

Technology



"The introduction of the V136-3.45 MW™ turbine as well as various other upgrades once again proves our ability to develop very competitive offerings based on our existing product portfolio – and with a time-to-market consistent with our customers' needs."

Anders Vedel
Executive Vice President & CTO



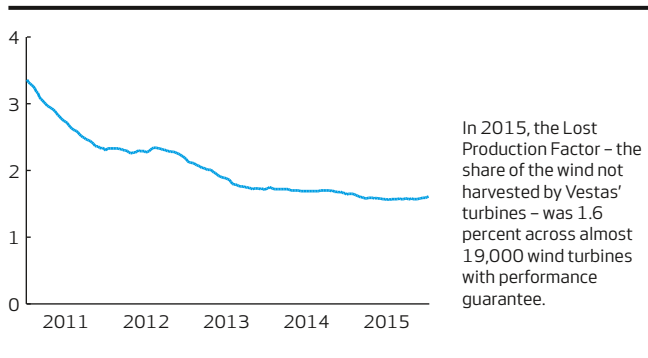
Vestas' technology strategy

Being the global wind leader requires a long-term line of sight in technology development. Vestas continuously strives to bring commercially relevant products to the market in a profitable way. The Vestas technology strategy derives its strength from a market-driven product development and extensive testing at Vestas' test facility in Denmark – the largest test facility in the wind power industry. This enables Vestas to continuously innovate new and integrate proven technologies to create high-performing products and services in pursuit of the over-riding objective: lowering the cost of energy.

By building on existing platforms – the 2 MW and 3 MW – and using standardised and modularised "building blocks", it has been possible to offer energy-effective solutions for a wide variety of wind regimes across the global wind energy markets, but with minimal additional supply chain complexity. This product strategy has accelerated and streamlined product development, thereby meeting the customers' needs by reducing the time it takes to bring new products to the market while maintaining a broad product offering.

The technology strategy has furthermore resulted in steady reductions in the Lost Production Factor year-on-year.

Lost Production Factor
Percent



The versatile product portfolio is developed to address the conditions and constraints at all kinds of sites, whether in well-known, mature markets, or in new markets, and meeting specific local requirements, e.g. related to climate, geology, wildlife, population, industry standards, regulatory matters, etc.

Evolution of the 3 MW platform

From the design of the first wind turbine on the 3 MW platform years back, comprising just one size and suitable for a single type of site, Vestas has now developed a whole family of wind turbines within the same platform, based on relatively few, interchangeable parts.

With the variants added to the 3 MW platform since the V112-3.0 MW™, a scalable product architecture has been developed, which allows adding larger rotors and higher generator ratings, but utilising largely the same nacelle. With innovations such as the Large Diameter Steel Tower, adding more flexibility on tower heights, Vestas is now able to offer numerous combinations based on five rotor sizes, two nacelles, and 15 standard hub heights.

The flexible portfolio means that Vestas can offer the optimal wind turbine configuration and maximise energy production under all types of wind and site conditions across the world, underpinning Vestas' aim to expand its global reach.

During 2015, the 3 MW variants have increased their potential and were upgraded to a higher wind class. Also included was an upgrade of standard rating to 3.45 MW, power modes of up to 3.6 MW (except on the V136-3.45 MW™), tower heights of up to 166 metres and the introduction of a next-generation advanced control system. The new control system is significantly faster, and available input/output signals are significantly increased to secure availability to meet future requirements.

V136-3.45 MW™ turbine introduced

In September 2015, Vestas introduced the V136-3.45 MW™ turbine, the latest and as yet largest addition to the 3 MW wind turbine family, demonstrating the strong technological capabilities of the platform and how far Vestas has come in utilising the advantages of standardisation and modularisation. The V136-3.45 MW™ represents a performance upgrade in the low wind segment, making it possible to increase annual energy production (AEP) by more than 10 percent compared to the existing product (V126-3.3 MW™) depending on site-specific conditions.

136 metres

The V136-3.45 MW™ turbine with its 66.7 metre blades has a rotor diameter of 136 metres – larger than the London Eye, the ferris wheel on the bank of the River Thames in London, UK.

The V136 blade has been designed to balance loads, mass, and stiffness with performance to optimise cost of energy, without making significant changes to the nacelle. The blades make use of structural shell technology which, as with the V126-3.45 MW™ and V110-2.0 MW™ turbines, decreases weight while improving structural integrity and stability. The larger rotor diameter, implied by the longer blades, offsets the relatively low wind speeds it is designed for and in effect produces an output equivalent to that of shorter blades in high wind speed conditions.

With its 67 meter long blades, the V136-3.45 MW™ covers a swept area close to 40 percent larger than the first wind turbine on the 3 MW platform (the V112-3.0 MW™), and with the largest swept area in the Vestas product portfolio, the V136-3.45 MW™ turbine is optimised to deliver high output on low-wind sites, such as a typical mainland European site.

The new wind turbine is introduced with a standard generator rating of 3.45 MW, made possible by the innovation of a modularised full-scale converter, and features a higher torque gearbox, which lowers the sound emissions, and thereby makes the wind turbine suitable for populated areas.

Vestas received the first firm order for a project using V136-3.45 MW™ by the end of 2015, demonstrating customer confidence in Vestas' development process and supply chain capabilities.

The first V136-3.45 MW™ turbine is expected to be put into production and tested at the Østerild test facility in Denmark ultimo 2016, with IEC type certificate and serial production start planned for 2017.

Increasing versatility of the 2 MW platform

Vestas' 2 MW platform provides industry-leading reliability, serviceability and availability. To date, the wind turbines installed globally within the current 2 MW product platform amount to more than

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16,000. The 2 MW platform is a strong offering especially for infrastructure constrained locations. This platform, too, has undergone an evolution since its introduction in 1996, and has been gradually improved with e.g. increased rotor, improved wind turbine control, and optimised drivetrain technology including an increase in nominal output of up to 37.5 percent from the original 1.6 MW.

With V110-2.0 MW™, V100-1.8/2.0 MW™, and V90-1.8/2.0 MW®, the 2 MW platform offers a competitive selection of wind turbines for all wind segments. The platform's reliability, defined by a very low Lost Production Factor, is key to business case certainty, while the tried-and-tested design as a result of reliability ensures lower cost of energy for low, medium and high-wind onshore sites, even in extreme weather conditions.

Another evolution of the 2 MW platform in the past year is the expansion of the tower offering targeted at different turbulence classes. With now three standard tower types instead of just one, Vestas is able to cover all turbulence classes, achieving lower cost of energy for sites with lower turbulence levels.

Service solutions

Service solutions are to an increasing degree being integrated in the development of new wind turbine variants, e.g. by preparing up-tower repair solutions in the design of the wind turbine.

During the year, the PowerPlus™ programme, a series of upgrades designed to improve the performance of existing wind power plants, was extended to include a wider range of wind turbines. New aerodynamic upgrades have also been developed, so, in addition to the proved vortex generator solution, the wind power plant owners can now benefit from the latest development, the gurney flap. On the 2 MW platform, Vestas is combining vortex generators with the gurney flaps for the V90 and V100 turbines, delivering an AEP increase of up to 1.2 percent. This is a solution which is available across products.

In 2015, Vestas Online Enterprise was also introduced, enabling customers to access the data output from their wind turbines via a web-server. This makes it possible to actively manage the output of the wind turbines from anywhere in the world. The solution has also been made available for non-Vestas turbines.

Customer engagement

The Customer Advisory Board, which Vestas established in 2013 with participation of selected key customers, is creating great value, working as a compass for the medium to long-term technology strategy. At the annual meetings, the customers provide feedback on the broader product vision and have the opportunity to advise on specific challenges that Vestas can help overcome from a technological standpoint.

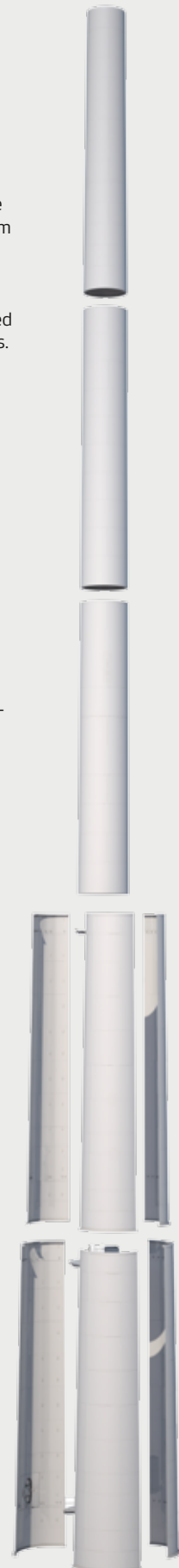
Large Diameter Steel Tower

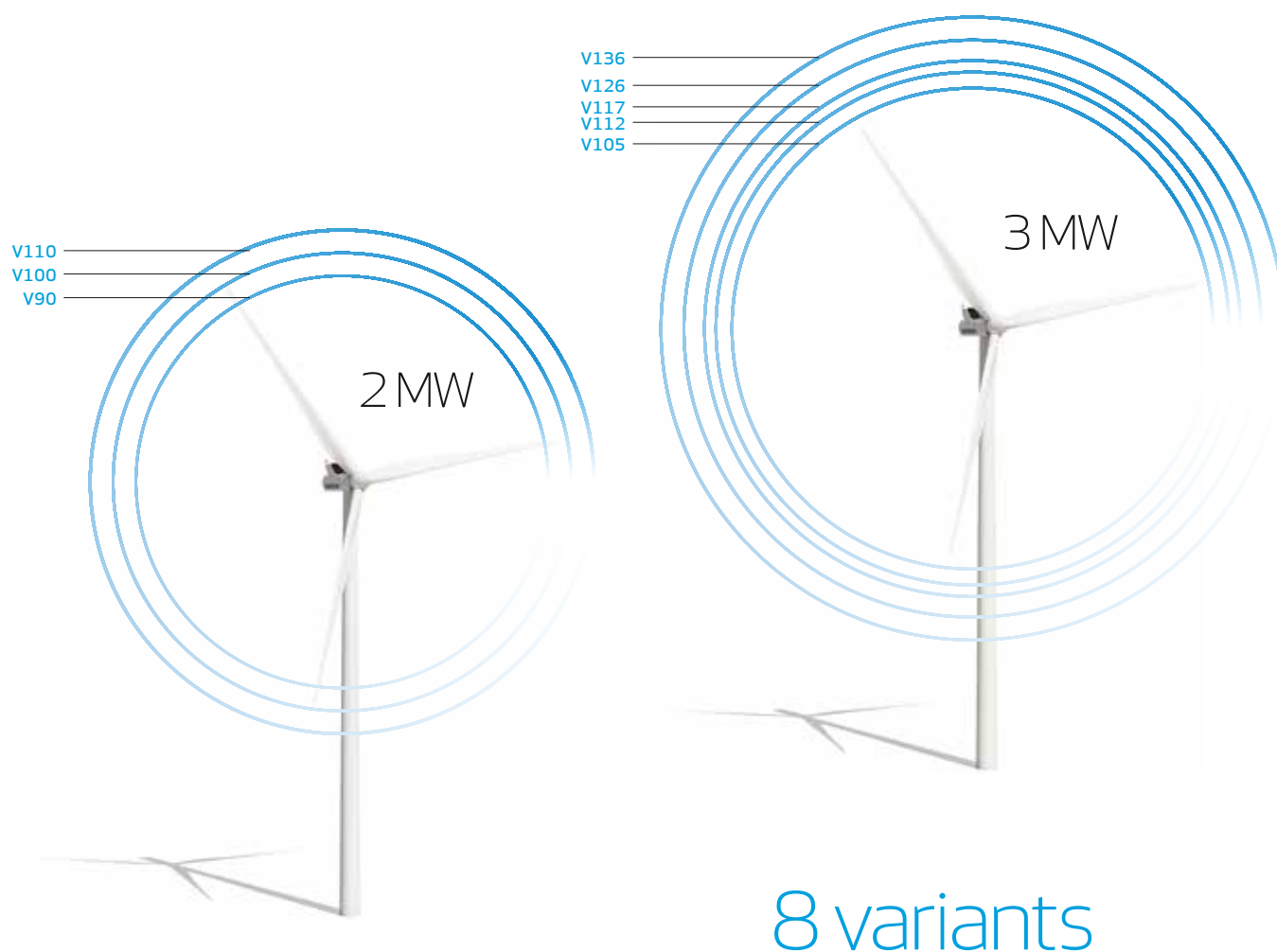
The Large Diameter Steel Tower (LDST) is a cost-effective technological solution especially suited for higher towers. LDST consists of standard tower sections in the middle and upper part and special sections with a larger diameter, the so-called LDST sections, in the bottom. By using a widened bottom section, the steel plate thickness can be reduced without sacrificing the strength of the tower. This decreases the amount of steel used and hence lowers production costs.

Due to regional transport restrictions, the LDST sections are sliced into three segments after production. Before slicing the sections, vertical flanges are welded on and used to re-assemble on site.

The LDST segments can be transported cost-effectively on flatbed trucks. The standard middle and upper sections are transported similar to a standard steel tower.

Vestas has year-to-date installed approx 150 LDST towers in Northern and Central Europe.





8 variants

With two product platforms and a total of eight wind turbine variants, Vestas covers all wind classes. The turbine variants can furthermore be tailored to specific sites with e.g. a wide range of options, towers, and power modes.

Wind classes - IEC ■ Standard IEC conditions ■ Site dependent

	IEC III (6.0 – 7.5 m/s)	IEC II (7.5 – 8.5 m/s)	IEC I (8.5 – 10.0 m/s)	Above 10.0 m/s
2 MW PLATFORM*				
V90-1.8/2.0 MW* IEC IIA/ IEC IIIA	■	■	■	
V100-1.8/2.0 MW™ IEC IIIA/IEC S	■	■		
V100-2.0 MW* IEC IIB		■	■	
V110-2.0 MW™ IEC IIIA	■	■		
3 MW PLATFORM*				
V105-3.45 MW™ IEC IA			■	■
V112-3.45 MW™ IEC IA			■	■
V117-3.45 MW™ IEC IB/IEC IIA		■	■	■
V126-3.45 MW™ IEC IIA		■	■	
V126-3.45 MW™ IEC IIB	■	■		
V126-3.45 MW™ IEC IIIA	■	■		
V136-3.45 MW™ IEC IIIA	■	■		

*Wind turbine application is flexible depending on site specific conditions.

Vestas turbine evolution

