GE Energy

Commercial Documentation Wind Turbine Generator Systems 2.5-2.75 Series

Technical Description and Data

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Table of Contents

1 Introduction

This document summarizes the technical description and specifications of the GE Energy 2.5-2.75 Series wind turbine generator system.

2 Technical Description of the Wind Turbine and Major Components

The 2.5-2.75 Series is a three bladed, upwind, horizontal-axis wind turbine with a rotor diameter of 100 or 103 meters. The turbine rotor and nacelle are mounted on top of a tubular tower giving a rotor hub height of 75, 85, 98.3 or 100 meters (see Fig. 1 to Fig. 4).

	2.5-100	2.5-103	2.75-100	2.75-103
50 Hz:	100 m, 85 m, 75 m	98.3 m, 85 m	100 m, 85 m, 75 m	98.3 m, 85 m
60 Hz:	98.3 m, 85 m	98.3 m, 85 m	98.3 m, 85 m	98.3 m, 85 m

Table 1: 2,5-2.75 Series hub heights depending on 50 or 60 Hz market

The machine employs active yaw control (designed to steer the machine with respect to the wind direction), active blade pitch control and variable speed generator (designed to regulate turbine rotor speed), and a power electronic converter system (see Fig. 6).

A transformer, supplied by General Electric, is located inside the tower or can be pad-mounted outside the tower. It transforms the voltage level of the generator to the required grid/collector system voltage (consult the Scope of Supply for available voltage options).

The wind turbine features a modular drive train design wherein the major drive train components including main shaft bearing, gearbox, generator and yaw drives are attached to a bedplate (see Fig. 5).

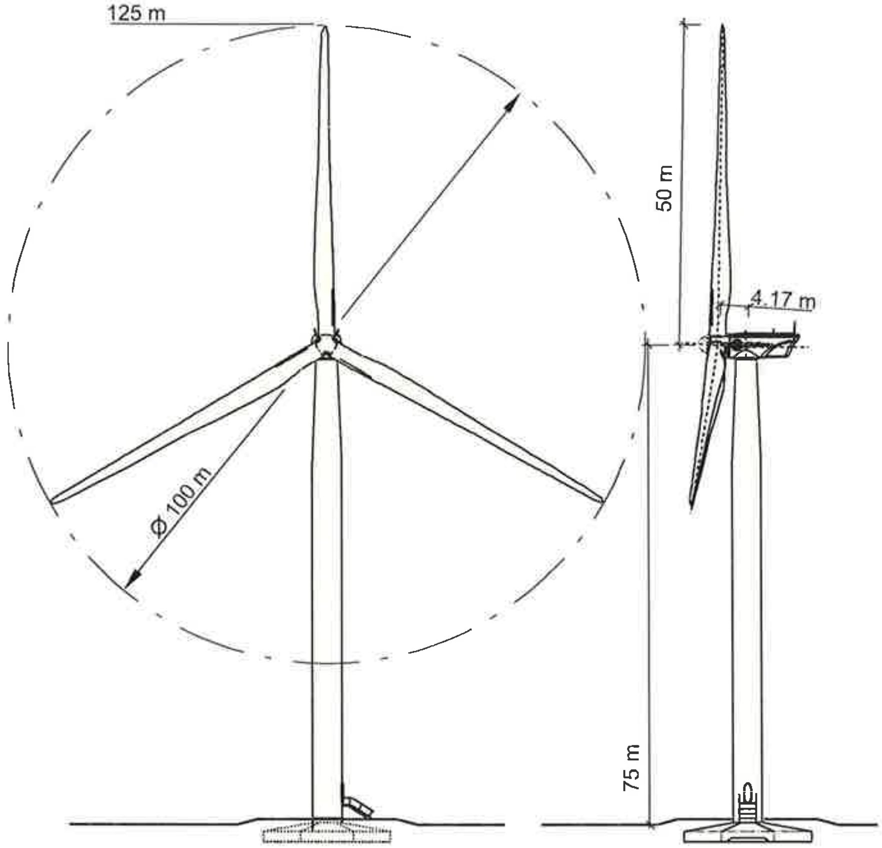

Fig. 1: 2.5-100 with 75 m hub height and 100 m rotor diameter

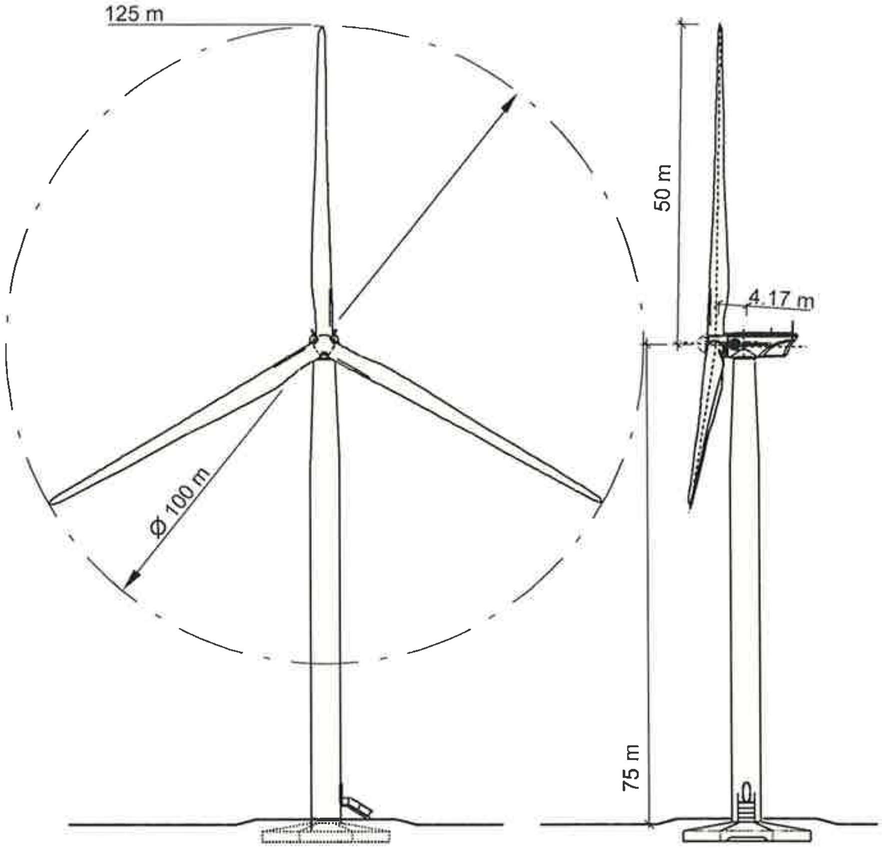

Fig. 2: 2.75-100 with 75 m hub height and 100 m rotor diameter

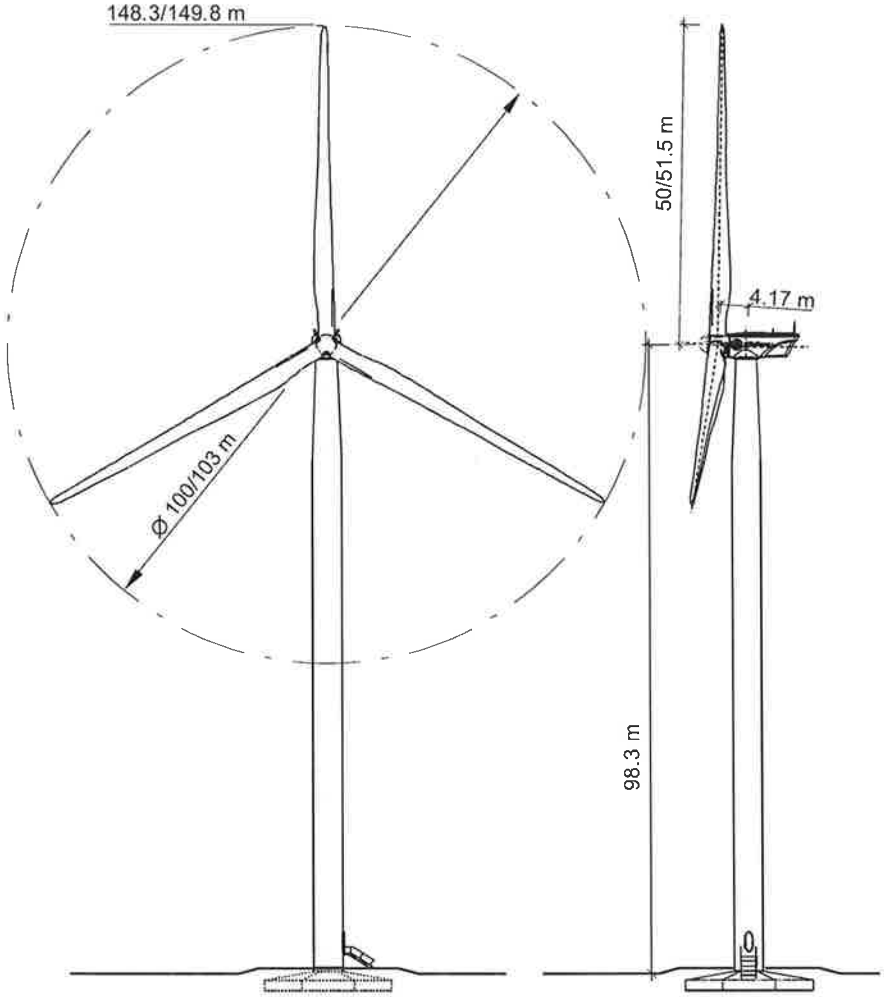

Fig. 3: 2.5-2.75 Series with 98.3 m hub height and 100/103 m rotor diameter

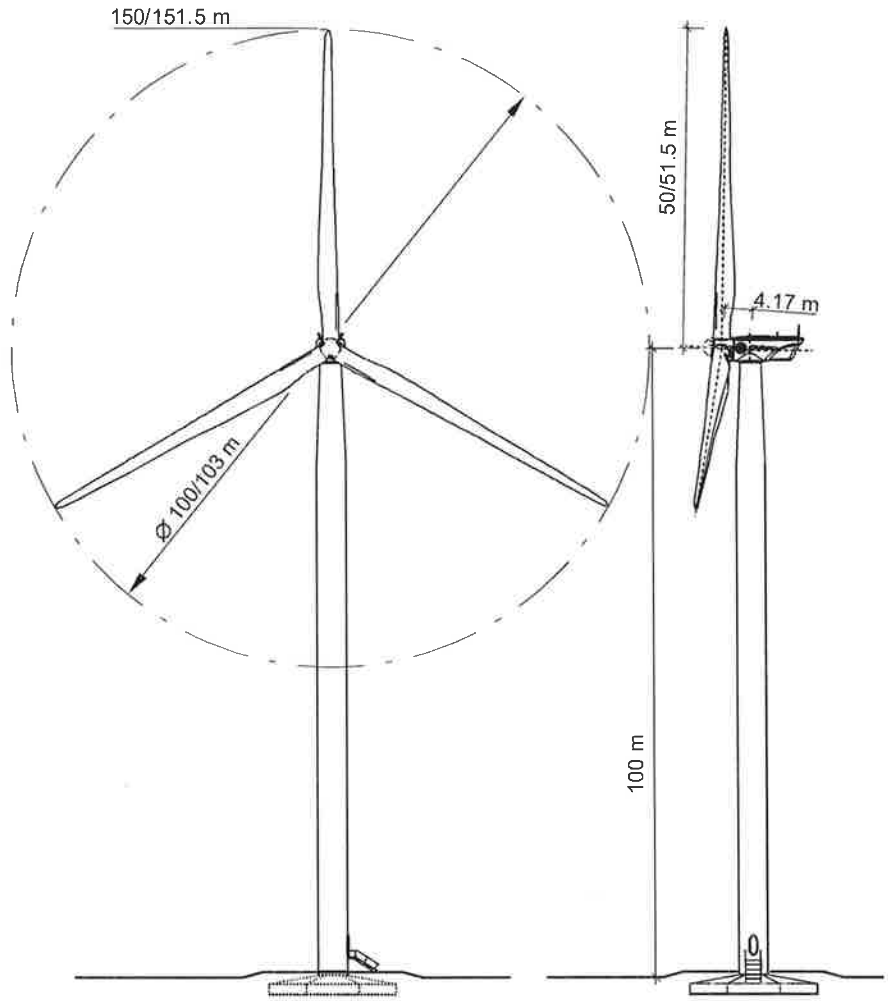

Fig. 4: 2.5-2.75 Series with 100 m hub height and 100/103 m rotor diameter

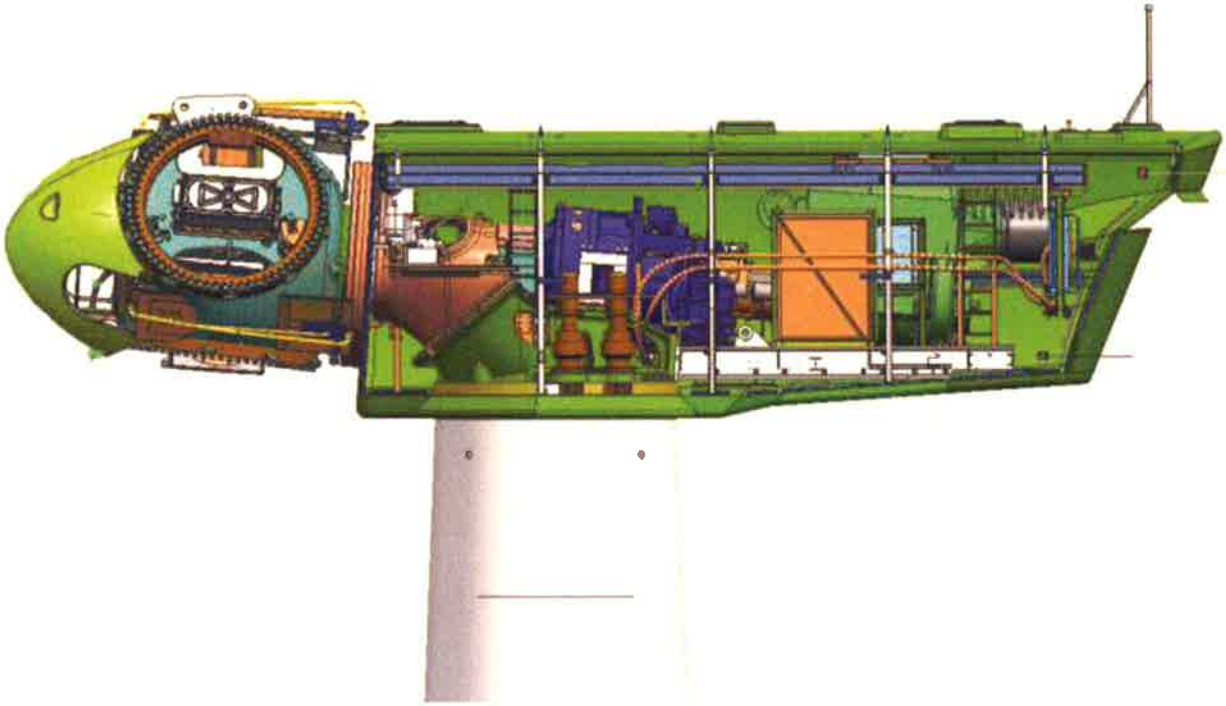

Fig. 5: 2.5-2.75 Series Nacelle

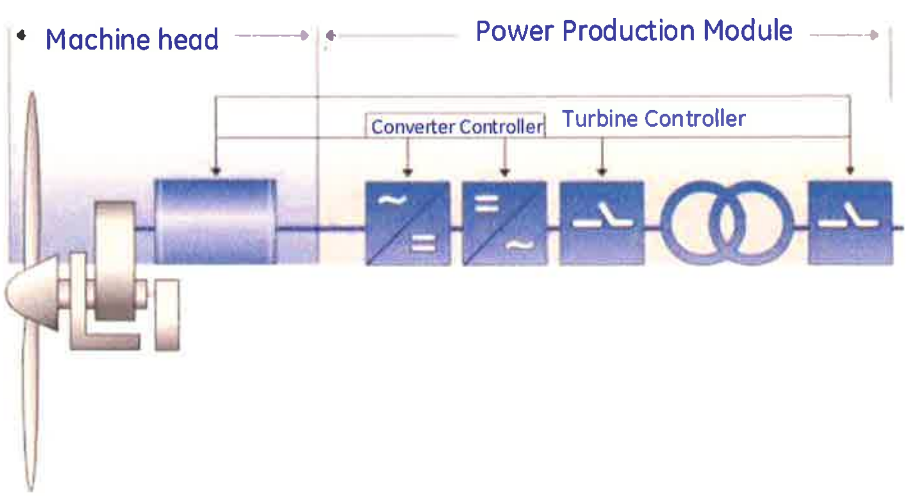

Fig. 6: 2.5-2.75 Series Electrical Concept

2.1 Rotor

The rotor diameter is 100 meters, resulting in a swept area of 7,854 m^2 or 103 meters with a swept area of 8,332 m^2 respectively. The rotor is designed to operate between 5 and 15 revolutions per minute (rpm). Rotor speed is regulated by a combination of blade pitch angle adjustment and generator/converter torque control. The rotor spins in a clockwise direction under normal operating conditions when viewed from an upwind location.

Full blade pitch angle range is approximately 90 degrees, with the zero degree position being with the blade flat to the prevailing wind. The blades being pitched to a full feather pitch angle of approximately 90 degrees accomplishes aerodynamic braking of the rotor whereby the blades "spill" the wind, thus limiting rotor speed.

2.2 Blades

There are three rotor blades used on each General Electric Energy 2.5-2.75 Series wind turbine. The airfoils transition along the blade span with the thicker airfoils being located inboard towards the blade root (hub) and gradually tapering to thinner cross sections out towards the blade tip.

2.3 Blade Pitch Control System

The rotor utilizes a pitch system to provide adjustment of the blade pitch angle during operation.

General Electric`s active pitch controller enables the wind turbine rotor to regulate speed, when above rated wind speed, by allowing the blade to "spill" excess aerodynamic lift. Energy from wind gusts below rated wind speed is captured by allowing the rotor to speed up, transforming this gust energy into kinetic energy that may then be extracted from the rotor.

Independent back up is provided to drive each blade in order to feather the blades and shut down the machine in the event of a grid line outage or other fault. By having all three blades outfitted with independent pitch systems, redundancy of individual blade aerodynamic braking capability is provided.

2.4 Hub

The hub is used to connect the three rotor blades to the turbine main shaft. The hub also houses the blade pitch system and is mounted directly to the main shaft. To carry out maintenance work, the hub is entered through a hatch.

2.5 Gearbox

The gearbox in the wind turbine is designed to transmit torsional power between the low-rpm turbine rotor and high-rpm electric generator. The gearbox is a multi-stage planetary/helical design. The gearbox is mounted to the machine bedplate. The gearbox mounting is designed such that it minimizes vibration and noise transfer to the bedplate. The gearbox is lubricated by a forced, cooled lubrication system and a filter maintains oil cleanliness.

2.6 Bearings

The blade pitch bearing is designed to allow the blade to pitch about a span-wise pitch axis. The inner race of the blade pitch bearing is outfitted with a blade drive gear that enables the blade to be driven in pitch.

The main shaft bearing is a two-bearing system, designed to provide bearing and alignment of the internal gearing shafts and accommodate radial and axial loads.

2.7 Brake System

The blade pitch system acts as the main braking system for the wind turbine. Braking under normal operating conditions is accomplished by feathering the blades out of the wind. Only two feathered rotor blades are required to decelerate the rotor safely into idling mode, and each rotor blade has its own backup to drive the blade in the event of a grid line loss.

2.8 Generator

The generator is mounted to the bedplate with a mounting so designed as to reduce vibration and noise transfer to the bedplate.

2.9 Gearbox/Generator Coupling

Designed to protect the drive train from excessive torque loads, a special coupling is provided between the generator and gearbox output shaft. This coupling is equipped with a torque-limiting device sized to keep the maximum allowable torque below the maximum design limit of the drive train torque.

2.10 Yaw System

The bearing attached between the nacelle and tower facilitates yaw motion. Yaw drives (with brakes that engage when the drive is disabled) mesh with the gear of the yaw bearing and steer the machine to track the wind in yaw. The automatic yaw brakes engage in order to prevent the yaw drives from seeing peak loads from any turbulent wind.

The controller activates the yaw drives to align the nacelle to the wind direction based on the wind vane sensor mounted on the top of the nacelle.

A sensor provides a record of nacelle yaw position and cable twisting. After the sensor detects excessive rotation in one direction, the controller automatically brings the rotor to a complete stop, untwists the cable by counter-yawing of the nacelle, and restarts the wind turbine.

2.11 Tower

The wind turbine is mounted on top of a tubular tower. Access to the turbine is through a door at the base of the tower. Service platforms are provided. A ladder provides access to the nacelle and also supports a fall arrest safety system. Interior lights are installed at critical points from the base of the tower to the tower top.

The tower can as an option be equipped with a moving platform, which is capable of transporting people or material up to a certain total weight limit. Specific information is provided on the document describing this option.

2.12 Nacelle

The nacelle houses the main components of the wind turbine generator. Access from the tower into the nacelle is through the bottom of the nacelle. The nacelle is ventilated, and illuminated by electric lights. A hatch provides access to the blades and hub.

2.13 Anemometer, Wind Vane and Lightning Rod

An anemometer, wind vane, and lightning rod are mounted on top of the nacelle housing. Access to these sensors is accomplished through the hatch in the nacelle.

2.14 Lightning Protection

The rotor blades are equipped with lightning receptors mounted in the blade. The turbine is grounded and shielded to protect against lightning; however, lightning is an unpredictable force of nature and it is possible that a lightning strike could damage various components notwithstanding the lightning protection employed in the machine.

2.15 Wind Turbine Control System

The wind turbine machine can be controlled locally either automatically or manually. Control signals can also be sent from a remote computer via a Supervisory Control and Data Acquisition System (SCADA) (purchased separately), with local lockout capability provided at the turbine controller.

Service switches at the tower top prevent service personnel at the bottom of the tower from operating certain systems of the turbine while service personnel are in the nacelle. To override any machine operation, emergency-stop buttons located in the tower base and in the nacelle can be activated to stop the turbine in the event of an emergency.

2.16 Power Converter

The wind turbine uses a power converter system that consists of a converter on the rotor side, a DC intermediate circuit, and a power inverter on the grid side. This allows for variable rotor speed while keeping in synchronization with the grid frequency. The converter system consists of a power module and associated electrical equipment accommodated in the base of the tower or installed on an external skid outside the tower. Variable output frequency of the converter allows variable speed operation of the generator.

3 Technical Data for the 2.5-2.75 Series

3.1 2.5 WTG

3.1.1 2.5-100 m Rotor

Diameter:	100 m
Number of blades:	3
Swept area:	7,854 m^2
Rotor speed range:	4.7 – 14.1 min^{-1}
Rotational direction:	Clockwise viewed from an upwind location
Maximum speed of the blade tips:	73.6 m/s
Orientation:	Upwind
Speed regulation:	Pitch control
Aerodynamic brake:	Full feathering

3.1.2 2.5-103 m Rotor

Diameter:	103 m
Number of blades:	3
Swept area:	8,332 m^2
Rotor speed range:	4.7 – 13.7 min^{-1}
Rotational direction:	Clockwise viewed from an upwind location
Maximum speed of the blade tips:	74.0 m/s
Orientation:	Upwind
Speed regulation:	Pitch control
Aerodynamic brake:	Full feathering

3.2 2.75 WTG

3.2.1 2.75-100 m Rotor

Diameter:	100 m
Number of blades:	3
Swept area:	7,854 m^2
Rotor speed range:	4.7 – 14.8 min^{-1}
Rotational direction:	Clockwise viewed from an upwind location
Maximum speed of the blade tips:	77.4 m/s
Orientation:	Upwind
Speed regulation:	Pitch control
Aerodynamic brake:	Full feathering

3.2.2 2.75-103 m Rotor

Diameter:	103 m
Number of blades:	3
Swept area:	8,332 m^2
Rotor speed range:	4.7 – 14.8 min^{-1}
Rotational direction:	Clockwise viewed from an upwind location
Maximum speed of the blade tips:	79.7 m/s
Orientation:	Upwind
Speed regulation:	Pitch control
Aerodynamic brake:	Full feathering

3.3 Operational Limits

Wind turbine design standard	IEC 61400-1, second edition: 'Wind turbine generator systems'
Height above sea level	Maximum 1000 m with the maximum standard operational temperature of +40 °C (2.5 Series) / +35° C (2.75 Series). Above 1000 m, the maximum operational temperature is reduced per DIN IEC 60034-1 (e.g., maximum operational temperature reduced to +30 °C at 2000 m). For installations above 1000 m isolation distances of medium voltage terminals must also be re-evaluated.
Standard Weather Option (STW)	-15 °C — +40 °C (2.5 Series) / +35° C (2.75 Series) 2.75 Series derates up to 10 % from + 35 °C to + 40 °C
Cold Weather Option (CWE, in preparation for 2.75-103, available for all other types)	-30 °C — +40 °C (2.5 Series) / +35° C (2.75-100) 2.75 Series derates up to 10 % from + 35 °C to + 40 °C
Wind conditions according to IEC 61400-1 (ed. 2) for the standard temperature range	100 m and 98.3 m hub height: 8.0 m/s average wind speed (TC S, B-turbulence) 85 m and 75 m hub height: capable of both 7.5 m/s average wind speed and 8.5 m/s average wind speed (both TC IIb and IIIa TC S, B-turbulence)
Maximum extreme gust (10 min) according to IEC 61400-1 (ed. 2) for the standard temperature range	TC IIIa TC S, B-turbulence: approx. 37.5 m/s TC IIb and TC S, B-turbulence: approx. 42.5 m/s

Design guideline and wind class:
For **2.5-100** m rotor diameter

100 m hub height:	DIBt WZ III, IEC IIIa
98.3 m hub height:	DIBt WZ III, IEC IIIa
85 m hub height:	DIBt WZ II, IEC IIb
75 m hub height:	DIBt WZ II, IEC IIb

Design guideline and wind class:
For **2.5-103** m rotor diameter

100 m hub height:	IEC IIIa
98.3 m hub height:	IEC IIIa
85 m hub height:	IEC IIIa

Design guideline and wind class:
For **2.75-100** m rotor diameter

100 m hub height:	S: 8.0 m/s average wind speed; b-turbulence
98.3 m hub height:	S: 8.0 m/s average wind speed; b-turbulence
85 m hub height:	IEC IIb
75 m hub height:	IEC IIb

Design guideline and wind class:
For **2.75-103** m rotor diameter

98.3 m hub height:	DIBt WZ II, S: 8.5 m/s average wind speed; b-turbulence
85 m hub height:	S: 8.5 m/s average wind speed; b-turbulence

Atmospheric corrosion protection (corrosion categories as defined by ISO 12944-2:1998)					
		Standard		Enhanced (Option)	
		Internal	External	Internal	External
Americas	Tower shell	C-2	C-3	C-4	C-5M
	All other components	C-2	C-3	C-2	C-3
Europe	Tower shell	C-4	C-5M		
	All other components	C-2	C-3		