GE Energy

Commercial Documentation Wind Turbine Generator Systems GE 2.5xl

Technical Description and Data

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GE Energy

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1 Introduction

This document summarizes the technical description and specifications of the GE Energy (GE) 2.5xl (capable of both 50 & 60 Hz) wind turbine generator system.

2 Technical Description of the Wind Turbine and Major Components

The 2.5xl is a three bladed, upwind, horizontal-axis wind turbine with a rotor diameter of 100 meters. The turbine rotor and nacelle are mounted on top of a tubular tower giving a rotor hub height of 75, 85 or 100 meters (see Fig. 1 to Fig. 3). 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 (cf. Fig. 5: GE 2.5xl Electrical Concept).

A transformer, supplied by GE, is located inside the tower, 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. 4).

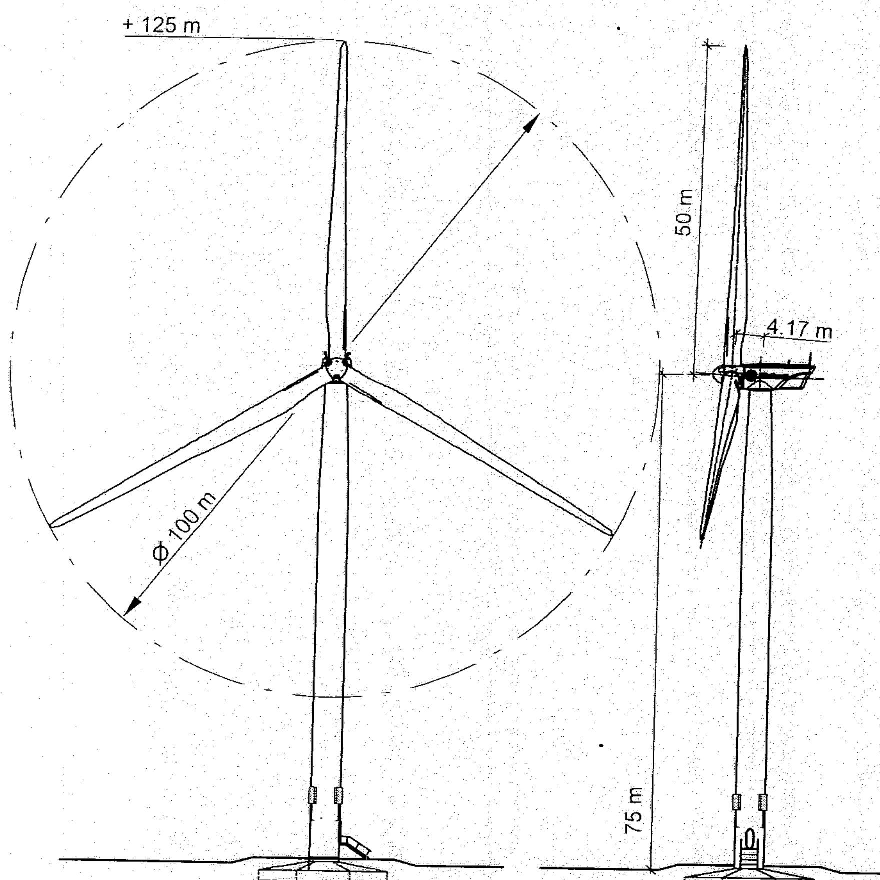

Fig. 1: GE 2.5xl with 75 m hub height

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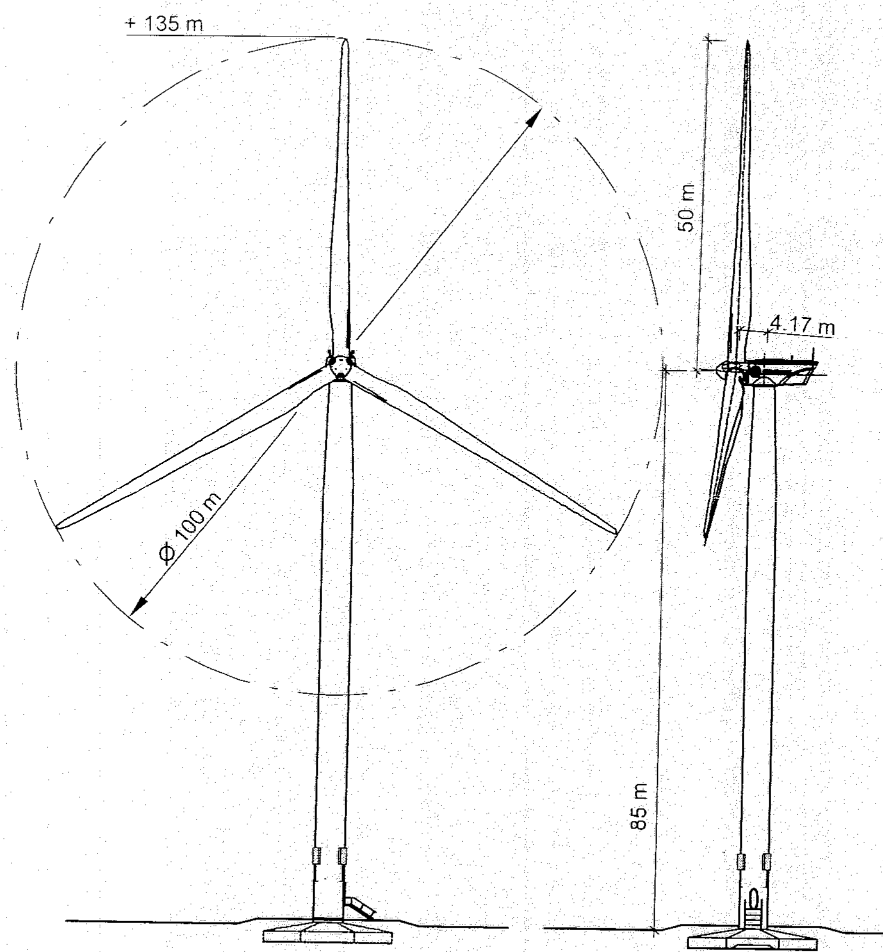

Fig. 2: GE 2.5xl with 85 m hub height

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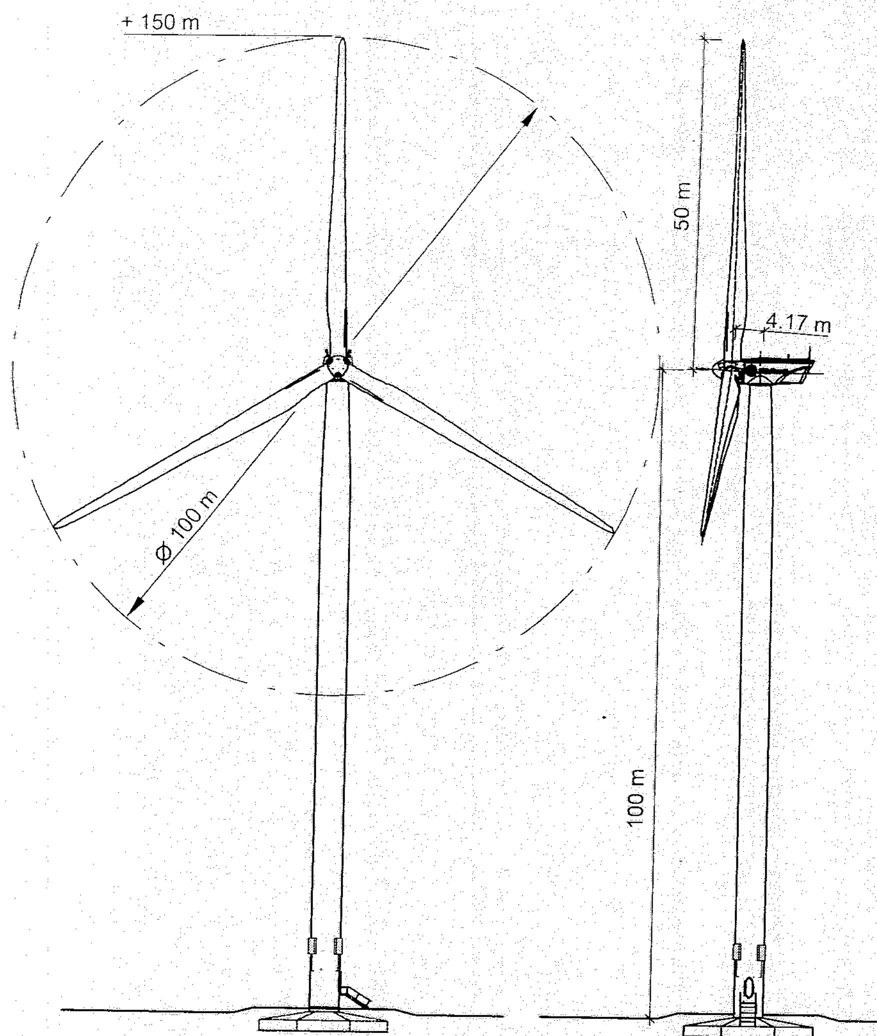

Fig. 3: GE 2.5xl with 100 m hub height

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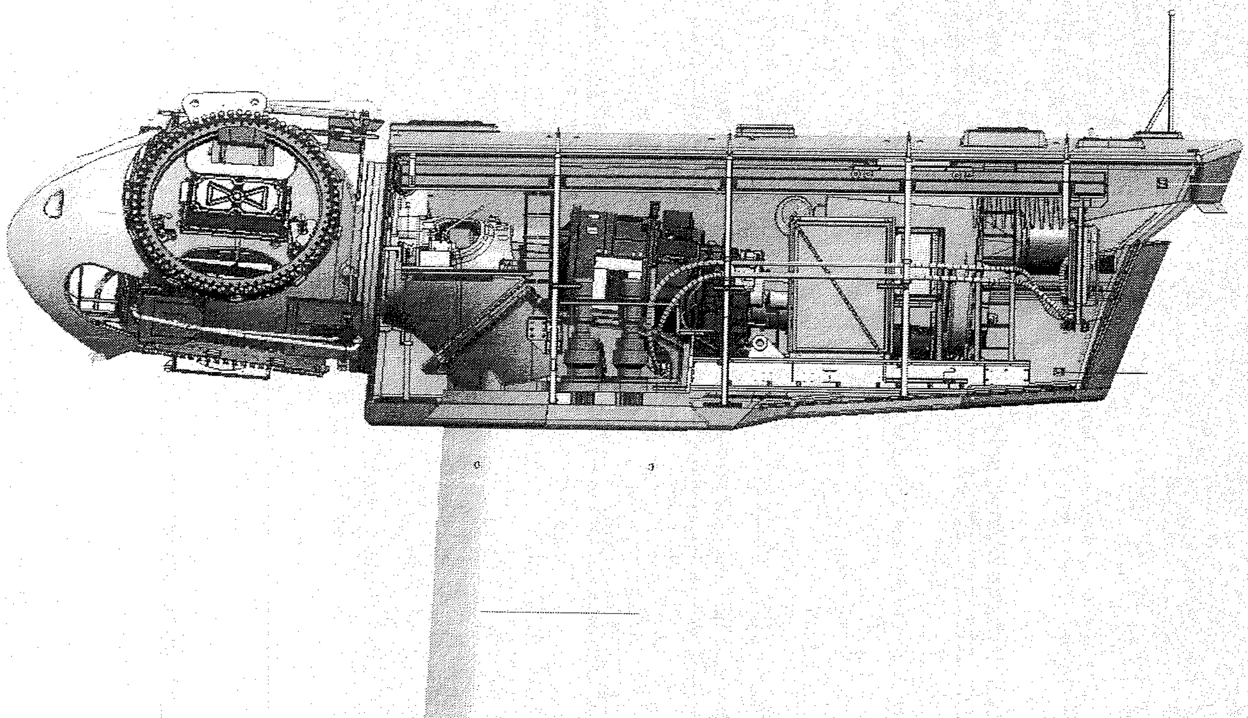

Fig. 4: GE 2.5xl Nacelle

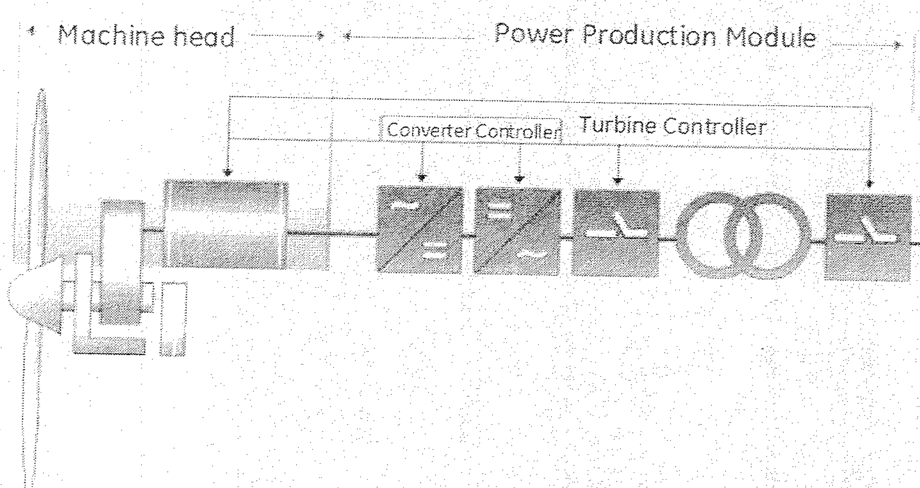

Fig. 5: GE 2.5xl Electrical Concept

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2.1 Rotor

The rotor diameter is 100 meters, resulting in a swept area of 7,854 m^2, and is designed to operate between 5 and 14 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 GE Energy 2.5xl 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.

GE'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.

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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, which 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.

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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. Variable output frequency of the converter allows variable speed operation of the generator.

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3 Technical Data for the 2.5xl

3.1 Rotor

Diameter:	100 m
Number of blades:	3
Swept area:	7,854 m^2
Rotor speed range:	5 – 14 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

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3.2 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. Above 1,000 m, the maximum operational temperature is reduced per DIN IEC 60034-1 (e.g., maximum operational temperature reduced to 30 °C at 2,000 m). For installations above 1000 m isolation distances of medium voltage terminals must also be re-evaluated.
Minimum standard ambient temperature (operational/survival)	-15 °C / -20 °C Switching on takes place with a hysteresis of 5 °C (at -10 °C) after a cold temperature trip
Wind conditions according to IEC 61400-1 (ed. 2) for the standard temperature range	100 m hub height: 7.5 m/s @ 18 % turbulence (IEC TC IIIa sites) 75, 85 m hub height: capable of both 7.5 m/s @ 18 % turbulence and 8.5 m/s @ 16 % turbulence (both IEC TC IIIa and IIb sites)
Maximum extreme gust (3 s) according to IEC 61400-1 (ed. 2) for the standard temperature range	TC IIIa sites: 52.5 m/s TC IIb sites: 59.5 m/s

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		

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2 GE 2.5xl 50 & 60 Hz Product Acoustic Specifications; per IEC-61400-11

2.1 GE 2.5xl Product Normal Operation Apparent Sound Power Level

The **Table 1** provides GE 2.5xl wind turbine acoustic specifications relative to wind speed V_{10m} per IEC-61400-11 standard:

Wind speed at V_{10m} [m/s]	$L_{WA,k}$ Apparent sound power level [dBA RE. 10^{-12} W]	σ_P product variability [dB]
3	≤ 95	-
4	≤ 96	-
5	≤ 99	-
6	≤ 102	-
7	≤ 105	-
8	≤ 105	≤ 1.0
9	≤ 105	≤ 1.0
10	≤ 105	≤ 1.0
11- cut out	≤ 105	≤ 1.0

$L_{WA,k}$ indicates apparent sound power level per IEC 61400-11 standard measured in dBA, A-weighted 10 times logarithmic value of apparent sound power level value relative to reference [illegible] 10^{-12} W

Table 1. Normal operations GE 2.5xl product apparent sound power level

2.2 GE 2.5xl Product Normal Operation 95% Rated Power Noise Emission Guarantee

The GE 2.5xl product apparent sound power level for one wind turbine unit operating in normal operation at 95% rated electrical power shall be:

- **$L_{WA,K}$ ≤ 105.0dBA** (referenced to 1E-12W) at 95% rated electrical with product variation **σ_P ≤ 1.0dB** when test reproducibility **σ_R ≤ 1.0dB** ; per IEC-61400-11
- Tonal noise relative level **$\Delta L_{a,k}$ ≤ 4 dB** ; per IEC-61400-11

The GE 2.5xl product **guaranteed performance** for apparent sound power level on **normal operations** shall be: **$L_{WA,K}$ + 1x σ_P ≤ 106.0dBA** (referenced to 1E-12W) at 95% rated electrical; per IEC-61400-11

2.3 Terms Definition

Terminology per the IEC 61400-11 standards:

- $L_{WA,K}$ is wind turbine apparent sound power level (referenced to 1E-12W) measured with A-weighting as function of hub height wind speed V_{10m}. Derived from multiple measurement reports per IEC 61400-11, it is considered as a mean value.
- σ_P is the product variation i.e. the maximum 2.5xl unit-to-unit product variation
- σ_R is the overall measurement testing reproducibility
- $\Delta L_{a,k}$ is the tonal noise relative to the broadband noise level, described as potentially audible narrow band sound

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