasonably higher than the current adopted amount of offshore wind in IRP. These higher planning goals would allow flexibility as IRP and TPP and other LSEs in the state continue to direct the optimal procurement of generation and transmission for ratepayers over the coming years. Allowing for a buffer above the current adopted amount in IRP helps prepare California to take advantage of the generation profile of offshore wind to help ensure California meets its SB 100 energy goals.

4. The generation profile of offshore wind off the California coast.

   The generation profile of offshore wind goes hand in hand with the shifting peak load factor above in terms of informing the MW planning goals. Reliability modeling considers historical weather patterns, projects climate change and the related impact on generation and demand and uses this information in stochastic analysis to project expected reliability of future electricity generation portfolios. Further real-time wind data collection and ongoing modeling as part of efforts including the IRP process and other studies will continue to improve understanding of the inherent patterns of variability across specific areas with offshore wind technical potential. More study is also needed to investigate strategies that maximize the use of storage technologies and other grid integration solutions with offshore wind resources as part of a portfolio of renewable and zero-carbon resources.

5. Potential impacts on coastal resources, fisheries, Native American and Indigenous peoples, and national defense, and strategies for addressing those potential impacts.

   The degree, magnitude, and extent of potential impacts of offshore wind generation will be identified and assessed by CEC staff during and after the AB 525 identification of sea space component of the strategic plan. The recommended MW planning goals do not consider potential impacts to ocean use and environmental considerations. The assessment of potential impacts and the strategies for addressing those impacts that are identified for the strategic plan will inform and may potentially limit the amount of maximum feasible capacity of offshore wind and the MW planning goals that are ultimately identified in the strategic plan

As discussed in Chapter 2, CEC staff reviewed the NREL 2021 ATB for Offshore Wind,[123] which examines the future costs for three technology innovation scenarios, including conservative, moderate, and advanced technology scenarios. The technology assumptions of these three scenarios are highlighted below:

- Conservative Technology Innovation Scenario (Conservative Scenario): turbine size remaining at a level consistent with the technology solutions available in today's markets; limited advancements in technology innovation are characteristic of this scenario. Logistical and manufacturing constraints are similar to those today, and they limit turbine size growth.
- Moderate Technology Innovation Scenario (Moderate Scenario): turbine size increasing at a rate commensurate with growth in recent years. Logistical, manufacturing, operating and performance constraints are addressed by technology innovation in turbine, substructure, and port and vessel capabilities to enable the next generation of offshore wind technology. These increases in turbine size are accompanied by continued increases in supply chain efficiencies.
- Advanced Technology Innovation Scenario (Advanced Scenario): turbine size increasing at a rate that is considerably higher than in recent years. Accelerated technology innovation enables large turbine systems and fundamentally changes the manufacturing, installation, operation, and performance of a wind plant.

For developing the strategic plan, the CEC is considering the range of technology scenarios and will examine, among other sources, the Moderate and Advanced Scenarios, which align best with the assumptions used in the state's approach to offshore wind. Under the Moderate Scenario, assumptions for representative technology include a 15 MW turbine mounted on a floating substructure using improved and highly tailored technology and materials. The turbine

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123 "Annual Technology Baseline, Electricity, Offshore Wind, National Renewable Energy Laboratory, 2021." https://atb.nrel.gov/electricity/2021/offshore.

system is installed and operated using greatly enhanced port infrastructure and vessel capabilities relative to what exists today. Under the NREL Advanced Scenario, an 18 MW turbine would be mounted on a floating substructure using next-generation technology and materials, port infrastructure, and vessel capabilities. Efficiency gains are achieved through accelerated standardization, large economies of scale, and increased competition.

Under both scenarios, the levelized cost of energy for offshore wind generation is projected to continue to drop. This drop is primarily due to increasing capability and efficiency of the supply chain to support offshore wind and to the economies of turbine size and offshore generation facility scale. Technological developments for offshore wind infrastructure may include advanced monitoring systems, mooring systems, flexible cabling, and increased turbine size. The CEC staff will evaluate this potential as it continues to identify sea space and develop the strategic plan. The CEC staff will continue to work with stakeholders to create a strategic plan that takes technological innovation into account.

The primary studies discussed at the CEC's June 27, 2022, workshop provided additional information to inform the MW planning goals.

The NREL *Assessment of Offshore Wind Energy Leasing Areas for Humboldt and Morro Bay Wind Energy Areas* report identifies two potential lease areas in the Humboldt WEA, with a total generation capacity of 1.5 GW to 3 GW.[124] For the Morro Bay WEA, NREL identifies three potential lease areas with a total generation capacity between 3 GW and 5 GW. This NREL report confirms that by increasing the density of turbines deployed, developers could achieve a range of between 4.5 GW and 8 GW of total generation capacity within these two BOEM call areas. The density of turbines would depend on the type of floating platform technology and anchoring technology selected. This information suggests higher nameplate capacity goals could potentially be achieved in other suitable areas off the California coast.

A set of studies, by Energy Innovation, Telos Energy, and GridLab indicated that California can reliably meet an 85% clean electricity standard by 2030 through multiple resource pathways, which are based primarily on wind and solar generation, and battery storage.[125] As modeling assumptions, minimum buildouts of 2 GW of geothermal and 4 GW of offshore wind were used in the modeling work for 2030 and assumes that 4 GW of offshore wind is available. CEC staff used information from this study to project an amount of offshore wind capacity for 2045. Starting with the assumption of 4 GW of offshore wind by 2030 and applying a deployment rate of 1 GW to 1.5 GW per year to support ongoing manufacturing and supply chain for offshore wind, the state could expect between 20 GW to 27 GW of capacity to be deployed by

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124 Cooperman, Aubryn, Patrick Duffy, Matt Hall, Ericka Lozon, Matt Shields, and Walter Musial. April 2022. *Assessment of Offshore Wind Energy Leasing Areas for Humboldt and Morro Bay Wind Energy Areas, California*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-82341. https://www.nrel.gov/docs/fy22osti/82341.pdf.

125 GridLab. May 2022. *Reliability reaching California's clean electricity targets: Stress testing an accelerated 2030 clean portfolio*. https://gridlab.org/wp-content/uploads/2022/05/GridLab_California-2030-Study-Technical-Report-5-9-22-Update1.pdf.

2045. Based on the CEC staff's assessment of existing information as presented and evaluated in this report, CEC staff recommends the preliminary MW planning goals summarized in **Table 3**. The information from the studies discussed in this report indicate that the range of MW planning goals are potentially feasible if significant investment is made toward the rapid deployment of the required transmission infrastructure and other related deployment infrastructure, such as ports. Moreover, these MW planning goals are within the range necessary to support and sustain employment and economic benefits to the state as discussed in Chapter 2. Finally, this range of MW planning goals are considered appropriate to receive additional study, assessment, and discussion in the strategic plan. These goals will be revised as appropriate based on findings in the strategic plan and learnings from early offshore wind projects. The goals do not represent procurement targets. The goals will facilitate the study of infrastructure needs and impacts to inform future procurement goals.

Table 3: Offshore Wind Megawatt Planning Goals for 2030 and 2045 for California Offshore Wind in Federal Waters

Objective	Approximate Nameplate Capacity
Maximum Feasible Capacity of California Offshore Wind in Federal Waters	*Maximum* feasible capacity to be determined in strategic plan, but nearly 21,800 MW (21.8 GW) of studied technical potential is the current reference point
Offshore wind planning goal for 2030	2,000 MW (2 GW) - 5,000 MW (5 GW)
Offshore wind planning goal for 2045	25,000 MW (25 GW)

Source: California Energy Commission

California Offshore Wind Planning Goal of 2,000 MW - 5,000 MW by 2030

For completing the strategic plan, the CEC recommends establishing a preliminary planning goal range of 2,000 MW–5,000 MW of offshore wind by 2030. This goal could come from a full build-out of Morro Bay Wind Energy Area or a combination of a partial build-out of each of the Morro Bay and Humboldt Wind Energy Areas, which the CEC will further explore when identifying suitable sea space for the 2030 MW planning goals. The lower end of that range reflects an understanding that achieving a 2030 online date will require a significant mobilization of effort and resources and timely infrastructure investments, among other factors. The CEC will work with state and federal partners to identify process steps and milestones that could allow for a 2030 online date for California's first offshore wind projects.

The ISO estimated transmission infrastructure for 1.6 GW from the Humboldt Wind Energy Area ranged from $2.1 billion to $4.0 billion and estimated that up to 5.3 GW of offshore wind from Central California could be deliverable through the existing transmission system without mitigation and minimal investment.[126] Realizing California-based economic benefits from the supply chain would also require in-state port modifications or improvements to support some level of fabrication or assembly of floating offshore wind components or both.

California Offshore Wind Planning Goal of 25,000 MW by 2045

For completing the strategic plan, the CEC recommends establishing a preliminary planning goal of 25,000 MW of offshore wind by 2045. These goals for 2030 and 2045 will be evaluated as part of the AB 525 strategic plan as more information becomes available from the analysis of suitable sea space and potential impacts on coastal resources, fisheries, Native American and Indigenous people, and national defense, as well as other topics addressed in the strategic plan.

These preliminary MW planning goals are designed to be potentially achievable but aspirational and are established at a level that can contribute significantly to achieving the climate goals. The planning goals reflect the best available data and science and evaluation of the 12 factors prescribed by AB 525, including the latest information presented in the series of public workshops discussed in Chapter 3. The information available supports the feasibility of at least 20 GW by 2045. However, the offshore wind industry, including floating turbine technology, continues to quickly evolve. The 25 GW target signals that the state sees a need for additional capacity and developing a threshold for creating the momentum necessary to unlock a robust offshore wind industry in California.

Higher goals do not commit California to those deployment levels. Offshore wind resources will still need to go through siting and procurement processes, including environmental review, and stakeholder engagement will be critical to identifying new BOEM wind energy areas. However, these higher planning goals prepare the state for potential impacts due to the possible integration of significant offshore wind.

In consultation with state, local, federal agencies, a variety of stakeholders, and California Native American tribes, the CEC will use these MW planning goals to inform development of a strategic plan for offshore wind in federal waters off the California coast. In particular, the 2030 and 2045 MW planning goals are presented as a range to inform further analysis of the considerations that must be balanced when identifying suitable sea space, developing a plan to improve waterfront facilities, assessing transmission upgrades, identifying potential environmental impacts, and other related requirements of AB 525.

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126 California ISO. March 2022. *2021–2022 Transmission Plan*.
http://www.caiso.com/InitiativeDocuments/ISOBoardApproved-2021-2022TransmissionPlan.pdf.

APPENDIX A: List of Acronyms

AB – Assembly Bill

ATB — Annual Technology Baseline

BOEM — Bureau of Ocean Energy Management

CEC — California Energy Commission

CNRA — California Natural Resources Agency

CPUC — California Public Utilities Commission

CZMA — Coastal Zone Management Act

DOE — U.S. Department of Energy

DOI — U.S. Department of the Interior

EPIC — Electric Program Investment Charge

GW — gigawatt

IRP — integrated resource planning

ISO — Independent System Operator

ITC — Investment Tax Credit

LCOE — levelized cost of energy

LSE — load-serving entities

MW — megawatt

nm — nautical miles

NREL — National Renewable Energy Laboratory

OCS — outer continental shelf

PSP — Preferred System Plan

SB — Senate Bill

TPP — transmission planning process

USC — University of Southern California

WEA — Wind Energy Area

APPENDIX B: Glossary of Terms

Distributed Energy Generation: A distributed generation system involves small amounts of generation located on a utility's distribution system for meeting local (substation level) peak loads or displacing the need to build additional (or upgrade) local distribution lines or both. Photovoltaics, fuel cells, and battery storage are some examples of distributed energy generation resources.

Energy-Only Resources Deliverability: A condition for a Large Generating Facility connected to the ISO Controlled Grid, meaning the facility cannot provide capacity to ensure resource adequacy.

Full Capacity Resource Deliverability: A status for a Large Generating Facility connected to the ISO Controlled Grid meaning the facility can supply and is eligible to sell capacity to ensure resource adequacy.

Gigawatt (GW): One thousand megawatts (1,000 MW) or, one million kilowatts (1,000,000 kW) or one billion watts (1,000,000,000 watts) of electricity. One GW is enough to supply the electric demand of about one million average California homes.

CPUC Integrated Resource Planning (IRP): A planning proceeding to consider all the CPUC's electric procurement policies and programs and ensure California has a safe, reliable, and cost-effective electricity supply. The integrated resource planning process ensures that load-serving entities (LSEs) detail the procured and planned resources in their portfolios that allow the electricity sector to contribute to California's economywide greenhouse gas emissions reductions goals.

Levelized Cost of Energy (LCOE): The average total cost of an energy generation project per unit of total electricity generated. Also referred to as the levelized cost of electricity or the levelized energy cost (LEC), LCOE is a measurement to assess and compare alternative methods of energy production. The LCOE of an energy-generating asset can be thought of as the average total cost of building and operating the asset per unit of total electricity generated over an assumed lifetime.

Maximum Feasible Capacity (AB 525/CEC definition): California Code of Regulations, Title 20, section 1201(h), defines "feasible" as "capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social, and technological factors." Maximum feasible capacity is the amount of offshore wind that California can expect to generate with realistic projections of what could be achieved by 2030 and 2045, considering the broad range of specified factors identified in AB 525.

Megawatt (MW): One thousand kilowatts (1,000 kW) or 1 million (1,000,000) watts. One MW is enough electrical capacity to power 1,000 average California homes. (Assuming a loading factor of 0.5 and an average California home having a 2 kilowatt peak capacity.)

Nameplate Capacity, Rated Capacity: The total manufacturer-rated capacities (or full-load sustained output) of equipment such as turbines, generators, condensers, transformers, and other system components.

Net Qualifying Capacity: The amount of capacity from each generation resource that can be counted toward meeting resource adequacy requirements.

Outer Continental Shelf (OCS): Includes the area between state jurisdiction to 200 nautical miles from shore.

Renewables Portfolio Standard: One of California's key programs for advancing renewable energy. The program sets continuously escalating renewable energy procurement requirements for the state's load-serving entities.

Technical Potential (for floating offshore wind): Areas offshore that can generate electricity using offshore wind and meet certain technical requirements for the deployment of floating offshore wind technology. Technical requirements include waters that are greater than 60 meters and less than 1,300 meters in depth, have an annual average windspeed of seven meters per second or greater, and can be commercially developed using available technology.

The ISO Transmission Planning Process (TPP): Annual stakeholder process that provides a comprehensive evaluation of the ISO transmission grid to identify upgrades needed to maintain reliability, successfully meet public policy goals, and identify transmission projects that can bring economic benefits to consumers.

Utility-Scale Energy Generation: A utility-scale generation system involves large energy facilities that are designed to generate large amounts of electricity to be place directly onto the regional transmission grid.