Fred.Olsen Renewables AS

FRED. OLSEN RENEWABLES ITALY S.R.L.

VIALE CASTRO PRETORIO 122 - 00185 ROMA (RM)

PROGETTO PER LA REALIZZAZIONE DI UN IMPIANTO PER LA PRODUZIONE DI ENERGIA MEDIANTE LO SFRUTTAMENTO DEL VENTO NEL TERRITORIO COMUNALE DI SAN GIULIANO DI PUGLIA (CB) E SANTA CROCE DI MAGLIANO (CB)

PROGETTO DEFINITIVO

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R.2.1 SCHEDA TECNICA AEROGENERATORE

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General Description

EnVentus™

Table of contents

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1 Introduction

This *General Description* document contains data and general descriptions of the EnVentus™ wind turbine range. The EnVentus™ turbine range consists of various turbine variants, with different rotors and ratings.

For turbine variant specific information related to wind class definitions and performance details, please refer to the accompanying Performance Specification document.

2 General Description

A wind turbine within the EnVentus™ turbine range is a pitch regulated upwind turbine with active yaw and a three-blade rotor.

The wind turbine utilises the OptiTip® concept and a power system based on a permanent magnet generator and full-scale converter. With these features, the wind turbines are able to operate the rotor at variable speed and thereby maintain the power output at or near rated power even in high wind speed. At low wind speed, the OptiTip® concept and the power system work together to maximise the power output by operating at the optimal rotor speed and pitch angle.

3 Mechanical Design

3.1 Rotor

The wind turbine is equipped with a rotor consisting of three blades and a hub. The blades are controlled by the microprocessor pitch control system OptiTip®. Based on the prevailing wind conditions, the blades are continuously positioned to optimise the pitch angle.

Rotor	V162
Diameter	162 m
Swept Area	20612 m^2
Speed, Dynamic Operation Range	4.3 -12.1 rpm
Rotational Direction	Clockwise (front view)
Orientation	Upwind
Tilt	6°
Hub Coning	6°
No. of Blades	3
Aerodynamic Brakes	Full feathering

Table 3-1: Rotor data

3.2 Blades

The blades are made of carbon and fibreglass and consist of two airfoil shells with embedded structure.

Blades	V162
Blade Length	79.35 m
Maximum Chord	4.3 m
Chord at 90% blade radius	1.68 m
Type Description	Structural airfoil shell
Material	Fibreglass reinforced epoxy, carbon fibres and Solid Metal Tip (SMT)
Blade Connection	Steel roots inserted
Airfoils	High-lift profile

Table 3-2: Blade data

3.3 Blade Bearing

The blade bearings allow the blades to operate at varying pitch angles.

Blade Bearing	
Blade bearing type	High-capacity slewing bearing
Lubrication	Manual grease lubrication

Table 3-3: Blade bearing data

3.4 Pitch System

The turbine is equipped with a hydraulic, individual pitch system for each blade. Each pitch system is connected to the hydraulic rotating transfer unit in the nacelle by means of distributed hydraulic hoses and pipes. The hydraulic power unit is positioned in the nacelle.

Each pitch system consists of a hydraulic cylinder mounted to the hub and a piston rod mounted to the blade bearing. Valves facilitating operation of the pitch cylinder are installed on a pitch block bolted directly onto the cylinder.

Pitch System	
Type	Hydraulic
Number	1 cylinder per blade
Range	-5° to 95°

Table 3-4: Pitch system data

Hydraulic System	
Main Pump	Redundant internal-gear oil pumps
Pressure	Max. 260 bar
Filtration	3 µm (absolute) 40 µm in line

Table 3-5: Hydraulic system data.

3.5 Hub

The hub supports the three blades and transfers the reaction forces and the torque to the Main Shaft. The hub structure also supports blade bearings and pitch cylinders.

Hub	
Type	Ball shell hub
Material	Cast iron

Table 3-6: Hub data

3.6 Main Shaft

The main shaft transfers the reaction forces to the main bearing and the torque to the gearbox.

Main Shaft	
Type Description	Hollow shaft
Material	Cast iron

Table 3-7: Main shaft data

3.7 Main Bearing Housing

The main bearing housing carries the main bearings and is the connection point for the drive train system to the nacelle structure.

Main Bearing Housing	
Material	Cast iron

Table 3-8: Main bearing housing data

3.8 Main Bearing

The main bearings constitute the main load transfer path for the rotor and drivetrain to the nacelle structure.

Main Bearing	
Type	Rolling bearings
Lubrication	Oil circulation

Table 3-9: Main bearing data

3.9 Gearbox

The main gear converts the rotation of the rotor to generator rotation.

Gearbox	
Type	2 Planetary stages
Gear House Material	Cast
Lubrication System	Pressure oil lubrication
Total Gear Oil Volume	900-1100 L
Oil Cleanliness Codes	ISO 4406-/15/12

Table 3-10: Gearbox data

3.10 Generator Bearings

Generator bearings ensures a constant airgap between the generator rotor and stator. The bearings are arranged in an assembly that allows for up-tower service.

Generator Bearing	
Type	Rolling bearings
Lubrication	Oil circulation

Table 3-11: Generator bearing data

3.11 Yaw System

The yaw system is an active system based on a pre-tensioned plain bearing.

Yaw System	
Type	Plain bearing system
Material	Forged yaw ring heat-treated. Plain bearings PETP
Yaw gear type	Multiple stages planetary gear
Yawing Speed (50 Hz)	Approx. 0.4°/sec.
Yawing Speed (60 Hz)	Approx. 0.5°/sec.

Table 3-12: Yaw system data

3.12 Crane

The nacelle is equipped with an internal service crane (single system hoist).

Crane	
Lifting Capacity	Max 800 kg

Table 3-13: Crane data

3.13 Towers

Tubular Steel Towers and Concrete Hybrid Towers (CHT) are available as standard for several WTG configuration and hub height options.

Tubular steel towers consist of flange joined steel sections.

Concrete Hybrid Towers consists of a concrete bottom part with a transition piece towards a tubular steel top. The concrete part is made of precast high strength concrete rings, and the tubular steel top is made of flange joined steel sections.

Towers includes modular internals, which are certified to relevant type approvals.

Available hub heights are listed in the Performance Specification for each turbine variant. Designated hub heights include a distance from tower top flange to centre of the hub of approximately 2.5m. For steel towers the designated hub height also includes a distance from the foundation section to the ground level of approximately 0.2 m depending on the thickness of the bottom flange.

For steel towers, raised foundations of up to 3 m can be made available on a site-specific basis subject to soil and project conditions which raises the hub height also by up to 3m.

Further WTG configuration and hub height options are developed as non-standard products on site-specific basis.

Towers	
Type	Tubular steel towers Concrete Hybrid Towers

Table 3-14: Tower structure data

3.14 Modularized Nacelle

The modularized nacelle consists of three main elements. A cast iron front part, the base frame, and two modularized structures, the main nacelle house and the side-compartment. The base frame is the foundation for the power train and transmits loads from the rotor to the tower through the yaw system. The bottom surface is machined and connected to the yaw bearing and the yaw gears are bolted to the base frame. The base frame also includes a heavy-duty interface on each side. One interface is used to carry the HV transformer in the side-compartment. The additional interface can be used for several purposes, for example attaching a service crane for main component exchange operations.

The main nacelle house hosts the power train, hydraulic power unit, cooling systems and main control panels. The main nacelle house has an internal crane rail system that allows service and maintenance operations inside the main nacelle house.

The side-compartment structure hosts and integrates the main power production components as converter and HV transformer.

Both main nacelle house and side-compartment structures act as enclosures. The main nacelle house has a hatch positioned in the floor for lowering or hoisting equipment and evacuation of personnel.

The roof section is equipped with skylights, which can be opened both from inside out, and outside in. Access from the tower to the main nacelle house is through the base frame.

Type Description	Material
Main nacelle house and side compartment structure	Sheet metal structure. GRP components in roof dome and front cover.
Base frame	Cast iron

Table 3-15: Nacelle structure and cover data

3.15 Thermal Conditioning System

The thermal conditioning system consists of:

- A Liquid Cooling System
- The Vestas Cooler Top®
- Air cooling of the internal main nacelle house and side-compartment
- Air cooling of the converter including a filter function

3.15.1 Liquid Cooling

The liquid cooling system removes heat losses from gearbox, generator, hydraulic power unit, converter and the HV transformer.

The liquid cooling system pump unit includes a set of dynamic flow valves securing the right flow to the different systems. The pump unit also includes an electrical controlled valve for controlling the liquid temperature and a bypass filter for removal of particles in the cooling liquid.

3.15.2 Cooler Top®

The Vestas Cooler Top® located on top of the rear end of the nacelle main house. The Cooler Top® is a free flow cooler, thus ensuring that there are no electrical components in the thermal conditioning system located outside the nacelle. The Cooler Top® serves as base for the wind sensors, and the optional ice detection-, precipitation- and visibility sensors as well as aviation lights.

3.15.3 Main Nacelle House Conditioning

Hot air generated by mechanical and electrical equipment is dissipated from the main nacelle house by a fan system located in the nacelle main house structure. The conditioning system is taking ambient air into the main nacelle house and exhaust the hot air in the end of the main nacelle house.

3.15.4 Converter and Side-Compartment Air Cooling

The converter is both liquid and air cooled. The converter air cooling system comprises an air-to-air heat exchanger, which separates ambient air from converter internal air. The ambient air flow is provided by fan units delivering ambient air to the air-to-air heat exchanger through a filter. Fans on the internal side of the air-to-air exchanger provides the converter internal air circulation. The converter air cooling also provides air flow cooling to the side-compartment which is redirected by ducts to the critical spots.

4 Electrical Design

4.1 Generator

The generator is a three-phase permanent magnet generator connected to the grid through a full-scale converter. The generator housing allows the circulation of cooling air within the stator and rotor.

The heat generated by the losses is removed by an air-to-water heat exchanger.

Generator	
Type	Permanent Magnet Synchronous generator
Rated Power [P_N]	Up to 7600 kW (depending on turbine variant)
Frequency range [f_N]	0-126 Hz
Voltage, Stator [U_{NS}]	3 x 800 V (at rated speed)
Number of Poles	36
Winding Type	Form with Vacuum Pressurized Impregnation
Winding Connection	Star
Operational speed range	0-420 rpm
Overspeed Limit (2 minutes)	660 rpm
Temperature Sensors, Stator	PT100 sensors placed in the stator hot spots.
Insulation Class	H
Enclosure	IP54

Table 4-1: Generator data

4.2 Converter

The converter is a full-scale converter system controlling both the generator and the power delivered to the grid. The converter consists of 4 machine-side converter units and 4 line-side converter units operating in parallel with a common controller.

The converter controls conversion of variable frequency AC power from the generator into fixed frequency AC power with desired active and reactive power levels (and other grid connection parameters) suitable for the grid.

The converter is located in the nacelle and has a grid side voltage rating of 720 V. The generator side voltage rating is nominally 800 V but depends on generator speed.

Converter	
Nominal Apparent Power [S_N] @ 1.0 p.u. voltage	7750 kVA
Nominal Grid Voltage	3 x 720 V
Rated Generator Voltage	3 x 800 V
Rated Grid Current @ 1.0 p.u. voltage	6488 A
Enclosure	IP54

Table 4-2: Converter data

4.3 HV Transformer

The transformer is a three-phase, three limb, two-winding, liquid immersed transformer. The transformer is equipped with an external water-cooling circuit. The insulation liquid used is environmentally friendly and low flammable.

The HV transformer is in the side-compartment, located in a separate transformer room with access through an interlock system.

The transformer is designed according to IEC standards and is available in the following version:

- Eco-design complying to Tier 2 of European Eco-design regulation No 548/2014 and No 2019/1783 set by the European Commission. Refer to Table 4-3.

4.3.1 General transformer data

Transformer	
Type description	Eco-design liquid immersed transformer
Basic layout	3 phase, 2 winding transformer
Applied standards	IEC 60076-1, IEC 60076-16, IEC 61936-1 Commission Regulation No 548/2014 Commission Regulation No 2019/1783
Cooling method	KF/WF
Rated power	8400 kVA
Expansion system	Sealed
Insulation liquid, Type/Fire point	Natural ester, biodegradable/ K-class (>300°C)
No-load reactive power	~21 kVar [1]
Full load reactive power	~882 kVar [1]

Transformer	
No-load current	~ 0.25 % [1]
Positive sequence short-circuit impedance @ rated power, 95°C	9.9 % [2]
Positive sequence short-circuit resistance@ rated power, 95°C	~0.9 % [1]
Zero sequence short-circuit impedance@ rated power, 95°C	~9.4 % [1]
Zero sequence short-circuit resistance@ rated power, 95°C	~0.9 % [1]
Rated voltage, turbine side	
U_m 1.1kV	0.720 kV
Rated voltage, grid side	
U_m 24.0kV	20.0-22.0 kV
U_m 36.0kV	22.1-33.0 kV
U_m 40.5kV	33.1-36.0 kV
Insulation level AC / LI / LIC	
U_m 1.1kV	3 / - / - kV
U_m 24.0kV	50 / 125 / 138 kV
U_m 36.0kV	70 / 170 / 187 kV
U_m 40.5kV	80 / 200 / 220 kV
Optional off-circuit tap changer	2±2 x 2.5 %
Frequency	50 Hz / 60 Hz
Vector group	Dyn11
Inrush peak current	<4 x $\hat{I}_n$ [1] (for Um=24.0kV)
	<8 x $\hat{I}_n$ [1] (for Um=36.0-40.5kV)
Half crest time	~ 0.5 s [1]
Sound power level	≤ 80 dB(A)
Average winding temperature rise	Class 120 (E) ≤65 K Class 130 (B) ≤75 K
Max altitude	3500 m
Insulation system	Hybrid insulation system Winding insulation: 120 (E), Thermally Upgrader Paper 130 (B), High temperature insulation Other materials can have different class.
Insulation liquid, Amount	≤ 3500 kg
Corrosion class	C3
Weight	≤15000 kg
Overvoltage protection	Plug-in surge arresters on HV bushings
High voltage bushings	Outer cone, interface C1

Table 4-3: General transformer data.

4.3.2 Eco-design – IEC 50 Hz/60 Hz version

The transformer loss limits are given at rated power as combination of load loss and no-load loss which shall fulfil the Peak Efficiency Index (PEI) of the Eco-design requirement.
The maximum losses are described by the PEI limit section of Figure 4-1 and stretch over a range between Loss variant 1 and Loss variant 2.
The loss variant values are selected based on energy loss optimization with the turbine user profile, hence the energy loss of transformers between Loss variant 1 and Loss variant 2 are comparable.

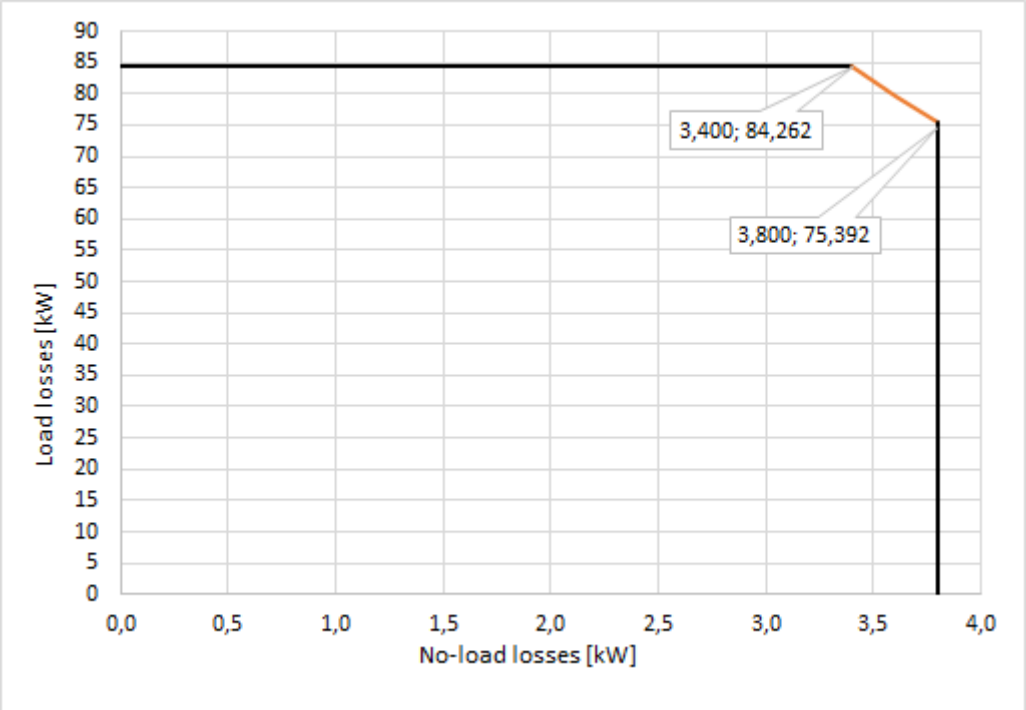


Figure 4-1: Transformer losses allowable area for 8400kVA

The actual load losses vary depending on the operational mode of the turbine, hence in *Table 4-4*, the load losses are provided at different operational modes for the two loss variants. For further recalculation of load losses at different operation modes, refer to Figure 4-2.

Transformer losses (rated power 8400kVA)				
Applied standards	Commission Regulation No 2019/1783			
Peak Efficiency Index (PEI)	≥ 99.597			
Loss variant 1				
No-load loss	3.40 kW			
Load loss @ power, 95°C	**@8400kVA**	**@7200kVA**	**@6800kVA**	**@6000kVA**
	≤84.262kW	≤61.91kW [3]	≤55.22kW [3]	≤42.99kW [3]
Loss variant 2				
No-load loss	3.80 kW			
Load loss @ power, 95°C	**@8400kVA**	**@7200kVA**	**@6800kVA**	**@6000kVA**
	≤75.32kW	≤55.34kW[3]	≤49.36kW[3]	≤38.43kW[3]

Table 4-4: Transformer losses for 8400kVA

Figure 4-2: Transformer load losses scaling

NOTE

[1] Based on an average of calculated values across voltages and manufacturers.
[2] Subjected to standard IEC tolerances.
[3] Informative non-binding values based on operation mode.

4.4 HV Cables

The high-voltage cable runs from the transformer in the side-compartment down the tower to the HV switchgear located at the bottom of the tower. The high-voltage cable will be constructed as:

- A three-core, rubber-insulated, halogen-free, high-voltage cable with a three-core split earth conductor.

HV Cables	
High-Voltage Cable Insulation Compound	Improved ethylene-propylene (EP) based material-EPR or high modulus or hard grade ethylene-propylene rubber-HEPR
Pre-terminated	T-Connector Type-C in transformer end. T-Connector Type-C in switchgear end.
Maximum Voltage (Um)	24 kV for 20-24.3 kV rated voltage 42 kV for 24.4-36.0 kV rated voltage
Conductor Cross Sections	Um: 42kV with 3x70 + 3x70/3 mm^2 Um: 24kV with 3x95 + 3x95/3 mm^2

Table 4-5: HV cables data

4.5 HV Switchgear

A gas insulated switchgear is installed in the bottom of the tower as an integrated part of the turbine. Its controls are integrated with the turbine safety system, which monitors the condition of the switchgear and high voltage safety related devices in the turbine. This system is named ‘Ready to Protect’ and ensures all protection devices are operational, whenever high voltage components in the turbine are

energised. To ensure that the switchgear is always ready to trip, it is equipped with redundant trip circuits consisting of an active trip coil and an undervoltage trip coil.

In case of grid outage, the circuit breaker will disconnect the turbine from the grid after an adjustable time.

When grid returns, all relevant protection devices will automatically be powered up via UPS.

When all the protection devices are operational, the circuit breaker will re-close after an adjustable time. The re-close functionality can furthermore be used to implement a sequential energization of a wind park, to avoid simultaneous inrush currents from all turbines once grid returns after an outage.

In case the circuit breaker has tripped due to a fault detection, the circuit breaker will be blocked for re-connection until a manual reset is performed.

To avoid unauthorized access to the transformer room during live condition, the earthing switch of the circuit breaker, contains a trapped-key interlock system with its counterpart installed on the access door to the transformer room.

The switchgear is available in three variants with increasing features, see Table 4-6. Beside the increase in features, the switchgear can be configured depending on the number of grid cables planned to enter the individual turbine. The design of the switchgear solution is optimized such grid cables can be connected to the switchgear even before the tower is installed and still maintain its protection toward weather conditions and internal condensation due to a gas tight packing.

The switchgear is available in an IEC version and in an IEEE version. The IEEE version is however only available in the highest voltage class. The electrical parameters of the switchgear are seen in Table 4-7 for the IEC version and in Table 4-8 for the IEEE version.

HV Switchgear			
Variant	**Basic**	**Streamline**	**Standard**
IEC standards	○	⊙	⊙
IEEE standards	⊙	○	⊙
Vacuum circuit breaker panel	⊙	⊙	⊙
Overcurrent, short-circuit and earth fault protection	⊙	⊙	⊙
Disconnector / earthing switch in circuit breaker panel	⊙	⊙	⊙
Voltage Presence Indicator System for circuit breaker	⊙	⊙	⊙
Voltage Presence Indicator System for grid cables	⊙	⊙	⊙
Double grid cable connection	⊙	⊙	⊙
Triple grid cable connection	⊙	○	○
Preconfigured relay settings	⊙	⊙	⊙
Turbine safety system integration	⊙	⊙	⊙
Redundant trip coil circuits	⊙	⊙	⊙

HV Switchgear			
Variant	**Basic**	**Streamline**	**Standard**
Trip coil supervision	⊙	⊙	⊙
Pendant remote control from outside of tower	⊙	⊙	⊙
Sequential energization	⊙	⊙	⊙
Reclose blocking function	⊙	⊙	⊙
Heating elements	⊙	⊙	⊙
Trapped-key interlock system for circuit breaker panel	⊙	⊙	⊙
Motor operation of circuit breaker	⊙	⊙	⊙
Cable panel for grid cables (configurable)	○	⊙	⊙
Switch disconnector panels for grid cables – max three panels (configurable)	○	⊙	⊙
Earthing switch for grid cables	○	⊙	⊙
Internal arc classification	○	⊙	⊙
Supervision on MCB's	○	⊙	⊙
Motor operation of switch disconnector	○	○	⊙
SCADA operation and feedback of circuit breaker	○	○	⊙
SCADA operation and feedback of switch disconnector	○	○	⊙

Table 4-6: HV switchgear variants and features

4.5.1 IEC 50/60Hz version

HV Switchgear	
Type description	Gas Insulated Switchgear
Applied standards	IEC 62271-103 IEC 62271-1, 62271-100, 62271-102, 62271-200
Insulation medium	SF_6
Rated voltage	
U_r 24.0kV	20.0-22.0 kV
U_r 36.0kV	22.1-33.0 kV
U_r 40.5kV	33.1-36.0 kV
Rated insulation level AC // LI Common value / across isolation distance	
U_r 24.0kV	50 / 60 // 125 / 145 kV
U_r 36.0kV	70 / 80 // 170 / 195 kV
U_r 40.5kV	85 / 90 // 185 / 215 kV
Rated frequency	50 Hz / 60 Hz
Rated normal current	630 A
Rated Short-time withstand current	
U_r 24.0kV	20 kA
U_r 36.0kV	25 kA

HV Switchgear	
U_r 40.5kV	25 kA
Rated peak withstand current 50 / 60 Hz	
U_r 24.0kV	50 / 52 kA
U_r 36.0kV	62.5 / 65 kA
U_r 40.5kV	62.5 / 65 kA
Rated duration of short-circuit	1 s
Internal arc classification (option)	
U_r 24.0kV	IAC A FLR 20 kA, 1 s
U_r 36.0kV	IAC A FLR 25 kA, 1 s
U_r 40.5kV	IAC A FLR 25 kA, 1 s
Connection interface	Outside cone plug-in bushings, IEC interface C1.
Loss of service continuity category	LSC2
Ingress protection	
Gas tank	IP 65
Enclosure	IP 2X
LV cabinet	IP 3X
Corrosion class	C3

Table 4-7: HV switchgear data for IEC version

4.5.2 IEEE 60Hz version

HV Switchgear	
Type description	Gas Insulated Switchgear
Applied standards	IEEE 37.20.3, IEEE C37.20.4, IEC 62271-200, ISO 12944.
Insulation medium	SF_6
Rated voltage	
U_r 38.0kV	33.1-36.0 kV
Rated insulation level AC / LI	70 / 150 kV
Rated frequency	60 Hz
Rated normal current	600 A
Rated Short-time withstand current	25 kA
Rated peak withstand current	65 kA
Rated duration of short-circuit	1 s
Internal arc classification (option)	IAC A FLR 25 kA, 1 s
Connection interface grid cables	Outside cone plug-in bushings, IEEE 386 interface type dead break, 600A.
Ingress protection	
Gas tank	NEMA 4X / IP 65
Enclosure	NEMA 2 / IP 2X
LV cabinet	NEMA 2 / IP 3X
Corrosion class	C3

Table 4-8: HV switchgear data for IEEE version

4.6 AUX System

The AUX system is supplied from a separate 720/400 V transformer located in the main nacelle house. The supply to this transformer primary side is provided from the converter cabinet. All auxiliary loads in the turbine such as motors, pumps, fans and heaters are supplied from this system.

The control system (DCN's) is also supplied from the Auxiliary Power System in all areas of the turbine.

The 400 V supply from the main nacelle house is transferred to tower controller cabinet, which is placed at the entrance platform of the turbine. This supply is then distributed for various 400 & 230 V loads such as service lift, working light system, additional / optional features & general-purpose loads, cabinet internal heating & ventilation. There is a 400/230 V control transformer placed inside the tower cabinet which provides supply to the Light Box/UPS (LBUPS) cabinet which is placed very near to the tower cabinet.

There is a 400 V service inlet provided in the tower control cabinet to connect an external power source that allows some of the systems to operate during installation & maintenance / service activities.

The working & emergency light system in Tower & Nacelle is supplied from the LBUPS cabinet which is placed in the entrance platform just beside the turbine entrance door. It is possible to add an optional battery cabinet to the LBUPS cabinet if extended back-up time is needed. The internal light in the hub is fed from built-in batteries in the light armature.

Power Sockets	
Single Phase (Nacelle)	230 V (16 A) (standard) 110 V (16 A) (option)
Single Phase (Tower Platforms)	230 V (10 A) (standard) 110 V (16 A) (option)
Three Phase (Nacelle)	3 x 400 V (20 A)

Table 4-9: AUX system data

4.7 Wind Sensors

The turbine is equipped with one ultrasonic wind sensor and one mechanical wind vane. The sensors have built-in heaters to minimise interference from ice and snow.

The turbine software will automatically detect and inform when a wind sensor is worn and needs to be replaced. The turbine will continue to operate using the other wind sensor without any production loss until the worn wind sensor is replaced.

4.8 Vestas Multi Processor (VMP) Controller

The turbine is controlled and monitored by the VMP8000 control system.

VMP8000 is a multiprocessor control system comprised of main controller, distributed control nodes, distributed IO nodes and ethernet switches and other network equipment. The main controller is placed in the tower bottom of the turbine. It runs the control algorithms of the turbine, as well as all IO communication.

The communications network is a time triggered Ethernet network (TTEthernet).

The VMP8000 control system serves the following main functions:

- Monitoring and supervision of overall operation.
- Synchronizing of the generator to the grid during connection sequence.
- Operating the wind turbine during various fault situations.
- Automatic yawing of the nacelle.
- OptiTip® - blade pitch control.
- Reactive power control and variable speed operation.
- Noise emission control.
- Monitoring of ambient conditions.
- Monitoring of the grid.
- Monitoring of the smoke detection system.

4.9 Uninterruptible Power Supply (UPS)

During grid outage, an UPS system will ensure power supply for specific components.

The UPS system consists of 3 subsystems:

1. 230V AC UPS for all power backup to nacelle and hub control systems
2. 24V DC UPS for power backup to tower base control systems and ready to protect
3. 230V AC UPS for power backup to internal lights in tower, main nacelle house, side-compartment and hub

Backup Time	Standard	Optional
Control System* (230V AC and 24V DC UPS)	Up to 30 min	Up to 19.5 hours**
Emergency Lights (230V AC UPS)	30 min	60 min***
Ready to protect (24V DC UPS)	7 days	37 days****

Table 4-10: UPS data

NOTE

*The control system includes: Turbine controller (VMP8000), HV switchgear functions, and remote-control system
**Requires upgrade of the 230V UPS for control system with extra batteries
***Requires upgrade of the 230V UPS for internal light with extra batteries
****Requires upgrade of the 24V DC UPS with extra batteries

NOTE For alternative backup times, contact Vestas.

5 Turbine Protection Systems

5.1 Braking Concept

The main brake on the turbine is aerodynamic. Stopping the turbine is done by full feathering the three blades (individually pitching of each blade). Each blade has a hydraulic accumulator to supply power for pitching the blade.

In addition, there is a hydraulic activated mechanical disc brake integrated into the generator. The mechanical brake is only used as a parking brake and when activating the emergency stop buttons.

5.2 Short Circuit Protections

Breakers	Breaker for Aux. Power.	Breaker 1 for Converter Modules	Breaker 2 for Converter Modules
Breaking Capacity Icu, Ics	Icu 91 kA Ics 75% Icu	Icu 91 kA Ics 50% Icu	91 kA Ics 50% Icu
Making Capacity Icm	223 kA	223 kA	223 kA

Table 5-1: Short circuit protection data

5.3 Overspeed Protection

The safety system integrated in the VMP8000 control system monitors the rotor speed, using a combination of sensors in the hub. In case of an overspeed situation, the safety system activates the hydraulic safety pitch system, which will feather the blades and bring the turbine to standstill.

Overspeed Protection	
Sensor Type	MEMS
Trip Level	Variant dependent

Table 5-2: Overspeed protection data

5.4 Arc Detection

The turbine is equipped with an Arc Detection system including multiple optical arc detection sensors placed in the HV transformer compartment and the converter cabinet. The Arc Detection system is connected to the turbine safety system via a dedicated arc detection relay ensuring immediate opening of the HV switchgear if an arc is detected.

5.5 Smoke Detection

The turbine is equipped with a Smoke Detection system including multiple smoke detection sensors placed in the main nacelle house, in the side-compartment, in the transformer compartment, in main electrical cabinets both in nacelle and in the tower base. The Smoke Detection system is connected to the turbine control system ensuring immediate opening of the HV switchgear if smoke is detected.

5.6 Lightning Protection of Blades, Nacelle, Hub and Tower

The Lightning Protection System (LPS) helps protect the wind turbine against the physical damage caused by lightning strikes. The LPS consists of five main parts:

- Air termination system e.g. lightning receptors. All lightning receptor surfaces on the blades are unpainted, excluding the Solid Metal Tips (SMT)
- Down conducting system (a system to conduct the lightning current down through the wind turbine to help avoid or minimise damage to the LPS itself or other parts of the wind turbine)
- Protection against overvoltage and overcurrent
- Shielding against magnetic and electrical fields
- Earthing system

Lightning Protection Design Parameters			Protection Level I
Current Peak Value	I_{max}	[kA]	200
Impulse Charge	$Q_{impulse}$	[C]	100
Total Charge	Q_{total}	[C]	300
Specific Energy	W/R	[MJ/Ω]	10
Average Steepness	di/dt	[kA/μs]	200

Table 5-3: Lightning protection design parameters (IEC)

5.7 EMC

The turbine and related equipment fulfil the EU Electromagnetic Compatibility (EMC) legislation:

- DIRECTIVE 2014/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility.

The EMC performance is based on fulfilment of following standards:

Emission

- IEC/CISPR 11 at wind turbine level
- IEC 61000-6-4 for telecommunications

Immunity

- IEC 61000-6-2 for electronics installed
- IEC 61400-24 for lightning protection of electronics installed

Beside DIRECTIVE 2014/30/EU, electronics related to the functional safety evaluation shall fulfil

- IEC 62061 Safety on machinery (Directive 2006/42/EU Machinery)

5.8 RED (Radio Equipment Directive)

Related radio equipment installed in the turbine fulfil the EU legislation:

DIRECTIVE 2014/53/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014.

5.9 EMF (ElectroMagnetic Fields)

Electromagnetic fields in the wind turbine are identified to ensure safe stay for personnel during design, production, operation and service.

The following directive is basis for ensuring minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents.

DIRECTIVE 2013/35/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 June 2013.

5.10 Earthing

The Vestas Earthing System consists of individual earthing electrodes interconnected as one joint earthing system.

The Vestas Earthing System includes the TN-system and the Lightning Protection System for each wind turbine. It works as an earthing system for the medium voltage distribution system within the wind farm.

The Vestas Earthing System is adapted for the different types of turbine foundations. A separate set of documents describe the earthing system in detail, depending on the type of foundation.

In terms of lightning protection of the wind turbine, Vestas has no separate requirements for a certain minimum resistance to remote earth (measured in ohms) for this system. The earthing for the lightning protection system is based on the design and construction of the Vestas Earthing System.

A primary part of the Vestas Earthing System is the main earth bonding bar placed where all cables enter the wind turbine. All earthing electrodes are connected to this main earth bonding bar. Additionally, equipotential connections are made to all cables entering or leaving the wind turbine.

Requirements in the Vestas Earthing System specifications and work descriptions are minimum requirements from Vestas and IEC. Local and national requirements, as well as project requirements, may require additional measures.

5.11 Corrosion Protection

The turbine is as standard designed to withstand below corrosion environments according to ISO 12944-2:

Corrosion Protection	External Areas	Internal Areas
Nacelle	C5	C3
Hub	C5	C3
Tower	C5	C3

Table 5-5: Corrosion protection data for nacelle, hub, and tower

As an option, the turbine can be protected to withstand alternative external corrosion environments – consult Vestas for further details.

6 Safety

The safety specifications in this section provide limited general information about the safety features of the turbine and are not a substitute for Buyer and its agents taking all appropriate safety precautions, including but not limited to (a) complying with all applicable safety, operation, maintenance, and service agreements, instructions, and requirements, (b) complying with all safety-related laws, regulations, and ordinances, and (c) conducting all appropriate safety training and education.

6.1 Access

Access to the turbine from the outside is through a door located at the entrance platform approximately 3 meters above ground level. The door is equipped with a lock. Access from the entrance platform to the tower top is by a ladder with fall arrest system or service lift. From the tower top there is two separate access routes to the nacelle main house, both via a ladder.

The nacelle consists of the main nacelle house which hosts the power train, and a side-compartment, which hosts converter and high voltage transformer. Access to the transformer room is controlled with an interlock.

Inside the nacelle main house, there are walkways along either side of the power train and in the rear end of the nacelle main house. The side-compartment has two access openings, one in the front and one in the back.

Access to the rotor is restricted with fixed or moveable guard with interlock.

6.2 Evacuation and Rescue

The basic principle for evacuation is inside and down via the normal access routes. From the centre of the nacelle main house there are two separate exit points to the tower, one on each side of the power train. The evacuation route to the tower is on fixed ladders with fall arrest system.

With two separate evacuation routes from the nacelle main house to the tower, it is the intention to avoid escape by means of descent device.

However, the turbine design still enables the possibility to descent directly from nacelle to ground via the service hatch in the bottom of the nacelle main house. Dedicated attachment points for a descent device are provided above the hatch.

It is a prerequisite that one or more descent devices are available in the turbine when there are people present in the turbine.

For rescue the normal access routes can be used, in addition to this it is possible to lower an injured person to the ground through the service hatch, one of the hatches in the spinner or from the roof.

The skylights in the roof can be opened from both the inside and outside.

Evacuation from the service lift is by ladder.

6.3 Rooms/Working Areas

The tower, nacelle main house and side-compartment are equipped with power sockets for electrical tools for service and maintenance of the turbine.

6.4 Floors, Platforms, Standing, and Working Places

All floors have anti-slip surfaces. There is one floor per tower section.

Rest platforms are provided at intervals of 12 metres along the tower ladder between platforms.

6.5 Service Lift

Towers for the EnVentus turbines are as standard delivered with a service lift. But for lower hub heights, towers without a service lift can be provide as an option. Please contact Vestas for additional details.

6.6 Work restraint and fall arrest

The tower ladder is equipped with a fall arrest system, either a rail or a wire.

The service areas in the turbines are equipped with yellow coloured anchor points. The anchor point may be used for work positioning, fall restraint, fall arrest and to attach a descent device to perform rescue or escape from the turbine.

The strength of the anchor point is verified by static and dynamic tests. The minimum required static test load is 22.5 kN.

6.7 Moving Parts, Guards, and Blocking Devices

All moving parts in the nacelle are shielded.

The turbine is equipped with a rotor lock to block the rotor and power train.

Blocking the pitch of the blade can be done both automatically and manually with a mechanical blade lock.

6.8 Lights

The turbine is equipped with lights in the tower, nacelle main house, side-compartment and hub.

There is emergency light in case of the loss of electrical power.

6.9 Emergency Stop

There are emergency stop buttons in the nacelle, hub and tower.

6.10 Power Disconnection

The turbine is equipped with breakers to allow for disconnection from all power sources during inspection or maintenance. The switches are marked with signs and are located in the nacelle and bottom of the tower.

6.11 Fire Protection/First Aid

When there are people present in the turbine, following fire and safety equipment must be available. In the nacelle: A first aid kit, a handheld fire extinguisher, and a fire blanket. In the tower a handheld fire extinguisher and a fire blanket at the entrance platform.

6.12 Warning Signs

Warning signs placed inside or on the turbine must be reviewed before operating or servicing the turbine.

6.13 Manuals and Warnings

The Vestas Corporate OH&S Manual and manuals for operation, maintenance and service of the turbine provide additional safety rules and information for operating, servicing or maintaining the turbine.

7 Environment

7.1 Chemicals

Chemicals used in the turbine are evaluated according to the Vestas Wind Systems A/S Environmental System certified according to ISO 14001:2015. The following chemicals are used in the turbine:

- Anti-freeze to help prevent the cooling system from freezing.
- Gear oil for lubricating the main bearing, gearbox and generator
- Hydraulic oil to pitch the blades, operate the brake and operate the rotor lock
- Grease for yaw system lubrication
- Transformer insulation liquid for HV transformer
- Various cleaning agents and chemicals for maintenance of the turbine.

8 Design Codes

8.1 Design Codes – Structural Design

The turbine design has been developed and verified in accordance with, but not limited to, the following main standards:

Design Codes	
Nacelle and Hub	IEC 61400-1 Edition 4 EN 50308
Tower (IEC)	IEC 61400-1 Edition 4 IEC 61400-6 Edition 1
Tower (DIBt)	Richtlinie für Windenergieanlagen, DIBt, Ausgabe: Oktober 2012
Blades	IEC 61400-5:2020 IEC 1024-1 IEC 60721-2-4 IEC 61400 (Part 1, 12 and 23) DEFU R25 DS/EN ISO 12944-2
Gearbox	IEC 61400-4
Generator	IEC 60034 (relevant parts)
Transformer	IEC 60076-11 IEC 60076-16 CENELEC HD637 S1
Lightning Protection	IEC 61400-24:2019
Safety of Machinery, Safety-related Parts of Control Systems	EN ISO 13849-1:2015
Safety of Machinery – Electrical Equipment of Machines	EN 60204-1:2018

Table 8-1: Design codes

9 Colours

9.1 Nacelle Colour

Colour of Vestas Nacelles	
Standard Nacelle Colour	RAL 7035 (light grey)
Standard Logo	Vestas

Table 9-1: Colour, nacelle

9.2 Tower Colour

Colour of Vestas Tower Section		
	External:	**Internal:**
Standard Steel Tower	RAL 7035 (light grey)	RAL 9001 (cream white)
Standard Concrete Hybrid Tower	**Concrete part:** Unpainted concrete, corresponds approx. to RAL 7023 (concrete grey) **Steel part:** RAL 7035 (light grey)	**Concrete part:** Unpainted concrete, corresponds approx. to RAL 7023 (concrete grey) **Steel part**: RAL 9001 (cream white)
Option for Concrete Hybrid Tower	Concrete part can be painted with RAL 7035 (light grey)	

Table 9-2: Colour, tower

9.3 Blade Colour

Blade Colour	
Standard Blade Colour	RAL 7035 (light grey). All lightning receptor surfaces on the blades are unpainted, excluding the Solid Metal Tips (SMT).
Tip-End Colour Variants	RAL 2009 (traffic orange), RAL 3020 (traffic red)
Gloss	< 30% ISO 2813

Table 9-3: Colour, blades

10 Operational Envelope and Performance Guidelines

Actual climate and site conditions have many variables and should be considered in evaluating actual turbine performance. The design and operating parameters set forth in this section do not constitute warranties, guarantees, or representations as to turbine performance at actual sites.

10.1 Climate and Site Conditions

Values refer to hub height:

Extreme Design Parameters	
Wind Climate	**All**
Ambient Temperature Interval (Standard Temperature Turbine)	-40° to +50°C

Table 10-1: Extreme design parameters

10.2 Operational Envelope – Temperature and Altitude

Values below refer to hub height and are determined by the sensors and control system of the turbine.

Operational Envelope – Temperature	
Ambient Temperature Interval	-20° to +45°C
Ambient Temperature Interval (Low Temperature Operation)	-30° to +45°C

Table 10-2: Operational envelope – temperature

NOTE

The wind turbine will stop producing power at ambient temperatures above 45°C.

For turbine variant specific information related to power performance within the operational envelope, please refer to turbine variant specific Performance Specifications.

For the low temperature operation of the wind turbine, consult Vestas for site specific evaluation.

The turbine is designed for use at altitudes up to 1000 m above sea level as standard and optional up to 2000 m above sea level.

10.3 Operational Envelope – Grid Connection

Operational Envelope – Grid Connection		
Nominal Phase Voltage	[U_{NP}]	720 V
Nominal Frequency	[f_N]	50/60 Hz
Maximum Frequency Gradient	±4 Hz/sec.	
Maximum Negative Sequence Voltage	3% (connection) 2.5% (operation)	
Minimum Required Short Circuit Ratio at Turbine HV Connection	5.0 (contact Vestas for lower SCR levels)	
Maximum Short Circuit Current Contribution	Contact Vestas for details	

Table 10-3: Operational envelope – grid connection

The generator and the converter will be disconnected if*:

Protection Settings	
Voltage Above 110% of Nominal for 1800 Seconds**	792 V
Voltage Above 116% of Nominal for 60 Seconds	835 V
Voltage Above 125% of Nominal for 2 Seconds	900 V
Voltage Above 136% of Nominal for 0.150 Seconds	979 V
Voltage Below 90% of Nominal for 180 Seconds (FRT)**	648 V
Voltage Below 85% of Nominal for 12 Seconds (FRT)	612 V
Voltage Below 80% of Nominal for 4.8 Seconds (FRT)	576 V
Frequency is Above 106% of Nominal for 120 Seconds	53/63.6 Hz
Frequency is Above 110% of Nominal for 0.2 Seconds	55/66 Hz
Frequency is Below 94% of Nominal for 0.2 Seconds	47/56.4 Hz

Table 10-4: Generator and converter disconnecting values

NOTE

* Over the turbine lifetime, grid drop-outs are to occur at an average of no more than 50 times a year.

** The turbine may be configured for continuous operation @ +/- 13 % voltage.

10.4 Operational Envelope – Reactive Power Capability

For turbine variant specific reactive power capability, please refer to the variant specific Performance Specification.

10.5 Performance – Fault Ride Through

The turbine is designed to stay connected during grid disturbances within the voltage tolerance curve as illustrated below:

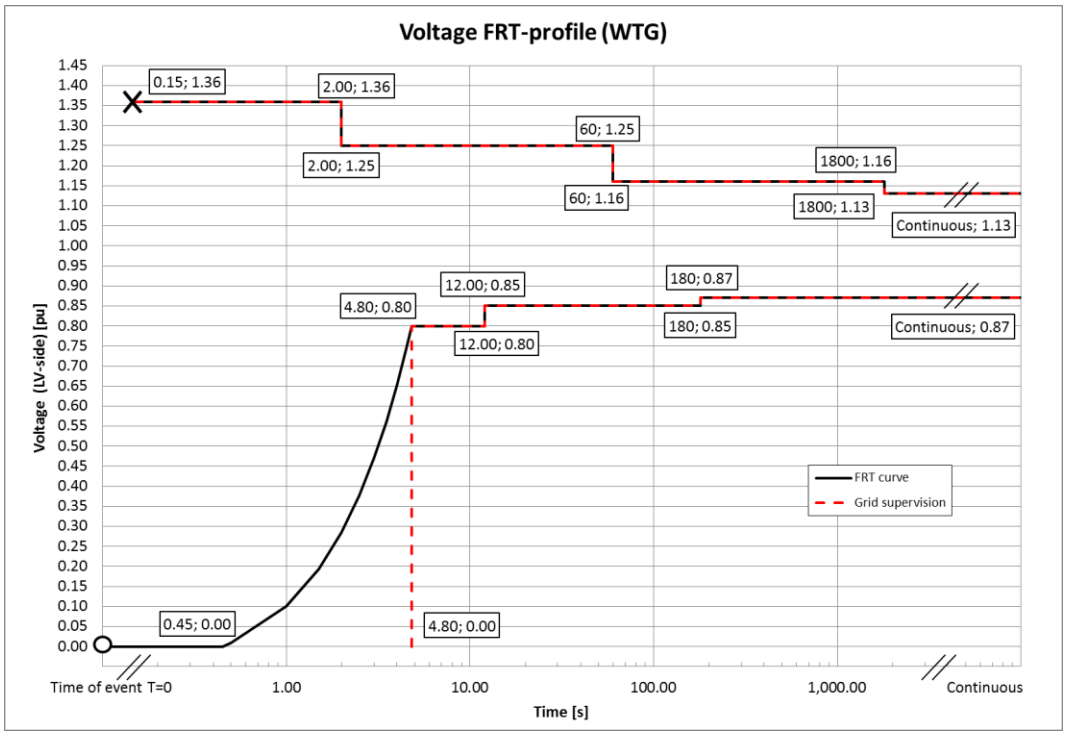


Figure 10-1: Voltage tolerance curve for symmetrical and asymmetrical faults, where U represents voltage as measured on the grid.

For grid disturbances outside the tolerance curve in Figure 10-1, the turbine will be disconnected from the grid.

Power Recovery Time	
Power Recovery to 90% of Pre-Fault Level	Maximum 0.1 seconds

Table 10-5: Power recovery time

10.6 Performance – Reactive Current Contribution

The reactive current contribution depends on whether the fault applied to the turbine is symmetrical or asymmetrical.

10.6.1 Symmetrical Reactive Current Contribution

During symmetrical voltage dips, the wind farm will inject reactive current to support the grid voltage. The reactive current injected is a function of the measured grid voltage.

The default value gives a reactive current part of 1 p.u. of the rated active current at the high voltage side of the HV transformer. Figure 10-2, indicates the reactive current contribution as a function of the voltage. The reactive current contribution is independent from the actual wind conditions and pre-fault power level. As seen in Figure 10-2, the default current injection slope is 2% reactive current increase per 1% voltage decrease. The slope can be parameterized between 0 and 10 to adapt to site specific requirements.

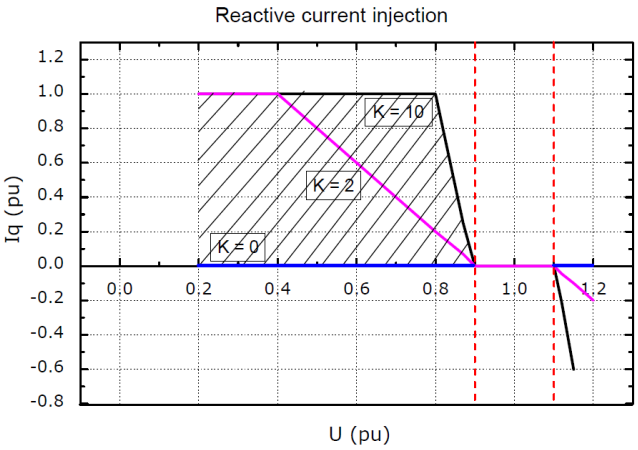


Figure 10-2: Reactive current injection

10.6.2 Asymmetrical Reactive Current Contribution

The injected current is based on the measured positive sequence voltage and the used K-factor. During asymmetrical voltage dips, the reactive current injection is limited to approximate 0.4 p.u. to limit the potential voltage increase on the healthy phases.

10.7 Performance – Multiple Voltage Dips

The turbine is designed to handle re-closure events and multiple voltage dips within a short period of time due to the fact that voltage dips are not evenly distributed during the year. For example, the turbine is designed to handle 10 voltage dips of duration of 200 ms, down to 20% voltage, within 30 minutes.

10.8 Performance – Active and Reactive Power Control

The turbine is designed for control of active and reactive power via the VestasOnline® SCADA system.

Maximum Ramp Rates for External Control	
Active Power	0.1 p.u./sec for max. power level change of 0.3 p.u. 0.3 p.u./sec for max. power level change of 0.1 p.u.
Reactive Power	20 p.u./sec

Table 10-6: Active/reactive power ramp rates

To support grid stability the turbine is capable to stay connected to the grid at active power references down to 10 % of nominal power for the turbine. For active power references below 10 % the turbine may disconnect from the grid.

10.9 Performance – Voltage Control

The turbine is designed for integration with VestasOnline® voltage control by utilising the turbine reactive power capability.

10.10 Performance – Frequency Control

The turbine can be configured to perform frequency control by decreasing the output power as a linear function of the grid frequency (over frequency). Dead band and slope for the frequency control function are configurable.

10.11 Distortion – Immunity

The turbine is able to connect with a pre-connection (background) voltage distortion level at the grid interface of 8% and operate with a post-connection voltage distortion level of 8%.

10.12 Main Contributors to Own Consumption

The consumption of electrical power by the wind turbine is defined as the power used by the wind turbine when it is not providing energy to the grid. This is defined in the control system as Production Generator 0 (zero).

The VMP8000 control system has a hibernate mode that reduces own consumption when possible. Similarly, cooling pumps may be turned off when the turbine idles.

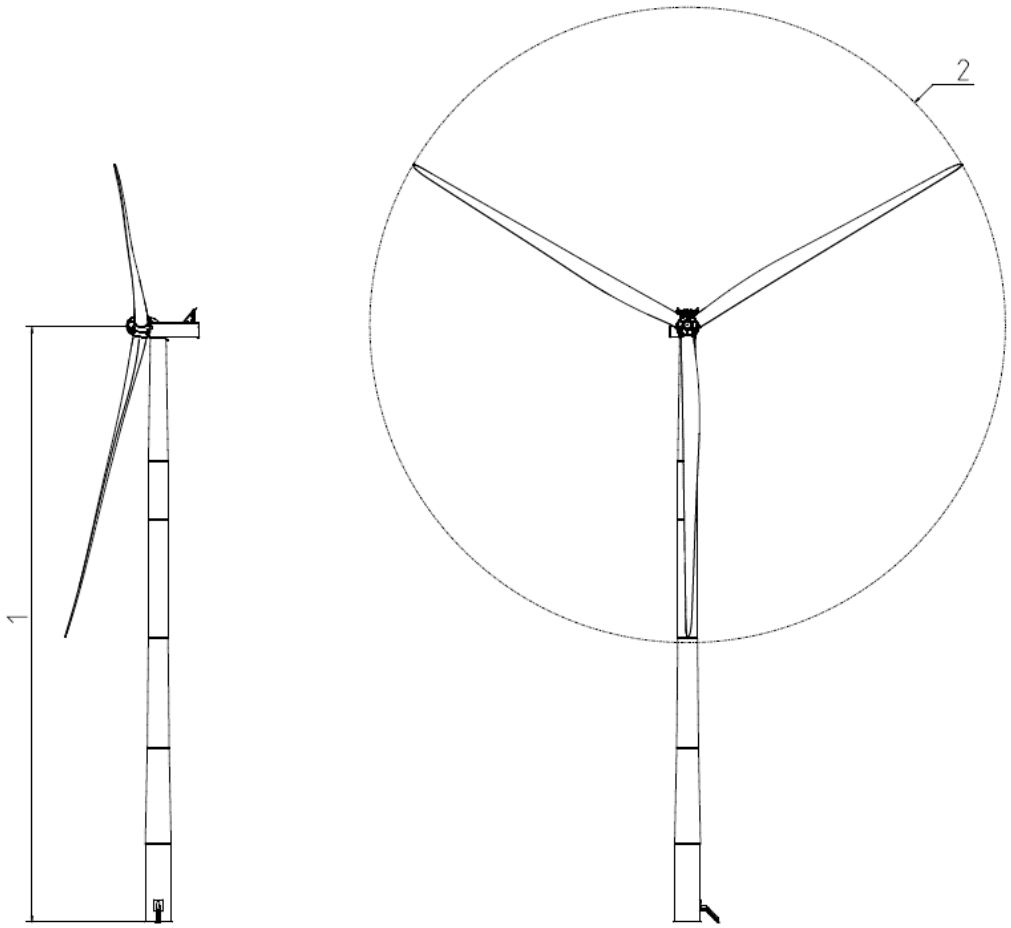
The components in Table 10-7 have the largest influence on the own consumption of the wind turbine. The values given are maximum component consumption, but the average consumption can be lower depending on the actual conditions, the climate, the wind turbine output, the cut-off hours, etc.

Main contributors to Own Consumption	
Hydraulic Motor	3 x 18.5 kW
Yaw Motors	35/42 kW for 50/60 Hz
Generator Cooling Fans	4 x 4 kW
Water Pumps	15 kW (max)
Oil Pump for Gearbox Lubrication	7.5 kW
Controller Including Heating Elements for the Hydraulics and all Controllers	Approximately 4 kW
HV Transformer No-load Loss	See section 4.3 HV Transformer

Table 10-7: Main contributors to own consumption data.

11 Drawings

11.1 Structural Design – Illustration of Outer Dimensions



1: Hub heights: See Performance Specification 2: Rotor diameter: 162 m

Figure 11-1: Illustration of outer dimensions – structure

12 General Reservations, Notes and Disclaimers

-
- The general descriptions in this document apply to the current version of the EnVentus™ turbines. Updated versions of the EnVentus™ turbines, which may be manufactured in the future, may differ from this general description. In the event that Vestas supplies an updated version of the EnVentus™ turbine, Vestas will provide an updated general description applicable to the updated version.
- Vestas recommends that the grid shall be as close to nominal as possible with limited variation in frequency and voltage.
- A certain time allowance for turbine warm-up must be expected following grid dropout and/or periods of very low ambient temperature.
- All listed start/stop parameters (e.g. wind speeds and temperatures) are equipped with hysteresis control. This can, in certain borderline situations, result in turbine stops even though the ambient conditions are within the listed operation parameters.
- The earthing system must comply with the minimum requirements from Vestas and be in accordance with local and national requirements and codes of standards.
- This document, General Description, is not an offer for sale, and does not contain any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method). Any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method) must be agreed to separately in writing.

Restricted
Document no.: 0114-3788 V02
2022-03-31

Performance Specification

EnVentus™

V162-6.8 MW 50/60 Hz

Vestas Wind Systems A/S · Hedeager 42 · 8200 Arhus N · Denmark · www.vestas.com

Table of contents

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See general reservations, notes and disclaimers (including, Section 5, p. 14) to this Performance Specification.

1 General Description

The Vestas V162-6.8 MW is a wind turbine variant within the EnVentus™ turbine range. It is a pitch regulated upwind turbine with active yaw and a three-blade rotor. The V162-6.8 MW turbine has a rotor diameter of 162 m and a rated power of 6.8 MW.

For more details, please refer to the General Description of the EnVentus™ turbine range (General Description EnVentus™ - 0112-2836).

2 Type Approvals and Available Hub Heights

The standard turbine is type certified according to the certification standards and available hub heights listed below:

Certification	Wind Class	Hub Height
IECRE OD-501	IEC S	119 / 166 m
DIBt 2012	DIBt S	119 / 169 m

3 Operational Envelope and Performance Guidelines

Actual climate and site conditions have many variables and should be considered in evaluating actual turbine performance. The design and operating parameters set forth in this section do not constitute warranties, guarantees, or representations as to turbine performance at actual sites.

3.1 Climate and Site Conditions

The standard turbine is designed for the wind climate conditions listed below. Values refer to hub height.

	DIBt towers		IEC towers		
Wind Class	**DIBt S**	**DIBt S**	**IEC S**	**IEC S**	**IEC S**
Hub Height	**119m**	**CHT* 169m**	**119m****	**119m**	**166m**
Power Rating	**6.8 MW**	**6.8 MW**	**6.8 MW**	**6.8 MW**	**6.8 MW**
Average design parameters					
Wind Speed (10 min average), V_{ave}	7.6 m/s	7.5 m/s	7.9 m/s	8.4 m/s	7.4 m/s
Weibull Scale Factor, *C*	8.6 m/s	8.5 m/s	8.9 m/s	9.5 m/s	8.3 m/s
Weibull Shape Factor, *k*	2.00	2.00	2.50	2.5	2.48
I_{ref} acc. to IEC 61400-1	S	S	14%	14%	15%
Turbulence Intensity, I_{90} (90% quant.)	S	S	15.7%	15.7%	16.90%
Wind Shear, α	0.25	0.27	0.22	0.15	0.3
Inflow Angle	8°	8°	8°	8°	8°
Extreme design parameters					
Extr Wind Speed (10 min average), V_{50}	39.5 m/s	37.6 m/s	39.5 m/s	41.5 m/s	35 m/s
Survival Wind Speed (3 s gust), V_{e50}	55.3 m/s	52.6 m/s	55.3 m/s	58.1 m/s	49 m/s
Turbulence intensity, $I_{v(z)}$	11.3%	11.1%	11%	11%	11%

*CHT refers to Concrete Hybrid Tower

** Low tower diameter to meet transport constraints

NOTE

The turbine is intended for low to medium wind speed sites and is classified as DIBt S and IEC S. Please contact Vestas Wind Systems A/S for further information if needed.

Climatic conditions for turbines with the optional Vestas Anti-icing System (VAS) may vary from above. Please contact Vestas Wind Systems A/S for further information.

3.1.1 Wind Power Plant Layout

Turbine spacing is to be evaluated site-specifically. Spacing below two rotor diameters (2D) may require sector-wise curtailment.

NOTE

As evaluation of climate and site conditions is complex, consult Vestas for every project. If conditions exceed the above parameters, Vestas must be consulted.

3.2 Operational Envelope – Wind

Values refer to hub height and are determined by the sensors and control system of the turbine.

Wind Climate	**DIBt S, IEC S**
	PO6800
Cut-In, V_{in}	3 m/s
Cut-Out (10 min exponential avg.), V_{out}	25 m/s
Re-Cut In (10 min exponential avg.)	23 m/s

3.3 Operational Envelope – Temperature and Altitude

Values below refer to hub height and are determined by the sensors and control system of the turbine.

Operational Envelope – Temperature	
Ambient Temperature Interval	-20° to +45°C
Ambient Temperature Interval (Low Temperature operation)	-30° to +45°C

NOTE

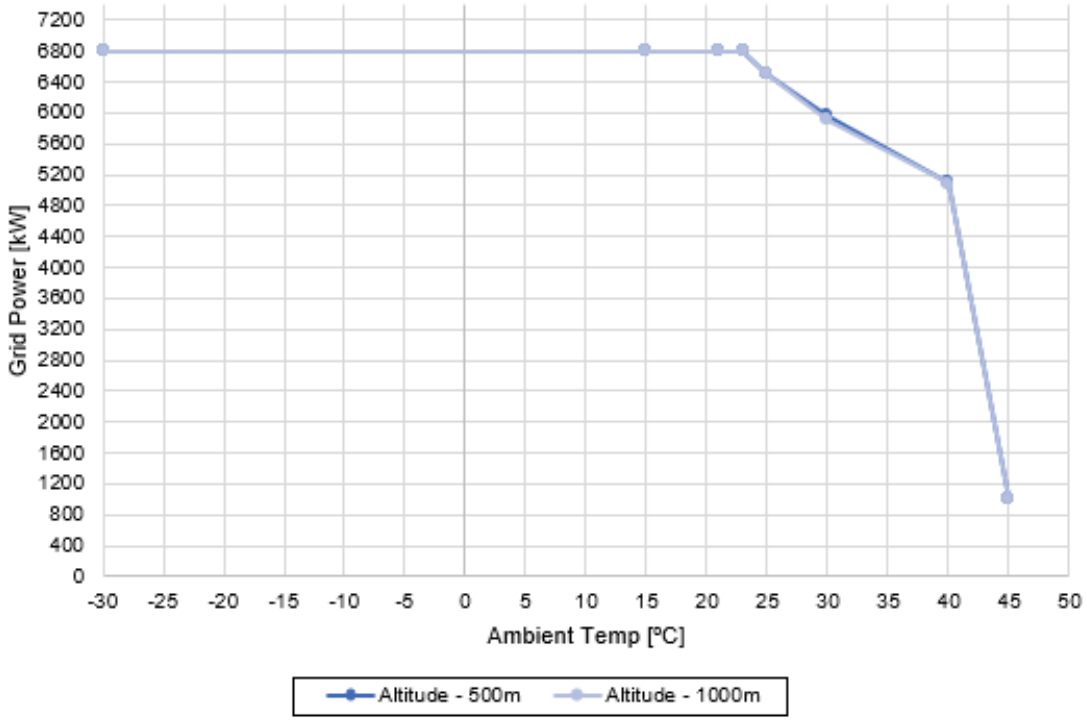
The wind turbine will stop producing power at ambient temperatures above 45°C.
For the low temperature operation of the wind turbine please consult Vestas.

The turbine is designed for use at altitudes up to 1000 m above sea level as standard and optional up to 2000 m above sea level. Contact Vestas for more details.

3.3.1 Temperature dependent operation

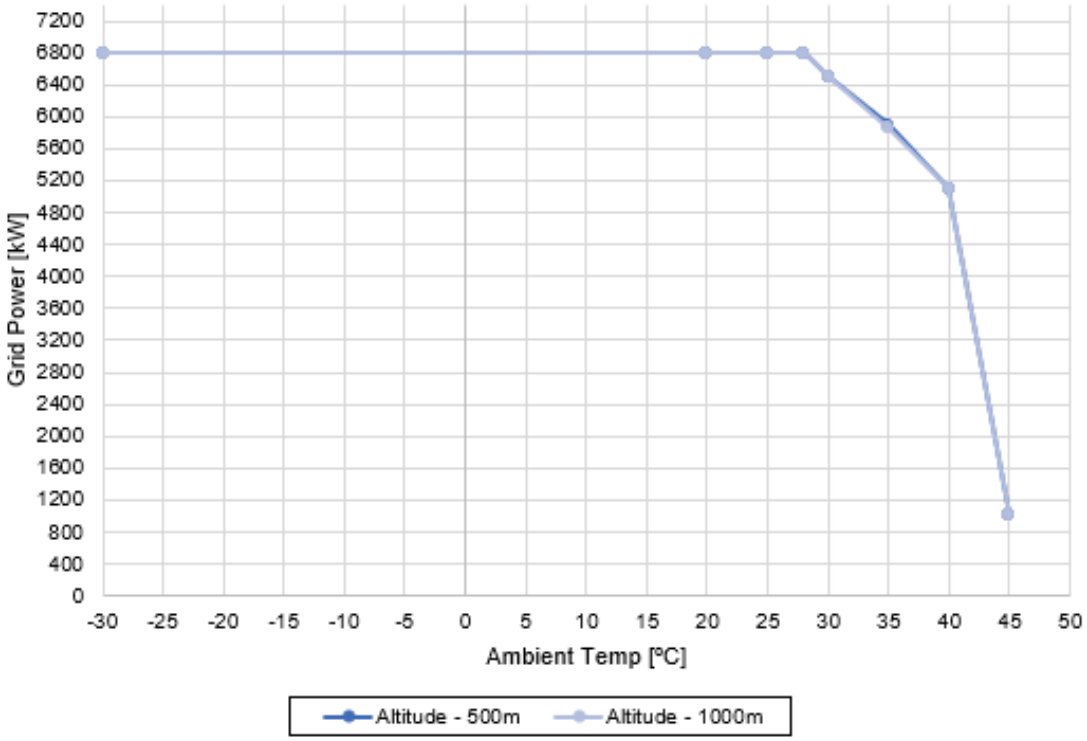
Values below refer to hub height and are determined by the sensors and control system of the turbine. At ambient temperatures above the thresholds shown for each operating mode, the turbine will maintain derated production.

The turbine will be available with two temperature performance steps a standard configuration (Performance Step 0, PS0) and an optional configuration (Performance Step 1, PS1).



Temperature derate points for Standard Cooler top (PS0), V162-6.8MW										
Altitude	**[°C]**	**[kW]**	**[°C]**	**[kW]**	**[°C]**	**[kW]**	**[°C]**	**[kW]**	**[°C]**	**[kW]**
500	23	6800	25	6500	30	5970	40	5100	45	1000
1000	23	6800	25	6500	30	5916	40	5086	45	1000

Figure 3-1: Temperature dependant derated operation – Standard cooler top (PS0)



Temperature derate points for Optional Cooler top (PS1), V162-6.8MW										
Altitude	**[°C]**	**[kW]**	**[°C]**	**[kW]**	**[°C]**	**[kW]**	**[°C]**	**[kW]**	**[°C]**	**[kW]**
500	28	6800	30	6500	35	5890	40	5100	45	1000
1000	28	6800	30	6500	35	5850	40	5100	45	1000

Figure 3-2: Temperature dependant derated operation – Optional cooler top (PS1)

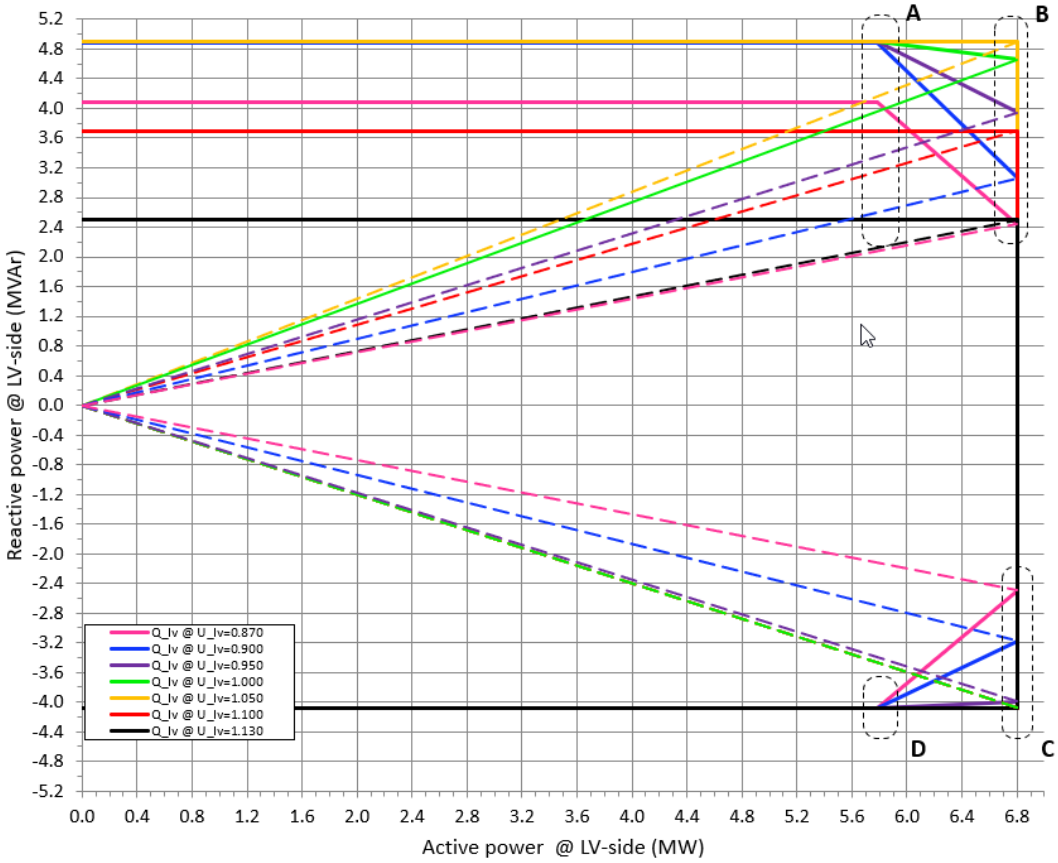
3.4 Operational Envelope – Conditions for Power Curve and Ct Values (at Hub Height)

Please consult section 6 and subsequent, for power curves and C_t values.

Conditions for Power Curve and C_t Values (at Hub Height)	
Wind Shear, *α*	0.00-0.30 (10-minute average)
Turbulence Intensity, *I*	6-12% (10-minute average)
Blades	Clean
Rain	No
Ice/Snow on Blades	No
Leading Edge	No damage
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ±2°
Grid Voltage	Nominal Voltage ±2.5%
Grid Frequency	Nominal Frequency ±0.5 Hz
Grid Active Power (LV-side)	Per tabulated values in Section 6 and following sections
Grid Reactive Power (LV-side)	Power Factor 1.0

3.5 Operational Envelope – Reactive Power Capability

The turbine has a reactive power capability on the low voltage side of the HV transformer as illustrated in Figure 3-3:



		Coordinates								Power factor	
	Point:	A		B		C		D		B (Capacitive)	C (Inductive)
	Coordinate:	x (P)	y (Q)	x (P)	y (Q)	x (P)	y (Q)	x (P)	y (Q)		
	Reactive power [kVAr] @ LV side @ U_lv = 0.870 p.u. voltage	5.780	4.080	6.800	2.441	6.800	-2.494	5.780	-4.080	0.941	0.939
	Reactive power [kVAr] @ LV side @ U_lv = 0.900 p.u. voltage	5.780	4.888	6.800	3.060	6.800	-3.174	5.780	-4.080	0.912	0.906
	Reactive power [kVAr] @ LV side @ U_lv = 0.950 p.u. voltage	5.780	4.896	6.800	3.945	6.800	-3.989	5.780	-4.080	0.865	0.863
	Reactive power [kVAr] @ LV side @ U_lv = 1.000 p.u. voltage	5.780	4.896	6.800	4.657	6.800	-4.080	5.780	-4.080	0.825	0.857
	Reactive power [kVAr] @ LV side @ U_lv = 1.050 p.u. voltage	5.780	4.896	6.800	4.896	6.800	-4.080	5.780	-4.080	0.812	0.857
	Reactive power [kVAr] @ LV side @ U_lv = 1.100 p.u. voltage	5.780	3.697	6.800	3.697	6.800	-4.080	5.780	-4.080	0.879	0.857
	Reactive power [kVAr] @ LV side @ U_lv = 1.130 p.u. voltage	5.780	2.499	6.800	2.499	6.800	-4.080	5.780	-4.080	0.939	0.857

Figure 3-3: Reactive power capability.

The turbine is able to maintain the reactive power capability at low wind with no active power production.

3.5.1 Temperature dependent reactive power capability

The reactive power capability shown in Figure 3-3 is valid for ambient temperatures at which no active power derate is needed according to *Figure 3-1* and Figure 3-2.

For ambient temperatures up to 40°C, where active power is derated below 6.8 MW because of ambient temperature, the shape of the PQ chart corresponding to 6.8 MW (Figure 3-4: A, B, C and D points) is maintained. The active power for the A, B, C and D points is however adjusted according to the overall WTG active power derate according to *Figure 3-1* and Figure 3-2.

For ambient temperatures between 40°C and 45°C, reactive power is derated proportional to the active power derate.

Figure 3-4 shows an illustrative example of the reactive power derate.

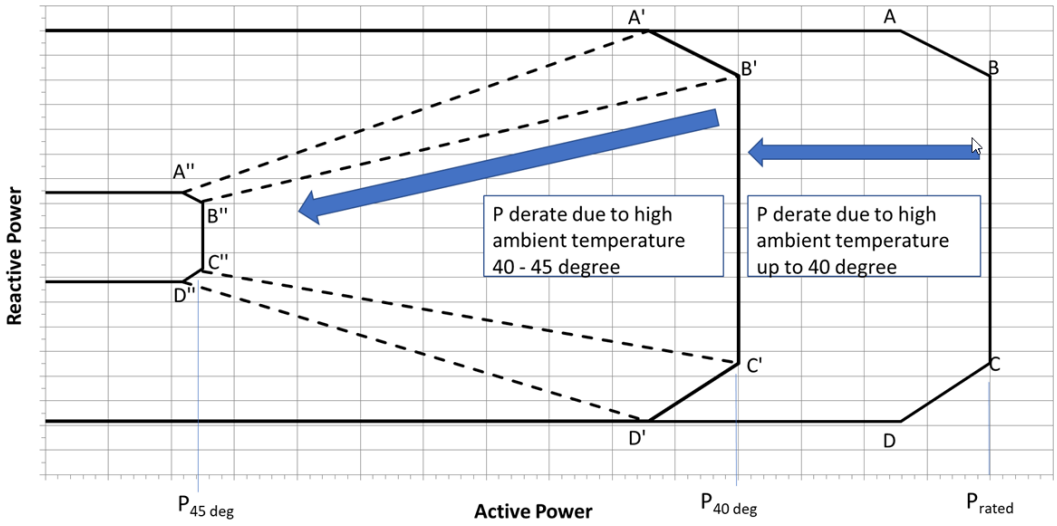


Figure 3-4 Reactive power capability temperature dependency. Illustrative example.

3.6 Sound Modes

The sound modes listed below are available for the turbine.

Sound modes			
Mode No.	**Maximum Sound Level**	**Serrated trailing edges**	**Available hub heights**
PO6800	104.5 dBA	Yes (standard)	119 / 166 / 169 m
PO6800-0S	106.3 dBA	No (option)	119 / 166 / 169 m

In addition, Sound Optimized (SO) modes as listed below are available as options for the turbine.

Sound Optimized (SO) modes			
Mode No.	**Maximum Sound Level**	**Serrated trailing edges**	**Available hub heights**
SO0	104.5 dBA	Yes (standard)	119 / 169 m
SO2	102 dBA	Yes (standard)	119 / 166 / 169 m
SO3	101 dBA	Yes (standard)	119 / 166 / 169 m
SO4	100 dBA	Yes (standard)	119 / 166 / 169 m
SO5	99 dBA	Yes (standard)	119 / 166 / 169 m
SO6	98 dBA	Yes (standard)	Site specific

NOTE Sound Optimized (SO) modes are only available with serrated trailing edges on the blades. For further details on sound performance and in case of specific requests, please contact Vestas Wind Systems A/S.

4 Drawings

Overview drawings describing the wind turbines, tower and foundation are shown in these documents.

V162 HH169 (DiBt) – 0110-5620
V162 HH119 (DiBt) – 0110-9356
V162 HH119 (IEC - Small Diameter) – 0110-4989
V162 HH166 (IEC) – 0110-4990
V162 HH119 (IEC) – 0110-5619

NOTE For detailed drawings, please contact Vestas Wind Systems A/S.

4.1 Turbine visual impression – side view

5 General Reservations, Notes and Disclaimers

-
- The performance specifications described in this document apply to the current version of the V162-6.8 MW wind turbine. Updated versions of the V162-6.8 MW wind turbine, which may be manufactured in the future, may differ from these performance specifications. In the event that Vestas supplies an updated version of the V162-6.8 MW wind turbine, Vestas will provide an updated performance specification applicable to the updated version.
- All listed start/stop parameters (e.g. wind speeds) are equipped with hysteresis control. This can, in certain borderline situations, result in turbine stops even though the ambient conditions are within the listed operation parameters.
- This document, Performance Specification, is not an offer for sale, and does not contain any guarantee, warranty and/or verification of the power curve and sound (including, without limitation, the power curve and sound verification method). Any guarantee, warranty and/or verification of the power curve and sound (including, without limitation, the power curve and sound verification method) must be agreed to separately in writing.

6 Power Curves, Ct Values and Sound Curves, Mode PO6800

6.1 Power Curves, Mode PO6800

Air density [kg/m^3]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**42**	32	33	34	35	36	37	38	39	39	40	41	43	44
3.5	**113**	70	74	77	80	84	88	92	96	100	104	108	117	122
4.0	**254**	168	176	184	192	200	207	215	223	231	239	246	262	269
4.5	**426**	306	316	327	338	349	360	371	382	393	404	415	437	448
5.0	**633**	466	481	497	512	527	542	558	573	588	603	618	648	663
5.5	**883**	660	680	700	720	741	761	781	802	822	842	863	904	924
6.0	**1189**	895	921	948	974	1001	1028	1055	1081	1108	1135	1162	1216	1243
6.5	**1549**	1174	1208	1242	1276	1311	1345	1379	1413	1447	1481	1515	1583	1617
7.0	**1969**	1502	1544	1587	1630	1672	1715	1757	1800	1842	1885	1927	2012	2054
7.5	**2449**	1876	1928	1980	2033	2085	2137	2189	2241	2293	2345	2397	2501	2553
8.0	**2993**	2302	2365	2428	2491	2555	2617	2680	2743	2806	2868	2931	3056	3118
8.5	**3605**	2781	2856	2932	3007	3082	3157	3232	3307	3381	3456	3530	3679	3753
9.0	**4272**	3307	3396	3484	3572	3661	3748	3836	3924	4011	4098	4185	4355	4438
9.5	**4944**	3857	3959	4060	4162	4263	4364	4464	4564	4665	4758	4851	5015	5086
10.0	**5613**	4440	4555	4671	4786	4902	5015	5127	5240	5353	5439	5526	5660	5708
10.5	**6191**	5014	5143	5272	5401	5530	5647	5764	5881	5998	6062	6127	6219	6247
11.0	**6613**	5546	5684	5822	5960	6099	6201	6303	6405	6507	6542	6577	6621	6630
11.5	**6761**	6030	6152	6274	6396	6518	6570	6622	6674	6726	6738	6749	6763	6765
12.0	**6789**	6420	6494	6569	6643	6718	6733	6749	6764	6780	6783	6786	6790	6791
12.5	**6798**	6664	6692	6720	6747	6775	6780	6784	6789	6794	6795	6796	6798	6799
13.0	**6800**	6755	6764	6773	6782	6791	6793	6794	6796	6798	6799	6799	6800	6800
13.5	**6800**	6782	6785	6789	6793	6797	6798	6798	6799	6800	6800	6800	6800	6800
14.0	**6800**	6793	6794	6796	6798	6800	6800	6800	6800	6800	6800	6800	6800	6800
14.5	**6800**	6797	6798	6799	6799	6800	6800	6800	6800	6800	6800	6800	6800	6800
15.0	**6800**	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800
15.5	**6800**	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800
16.0	**6800**	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800
16.5	**6800**	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800
17.0	**6800**	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800
17.5	**6800**	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800
18.0	**6800**	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800
18.5	**6800**	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800
19.0	**6800**	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800	6800
19.5	**6759**	6759	6759	6759	6759	6759	6759	6759	6759	6759	6759	6759	6759	6759
20.0	**6595**	6595	6595	6595	6595	6595	6595	6595	6595	6595	6595	6595	6595	6595
20.5	**6283**	6283	6283	6283	6283	6283	6283	6283	6283	6283	6283	6283	6283	6283
21.0	**5864**	5864	5864	5864	5864	5864	5863	5863	5863	5863	5863	5863	5864	5864
21.5	**5397**	5397	5397	5397	5397	5397	5397	5397	5397	5397	5397	5397	5397	5397
22.0	**4928**	4928	4928	4928	4928	4928	4928	4928	4928	4928	4928	4928	4928	4928
22.5	**4459**	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459
23.0	**3983**	3983	3983	3983	3983	3983	3983	3983	3983	3983	3983	3983	3983	3983
23.5	**3514**	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514
24.0	**3049**	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049
24.5	**2598**	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598
25.0	**2202**	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202

6.2 Ct Values, Mode PO6800

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.930**	0.938	0.938	0.937	0.936	0.935	0.935	0.934	0.933	0.932	0.932	0.931	0.929	0.928
3.5	**0.871**	0.876	0.876	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.870	0.870
4.0	**0.845**	0.854	0.853	0.852	0.851	0.850	0.850	0.849	0.848	0.847	0.847	0.846	0.844	0.844
4.5	**0.829**	0.836	0.836	0.835	0.834	0.834	0.833	0.832	0.832	0.831	0.830	0.830	0.829	0.828
5.0	**0.812**	0.810	0.811	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.813	0.813
5.5	**0.805**	0.801	0.802	0.802	0.802	0.803	0.803	0.803	0.804	0.804	0.804	0.804	0.805	0.805
6.0	**0.806**	0.804	0.804	0.804	0.804	0.805	0.805	0.805	0.805	0.806	0.806	0.806	0.806	0.806
6.5	**0.808**	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.808	0.808	0.808	0.808	0.808	0.808
7.0	**0.808**	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.807
7.5	**0.807**	0.809	0.809	0.809	0.808	0.808	0.808	0.808	0.808	0.807	0.807	0.807	0.806	0.806
8.0	**0.804**	0.808	0.808	0.808	0.808	0.807	0.807	0.807	0.806	0.806	0.805	0.805	0.804	0.803
8.5	**0.800**	0.806	0.805	0.805	0.804	0.804	0.803	0.803	0.802	0.802	0.801	0.800	0.799	0.798
9.0	**0.786**	0.796	0.795	0.794	0.794	0.793	0.792	0.791	0.790	0.789	0.788	0.787	0.783	0.780
9.5	**0.752**	0.776	0.775	0.774	0.773	0.772	0.771	0.770	0.769	0.767	0.762	0.757	0.739	0.726
10.0	**0.703**	0.753	0.752	0.751	0.750	0.749	0.746	0.744	0.742	0.740	0.728	0.716	0.685	0.666
10.5	**0.641**	0.715	0.714	0.713	0.712	0.711	0.706	0.702	0.697	0.692	0.675	0.658	0.623	0.604
11.0	**0.571**	0.668	0.666	0.664	0.663	0.661	0.652	0.643	0.635	0.626	0.608	0.590	0.554	0.537
11.5	**0.489**	0.614	0.608	0.602	0.596	0.590	0.576	0.563	0.549	0.535	0.520	0.505	0.476	0.463
12.0	**0.417**	0.557	0.545	0.534	0.522	0.510	0.496	0.481	0.467	0.453	0.441	0.429	0.407	0.397
12.5	**0.360**	0.493	0.479	0.464	0.450	0.435	0.424	0.412	0.400	0.389	0.379	0.370	0.352	0.344
13.0	**0.314**	0.427	0.415	0.402	0.389	0.376	0.367	0.357	0.347	0.338	0.330	0.322	0.308	0.301
13.5	**0.277**	0.372	0.362	0.351	0.340	0.330	0.322	0.313	0.305	0.297	0.290	0.284	0.271	0.265
14.0	**0.246**	0.327	0.318	0.309	0.300	0.291	0.284	0.277	0.270	0.263	0.257	0.252	0.241	0.236
14.5	**0.220**	0.290	0.282	0.274	0.267	0.259	0.253	0.247	0.241	0.235	0.230	0.225	0.215	0.211
15.0	**0.198**	0.258	0.252	0.245	0.238	0.232	0.226	0.221	0.216	0.211	0.206	0.202	0.194	0.190
15.5	**0.178**	0.232	0.226	0.220	0.214	0.209	0.204	0.199	0.195	0.190	0.186	0.182	0.175	0.172
16.0	**0.162**	0.210	0.204	0.199	0.194	0.189	0.185	0.181	0.176	0.172	0.169	0.165	0.159	0.156
16.5	**0.148**	0.190	0.186	0.181	0.176	0.172	0.168	0.164	0.161	0.157	0.154	0.151	0.145	0.142
17.0	**0.135**	0.173	0.169	0.165	0.161	0.157	0.153	0.150	0.147	0.143	0.141	0.138	0.132	0.130
17.5	**0.124**	0.159	0.156	0.152	0.148	0.144	0.141	0.138	0.135	0.132	0.130	0.127	0.122	0.120
18.0	**0.115**	0.146	0.143	0.140	0.136	0.133	0.130	0.127	0.124	0.122	0.119	0.117	0.113	0.110
18.5	**0.106**	0.135	0.132	0.129	0.125	0.122	0.120	0.117	0.115	0.112	0.110	0.108	0.104	0.102
19.0	**0.097**	0.124	0.121	0.118	0.115	0.112	0.110	0.108	0.106	0.103	0.101	0.099	0.096	0.094
19.5	**0.090**	0.114	0.111	0.109	0.106	0.104	0.102	0.099	0.097	0.095	0.093	0.092	0.088	0.087
20.0	**0.082**	0.103	0.101	0.099	0.096	0.094	0.092	0.090	0.088	0.087	0.085	0.083	0.080	0.079
20.5	**0.073**	0.092	0.090	0.088	0.086	0.084	0.082	0.080	0.079	0.077	0.076	0.074	0.072	0.070
21.0	**0.064**	0.080	0.078	0.077	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062
21.5	**0.055**	0.069	0.068	0.066	0.065	0.063	0.062	0.061	0.060	0.058	0.057	0.056	0.054	0.054
22.0	**0.048**	0.060	0.058	0.057	0.056	0.055	0.054	0.053	0.051	0.050	0.050	0.049	0.047	0.046
22.5	**0.041**	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.043	0.042	0.041	0.040
23.0	**0.035**	0.044	0.043	0.042	0.041	0.040	0.039	0.039	0.038	0.037	0.037	0.036	0.035	0.034
23.5	**0.030**	0.037	0.036	0.035	0.035	0.034	0.033	0.033	0.032	0.032	0.031	0.031	0.030	0.029
24.0	**0.025**	0.031	0.030	0.030	0.029	0.029	0.028	0.028	0.027	0.027	0.026	0.026	0.025	0.025
24.5	**0.022**	0.026	0.025	0.025	0.024	0.024	0.024	0.023	0.023	0.022	0.022	0.022	0.021	0.021
25.0	**0.018**	0.022	0.021	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.019	0.019	0.018	0.018

6.3 Sound Curves, Mode PO6800

Sound Power Level at Hub Height		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3 Maximum turbulence at hub height: 30% Inflow angle (vertical): 0 ±2° Air density: 1.225 kg/m^3**	
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA] Mode PO6800 (Blades with serrated trailing edge)**	**Sound Power Level at Hub Height [dBA] Mode PO6800-0S (Blades without serrated trailing edge)**
3	94.0	94.5
4	94.0	94.5
5	94.0	94.5
6	95.0	97.0
7	98.3	100.6
8	101.5	104.0
9	103.3	106.0
10	103.3	106.3
11	103.4	106.3
12	103.8	106.3
13	104.1	106.3
14	104.3	106.3
15	104.5	106.3

7 Power Curves, Ct Values and Sound Curves, Sound Optimized Modes

7.1 Power Curves, Sound Optimized Mode SO0

Air density [kg/m³]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**42**	32	33	34	35	36	37	38	39	39	40	41	43	44
3.5	**113**	70	74	77	81	84	88	92	96	100	104	108	117	122
4.0	**254**	168	176	184	192	200	208	215	223	231	239	247	262	269
4.5	**426**	306	317	327	338	349	360	371	382	393	404	415	437	448
5.0	**633**	466	482	497	512	527	543	558	573	588	603	618	649	664
5.5	**883**	660	680	700	721	741	761	782	802	822	842	863	904	924
6.0	**1189**	895	922	948	975	1001	1028	1055	1082	1109	1135	1162	1216	1243
6.5	**1550**	1175	1209	1243	1277	1311	1345	1379	1413	1448	1482	1516	1584	1618
7.0	**1970**	1502	1545	1588	1630	1673	1715	1758	1800	1843	1885	1928	2012	2055
7.5	**2450**	1876	1929	1981	2033	2086	2138	2190	2242	2294	2346	2398	2501	2553
8.0	**2994**	2303	2366	2429	2492	2555	2618	2681	2744	2807	2869	2932	3057	3119
8.5	**3606**	2782	2857	2933	3008	3083	3158	3233	3308	3383	3457	3531	3680	3754
9.0	**4273**	3309	3397	3485	3574	3662	3750	3838	3925	4013	4100	4186	4356	4439
9.5	**4946**	3859	3960	4061	4163	4264	4365	4465	4565	4666	4759	4852	5017	5088
10.0	**5614**	4441	4557	4672	4788	4903	5016	5129	5241	5354	5441	5528	5662	5709
10.5	**6193**	5016	5145	5274	5403	5532	5649	5766	5882	5999	6064	6128	6220	6248
11.0	**6613**	5548	5686	5824	5962	6100	6202	6304	6406	6508	6543	6578	6622	6631
11.5	**6761**	6031	6153	6275	6397	6519	6570	6622	6674	6726	6738	6749	6763	6765
12.0	**6789**	6421	6495	6569	6644	6718	6734	6749	6764	6780	6783	6786	6790	6791
12.5	**6798**	6665	6692	6720	6747	6775	6780	6784	6789	6794	6795	6796	6798	6799
13.0	**6800**	6755	6764	6773	6782	6791	6793	6794	6796	6798	6799	6799	6800	6800
13.5	**6800**	6782	6785	6789	6793	6797	6798	6798	6799	6800	6800	6800	6800	6800
14.0	**6800**	6793	6795	6796	6798	6800	6800	6800	6800	6800	6800	6800	6800	6800
14.5	**6800**	6797	6798	6799	6799	6800	6800	6800	6800	6800	6800	6800	6800	6800
15.0	**6797**	6796	6796	6796	6796	6796	6796	6796	6796	6796	6796	6797	6797	6797
15.5	**6780**	6776	6777	6777	6777	6778	6778	6778	6779	6779	6779	6780	6781	6781
16.0	**6758**	6754	6754	6754	6754	6755	6755	6755	6756	6756	6757	6757	6758	6759
16.5	**6735**	6730	6730	6730	6731	6731	6732	6732	6733	6733	6734	6734	6736	6736
17.0	**6711**	6704	6704	6705	6705	6706	6707	6707	6708	6709	6709	6710	6711	6712
17.5	**6685**	6677	6678	6678	6679	6679	6680	6681	6681	6682	6683	6684	6686	6687
18.0	**6658**	6651	6651	6652	6652	6653	6654	6654	6655	6656	6656	6657	6659	6660
18.5	**6634**	6627	6628	6628	6629	6629	6630	6630	6631	6632	6633	6633	6635	6636
19.0	**6612**	6605	6606	6606	6607	6607	6608	6609	6609	6610	6611	6612	6613	6614
19.5	**6587**	6580	6581	6581	6582	6582	6583	6584	6584	6585	6586	6586	6588	6589
20.0	**6475**	6469	6470	6470	6471	6471	6472	6472	6472	6473	6473	6474	6475	6476
20.5	**6225**	6222	6222	6222	6223	6223	6223	6224	6224	6224	6224	6225	6225	6225
21.0	**5848**	5846	5846	5847	5847	5847	5847	5847	5847	5847	5847	5847	5848	5848
21.5	**5397**	5397	5397	5397	5397	5397	5397	5397	5397	5397	5397	5397	5397	5397
22.0	**4928**	4928	4928	4928	4928	4928	4928	4928	4928	4928	4928	4928	4928	4928
22.5	**4459**	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459
23.0	**3983**	3983	3983	3983	3983	3983	3983	3983	3983	3983	3983	3983	3983	3983
23.5	**3514**	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514
24.0	**3049**	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049
24.5	**2598**	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598
25.0	**2202**	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202

7.2 Ct Values, Sound Optimized Mode SO0

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.930**	0.938	0.938	0.937	0.936	0.935	0.935	0.934	0.933	0.932	0.932	0.931	0.929	0.929
3.5	**0.871**	0.876	0.876	0.875	0.875	0.874	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.870
4.0	**0.845**	0.854	0.853	0.852	0.851	0.850	0.850	0.849	0.848	0.847	0.847	0.846	0.844	0.844
4.5	**0.829**	0.836	0.836	0.835	0.835	0.834	0.833	0.833	0.832	0.831	0.830	0.830	0.829	0.829
5.0	**0.813**	0.811	0.811	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.813	0.813
5.5	**0.805**	0.801	0.802	0.802	0.803	0.803	0.803	0.803	0.804	0.804	0.804	0.804	0.805	0.805
6.0	**0.806**	0.804	0.804	0.804	0.805	0.805	0.805	0.805	0.805	0.806	0.806	0.806	0.806	0.806
6.5	**0.808**	0.807	0.807	0.807	0.807	0.807	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808
7.0	**0.808**	0.809	0.809	0.809	0.809	0.809	0.809	0.808	0.808	0.808	0.808	0.808	0.808	0.808
7.5	**0.807**	0.809	0.809	0.809	0.809	0.809	0.808	0.808	0.808	0.808	0.807	0.807	0.806	0.806
8.0	**0.805**	0.809	0.808	0.808	0.808	0.807	0.807	0.807	0.806	0.806	0.805	0.805	0.804	0.804
8.5	**0.800**	0.806	0.806	0.805	0.805	0.804	0.804	0.803	0.802	0.802	0.801	0.801	0.799	0.798
9.0	**0.787**	0.796	0.795	0.794	0.794	0.793	0.792	0.791	0.790	0.790	0.789	0.788	0.783	0.780
9.5	**0.752**	0.776	0.775	0.774	0.773	0.772	0.771	0.770	0.769	0.768	0.762	0.757	0.739	0.726
10.0	**0.704**	0.753	0.752	0.751	0.750	0.749	0.746	0.744	0.742	0.740	0.728	0.716	0.685	0.666
10.5	**0.641**	0.715	0.714	0.713	0.712	0.711	0.707	0.702	0.697	0.692	0.675	0.658	0.623	0.604
11.0	**0.571**	0.668	0.666	0.664	0.663	0.661	0.652	0.643	0.635	0.626	0.608	0.589	0.554	0.537
11.5	**0.489**	0.614	0.608	0.602	0.596	0.590	0.576	0.563	0.549	0.535	0.520	0.504	0.476	0.463
12.0	**0.417**	0.557	0.545	0.534	0.522	0.510	0.496	0.481	0.467	0.453	0.441	0.429	0.407	0.397
12.5	**0.360**	0.493	0.479	0.464	0.450	0.435	0.424	0.412	0.400	0.388	0.379	0.370	0.352	0.344
13.0	**0.314**	0.427	0.414	0.402	0.389	0.376	0.367	0.357	0.347	0.338	0.330	0.322	0.307	0.301
13.5	**0.277**	0.372	0.362	0.351	0.340	0.330	0.322	0.313	0.305	0.297	0.290	0.284	0.271	0.265
14.0	**0.246**	0.327	0.318	0.309	0.300	0.291	0.284	0.277	0.270	0.263	0.257	0.252	0.241	0.236
14.5	**0.220**	0.290	0.282	0.274	0.267	0.259	0.253	0.247	0.241	0.235	0.230	0.225	0.215	0.211
15.0	**0.197**	0.258	0.252	0.245	0.238	0.231	0.226	0.221	0.216	0.210	0.206	0.202	0.194	0.190
15.5	**0.178**	0.231	0.225	0.220	0.214	0.208	0.203	0.199	0.194	0.189	0.186	0.182	0.175	0.171
16.0	**0.161**	0.208	0.203	0.198	0.193	0.188	0.183	0.179	0.175	0.171	0.168	0.164	0.158	0.155
16.5	**0.146**	0.188	0.184	0.179	0.175	0.170	0.166	0.163	0.159	0.155	0.152	0.149	0.143	0.141
17.0	**0.133**	0.171	0.167	0.163	0.159	0.155	0.151	0.148	0.145	0.141	0.139	0.136	0.131	0.128
17.5	**0.122**	0.157	0.153	0.149	0.145	0.142	0.139	0.136	0.133	0.130	0.127	0.125	0.120	0.118
18.0	**0.112**	0.143	0.140	0.136	0.133	0.130	0.127	0.124	0.122	0.119	0.117	0.114	0.110	0.108
18.5	**0.103**	0.131	0.128	0.125	0.122	0.119	0.117	0.114	0.112	0.109	0.107	0.105	0.101	0.099
19.0	**0.095**	0.120	0.118	0.115	0.112	0.109	0.107	0.105	0.103	0.100	0.098	0.097	0.093	0.091
19.5	**0.088**	0.111	0.109	0.106	0.103	0.101	0.099	0.097	0.095	0.093	0.091	0.089	0.086	0.084
20.0	**0.080**	0.101	0.099	0.097	0.095	0.092	0.090	0.089	0.087	0.085	0.083	0.082	0.079	0.077
20.5	**0.072**	0.091	0.089	0.087	0.085	0.083	0.081	0.080	0.078	0.076	0.075	0.074	0.071	0.070
21.0	**0.064**	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.061
21.5	**0.055**	0.069	0.068	0.066	0.065	0.063	0.062	0.061	0.060	0.058	0.057	0.056	0.054	0.054
22.0	**0.048**	0.060	0.058	0.057	0.056	0.055	0.054	0.053	0.051	0.050	0.050	0.049	0.047	0.046
22.5	**0.041**	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.043	0.042	0.041	0.040
23.0	**0.035**	0.044	0.043	0.042	0.041	0.040	0.039	0.039	0.038	0.037	0.037	0.036	0.035	0.034
23.5	**0.030**	0.037	0.036	0.035	0.035	0.034	0.033	0.033	0.032	0.032	0.031	0.031	0.030	0.029
24.0	**0.025**	0.031	0.030	0.030	0.029	0.029	0.028	0.028	0.027	0.027	0.026	0.026	0.025	0.025
24.5	**0.022**	0.026	0.025	0.025	0.024	0.024	0.024	0.023	0.023	0.022	0.022	0.022	0.021	0.021
25.0	**0.018**	0.022	0.021	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.019	0.019	0.018	0.018

7.3 Sound Curves, Sound Optimized Mode SO0

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO3 (Blades with serrated trailing edge)**
3	94.0
4	94.0
5	94.0
6	95.0
7	98.3
8	101.5
9	103.3
10	103.3
11	103.4
12	103.8
13	104.1
14	104.3
15	104.5

7.4 Power Curves, Sound Optimized Mode SO2

Air density [kg/m³]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**42**	32	33	34	35	36	37	38	39	39	40	41	43	44
3.5	**113**	71	74	77	81	84	88	92	96	100	104	108	117	122
4.0	**254**	168	176	184	192	200	208	215	223	231	239	247	262	270
4.5	**426**	306	317	327	338	349	360	371	382	393	404	415	437	448
5.0	**633**	466	482	497	512	527	543	558	573	588	603	618	648	664
5.5	**883**	660	680	700	720	741	761	781	802	822	842	863	904	924
6.0	**1189**	895	921	948	974	1001	1028	1055	1081	1108	1135	1162	1216	1243
6.5	**1549**	1174	1208	1243	1277	1311	1345	1379	1413	1447	1481	1515	1583	1617
7.0	**1970**	1502	1545	1587	1630	1673	1715	1758	1800	1843	1885	1927	2012	2054
7.5	**2450**	1876	1928	1981	2033	2085	2137	2190	2242	2294	2346	2398	2501	2553
8.0	**2993**	2302	2365	2428	2491	2554	2617	2680	2743	2806	2868	2930	3055	3117
8.5	**3593**	2773	2848	2923	2997	3072	3147	3221	3296	3371	3445	3519	3667	3741
9.0	**4239**	3281	3369	3457	3544	3632	3719	3806	3893	3980	4066	4153	4324	4408
9.5	**4894**	3807	3907	4007	4108	4208	4307	4407	4506	4605	4701	4798	4976	5058
10.0	**5524**	4331	4444	4557	4670	4783	4894	5006	5117	5228	5327	5425	5590	5657
10.5	**5980**	4802	4926	5051	5175	5300	5411	5522	5633	5744	5822	5901	6023	6066
11.0	**6247**	5211	5337	5463	5589	5715	5807	5900	5993	6085	6139	6193	6272	6297
11.5	**6313**	5546	5655	5763	5871	5980	6043	6107	6171	6235	6261	6287	6322	6332
12.0	**6301**	5780	5868	5957	6045	6134	6167	6201	6235	6269	6280	6290	6306	6312
12.5	**6273**	5951	6009	6067	6125	6183	6201	6220	6238	6256	6262	6267	6275	6277
13.0	**6239**	6053	6089	6126	6162	6198	6207	6215	6223	6232	6234	6236	6240	6242
13.5	**6208**	6092	6115	6138	6162	6185	6190	6194	6199	6204	6205	6206	6208	6209
14.0	**6178**	6118	6130	6142	6155	6167	6169	6172	6174	6176	6177	6177	6178	6178
14.5	**6150**	6120	6126	6132	6139	6145	6146	6147	6148	6149	6150	6150	6151	6151
15.0	**6124**	6110	6113	6116	6119	6122	6122	6122	6122	6123	6123	6123	6124	6125
15.5	**6098**	6092	6093	6094	6095	6096	6096	6096	6096	6097	6097	6097	6098	6099
16.0	**6073**	6069	6069	6070	6070	6070	6070	6071	6071	6071	6072	6072	6073	6074
16.5	**6050**	6046	6046	6046	6046	6047	6047	6047	6048	6048	6049	6049	6050	6051
17.0	**6027**	6023	6023	6023	6024	6024	6024	6025	6025	6025	6026	6027	6028	6028
17.5	**6003**	5998	5999	5999	5999	6000	6000	6001	6001	6002	6002	6003	6004	6005
18.0	**5980**	5975	5975	5976	5976	5976	5977	5977	5978	5978	5979	5979	5980	5981
18.5	**5960**	5956	5956	5956	5957	5957	5957	5958	5958	5958	5959	5959	5960	5961
19.0	**5940**	5936	5936	5936	5937	5937	5938	5938	5938	5939	5939	5940	5941	5941
19.5	**5921**	5916	5916	5916	5917	5917	5918	5918	5919	5919	5920	5921	5922	5922
20.0	**5900**	5894	5894	5895	5895	5896	5896	5897	5897	5898	5899	5899	5901	5901
20.5	**5836**	5830	5830	5831	5831	5832	5832	5833	5833	5834	5835	5835	5836	5837
21.0	**5656**	5652	5653	5653	5653	5653	5654	5654	5655	5655	5656	5656	5657	5657
21.5	**5358**	5357	5357	5357	5357	5357	5357	5358	5358	5358	5358	5358	5359	5359
22.0	**4926**	4926	4926	4926	4926	4926	4926	4926	4926	4926	4926	4926	4926	4926
22.5	**4459**	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459
23.0	**3983**	3983	3983	3983	3983	3983	3983	3983	3983	3983	3983	3983	3983	3983
23.5	**3514**	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514
24.0	**3049**	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049
24.5	**2598**	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598
25.0	**2202**	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202

7.5 Ct Values, Sound Optimized Mode SO2

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.930**	0.938	0.938	0.937	0.936	0.935	0.935	0.934	0.933	0.932	0.932	0.931	0.929	0.929
3.5	**0.871**	0.876	0.876	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.872	0.871	0.870
4.0	**0.845**	0.854	0.853	0.853	0.852	0.851	0.850	0.849	0.848	0.848	0.847	0.846	0.844	0.844
4.5	**0.829**	0.837	0.836	0.835	0.835	0.834	0.833	0.832	0.832	0.831	0.830	0.830	0.829	0.828
5.0	**0.812**	0.811	0.811	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.813	0.813
5.5	**0.805**	0.801	0.802	0.802	0.802	0.803	0.803	0.803	0.804	0.804	0.804	0.804	0.805	0.805
6.0	**0.806**	0.804	0.804	0.804	0.804	0.805	0.805	0.805	0.805	0.806	0.806	0.806	0.806	0.806
6.5	**0.808**	0.807	0.807	0.807	0.807	0.807	0.807	0.808	0.808	0.808	0.808	0.808	0.808	0.808
7.0	**0.808**	0.809	0.809	0.809	0.809	0.809	0.809	0.808	0.808	0.808	0.808	0.808	0.808	0.807
7.5	**0.807**	0.809	0.809	0.809	0.809	0.808	0.808	0.808	0.808	0.808	0.807	0.807	0.806	0.806
8.0	**0.803**	0.807	0.807	0.807	0.807	0.806	0.806	0.805	0.805	0.805	0.804	0.804	0.803	0.802
8.5	**0.792**	0.798	0.798	0.797	0.797	0.796	0.796	0.795	0.794	0.794	0.793	0.792	0.791	0.790
9.0	**0.775**	0.783	0.783	0.782	0.781	0.781	0.780	0.779	0.778	0.778	0.777	0.776	0.773	0.771
9.5	**0.743**	0.759	0.758	0.757	0.756	0.755	0.754	0.753	0.752	0.751	0.748	0.746	0.734	0.725
10.0	**0.693**	0.719	0.718	0.717	0.716	0.716	0.715	0.714	0.713	0.712	0.706	0.700	0.679	0.664
10.5	**0.618**	0.663	0.662	0.662	0.661	0.661	0.657	0.654	0.650	0.647	0.637	0.627	0.602	0.587
11.0	**0.533**	0.605	0.603	0.600	0.598	0.596	0.589	0.582	0.575	0.568	0.556	0.545	0.520	0.506
11.5	**0.450**	0.547	0.541	0.535	0.530	0.524	0.514	0.504	0.494	0.484	0.473	0.461	0.439	0.428
12.0	**0.382**	0.488	0.480	0.472	0.464	0.456	0.445	0.434	0.423	0.412	0.402	0.392	0.373	0.365
12.5	**0.329**	0.434	0.423	0.413	0.403	0.393	0.383	0.373	0.363	0.353	0.345	0.337	0.321	0.314
13.0	**0.286**	0.381	0.371	0.361	0.351	0.341	0.332	0.324	0.315	0.307	0.300	0.293	0.280	0.273
13.5	**0.251**	0.335	0.326	0.317	0.308	0.299	0.291	0.284	0.277	0.269	0.263	0.257	0.246	0.240
14.0	**0.222**	0.296	0.287	0.279	0.271	0.263	0.257	0.250	0.244	0.238	0.232	0.227	0.217	0.213
14.5	**0.198**	0.262	0.255	0.248	0.241	0.233	0.228	0.222	0.217	0.211	0.207	0.202	0.194	0.190
15.0	**0.177**	0.233	0.227	0.221	0.214	0.208	0.203	0.199	0.194	0.189	0.185	0.181	0.173	0.170
15.5	**0.159**	0.209	0.203	0.198	0.192	0.187	0.183	0.178	0.174	0.170	0.166	0.163	0.156	0.153
16.0	**0.144**	0.188	0.183	0.178	0.173	0.169	0.165	0.161	0.157	0.153	0.150	0.147	0.141	0.139
16.5	**0.131**	0.170	0.166	0.161	0.157	0.153	0.149	0.146	0.143	0.139	0.136	0.134	0.128	0.126
17.0	**0.119**	0.154	0.150	0.147	0.143	0.139	0.136	0.133	0.130	0.127	0.124	0.122	0.117	0.115
17.5	**0.110**	0.141	0.138	0.135	0.131	0.128	0.125	0.122	0.119	0.117	0.114	0.112	0.108	0.106
18.0	**0.101**	0.129	0.126	0.123	0.120	0.117	0.114	0.112	0.109	0.107	0.105	0.103	0.099	0.097
18.5	**0.093**	0.119	0.116	0.113	0.110	0.107	0.105	0.103	0.101	0.098	0.096	0.095	0.091	0.089
19.0	**0.085**	0.109	0.106	0.104	0.101	0.099	0.096	0.094	0.092	0.090	0.089	0.087	0.084	0.082
19.5	**0.079**	0.101	0.098	0.096	0.093	0.091	0.089	0.087	0.085	0.084	0.082	0.080	0.077	0.076
20.0	**0.073**	0.093	0.091	0.089	0.087	0.084	0.083	0.081	0.079	0.077	0.076	0.075	0.072	0.070
20.5	**0.068**	0.086	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.066	0.065
21.0	**0.061**	0.078	0.076	0.074	0.072	0.071	0.069	0.068	0.066	0.065	0.064	0.063	0.060	0.059
21.5	**0.055**	0.069	0.067	0.066	0.064	0.063	0.062	0.060	0.059	0.058	0.057	0.056	0.054	0.053
22.0	**0.048**	0.060	0.058	0.057	0.056	0.055	0.053	0.052	0.051	0.050	0.049	0.049	0.047	0.046
22.5	**0.041**	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.043	0.042	0.041	0.040
23.0	**0.035**	0.044	0.043	0.042	0.041	0.040	0.039	0.039	0.038	0.037	0.037	0.036	0.035	0.034
23.5	**0.030**	0.037	0.036	0.035	0.035	0.034	0.033	0.033	0.032	0.032	0.031	0.031	0.030	0.029
24.0	**0.025**	0.031	0.030	0.030	0.029	0.029	0.028	0.028	0.027	0.027	0.026	0.026	0.025	0.025
24.5	**0.022**	0.026	0.025	0.025	0.024	0.024	0.024	0.023	0.023	0.022	0.022	0.022	0.021	0.021
25.0	**0.018**	0.022	0.021	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.019	0.019	0.018	0.018

7.6 Sound Curves, Sound Optimized Mode SO2

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO3 (Blades with serrated trailing edge)**
3	94.0
4	94.0
5	94.0
6	95.0
7	98.3
8	101.3
9	102.0
10	102.0
11	102.0
12	102.0
13	102.0
14	102.0
15	102.0

7.7 Power Curves, Sound Optimized Mode SO3

Air density [kg/m³]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**42**	32	33	34	35	36	37	38	39	39	40	41	43	45
3.5	**113**	71	74	77	81	84	88	92	96	100	104	108	117	122
4.0	**254**	168	176	184	192	200	208	215	223	231	239	246	262	269
4.5	**426**	306	316	327	338	349	360	371	382	393	404	415	437	448
5.0	**633**	466	481	497	512	527	542	558	573	588	603	618	648	663
5.5	**883**	660	680	700	720	740	761	781	801	821	842	862	903	924
6.0	**1188**	894	921	948	974	1001	1028	1054	1081	1108	1135	1161	1215	1242
6.5	**1549**	1174	1208	1242	1276	1311	1345	1379	1413	1447	1481	1515	1583	1617
7.0	**1969**	1502	1544	1587	1630	1672	1715	1757	1800	1842	1884	1927	2011	2054
7.5	**2448**	1876	1928	1980	2032	2085	2137	2189	2241	2293	2345	2396	2500	2552
8.0	**2985**	2296	2359	2422	2485	2548	2611	2673	2736	2798	2861	2923	3047	3110
8.5	**3570**	2756	2830	2904	2979	3053	3127	3201	3275	3349	3423	3496	3643	3716
9.0	**4194**	3244	3331	3418	3505	3592	3678	3764	3851	3937	4023	4108	4279	4364
9.5	**4813**	3736	3835	3934	4033	4132	4230	4328	4425	4523	4620	4716	4905	4997
10.0	**5376**	4198	4308	4418	4528	4638	4747	4855	4964	5073	5174	5275	5457	5539
10.5	**5766**	4595	4715	4834	4954	5074	5183	5292	5401	5510	5595	5681	5825	5884
11.0	**5991**	4939	5062	5186	5309	5433	5525	5618	5710	5803	5865	5928	6024	6058
11.5	**6048**	5227	5337	5447	5557	5666	5737	5808	5878	5949	5982	6015	6063	6079
12.0	**6047**	5457	5548	5640	5731	5822	5866	5910	5954	5997	6014	6030	6053	6060
12.5	**6024**	5622	5690	5758	5826	5895	5921	5948	5975	6002	6010	6017	6027	6031
13.0	**5992**	5739	5786	5833	5880	5928	5941	5955	5968	5982	5985	5989	5994	5995
13.5	**5958**	5787	5820	5853	5886	5919	5927	5935	5944	5952	5954	5956	5959	5960
14.0	**5926**	5829	5848	5868	5887	5907	5911	5915	5919	5923	5924	5925	5926	5927
14.5	**5898**	5846	5857	5867	5878	5888	5890	5892	5894	5896	5897	5897	5898	5898
15.0	**5871**	5846	5851	5857	5862	5868	5868	5869	5869	5869	5870	5870	5871	5871
15.5	**5845**	5832	5834	5837	5840	5842	5842	5843	5843	5843	5844	5844	5845	5845
16.0	**5820**	5813	5814	5815	5816	5817	5817	5818	5818	5819	5819	5820	5820	5821
16.5	**5796**	5792	5793	5793	5793	5794	5794	5795	5795	5795	5796	5796	5797	5797
17.0	**5775**	5771	5771	5772	5772	5772	5772	5773	5773	5773	5774	5774	5775	5775
17.5	**5754**	5750	5750	5750	5750	5751	5751	5752	5752	5753	5753	5753	5754	5755
18.0	**5732**	5728	5728	5728	5729	5729	5729	5730	5730	5731	5731	5731	5732	5733
18.5	**5711**	5706	5707	5707	5707	5708	5708	5708	5709	5709	5710	5710	5711	5712
19.0	**5692**	5688	5688	5688	5688	5689	5689	5689	5690	5690	5691	5691	5692	5693
19.5	**5674**	5671	5671	5671	5672	5672	5672	5673	5673	5673	5674	5674	5675	5675
20.0	**5659**	5655	5655	5656	5656	5657	5657	5658	5658	5658	5659	5659	5660	5660
20.5	**5636**	5632	5632	5633	5633	5633	5634	5634	5634	5635	5635	5635	5636	5637
21.0	**5522**	5518	5518	5519	5519	5519	5520	5520	5520	5521	5521	5521	5522	5522
21.5	**5296**	5294	5294	5294	5295	5295	5295	5295	5295	5296	5296	5296	5296	5297
22.0	**4918**	4917	4917	4917	4917	4917	4917	4917	4917	4917	4917	4917	4918	4918
22.5	**4459**	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459
23.0	**3984**	3983	3983	3983	3983	3983	3983	3983	3984	3984	3984	3984	3984	3984
23.5	**3514**	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514
24.0	**3049**	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049
24.5	**2598**	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598
25.0	**2202**	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202

7.8 Ct Values, Sound Optimized Mode SO3

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.930**	0.938	0.938	0.937	0.936	0.935	0.935	0.934	0.933	0.932	0.932	0.931	0.929	0.928
3.5	**0.871**	0.876	0.876	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.870	0.870
4.0	**0.845**	0.854	0.853	0.852	0.852	0.851	0.850	0.849	0.848	0.848	0.847	0.846	0.844	0.843
4.5	**0.829**	0.837	0.836	0.835	0.835	0.834	0.833	0.833	0.832	0.831	0.830	0.830	0.829	0.828
5.0	**0.812**	0.810	0.811	0.811	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.813
5.5	**0.804**	0.801	0.802	0.802	0.802	0.803	0.803	0.803	0.803	0.804	0.804	0.804	0.805	0.805
6.0	**0.806**	0.803	0.804	0.804	0.804	0.805	0.805	0.805	0.805	0.805	0.806	0.806	0.806	0.806
6.5	**0.808**	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.808	0.808	0.808	0.807	0.807
7.0	**0.808**	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.807	0.807
7.5	**0.806**	0.809	0.808	0.808	0.808	0.808	0.808	0.808	0.807	0.807	0.807	0.807	0.806	0.806
8.0	**0.798**	0.803	0.802	0.802	0.802	0.801	0.801	0.801	0.800	0.800	0.799	0.799	0.798	0.797
8.5	**0.782**	0.789	0.788	0.788	0.787	0.787	0.786	0.786	0.785	0.784	0.784	0.783	0.782	0.781
9.0	**0.764**	0.771	0.770	0.770	0.769	0.769	0.768	0.767	0.767	0.766	0.765	0.764	0.762	0.761
9.5	**0.725**	0.733	0.733	0.732	0.731	0.731	0.730	0.729	0.728	0.728	0.727	0.726	0.721	0.717
10.0	**0.668**	0.680	0.679	0.679	0.678	0.678	0.677	0.677	0.676	0.675	0.673	0.670	0.660	0.651
10.5	**0.589**	0.620	0.619	0.619	0.618	0.618	0.616	0.613	0.611	0.608	0.602	0.596	0.579	0.569
11.0	**0.507**	0.562	0.560	0.559	0.558	0.557	0.551	0.545	0.539	0.534	0.525	0.516	0.496	0.485
11.5	**0.428**	0.508	0.504	0.500	0.496	0.492	0.484	0.476	0.467	0.459	0.449	0.439	0.418	0.408
12.0	**0.365**	0.458	0.451	0.445	0.439	0.433	0.423	0.413	0.403	0.393	0.384	0.374	0.357	0.348
12.5	**0.315**	0.409	0.401	0.392	0.384	0.375	0.366	0.357	0.348	0.339	0.331	0.323	0.308	0.301
13.0	**0.274**	0.364	0.355	0.346	0.337	0.327	0.319	0.311	0.302	0.294	0.287	0.281	0.268	0.262
13.5	**0.241**	0.321	0.312	0.304	0.295	0.287	0.280	0.273	0.265	0.258	0.252	0.246	0.235	0.230
14.0	**0.213**	0.284	0.276	0.268	0.261	0.253	0.246	0.240	0.234	0.228	0.223	0.218	0.208	0.204
14.5	**0.189**	0.252	0.245	0.238	0.231	0.224	0.219	0.213	0.208	0.203	0.198	0.194	0.186	0.182
15.0	**0.170**	0.224	0.218	0.212	0.206	0.200	0.195	0.191	0.186	0.181	0.177	0.173	0.166	0.163
15.5	**0.153**	0.201	0.196	0.190	0.185	0.180	0.175	0.171	0.167	0.163	0.160	0.156	0.150	0.147
16.0	**0.138**	0.181	0.176	0.171	0.167	0.162	0.158	0.155	0.151	0.147	0.144	0.141	0.135	0.133
16.5	**0.126**	0.164	0.159	0.155	0.151	0.147	0.143	0.140	0.137	0.134	0.131	0.128	0.123	0.121
17.0	**0.114**	0.148	0.145	0.141	0.137	0.134	0.131	0.128	0.125	0.122	0.119	0.117	0.112	0.110
17.5	**0.105**	0.136	0.133	0.129	0.126	0.123	0.120	0.117	0.115	0.112	0.110	0.108	0.103	0.101
18.0	**0.097**	0.125	0.122	0.118	0.115	0.112	0.110	0.108	0.105	0.103	0.101	0.099	0.095	0.093
18.5	**0.089**	0.114	0.112	0.109	0.106	0.103	0.101	0.099	0.097	0.094	0.093	0.091	0.087	0.086
19.0	**0.082**	0.105	0.102	0.100	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.083	0.080	0.079
19.5	**0.076**	0.097	0.094	0.092	0.090	0.088	0.086	0.084	0.082	0.080	0.079	0.077	0.074	0.073
20.0	**0.070**	0.090	0.087	0.085	0.083	0.081	0.080	0.078	0.076	0.075	0.073	0.072	0.069	0.068
20.5	**0.065**	0.083	0.081	0.079	0.077	0.075	0.074	0.072	0.071	0.069	0.068	0.067	0.064	0.063
21.0	**0.060**	0.076	0.074	0.073	0.071	0.069	0.068	0.066	0.065	0.063	0.062	0.061	0.059	0.058
21.5	**0.054**	0.068	0.067	0.065	0.064	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.053	0.052
22.0	**0.048**	0.060	0.058	0.057	0.056	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046
22.5	**0.041**	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.043	0.042	0.040	0.040
23.0	**0.035**	0.044	0.043	0.042	0.041	0.040	0.039	0.039	0.038	0.037	0.037	0.036	0.035	0.034
23.5	**0.030**	0.037	0.036	0.035	0.035	0.034	0.033	0.033	0.032	0.032	0.031	0.031	0.030	0.029
24.0	**0.025**	0.031	0.030	0.030	0.029	0.029	0.028	0.028	0.027	0.027	0.026	0.026	0.025	0.025
24.5	**0.022**	0.026	0.025	0.025	0.024	0.024	0.024	0.023	0.023	0.022	0.022	0.022	0.021	0.021
25.0	**0.018**	0.022	0.021	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.019	0.019	0.018	0.018

7.9 Sound Curves, Sound Optimized Mode SO3

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO3 (Blades with serrated trailing edge)**
3	94.0
4	94.0
5	94.0
6	95.0
7	98.2
8	100.8
9	100.9
10	101.0
11	101.0
12	101.0
13	101.0
14	101.0
15	101.0

7.10 Power Curves, Sound Optimized Mode SO4

Air density [kg/m³]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**42**	32	33	34	35	36	37	38	39	40	40	41	43	45
3.5	**113**	71	74	77	81	84	88	92	96	100	104	108	117	122
4.0	**254**	168	176	184	192	200	208	215	223	231	239	247	262	270
4.5	**426**	306	317	328	338	349	360	371	382	393	404	415	437	448
5.0	**633**	466	482	497	512	527	543	558	573	588	603	618	648	664
5.5	**883**	660	680	700	720	741	761	781	801	822	842	863	904	924
6.0	**1189**	895	921	948	974	1001	1028	1055	1081	1108	1135	1162	1216	1242
6.5	**1549**	1174	1208	1243	1277	1311	1345	1379	1413	1447	1481	1515	1583	1617
7.0	**1970**	1502	1545	1587	1630	1673	1715	1758	1800	1843	1885	1927	2012	2054
7.5	**2447**	1875	1927	1979	2031	2084	2136	2188	2240	2292	2343	2395	2499	2550
8.0	**2974**	2288	2350	2413	2476	2539	2601	2663	2725	2788	2850	2912	3036	3097
8.5	**3542**	2733	2806	2880	2954	3028	3101	3175	3249	3322	3396	3469	3615	3688
9.0	**4129**	3193	3278	3364	3449	3535	3620	3705	3790	3875	3960	4044	4213	4297
9.5	**4686**	3635	3731	3827	3924	4020	4116	4211	4307	4402	4497	4591	4779	4872
10.0	**5171**	4031	4137	4243	4349	4455	4560	4664	4769	4874	4973	5072	5258	5345
10.5	**5514**	4370	4484	4598	4712	4826	4933	5040	5147	5254	5341	5427	5579	5644
11.0	**5715**	4665	4785	4905	5025	5145	5236	5328	5419	5511	5579	5647	5756	5797
11.5	**5779**	4916	5026	5135	5245	5355	5432	5509	5586	5664	5702	5741	5803	5828
12.0	**5797**	5140	5231	5322	5414	5505	5559	5612	5666	5720	5746	5771	5806	5816
12.5	**5781**	5300	5376	5453	5529	5606	5641	5676	5711	5746	5758	5769	5786	5791
13.0	**5752**	5420	5476	5533	5589	5645	5668	5691	5713	5736	5741	5747	5754	5756
13.5	**5718**	5479	5524	5568	5612	5657	5669	5682	5695	5707	5711	5714	5719	5720
14.0	**5683**	5535	5564	5592	5621	5649	5656	5663	5670	5677	5679	5681	5683	5684
14.5	**5649**	5563	5580	5597	5615	5632	5636	5640	5643	5647	5648	5648	5650	5650
15.0	**5620**	5575	5585	5594	5603	5613	5614	5616	5617	5619	5619	5619	5620	5620
15.5	**5595**	5571	5576	5581	5587	5592	5592	5593	5593	5594	5594	5594	5595	5596
16.0	**5573**	5560	5562	5565	5568	5571	5571	5571	5571	5572	5572	5572	5573	5573
16.5	**5551**	5544	5545	5546	5548	5549	5549	5549	5550	5550	5550	5551	5551	5552
17.0	**5529**	5526	5526	5526	5527	5527	5527	5528	5528	5528	5529	5529	5530	5530
17.5	**5508**	5505	5505	5505	5506	5506	5506	5507	5507	5507	5507	5508	5508	5509
18.0	**5488**	5485	5485	5485	5485	5486	5486	5486	5486	5487	5487	5487	5488	5489
18.5	**5469**	5466	5466	5466	5466	5467	5467	5467	5467	5468	5468	5468	5469	5470
19.0	**5451**	5447	5448	5448	5448	5448	5449	5449	5449	5450	5450	5450	5451	5452
19.5	**5434**	5430	5430	5431	5431	5431	5431	5432	5432	5432	5433	5433	5434	5435
20.0	**5417**	5412	5413	5413	5413	5414	5414	5414	5415	5415	5416	5416	5417	5418
20.5	**5398**	5394	5394	5395	5395	5395	5396	5396	5396	5397	5397	5398	5399	5399
21.0	**5339**	5335	5335	5335	5336	5336	5336	5337	5337	5338	5338	5338	5339	5339
21.5	**5190**	5187	5187	5188	5188	5188	5189	5189	5189	5189	5190	5190	5191	5191
22.0	**4881**	4880	4880	4880	4880	4880	4880	4880	4880	4881	4881	4881	4881	4881
22.5	**4456**	4456	4456	4456	4456	4456	4456	4456	4456	4456	4456	4456	4456	4456
23.0	**3984**	3983	3983	3983	3983	3983	3983	3983	3983	3984	3984	3984	3983	3983
23.5	**3515**	3515	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3515	3515
24.0	**3049**	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049
24.5	**2598**	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598
25.0	**2202**	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202

7.11 Ct Values, Sound Optimized Mode SO4

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.930**	0.938	0.938	0.937	0.936	0.935	0.935	0.934	0.933	0.932	0.932	0.931	0.929	0.929
3.5	**0.871**	0.876	0.876	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.872	0.871	0.870
4.0	**0.845**	0.854	0.854	0.853	0.852	0.851	0.850	0.849	0.849	0.848	0.847	0.846	0.844	0.844
4.5	**0.829**	0.837	0.836	0.835	0.835	0.834	0.833	0.833	0.832	0.831	0.830	0.830	0.829	0.828
5.0	**0.812**	0.810	0.811	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.813	0.813
5.5	**0.805**	0.801	0.802	0.802	0.802	0.803	0.803	0.803	0.804	0.804	0.804	0.804	0.805	0.805
6.0	**0.806**	0.804	0.804	0.804	0.804	0.805	0.805	0.805	0.805	0.805	0.806	0.806	0.806	0.806
6.5	**0.808**	0.807	0.807	0.807	0.807	0.807	0.807	0.808	0.808	0.808	0.808	0.808	0.808	0.808
7.0	**0.808**	0.808	0.808	0.808	0.809	0.809	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.807
7.5	**0.804**	0.807	0.807	0.807	0.806	0.806	0.806	0.806	0.806	0.805	0.805	0.805	0.804	0.804
8.0	**0.791**	0.795	0.795	0.795	0.795	0.794	0.794	0.793	0.793	0.792	0.792	0.791	0.790	0.790
8.5	**0.773**	0.778	0.778	0.777	0.777	0.777	0.776	0.775	0.775	0.774	0.774	0.773	0.772	0.771
9.0	**0.744**	0.750	0.749	0.749	0.748	0.748	0.747	0.747	0.746	0.746	0.745	0.745	0.743	0.743
9.5	**0.691**	0.696	0.696	0.695	0.695	0.694	0.694	0.693	0.693	0.692	0.692	0.691	0.690	0.689
10.0	**0.629**	0.636	0.636	0.636	0.635	0.635	0.635	0.634	0.634	0.633	0.632	0.630	0.624	0.620
10.5	**0.554**	0.576	0.576	0.576	0.576	0.575	0.574	0.572	0.571	0.569	0.564	0.559	0.547	0.539
11.0	**0.480**	0.522	0.521	0.521	0.521	0.520	0.515	0.511	0.506	0.501	0.494	0.487	0.470	0.460
11.5	**0.408**	0.473	0.470	0.467	0.465	0.462	0.455	0.449	0.443	0.436	0.427	0.417	0.399	0.390
12.0	**0.349**	0.430	0.425	0.419	0.414	0.409	0.400	0.392	0.383	0.375	0.367	0.358	0.341	0.333
12.5	**0.302**	0.386	0.379	0.372	0.365	0.358	0.350	0.342	0.333	0.325	0.317	0.309	0.295	0.288
13.0	**0.263**	0.345	0.337	0.329	0.322	0.314	0.306	0.298	0.290	0.283	0.276	0.269	0.257	0.251
13.5	**0.231**	0.306	0.298	0.291	0.283	0.276	0.269	0.262	0.255	0.248	0.242	0.237	0.226	0.221
14.0	**0.204**	0.272	0.265	0.258	0.250	0.243	0.237	0.231	0.225	0.219	0.214	0.209	0.200	0.196
14.5	**0.182**	0.242	0.235	0.229	0.222	0.216	0.210	0.205	0.200	0.195	0.190	0.186	0.178	0.174
15.0	**0.163**	0.216	0.210	0.204	0.198	0.192	0.188	0.183	0.179	0.174	0.170	0.166	0.159	0.156
15.5	**0.146**	0.194	0.188	0.183	0.178	0.173	0.169	0.165	0.160	0.156	0.153	0.150	0.144	0.141
16.0	**0.133**	0.174	0.170	0.165	0.160	0.156	0.152	0.149	0.145	0.141	0.138	0.136	0.130	0.127
16.5	**0.120**	0.158	0.153	0.149	0.145	0.141	0.138	0.135	0.132	0.128	0.126	0.123	0.118	0.116
17.0	**0.110**	0.143	0.139	0.136	0.132	0.128	0.126	0.123	0.120	0.117	0.115	0.112	0.108	0.106
17.5	**0.101**	0.131	0.128	0.125	0.121	0.118	0.115	0.113	0.110	0.108	0.105	0.103	0.099	0.097
18.0	**0.093**	0.120	0.117	0.114	0.111	0.108	0.106	0.103	0.101	0.099	0.097	0.095	0.091	0.089
18.5	**0.085**	0.110	0.107	0.105	0.102	0.099	0.097	0.095	0.093	0.091	0.089	0.087	0.084	0.082
19.0	**0.078**	0.101	0.099	0.096	0.094	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.077	0.076
19.5	**0.073**	0.093	0.091	0.089	0.087	0.084	0.083	0.081	0.079	0.077	0.076	0.074	0.071	0.070
20.0	**0.067**	0.086	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.072	0.070	0.069	0.066	0.065
20.5	**0.063**	0.080	0.078	0.076	0.074	0.073	0.071	0.070	0.068	0.067	0.065	0.064	0.062	0.061
21.0	**0.058**	0.074	0.072	0.070	0.069	0.067	0.066	0.064	0.063	0.062	0.060	0.059	0.057	0.056
21.5	**0.053**	0.067	0.066	0.064	0.063	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.052	0.051
22.0	**0.047**	0.059	0.058	0.057	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.046	0.046
22.5	**0.041**	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.042	0.042	0.040	0.040
23.0	**0.035**	0.044	0.043	0.042	0.041	0.040	0.039	0.039	0.038	0.037	0.037	0.036	0.035	0.034
23.5	**0.030**	0.037	0.036	0.035	0.035	0.034	0.033	0.033	0.032	0.032	0.031	0.031	0.030	0.029
24.0	**0.025**	0.031	0.030	0.030	0.029	0.029	0.028	0.028	0.027	0.027	0.026	0.026	0.025	0.025
24.5	**0.022**	0.026	0.025	0.025	0.024	0.024	0.024	0.023	0.023	0.022	0.022	0.022	0.021	0.021
25.0	**0.018**	0.022	0.021	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.019	0.019	0.018	0.018

7.12 Sound Curves, Sound Optimized Mode SO4

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO3 (Blades with serrated trailing edge)**
3	94.0
4	94.0
5	94.0
6	95.0
7	98.2
8	100.0
9	100.0
10	100.0
11	100.0
12	100.0
13	100.0
14	100.0
15	100.0

7.13 Power Curves, Sound Optimized Mode SO5

Air density [kg/m³]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**42**	32	33	34	35	36	37	38	39	39	40	41	43	44
3.5	**113**	70	74	77	81	84	88	92	96	100	104	108	117	122
4.0	**254**	168	176	184	192	200	208	215	223	231	239	247	262	269
4.5	**426**	306	317	327	338	349	360	371	382	393	404	415	437	448
5.0	**633**	466	482	497	512	527	543	558	573	588	603	618	649	664
5.5	**883**	660	680	700	721	741	761	782	802	822	842	863	904	924
6.0	**1189**	895	922	948	975	1001	1028	1055	1082	1109	1135	1162	1216	1243
6.5	**1550**	1175	1209	1243	1277	1311	1345	1379	1413	1448	1482	1516	1584	1618
7.0	**1969**	1502	1544	1587	1630	1672	1715	1757	1800	1842	1885	1927	2011	2054
7.5	**2440**	1869	1921	1973	2025	2077	2129	2181	2233	2285	2337	2388	2491	2543
8.0	**2951**	2270	2332	2394	2456	2518	2580	2642	2704	2766	2828	2889	3012	3074
8.5	**3491**	2693	2765	2838	2911	2984	3057	3129	3202	3275	3347	3419	3563	3635
9.0	**4020**	3108	3191	3275	3358	3441	3524	3607	3690	3773	3855	3938	4102	4184
9.5	**4483**	3474	3566	3659	3751	3844	3936	4027	4119	4211	4301	4392	4573	4662
10.0	**4893**	3805	3905	4006	4106	4206	4306	4405	4505	4604	4700	4797	4978	5064
10.5	**5206**	4103	4211	4319	4426	4534	4638	4742	4846	4950	5035	5121	5277	5347
11.0	**5405**	4372	4486	4600	4714	4828	4920	5013	5105	5197	5267	5336	5457	5510
11.5	**5495**	4599	4709	4820	4931	5042	5117	5192	5267	5343	5393	5444	5527	5558
12.0	**5531**	4808	4902	4996	5090	5185	5245	5306	5366	5427	5461	5496	5549	5567
12.5	**5533**	4981	5059	5137	5215	5294	5338	5381	5425	5469	5490	5511	5540	5548
13.0	**5510**	5103	5166	5228	5291	5353	5386	5418	5450	5483	5492	5501	5514	5517
13.5	**5478**	5176	5226	5277	5328	5378	5399	5419	5440	5460	5466	5472	5480	5483
14.0	**5445**	5232	5271	5311	5351	5390	5402	5413	5424	5436	5439	5442	5446	5448
14.5	**5415**	5282	5307	5333	5359	5385	5391	5398	5404	5410	5412	5413	5416	5417
15.0	**5389**	5301	5320	5338	5356	5375	5378	5382	5385	5389	5389	5389	5390	5390
15.5	**5364**	5321	5330	5339	5349	5358	5359	5360	5362	5363	5363	5364	5364	5365
16.0	**5337**	5315	5319	5324	5329	5333	5334	5334	5335	5336	5336	5336	5337	5337
16.5	**5308**	5296	5298	5301	5303	5306	5306	5307	5307	5307	5308	5308	5309	5309
17.0	**5282**	5275	5276	5278	5279	5280	5280	5280	5281	5281	5281	5282	5282	5283
17.5	**5260**	5255	5255	5256	5257	5258	5258	5259	5259	5259	5259	5260	5260	5261
18.0	**5241**	5238	5239	5239	5239	5240	5240	5240	5240	5241	5241	5241	5242	5242
18.5	**5224**	5221	5221	5221	5221	5222	5222	5222	5223	5223	5223	5224	5224	5224
19.0	**5205**	5201	5201	5201	5202	5202	5202	5203	5203	5203	5204	5204	5205	5205
19.5	**5185**	5182	5182	5182	5182	5183	5183	5183	5184	5184	5185	5185	5186	5186
20.0	**5166**	5162	5162	5162	5163	5163	5163	5164	5164	5164	5165	5165	5166	5166
20.5	**5146**	5142	5142	5142	5142	5143	5143	5143	5144	5144	5145	5145	5146	5147
21.0	**5121**	5117	5117	5117	5118	5118	5118	5119	5119	5119	5120	5120	5121	5121
21.5	**5034**	5030	5031	5031	5031	5031	5031	5032	5032	5032	5033	5033	5034	5034
22.0	**4804**	4803	4803	4803	4803	4804	4804	4804	4804	4804	4804	4804	4805	4805
22.5	**4442**	4442	4442	4442	4442	4442	4442	4442	4442	4442	4442	4442	4442	4442
23.0	**3983**	3983	3983	3983	3983	3984	3983	3983	3983	3983	3983	3983	3983	3983
23.5	**3514**	3515	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514	3514
24.0	**3049**	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049
24.5	**2598**	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598
25.0	**2202**	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202

7.14 Ct Values, Sound Optimized Mode SO5

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.930**	0.938	0.938	0.937	0.936	0.935	0.935	0.934	0.933	0.932	0.932	0.931	0.929	0.929
3.5	**0.871**	0.876	0.876	0.875	0.875	0.874	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.870
4.0	**0.845**	0.854	0.853	0.852	0.851	0.850	0.850	0.849	0.848	0.847	0.847	0.846	0.844	0.844
4.5	**0.829**	0.836	0.836	0.835	0.835	0.834	0.833	0.833	0.832	0.831	0.830	0.830	0.829	0.829
5.0	**0.813**	0.811	0.811	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.813	0.813
5.5	**0.805**	0.801	0.802	0.802	0.803	0.803	0.803	0.803	0.804	0.804	0.804	0.804	0.805	0.805
6.0	**0.806**	0.804	0.804	0.804	0.805	0.805	0.805	0.805	0.805	0.806	0.806	0.806	0.806	0.806
6.5	**0.808**	0.807	0.807	0.807	0.807	0.807	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808
7.0	**0.807**	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.807	0.807
7.5	**0.798**	0.801	0.801	0.800	0.800	0.800	0.800	0.800	0.799	0.799	0.799	0.799	0.798	0.797
8.0	**0.781**	0.785	0.784	0.784	0.784	0.783	0.783	0.783	0.782	0.782	0.781	0.781	0.780	0.780
8.5	**0.756**	0.761	0.760	0.760	0.760	0.759	0.759	0.759	0.758	0.758	0.757	0.757	0.756	0.755
9.0	**0.708**	0.712	0.712	0.712	0.711	0.711	0.711	0.710	0.710	0.710	0.709	0.709	0.708	0.708
9.5	**0.643**	0.646	0.646	0.646	0.646	0.645	0.645	0.645	0.644	0.644	0.643	0.643	0.642	0.642
10.0	**0.581**	0.585	0.585	0.585	0.584	0.584	0.584	0.584	0.583	0.583	0.582	0.582	0.578	0.574
10.5	**0.516**	0.531	0.531	0.530	0.530	0.530	0.529	0.529	0.528	0.527	0.524	0.520	0.510	0.504
11.0	**0.452**	0.483	0.483	0.483	0.483	0.482	0.479	0.476	0.472	0.469	0.463	0.457	0.444	0.436
11.5	**0.388**	0.439	0.438	0.436	0.435	0.433	0.428	0.422	0.417	0.412	0.404	0.396	0.380	0.372
12.0	**0.334**	0.401	0.397	0.393	0.389	0.385	0.378	0.372	0.365	0.358	0.350	0.342	0.327	0.319
12.5	**0.289**	0.364	0.358	0.353	0.347	0.342	0.334	0.326	0.319	0.311	0.304	0.297	0.283	0.276
13.0	**0.252**	0.326	0.320	0.313	0.306	0.300	0.293	0.286	0.279	0.272	0.265	0.259	0.247	0.241
13.5	**0.222**	0.291	0.284	0.278	0.271	0.265	0.258	0.252	0.245	0.239	0.233	0.228	0.217	0.212
14.0	**0.196**	0.260	0.253	0.247	0.241	0.234	0.228	0.223	0.217	0.211	0.206	0.201	0.192	0.188
14.5	**0.175**	0.233	0.226	0.220	0.214	0.208	0.203	0.198	0.193	0.187	0.183	0.179	0.171	0.168
15.0	**0.157**	0.208	0.202	0.197	0.191	0.186	0.181	0.177	0.172	0.168	0.164	0.160	0.153	0.150
15.5	**0.141**	0.187	0.182	0.177	0.172	0.167	0.163	0.159	0.155	0.151	0.148	0.144	0.138	0.135
16.0	**0.127**	0.168	0.164	0.159	0.155	0.150	0.147	0.143	0.140	0.136	0.133	0.130	0.125	0.122
16.5	**0.116**	0.152	0.148	0.144	0.140	0.136	0.133	0.130	0.127	0.123	0.121	0.118	0.113	0.111
17.0	**0.105**	0.138	0.134	0.131	0.127	0.124	0.121	0.118	0.115	0.112	0.110	0.108	0.103	0.101
17.5	**0.097**	0.126	0.123	0.120	0.117	0.113	0.111	0.108	0.106	0.103	0.101	0.099	0.095	0.093
18.0	**0.089**	0.116	0.113	0.110	0.107	0.104	0.102	0.099	0.097	0.095	0.093	0.091	0.087	0.086
18.5	**0.082**	0.106	0.103	0.101	0.098	0.096	0.093	0.091	0.089	0.087	0.085	0.084	0.080	0.079
19.0	**0.075**	0.097	0.095	0.092	0.090	0.088	0.086	0.084	0.082	0.080	0.078	0.077	0.074	0.072
19.5	**0.070**	0.090	0.087	0.085	0.083	0.081	0.079	0.077	0.076	0.074	0.073	0.071	0.068	0.067
20.0	**0.065**	0.083	0.081	0.079	0.077	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.063	0.062
20.5	**0.060**	0.077	0.075	0.073	0.071	0.070	0.068	0.067	0.065	0.064	0.062	0.061	0.059	0.058
21.0	**0.056**	0.071	0.070	0.068	0.066	0.065	0.063	0.062	0.061	0.059	0.058	0.057	0.055	0.054
21.5	**0.052**	0.066	0.064	0.063	0.061	0.060	0.058	0.057	0.056	0.055	0.054	0.053	0.051	0.050
22.0	**0.046**	0.059	0.057	0.056	0.055	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046	0.045
22.5	**0.041**	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.044	0.043	0.042	0.041	0.040	0.039
23.0	**0.035**	0.044	0.043	0.042	0.041	0.040	0.039	0.039	0.038	0.037	0.036	0.036	0.035	0.034
23.5	**0.030**	0.037	0.036	0.035	0.035	0.034	0.033	0.033	0.032	0.031	0.031	0.030	0.030	0.029
24.0	**0.025**	0.031	0.030	0.030	0.029	0.029	0.028	0.028	0.027	0.027	0.026	0.026	0.025	0.025
24.5	**0.022**	0.026	0.025	0.025	0.024	0.024	0.024	0.023	0.023	0.022	0.022	0.022	0.021	0.021
25.0	**0.018**	0.022	0.021	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.019	0.019	0.018	0.018

7.15 Sound Curves, Sound Optimized Mode SO5

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO3 (Blades with serrated trailing edge)**
3	94.0
4	94.0
5	94.0
6	95.0
7	98.2
8	99.0
9	99.0
10	99.0
11	99.0
12	99.0
13	99.0
14	99.0
15	99.0

7.16 Power Curves, Sound Optimized Mode SO6

Air density [kg/m³]														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**42**	32	33	34	35	36	37	38	39	39	40	41	43	45
3.5	**113**	71	74	77	81	84	88	92	96	100	104	108	117	122
4.0	**254**	168	176	184	192	200	208	215	223	231	239	246	262	269
4.5	**426**	306	316	327	338	349	360	371	382	393	404	415	437	448
5.0	**633**	466	481	497	512	527	542	558	573	588	603	618	648	663
5.5	**883**	660	680	700	720	740	761	781	801	821	842	862	903	924
6.0	**1188**	894	921	948	974	1001	1028	1054	1081	1108	1135	1161	1215	1242
6.5	**1549**	1174	1208	1242	1276	1310	1344	1378	1412	1447	1481	1515	1583	1617
7.0	**1965**	1499	1542	1584	1627	1669	1711	1754	1796	1839	1881	1923	2007	2050
7.5	**2422**	1856	1908	1959	2011	2063	2114	2166	2217	2269	2320	2371	2473	2524
8.0	**2910**	2237	2299	2360	2421	2483	2544	2605	2666	2727	2788	2849	2970	3031
8.5	**3399**	2621	2692	2763	2834	2905	2976	3047	3117	3188	3258	3329	3469	3540
9.0	**3851**	2976	3056	3136	3215	3295	3375	3455	3534	3614	3693	3772	3930	4008
9.5	**4248**	3290	3377	3465	3553	3640	3728	3815	3902	3989	4076	4162	4334	4420
10.0	**4603**	3574	3668	3763	3858	3953	4047	4140	4234	4328	4420	4512	4692	4780
10.5	**4894**	3829	3930	4032	4133	4234	4333	4432	4531	4630	4718	4806	4967	5040
11.0	**5088**	4053	4159	4266	4372	4479	4578	4676	4775	4873	4945	5016	5145	5203
11.5	**5198**	4204	4315	4425	4536	4647	4737	4827	4917	5007	5070	5134	5232	5266
12.0	**5220**	4281	4393	4505	4617	4729	4815	4901	4987	5073	5122	5171	5250	5280
12.5	**5208**	4298	4408	4519	4630	4741	4824	4907	4990	5072	5117	5162	5232	5256
13.0	**5183**	4316	4424	4532	4641	4749	4827	4905	4982	5060	5101	5142	5204	5225
13.5	**5170**	4474	4564	4655	4745	4835	4895	4954	5014	5073	5106	5138	5187	5205
14.0	**5176**	4713	4781	4849	4916	4984	5019	5055	5091	5127	5143	5159	5184	5193
14.5	**5180**	4914	4958	5003	5048	5093	5109	5126	5142	5158	5166	5173	5183	5187
15.0	**5162**	5002	5032	5062	5092	5122	5130	5138	5146	5154	5157	5159	5163	5163
15.5	**5129**	5044	5062	5080	5097	5115	5118	5121	5124	5128	5128	5129	5130	5130
16.0	**5099**	5055	5064	5073	5082	5091	5093	5095	5096	5098	5098	5098	5099	5099
16.5	**5072**	5049	5054	5059	5063	5068	5069	5070	5071	5071	5072	5072	5072	5073
17.0	**5050**	5035	5038	5042	5045	5048	5048	5048	5049	5049	5049	5049	5050	5050
17.5	**5031**	5021	5023	5025	5027	5029	5030	5030	5030	5030	5030	5030	5031	5031
18.0	**5013**	5006	5007	5009	5010	5012	5012	5012	5012	5012	5013	5013	5013	5014
18.5	**4996**	4991	4992	4993	4993	4994	4994	4994	4995	4995	4995	4996	4996	4997
19.0	**4978**	4973	4973	4974	4975	4976	4976	4976	4977	4977	4977	4978	4978	4978
19.5	**4960**	4956	4957	4957	4958	4958	4959	4959	4959	4960	4960	4960	4961	4961
20.0	**4943**	4940	4940	4940	4940	4941	4941	4941	4941	4941	4942	4942	4943	4943
20.5	**4924**	4921	4921	4921	4921	4921	4922	4922	4922	4923	4923	4924	4924	4925
21.0	**4903**	4899	4899	4899	4900	4900	4900	4901	4901	4901	4902	4902	4903	4904
21.5	**4859**	4855	4855	4855	4856	4856	4856	4857	4857	4858	4858	4859	4859	4860
22.0	**4701**	4698	4698	4699	4699	4699	4700	4700	4700	4701	4701	4701	4702	4702
22.5	**4401**	4399	4399	4399	4399	4399	4399	4400	4400	4400	4400	4401	4401	4401
23.0	**3982**	3982	3982	3982	3982	3982	3982	3982	3982	3982	3982	3982	3982	3982
23.5	**3515**	3514	3514	3514	3514	3515	3514	3514	3514	3514	3514	3514	3515	3515
24.0	**3049**	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049	3049
24.5	**2598**	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598	2598
25.0	**2202**	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202

7.17 Ct Values, Sound Optimized Mode SO6

Air density kg/m³														
Wind speed [m/s]	**1.225**	**0.950**	**0.975**	**1.000**	**1.025**	**1.050**	**1.075**	**1.100**	**1.125**	**1.150**	**1.175**	**1.200**	**1.250**	**1.275**
3.0	**0.930**	0.938	0.938	0.937	0.936	0.935	0.935	0.934	0.933	0.932	0.932	0.931	0.929	0.928
3.5	**0.871**	0.876	0.876	0.875	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871	0.870	0.870
4.0	**0.845**	0.854	0.853	0.853	0.852	0.851	0.850	0.849	0.848	0.848	0.847	0.846	0.844	0.843
4.5	**0.829**	0.837	0.836	0.835	0.835	0.834	0.833	0.833	0.832	0.831	0.830	0.830	0.829	0.828
5.0	**0.812**	0.810	0.811	0.811	0.811	0.811	0.811	0.812	0.812	0.812	0.812	0.812	0.812	0.813
5.5	**0.804**	0.801	0.802	0.802	0.802	0.803	0.803	0.803	0.803	0.804	0.804	0.804	0.805	0.805
6.0	**0.806**	0.803	0.804	0.804	0.804	0.805	0.805	0.805	0.805	0.805	0.806	0.806	0.806	0.806
6.5	**0.807**	0.806	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807
7.0	**0.803**	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.803	0.803
7.5	**0.788**	0.790	0.790	0.790	0.790	0.790	0.789	0.789	0.789	0.789	0.788	0.788	0.787	0.787
8.0	**0.765**	0.768	0.768	0.768	0.767	0.767	0.767	0.767	0.766	0.766	0.766	0.765	0.765	0.764
8.5	**0.720**	0.723	0.723	0.723	0.723	0.722	0.722	0.722	0.722	0.721	0.721	0.721	0.720	0.720
9.0	**0.655**	0.658	0.658	0.657	0.657	0.657	0.657	0.656	0.656	0.656	0.656	0.655	0.655	0.654
9.5	**0.593**	0.596	0.595	0.595	0.595	0.595	0.594	0.594	0.594	0.594	0.593	0.593	0.593	0.592
10.0	**0.536**	0.539	0.539	0.539	0.538	0.538	0.538	0.538	0.538	0.537	0.537	0.537	0.535	0.534
10.5	**0.480**	0.488	0.488	0.488	0.488	0.488	0.488	0.487	0.487	0.487	0.484	0.482	0.476	0.472
11.0	**0.422**	0.441	0.440	0.440	0.440	0.440	0.439	0.438	0.437	0.436	0.431	0.427	0.417	0.411
11.5	**0.365**	0.389	0.389	0.389	0.389	0.389	0.386	0.384	0.382	0.379	0.375	0.370	0.358	0.351
12.0	**0.313**	0.338	0.338	0.338	0.338	0.338	0.336	0.333	0.331	0.329	0.324	0.319	0.308	0.302
12.5	**0.271**	0.293	0.293	0.292	0.292	0.292	0.290	0.288	0.286	0.283	0.279	0.275	0.266	0.261
13.0	**0.236**	0.257	0.257	0.256	0.256	0.256	0.254	0.252	0.249	0.247	0.244	0.240	0.232	0.228
13.5	**0.209**	0.238	0.237	0.235	0.233	0.232	0.229	0.226	0.223	0.220	0.216	0.213	0.205	0.202
14.0	**0.187**	0.228	0.225	0.222	0.218	0.215	0.211	0.207	0.203	0.199	0.195	0.191	0.183	0.179
14.5	**0.168**	0.216	0.211	0.207	0.202	0.197	0.193	0.188	0.184	0.179	0.176	0.172	0.164	0.161
15.0	**0.151**	0.197	0.193	0.188	0.183	0.178	0.174	0.170	0.166	0.161	0.158	0.154	0.148	0.144
15.5	**0.135**	0.180	0.175	0.170	0.165	0.161	0.157	0.153	0.149	0.145	0.142	0.139	0.133	0.130
16.0	**0.122**	0.162	0.158	0.153	0.149	0.145	0.141	0.138	0.134	0.131	0.128	0.125	0.120	0.117
16.5	**0.111**	0.147	0.143	0.139	0.135	0.131	0.128	0.125	0.122	0.119	0.116	0.114	0.109	0.107
17.0	**0.101**	0.133	0.130	0.126	0.123	0.119	0.116	0.114	0.111	0.108	0.106	0.104	0.099	0.097
17.5	**0.093**	0.122	0.119	0.116	0.113	0.109	0.107	0.104	0.102	0.099	0.097	0.095	0.091	0.090
18.0	**0.086**	0.112	0.109	0.106	0.103	0.100	0.098	0.096	0.093	0.091	0.089	0.087	0.084	0.082
18.5	**0.079**	0.102	0.100	0.097	0.095	0.092	0.090	0.088	0.086	0.084	0.082	0.080	0.077	0.076
19.0	**0.072**	0.094	0.091	0.089	0.087	0.084	0.082	0.081	0.079	0.077	0.075	0.074	0.071	0.070
19.5	**0.067**	0.086	0.084	0.082	0.080	0.078	0.076	0.075	0.073	0.071	0.070	0.068	0.066	0.064
20.0	**0.062**	0.080	0.078	0.076	0.074	0.072	0.071	0.069	0.068	0.066	0.065	0.063	0.061	0.060
20.5	**0.058**	0.074	0.072	0.071	0.069	0.067	0.066	0.064	0.063	0.061	0.060	0.059	0.057	0.056
21.0	**0.054**	0.069	0.067	0.065	0.064	0.062	0.061	0.060	0.058	0.057	0.056	0.055	0.053	0.052
21.5	**0.050**	0.064	0.062	0.061	0.059	0.058	0.057	0.055	0.054	0.053	0.052	0.051	0.049	0.048
22.0	**0.046**	0.058	0.056	0.055	0.054	0.052	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.044
22.5	**0.040**	0.051	0.050	0.049	0.047	0.046	0.045	0.044	0.044	0.043	0.042	0.041	0.040	0.039
23.0	**0.035**	0.044	0.043	0.042	0.041	0.040	0.039	0.038	0.038	0.037	0.036	0.036	0.034	0.034
23.5	**0.030**	0.037	0.036	0.035	0.035	0.034	0.033	0.033	0.032	0.031	0.031	0.030	0.029	0.029
24.0	**0.025**	0.031	0.030	0.030	0.029	0.028	0.028	0.027	0.027	0.026	0.026	0.026	0.025	0.024
24.5	**0.021**	0.026	0.025	0.025	0.024	0.024	0.023	0.023	0.023	0.022	0.022	0.022	0.021	0.021
25.0	**0.018**	0.021	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.019	0.019	0.018	0.018	0.018

7.18 Sound Curves, Sound Optimized Mode SO6

Sound Power Level at Hub Height	
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 3** **Maximum turbulence at hub height: 30%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**
Wind speed at hub height [m/s]	**Sound Power Level at Hub Height [dBA]** **Sound Optimized Mode SO6 (Blades with serrated trailing edge)**
3	94.0
4	94.0
5	94.0
6	95.0
7	97.8
8	98.0
9	98.0
10	98.0
11	98.0
12	98.0
13	98.0
14	98.0
15	98.0