Reduce Levelised Cost of Energy

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Aarhus, 12 June 2014
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1. Looking back: What have we done since 2012?

2. Looking forward: What are the main strategic focus areas for product and service solutions?
   - Reducing the Levelised Cost of Energy
   - Innovation
   - Industrialisation and modularisation
Faster delivery of wind turbines and services to the market

Harvesting the full potential of our 2 and 3 MW platforms

We have developed **new competitive products while reducing R&D cash spend by more than 40 per cent.**
Vestas’ turbines are performing well

Warranty consumption and LPF continue at a low level

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
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</thead>
<tbody>
<tr>
<td>Warranty provisions consumed</td>
<td>4.5</td>
<td>5.6</td>
<td>4.4</td>
<td>5.1</td>
<td>3.7</td>
<td>3.1</td>
<td>1.6</td>
<td>1.4</td>
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Lost Production Factor (LPF)

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>LPF</td>
<td>5.1</td>
<td>4.4</td>
<td>3.1</td>
<td>2.0</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Key takes:

- Warranty consumption constitutes approx 1.5 per cent of revenue over the last 12 months.

Key takes:

- LPF continues at a low level below 2.0.
- LPF measures potential energy production not captured by the wind turbines.
Our customers are satisfied with our products

Positive trend from the Customer Loyalty Survey 2013

Customer Loyalty Survey 2013
Index number

<table>
<thead>
<tr>
<th>Category</th>
<th>2012</th>
<th>2013</th>
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<tbody>
<tr>
<td>Power generation</td>
<td>74</td>
<td>77</td>
</tr>
<tr>
<td>WTG portfolio</td>
<td>78</td>
<td>80</td>
</tr>
<tr>
<td>Power curve performance</td>
<td>73</td>
<td>75</td>
</tr>
</tbody>
</table>
Agenda

1. Looking back: What have we done since 2012?

2. Looking forward: What are the main strategic focus areas for product and service solutions?
   - Reducing the Levelised Cost of Energy
   - Innovation
   - Industrialisation and modularisation
Profitable Growth for Vestas
Reducing Levelised Cost of Energy to support Vestas’ mid-term ambitions

Vision: To be the undisputed global wind leader
Strongest brand in industry | Best-in-class margins
Market leader in volume | Bringing wind on a par with coal and gas

- Grow profitably in mature & emerging markets
- Capture full potential of the service business
- Reduce Levelised Cost of Energy
- Improve operational excellence
- Governance, leadership and culture

Mid-term (3-5 years)
Reduce cost of energy faster than market average

Reducing Levelised Cost of Energy to support Vestas’ mid-term ambitions

<table>
<thead>
<tr>
<th>STRATEGY</th>
<th>OBJECTIVE</th>
<th>MID-TERM AMBITIONS &amp; INITIATIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Reduce Levelised Cost of Energy faster than market average</td>
</tr>
<tr>
<td>1</td>
<td>Grow profitably in mature &amp; emerging markets</td>
<td>• Cost out and optimised performance: Increase product competitiveness and continue cost out on the 2 MW and 3 MW platforms.</td>
</tr>
<tr>
<td>2</td>
<td>Capture full potential of the service business</td>
<td>• Industrialisation and modularisation: Work towards a new flexible and scalable product architecture.</td>
</tr>
<tr>
<td>3</td>
<td>Reduce the Levelised Cost of Energy</td>
<td>• Innovation: Ensure new growth for Vestas through an innovative company culture.</td>
</tr>
<tr>
<td>4</td>
<td>Improve operational excellence</td>
<td>Largest wind R&amp;D to focus on industrialisation and cost out.</td>
</tr>
</tbody>
</table>
Introducing deep dives into strategic focus areas
Reduce Levelised Cost of Energy, innovation and industrialisation

Reduce levelised cost of energy
Johnny Thomsen, SVP, Product Management

Industrialisation and modularisation
Jorge Magalhaes, SVP, Engineering Solutions

Innovation
Jorge Magalhaes, SVP, Engineering Solutions
1. Looking back: What have we done since 2012?

2. Looking forward: What are the main strategic focus areas for product and service solutions?
   - Reducing the Levelised Cost of Energy
   - Innovation
   - Industrialisation and modularisation
Hmmm, is that what we are talking about?

Complicated formula to be simplified into…

\[
\text{LEC} = \sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1 + r)^t} \div \sum_{t=1}^{n} \frac{E_t}{(1 + r)^t}
\]

LEC = Average lifetime levelised electricity generation cost.

I_t = Investment expenditures in year t.

M_t = Operations and maintenance expenditures in the year t.

F_t = Fuel expenditures in the year t.

E_t = Electricity generation in the year t.

r = Discount rate.

n = Life of the system.
Hmmm, is that what we are talking about?

... something more tangible

\[
LCoE = \frac{\text{Annualised CAPEX} + \text{Annualised OPEX}}{\text{Average Annual Energy Production}}
\]
Being competitive

Cost of ownership is important…

... and in our industry it is called **Levelised Cost of Energy**.
Why is Levelised Cost of Energy important?

LCoE is important because…

1. Vestas needs to stay competitive and increase shareholder value.

2. Customers request wind power at lower cost of energy.

3. Wind support schemes are under pressure.

4. The world needs clean, affordable and predictable energy.
Levelised Cost of Energy for onshore wind

LCoE depends on different factors resulting in different cost of energy ranges for different sites

USD 37-187 per MWh

- Production/wind climate
- CAPEX
- OPEX
- Finance cost

What does it take to lower LCoE by 3 per cent?

Approximate figures

-3% Cost of Energy
- all other factors being equal

-9% Bill of material
+3% Rotor
+10% Rating
-17% Service
-15% Balance of Plant
Levelised Cost of Energy

How much can Vestas affect?

\[ \text{LCoE} = \frac{\text{Annualised CAPEX} + \text{Annualised OPEX}}{\text{Average Annual Energy Production}} \]

- **Turbine**
- **Tower and foundations**
- **Electrical infrastructure**
- **Installation, construction, commissioning**
- **Cost of capital**
- **Project management and other**
- **Operation, maintenance, aftermarket improvements**
- **Administration and management**
- **Rated power, power curve**
- **Wind resources (e.g. wind speed)**
- **Availability, Lost Production Factor**
- **Site layout, electrical losses**

<table>
<thead>
<tr>
<th>Fully influenced by Vestas</th>
<th>Partially influenced by Vestas</th>
</tr>
</thead>
</table>

CAPEX [EUR/year]

OPEX [EUR/year]

Production [MWh/year]
Value creation and capture

A business case has to consider all aspects to improve ROIC and/or to create growth.
Turbine quality and operation strategies lowers LCoE

Examples on lowering cost of energy

Lost Production Factor (LPF)
Percentage

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<tr>
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<tbody>
<tr>
<td>21</td>
<td></td>
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</table>

Testing facilities

Translates into 2.8 per cent more annual energy production on the installed base and for new turbines.
3 MW platform – standardising and modulising

Examples of lowering cost of energy

2012

<table>
<thead>
<tr>
<th>Model</th>
<th>Year</th>
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</thead>
<tbody>
<tr>
<td>V100-2.6 MW</td>
<td>2012</td>
</tr>
<tr>
<td>V90-3.0 MW</td>
<td></td>
</tr>
<tr>
<td>V112-3.0 MW</td>
<td></td>
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</tbody>
</table>

2014

<table>
<thead>
<tr>
<th>Model</th>
<th>Year</th>
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</thead>
<tbody>
<tr>
<td>V105</td>
<td>2014</td>
</tr>
<tr>
<td>V112</td>
<td></td>
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<tr>
<td>V117</td>
<td></td>
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<tr>
<td>V126</td>
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</tbody>
</table>

IEC1A

+22% AEP**

IEC1B & 2A

+3% AEP*

IEC2A

+8% AEP*

IEC3A

+17% AEP*

Note: AEP improvements depend on assumptions.

* Compared to V112-3.0 MW. ** Compared to V90-3.0 MW.
2 MW platform transition - simplification and AEP

Examples of lowering cost of energy

2012

- 2 MW Mk 7
- 2 MW Mk 8
- 2 MW Mk 9
- 2 MW Mk 7H 60Hz

Update - 2 MW Mk 10

2014

- IEC2B
  - V100
    - +12% AEP*
- IEC3A
  - V110
    - +13% AEP**

Note: AEP improvements depend on assumptions.

* Compared to V90-1.8/2.0 MW. ** Compared to V100-1.8/2.0 MW.
Large diameter steel tower for the 3 MW platform

Examples of lowering cost of energy

- **137 m tower** for V126-3.3 MW.
- **141.5 m tower** for V117-3.3 MW.
Vestas PowerPlus™—LCoE improvements in the aftermarket

Examples on lowering cost of energy

Vestas PowerPlus™ is the newly launched product bundle for production improvement solutions dedicated to the aftermarket.

It currently consists of the following solutions:
• Power Uprate
• Extended Cut Out
• Aerodynamic Upgrades

Note: AEP improvements depend on assumptions.

Up to
5% AEP

Site-specific optimisation of control parameters and aerodynamic performance.

Building on extensive wind turbine knowledge and industry-leading R&D.

Wind. It means the world to us.
Summary

What have we learned

1. LCoE continues to go down year-on-year.

2. Vestas’ ambition is to lower LCoE faster than the market in general.

3. The new product roadmap focus initiated in 2012 resulted in products and services with lower LCoE. This contributes to a strong order intake and growth possibilities.

4. To create profitable growth, Vestas will maintain a strong focus on capturing the value of the LCoE improvements.

5. Vestas focuses on all parts of the value chain. Vestas uses its global reach and combined knowledge about wind technology & operations.
Agenda

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   - Innovation
   - Industrialisation and modularisation
Building on a strong innovation heritage as pioneer in wind

1,100 patent applications filed and ability to commercialise innovation at scale

- **1985**: OptiTip, Pitch control on V25 improving power and control
- **1991**: Pre-bend blades for lower weight
- **1994**: OptiSlip, introduce variable speed
- **1997**: Individual pitch systems for higher functional safety
- **1998**: Composite coupling for torque transmission
- **1999**: Mid-span pitch + ultra-flexible blades
- **1999**: OptiSpeed, converter system enables variable speed and increases AEP at low wind sites
- **2000**: Vortex Generators for AEP
- **2001**: Carbon prepreg blades on V90
- **2003**: Vestas fibre-optical strain gauge
- **2003**: Magnetic attachment of internals to create stronger towers
- **2007**: Wood-carbon/pultrusions for low CAPEX production
- **2009**: Fully modular hi-volume blade construction
- **2010**: Active flap loads control
- **2011**: Blade transport – tip elevation
- **2012**: Industry leading fleet data knowledge, delivering design and service optimisation
- **2012**: Adv. lightning protection system on Blades
- **1994**: Vortex Generators for AEP
- **2001**: Carbon prepreg blades on V90
- **2003**: Magnetic attachment of internals to create stronger towers
- **2007**: Nacelle self-loading/unloading
- **2010**: Active flap loads control
- **2011**: Blade transport – tip elevation
- **2012**: Industry leading fleet data knowledge, delivering design and service optimisation
- **1998**: Composite coupling for torque transmission
- **2003**: Self supporting nacelle suspended between two wheel sets
- **2009**: Fully modular hi-volume blade construction

**Wind. It means the world to us.**
What is the purpose of innovation at Vestas?
Ensuring competitive products and capabilities also in the long-term

To bring commercially relevant, game-changing ideas to the market in a profitable way, enabling Vestas to fulfill its vision:

“To be the undisputed global wind leader.”
How will we do that?
Focus on the entire value chain

Innovation culture
- Build on Vestas’ capability to innovate across the value chain … unleash it throughout the organisation.
- Share knowledge and collaborate.

External leverage
- Highly networked with thought leaders in academia and in the industry.
- Complementary competences to solve application-specific challenges.

Business driven
- Efficient and effective idea selection and incubation.
- Commercially driven innovation in selected target areas: managed as a portfolio of time-to-market and risk/reward opportunities.
Example Product: New generation structural shell blades
Innovation across the value chain: Design, manufacturing and transportation

Enables delivery of a 110 m rotor on the proven 2 MW platform:

• Innovative aeroelastic carbon design ensures light-weight, low-load blades.

• Flexible, scalable, low-CAPEX architecture

• Vertical integration enables rapid roll-out of structural shell technology across all wind turbine platforms

• New transportation mechanism allows low-cost delivery to customer
Example Product: Large diameter steel tower (LDST)

Innovation across the value chain: Design, manufacturing and transportation

Vestas has launched the Large Diameter Steel Tower, a cost effective solution to increase tower height for 3 MW turbines to over 140 m. The new solution boosts annual energy production and reduces cost significantly compared to concrete/hybrid towers.

- Faster, mature and 100 per cent recyclable.
Example of innovation across the value chain

Foundation for the V126-3.3 MW prototype at Oesterild, Denmark
Example of innovation across the value chain

V110-2.0 MW in Hoevsoere, Denmark
Example of innovation across the value chain
Tooling and transport: V126-3.3 MW blade lift test in Lem, Denmark
Example: Big data-driven solutions for wind power plants

Integrating data insights from value chain with state-of-art analytics and supercomputing

**Big data**

- Product design
- Validation testing
- Operations & maintenance
- Sourcing & production
- Project siting

**47 GW Monitored:**

+25,000 wind turbines
Data every 10th minute
24/7 surveillance
Up to 500 data points

**Continued leadership in design capability for WPP* (Siting) & Operations**

* Wind Power Plant.
Example: Maximising site-optimality of wind power plants
The ability to optimise every link of the WPP - from the wind to electrons to local conditions

Via sentient controls that allow turbines to run harder and smarter (load & power modes)

• PowerPlusTM commercial launch: up to 5 per cent increase of Annual Energy Production (AEP) when combined with aero upgrades.
• Load Dependent Operation: allows siting in harsher climates or conditions.

Via site-specific towers to reduce cost

Via smarter wind power plant operations

• Increased energy and reliability/life.
Vestas blades – architecture and focus
High performance, manufacturability, supply chain efficiency and lowered costs

1. Modular Architecture
2. Standardisation & fabrication
3. Advanced materials
4. Customisation & options
5. Enhanced aerofoils

Reduce Levelised Cost of Energy – CMD 2014

Wind. It means the world to us.
Vestas blades – architecture and focus
High performance, manufacturability, supply chain efficiency and lowered costs

Future power plants and services
- Wind turbines which are simple, auto-configured on set-up, self-monitoring and self-adapting to site and specific conditions.

New capabilities for construction
- Minimise the need for cranes.

Innovation to ensure future transportability
- Modularity to enable more cost-effective transportation.

New capabilities for maintenance
- Continued focus on creative ways to reduce OPEX.
1. Looking back: What have we done since 2012?

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25 times more Annual Energy Production now than in 1985

From pioneer years to industrialisation

- **1)** Pioneer years.
- **2) Engineering/science start.**
- **3) Optimisation of products. Size became an issue.**
- **4) Field optimisation and reflections theory vs real life difference.**
- **5) Industrialisation.**

**Annual energy production (MWh):**
- 1985: 16,000 MWh
- 1990: 14,000 MWh
- 1995: 12,000 MWh
- 2000: 10,000 MWh
- 2005: 8,000 MWh
- 2010: 6,000 MWh
- 2015: 4,000 MWh
- 2020: 2,000 MWh
What is the objective of industrialisation?

Flexibility, speed and cost

To offer more **options** and **flexibility** to the market and supply chains **faster** and with significantly **reduced internal complexity and cost**.
What is industrialisation?
Moving from “one-size-fits all” to customer configurability based on standardised building blocks

Modularisation

• All products share the same architecture and the same interfaces, enabling configurability through a selection of modules suiting the actual customer needs.

Standardisation

• Scalable modules and components are reused across product families to focus the engineering effort, ensure economy of scale, and ease operations.
Industrialisation addresses key market challenges
Enabling flexibility in design to enable right market requirements at right time and right cost

1. **Global varying and diverse requirements:** Being the most global player, Vestas is exposed to the largest demand for variety in performance, compliance, service and supply chain requirements.

2. **Market uncertainty:** It is challenging to predict the markets’ needs for turbine configurations, but we can foresee how variation will impact the design.

3. **Increasing local content:** Demand for local content requires design to accommodate cost effectively.

4. **Supply chain flexibility through asset-light strategy:** Vestas has historically been highly vertically integrated. Going forward, we will to a greater extent leverage and source from suppliers.
More value propositions at lower complexity

Illustration

- Delta bill of material cost for average customer demands
- Internal complexity costs
- Impact of modularisation and standardisation

- "One-size-fits-all"
- "One-size 4 rotors"
- "One-size optimised for each sale"

2008-10 2013 201X
Part simplification and re-use across platforms

Illustration

Unique items

Total nacelle component numbers across product platforms

40 per cent reduction in unique items

60 per cent shared items

13 per cent shared items today

Time
Modularity on sub-module level in practice

Examples

Transformer component

Transformer “component”

Trafo (sub) module

Sales configurator linked to BoM*.

Hydraulic module design across 2 and 3 MW

Old

New

Sub-module level – still ensure use of standard components.

* Bill of Material.
Sourcing of design and assembly at sub-system level

Close collaboration with suppliers

Benefits for Vestas

- Part simplification – 150 to 1.
- Supplier simplification – from 30 to 1.
- Transferred value chain responsibility.
- Reduced number of internal transactions.
- More resources for core technology projects.
Full value chain and life cycle impact

Cost model used for holistic cost and trade-off analyses

- Market and customer optimised solutions.
- Reduced number of tasks and time-to-market.
- Buying power and fewer higher level supplies.
- Flexibility in footprint and reduced inventory.
- Standard solutions and flexibility.
- Skill and facility independency.
- Configurability to service agreements, facility and skills independency and reduced inventory.

* Operations & maintenance.
Externals’ view on potential savings by standardisation

Significant reduction in bill of material, fixed costs and time-to-market

Realizable Saving Potentials by Product Standardization

- **Reduction of development cost**
  - min: -5%
  - Ø: -37%
  - max: -60%

- **Reduction of product cost**
  - min: -5%
  - Ø: -23%
  - max: -40%

- **Reduction in maintenance and service cost**
  - min: -5%
  - Ø: -30%
  - max: -50%

- **Reduction in development time for derived designs**
  - min: -20%
  - Ø: -50%
  - max: -80%

- **Reduction in parts count**
  - min: -20%
  - Ø: -63%
  - max: -95%

Source: McKinsey, 3DSE research
Summary

What have we learned

1. Innovation, building on creative heritage and commercially focused, highly leveraged and networked and focused on developing a sustainable culture that delivers game changing profitable ideas.

2. Innovation focused across the entire value chain.

3. Industrialisation will offer more options and flexibility to the market and supply chain faster and with significantly reduced internal complexity and cost.

4. Industrialisation focused on modularization and standardization.

5. Benefits of industrialising platform are significant across the value chain.
Thank you for your attention