Improved structural support for wind turbines could lead to 100% greater efficiency

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Wind turbines in the Thames estuary with heavy supporting structures under water. Credit: Phault (Flickr)

(Phys.org)—A University of Cambridge's Department of Engineering study suggests that offshore wind farms could be 100 per cent more efficient in terms of energy payback if manufacturers embraced new methods for making the structures that support the turbines.

As wind farms are increasingly sited offshore rather than on land, and installed at water depths of up to 40 metres, a Cambridge University engineer is urging the wind power industry to look again at the design of the heavy supporting towers and foundations used out at sea in order to improve the energy payback achieved.

Jim Platts of the Engineering Department's Institute for Manufacturing (IfM) believes that the wind power sector could achieve significantly higher payback ratios if turbine manufacturers used guyed towers (towers held in place by steel cables) made in composite materials rather than free-standing towers made in conventional steel materials.

A preliminary study undertaken at the IfM suggests that payback ratios for offshore wind farms could be doubled if the industry embraced new construction methods.

Jim says: "The development of the wind turbine industry, and the way in which it works with the civil engineers who make the heavy supporting towers and foundations, which are not visible out at sea once the turbines are installed, mean that we have ignored something which is almost embarrassingly obvious in our race to meet the targets set for renewable energy production.

"We urgently need to reduce the high levels of energy embedded in offshore wind turbines which make them both ineffective in energy payback and costly in financial terms. We can do this fairly easily if we invest in more innovative methods for making and installing the towers and foundations that support them."

The effectiveness of wind turbines is determined by a key figure: the harvesting ratio. This ratio is a measure of the energy it provides set against the energy embedded in it (energy used in manufacturing it). Wind turbines comprise four main elements: the blades that harness the wind energy; the gearbox and generator mechanisms that produce the electricity; the tower that supports these moving parts and the foundations that hold the tower in place. The tower is conventionally made of steel and the foundation in steel and concrete.

For a turbine designed for use on land, the energy embedded in the moving parts represents two-thirds of the total energy invested in the installation while the supporting structure (tower and foundation) represents the remaining third. Onshore turbines typically achieve a harvesting ratio of 40:1.

When wind turbines are sited offshore, the towers required are both taller and heavier and the foundations more massive, using up to four times the amount of steel and concrete. "When you look at offshore wind turbines you see a series of slim structures - what you don't see are the far heavier supporting structures below the surface that they slot into," explains Jim.

Both steel and concrete are highly energy intensive to produce so the harvesting ratio of offshore turbines reduces to typically 15:1 - far lower than for onshore turbines.

On top of this, offshore turbines are subject to corrosion, which reduces the lifespan of the steel used. "Steel is prone to corrosion and to fatigue," comments Jim. "This begs the question: could we do better with other materials. The answer is yes, we can use composites for towers just as we do for blades. They are lighter, stronger, corrosion free and more resilient than steel."

A preliminary study undertaken by the IfM suggests that guyed towers offer significant advantages over conventional towers. The use of steel cables, fixed to the sea bed by screw anchors, means that towers can be significantly slimmer as the tent-like guyed shape distributes the loads more efficiently to the seabed. Similarly, the foundations required are substantially less weighty.

The resulting reduction in the volume of steel and concrete needed means that a harvesting ratio of 25:1 can be achieved, the study concluded.

"The use of guyed towers is just the first step for the industry to take. The second step would be to make towers in composite materials which are less energy intensive to make than steel which relies on smelting and concrete that also depends on a chemical reduction process in manufacturing cement. Composites also have a longer life than steel as they stand up to fatigue much better. Using these new materials could increase the harvesting ratio still further to 32:1 and extend the lifetime of a turbine installation from the present 20 years to up to 60 years," says Jim.

"The Finnish wind turbine manufacturer Mervento has shown the way with a guyed turbine designed for use in the Baltic. Other producers - such as those making turbines for sites in the North Sea - need to take heed and invest in research into designs that take a similar approach to making the industry far more energy efficient and sustainable."

The wind turbine industry has experienced an average of 25 per cent per annum growth over the past 20 years. It has pioneered many composite materials developments that have benefited other sectors, such as aerospace. Wind turbine manufacturers use ten times more composite materials than the car and aerospace industries combined.

"It's often overlooked that manufacturers of turbines have driven advances in composites, producing materials with 95 per cent of the performance of the high-cost composites made for the aeronautical sector at 5 per cent of the cost. Much of this work has been led by UK companies. These companies now need to look at new ways of working," says Jim.

In the 1980s, Jim Platts developed the designs, the manufacturing processes, the team and the company that made all the large wind turbine blades in the UK. That team is now the Global Blade Technology division of Vestas, the world's largest wind turbine manufacturing company.

Provided by University of Cambridge

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