How do floating wind turbines work?

December 9 2022, by Matthew Lackner

Equinor’s Hywind Scotland became the world’s first floating wind farm in 2017. Credit: Øyvind Gravås/Woldcam via Equinor

Northern California has some of the strongest offshore winds in the U.S., with immense potential to produce clean energy. But it also has a problem. Its continental shelf drops off quickly, making building traditional wind turbines directly on the seafloor costly if not impossible.

Once water gets more than about 200 feet deep—roughly the height of an 18-story building—these "monopile" structures are pretty much out of the question.

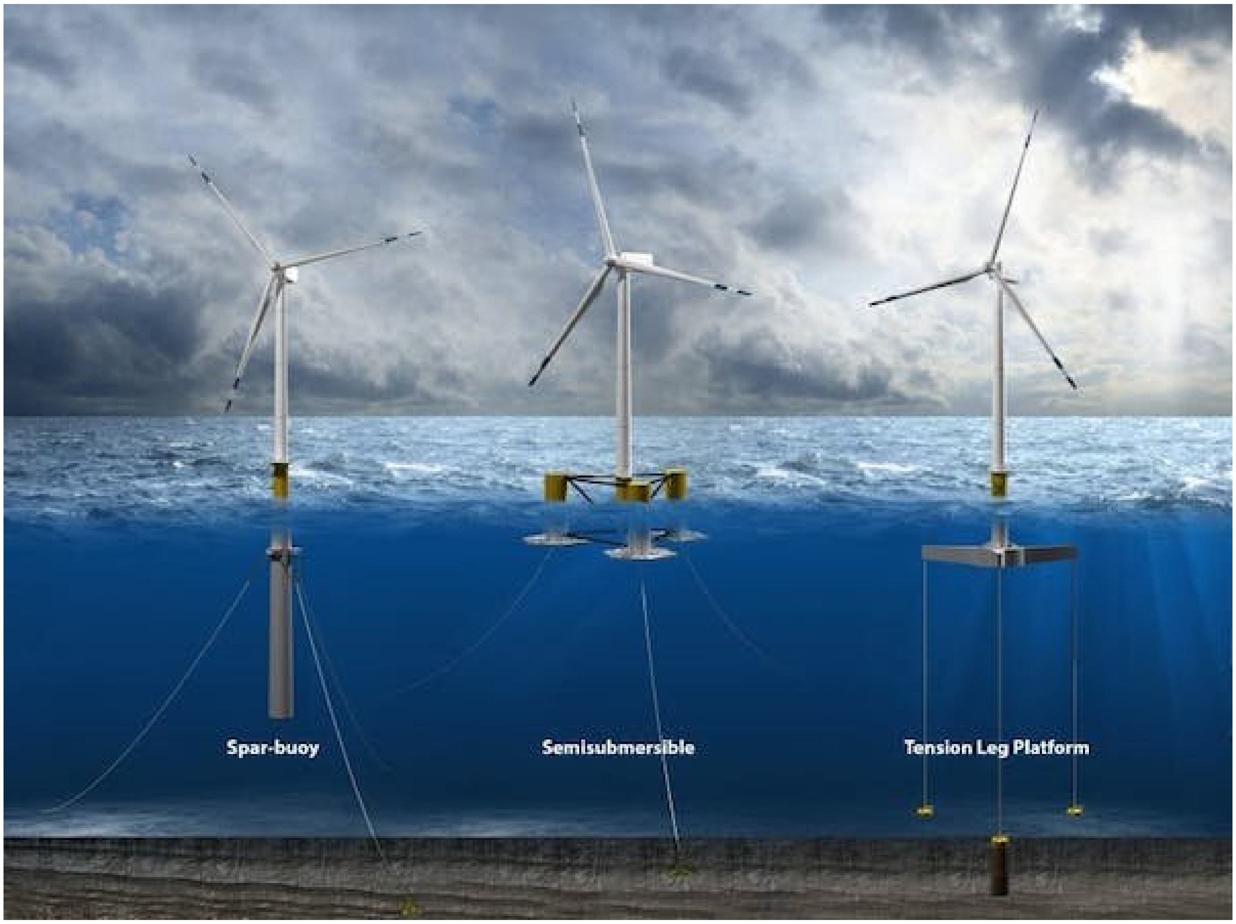
A solution has emerged that's being tested in several locations around the world: wind turbines that float.

In California, where drought has put pressure on the hydropower supply, the state is moving forward on a plan to develop the nation's first floating offshore wind farms. On Dec. 7, 2022, the federal government auctioned off five lease areas about 20 miles off the California coast to companies with plans to develop floating wind farms. The bids were lower than recent leases off the Atlantic coast, where wind farms can be anchored to the seafloor, but still significant, together exceeding US$757 million.

So, how do floating wind farms work?

Three main ways to float a turbine

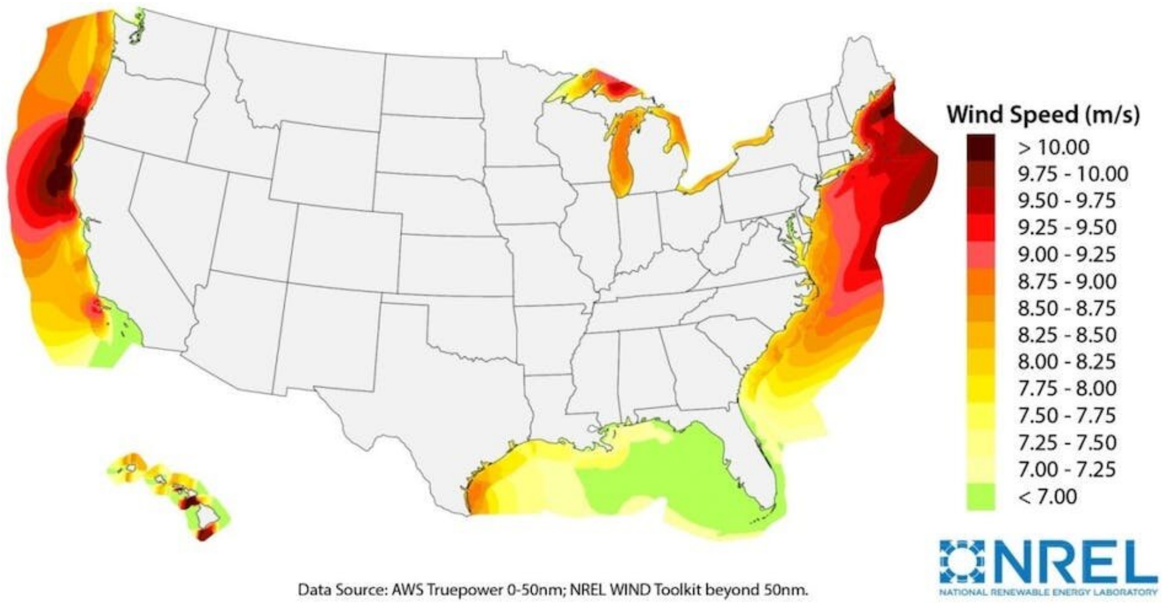
A floating wind turbine works just like other wind turbines—wind pushes on the blades, causing the rotor to turn, which drives a generator that creates electricity. But instead of having its tower embedded directly into the ground or the seafloor, a floating wind turbine sits on a platform with mooring lines, such as chains or ropes, that connect to anchors in the seabed below.



Three of the common types of floating wind turbine platform. Credit: Josh Bauer/NREL

These mooring lines hold the turbine in place against the wind and keep it connected to the cable that sends its electricity back to shore.

Most of the stability is provided by the floating platform itself. The trick is to design the platform so the turbine doesn't tip too far in strong winds or storms.



Some of the strongest offshore wind power potential in the U.S. is in areas where the water is too deep for fixed turbines, including off the West Coast. Credit: NREL

There are three main types of platforms:

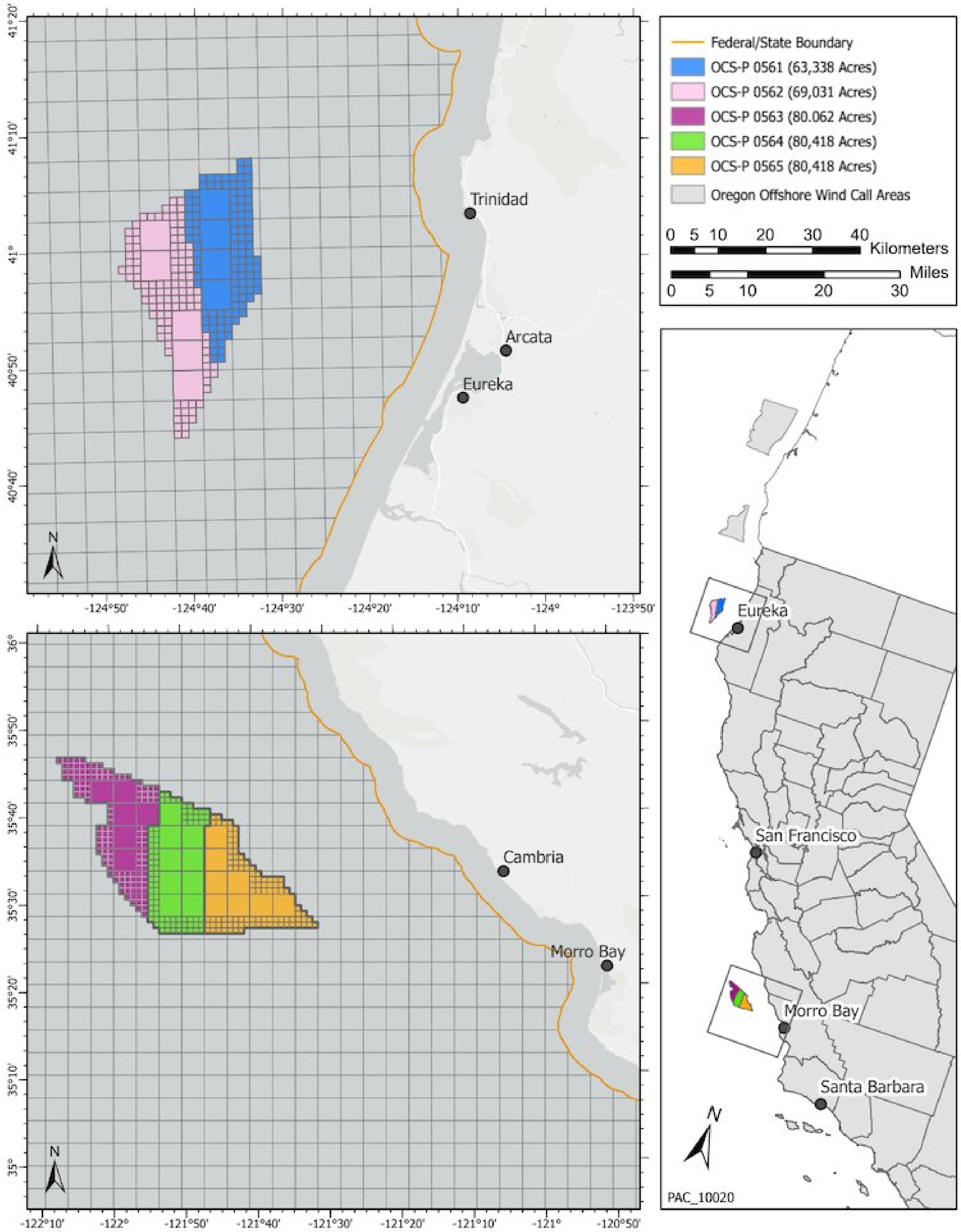
- A spar buoy platform is a long hollow cylinder that extends downward from the turbine tower. It floats vertically in deep water, weighted with ballast in the bottom of the cylinder to lower its center of gravity. It's then anchored in place, but with slack lines that allow it to move with the water to avoid damage. Spar buoys have been used by the oil and gas industry for years for offshore operations.

- Semisubmersible platforms have large floating hulls that spread out from the tower, also anchored to prevent drifting. Designers have been experimenting with multiple turbines on some of these hulls.

- Tension leg platforms have smaller platforms with taut lines running straight to the floor below. These are lighter but more vulnerable to earthquakes or tsunamis because they rely more on the mooring lines and anchors for stability.

Each platform must support the weight of the turbine and remain stable while the turbine operates. It can do this in part because the hollow platform, often made of large steel or concrete structures, provides buoyancy to support the turbine. Since some can be fully assembled in port and towed out for installation, they might be far cheaper than fixed-bottom structures, which require specialty vessels for installation on site.

Floating platforms can support wind turbines that can produce 10 megawatts or more of power—that's similar in size to other offshore wind turbines and several times larger than the capacity of a typical onshore wind turbine you might see in a field.



The first five federal lease areas for Pacific coast offshore wind energy development. Credit: Bureau of Ocean Energy Management

Why do we need floating turbines?

Some of the strongest wind resources are away from shore in locations with hundreds of feet of water below, such as off the U.S. West Coast, the Great Lakes, the Mediterranean Sea and the coast of Japan.

The U.S. lease areas auctioned off in early December cover about 583 square miles in two regions—one off central California's Morro Bay and the other near the Oregon state line. The water off California gets deep quickly, so any wind farm that is even a few miles from shore will require floating turbines.

Results of the first US Pacific Ocean wind lease sale

Forty-three companies were cleared by the federal government to bid on five lease areas for developing floating wind farms off the California coast. The provisional winners were announced Dec. 7, 2022.

Location	Lease size	Winning bid	Provisional winner
Northern California	63,338 acres	$157,700,000	RWE Offshore Wind Holdings, LLC
Northern California	69,031 acres	$173,800,000	California North Floating, LLC (Copenhagen Infrastructure Partners)
Central California	80,062 acres	$130,000,000	Equinor Wind US, LLC
Central California	80,418 acres	$150,300,000	Central California Offshore Wind, LLC (Ocean Winds)
Central California	80,418 acres	$145,300,000	Invenergy California Offshore LLC

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Credit: The Conversation

Once built, wind farms in those five areas could provide about 4.6 gigawatts of clean electricity, enough to power 1.5 million homes, according to government estimates. The winning companies suggested they could produce even more power.

But getting actual wind turbines on the water will take time. The winners of the lease auction will undergo a Justice Department anti-trust review and then a long planning, permitting and environmental review process that typically takes several years.

Globally, several full-scale demonstration projects with floating wind turbines are already operating in Europe and Asia. The Hywind Scotland project became the first commercial-scale offshore floating wind farm in 2017, with five 6-megawatt turbines supported by spar buoys designed by the Norwegian energy company Equinor.

Equinor Wind US had one of the winning bids off Central California. Another winning bidder was RWE Offshore Wind Holdings. RWE operates wind farms in Europe and has three floating wind turbine demonstration projects. The other companies involved—Copenhagen Infrastructure Partners, Invenergy and Ocean Winds—have Atlantic Coast leases or existing offshore wind farms.

While floating offshore wind farms are becoming a commercial technology, there are still technical challenges that need to be solved. The platform motion may cause higher forces on the blades and tower, and more complicated and unsteady aerodynamics. Also, as water depths get very deep, the cost of the mooring lines, anchors and electrical cabling may become very high, so cheaper but still reliable technologies will be needed.

Provided by The Conversation

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