CUTTING COSTS WITH TWO BLADES

Ming Yang's revolutionary 6MW prototype turbine — due to be installed in the North Sea wilds off Norway — could reduce the cost of offshore wind by up to 30%, writes **Darius Snieckus** in Haugesund

Today, there is little to see looking off the rugged, western Norwegian coastline except white-capped, storm-grey seas and drifting seabirds. By next spring, however, Chinese manufacturer Ming Yang is on course to have a 6MW turbine spinning in the shallows here that could change the face of offshore wind power

The two-bladed, downwind giant will be erected on the seabed off Karmøy island, a short boat journey from energy giant Statoil's floating Hywind prototype. The machine could be revolutionary from the blades through to the helipad-topped nacelle to the hybrid jacket foundation, which will be anchored to the seafloor by a concrete base, removing the need for expensive, labour-intensive piling operations.

But the SCD (super compact drive) turbine concept is more than novel technology. The design — the flagship of which is about to begin trials on the edge of the East China Sea — could rewrite the commercial logic of offshore wind. Calculations suggest a levelised cost of energy (LCoE) of just over €100 ($116) per MWh for a 500MW development powered by the propeller-topped turbines — some 30% below the LCoE currently being averaged off Europe and a massive step towards making offshore wind competitive with other energy sources.

For Ming Yang, a successful debut for the 6MW machine in the North Sea would prove it up as an "ideal solution" for projects in one of the planet's most hostile marine environments, opening the door for the ambitious Chinese turbine-maker to what is currently the biggest offshore wind market in the world.

"It is true that this wind turbine is unconventional, a two-bladed and downwind concept, but it has been purpose-designed with offshore in mind," states Richard Zhu, vice-president and head of offshore engineering at Ming Yang. "We have every belief it will be the right turbine for this market."

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The site chosen for the pilot — where, in Norse mythology, the thunder god Thor was said to wade every morning — will test the turbine to the extreme. The gales that buffet this treacherous coastal region are legendary: the seabed off Karmøy is littered with shipwrecks, and, in 2011, ten-metre waves and winds of 40 metres per second (m/s) whipped up by the storm Berit sank the part-scale Norwegian turbine prototype, the Sway. Shoreward winds here average a fresh 9.4m/s.

"The most difficult challenge posed [by the Karmøy prototype] is that of the weather and the sea conditions, which are much rougher than in China," continues Zhu. "So not only does the turbine and jacket foundation have to be fit for purpose [the Ming Yang machine is typhoon class, able to ride out winds of 50m/s] but it also has to be part of a concept that makes installation as simple and fast as possible because weather windows in the North Sea are very small."

Trials are slated to start next spring at the Marine Energy Test Centre (MetCentre), a 40MW offshore wind laboratory owned by Statoil and the local authorities. The €30m Karmøy demonstrator project will be testing the turbine, foundation and the cost-cutting installation method. Contractor Seaway Heavy Lifting

Photograph: Ming Yang

UP AND AWAY: Ming Yang's 6MW rotor being hosted into place in Rudong, China

SCALING UP: MetCentre general manager Arvid Nesse next to the Hywind turbine; *below:* CAD drawing of Owec's jacket foundation

FAST WORK: *Top centre:* The nacelle and rotor of the 6MW prototype is lifted into position in the East China Sea, and, *above left*, the finished turbine. *Inset:* Ming Yang vice-president Richard Zhu

Two-blade pioneer comes of age

Ming Yang's 6MW offshore turbine is built around a 140-metre-diameter rotor turning a SCD (super compact drive) two-stage gearbox and permanent-magnet generator housed in an 11-metre-long, water-cooled sealed nacelle.

Erection of the innovative two-bladed machine at the Longyuan Rudong intertidal demonstrator testing site in the shallows of the East China Sea has suffered a series of delays, the latest being alterations to the machine's six-legged steel jacket foundation, which has hampered the commissioning process.

Expectations are that the prototype will now be operational by the end of February, according to Ming Yang's Richard Zhu.

Installation of the nacelle and rotor took an "amazing" two hours, he notes, compared to the industry standard of ten to 12 hours, a fillip for plans to mass produce the machines for hostile offshore wind regions where installation time at sea can be limited.

Once on line, a two-year test programme is on the cards for the Rudong prototype, which stands in up to six metres of water on a tidal plain.

The 6MW design — which flies 69-metre carbon-capped glass-fibre blades and can ride out typhoons and Arctic storms by locking the rotor in a horizontal position — has been modelled to be able to generate 40GWh a year in Chinese offshore gusts.

Ming Yang manufactured components for a pair of the 6MW SCD machines at its Blue Island shipyard in Nantong, on the Yangtze River. One set makes up the Rudong machine, the other is earmarked for the European prototype being installed in the spring of 2016 in the Norwegian North Sea on a four-legged steel jacket supplied by Owec.

Turbine designer Aerodyn also has a 168-metre-diameter rotor 8MW version of the SDC concept on the drawing board, mateable to either a fixed jacket or its own Nezzy floating foundation.

Photography: Ming Yang | MetCentre | Owec Tower

crane vessel to try out a single-lift method to get the turbine erected in two hoists.

"Practically speaking, the project has three innovations: a new offshore wind turbine for the European market; a hybrid jacket for sites where driven piles cannot be used; and, of course, to test a new installation method," explains MetCentre general manager Arvid Nesse. "All in all, it's about reducing the cost of offshore energy."

The numbers look good. The project team's figuring puts the per-MW capital cost of the Karmøy prototype at "under €3m", he continues. "Larger turbines, improved structures and more efficient installation methods hold a great part of the potential for cost reduction.

"Most of all it is about demonstrating ways of doing things smarter."

The Ming Yang SCD turbine is the first full-scale two-bladed wind turbine to dip its toe in true offshore waters (the Rudong unit stands on a tidal plain). For the cold, foaming sea off Norway, it will be mated to the latest version of Owec Tower's workhorse quattropod, earlier models of which have seen installation on pioneering wind projects from the Beatrice demonstrator off Scotland in 2006, to the Haliade-150 prototype off Belgium in 2011.

The hybrid jacket is made up of three main elements: the caisson base — 3,000 tonnes, with another 3,300 tonnes of rock ballast — with preinstalled piles; trussed lower jacket legs; and a patented "mid-section" with built-in transition piece, together weighing 760 tonnes. Altogether, the unit will be 47 metres tall and tip the scales at 7,000 tonnes.

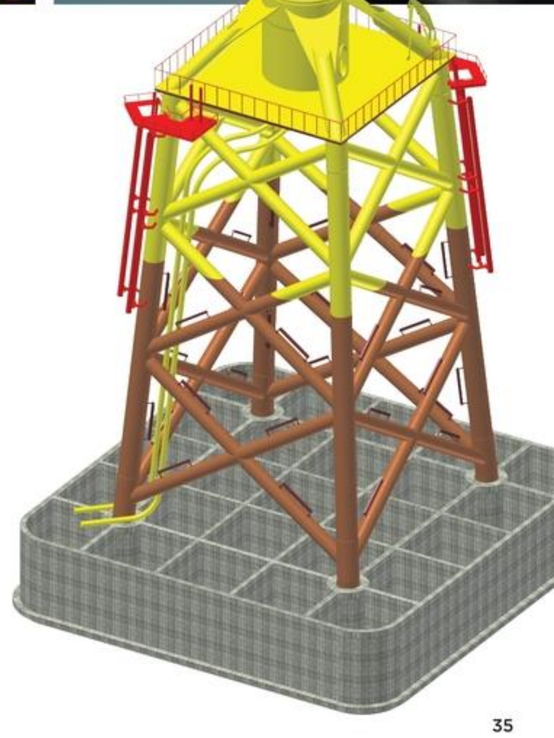
> Most of all it is about demonstrating ways of doing things smarter

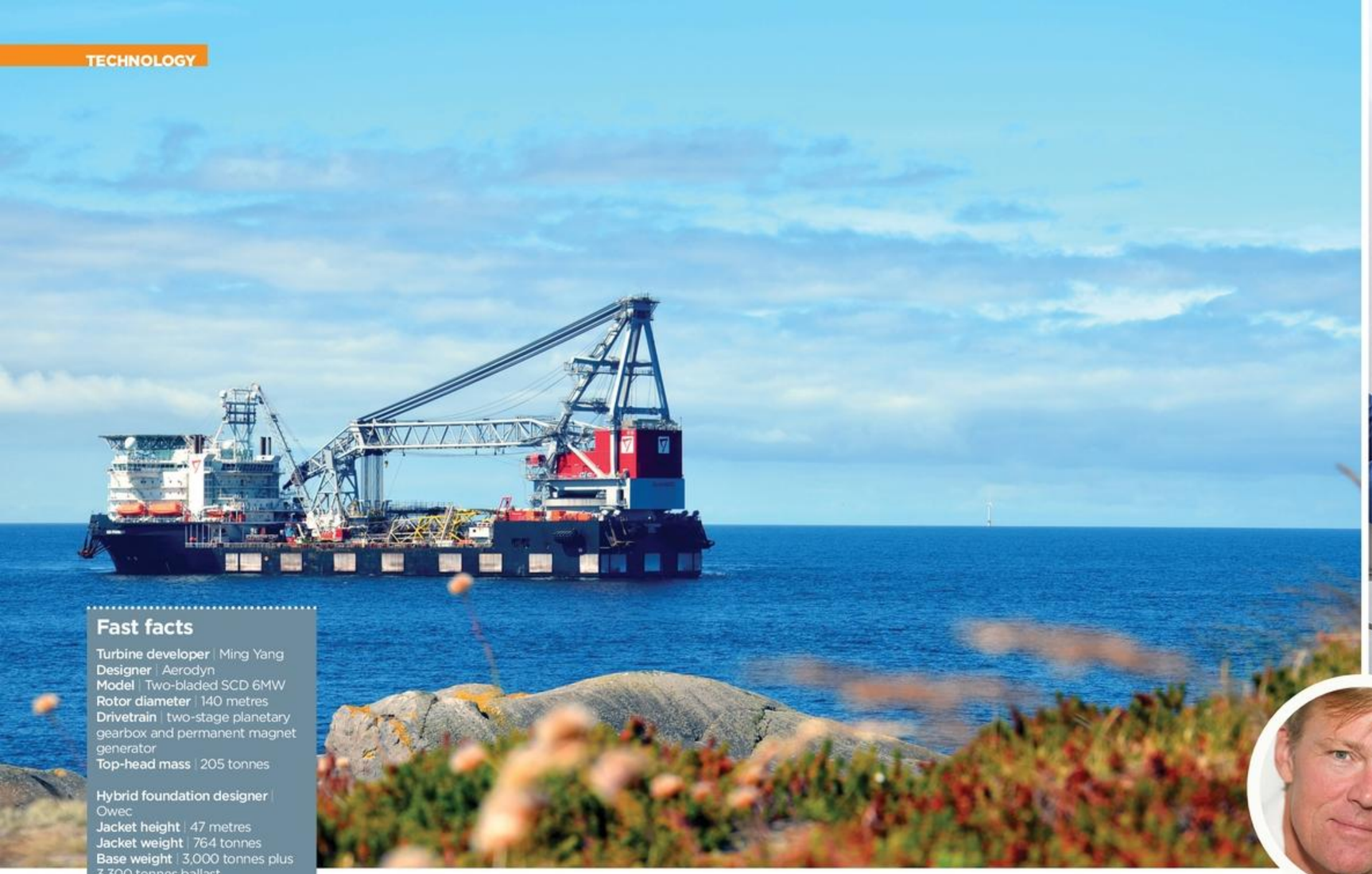
"In the beginning, I don't think anybody knew how to design a jacket for an offshore wind turbine," says Owec chief executive Johan Fredriksson.

"All the designs were oversized and used an outdated methodology. We had to develop a modelling software that would allow us to carry out all the necessarily load calculations for a jacket."

Not a straightforward task off Karmøy. A "difficult" seafloor, ferocious currents and crashing wave loads all feed into the hybrid jacket foundation's "optimisation" — as well as cross-over design analysis with turbine developers Ming Yang and Aerodyn. In the end, Owec found a means of engineering out 15-20% of the steel used in earlier designs, while sharpening the fabrication process to further carve out costs.

"Though important, it is not always the steel weight that is governing the cost," says Fredricksson. "It's really about how you can put it all together in the yard. The progress





Fast facts

Turbine developer | Ming Yang
Designer | Aerodyn
Model | Two-bladed SCD 6MW
Rotor diameter | 140 metres
Drivetrain | two-stage planetary gearbox and permanent magnet generator
Top-head mass | 205 tonnes

Hybrid foundation designer | Owec
Jacket height | 47 metres
Jacket weight | 764 tonnes
Base weight | 3,000 tonnes plus 3,300 tonnes ballast
Footprint | 31 x 31 metres

JUST VISITING: The *Oleg Strashnov* vessel on a reconnaissance mission to the Norwegian installation site; *top right:* the Owec foundation in use at the Beatrice wind farm off Scotland; *far right:* the wild waters off Karmøy island; *inset:* Owec chief executive Johan Fredriksson

we have made in some part is about standardising design for serial production.

"It is hard to say how quickly these could be built — the Karmøy jacket is a prototype, of course — but certainly one a day is reasonable, or two, side by side, if you have the space in the yard." He adds that Owec has explored the option of setting up a mobile fabrication facility on the North Sea coast, with jacket elements arriving "flat-packed" for assembly.

The high-price business of getting the SCD turbine ferried out to site and installed also factored in to Owec's thinking, with the designer collaborating with SHL to fine-tune an installation technique that will see the prototype swiftly put in place via two heavy lifts, first the jacket-topped gravity-base, then the tower and turbine as one, in 25 metres of water.

One of the real and potentially industrially resonant advances in the Karmøy prototype project has been its transparency, agree Nesse and Fredriksson. Where in past years, the top-of-the-league OEMs were often "a black box" when it came to integrating engineering between turbine and jacket, Ming Yang is showing there is another way.

"That openness has made a tremendous difference — particularly with a two-blader, which wasn't harder to engineer with the jacket, just took a little more thought," says Fredriksson.

Momentum is building at Karmøy. The 15MW export cable — shared with the Hywind — is ready to wire in the new machine; the *Oleg Strashnov* made a reconnaissance to the turbine's installation site last summer; and the components for the 6MW SCD prototype are warehoused and set to be shipped out on their 25-day sea journey from China to Norway.

"So far, our 6MW turbine has attracted a lot of attention in the industry from developers [with plans for industrial-scale projects in European waters]," says Zhu. "But for us, our focus remains on the testing phase: we have to make sure it runs well off China and we are very much looking forward to the European market in the next few years."

The commercial prospects of two-bladers such as Ming Yang's naturally hinge on the performance of the first 6MW-plus models. If the LCoE promised by the concept is field-proven, then mainstream take-up of the technology looks inevitable, with some analysts going as far as suggesting two-bladers could account for 20% of the expected annual deliveries into offshore waters as early as 2020.

"This concept, we strongly believe, is ideal for offshore, and increasing [the nameplate capacity] from 6MW to 8MW won't be a problem," says Zhu. "We are very encouraged, looking at the longer term." ◻

Photography: MetCentre | Jan Oelker | Henry Lervoll | Owec Tower