California Offshore Wind

By John Benson

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1. Introduction

I recently posted a two-part series on offshore wind (linked below). In that series I focused on the U.S. East-coast states with political support for offshore wind and active offshore wind projects. I also indicated that there were no active projects on the U.S. West Coast. Although that is still basically true, there is quite a bit of early-stage activity on the California coast. This post reviews that activity, and possible barriers to future development.

https://www.energycentral.com/c/cp/shore-wind-update-%E2%80%93-part-1

https://www.energycentral.com/c/cp/shore-wind-update-%E2%80%93-part-2

1.1. Critical Technology

As a starting-point, any offshore wind project in California will need to be at least 10 miles offshore in order to avoid major visual impacts, and this puts these projects in rather deep water –somewhat less than 1,000 meters for a large majority of potential sites. This depth requires floating wind turbines, and this technology has only recently been proven via Equinor's Hywind Scotland Project which started operation in 2017 (go through the link below to a past paper, then to section 4.1.1).

https://www.energycentral.com/c/pip/large-wind-small-wind-and-future-wind

Hywind Scotland has been very successful, withstanding extreme weather, and operating at a record capacity factor.[1] Although this is a small project, it has definitely proven that this technology works as well as ocean-floor mounted turbines.

1.2. Early Evaluation

A NREL Study published in 2016 and referenced here[2] identified six potential wind resource areas as a result of an analysis that looked at the following factors:

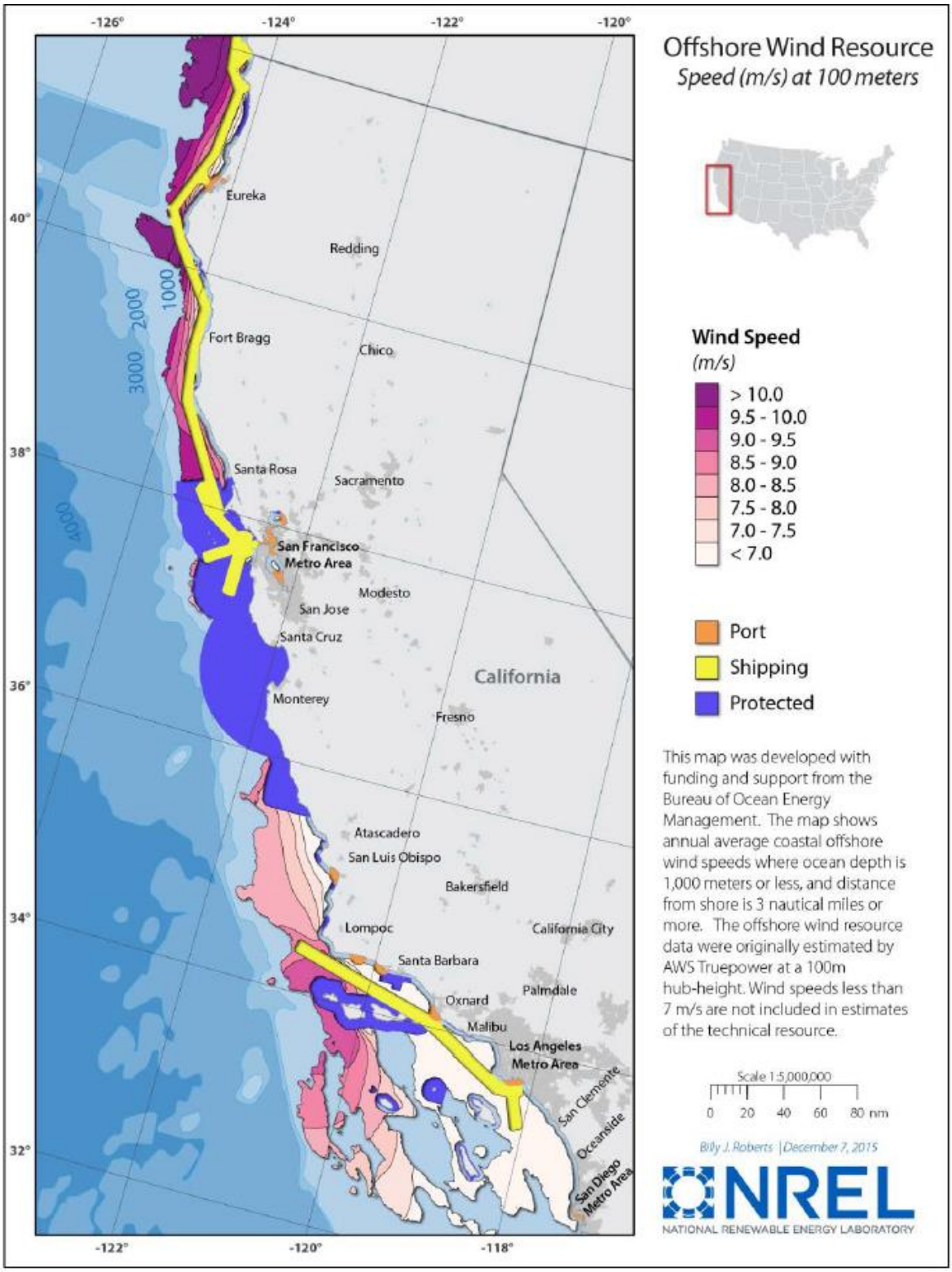
- Annual average wind speeds greater than 7 meters per second (m/s)
- Water depths shallower than 1,000 meters
- Lowest use conflicts
- Access to electric transmission on land (not required but evaluated)
- Suitable ports for installation and service
- Minimal visual impacts from nearshore siting.

Below are two graphics and a table from this report. The first looks at the whole coast as well as potential conflicts like shipping lanes (including a buffer zone recommended by

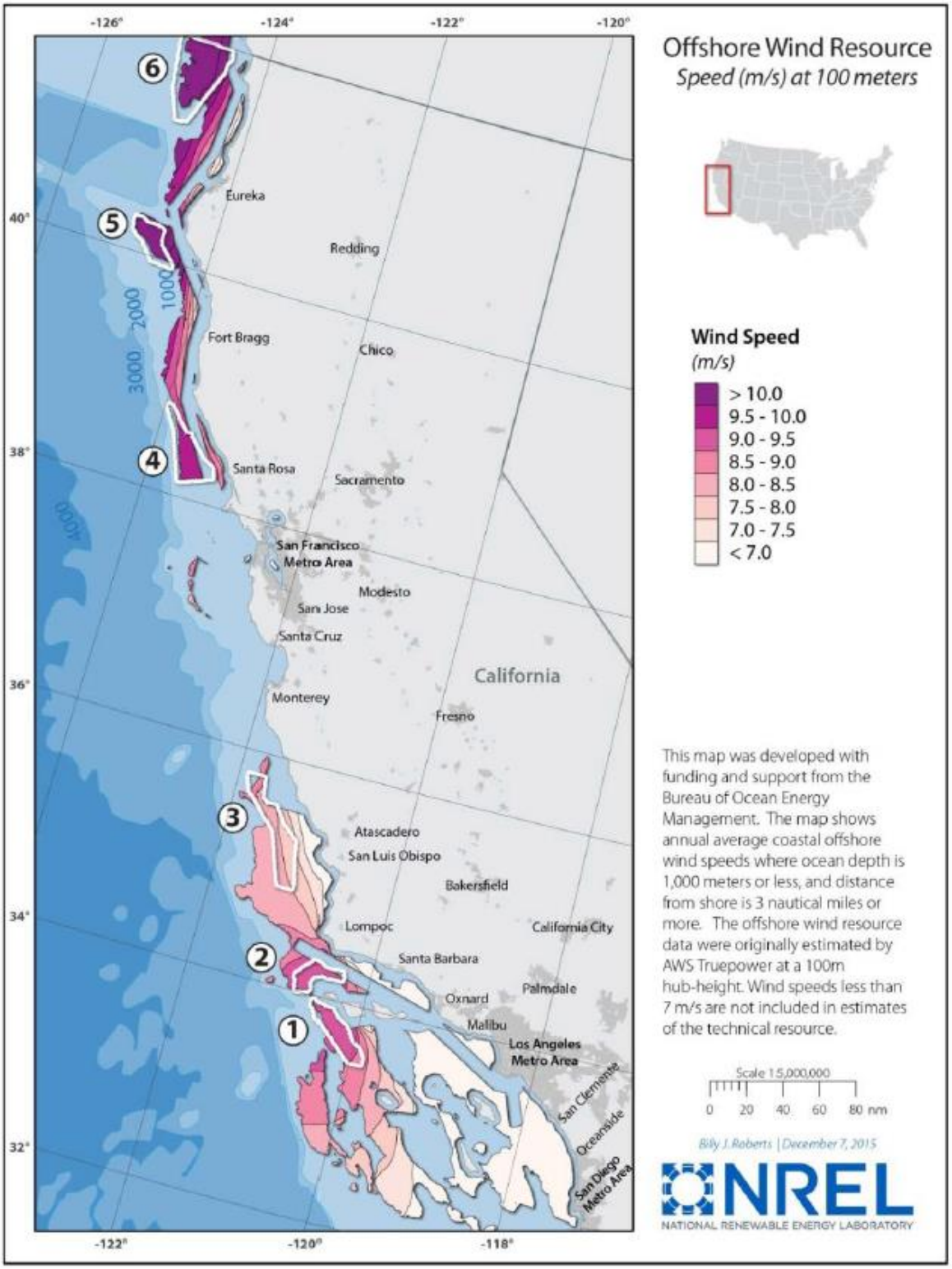
[1] Michael J. Coren, Quartz, "Floating wind farms just became a serious business", June 22, 2019, https://qz.com/1650433/hywind-scotland-makes-floating-wind-farms-a-serious-business/

[2] Walter Musial, Philipp Beiter, Suzanne Tegen and Aaron Smith, National Renewable Energy Laboratory (NREL), "Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs", December, 2016, https://www.nrel.gov/docs/fy17osti/67414.pdf

maritime operators), other protected areas, wind speed, and supporting infrastructure. It also only looks at areas that are in waters shallower than 1,000 meters.



The second graphic (below) eliminates potential conflicts from consideration and identifies the six potential areas



And finally the table below identifies the six areas with various details.

Offshore Wind Reference Area	Channel Islands South	Channel Islands North	Morro Bay Area	Bodega Bay Area	Humboldt Bay Area	Crescent City Area
Site Identification Number	1	2	3	4	5	6
Representative Point Latitude	33.734614°	34.188565°	35.458256°	38.355489°	40.133304°	41.699739°
Representative Point Longitude	120.18475°	120.66088°	121.50439°	123.52929°	124.73094°	124.76659°
Centroid Latitude	33.72	34.16	35.32	38.41	40.13	41.66
Centroid Longitude	-120.21	-120.59	-121.45	-123.59	-124.72	-124.80
Representative Aliquot ID	NI10-09-6235J	NI10-06-6875H	NI09-03-6559F	NJ09-05-6711J	NK10-10-6974B	NK10-07-6273N
Mean Annual Wind Speed (m/s)	9.30	8.86	7.81	9.22	9.73	10.28
Min, Mean, Max Annual Significant Wave Height (m)	1.5/2.0/2.3	1.8/2.3/2.5	2.2/2.3/2.4	2.2/2.5/2.6	2.7/2.7/2.8	2.4/2.6/2.7
Min, Mean, Max Depth (meters) for Representative Aliquot	318/746/960	198/575/774	461/713/996	113/446/990	592/870/994	155/805/997
Construction Port	Port Hueneme, CA	Port Hueneme, CA	Port Hueneme, CA	Fields Landing, CA	Fields Landing, CA	Fields Landing, CA
Construction Port (Lat. Long)	(34.15,-119.2)	(34.15,-119.2)	(34.15,-119.2)	(40.72, -124.22)	(40.72, -124.22)	(40.72, -124.22)
Centroid Distance to Construction Port (straight line–km)	104	127	242	264	78	115
Centroid Distance to Construction Port (avoids land–km)	104	127	266	291	87	116
Operation and Maintenance (O&M) Port	Port Hueneme, CA	Port Hueneme, CA	Morro Bay, CA	Bodega Bay, CA	Fields Landing, CA	Crescent City, CA
O&M Port (Lat. Long)	(34.15,-119.2)	(34.15,-119.2)	(35.37, -120.86)	(38.33,-123.05)	(40.72, -124.22)	(41.75,-124.18)
Centroid Distance to Centroid Distance to O&M Port (straight line–km)	104	127	53	47	78	52
Centroid Distance to Centroid Distance to O&M Port (Avoids Land–km)	104	127	54	54	87	52
Interconnection Point	Goleta, CA	Goleta, CA	Diablo Canyon Nuclear Plant, CA	Jenner, CA (Hwy 116 and Hwy 1)	Eureka, CA	Crescent City, CA
Interconnection Point 1 (Lat. Long)	(34.43,-119.91)	(34.43,-119.91)	(35.21,-120.86)	(38.45,-123.13)	(40.74,-124.21)	(41.87,-124.21)
Centroid Distance to Interconnection 1 (Offshore Until Landfall) (Straight Line–km)	83	69	55	40	80	54
Centroid Distance to Interconnection 1 (Offshore Until Landfall) (Avoids Land–km)	101	69	55	40	87	54
Distance Point of Cable Landfall to Interconnect 1 (km)	6	6	5	5	5	5
Area (km^2)	753	445	1,234	799	431	1,752
Area (sq miles)	291	172	476	308	166	676
Total Potential Capacity (MW)	2,259	1,335	3,702	2,397	1,293	5,256

1.3. The Full Potential

From the report referenced at the end of this paragraph: *"With 112 GW of technical offshore wind resource potential along its coastline, enough to supply about 1.5 times the state's annual electric energy use, California has the eighth-highest resource potential in the United States. As the state moves toward a zero-carbon electricity mix in 2045, offshore wind can provide value to the grid by balancing solar generation. Floating offshore wind technology, which is better suited for California due to its deep waters, is relatively new but has demonstrated impressive capacity factors. Scientists project that California's floating offshore wind turbines could reach capacity factors of over 70 percent, in other words, generating 70 percent of their maximum theoretical output. This capacity factor is two to three times that of solar, nearly twice that of land-based wind, and even greater than that of coal."* [3]

[3] American Jobs Project, "The California Offshore Wind Project: A Vision for Industry Growth", February, 2019, http://americanjobsproject.us/wp/wp-content/uploads/2019/02/The-California-Offshore-Wind-Project.pdf

2. The Process

The process described below started shortly after NREL released the above-referenced report. It evolve through a series of meetings to identify potential offshore resource areas based on interest by parties that will support development of these areas.

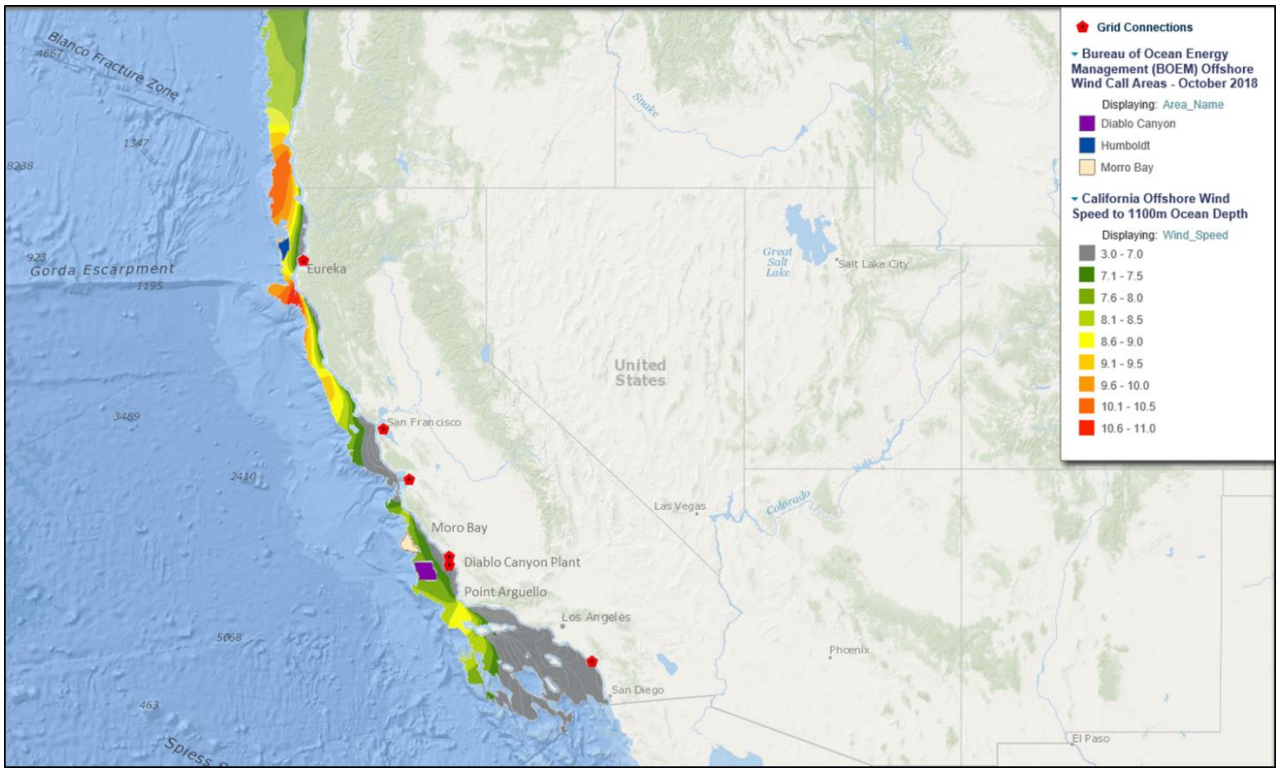
I found a BOEM Site that is dedicated to this process (first link below) and this led to other sites, including the second site below.

https://www.boem.gov/california/

https://caoffshorewind.databasin.org/

This *Call for Information and Nominations ("Call")*, started with meetings in 2016 through last year. All interested parties provided comments and these (and other meeting material) are linked on the above "…boem.gov/california/" site.

There are currently three Call areas currently being considered for offshore wind energy leases (see map below).



- Offshore from the Diablo Canyon Nuclear Pant (purple)
- Redwood Coast Energy Authority's proposed Redwood Coast Offshore Wind Project "Humboldt" offshore from Eureka, in far Northern California (blue)
- Offshore near Morro Bay, just north of Diablo Canyon (tan).

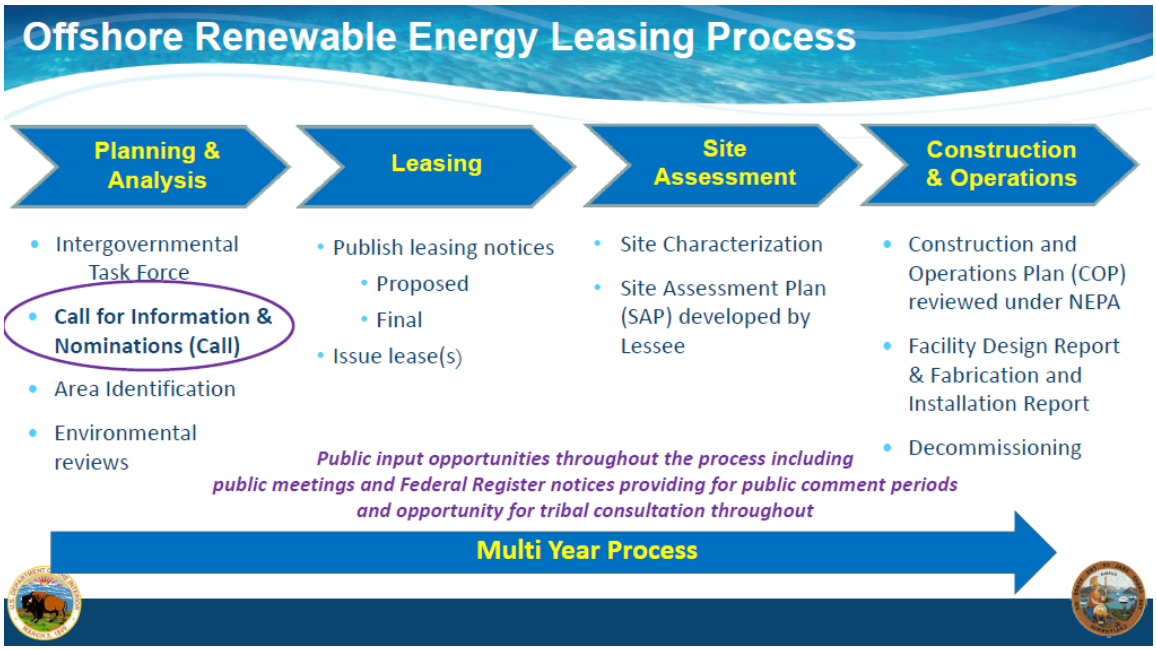
In the above map, you can see these areas, wind-speeds and proposed grid connection points. Each project that is considering using one of these three potential sites is briefly described in the next section.

2.1. Full Process

The diagram below is from a presentation that was given at the last stake-holders meeting late last year (linked on above "…boem.gov/california/" site). Note that the current phase of this process is circled. Although this sheet is not specific, I would guess the total time from now until the first kWh comes ashore from the first turbine is no less than five years. This is considering the better support for renewables by California vs. east-shore states.

There are several pieces of good news regarding this period:

- This allows more time for further development of floating turbine technology.
- This allows at least the next generation of off-shore turbines (10 to 12 MW) to mature.
- California's next goal for renewable power (60%) is in 2030, which should allow sufficient time to complete all three of these planned/potential projects.



3. Initial Projects

Each subsection below covers one of the potential projects, and includes all of the information on it I can find at this time.

3.1. Redwood Coast Offshore Wind Project

This is the smallest, furthest along and likely to be the first completed project. About a year ago the Redwood Coast Energy Authority submitted an unsolicited lease application. Much of the information is drawn from this application, which is referenced here.[4]

[4] Redwood Coast Energy Authority (RCEA), "Unsolicited Application for an Outer Continental Shelf Renewable Energy Commercial Lease", September, 2018, https://redwoodenergy.org/wp-content/uploads/2018/09/Unsolicited-Lease-Request_RCEA_20180910_Final_PUBLIC.pdf

From their website (linked below): *The Redwood Coast Energy Authority (RCEA) develops and implements sustainable energy initiatives that reduce energy demand, increase energy efficiency, and advance the use of clean, efficient and renewable resources.*

https://redwoodenergy.org/

RCEA is a local government Joint Powers Agency founded in 2003 whose members include the County of Humboldt, the Cities of Arcata, Blue Lake, Eureka, Ferndale, Fortuna, Rio Dell, and Trinidad, and the Humboldt Bay Municipal Water District.

Additional partners in this project include EDP Renewables Offshore North America LLC ("EDPR Offshore"), Principle Power, Inc. (PPI), and Aker Solutions Inc. ("ASI"). Links to their websites are below.

https://www.edprnorthamerica.com/

http://principlepowerinc.com/

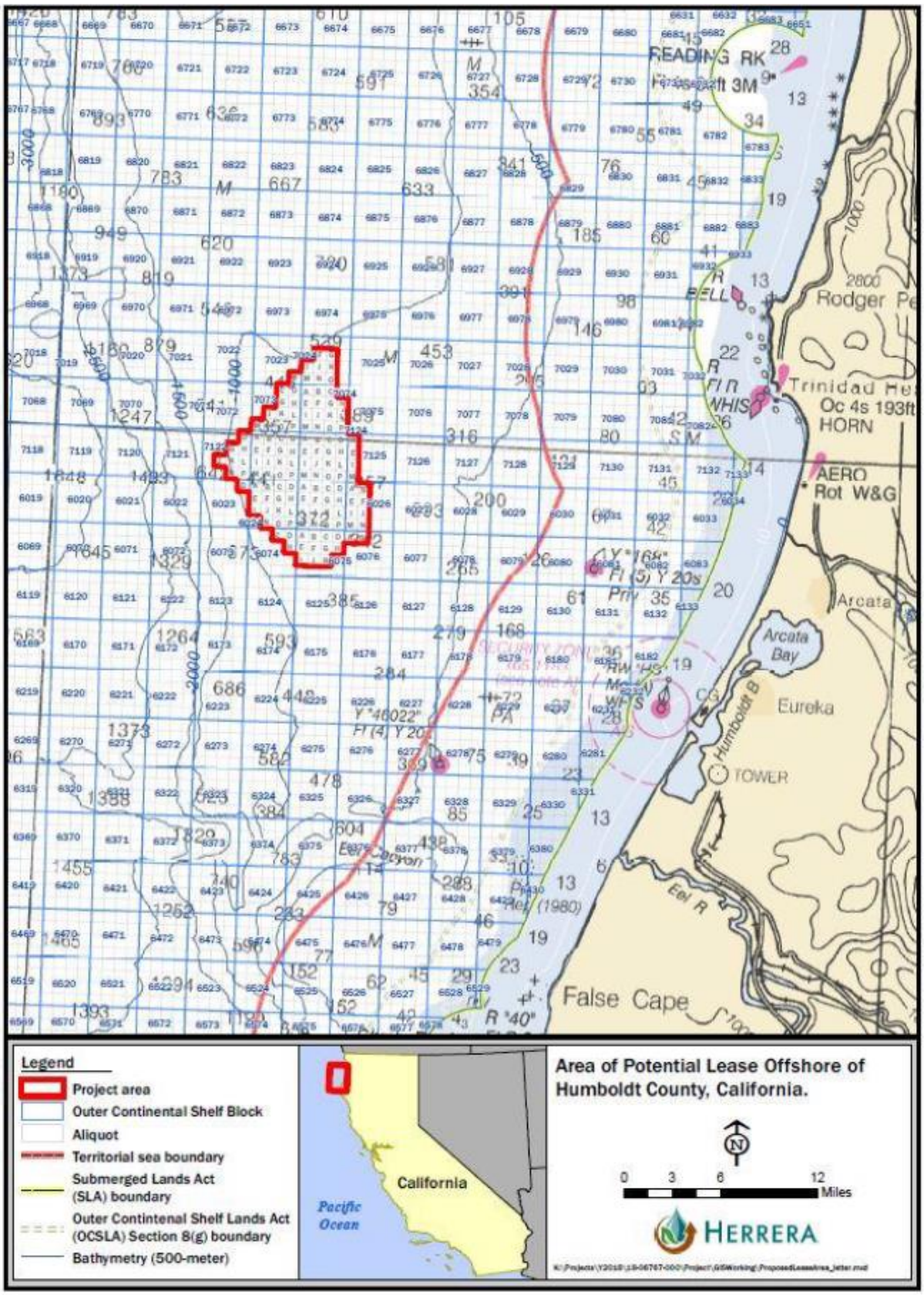
https://akersolutions.com/what-we-do/products-and-services/offshore-wind-solutions/

The approximately 100-150 megawatt (MW) project is expected to consist of approximately 8 to 16 WindFloat foundations outfitted with large scale commercial offshore wind turbines not smaller than 8.0MW. The floating wind farm would be sited in 600-1,000 meters of water approximately 24 to 33 miles from shore. An offshore grid and subsea cable would be used to export produced electricity to facilities at the Humboldt substation. Infrastructure planning in conjunction with the Port of Humboldt Bay is already underway.

The Project Partners plan for facilities at the Port of Humboldt Bay to potentially serve as the final assembly, hull load-out, turbine installation, and future maintenance base for WindFloat units. As a result, the Redwood Coast Project would require investment and revitalization of local infrastructure at the Port of Humboldt Bay and other nearby onshore facilities. To the greatest extent possible, the Redwood Coast Project will maximize the use of existing facilities and collaborate with local stakeholders to identify and address local infrastructure improvements. These investments will require skilled labor from the immediate and surrounding area and will create jobs and training to fulfill these commitments, thus advantageously positioning Humboldt County for future offshore development up and down the West Coast. RCEA and Project Partners believe this project will kick off the offshore wind industry and increase the interest and success of future BOEM leases.

The proposed site location, 21 to 29 nautical miles from shore, avoids or minimizes impacts on marine navigation corridors, major commercial fishing areas and environmental resources such as wildlife migratory corridors, sensitive habitats, and threatened or endangered species. Most importantly, this site location is de-conflicted from groundfish commercial fishing activities as much as possible. RCEA and Project Partners will continue proactive community and stakeholder outreach, including further dialogue with the commercial fishing community and recreational fishers, as the project progresses to understand and address potential concerns.

Below is a detailed map of the proposed lease location.


READING RK
Trinidad Hd
Oc 4s 193ft
HORN
AERO
Rot W&G
Arcata
Arcata Bay
Eureka
Humboldt B
TOWER
Eel R
False Cape
Legend
Project area
Outer Continental Shelf Block
Aliquot
Territorial sea boundary
Submerged Lands Act (SLA) boundary
Outer Contintenal Shelf Lands Act (OCSLA) Section 8(g) boundary
Bathymetry (500-meter)
California
Pacific Ocean
Area of Potential Lease Offshore of Humboldt County, California.
0 3 6 12
Miles
HERRERA

Additional extensive details regarding this project are provided by the Lease Application, which is referenced above.

3.2. Castle Wind Offshore

This project is identified as "Morro Bay" in the above referenced NREL study and the BOEM Call process. This project is much less developed to date, and a much more ambitious scope than the above described Redwood Coast project. The site for this project is linked below.

http://castlewind.com/morro-bay-project/

Per this site: "*Castle Wind Offshore (CWO) will consist of approximately 100 floating offshore wind systems (FOWS) that will harvest the vast offshore wind resources for the benefit of the California electric consumers. Each FOWS will consist of a commercially available floating support structure and a large offshore wind turbine generator (OWTG) with a nameplate capacity greater than 8 MW. Each FOWS is moored to the ocean floor using conventional properly sized, vertical load, drag imbedded, or torpedo anchors…*

The CWO wind farm is planned to be located over 30 miles offshore, taking advantage of a consistent wind resource with an average speed of 8.5 meters/sec.

Castle Wind was formed in a joint venture between an American division of a large German Company (EnBW North America), and a small Washington State firm (Trident Winds). EnBW AG (European Headquarters Company) has significant experience in off-shore wind, but none that I could find in floating wind turbines. The Founder and CEO of Trident was previously the President and CEO of Principle Power Inc. Principle Power is a partner in the Redwood Coast project and has significant experience in floating offshore wind turbine support structures. Principal is linked in the prior subsection, and EnBW and Trident are linked below.

https://www.enbw.us/

http://www.tridentwinds.com/

3.3. Diablo Canyon

There has been no development of the "Diablo Canyon" area that has attracted a team that I could identify. However the Diablo Canyon Power Plant is currently scheduled to close in 2025, and several parties identified the potential of a large wind project in this area to displace a large percentage of the lost electric capacity resulting from the closure of this plant and also provide employment and community support. Interested parties that are identified in the following subsection or others may step in to assume the role of developers and/or provide other support for development.

3.4. Other Potential Developers

Avangrid Renewables is the primary developer of Vineyard Wind (offshore) in New England. They are also active in onshore wind projects in California. From the reference here[5]: *"California Choice Energy Authority (CalChoice) announced three new power purchase agreements (PPA) for wind energy from Avangrid Renewables' Mountain View*

[5] Michelle Froese, Windpower Engineering & Development, "CalChoice enters PPA with Avangrid Renewables for California wind energy", August 19, 2019, https://www.windpowerengineering.com/business-news-projects/calchoice-enters-ppa-with-avangrid-renewables-for-california-wind-energy/

III Wind Farm in Palm Springs, California. CalChoice will buy the entire output of the 22.44-MW wind farm starting in 2021 on behalf of three of its members: Apple Valley Choice Energy (AVCE), the Rancho Mirage Energy Authority (RMEA), and Lancaster Choice Energy (LCE)."

The following are entities that are potential developers or other participants in California offshore wind developments (not previously identified above) that submitted comments to BOEM during the Call process. There is a link to all comments on the "boem.gov/california/" site, linked in section 2 above.

Cierco Corporation, http://ciercoenergy.com/

Equinor Wind US LLC, https://www.equinor.com/en/what-we-do/new-energy-solutions/our-offshore-wind-projects.html

4. Potential Support and Barriers

Several factors listed below could accelerate or slow the progress of California offshore windpower development.

4.1. Political Support

Although some eastern states are developing strong political support, California has always has strong support for renewables, and pioneered many renewable energy technologies, including wind-power.

4.2. Reserved Areas

Southern California has a large offshore area that our military uses extensively for training, and the Department of Defense (DoD) has strongly discouraged off-shore wind-power development here. They also have suggested that other areas, including those being developed or proposed for windpower development should be reserved for DoD use.

4.3. Competition

With the downward trajectory of photovoltaic (PV) plus battery energy storage systems (BESS) power purchase agreement (PPA) pricing, the question becomes: can offshore wind match or beat this pricing? I believe it is in California's, the United States', and local communities' best interest to develop this, so those bodies may need to provide incentives to balance the scale should PV+BESS PPA pricing continue its dramatic decrease.