美國能源創新動態報導

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Wind on The Waves: Floating Wind Power Is Becoming a Reality

海上浮動風力正在實現

Worldwide, 13,000 megawatts of offshore wind has been deployed —yet the U.S. only has one offshore wind farm.

For the last year, the Block Island Wind Farm has been operating off the coast of Rhode Island.

As the United States looks to deploy more offshore wind, several U.S. specific technical challenges will need to be overcome. This blog addresses challenges posed by deep waters (stay tuned for future blogs on other U.S. offshore wind topics such as hurricanes, vessels, and installation techniques).

The Consortium

Today, the U.S. Department of Energy (DOE) announced a funding opportunity to establish an offshore wind research and development

本期摘要(KEY INFORMATION)

◎2017 年 12 月，美國能源部(DOE)宣布了投資建立海上風力發電研發(R&D)聯盟。該聯盟將匯集各式各樣的研究人員、海上風能產業的成員。由於美國希望佈建更多的海上風力發電，沿海地區的水域深度將是重大挑戰，迄今為止大多數歐洲的設施都位於淺水區域，但美國海洋風能資源約 60%位於深水區(超過 60 公尺)，意即傳統的底部安裝基礎不具有經濟可行性，目前最具成本效益的安裝方法似乎是一個「拖出」的概念，讓基礎和渦輪機在港口建造，然後拖出到錨點，即便如此，風力渦輪機的動態特性以及保持漂浮所需的重量分佈，也帶來了許多需要克服的工程問題。

◎大西洋沿岸及墨西哥灣的離岸風機面臨颶風的挑戰，除了更強烈的風暴之外，其基礎也必須與巨浪搏鬥。美國能源部國家可再生能源實驗室(NREL)與邁阿密大學合作，結合風力渦輪機模擬軟體（FAST）與大氣波海洋預報模型，進行颶風研究與預測，以創建一個新的「風暴環境下的耦合式水力空氣動力學介面」。該工具可幫助風力系統設計人員降低位於極端氣候區域的海上風機系統的風險。NREL 還設計一個 500 兆瓦的模擬海上風電場，將佈建在墨西哥灣 25 公尺的海域。風力渦輪機採用順風方向，這使得葉片更加靈活，並且允許它們在強風中彎曲而免去撞擊塔架的風險，以降低颶風來襲期間結構損壞的風險。

(R&D) consortium. This consortium will bring together a diverse group of researchers who will add to the offshore knowledge base in an accelerated manner. It will include members of the offshore wind industry, who will contribute funds and expertise to the research results and validate technologies developed by the consortium.

The Challenge

One significant challenge to building offshore wind turbines in the United States is the depth of the waters along many coastal areas. While most European installations to date have occurred in shallow waters, most (roughly 60%) of our nation's offshore wind resources are situated in deep waters — more than 60 meters down (or nearly 200 feet). This means traditional bottom-mounted foundations aren't economically viable in these areas.

The Technology

So, how does the U.S. overcome this challenge? It may seem like something out of a science fiction story, but researchers and engineers are finding ways to create platforms that float, while giving the top-heavy turbine enough stability to operate effectively. Tethered to the sea floor, floating foundations allow wind turbines to operate in areas where water depths may be greater than 165 feet. Floating foundation technologies make offshore wind feasible in locations, including California (where nearly 95% of the available offshore wind resource has a depth greater than 60 meters), Hawaii, and Maine.

This technology, largely adapted from the oil and gas industry, is already successful at the prototype stage, with more extensive test and demonstration projects underway. Currently, the most cost-effective installation method appears to be a "tow-out" concept, in which the foundation and turbine are constructed in port and then towed out to an anchor site. This method addresses several of the infrastructure and logistical challenges associated with constructing and maintaining offshore wind farms—the subject of a subsequent blog in this series.

Even so, the dynamic nature of wind turbines, along with the weight distribution needed to stay afloat, presents a number of engineering issues to overcome. A concept used by several floating offshore wind pilot projects to date is the "semisubmersible" platform concept (see center illustration below), which has several cylinders filled with water, serving as ballast for stability. The University of Maine plans to use this type of platform for their Aqua Ventus I project, which is supported by DOE's offshore wind demonstration program. Another floating foundation option is a "spar" concept (see left illustration below), which relies on a large submerged mass to maintain stability.

Other nations are also working on innovative floating offshore wind technology solutions. The first project to scale up—using multiple large (6-megawatt capacity) offshore wind turbines on floating foundations—is Hywind Scotland, which uses a spar buoy foundation design that has one large ballast-stabilized spar. France also has an

R&D program with three demonstration projects in early stages of development.

What's Next

While floating technologies may have the potential to become more cost-effective than traditional bottom-mounted foundations in the long term, significant research is needed to reduce costs and to validate the engineering tools used to design and optimize floating foundations. DOE has established the Offshore Wind R&D Consortium to conduct research on floating foundations and other technical innovations.

原始連結：

https://www.energy.gov/eere/articles/wind-waves-floating-wind-power-becoming-reality

Wind Turbines in Extreme Weather: Solutions for Hurricane Resiliency

極端天氣下的風力渦輪機：從颶風災害中復原的解決方案

Offshore wind turbines on the Atlantic coast (as well as the Gulf Mexico) have several challenges to contend with—including hurricanes. The Energy Department is developing tools to help wind system designers lower the risk for offshore wind turbine systems located in extreme weather areas.

As noted earlier in this blog series, 13,000 megawatts of offshore wind has been deployed worldwide, yet the U.S. only has one commercial offshore wind farm in operation. The first blog explained that technological advancements in floating foundations are needed to make offshore wind economically feasible in the deep waters off the U.S. Pacific coast, as well as off the coasts of Maine and Hawaii.

This might be part of the reason why most near-term offshore wind development is planned for the East Coast from Massachusetts to North Carolina, where a substantial part of offshore wind resources involve water shallow enough for fixed-bottom foundations. However offshore wind turbines on the Atlantic coast (as well as the Gulf Mexico), have another challenge to contend with: hurricanes, which we'll explore below.

What's too Windy?

Recent hurricanes Irma and Maria inflicted a lot of damage on infrastructure, including energy infrastructure. Wind turbines, whether they are land-based or offshore, have built-in mechanisms to lock and feather the blades (reducing the surface area that's pointing into the wind) when wind speeds exceed 55 miles per hour. Basically, the wind turbine is essentially in "survival mode," waiting for the storm to subside, so it can safely go back to producing energy.

Offshore, storms can be even stronger. In addition to the wind hitting the turbine, the turbine's foundation also has to contend with large, powerful waves. The engineers who design wind turbine systems use models to understand how different loads, like winds and waves, will impact a wind turbine and its foundation. The models they use need to be further refined to predict turbine loading in extreme conditions.

The Solution

The Energy Department has previously funded work in this area through the National Renewable Energy Laboratory (NREL). NREL, working with the University of Miami, linked its preexisting wind turbine simulation software (called FAST) up with the atmosphere-wave-ocean forecast model. It is used for hurricane research and prediction to create a new "Coupled Hydro-Aerodynamic Interface for Storm Environments." This tool helps wind system designers to lower the risk for offshore wind turbine systems located in extreme weather areas.

Offshore wind developments have already been proposed in hurricane-prone regions of the United States. In fact, research priorities of a new offshore wind R&D consortium to be funded by DOE may include a focus on improving the understanding of extreme metocean conditions—such as those experienced during hurricanes—to better predict potential failure modes of turbines operating in these areas, leading to the adoption of more robust engineering designs.

Designing Hurricane-Resilient Systems

While there is currently limited data due to the small number of deployments, the twisted jacket foundation discussed in the previous blog in this series may be a promising design for hurricane-prone areas. A foundation of this type used by the oil and gas industry withstood a direct hit from Hurricane Katrina (category 5) in 2005 and emerged unscathed.

In another DOE-funded project, NREL designed and analyzed a hypothetical 500-megwatt offshore wind plant to be deployed in 25-meter (over 80-foot) waters in the Gulf of Mexico. Some of the features of this hypothetical wind farm included a twisted jacket foundation from Keystone Engineering and a customized lightweight direct drive generator from Siemens.

Perhaps the most surprising component of this system is the rotor designed by Wetzel Engineering. To optimize the project for hurricane resiliency and structural efficiency, the wind turbines use a downwind orientation—opposite from the upwind design used in virtually all utility-scale wind turbines today. Upwind turbines use a wind vane and a yaw drive to constantly turn the top of the turbine to face into the wind. A downwind turbine avoids these components and lets the wind blow the blades away from the tower. This allows the blades to be more flexible, and permits them to bend in high winds without the risk of them hitting the tower, thereby reducing the risk of structural damage during a hurricane.

Although hurricanes and the damage they can cause remain difficult to predict, with current R&D, the Energy Department is taking steps to alleviate potential risks to offshore wind systems that will eventually be deployed in the southeastern and mid-Atlantic regions.

原始連結：

https://www.energy.gov/eere/articles/wind-turbines-extreme-weather-solutions-hurricane-resiliency