APPENDIX B

TURBINE DRAWINGS
2 MW
PLATFORM

Wind. It means the world to us.™
Wind energy means the world to us. And we want it to mean the world to our customers, too, by maximising your profits and strengthening the certainty of your investment in wind power.

That's why, together with our partners, we always strive to deliver cost-effective wind technologies, high quality products and first class services throughout the entire value chain. And it's why we put so much emphasis on the reliability, consistency and predictability of our technology.

These aren't idle words. We have over 35 years' experience in wind energy. During that time, we've delivered more than 83 GW of installed capacity and we currently monitor over 33,000 wind turbines across the globe. Tangible proof that Vestas is the right partner to help you realise the full potential of your wind site.

Are you looking for the maximum return on your investment in wind energy?

What is the 2 MW platform?
Our 2 MW platform provides industry-leading reliability, serviceability and availability. Durable and dependable, the platform is built on technology that has been proven in the field over more than a decade. The 2 MW platform reduces your costs, minimises the risk of turbine downtime and helps to safeguard your investment.

You can choose from five turbines on the 2 MW platform:
- V90-1.8/2.0 MW® IEC IIA/IEC IIIA
- V100-2.0 MW® IEC IIB
- V110-2.0 MW™ IEC IIIA
- V116-2.0 MW™ IEC IIB
- V120-2.0 MW™ IEC IIIB/IEC S

Each 2 MW turbine incorporates enhancements that improve performance and reliability, reducing your cost of energy. The platform's predictability allows you to forecast confidently, strengthening the business case for investment, while the tried-and-tested design ensures you can produce energy on ultra-low, low, medium and high-wind onshore sites at the lowest possible cost, even in extreme weather conditions. In addition, remote monitoring and easy servicing keep operational costs at a minimum, while its highly-tested components and power and control systems enhance reliability.
Due to the strong performance and reliability of the 2 MW platform, over 18,500 turbines have been installed since 2000.
How does the 2MW platform increase reliability and performance?

Created with future generations of turbines in mind, the 2 MW platform’s single-piece bed frame and strong main bearing housing provide a better foundation for loads. The frame and housing – each made from single-piece castings – work in conjunction to absorb higher loads from the rotor.

Additionally, the housing ensures correct alignment during bearing assembly, making the process accurate and efficient and distributing loads evenly.

A reliable performer
The 2 MW platform is an extremely reliable turbine, which is documented through its strong availability performance. With the newest addition of rotor sizes, the 2 MW platform offers a competitive selection of turbines for all wind segments.

Thoroughly tested
The current 2 MW platform is built on unique knowledge from more than a decade of operational experience. We constantly monitor the majority of the installed 2 MW turbines, providing us with very detailed and invaluable information about how the turbine operates under all kinds of site conditions.

Our quality-control system ensures that each component is produced to design specifications and performs to peak potential at site. We also employ a Six Sigma philosophy and have identified critical manufacturing processes (both in-house and for suppliers). We systematically monitor measurement trends that are critical to quality, locating defects before they occur.

Innovative CoolerTop®
Our exclusive CoolerTop® technology uses the wind’s own energy to generate the cooling required, rather than consuming energy from the wind turbine generator. CoolerTop® has no moving parts and requires little maintenance. Furthermore, the absence of cooling fans contributes to turbine efficiency and makes no noise.

Power Optimised Modes increase energy output
The 2 MW platform supports Power Optimised Modes, used to maximise energy production under specific wind and site conditions. Based on a site analysis and under mild wind conditions, the V100-2.0 MW* and V110-2.0 MW* can be uprated up to 2.2 MW - maximising annual energy production.
Low Balance of Plant, installation and transportation costs
At Vestas, we use technology tailored to control loads on specific tower heights. We have applied this principle to the 2 MW platform by reducing both the weight of the turbine and the loads on the tower and foundation. This reduces foundation costs, saving you unnecessary expense.

All 2 MW turbines are easy to transport (by rail, truck or ship) to virtually any site around the world. In terms of weight, height and width, all components comply with local and international standard transportation limits, ensuring you incur no unforeseen costs. In addition, 2 MW turbines are built and maintained using tools and equipment that are standard in the installation and servicing industries – minimising maintenance costs.

Vestas Online® Business
All Vestas wind turbines benefit from Vestas Online® Business, the latest Supervisory Control and Data Acquisition (SCADA) system for modern wind power plants. This flexible system includes an extensive range of monitoring and management functions to control your wind power plant in the same way as a conventional power plant. Vestas Online® Business enables you to optimise production levels, monitor performance, and produce detailed, tailored reports from anywhere in the world. The system’s power plant controller provides active and reactive power regulation, power ramping and voltage control.

Options available for the 2 MW platform
- Power Optimised Modes up to 2.2 MW (Available for V100-2.0 MW® and V110-2.0 MW®)
- Condition Monitoring System
- Vestas Ice Detection
- Smoke Detection
- Shadow Detection
- Low Temperature Operation to -30°C
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

24/7 remote surveillance with VMP Global® and Vestas Online® Business
To reduce the cost of energy, the 2 MW platform is equipped with VMP Global®, our latest turbine control and operation software. Developed to run this latest generation of turbines, VMP Global®, combined with Vestas Online® Business, automatically manages the turbine 24/7 and ensures maximum power generation. The application also monitors and troubleshoots the turbines – both onsite and remotely – saving further expense on servicing.

Designed for serviceability
Service is facilitated by the overall design of the 2 MW platform and components are specifically positioned for easy access.

The 2 MW platform covers a wide range of wind segments enabling you to find the best turbine for your specific site.

| WINDCLASSES - IEC |
| --- | --- | --- |
| TURBINE TYPE | IEC III (6.0 – 7.5 m/s) | IEC II (7.5 – 8.5 m/s) | IEC I (8.5 – 10.0 m/s) |
| 2 MW TURBINES | | | |
| V90-1.8/2.0 MW* IEC IIA/IEC IIIA | | | |
| V100-2.0 MW* IEC IIIB | | | |
| V110-2.0 MW* IEC IIIA | | | |
| V116-2.0 MW™ IEC IIIB | | | |
| V120-2.0 MW™ IEC IIIIB/IEC S | | | |

- Standard IEC conditions
- Site dependent
Would you benefit from uninterrupted control of wind energy production?

Knowledge about wind project planning is key
Getting your wind energy project up and operating as quickly as possible is fundamental to its long-term success. One of the first and most important steps is to identify the most suitable location for your wind power plant. Vestas’ SiteHunt® is an advanced analytical tool that examines a broad spectrum of wind and weather data to evaluate potential sites and establish which of them can provide optimum conditions for your project.

In addition, SiteDesign® optimises the layout of your wind power plant. SiteDesign® runs Computational Fluid Dynamics (CFD) software on our powerful in-house supercomputer Firestorm to perform simulations of the conditions on site and analyse their effects over the whole operating life of the plant. Put simply, it finds the optimal balance between the estimated ratio of annual revenue to operating costs over the lifetime of your plant, to determine your project’s true potential and provide a firm basis for your investment decision.

The complexity and specific requirements of grid connections vary considerably across the globe, making the optimal design of electrical components for your wind power plant essential. By identifying grid codes early in the project phase and simulating extreme operating conditions, Electrical PreDesign provides you with an ideal way to build a grid compliant, productive and highly profitable wind power plant. It allows customised collector network cabling, substation protection and reactive power compensation, which boost the cost efficiency of your business.

Advanced monitoring and real-time plant control
All our wind turbines can benefit from VestasOnline® Business, the latest Supervisory Control and Data Acquisition (SCADA) system for modern wind power plants.

This flexible system includes an extensive range of monitoring and management functions to control your wind power plant. VestasOnline® Business enables you to optimise production levels,
The Vestas Performance and Diagnostics Centre monitors more than 33,000 turbines worldwide. We use this information to continually develop and improve our products and services.

Surveillance, maintenance and service

Operating a large wind power plant calls for efficient management strategies to ensure uninterrupted power production and to control operational expenses. We offer 24/7 monitoring, performance reporting and predictive maintenance systems to improve turbine performance and availability. Predicting faults in advance is essential, helping to avoid costly emergency repairs and unscheduled interruptions to energy production.

Our Condition Monitoring System (CMS) assesses the status of the turbines by analysing vibration signals. For example, by measuring the vibration of the drive train, it can detect faults at an early stage and monitor any damage. This information allows pre-emptive maintenance to be carried out before the component fails, reducing repair costs and production loss.

Additionally, our Active Output Management® (AOM) concept provides detailed plans and long term agreements for service and maintenance, online monitoring, optimisation and troubleshooting. It is possible to get a full scope contract, combining your turbines’ state-of-the-art technology with guaranteed time or energy-based availability performance targets, thereby creating a solid base for your power plant investment. The Active Output Management® agreement provides you with long term and financial operational peace of mind for your business case.
# V90-1.8/2.0 MW®
## IEC IIA/IEC IIIA

### Facts & figures

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<tr>
<th><strong>POWER REGULATION</strong></th>
<th>Pitch regulated with variable speed</th>
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<td><strong>OPERATING DATA</strong></td>
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<tr>
<td>Rated power</td>
<td>1,800/2,000 kW</td>
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<tr>
<td>Cut-in wind speed</td>
<td>4 m/s</td>
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<tr>
<td>Cut-out wind speed</td>
<td>25 m/s</td>
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<td>Re cut-in wind speed</td>
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<tr>
<td>Wind class</td>
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<td>Standard operating temperature range from -20°C to 40°C</td>
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<tr>
<th><strong>SOUND POWER</strong></th>
<th>Maximum 104 dB*</th>
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<tr>
<td></td>
<td>*Noise modes available</td>
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<table>
<thead>
<tr>
<th><strong>ROTOR</strong></th>
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<tbody>
<tr>
<td>Rotor diameter</td>
<td>90 m</td>
</tr>
<tr>
<td>Swept area</td>
<td>6,362 m²</td>
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<tr>
<td>Air brake</td>
<td>full blade feathering with 3 pitch cylinders</td>
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<tr>
<th><strong>ELECTRICAL</strong></th>
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<tbody>
<tr>
<td>Frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Generator type</td>
<td>4-pole (50 Hz)/6-pole (60 Hz)</td>
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<tr>
<td></td>
<td>doubly fed generator, slip rings</td>
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<tr>
<th><strong>GEARBOX</strong></th>
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<tbody>
<tr>
<td>Type</td>
<td>two planetary stages and one helical stage</td>
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<tr>
<th><strong>TOWER</strong></th>
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<tbody>
<tr>
<td>Hub heights</td>
<td>80 m (IEC IIA), 95 m (IEC IIA), and 105 m (IEC IIA)</td>
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<thead>
<tr>
<th><strong>NACELLE DIMENSIONS</strong></th>
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<tbody>
<tr>
<td>Height for transport</td>
<td>4 m</td>
</tr>
<tr>
<td>Height installed</td>
<td>5.4 m</td>
</tr>
<tr>
<td>Length</td>
<td>10.4 m</td>
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<tr>
<td>Width</td>
<td>3.5 m</td>
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<table>
<thead>
<tr>
<th><strong>HUB DIMENSIONS</strong></th>
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<tbody>
<tr>
<td>Max. transport height</td>
<td>3.4 m</td>
</tr>
<tr>
<td>Max. transport width</td>
<td>4 m</td>
</tr>
<tr>
<td>Max. transport length</td>
<td>4.2 m</td>
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<tr>
<th><strong>BLADE DIMENSIONS</strong></th>
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<tbody>
<tr>
<td>Length</td>
</tr>
<tr>
<td>Max. chord</td>
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| **Max. weight per unit for transportation** | 70 metric tonnes |

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<tr>
<th><strong>TURBINE OPTIONS</strong></th>
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<td>Condition Monitoring System</td>
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<tr>
<td>Vestas Ice Detection</td>
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<td>Smoke Detection</td>
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<td>Shadow Detection</td>
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<tr>
<td>Low Temperature Operation to -30°C</td>
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<td>Aviation Lights</td>
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<tr>
<td>Aviation Markings on the Blades</td>
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<tr>
<td>Vestas InteliLight™</td>
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<tr>
<th><strong>ANNUAL ENERGY PRODUCTION</strong></th>
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![Graph showing energy production](image)

**Assumptions**
One wind turbine, 100% availability, 0% losses, k factor = 2, Standard air density = 1.225, wind speed at hub height =
V100-2.0 MW®
IEC IIB
Facts & figures

POWER REGULATION
- Pitch regulated with variable speed

OPERATING DATA
- Rated power: 2,000 kW
- Cut-in wind speed: 3 m/s
- Cut-out wind speed: 22 m/s
- Re cut-in wind speed: 20 m/s
- Wind class: IEC IIB
- Standard operating temperature range from -20°C to 45°C

SOUND POWER
- Maximum: 105 dB*
  * Noise modes available

ROTOR
- Rotor diameter: 100 m
- Swept area: 7,854 m²
- Air brake: full blade feathering with 3 pitch cylinders

ELECTRICAL
- Frequency: 50/60 Hz
- Generator type: 4-pole (50 Hz)/6-pole (60 Hz) doubly fed generator, slip rings

GEARBOX
- Type: two planetary stages and one helical stage

TOWER
- Hub heights: 80 m (IEC IIB) and 95 m (IEC IIB)

HUB DIMENSIONS
- Max. transport height: 3.4 m
- Max. transport width: 4 m
- Max. transport length: 4.2 m

BLADE DIMENSIONS
- Length: 49 m
- Max. chord: 3.9 m
- Max. weight per unit for transportation: 70 metric tonnes

ANNUAL ENERGY PRODUCTION

TURBINE OPTIONS
- Power Optimised Modes up to 2.2 MW (site specific)
- Condition Monitoring System
- Vestas Ice Detection
- Smoke Detection
- Shadow Detection
- Low Temperature Operation to -30°C
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

NACELLE DIMENSIONS
- Height for transport: 4 m
- Height installed (incl. CoolerTop®): 5.4 m
- Length: 10.4 m
- Width: 3.5 m

Assumptions:
- One wind turbine, 100% availability, 0% losses, k factor = 2
- Standard air density = 1.225
- Yearly average wind speed m/s
V110-2.0 MW®
IEC IIIA
Facts & figures

POWER REGULATION
Pitch regulated with variable speed

OPERATING DATA
Rated power 2,000 kW
Cut-in wind speed 3 m/s
Cut-out wind speed 21 m/s
Re-cut-in wind speed 18 m/s
Wind class IEC IIIA
Standard operating temperature range from -20°C to 45°C

SOUND POWER
Maximum 107.6 dB*
* Noise modes available

ROTOR
Rotor diameter 110 m
Swept area 9,503 m²
Air brake full blade feathering with 3 pitch cylinders

ELECTRICAL
Frequency 50/60 Hz
Generator type 4-pole (50 Hz)/6-pole (60 Hz) doubly fed generator, slip rings

GEARBOX
Type two planetary stages and one helical stage

TOWER
Hub heights 75 m (IEC IIIA), 80 m (IEC IIIA), 95 m (IEC IIIA/IEC IIIB), 110 m (IEC IIIB), 120 m (IEC IIIB) and 125 m (IEC IIIB)

NACELLE DIMENSIONS
Height for transport 4 m
Height installed (incl. CoolerTop®) 5.4 m
Length 10.4 m
Width 3.5 m

HUB DIMENSIONS
Max. transport height 3.4 m
Max. transport width 4 m
Max. transport length 4.2 m

BLADE DIMENSIONS
Length 54 m
Max. chord 3.9 m
Max. weight per unit for transportation 70 metric tonnes

TURBINE OPTIONS
• Power Optimised Modes up to 2.2 MW (site specific)
• Condition Monitoring System
• Vestas Ice Detection
• Smoke Detection
• Shadow Detection
• Low Temperature Operation to -30°C
• Aviation Lights
• Aviation Markings on the Blades
• Vestas InteliLight™

ANNUAL ENERGY PRODUCTION

Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2,
Standard air density = 1.225, wind speed at hub height
V116-2.0 MW™
IEC IIB
Facts & figures

POWER REGULATION
Pitch regulated with variable speed

OPERATING DATA
Rated power 2,000 kW
Cut-in wind speed 3 m/s
Cut-out wind speed 20 m/s
Re cut-in wind speed 18 m/s
Wind class IEC IIB
Standard operating temperature range from -20°C to 45°C

SOUND POWER
Maximum 109.5 dB*
* Serrated trailing edges available to reduce sound power level

ROTOR
Rotor diameter 116 m
Swept area 10,568 m²
Air brake full blade feathering with 3 pitch cylinders

ELECTRICAL
Frequency 50/60 Hz
Generator type 4-pole (50 Hz)/6-pole (60 Hz) doubly fed generator, slip rings

GEARBOX
Type two planetary stages and one helical stage

TOWER
Hub heights Site and country specific

NACELLE DIMENSIONS
Height for transport 4 m
Height installed (incl. CoolerTop*) 5.4 m
Length 10.4 m
Width 3.5 m

HUB DIMENSIONS
Max. transport height 3.6 m
Max. transport width 4 m
Max. transport length 4.2 m

BLADE DIMENSIONS
Length 57 m
Max. chord 3.9 m
Max. weight per unit for transportation 70 metric tonnes

TURBINE OPTIONS
• Condition Monitoring System
• Vestas Ice Detection
• Smoke Detection
• Shadow Detection
• Low Temperature Operation to -30°C
• Aviation Lights
• Aviation Markings on the Blades
• Vestas IntelliLight™

ANNUAL ENERGY PRODUCTION

Assumptions
One wind turbine, 100% availability, 0% losses, k factor = 2,
Standard air density = 1.225, wind speed at hub height

GWh
0 2 4 6 8 10
6.0 6.5 7.0 7.5 8.0 8.5
Yearly average wind speed m/s

V116-2.0 MW IEC IIB
V120-2.0 MW™
IEC IIIB/IEC S
Facts & figures

**POWER REGULATION**
Pitch regulated with variable speed

**OPERATING DATA**
- **Rated power**: 2,000 kW
- **Cut-in wind speed**: 3 m/s
- **Cut-out wind speed**: 18 m/s
- **Re cut-in wind speed**: 16 m/s
- **Wind class**: IEC IIIB/IEC S
- **Standard operating temperature range**: from -20°C to 45°C

**SOUND POWER**
- **Maximum**: 110.5 dB*
  - *Serrated trailing edges available to reduce sound power level

**ROTOR**
- **Rotor diameter**: 120 m
- **Swept area**: 11,310 m²
- **Air brake**: full blade feathering with 3 pitch cylinders

**ELECTRICAL**
- **Frequency**: 50/60 Hz
- **Generator type**: 4-pole (50 Hz)/6-pole (60 Hz) doubly fed generator, slip rings

**GEARBOX**
- **Type**: two planetary stages and one helical stage

**TOWER**
- **Hub heights**: Site and country specific

**NACELLE DIMENSIONS**
- **Height for transport**: 4 m
- **Height installed (incl. CoolerTop*)**: 5.4 m
- **Length**: 10.4 m
- **Width**: 3.5 m

**HUB DIMENSIONS**
- **Max. transport height**: 3.6 m
- **Max. transport width**: 4 m
- **Max. transport length**: 4.2 m

**BLADE DIMENSIONS**
- **Length**: 59 m
- **Max. chord**: 3.9 m
- **Max. weight per unit for transportation**: 70 metric tonnes

**TURBINE OPTIONS**
- Condition Monitoring System
- Vestas Ice Detection
- Smoke Detection
- Shadow Detection
- Low Temperature Operation to -30°C
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

**ANNUAL ENERGY PRODUCTION**

Assumptions
- One wind turbine, 100% availability, 0% losses, k factor =2
- Standard air density = 1.225, wind speed at hub height
Ensuring Business Case Certainty.

Our business depends on your success. We are committed to delivering maximum certainty on the revenue and costs of your wind farm.
Conformity evaluation has been carried out according to IEC 61400-22: 2010 "Wind Turbines - Part 22: Conformity Testing and Certification". This conformity statement attests compliance with SELECT: IEC 61400-22 concerning the design basis. Any change in the design basis is to be approved by DNV. Without approval the Statement loses its validity.

Evaluation reports:
Technical Report: PD-2330-18DO0L5-10 Rev. 00

Wind Turbine specification:
IEC WT class: IIIA. For further information see Appendix 1 of this Certificate.

Date: 2013-12-11

Claus Fridtjof Christensen
Management Representative
Det Norske Veritas, Danmark A/S

Date: 2013-12-11

Mark Wollenberg
Project Manager
Det Norske Veritas, Danmark A/S
APPENDIX 1 - WIND TURBINE TYPE SPECIFICATION

General:
- Rotor diameter: 110 m
- Rated power: 2.0 MW
- Rated wind speed $V_r$: 9.8 m/s
- Hub height(s): Various
- Operating wind speed range $V_{in}-V_{out}$: 3-20 m/s
- Design life time: 20 years

Wind conditions:
- $V_{ref}$ (hub height): 37.5 m/s
- $V_{ave}$ (hub height): 7.5 m/s
- $I_{ref}$ acc. to IEC 61400-1 ed. 2: 1999 / 3: 2005 incl. A1: 0.16
- Mean flow inclination: 8°

Electrical network conditions:
- Normal supply voltage and range: 6-35 kV
- Normal supply frequency and range: 50/60 Hz

Other environmental conditions (where taken into account):
- Air density, annual mean: 1.225 kg/m$^3$
- Operating temperature*: -20°C to +40°C (standard)
  -30°C to +40°C (LT)
- Extreme temperature, stand still:
  -30°C to +50°C (standard)
  -40°C to +50°C (LT)
*LT: The -30°C minimum operating temperature has been verified for loads and structural integrity by considering an air density of 1.325 kg/m$^3$.

Main components:
- Blade type: Vestas structural shell 54 m
- Gear box type: Three-stage differential gearbox – all stages are planetary
  1 planetary stage/2 helical stages
- Generator type: VND
- Tower type: Tubular steel tower
- Service lift: Avanti, Power Climber
  As an option, VESTAS offers lift
- Crane: Liftket / GIS AG
  800 kg.

DET NORSKE VERITAS, DANMARK A/S