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Rethinking wind power's towers and turbines

New materials and designs can make a leading source of renewable energy both greener and cheaper.

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At first glance, the wind-turbine tower that rises from the green landscape in the Swedish municipality of Skara looks like any other. It reaches a height of 105 metres and, at the top, supports a familiar trio of big rotating blades.

But unlike most wind-turbine towers, which are made of steel, this one is wooden. It represents the first commercial installation by Swedish engineering company Modvion – and it could point to the future of wind energy.

Towering wood

When it comes to renewable energy, wood can make wind power even greener by serving as the material for the towers.

What's more, wood can help wind turbines to become cheaper and more powerful, providing an economic incentive on top of the environmental one, according to Modvion Chief Executive Officer Otto Lundman.

'Wooden turbine towers are lighter, more modular and can be built taller than steel towers,' said Lundman.

Modvion received EU funding to advance the goal of high-altitude wind turbines with wooden towers. The project ran from October 2020 through September 2023.

The tower of the Skara turbine emerged from the project and is made of laminated wood from Modvion's factory in Gothenburg located about 130 kilometres to the southwest.

It took around a year to build and entered into operation for Swedish power company Varberg Energi in February 2024. Denmark-based Vestas supplied the turbine.

‘Building and designing towers like this requires large investments,’ said Lundman. ‘EU funding was instrumental in allowing us to develop this technology.'

Going for growth

Wind energy has grown rapidly across Europe in recent years and in 2022 met 16% of the EU’s electricity needs. Wind also accounted for 37% of the electricity generated from renewable sources in the EU in 2021.

A record 17 gigawatts of wind energy was built in Europe in 2023, according to industry association WindEurope.

Nonetheless, wind power must expand further for the EU to meet goals of cutting greenhouse-gas emissions by 55% in 2030 compared with 1990 levels and increasing the market share of renewables to 42.5% at the end of the decade from around 23% currently.

To help achieve those targets, 30 gigawatts of wind turbines need to be built every year between now and 2030.

The thinking in some industry circles is that new designs able to boost profitability are needed, driving scientific efforts.

‘The wind energy sector has done a great job of incrementally decreasing the cost of energy in recent decades,’ said Dr James Carroll, an associate professor at the University of Strathclyde in the UK. ‘But cost improvements in traditional turbines have been slowing down. That’s why we need to look for more radical improvements.’

Count the gains

That’s where Modvion’s wooden wind-turbine tower offers promise – for three notable economic reasons.

One has to do with strength. The laminated veneer lumber used by Modvion is 55% stronger per weight than the steel traditionally used in wind-turbine towers, according to the company.

Modvion calls its engineered wood “nature’s carbon fibre”.

Another reason for optimism is weight. A wooden tower is a third lighter than a comparable steel one and, as a result, is easier to transport.

Then there’s height. With the strength and transport advantages of wood, Modvion wants to build taller towers.

‘The higher you go, the more wind you can get,’ said Lundman.

Broader bases

To understand the technical challenge with towers, consider that they are built like an upside-down cone: broader below and narrower on top. The taller the tower, the broader the base needs to be.

Traditionally, this is achieved by stacking steel cylinders onto each other. But above a certain tower height it becomes virtually impossible to transport the base cylinders over roads because of their size and weight.

By contrast, a wooden construction uses C-shaped panels, which are glued together to form a cylinder. This makes the construction more modular and the shipping of parts much easier – a bit like IKEA for wind-turbine towers.

Using similar, modular steel structures would be inefficient because they would have to be bolted together, greatly increasing costs, according to Lundman.

Climate relief

Beyond the economic advantages of wood are the environmental ones.

Wood is better for the climate than steel. Steel production is energy-intensive and involves the burning of fossil fuels that emit greenhouse gases.

‘By switching from a steel to a wooden tower, you reduce the emissions from producing the tower by 90%,’ said Lundman.

Because forests are important storers of carbon, Modvion sources its wood from sustainably managed ones in Scandinavia. The company’s towers can also be recycled after decommissioning, offering another green gain.

Following the EU funding, Modvion’s priority is to scale up production.

‘Producing wood towers like this hasn’t been done before at an industrial scale,’ said Lundman. ‘We, for example, needed to make the lamination machines ourselves. They simply didn’t exist for our purpose in these sizes.’

He said Modvion aims to have a larger volume factory up and running by 2027. The objective is to supply 10% of the global wind-energy market within a decade.

Turbine test

Work on the next generation of wind-energy equipment involves not just the towers but also the turbines.

Another EU-funded project has reimagined what a wind turbine might look like and how it would operate.

Called XROTOR, the project has examined the feasibility of a vertical-axis turbine combined with horizontal-axis secondary rotors instead of just the conventional horizontal axis. A vertical-axis turbine rotates around its tower.

‘The idea goes back more than 10 years,’ said William Leithead, a professor of systems and control at the University of Strathclyde. ‘I saw that vertical-axis wind turbines without secondary rotors just couldn’t work in an economically efficient way and started thinking about a solution.’

Leithead and Carroll lead XROTOR, which is due to end in April 2024 after three years and four months.

While vertical-axis turbines can be placed closer together, they have a big disadvantage: their blades turn more slowly. That increases the turbine drive, train size and cost for the given energy generated, weakening the economic case for such a design.

‘Fundamentally, they are too costly for the energy they generate,’ said Leithead.

X-shaped rotor

In response, the XROTOR researchers adapted the concept. They designed a vertical-axis turbine with an X-shaped primary rotor that has smaller, horizontal-axis turbines at the tips.

The secondary rotors rotate very fast and generate the energy of the turbine. This design could combine the advantages of both vertical-axis and horizontal-axis turbines.

‘You can place these turbines closer together offshore,’ said Leithead. ‘Conventional turbines produce a wind wake, which means you can’t put them too close together or their performance will be affected.’

At present, wind farms are being pushed farther out to sea to find unfilled areas. That increases costs because turbines need to be more resistant to extreme weather and more cables need to be laid.

If turbines could be placed closer together, more electricity could be produced nearer to shore.

‘The impact of this could be huge,' said Leithead. ‘We’re looking here at a cost saving of 20% compared to similar size horizontal-axis turbines.’

While it has gone through simulations, the new concept has yet to be built and tested in a real-life setting, so the potential benefits still need to be proven.

Leithead and his colleagues are preparing to share the XROTOR results and to seek follow-up financing from private and public investors.

‘It will take at least four years and probably more before we will see this concept in the real world,’ said Leithead. ‘It’s a radical new idea, but that’s what makes the research so fun.’

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