Vestas Product Offering – V150-4.2 MW at a Glance

Renato Loureiro Gonçalves – Wind & Site Engineer
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The Vestas’ portfolio of wind solutions
From siting to aftersales, our offering spans across turbines and services

Expertise
built from more than 35 years of wind industry experience
The Vestas’ 2 MW and 4 MW platforms
Mature platforms with proven track records

- Introduced in 2000 and incrementally improved over the years
- + 20,500 units installed globally*
- Well suited for sites with infrastructure constraints

- Introduced in 2010, now fourth generation
- + 5,500 units installed globally*
- Grid compliant across the world due to full converter solution

* As of 31 March 2018
4 MW: Next step in the evolution of a proven platform

Significant AEP increase driving down Cost of Energy

- **3.0 MW**: V112-3.0 MW first member of new 3 MW Platform
  - V90-3.0 MW®
  - V112-3.0 MW®
  - YEAR OF ANNOUNCEMENT: 2010

- **3.3 MW**: Upgrade to 3.3 MW
  - New rotors: 105/117/126m
  - V105-3.3 MW®
  - V117-3.3 MW®
  - V126-3.3 MW®
  - YEAR OF ANNOUNCEMENT: 2012/13

- **3.45 MW**: Upgrade to 3.45 MW
  - New rotor: 136m
  - 3.6 MW Power Mode
  - V105-3.45 MW™
  - V117-3.45 MW™
  - V126-3.45 MW™
  - YEAR OF ANNOUNCEMENT: 2015/16

- **4.2 MW**: Upgrade to 4 MW
  - New rotor: 150m
  - 4.2 MW Power Mode
  - New Segment: Typhoon Class
  - V117-4.2 MW™ (incl. Typhoon)
  - V136-4.2 MW™
  - V150-4.2 MW™
  - YEAR OF ANNOUNCEMENT: 2017—...
4 MW Platform
# Vestas 4 MW Platform Portfolio

One common platform, powering 8 turbine variants for broad wind spectrum coverage

## WINDCLASSES – IEC

<table>
<thead>
<tr>
<th>TURBINE TYPE</th>
<th>IEC III (6.0 – 7.5 m/s)</th>
<th>IEC II (7.5 – 8.5 m/s)</th>
<th>IEC I (8.5 – 10.0 m/s)</th>
<th>Above 10.0 m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>V105-3.45 MW™ IEC IA</td>
<td>Power Optimised Mode up to 3.6 MW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V112-3.45 MW® IEC IA</td>
<td>Power Optimised Mode up to 3.6 MW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V117-3.45 MW® IEC IB/IEC IIA</td>
<td>Power Optimised Mode up to 3.6 MW</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>V117-4.2 MW™ IEC IB/IEC IIA/IEC S/IEC T</td>
<td>4.2 MW Power Optimised Mode</td>
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<td></td>
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<tr>
<td>V126-3.45 MW™ IEC IIB/IEC IIA</td>
<td>Power Optimised Mode up to 3.6 MW</td>
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<tr>
<td>V136-3.45 MW™ IEC IIB/IEC IIIA</td>
<td>Power Optimised Mode up to 3.6 MW</td>
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<tr>
<td>V136-4.2 MW™ IEC IIB/IEC S</td>
<td>4.2 MW Power Optimised Mode</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V150-4.2 MW™ IEC IIIIB/IEC S</td>
<td>4.2 MW Power Optimised Mode</td>
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</tr>
</tbody>
</table>

*Based on nominal rating
# Platform Evolution

## Incremental step-wise performance upgrades

<table>
<thead>
<tr>
<th>Year</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>2010</td>
<td>V112-3.0 MW™</td>
</tr>
<tr>
<td>2012/13</td>
<td>V105-3.3 MW™, V117-3.3 MW™, V126-3.3 MW™</td>
</tr>
<tr>
<td>2015</td>
<td>Upgrade to 3.45 MW, V136-3.45 MW®</td>
</tr>
<tr>
<td>2017</td>
<td>V117-4.2 MW™, V136-4.2 MW™, V150-4.2 MW™</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>2010</th>
<th>2012/13</th>
<th>2015</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gearbox</td>
<td>2 planetary and 1 helical stages</td>
<td>Upgraded Gearbox</td>
<td>Upgraded Gearbox</td>
<td>Upgraded Gearbox</td>
</tr>
<tr>
<td>Generator</td>
<td>IG 3.0 MW</td>
<td>3.3 MW 3.45 MW*</td>
<td>3.45 MW 3.6 MW*</td>
<td>4.0 MW 4.2 MW*</td>
</tr>
<tr>
<td>Converter</td>
<td>Full Scale Upgrade</td>
<td>Upgrade</td>
<td>Upgrade</td>
<td>Upgrade</td>
</tr>
<tr>
<td>Blade Design</td>
<td>Structural Spar</td>
<td>Structural spar</td>
<td>Structural Shell</td>
<td>Structural Shell</td>
</tr>
<tr>
<td>Nacelle Dimensions</td>
<td>L: ~10.8 m H: ~3.4 m W: ~4.0 m</td>
<td>Same design</td>
<td>Same design</td>
<td>Updated Nacelle dimensions virtually unchanged*</td>
</tr>
</tbody>
</table>

*Power Optimised Mode
4 MW platform provides **industry-leading** track record and performance
Strengthened market coverage
V117-4.2 MW™, V136-4.2 MW™ and V150-4.2 MW™

V117-4.2 MW™, V136-4.2 MW™ and V150-4.2 MW™ have global applicability, strengthening competitiveness of the 4 MW platform under certain market or site conditions.

V150-4.2 MW™
Highest yielding onshore turbine in the industry

V136-4.2 MW™
Improved AEP performance combined with class leading low sound power level

V117-4.2 MW™
Expands 4 MW applicability to IEC T (Tropical) wind conditions
Operational data, generated every 10 minutes from more than 3,000 turbine sites* across the globe, providing valuable insights for Vestas’ engineers to fine-tune performance - in unrelenting pursuit of lower cost of energy.

* All Vestas turbines, not specific to 4 MW
** As of 31 March 2018
Platform Installation Track Record
The 4 MW platform is proven, already performing in volumes across the world.

The 4 MW platform is the primary component in wind power plants installed in 35 countries across the world. With +18 GW or +5,500 WTGs of accumulated installations, the Vestas 4 MW is a trusted performer.

* As of 31 March 2018

First V112-3.0 MW™ (2010)
Advantage of evolutionary approach: steady performance
Continued reliable performance across Vestas-serviced fleet

While the number of Vestas installed turbines increase, fleet Lost Production Factor (LPF) has stabilised at a very low level. This is the result of the Vestas evolutionary product development approach.
Latest Performance Upgrades
Latest Performance Upgrades

New variants enabled by strengthened platform components

For V117-4.2 MW™, V136-4.2 MW™ and V150-4.2 MW™, the 4 MW platform has been strengthened through **upgrades to existing proven component and systems.**

**More Torque**
- Upgraded gearbox, same proven design. Powering V136-4.2 MW™ and V150-4.2 MW™
- Application of known gearbox in V117-4.2 MW™

**Upgraded Blades & Hub**
- Vestas most advanced blade design & advanced materials applied to 73.7 m blades (V150-4.2 MW™)
- Strengthened 57.2 m (V117-4.2 MW™) blade
- Enforced blade bearings & pitch capacity (V150-4.2 MW™)

**4.0 MW nominal rating**
- Upgrade to proven generator and transformer system
- Upgraded water cooling & Cooler Top™
- 4.2 MW Power Optimised Mode

**Upgraded Converter**
- Upgraded full-scale converter, leveraging modularized design
Increased Annual Energy Production

Latest upgrade enables double-digit AEP gains in all standard wind classes

*V150-4.2 MW™ with 4.2 MW Power Optimised Mode in IEC III Compared to V136-3.45 MW™ Actual figures depend on site specific conditions.

**AEP=Annual Energy Production.**
V150-4.2 MW™ turbine variant

Highest yielding onshore turbine in the industry

Larger Swept Area
Blade length increased to 73.7 m using Vestas most advanced aerofoil design and materials

17,671 m²
swept area

+22% swept area*

Higher Energy Production
Combined with increase in capacity factor

Up to 21% AEP Increase*

Reduced Sound Power Levels
Segment leading energy production combined with very low 104.9 dB(A)

Maximum 104.9 dB(A)

Tower Portfolio
- Site specific tower portfolio to meet tip heights ranging from 180-241 meter leveraging industry leading 166 m hub height

*Compared to V136-3.45 MW. Depending on wind condition
V150-4.2 MW™ offering
Operating strategy for maximizing siting capability and power performance

Application Space

Energy Production

Classification: Restricted
Vestas track record
Really proven performance – deliver what we promised

Vestas has asked third party to review our performance in operational fleet

Figure 1: Vestas Fleet performance as expressed by MEO/WEO

<table>
<thead>
<tr>
<th>Classification: Restricted</th>
<th>Average</th>
<th>Median</th>
<th>StdDev</th>
<th>Number of tests</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>99.8</td>
<td>99.8</td>
<td>2.5</td>
<td>324</td>
</tr>
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Grid compliance for both plant and turbines

**Grid Compliance**
- The grid performance for the V150-4.0/4.2 MW will be similar to the V136-3.45 MW with 3.6 MW Power Optimised Mode.

**Plant Compliance – Grid Stabilisation**
- Synthetic inertia ie. Overboosting
- Frequency response
- Ramp-up requirement
- Fault ride through (up to 450 msec with 0.0 pu)

**Turbine Compliance**
- Consumption (active/reactive power)
- Power quality conditions ie. Flicker and harmonics
- Temporary overvoltage (TOV)
Calibrated turbine input ensures optimal production

Adaptive Wind Sensing and Wind Speed Estimator provides up to 0.6% more AEP*

- Adaptive Wind Sensing and Wind Speed Estimator uses advanced algorithms to **calibrate upwind yaw position and more accurately measure wind speed** in front of the rotor. The increased accuracy results in more power and less loads.

- **Adaptive Wind Sensing** continuously and automatically calibrates its upwind yaw positions, updating the wind correlation parameters for each individual wind turbine

- The algorithm uses the natural variation in wind direction (+/- 6 degrees) to calculate optimum yaw position based on power production

- The improved upwind yaw accuracy leads to improved operation, reduced loads, and enables accurate performance according to warranted power curves

- **Wind Speed Estimator** reverses the measurement process by calculating the wind speed from the turbine's pitch, speed, and power readings

- Also, it continuously and automatically corrects the wind correlation parameters for each individual wind turbine

- The algorithm allows Vestas to more accurately measure the wind speed in front of the entire rotor, resulting in optimized operational settings

*Actual AEP (Annual Energy Production) depends on turbine type and site conditions
Market Timing
Time to market
Overview

V105-3.45 MW™
V112-3.45 MW®
V117-3.45 MW®
V126-3.45 MW®

H1 2016
First installation
Q4 2016
First deliveries
Q1 2017
IEC type certificate

V136-3.45 MW®
V126-3.45 MW®*

Q4 2016
First installation
Q4 2017
IEC type certificate
Q3 2017
First deliveries

V117-4.2 MW™
V136-4.2 MW™
V150-4.2 MW™

Q4 2018
First installation
(V150-4.2 MW™)
Q4 2019
First installation
(V117-4.2 MW™)
Q3 2019
IEC type certificate
(V117-4.2 MW™)

*V126-3.45 MW™HTq (low sound power variant)
Q&A
Thank you for your attention