



**Vestas**<sup>®</sup>

**Wind.** It means the world to us.<sup>™</sup>

# Technology evolution and new market developments

NZWEA Conference 2016

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Vestas New Zealand

# Agenda

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## **FASTER**

*Turbine technology trends, modular platforms, larger rotors*

## **HIGHER**

*Tower technology – the only way is up*

## **STRONGER**

*Mesoscale, CFD, Big Data, field upgrades*

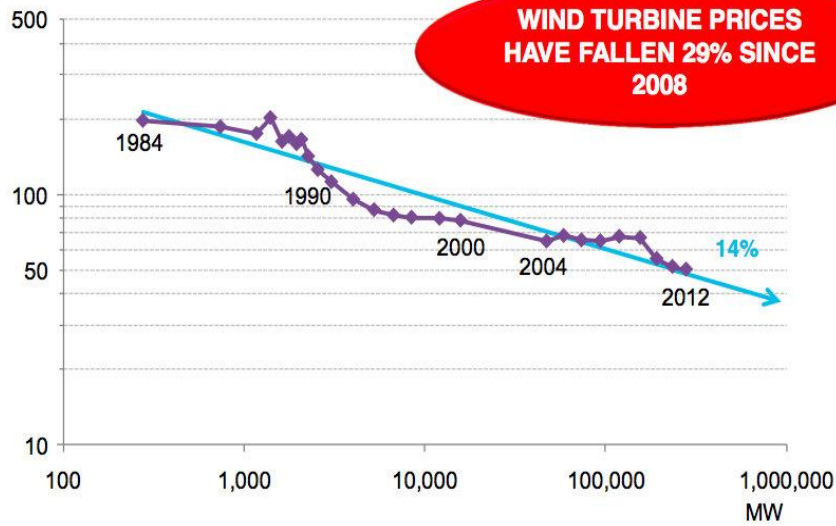
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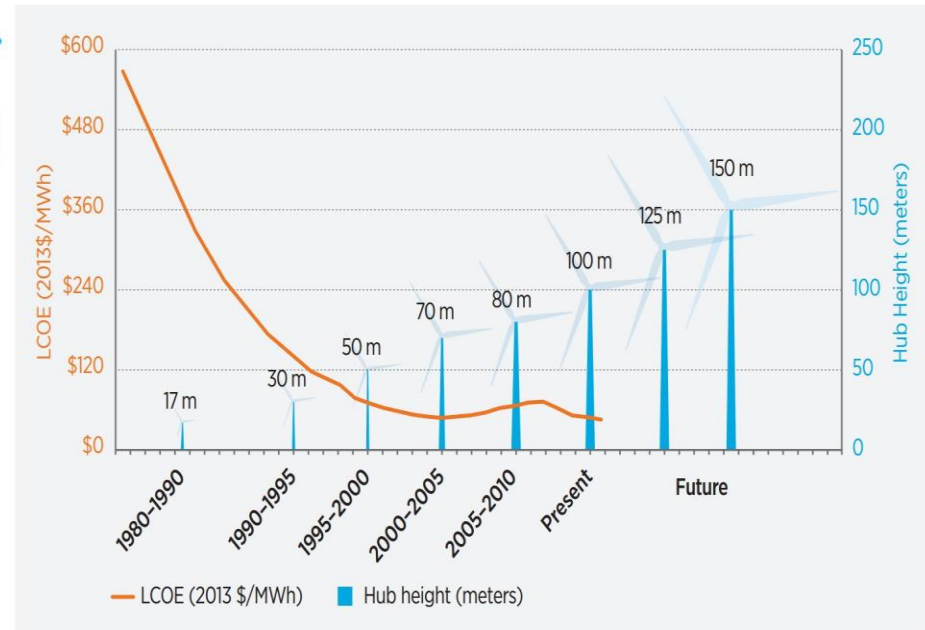
# Turbine Technology Trends



# AVERAGE LEVELISED COST OF ONSHORE WIND, 1984-2012 (€/MWh)



Scale-up of wind technology has supported cost reductions.



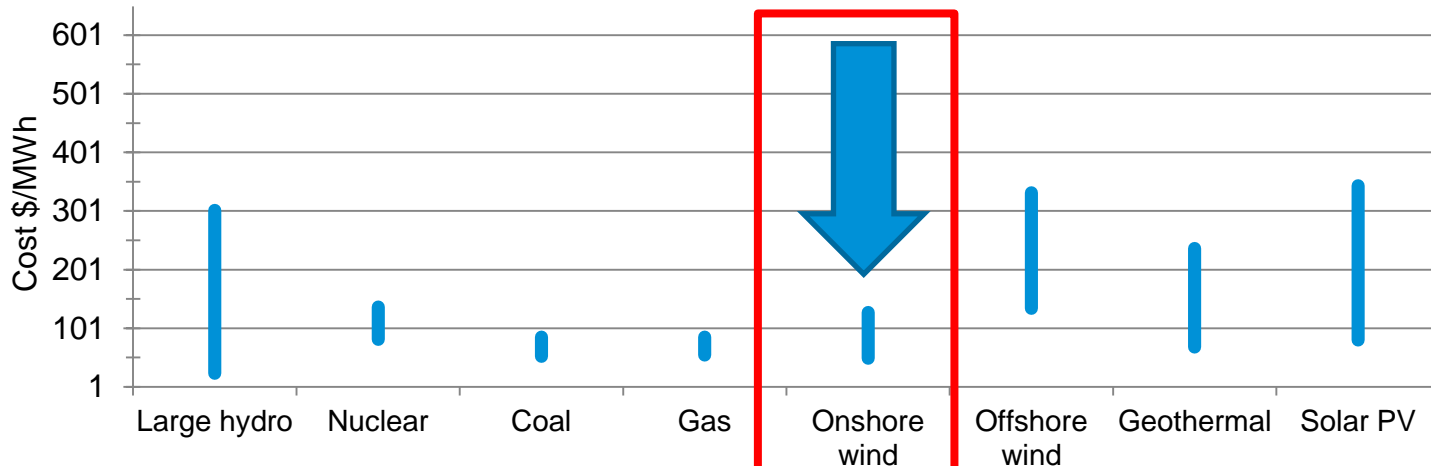
Note: Learning curve (blue line) is least square regression:  $R^2 = 0.88$  and 14% learning rate. Source: Bloomberg New Energy Finance, ExTool

Note: LCOE is estimated in good to excellent wind resource sites (typically those with average wind speeds of 7.5 m/s or higher), excluding the federal production tax credit. Hub heights reflect typical turbine model size for the time period.

**Bloomberg** NEW ENERGY FINANCE // MICHAEL LIEBREICH, Delhi, 17 April 2013 // TWITTER: @MLiebreich

Figure ES.2-5. Wind technology scale-up trends and the levelized cost of electricity

## Cost ranges for selected energy technologies



# Turbine Technology - Modularisation

Maximise AEP | Lower CoE | Solutions tailored for each unique site

- Modularisation philosophy borrowed from automotive industry
- Solid platform underpins performance
- Commonisation of key interfaces allows interchangeability of modules
- Module combinations provides enhanced versatility



**3MW PLATFORM**

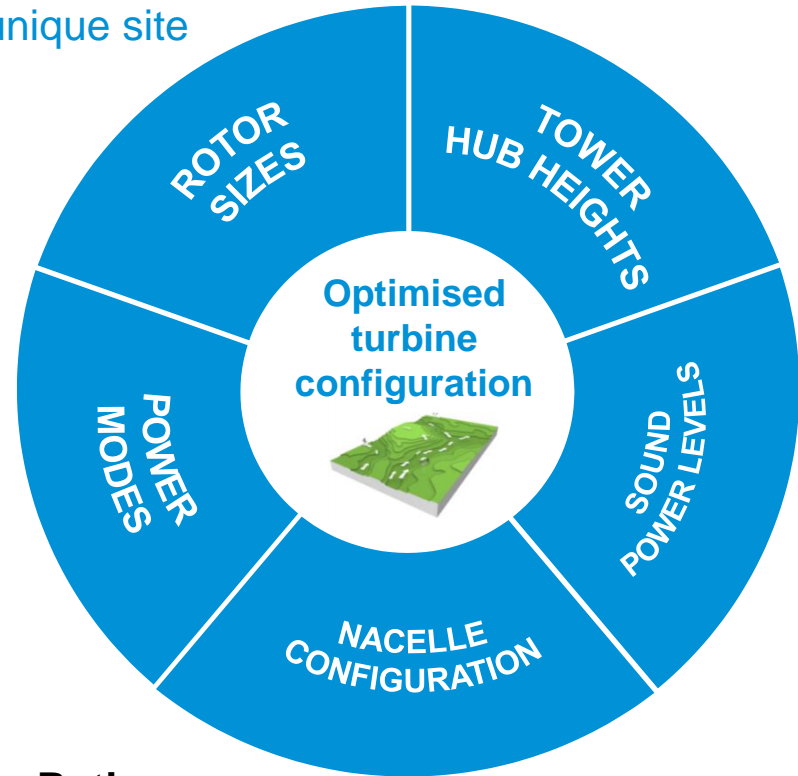
V105  
V112  
V117  
V126  
V136

• = 5 rotors

15 hub heights  
up to 166m

## Generator Ratings

3.0MW  
3.3MW  
3.45MW  
3.6MW



- Power Optimised modes
- Load Optimised modes
- Sound Optimised modes
- Operating strategy
- Site layout optimisation
- Grid solutions

# Turbine Technology – Larger Rotors/Load Management

Load Management Enables Larger Rotors in Higher Wind Classes

**+18-35%  
AEP  
increase  
since 2010\***



**3.0 MW**

- V112-3.0 MW first member of “new” 3 MW Platform



**3.3 MW**

- Upgrade to 3.3 MW nominal rating
- New rotors: 105m, 117m, 126m



**3.45 MW**

- Upgrade to 3.45 MW nominal rating
- New rotor: 136m

IEC I

V105-3.3 MW®  
V112-3.3 MW®

V105-3.45 MW™  
V112-3.45 MW™  
V117-3.45 MW™

IEC II

V112-3.0 MW®

V117-3.3 MW®

V126-3.45 MW™

IEC III

V126-3.3 MW®

V136-3.45 MW™

SAME PLATFORM

YEAR OF  
ANNOUNCEMENT

**2010**

**2012/13**

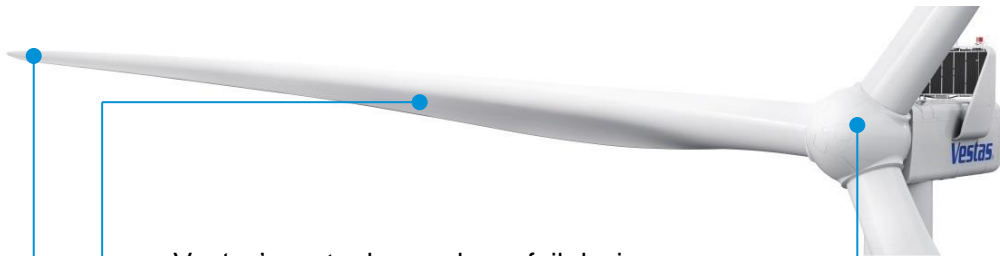
**2015**

IMPROVED LOAD MANAGEMENT

# Blade Design | V136-3.45 MW™ rotor

Advanced aerofoil design to increase lift and minimise drag

V136-3.45MW™ features Vestas' most advanced aerofoil to-date, designed specifically with cost of energy in mind. Improved aerodynamics enable improved lift to drag ratio, thereby **improving AEP performance without adding load associated costs.**



Vestas' most advanced aerofoil design

Blade tips aerodynamically optimised for lower sound emissions

Aerodynamics powered by wind data from 27,000 turbines under surveillance

**17%**  
larger swept area  
compared to V126-3.3/3.45MW™

**105.5 dbA**  
mode 0

**+12%**  
AEP\*

A close-up photograph of a wind turbine blade, showing its curved, aerodynamic shape. The blade is illuminated from the side, creating a strong highlight along its leading edge and casting the rest into deep shadow. The surface of the blade has a textured, fibrous appearance. In the lower-left quadrant, there are faint, handwritten technical markings in white or light-colored ink, including a large 'D' and a smaller 'P' with a line pointing to a specific location on the blade's surface.

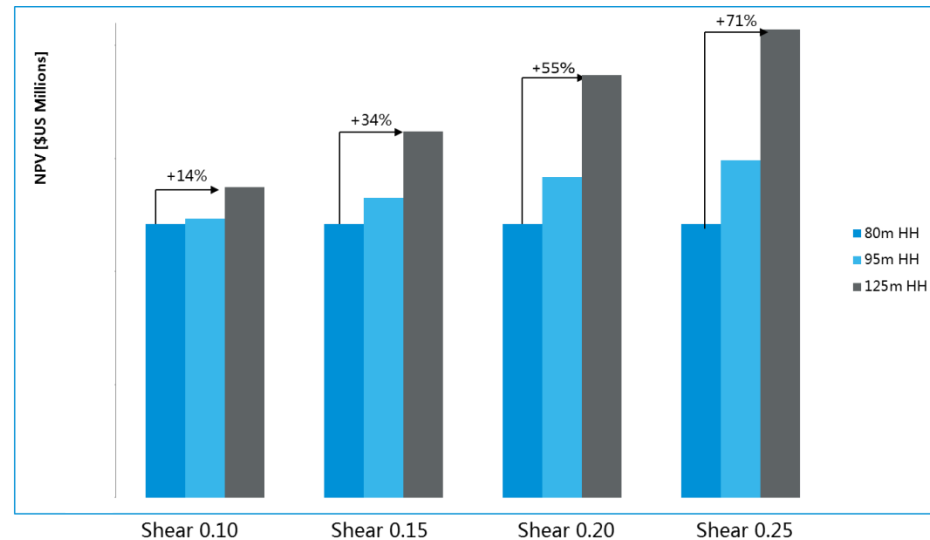
# Tower Technology Trends



# Tower Technology – the only way is up

## Cost effective solutions for higher hub heights

- Higher hub heights provide higher AEP, even with low wind shear
- Needed to accommodate increase rotor diameter
- Unless the base diameter can be increased – traditional steel towers will be too expensive
- New technology to increase base diameter while maintaining transportability and constructability



Measured wind speed 5.7m/s @ 80m  
K wind shape factor 2.0



# Large Diameter Steel Tower (LDST)

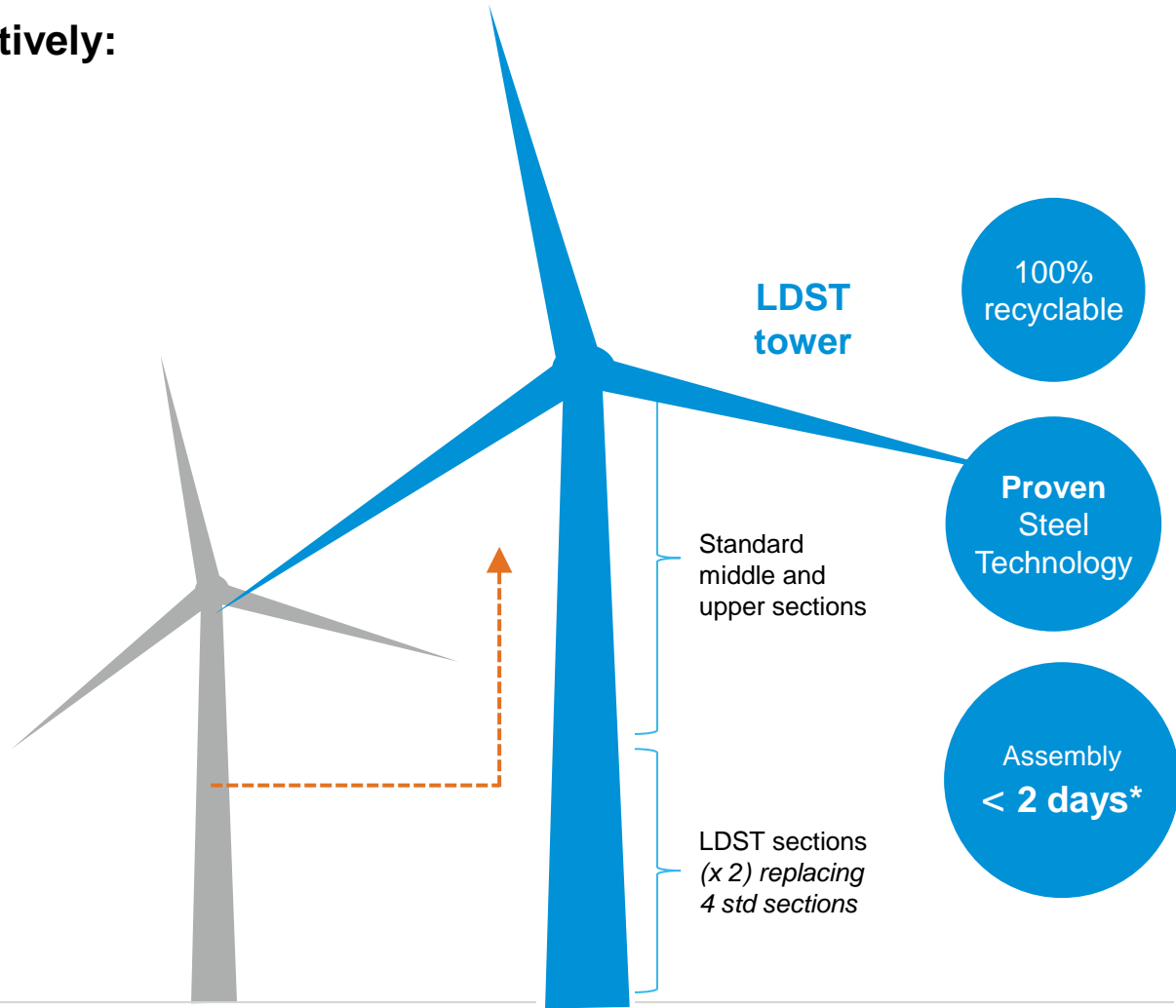
Combining innovative design with proven technology for improved reach and cost of energy

## How to get higher cost effectively:

- Standard steel?
- Concrete hybrid?
- Lattice?

## Vestas' Large Diameter Steel Tower (LDST) technology offers you:

- Tall hub heights with efficient use of materials
- Proven Vestas technology, certified steel tower design
- 100% recyclable materials
- Simple and efficient site delivery
- Fast installation, site assembly possible in all weather conditions



\* turbine and site dependent

# Large Diameter Steel Tower (LDST)

LDST technology is designed for easy transportation and quick installation

## Assembly process



- 1 The hardstand is checked for flatness and the two roller beds are placed appropriately



- 2 The first segment is lifted from the ground and placed on the roller beds



- 3 The second segment is lifted and turned from the ground and attached initially to the first segment using mountings and bolts



- 4 The two attached segments are turned using the roller beds. The two segments are connected by the longitudinal flanges



- 5 The final segment is lifted from the ground and initially attached to the two connected segments using mountings and bolts



- 6 Turn the construction. Bolt the pre-attached aluminium bars between the longitudinal flanges together (x2). Mount internals

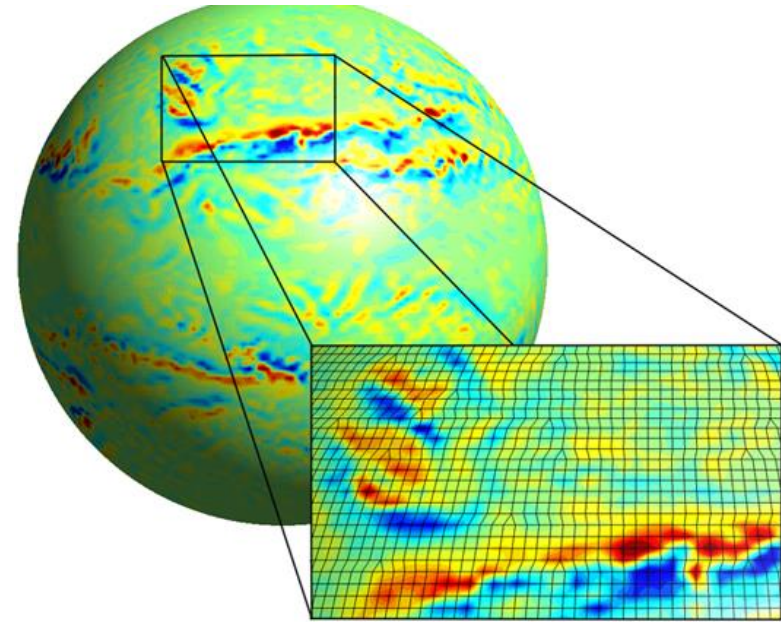
# Siting and Forecasting Trends



# Siting Capability Trends | Mesoscale Modelling

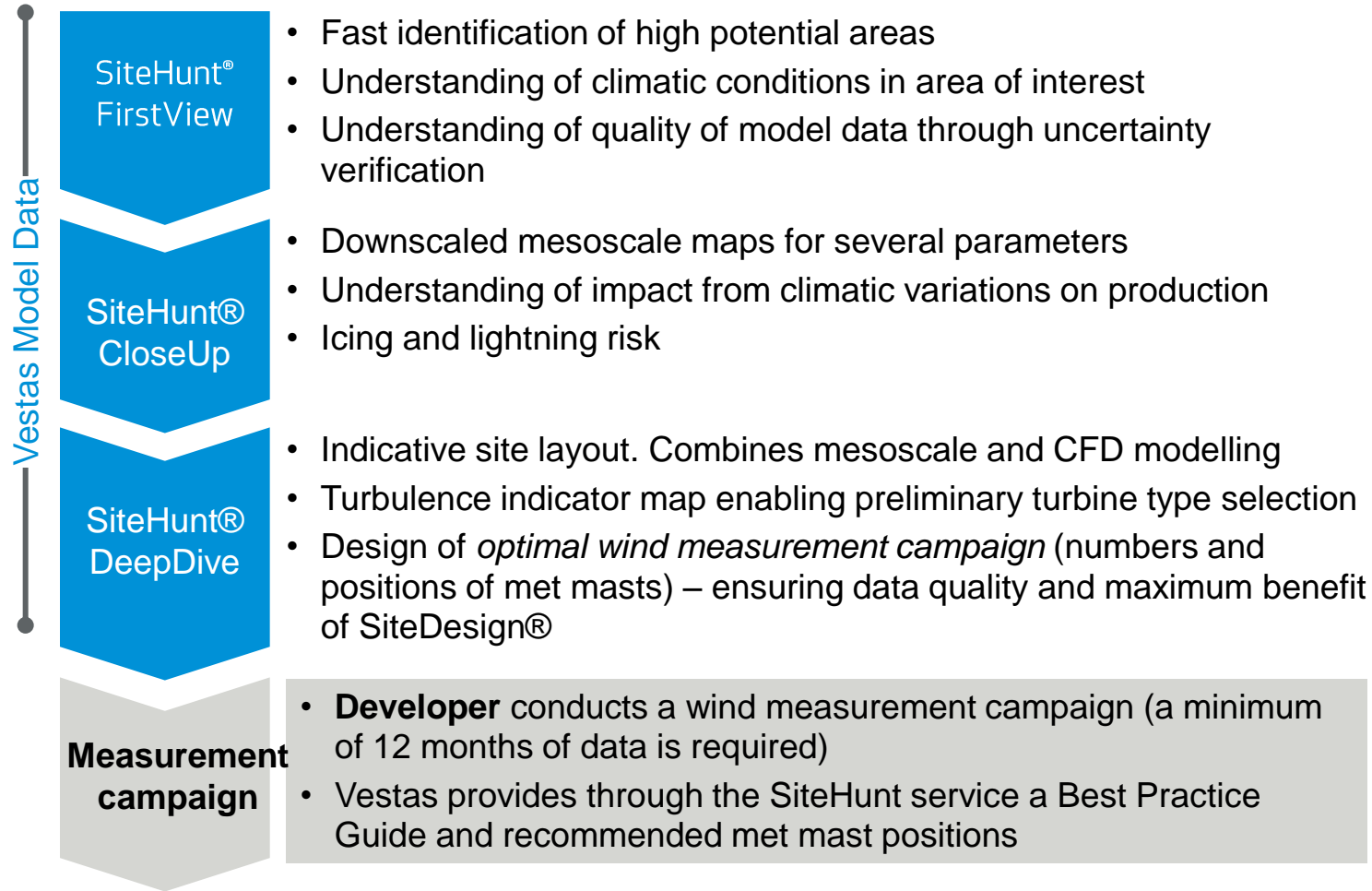
Better climate knowledge earlier

- Based on **numerical weather prediction** models
- Aggregation of **observed data**; metrological stations, weather balloons, ocean buoys, satellite, radar etc. etc.
- Provides “**mesoscale**” 10 x 10km grided resolution of the global climate
- Includes long term data for **improved** long term prediction
- Gives an insight into the climate **before** met mast data is available

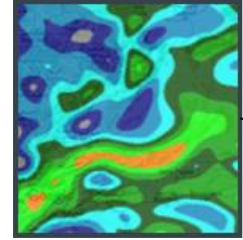


# Siting & Forecasting | Mesoscale Modelling

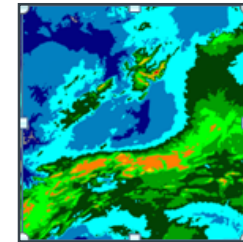
Vestas SiteHunt™ leverages Mesoscale to identify development opportunities



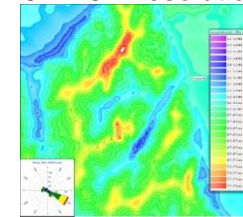
SiteHunt® FirstView  
3km resolution



SiteHunt® CloseUp  
300m - 1km resolution



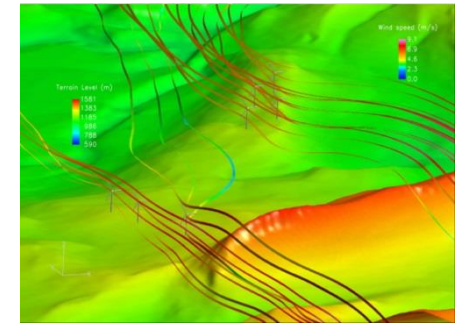
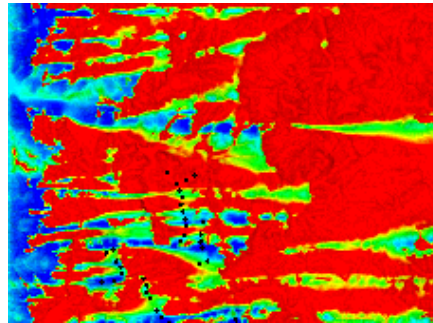
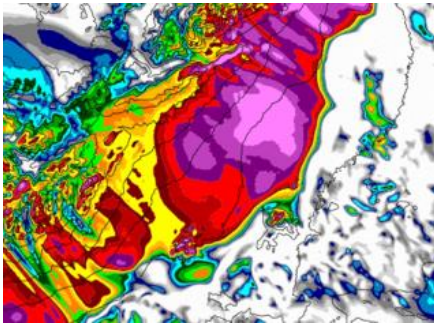
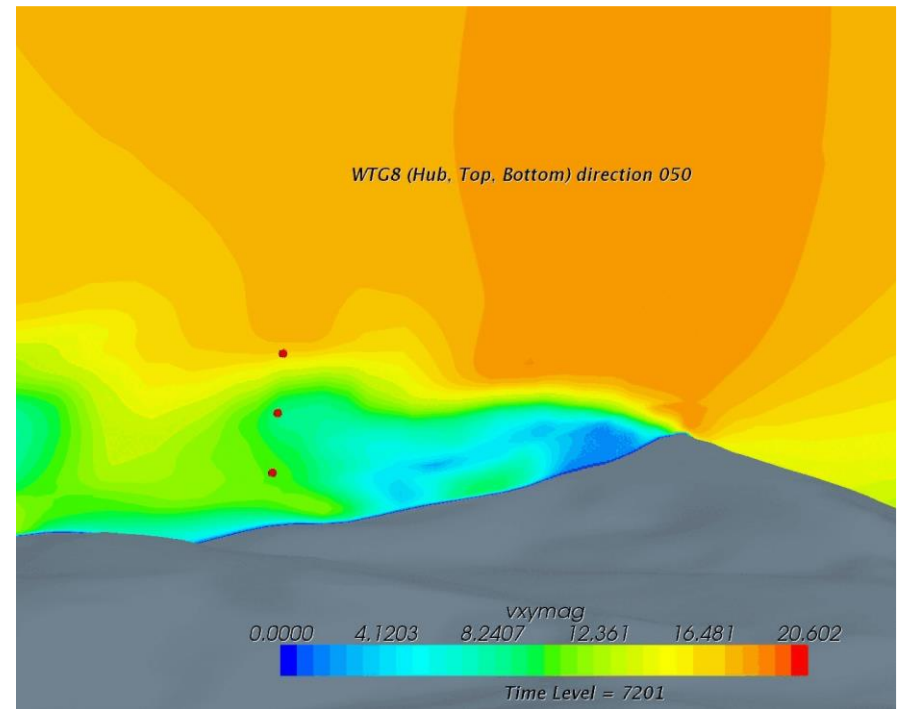
SiteHunt® DeepDive  
10 – 25m resolution



# Siting & Forecasting | Computational Fluid Dynamics (CFD)

Industry-leading capabilities and tools for understanding wind resources and suitability

- CFD is increasingly being used to understand flow dynamics
  - Horizontal flow modelling / complex sites
  - Diurnal forcing
  - Wake modelling
  - Turbulence mapping
- **Enhanced** micro-climate understanding => **improved** turbine optimisation => **better** utilisation of the turbine capability



# Trends in Operations

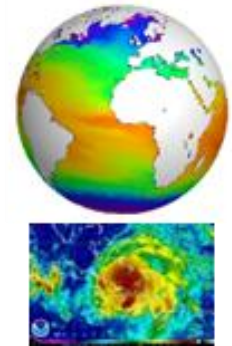
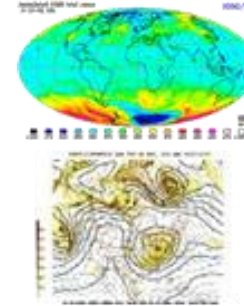




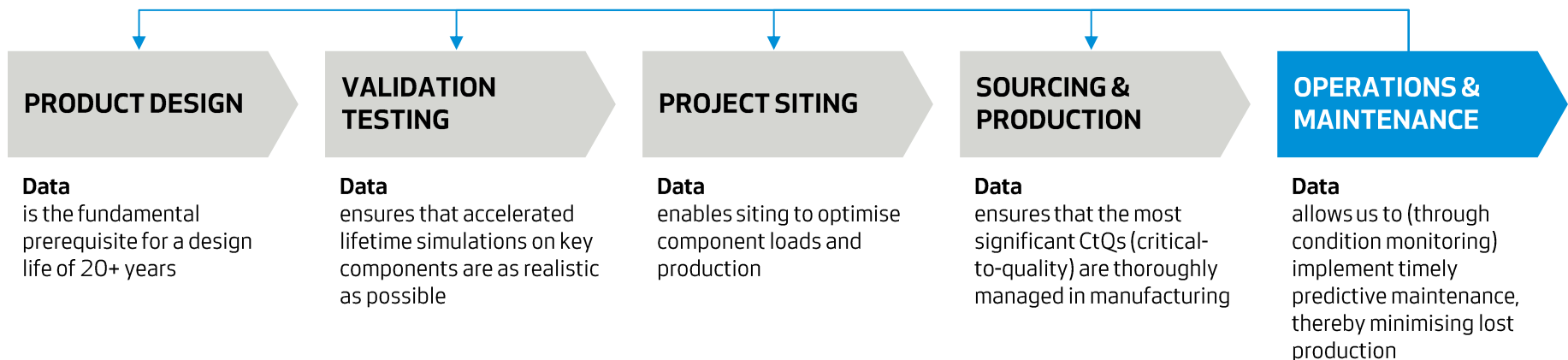
# The power of big data

Vestas applies learnings from 27,000 WTGs worldwide to deliver quality products, world-class siting capabilities, and maintenance.

- WTGs are more **instrumented** than ever => enormous amounts of field data
- Techniques in **analytics** enable operational **insights**
- Can also be used for **improvements** in the operational strategy, PowerForecasting, etc.



Turbines under surveillance feed back data to the rest of Vestas value chain



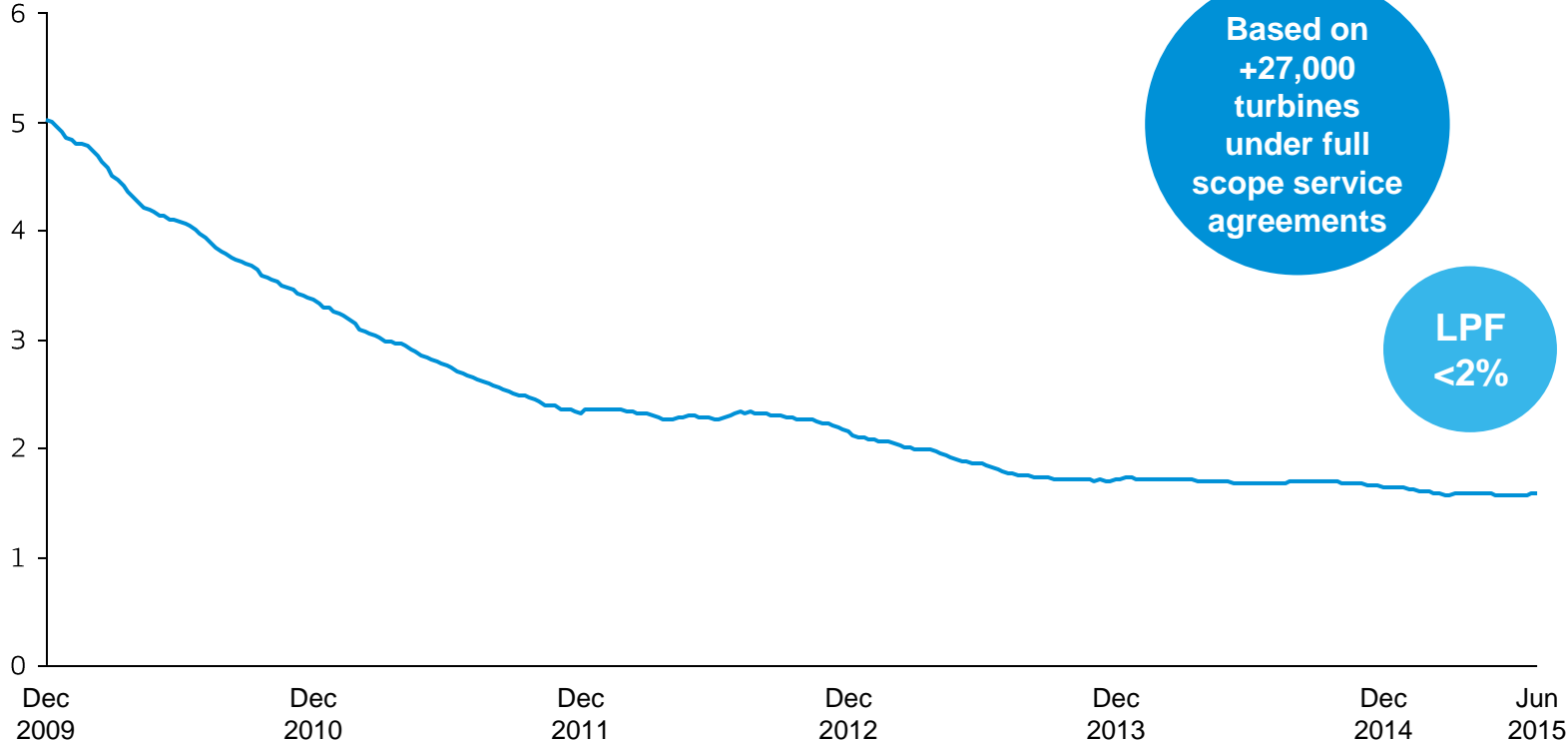
# Lost Production Factor

Continuous strive to deliver world-class reliability – Real World Big Data Results

Despite the growing number of installations, LPF continues to decrease and stabilise. Reliable production ensures **business case certainty**

## Lost Production Factor (LPF)

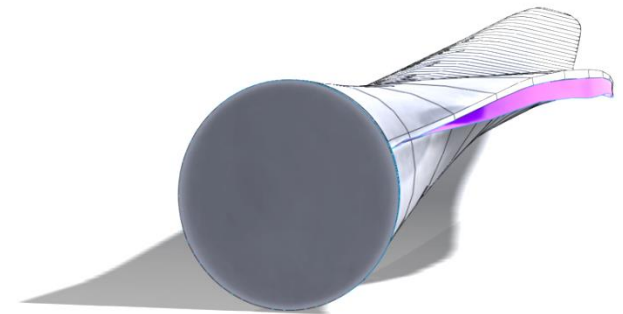
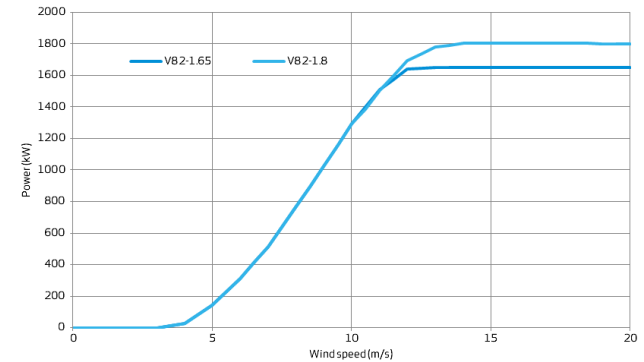
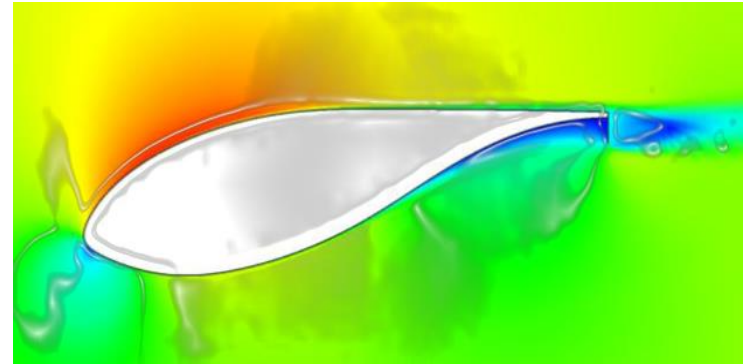
Percent



# Field Upgrades & Improvements

Vestas PowerPlus™ - Solutions for getting more from operating assets

- Two drivers for field upgrades:
  - Operational understanding of the site
  - Improved turbine capabilities through R&D
- Examples of field upgrades (PowerPlus)
  - Power up-rating
  - Aerodynamics add-ons
    - Vortex Generators
    - Gurney Flaps
    - Serrated Trailing Edges
  - Extended Cut-Cut
  - Power Curve Optimisation
- Turbines in the field are now included in the R&D learning cycle



# *What's next? How to keep the cost curve momentum*

- *Machine Learning – adaptive loads and production control*
- *IoT – better connectivity and online health monitoring*
- *Wind Power Plant Control – maximising output at the wind farm level*
- *Active Aerodynamics – adapting to the conditions*
- *Innovative Transport Solutions – enabling longer blades and taller towers*

# Summary

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## **TURBINE TECHNOLOGY**

*Modular Platforms > more turbine configurations > optimised to project  
Load Management > larger rotors in higher wind speeds*

## **TOWER TECHNOLOGY**

*Innovative Higher Hub Height > Cost effective solutions > LDST*

## **SITING TECHNOLOGY**

*Mesoscale modelling > Certainty in the wind resource  
Computational Fluid Dynamics > Better micrositing*

## **OPERATIONS TECHNOLOGY**

*Big Data Analytics > Insights across the value chain  
Field Upgrades > Upside throughout the operations*

**Vestas**<sup>®</sup>

Thank you for  
your attention

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