WIND

How to build the world's biggest turbine blades

The Isle of Wight was once the focal point of an industrial dispute that grew into a nationwide debate about the future direction of onshore wind in the UK. But now huge wind turbine blades for the UK's flourishing offshore wind market are being produced on the island. *Marc Height* went to visit.

'Is that blade trying to escape?' I thought as I caught a view of the inside of a large testing hall for wind turbine blades in the centre of the Isle of Wight.

I was at the development and production facility for Vestas and MHI Vestas Offshore Wind (MVOW) turbine blades, just north of Newport. A central walkway past the building's airy reception area is flanked by two large factory spaces, one for producing blades, and the other for testing them. In the testing room, a large machine was essentially flapping a large turbine blade – a fatigue test for strength and flexibility – but giving the impression it was actually trying to take off.

Other machines were busy putting blades through their paces in various other ways. My gaze turned to the adjacent factory space – the lead blade manufacturing facility for MVOW's flagship V164 offshore wind turbine. The blades being constructed here will eventually find themselves attached to wind turbine nacelles off the east and west coasts of the UK, and in European waters.

Non-disclosure agreements signed (on the ferry over from Portsmouth), and personal protection equipment donned, our party entered the space, oddly quiet as automated equipment scanned with lasers the dimensions of these 80 m-long, carbon-enforced lengths of wing-like fibreglass.

Next-level turbines

The Vestas West Medina Mills facility, located on the western bank of the River Medina, is where new Vestas turbine blades are prototyped and tested, but it is also MVOW's serial blade production hub for the company's 9.5 MW V164 turbine – which was developed on the same site. MVOW leases the production hall at the facility to continuously produce the blades 24 hours a day, seven days a week.

The V164 originally began its design life as a 6 MW turbine, but by the time it reached production it had morphed up to 7 MW, and an 8 MW version has been available commercially since 2017. Now, tweaks to how it operates and the use of other technologies within the nacelle have squeezed an extra 1.5 MW of power out of the turbine, with a 9.5 MW version available on the market.

Two 8.8 MW versions of the same turbine (along with nine 8.4 MW machines) are used in Vattenfall's European Offshore Wind Deployment Centre, located 3 km off the coast of Aberdeen Bay – a development that Donald Trump was notably opposed to and tried to stop being built on numerous occasions (due to the proximity to his Balmedie golf course). This particular wind farm tests innovative offshore wind foundation and cabling technologies, and insights into turbine operation (amongst other things) are fed back to MVOW and the wider industry (see also page 22).

V164 turbines are also in operation at an offshore demonstration project off the coast of Blyth, Northumberland, and have been used in Ørsted's Burbo Bank Extension project in Liverpool Bay, as well as in Walney Extension West.

Firm orders for the turbines have been placed in Belgium, Germany, Denmark and the Netherlands – in the latter for the Borssele III and IV projects which will use 77 of the 9.5 MW version of the turbines, with a combined capacity of 731 MW. The 9.5 MW V164 is also scheduled for use in the near-GW scale Triton Knoll and Moray East offshore wind farms in the UK.

V164 8 MW turbines in operation at Burbo Bank Extension

Photo: MHI Vestas Offshore Wind

A massive machine

The V164 is a massive machine, 187 m high, with a rotor diameter of 164 m and a swept area of 21,100 m^2 (larger than the London Eye, which has a diameter of 120 m). The turbine's weight, even without its supporting tower, is 500 tonnes.

The 80-metre-long blades are, according to James Luter, Production Director at MHI Vestas, the world's longest serially produced blade.

Luter, who has been making turbine blades on the Isle of Wight for nearly 20 years, began his career in the wind industry making 23 m long blades for a company called Aero laminates, which set up on the Isle of Wight in 2000. The company was bought and then merged with Vestas in 2003.

At this time, Vestas was making 40 m long blades on the island, partly from wood. The 80 m MVOW blades, by comparison, dwarf their forbearers and are constructed in a completely different way (see box out below).

The V164's blades have been in development since 2010, with initial manufacturing at West Medina Mills beginning in 2012 and then ramping up as a result of Vestas, and MHI's joint venture in 2015. Since 2017 the facility has been making turbine blades 24 hours a day.

From the Isle of Wight the finished blades are shipped one-at-a-time to Fawley near Southampton, to a site that formerly housed an oil-fired power station. They make the two-hour journey on a barge rather aptly named 'Blade Runner', and on arrival they are edge protected, then stacked ready for shipping (six or eight at a time) for eventual assembly with V164 nacelles – for the UK market either in Belfast for wind farms off the west coast, or in Esbjerg, on the west coast of Denmark, for wind farms off the UK's east coast.

The Fawley facility can store 100 blades at any one time. There the blades are also painted to protect the fiberglass against UV degradation from exposure to sunlight.

From onshore to offshore

Vestas' history on the Isle of Wight goes back beyond researching and developing these particular blades. The company closed an onshore wind blade production facility on the outskirts of Newport in 2009 and moved the manufacturing jobs to the US – which resulted in a well-publicised 18-day sit-in protest by workers, forcing Vestas to apply for a warrant to remove them.

The decision, which cost over 400 jobs on the island, came as a result of Vestas deciding there wasn't a strong future for onshore wind in the UK following a drop in demand for its turbines. The story grew and grew to be explored in the context of a then Labour government said to be not supporting clean energy jobs in a time of recession, prompting a mix of trade unions and green activists to speak out against the decision.

It was suggested that the government bail out the firm, but the ultimate issue was largely one of the burdensome planning process for onshore wind in the UK, magnified by the NIMBYists that opposed the technology.

At that time workers may not have predicted that Vestas' operations on the island would in time re-emerge in the form of a strategic hub for the production of turbine blades, but this time as part of a joint venture with a Japanese company, and to service the UK's world-leading offshore wind market.

Given the difficulties still seen in securing UK onshore wind projects, and the Conservative government's ongoing negative stance on onshore wind, in retrospect it looked like a sensible decision by Vestas to shift onshore wind manufacturing elsewhere.

However the Isle of Wight has a strong background in composite manufacturing, and Vestas kept a research element of its operations running and in time opened the West Medina Mills test centre in 2011. MHI joined the scene in 2015.

A recipe for making blades

The V164 blades are constructed in two halves – the windward and leeward sides – that, when completed, are guided with lasers and glued together.

Each half is made of layers of fibreglass on top of a gel coating, reinforced with carbon fibre material positioned along the length of the middle of the blade. The blade is then filled in with a type of foam to form a core, followed by another layer of glass material,

Blade construction at West Medina Mills – showing a cross section of one half of a V164 blade *Photo: MHI Vestas Offshore Wind*

then a resin is applied which is vacuum sucked into place to fill any voids.

Fitted in between each half of the blade is an internal 'web', also made out of fibreglass, which acts, along with the lengths of carbon fibre, to transfer tension and forces throughout the length of the blade so stresses don't build up in any particular area. These MVOW 'I-webs' are made a kilometre or so upstream on the River Medina at MHI Vestas' St Cross manufacturing facility.

The webs are inserted into the blade in 12-metre-long sections. Previously, smaller blades would be fitted with internal 'spars' to fulfil the same function. Any blade over 50 m in length would need to use some form of internal web, says Luter.

The webs are attached via a flange to the carbon fibre enforcements along the length of the turbine blade.

To improve efficiency and increase output, MVOW has sped up the process of laying the carbon fibre lengths within the blade dramatically. Originally the carbon was put into the blade in sections, and this would take three to four days. Now, the carbon fibre strips are inserted in one go, and positioned with lasers, in two hours.

Each completed wind turbine blade is made up of 33 tonnes of material. Each one needs to weigh roughly the same, so any discrepancy in this figure is levelled out with basalt.

The blades are finished by aerodynamically profiling each edge and installing a lightning protection system made of copper and aluminium. The leading edge is laminated and then sanded off, and then they are good to be shipped off for painting and, eventually, attached to a nacelle to face the elements.

MVOW is a 50:50 joint venture between Vestas and MHI, and the Isle of Wight blade factory now employs 350 staff (of 500 across the UK). The company has grown fivefold in four years and as Mary Thorogood, UK Government and Stakeholder Relations Lead at MVOW said, it was set up as a challenger brand to Siemens, which has dominated the offshore wind turbine market for some time.

Siemens, now Siemens Gamesa, had 50% of the installed market share of offshore wind in Europe in 2017, according to the trade body WindEurope, and is by far the biggest offshore wind supplier globally, according to Bloomberg New Energy Finance's 2018 *Global Wind Turbine Market Shares* report. But MVOW turbines are winning bids, with over half of the capacity in the UK's latest contracting round going to MHI Vestas turbines.

Stepping up

While the West Medina Mills facility is currently producing 80 m blades, it was designed with the capability to make blades over 100 m in length. This means it has the ability to produce blades for a new generation of MVOW turbines, were the company to decide to launch a new platform.

'This facility is designed and built around 100 metres plus,' said Luter. 'That was the thought process six or seven years ago – to invest that amount of money in a facility like this... there is that belief that we can go that big.'

The V164 is currently the world's largest available wind turbine. Over the last few years Siemens Gamesa, which currently markets an 8 MW machine, has indicated that it is working on a next-generation platform, without much more in the way of any detail.

But earlier this year the US' GE unveiled plans to break the 10 MW barrier first (see *Energy World* April), announcing its 12 MW Haliade-X, which it is planning to start producing in 2021. This is a big jump up from its existing 6 MW offering, and the turbine will use blades made by the GE-owned LM Wind Power – which will be a whopping 107 m long. The machine will be tested at the UK's Offshore Renewable Energy Catapult facility in Blyth, Northumberland.

It is logical that other manufacturers will be looking to eventually follow GE's lead, according to Giles Hundleby, Director at renewables consultancy BVG Associates, who also says that the next-generation platforms such as the Haliade-X will in time end up as larger machines, potentially up to 18 MW in size.

This is due to several reasons, including what Hundleby calls the 'stretch factor'. Similarly to the V164 growing from 7 MW to a 9.5 MW machine that has the same external physical specifications, the same growth is likely to be planned for next-generation turbines.

As MVOW has done with the V164, this is 'partly because you have to amortise the massive investment cost of prototyping and developing of a new turbine, so you want to make it last a long time,' says Hundleby. 'And secondly, because you learn a lot from the first units you put in you can find where the stresses really are, or where the weak points are, where the strong points are – and what you need to do to upgrade it.'

Hundleby speculates that 'almost certainly all who are looking at next-generation turbines have a planned upgrade. Maybe a 50% stretch is probably what they want... I would expect they all have this in mind. So somebody bringing out a 12 MW machine will probably have a fairly clear road map for how they're going to get it to 18 MW. And if it turns out they can stretch it a bit further then that's great.'

This could mean that wind turbines, either in the next step or the one after that, eventually reach 20 MW, but Hundleby thinks that this will be around their upper limit. 'We're already in the situation where the turbine itself, or all of hardware taken together on a per megawatt basis, is actually starting to get more expensive now as the turbines get bigger,' he says. This is due to maintaining a constant blade tip speed with larger machines for stress reasons, which means the revolutions per minute of the turbine drops – and this results in a larger torque on the drivetrain, which increases its cost.

Also, 'the structural elements needed in the turbine blade to keep it stiff enough at the ever-longer lengths, avoid tower strike and just keep it in the right aerodynamic position... is a driving factor [on cost],' says Hundleby.

But these factors are offset by a drop in per-megawatt cost when it comes to having to install fewer foundations and array cables, and also operate and maintain fewer turbines when the wind farm is built. Hence there is a drive in the market to still increase turbine size.

Assessing markets

MVOW still sees much value in its existing machine, with the company's CEO Philippe Kavafyan stating that there is a strong business case for the current generation of turbines. Increasing platform size means supporting infrastructure will also need to accommodate larger and heavier bits of kit, which will have cost impacts for the whole industry.

MVOW's Luter iterates the work that has gone into producing the 80 m blade. 'The things that we were able to do on the smaller size blades you were unable to do [with larger lengths]. We needed to develop different ways of putting the materials in, for example.'

'That just went for blade manufacture,' he says. 'Then it goes onto the blade handling, and how do you install it? What stresses and strains are you going to be getting with that extra length? How are you going to control that? That takes a huge amount of time to model, to think about and then test.'

It is costly to develop new blades. And to think about the support and installation vessels that will handle them, alongside larger nacelles. 'Vestas has pushed what they can get out of their 80 m blade quite well,' says Hundleby. But clearly there is a lot to think about for when it is cost-effective to decide to design a new blade with an extra 15 or 20 metres. 'These things go in steps, naturally,' he says.

Some of the wind farms planned in Europe for the early to mid-2020s have seen developers put in 'no subsidy' bids, and the thinking behind this relies on larger, next-generation turbines that are not yet on the market, such as the Haliade-X.

But there are other offshore wind markets emerging outside of Europe, and MVOW has recently announced it is planning on using Taiwan as a production hub to service the growing Asia Market. Taiwan alone is seeking to increase its own offshore wind capacity from just 8 MW today to 5.5 GW by 2025.

With a set of firm orders and the potential for lucrative future markets, the world's current largest offshore wind turbine has some way to go. Due to the stretches seen in the V164's capacity, the Isle of Wight facility will be producing a lot more of its current blades before it could be tested to add those extra 20 metres.

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