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Wind power tests the waters

The United States has plenty of strong winds offshore, but it has struggled to harness them for energy.

BY GENE RUSSO

The town of Castine, Maine, feels like a place bypassed by time. First settled in the early seventeenth century, its streets are lined with buildings hundreds of years old. Boats bob in its small harbour and a white lighthouse, constructed of rough-hewn stone, stands guard from a high hill.

But just half a kilometre offshore, a harbinger of the future pokes out of the grey mist. A canary-yellow wind turbine rocks in the waves, its thin blades slowly rotating. Installed in June last year, the 20-metre-tall structure is an experimental floating design just one-eighth in scale. It provides a maximum of 20 kilowatts of electricity, barely enough to power half a dozen US homes. But the structure, called VolturnUS, stands out because it is the only offshore wind turbine in US waters.

A floating turbine in Castine, Maine, is the only existing offshore wind facility in the United States.

Other countries, such as Belgium, the United Kingdom, Denmark and Germany, have built massive turbine farms off their coastlines in the past few decades. In the United States, however, efforts to tap the power of coastal winds have gone nowhere because of environmental concerns, bureaucratic tangles and political opposition. That may soon change. Ecological studies indicate that carefully planned wind farms should not significantly harm birds or marine mammals. And business and politicians are increasingly interested in exploring and investing in offshore wind power.

This May, the US Department of Energy awarded money to three demonstration projects, planned for the coasts of New Jersey, Oregon and Virginia. Several state governments are forging ahead with their own ambitions for offshore wind farms, and commercial developers say that they could start planting turbines in the ocean as early as next year.

In theory, the potential is tremendous. Including harder-to-reach deep-water sites, the offshore territory of the United States has the capacity to generate an estimated 4,200 gigawatts of electricity, enough to supply four times the nation's current needs. But before the field can take off, proponents will have to prove that offshore wind can compete financially against other energy sources, and can clear the thicket of state and federal regulations that govern projects in coastal waters.

"I don't think we're looking at easy street here," says Walt Musial, a long-time offshore-wind researcher at the National Renewable Energy Laboratory in Louisville, Colorado. "We really need to demonstrate that it can be done."

SEA TEST

No project encapsulates the challenges facing offshore wind power better than Cape Wind, being developed by Energy Management of Boston, Massachusetts. The venture aims to take advantage of the strong winds and relatively calm waters of Nantucket Sound near Cape Cod, Massachusetts, some 350 kilometres southwest of Castine.

The plan for Cape Wind consists of 130 turbines, each standing nearly 80 metres tall, over an area of 65 square kilometres. Energy Management says that the completed wind farm will have a capacity of 468 megawatts, able to produce 75% of the electricity for Cape Cod and the nearby islands of Martha's Vineyard and Nantucket.

But the project has faced strong opposition for more than a decade. Organizations including the non-profit group Save Our Sound have brought dozens of lawsuits against Cape Wind, claiming that the project would harm birds and other wildlife, increase electricity rates for consumers and endanger aeroplanes flying into local airspace. Except for one temporary decision, all of the judicial rulings have been in favour of Cape Wind. Spokesperson Mark Rodgers says that even with court appeals coming, the project intends to commence construction by spring 2015. "There are no merits to any of these legal complaints," he says.

Cape Wind has already broken new ground by being the first US offshore wind project to complete a major environmental assessment. That study — thousands of pages long — and independent analyses have helped to appease some groups that were sceptical of the initial proposal.

The conservation group Mass Audubon in Lincoln, Massachusetts, for example, spent three years tracking roseate terns (*Sterna dougallii*), migratory songbirds and sea ducks wintering in the area, and found little cause for concern. The songbirds typically fly above 300 metres, making collisions unlikely. And the terns and ducks stay close to shore during migration and breeding.

The effects on marine mammals may be harder to predict. Researchers and environmentalists have worried in particular about the construction stage of offshore wind farms, which so far have almost exclusively used turbines fixed to the ocean floor. Pounding huge steel beams into the seabed generates sounds equivalent to a small explosion — enough to disrupt the behaviour of some marine mammals, at least temporarily.

In the early 2000s, Jakob Tougaard, a marine bioacoustician at Aarhus University in Roskilde, Denmark, studied the effects of wind-farm construction on harbour porpoises (*Phocoena phocoena*) off the coast of Denmark. Using recordings of porpoise vocalizations, he found[1] evidence that animals shied away from the construction site even up to distances of 21 kilometres. "In most cases, there's a strong effect from construction," says Tougaard. But his work and follow-up studies by other researchers show[2] that porpoise visits to the wind-farm area increase once construction has finished.

To avoid severe problems such as damaging the hearing of marine mammals, Cape Wind is required as part of its lease to have at least one observer monitoring each turbine installation. The company will delay pile driving if a marine mammal comes within 750 metres of the site, says Rachel Pachter, a permitting and environmental project manager for Cape Wind.

Other projects might have to take stronger measures to accommodate the endangered North Atlantic right whale (*Eubalaena glacialis*). Cape Wind is outside the whales' typical migration path, but the animals pass closer to many other potential wind-farm sites along the East Coast. In 2012, several environmental groups and developers agreed to guidelines that would minimize risks to the whales. For example, during certain migratory periods, developers are expected to mitigate the noise through measures such as generating curtains of bubbles around the project to dissipate sound waves.

Peter Tyack, a marine biologist at the Woods Hole Oceanographic Institution in Massachusetts, says that these and other measures will reduce the effects of construction on whales. "I would be surprised if it has a big impact on them," he says, although he advocates putting measures in place to reduce the risk.

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Once construction is over, wind farms could even provide benefits to the marine animals. Researchers have suggested that forests of offshore turbines can become artificial reefs, and a study published[3] this year using tracking data found that seals sought out turbines at active wind farms in Germany and the United Kingdom, perhaps to forage around them. "What really shocked me was the pattern they showed," says Deborah Russell, a marine biologist at the University of St Andrews, UK, who led the study. The seals may like the protection that the wind farm provides from boats, she says.

Beyond concerns over wildlife, US proponents of offshore wind farms have had to address the issue of hurricanes, which could buffet turbines with gusts much stronger than those experienced by facilities in Europe. Although no East Coast hurricane has tested an offshore turbine, engineers say that wind farms can be built to withstand them. Experience with offshore structures such as oil platforms provides confidence that widespread failure of turbines should not be a problem, says James Manwell, a mechanical engineer and director of the Wind Energy Center at the University of Massachusetts Amherst. But fortifying turbines requires extra steel, which drives up expenses. Companies will have to determine how to balance the costs and benefits of reinforcing wind farms for infrequent hurricanes.

ROCKY WATERS

For developers, the big question is whether it makes economic sense to develop wind farms off US shores. Any extra effort associated with meeting environmental regulations or preparing for severe storms will increase the cost of construction, at a time when wind farms have to compete with a bounty of cheap natural gas.

So developers are experimenting with different designs in the hope of driving down costs.

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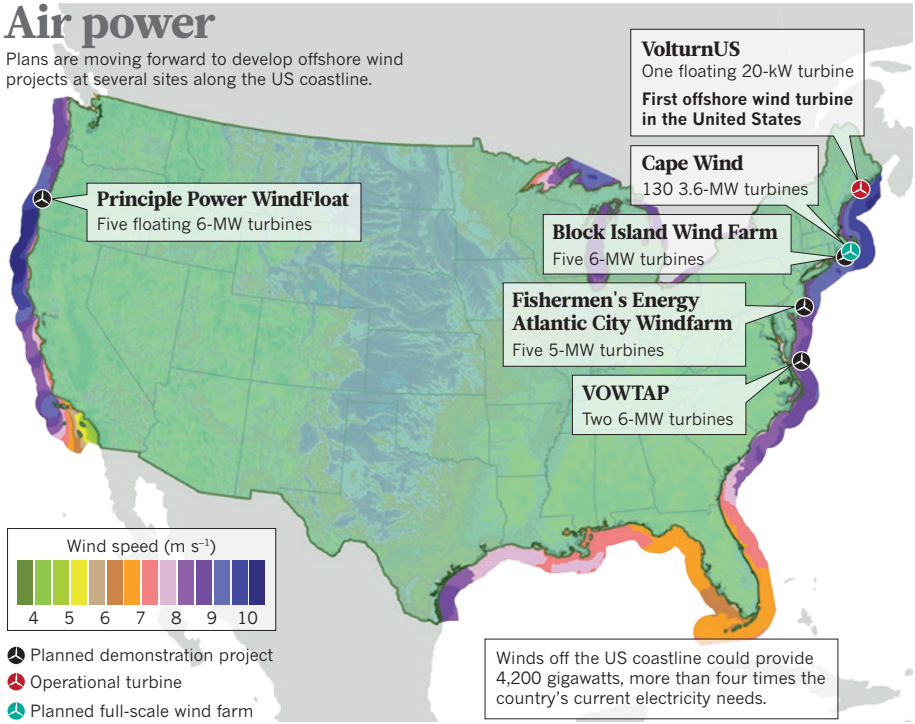
For a video about the Castine turbine, see.
go.nature.com/m9hqng



SOURCE: NREL

Monopile foundations — made of a single huge tube driven into the seabed — are generally cheapest and well tested, but some developers are trying foundations that twist three piles around a central column, similar to structures used for offshore oil and gas platforms. As turbines get larger, these multi-pile designs may be more stable and cost effective than monopiles.

Another solution could be simply to float the turbines, as researchers have done with the experimental design in Castine. Habib Dagher, an engineer at the University of Maine in Orono, and his colleagues constructed the base of the turbine out of hollow concrete tubes; it is held steady in the waves by three cables attached to anchors on the sea floor. Such a design could operate in much deeper waters — where it is impractical to use a monopile that reaches all the way to the sea floor — and would be relatively cheap to construct, because it could be manufactured onshore and simply towed out to the designated location, says Dagher.

He and others will have to prove that the full-size floating structures can stay upright and stable during major storms. Measurements taken since the demonstration turbine's launch suggest that the design will perform well. Even in winds up to about 80 kilometres per hour, the turbine leans by only 5.9 degrees, which indicates that a full-sized device should remain stable during storms so powerful they are expected to strike only once every 500 years, says Dagher.

Floating turbines were not taken seriously ten years ago, but now they are emerging as serious contenders, says Musial. An experimental 2-megawatt floating turbine off the coast of Portugal has been working since 2012, and Japan has two floating turbines already connected to the power grid. The US energy department has also expressed interest in the design: one of the three demonstration projects funded by the agency this year will station five 6-megawatt floating turbines in 350 metres of water off the coast of Coos Bay, Oregon (see 'Air power').

POLITICAL PROBLEMS

Experts say that the environmental and technical challenges for offshore wind are surmountable. The biggest barrier at the moment is the tangled fabric of policy rules that slow projects and provide insufficient certainty for developers and investors, says Willett Kempton, who studies offshore-wind policy at the University of Delaware in Newark. In New Jersey, a group of investors from the commercial fishing industry called Fishermen's Energy succeeded in securing one of the three Department of Energy grants, but has been locked in a court battle with the state Board of Public Utilities. The board has rejected the group's application for a demonstration project off the coast of Atlantic City, saying that the state's electricity users would bear too much of the cost. The most recent decision, handed down by a New Jersey appellate court on 18 August, will force the board to reconsider the application.

Other projects have also fallen prey, at least in part, to concerns over politics, policy and costs. In Maine, for example, a deal to build a US$120-million wind farm, involving the Norwegian energy company Statoil, fell apart after the state's governor elected to reopen the bidding process to other developers.

Kempton lauds the energy policies and financial incentives of the European countries that have pushed ahead with offshore wind. Denmark, for example, has set a target of getting 50% of its power from wind by 2020. To help meet that goal, it requires that the grid connect to offshore wind farms, and it sets a price for electricity from those facilities.

Such long-term support is much more attractive to the wind-energy industry than the kind of short-term tax credits offered by the US federal government, which appear and disappear depending on the whims of Congress as it moves through its two-year election cycle. Some US states are starting to provide better support for projects that could encourage investors and developers. For example, early efforts to build a large wind farm off the coast of Maryland have been buoyed by the state's offer of subsidies for developers. On 19 August, Italian energy company Renexia won an auction to lease 32,000 hectares off Maryland's coast, with a bid of $8.7 million.

For now, however, the greatest chance of getting turbines into the water lies farther to the north. In September, developer Deepwater Wind received what it says is the final federal approval required to install turbines off the coast of Rhode Island in the middle of next year as part of a demonstration project. And Energy Management hopes to start constructing its much larger Cape Wind project even sooner.

To make that possible, the port of New Bedford, Massachusetts, is hurrying to finish preparations that will enable it to handle the 1,400-tonne cranes required to lift the turbines onto ships that will carry them to the Cape Wind site. Massive excavators are working 24 hours a day to deepen the port.

"I think in the next several months we're going to know whether Cape Wind is going to be real or not," says Bill White, senior director for offshore wind at the Massachusetts Clean Energy Center, which is managing the New Bedford site.

Out on a small boat touring the port, White says that Cape Wind is only the beginning for New Bedford's long-term plans. The hope is that the upgraded harbour will serve as a staging ground for offshore-wind projects all along the eastern seaboard.

White and the project engineers have visited ports in Europe, where they learned some valuable lessons — in particular, that loading areas for offshore-wind parts must handle a tremendous amount of weight. A carefully orchestrated sandwich of concrete, steel and sand has added many metres of sturdy land to the port.

The Europeans also taught him something else. "They said be careful with expectations," White says. "It's going to take some time." ■

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