SUZLON

POWERING A GREENER TOMORROW

Technical Specification
Wind Turbine Generator

S111-2.1 MW

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1 Responsibility

Technical approval: Chief Systems Engineer

Product approval: Technical Product Manager

Release: Program Manager

List of changes*

Issue/Revision	Name/Date	Change aspect (by buyer, manufacturer or developer)
01-00	Lutz Stiller 2014-02-24	New document, all variants included

* Changes to the design of the wind turbine generator (WTG) from the standard detailed in this specification have to be made as follows:

Buyer originated changes
This specification can be revised by Specification Change Notices (SCN) which describe the changes to be made to the specification.

Manufacturer originated changes
This specification can be revised by the seller without the buyer's consent to incorporate development changes if such changes do not adversely affect price, delivery, guaranteed performance of the WTG, or the interchangeability or replaceability requirements of this specification.

Development changes
Development changes are changes considered necessary to improve the WTG, prevent delays or to ensure compliance with the purchase agreement. The seller has to notify the buyer of all changes that are made as described in this section, by giving the buyer revised pages for this specification on a periodic basis.

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2 Preamble

Preamble

This technical specification describes the S111-2.1 MW wind turbine generator. The specification has to be recognised by its reference "Technical Specification Wind Turbine Generator" S111-2.1 MW at Issue/Revision 01-00. The seller must not recognise this specification at any other issue or revision level unless accepted by him in writing. Each page carries its specific revision date and revision code. Chapter numbers that are not included in this specification are unassigned.

If typographical errors or conflicts exist between a customer purchase agreement and this standard specification, SUZLON Energy Ltd. reserves the right to issue a revision or a temporary revision. It is the user's responsibility to ensure to have the correct issue and revision level where applicable. The information in this document contains a general description of the technical options available which may not apply in all cases. Some technical options cannot be combined or require additional technical options. The required technical option is therefore to be specified in the contract.

This document can be revised by SUZLON and its affiliates without consent or prior notice to incorporate development changes if such changes do not adversely affect price, delivery, guaranteed performance, functionality, integrity and safety of the WTG.

Reconciliation with purchase agreement

In the event of any conflict or discrepancy between this specification and the purchase agreement, the controlling document must be the purchase agreement.

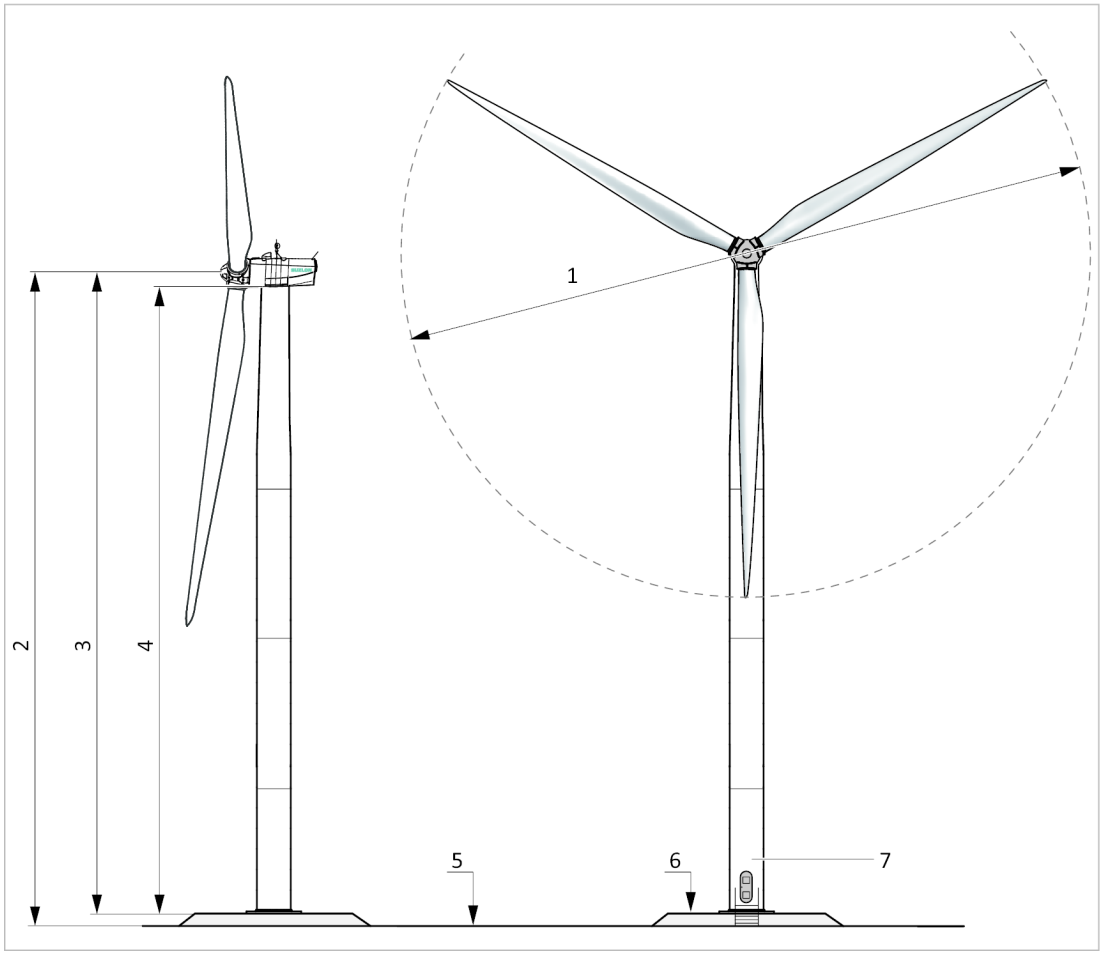
Reconciliation with illustrations

The illustrations contained in this specification are intended to assist in understanding the text and do not form part of this specification for contractual purposes, except where otherwise stated.

Specification precedence

In the event of any conflict or discrepancy between the requirements of this specification and any other specification referred to in this specification the requirements of the text of this specification must be held to govern.

3 Basic data



Dimensions of wind turbine generator (WTG)

1	Rotor diameter	111.80 m
2	Hub height	90 m | 120 m (depends on tower type [▷ 13])
3	Rotor height	Refer to [▷ 15]
4	Tower height	Refer to [▷ 15]
5	Ground top level	Site-specific (0 m)
6	Foundation level	Site-specific (1 m)
7	Tower type	Tubular steel tower | Hybrid lattice tower | Hybrid concrete tower

3.1 General data

Description	Information
WTG type	Pitch regulated with active yaw and a three blade rotor
Rotational direction	Clockwise (front view)
Rotor orientation	Upwind
Main brake system	Blade pitch control
Second brake system	Disk brake

3.2 Design data

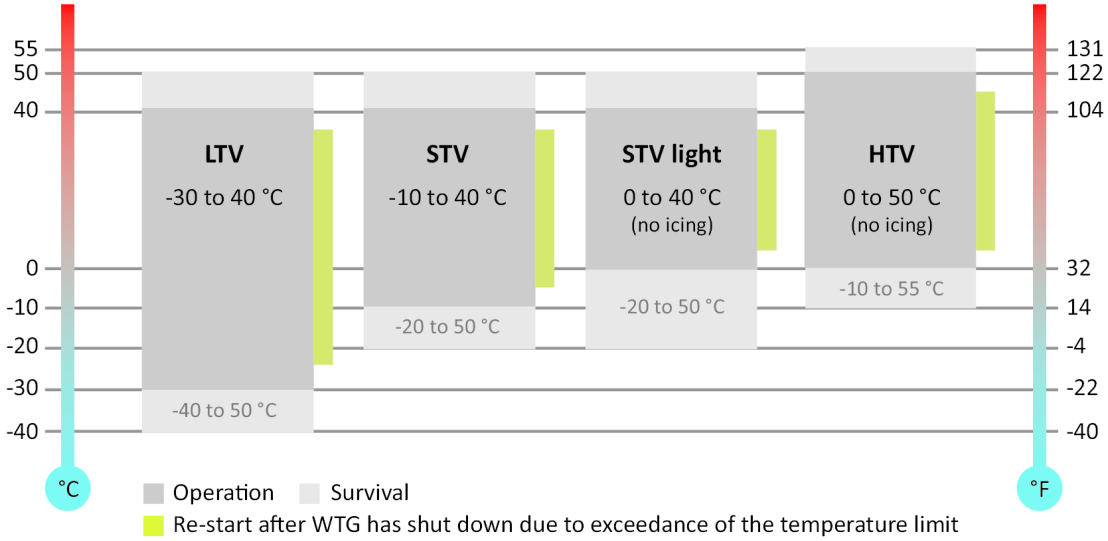
Description	Information
Wind class	IIIa
WTG certification/design codes	IEC 61400 edition 3 (refer to "TGX-CE-R-TPC-02545 Design Basis S11x" for details)
Quality standard	ISO 9001
Estimated service life	20 years
A-factor	8.46 m/s
Form factor, c	2.0
Ice/snow on blades	Considered in calculation of structural design
Annual average wind speed	7.5 m/s
Vertical average shear component	0.2
Extreme wind speed	37.5 m/s (10-minute average)
Survival wind speed	52.5 m/s (3-second average)
Characteristic turbulence intensity according to IEC 61400 (15.0 m/s)	16.0% (according to IEC edition 3; equivalent to 18% GL2010)
Air density	1.225 kg/m³
Altitude (refers to tower bottom ground level)	Max. 2000 m above sea level If the altitude exceeds maximum level special considerations must be taken regarding e.g. power and cooling performance. Consult SUZLON for further information.

3.3 Operating data

Description	Information	
Rated power at rated wind speed	2.1 MW	
Rotor speed range	9.4 to 13.0 rpm	
Power regulation	Active pitch regulated	
Rated wind speed	10.0 m/s (without turbulence intensity according to IEC 61400)	
Cut in wind speed	3.0 m/s (30-second average)	
Cut out wind speed	30.0 m/s (3-second average)	
Cut out wind speed	21.0 m/s (10-minute average)	
Restart wind speed	18.0 m/s (10-minute average)	
Maximum overspeed (generator, max. 2 minutes without damage)	50 Hz: 1540 rpm	60 Hz: 1850 rpm

3.4 Climate conditions

Description	Information
Temperature variants	STV: Standard temperature variant STV light: Standard temperature variant light LTV: Low temperature variant HTV: High temperature variant
Ambient temperature range	See following figure.



Beyond the ambient temperature range for operation the WTG shut down. Values refer to hub height.

Description	Information
Permissible relative ambient humidity	0 to 100%
Permissible relative humidity during operation (outside cabinet, inside WTG)	30 to 99% (no precipitation)
Permissible relative humidity during operation (inside cabinet)	20 to 95% (no precipitation)

3.5 Corrosion protection

The corrosion protection applies in accordance with ISO 12944-2.

Description	Information	
Corrosion protection class	External areas	Internal areas
	C4 High	C4 High
	C5-M High (optional)	C4 High
Corrosion protection	Anti-corrosion paint (dry film thickness according corrosion protection class)	

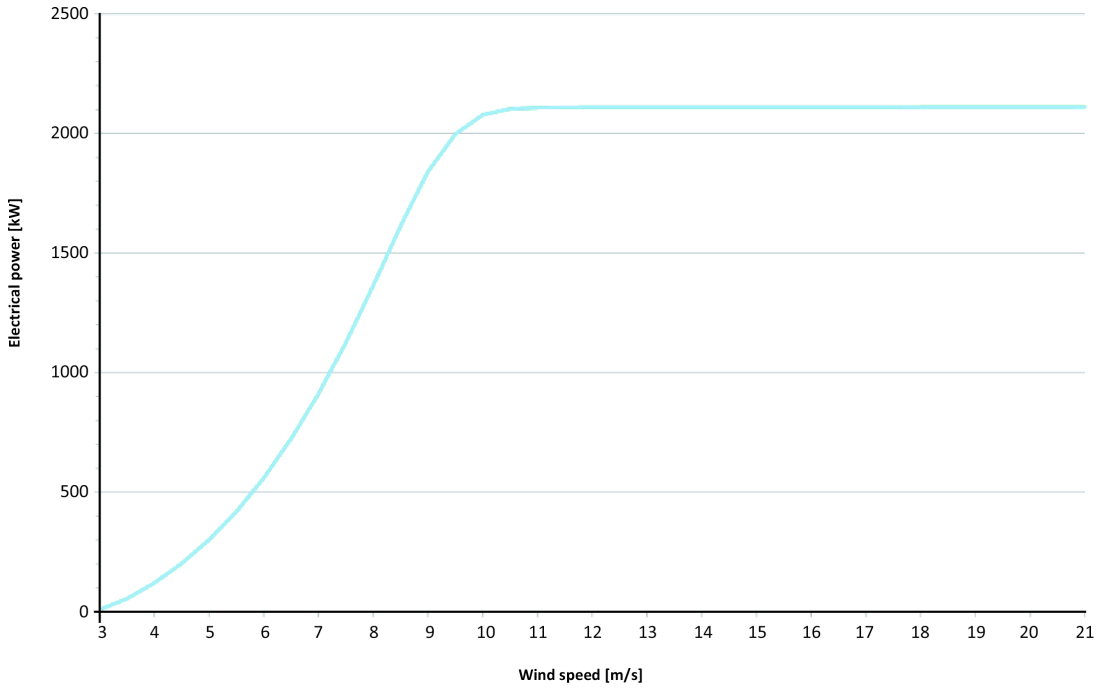
3.6 Noise curve and tonality

For noise curve refer to "TGX-CD-G-TGA-02555_Sound_level_S111".

The tonality applies according to the noise curve and in accordance with IEC 61400-11. With an optional reduction kit the tonality of the measured sound power level will be below $\Delta L_a \leq 0$ dB at a distance above 500 m from the tower base.

3.7 Power curve

Description	Information	
Energy yield (air density 1.225 kg/m³)	Annual average energy yield	Annual average wind speed
	6578 MWh/a	6.0 m/s
	7527 MWh/a	6.5 m/s
	8432 MWh/a	7.0 m/s
	9235 MWh/a	7.5 m/s
	9944 MWh/a	8.0 m/s
	10555 MWh/a	8.5 m/s
	11067 MWh/a	9.0 m/s
Turbulence intensity for power curve	10% at 15 m/s (variable with windspeed)	
Power curve as a function of air density	Refer to "Official power curve – different air densities"	



Power curve according to wind class IIIa and air density 1.225 kg/m³
The released power curve has been created according to IEC 61400-12 guidelines. The actual power curve on specific sites varies due to site-specific conditions.

Wind speed [m/s]	Electrical power [kW]	c_p [–]	c_t [–]
3.0	8.4	0.0516	0.8926
3.5	54.9	0.2123	0.8965
4.0	120.6	0.3122	0.8839
4.5	202.2	0.3677	0.8609
5.0	300.6	0.3985	0.8403
5.5	418.4	0.4168	0.8326
6.0	559.6	0.4293	0.8348
6.5	723.8	0.4368	0.8374
7.0	912.0	0.4406	0.8368
7.5	1125.8	0.4422	0.8290
8.0	1363.4	0.4413	0.8082
8.5	1613.8	0.4355	0.7724
9.0	1841.4	0.4186	0.7101
9.5	1997.1	0.3860	0.6217

Wind speed [m/s]	Electrical power [kW]	c_p [–]	c_t [–]
10.0	2078.6	0.3445	0.5249
10.5	2100.0	0.3011	0.4369
11.0	2100.0	0.2625	0.3680
11.5	2100.0	0.2298	0.3149
12.0	2100.0	0.2023	0.2732
12.5	2100.0	0.1790	0.2394
13.0	2100.0	0.1592	0.2115
13.5	2100.0	0.1421	0.1881
14.0	2100.0	0.1274	0.1684
14.5	2100.0	0.1147	0.1516
15.0	2100.0	0.1036	0.1371
15.5	2100.0	0.0939	0.1245
16.0	2100.0	0.0854	0.1136
16.5	2100.0	0.0779	0.1040
17.0	2100.0	0.0712	0.0955
17.5	2100.0	0.0653	0.0881
18.0	2100.0	0.0600	0.0814
18.5	2100.0	0.0552	0.0754
19.0	2100.0	0.0510	0.0701
19.5	2100.0	0.0472	0.0653
20.0	2100.0	0.0437	0.0609
20.5	2100.0	0.0406	0.0570
21.0	2100.0	0.0378	0.0534

Wind speed, electrical power, c_p and c_t according to wind class IIIa and air density 1.225 kg/m³

4 Features and options

		Standard 50 Hz	India 50 Hz	Europe 50 Hz	North America 60 Hz	Brazil 60 Hz
Temperature/environmental						
STV (Standard Temperature Version)		●	–	●	○	●
STV light (Standard Temperature Version light)		–	●	–	–	–
LTV (Low Temperature Version)		–	–	○	●	–
HTV (High Temperature Version)		–	○	–	–	○
Air densitiy	1.225 kg/m³	●	–	●	●	●
	1.2 kg/m³	–	●	–	–	–
Corrosion protection class	C4 High	●	●	●	●	●
	C5-M High	○	○	○	○	○
Towers/accessories						
Tubular steel tower 90 m hub height		●	○	●	●	●
Hybrid lattice tower 120 m hub height		–	●	–	–	–
Hybrid concrete tower 120 m hub height		○	–	○	○	○
Climbing device	Ladder	●	●	●	●	●
	Service lift	○	○	○	○	○
	Climbing assistance	○	○	○	○	○
POT (Power out Tower – transformer outside tower)		●	●	○	●	●
PIT (Power in Tower – transformer inside tower)		○	–	●	–	–
Software/control packages						
SCADA (Supervisory Control and Data Acquisition)		○	○	○	○	○
SC-POWER PLANT CONTROLLER		○	○	○	○	○
CMS (Condition Monitoring System)		○	○	○	○	○

Standard ● / Option ○ / not available –

		Standard 50 Hz	India 50 Hz	Europe 50 Hz	North America 60 Hz	Brazil 60 Hz
Further features						
Fire suppression system		○	○	○	○	○
Tonality reduction kit (nacelle attenuation)		○	–	○	○	○
Reduced sound power level (nacelle attenuation and power reduced mode)		○	–	○	○	○
Aviation light	Mounting provision	●	●	●	●	●
	Lights	○	○	○	○	○
Comlicance	CE	–	–	○	–	–
	UL	–	–	–	○	–
	CSA	–	–	–	○	–

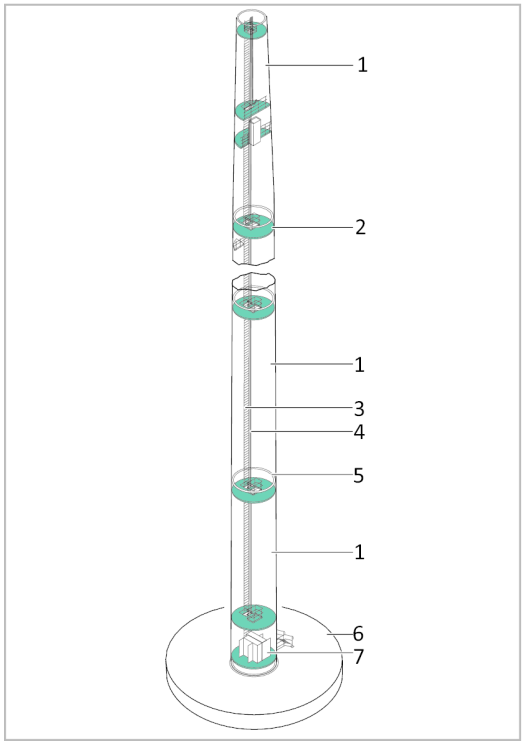
Standard ● / Option ○ / not available –

5 Mechanical design

5.1 Foundation and tower

Tubular steel tower

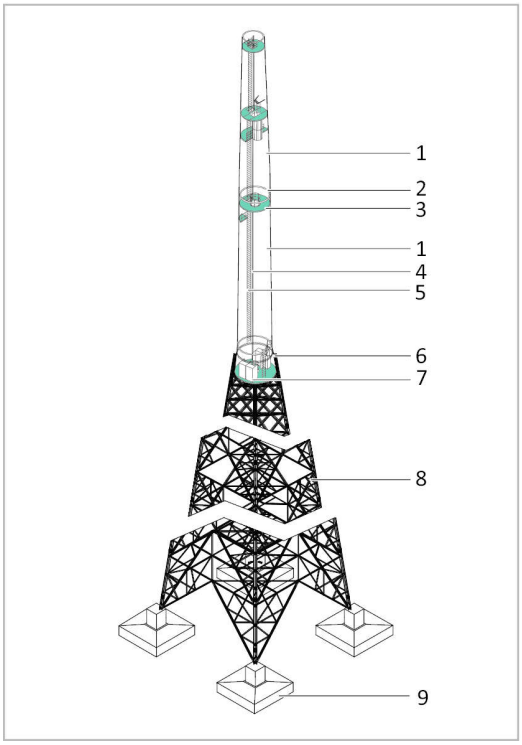
The tubular steel tower consists of sections [1] joint by means of bolted flanges [5]. The tower is built on the foundation [6] using anchor bolts, which are set into concrete at the foundation. The tower can be climbed from the inside and is equipped with working platforms [2] and a ladder [3] with fall protection system. Optionally, a service lift or climbing assistance can be installed. The bottom cabinet sections [7] are arranged in the tower bottom. The cabinet sections are connected to the generator and the top cabinet in the nacelle via power and control cables [4]. At the tower top the cables are routed through a cable loop. It allows the nacelle to turn several times in each direction without damaging the cables. The power cables between WTG and grid are routed through conduits. The tower is protected against corrosion with a special sandblasting procedure and by applying an epoxy resin coating to the tower surface. The foundation is project-specific, depending on the ground conditions and the local rules and regulations.



Description	Information
Type	4 section tubular steel tower
Material	Welded steel plate according to EN 10025
Net weight	176 t (refer to TDC0002-02 "Transport" for details)
Heights	Tower: 87.10 m Rotor: 89.00 m Hub: 90.00 m
Top outer diameter	3.02 m (refer to TDC0002-02 "Transport" for details)
Bottom outer diameter	4.30 m (refer to TDC0002-02 "Transport" for details)
Foundation	Project-specific
Colour outside	RAL 9003

Hybrid lattice tower

With hybrid lattice tower greater hub heights can be achieved. It consists of the three components lattice tower [8], adapter [6] and tubular tower [1].
The lattice tower is set on the foundation and is assembled directly at site. Adapter connects the lattice tower to the tubular tower. The tubular tower consists of sections joint by means of bolted flanges [2].
The tower can be climbed from the inside and is equipped with working platforms [3] and a ladder [5] with fall protection system.
Optionally, a service lift or climbing assistance can be installed. The bottom cabinet sections [7] are arranged in the adapter. The cabinet sections are connected to the generator and the top cabinet in the nacelle via power and control cables [4]. At the tower top the cables are routed through a cable loop. It allows the nacelle to turn several times in each direction without damaging the cables. The power cables between WTG and grid are routed through conduits. The tower is protected against corrosion with special coating. The foundation is project-specific, depending on the ground conditions and the local rules and regulations.



Description	Information
Type	Hybrid lattice tower (lattice tower, adapter, tubular tower)
Material	S355
Net weight	206 t (refer to TDC0002-02 "Transport" for details)
Heights	Tower: 118.10 m Rotor: 118.50 m Hub: 120.00 m
Dimensions	Refer to TDC0002-02 "Transport" for details
Foundation concrete	C30/37
Foundation reinforcement	BSt500S
Colour	RAL 9003 (tubular sections outside)

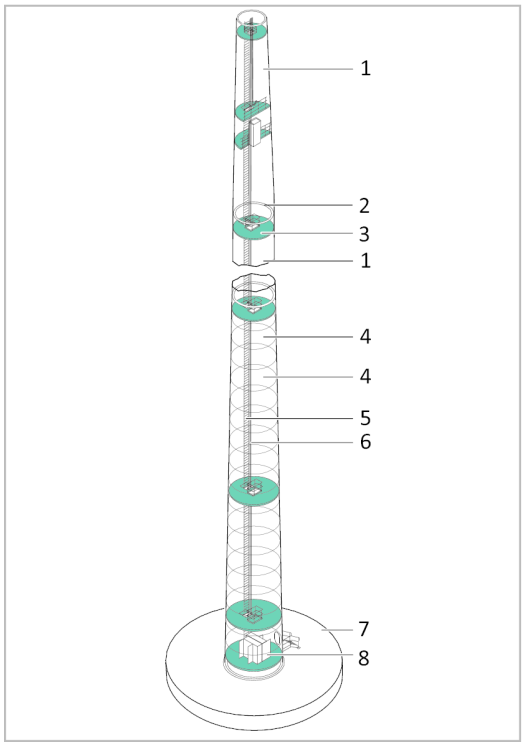
Hybrid concrete tower

Hybrid concrete towers are precast towers developed to suit different hub heights and wind condition. Concrete tower can be tailored to meet specific requirements. Concrete adds value in the area of:

- High durability
- Better fatigue properties
- Higher material damping properties
- Flexibility of design
- Minimization of the transportation cost
- Reduced maintenance cost

The concrete tower consists of separate prefabricated component sections [4]. These sections are assembled directly at site. The tubular tower consists of sections [1] joint by means of bolted flanges [2].

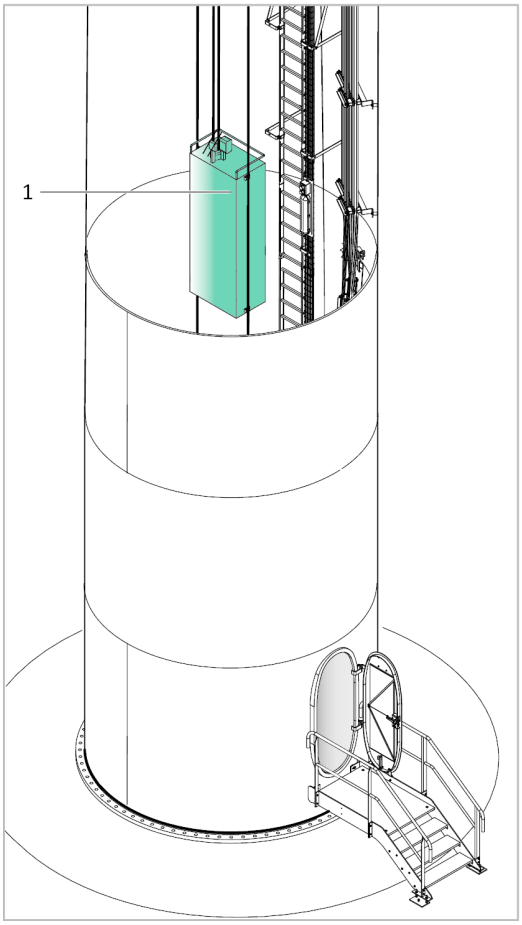
The tower can be climbed from the inside and is equipped with working platforms [3] and a ladder [5] with fall protection system. Optionally, a service lift or climbing assistance can be installed. The bottom cabinet sections [8] are arranged in the tower bottom. The cabinet sections are connected to the generator and the top cabinet in the nacelle via power and control cables [6]. At the tower top the cables are routed through a cable loop. It allows the nacelle to turn several times in each direction without damaging the cables. The power cables between WTG and grid are routed through conduits. The foundation [7] is project-specific, depending on the ground conditions and the local rules and regulations.



Description	Information
Type	Hybrid concrete tower
Hub height	120 m
Dimensions	Refer to TDC0002-02 "Transport" for details

5.1.1 *Service lift/climbing assistance*

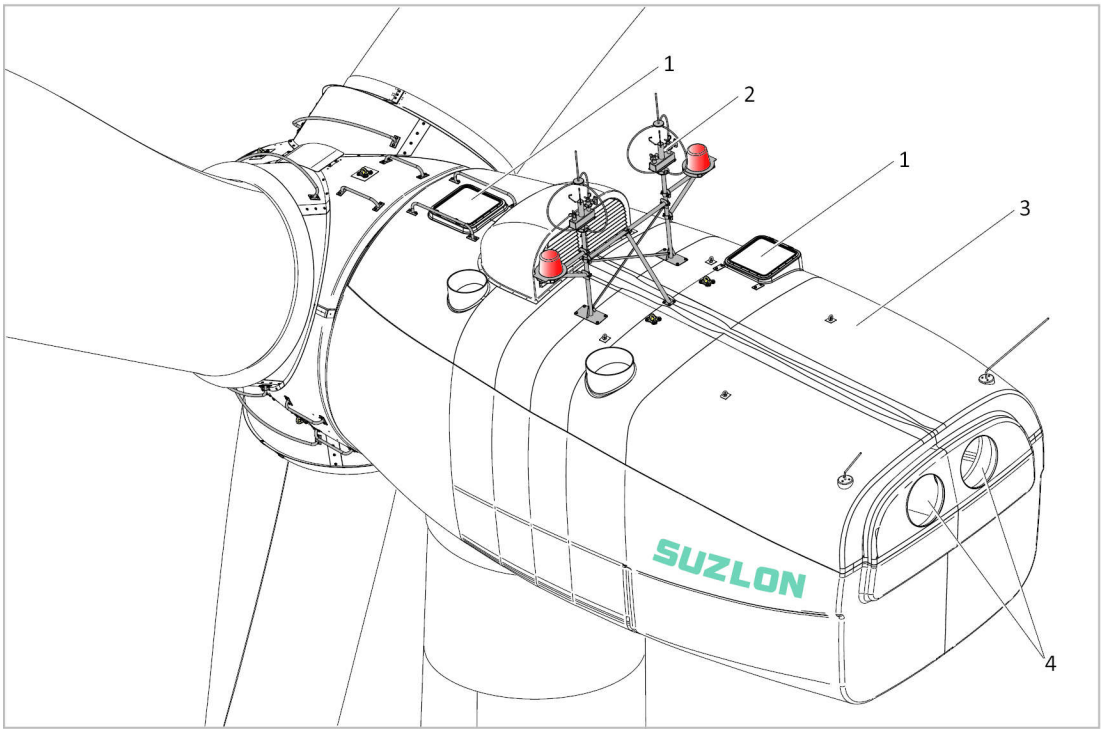
The service lift [1] is meant to transport staff and their equipment up and down easily. The service lift is constructed for permanent installation inside the tower. Function and equipment depends on supplier. In general the transportation is performed by means of a pressure system with an automatic safety control device. Additionally, a fast driving tempo is guaranteed. Upward and downward movement can be controlled by an electric control box from inside the cabin or from outside the cabin trough an open window. A lifting force limiter prevents upward movement in case of an overload of the cabin. Two guide wires on both sides of the cabin prevent the service lift from swinging.
The climbing assistance improves climber comfort. In general it consists of an endless rope which is fastened to the staffs harness with a clamp. Function and equipment depends also on supplier. Giving a gentle tug starts a motor which pulls on the rope. The rope runs along the ladder and the pull weight is set by the staff. The safety systems ensure that the staff can stop the system at any time because the pull weight is set so that the staff only need stand still on the ladder and after a few seconds without movement, the pull force stops.



Description	Information
Service lift (rounded data, specification depends on supplier)	
Load capacity	240 to 320 kg, max. 1 to 3 persons (higher load capacities available)
Speed	18 m/min
Climbing assistance (rounded data, specification depends on supplier)	
Adjustable pulling force	35 to 45 kg

5.2 Nacelle

The nacelle consists of the following main parts: main frame and girder system that carries the drive train, as well as top cabinet and on-board hoist. The nacelle is covered by the nacelle housing and connected to the tower via the yaw assembly.
The nacelle housing [3] protects the internal components against various ambient conditions. Two access hatches [1] in the nacelle housing provide access to the measuring instruments [2] on the nacelle roof and the rotor.
The nacelle housing is made in sandwich construction to avoid a quick cool down. The nacelle is equipped with several fan heaters [4]. The temperature is controlled by temperature sensors controlled via the SCS.



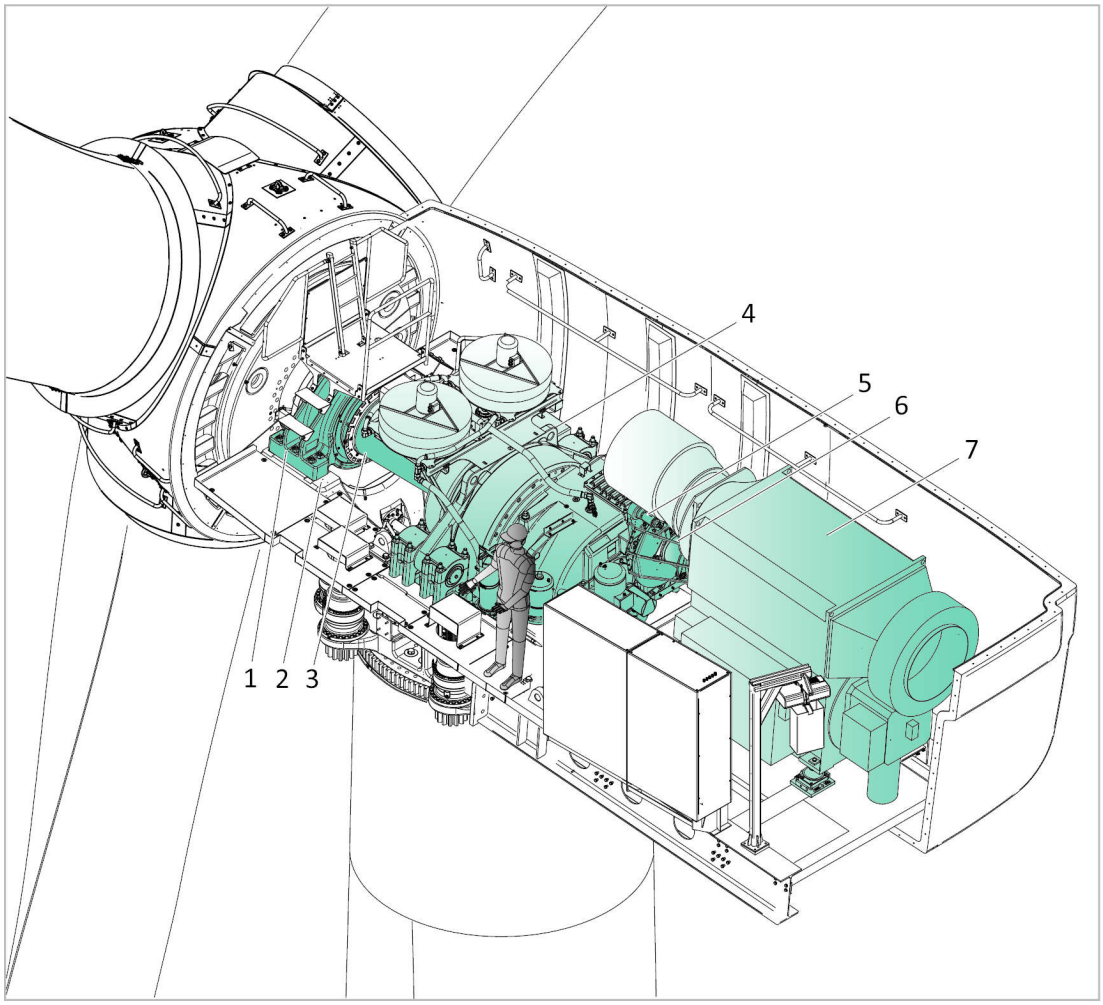
Description	Information
Net weight	74.5 t (refer to TDC0002-02 "Transport" for details)
Colour	RAL 9003

5.2.1 Drive train

The drive train belonging components transmit and convert the rotor speed to the generator.

The main shaft is supported by the main bearing on the rotor side. A shrink disc connects the main shaft to the gearbox. Inside the gearbox the main shaft is supported by a cylindrical roller bearing. The main shaft is hollow to guide the hub cables.

In a defined temperature range, the main bearing housing of the WTG is preheated during the start procedure by a fan heater (LTV variant only). The main bearing fan heater is directly connected to the grid. It is independent from the SCS, switched by a second thermostat for holding the temperature in the nacelle in case of a SCS failure.



1 Main bearing
2 Main frame
3 Main shaft
4 Gearbox
5 Mechanical brake
6 High speed shaft
7 Generator

Description	Information
Main frame	
Type	Cast frame
Material	EN-GJS-400
Main shaft	
Type	Forged shaft and flange
Material	42CrMo4
Main bearing	
Bearing type	Spherical roller bearing

Description	Information	
Housing type	Cast housing, flanged feet	
Housing material	EN-GJS-400	
Lubrication	Centralised automatic lubrication system (CALS) for main and yaw bearing Tank capacity: 8 l	
Heating	STV, STV light, HTV:	No heating
	LTV:	1 fan heater

Gearbox

The gearbox converts the low rotor speed of the main shaft into high rotational speed which is necessary for generator operation.
A mechanical oil pump supplies the gearbox with oil. The oil is filtered by a micro-filter system and comprises an oil-cooling device.
The internal oil heating is equipped with heating rods. It operates when the oil sump temperature is below a defined temperature value.

External fan heaters are mounted underneath the gearbox. If the oil temperature is below a defined value, the gearbox is heated before it starts operating (LTV variant only).

Description	Information	
Type	1 planetary stage, 2 helical stages	
Housing material	Cast	
Gearbox mount material	Elastomer	
Shaft seals	Maintenance-free labyrinth seals	
Cooling	Forced oil cooling lubrication system	
Mechanical power	2.3 MW	
Heating	STV, STV light, HTV:	No heating
	LTV:	2 fan heaters, 3 oil sump heaters
Gear ratio	50 Hz: 1:90	60 Hz: 1:108
Oil capacity	Max. 500 l (max. oil exchange intervall: 5 years)	
Gearbox - electric oil pump Voltage (phase to phase)	3 × 690 V	

High speed shaft coupling

The flexible coupling transmits the torque of the gearbox high speed output shaft to the generator input shaft.

Generator

The WTG is equipped with a doubly-fed induction generator (DFIG) with a converter in the rotor circuit of the generator.
During operation, the stator side of the generator is permanently connected to the grid. The rotor windings are connected to the grid via slip rings and a converter that controls both the rotor and the grid current. Thus, rotor frequency can freely differ from the grid frequency. By controlling the rotor current with the converter it is possible to adjust the active and reactive power fed to the grid from the stator and rotor.

An air cooling system keeps the generator at an optimal operating temperature.

The generator is equipped with anti-condensation heaters which are activated when the generator is not in operation (generator switched off or rather is disconnected from the grid) and vice versa. This is done to keep the air temperature inside the generator (not in operation) slightly higher than the surrounding ambient temperature to prevent condensation of moisture inside generator on active parts.

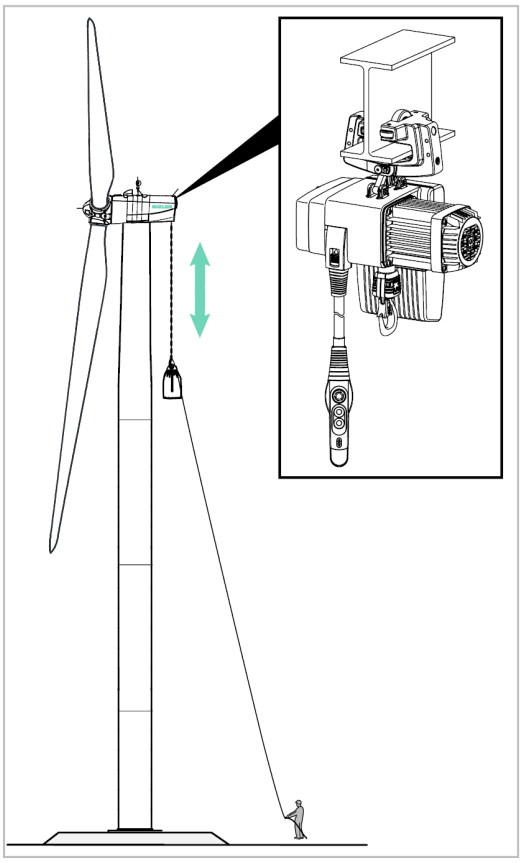
The generator bearings are equipped with a time-controlled centralised automatic lubrication system (CALS).

For technical data refer to Chapter "Electrical Design" [▶ 35].

5.2.2 On-board hoist

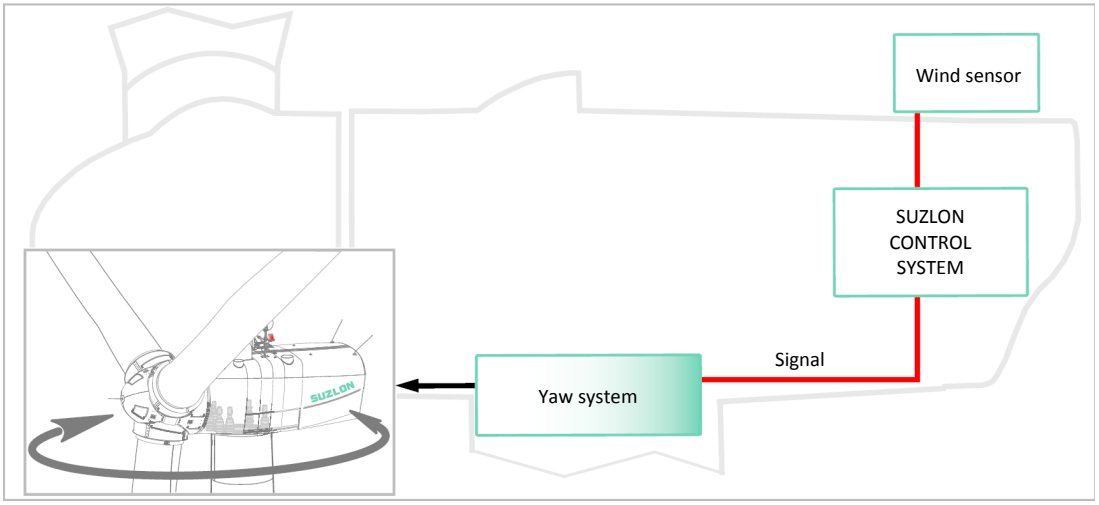
The on-board hoist is located inside the nacelle to carry material items into and out of the nacelle through a hatch. The on-board hoist is driven by an electric motor and attached to the nacelle housing underneath the roof.

Type	Stepless chain hoist
Load capacity	500 kg



5.2.3 *Yaw system*

The yaw system is used to ensure an optimal alignment of the nacelle/rotor to the wind. The wind direction is measured by two independent wind sensors at the equipment frame on the nacelle roof. The sensors transmit the measured values to the SCS. The yawing is performed by the electromechanical yaw drives, which are activated as soon as the SCS recognises a certain predefined difference between the rotor axis and the current wind direction. The yaw angle sensor measures the actual position of the yaw system. The sensor is located on the gear rim and counts the number of turns the nacelle performs in the given direction to avoid cable twist. If the nacelle turns more than a predefined number of times in the same direction, the WTG shuts down temporarily and starts untwisting automatically. Afterwards the WTG restarts automatically. In case the yaw angle sensor fails, the yaw twist stop switch activates the safety chain.



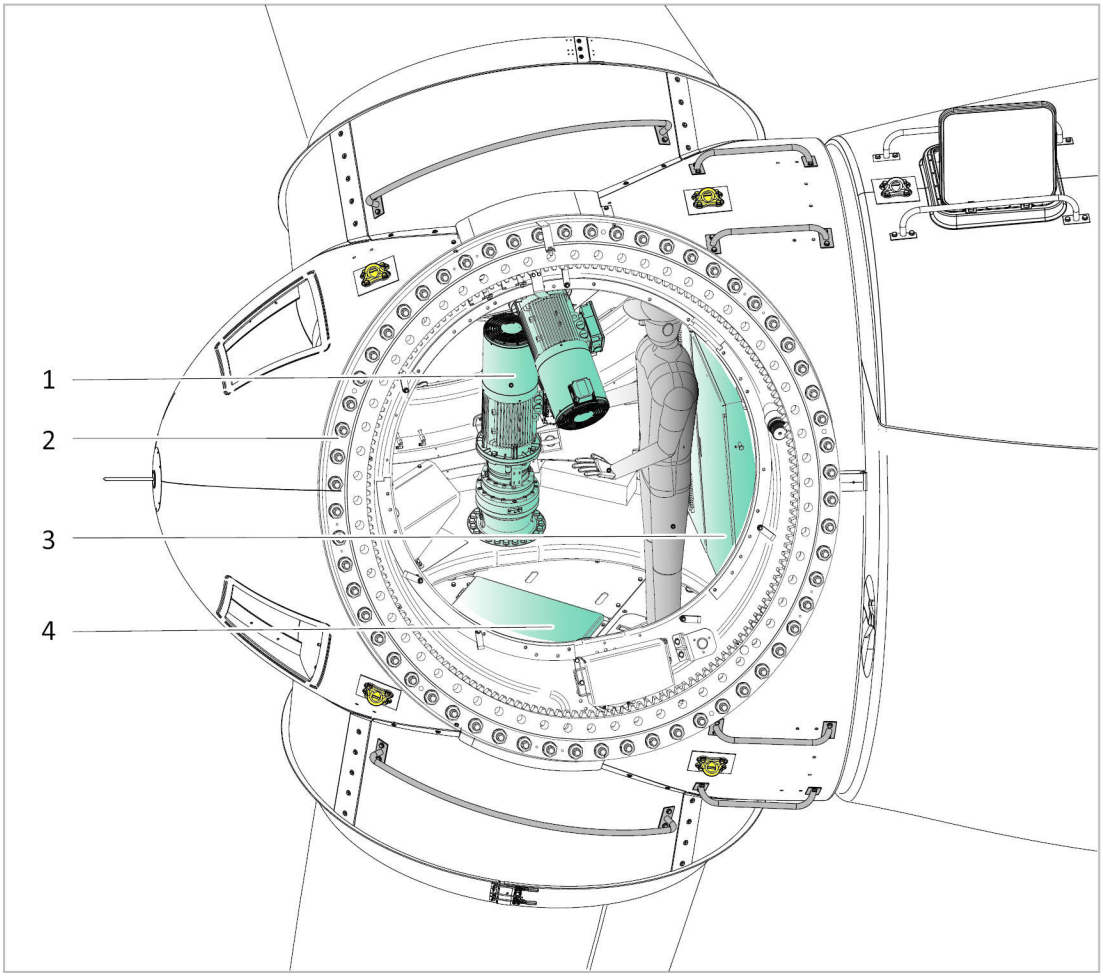
Description	Information
Yaw bearing	
Type	Friction bearing with gear rim
Lubrication yaw bearing	Centralised automatic lubrication system (CALS) for main and yaw bearing Tank capacity: 8 l
Lubrication yaw bearing gear rim	Centralised automatic lubrication system (CALS) Tank capacity: 4 l

Description	Information	
Yaw drives		
Type	Compact cantilever drive	
Quantity	6	
Yaw speed	50 Hz: 0.37 °/s	60 Hz: 0.44 °/s
Breakdown speed	900 rpm (corresponds to 0.42 rpm at output pinion corresponds to 0.039 rpm transferred to nacelle)	
Voltage (phase to phase)	3 × 690 V	
Rated output power	3.0 kW per drive	

5.3 Rotor

The rotor consists of:

- hub
- nose cone (covers the hub)
- three blades



1	Pitch motor	3	Blade bearing
2	Hub cabinet	4	Battery box

A double-row ball bearing connects each blade to the hub. The hub transmits the rotor speed via the drive train to the generator. The pitch system is meant to rotate the blades [▷ 27].

Description	Information
Swept Area	9852 m²
Rotor speed at rated power	13.0 rpm
Tip speed at rated power	76.0 m/s

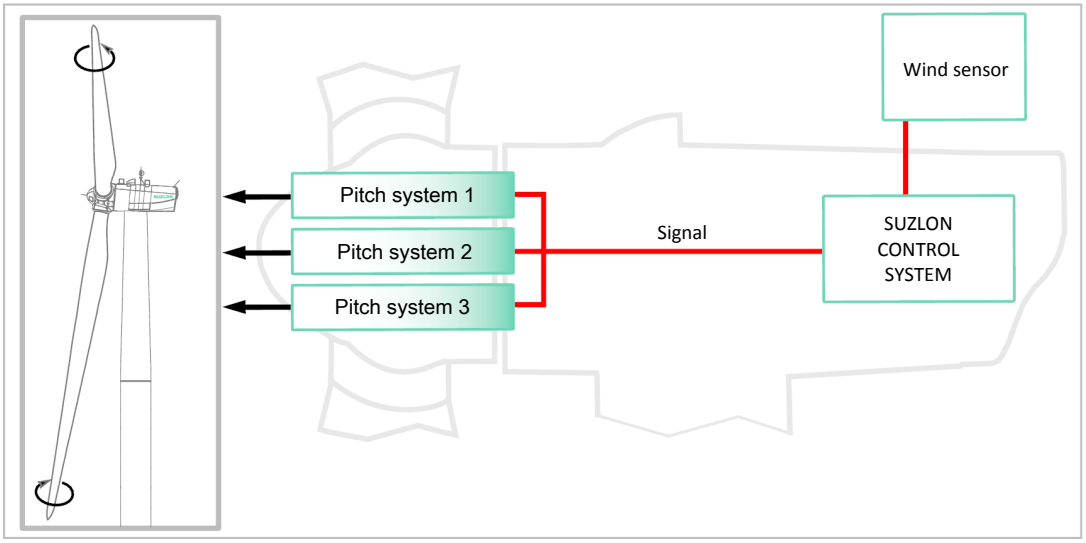
Description	Information
Rotor cone angle	3.5°
Main shaft tilt angle	5°
Power regulation	Electric blade pitch control
Net weight (without blades)	21 t (refer to TDC0002-02 "Transport" for details)
Colour	RAL 9003

Blades

Description	Information
Type	SB54
Quantity	3
Length	54.6 m
Material	Glass-reinforced Epoxy, vacuum-infused
Blade flange	Glass-reinforced Epoxy, vacuum-infused. Hub connection with barrel nuts.
Largest chord	3.94 m
Type of aerodynamic brake	Pitch/full blade
Profiles	Risø C2
Net weight	10.8 t (+0.215 t/-0.415 t) (refer to TDC0002-02 "Transport" for details)
Colour	RAL 9002, RAL 7035, RAL 9015

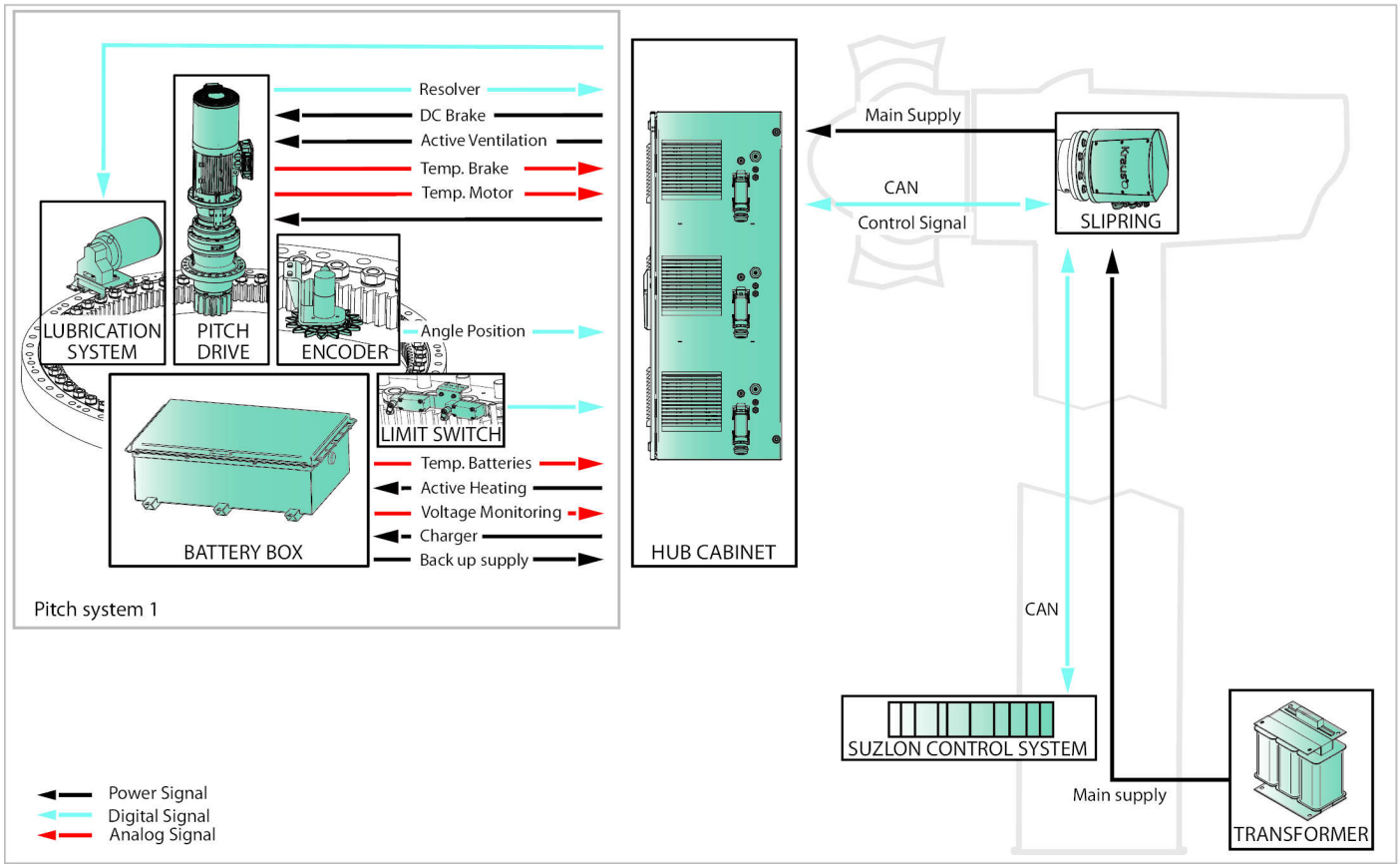
5.3.1 Pitch system

The pitch system regulates the rotor speed to given set points. It is used as aerodynamic brake in addition to the mechanical brake Hydraulic system. The pitch system operates as follows: Below the nominal wind speed, the pitch angle is set to a defined blade angle. Once the wind speed reaches nominal speed, the pitch system starts to adjust the pitch angle to limit the rotor speed of the WTG to nominal speed. The optimal energy output is reached at nominal rotor speed.
Each blade has its own pitch drive system consisting of an electrical motor with gear box driven by a frequency converter, a battery backup system and a forced ventilation system. The SCS transmits the required set points for the blade position. Each blade is controlled separately and independently by the respective frequency converter that is connected with the SCS via a CAN bus interface. The pitch drive motors are located inside the hub and equipped with an internal brake, which holds the blade position when the pitch system is not active.



The battery backup, located in battery boxes inside the hub, ensures the individual pitch drive functionality, even if grid connection is not available. In this case the WTG stops immediately and the blades pitch into feathering position using the battery boxes belonging to the battery backup system. The UPS belonging to the SCS shuts down the WTG in case of no grid connection. The supply and communication cables from hub to the nacelle are routed through the hollow main shaft. A slip ring behind the gear box transmits the electric signals from a static to a rotational condition.

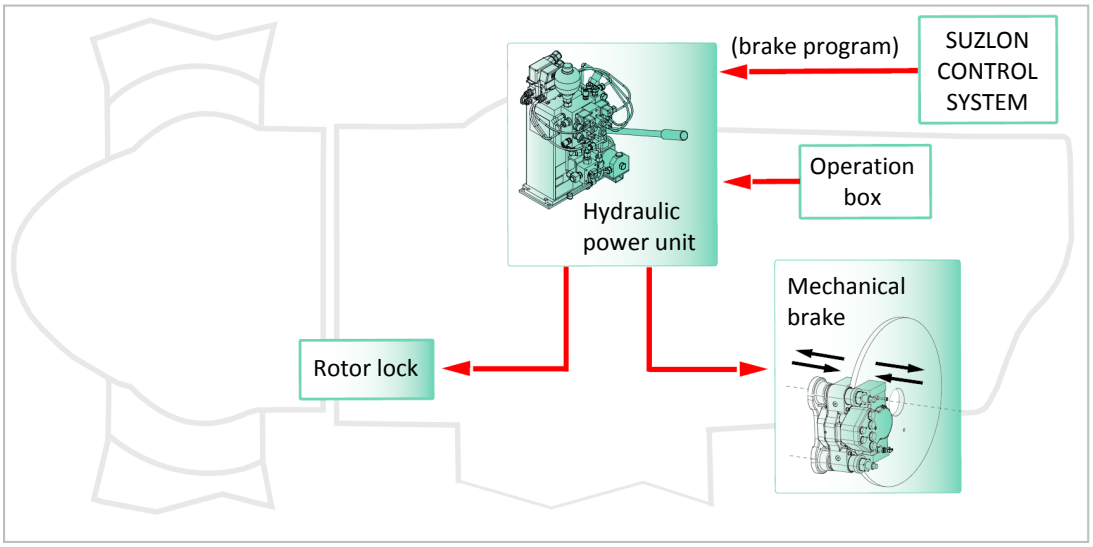
The temperature inside the battery boxes is monitored anytime. The pitch system is equipped with one heater within each battery box. It heats up the battery backup system and prevents humidity inside the battery box. Heating is controlled via thermostats. A temperature sensor is installed inside each battery box. The temperature sensor forces the WTG not to start in case of low battery temperature or to shut down the WTG safely in case of high temperatures of the batteries. Each pitch drive is equipped with an absolute encoder to localise the absolute position of the blade. The pitch drive speed is measured by a resolver at all times.



Description	Information
Type	Electric asynchronous motor with forced ventilation unit, electric motor brake (spring-applied), 3-stage planetary gearbox with output pinion, frequency converter and batteries
Pitch angle range (operating range)	–5 to 95°
Pitch system – blade bearing	
Type	Eight point contact ball bearing/PCD 2421 mm
Lubrication blade bearing and blade bearing gear teeth	Centralised automatic lubrication system (CALS) Tank capacity: 15 l
Pitch system – pitch drives	
Type	Electric asynchronous motor with forced ventilation unit, electric motor brake (spring-applied), 3-stage planetary gearbox with output pinion
Quantity	3 (1 per blade)
Pitch speed	0 to 4.5°/s
Emergency pitch speed	4.5 °/s
Rated output power	7.5 kW per drive
Pitch system – pitch batteries	
Quantity	30 (no booster)
Service life	2 to 4 years
Rated voltage per battery	12 V
Rated capacity per battery (20 hour rate)	7.2 Ah
Heater	STV, LTV: Applicable STV light, HTV: No heating
Thermal insulation	Applicable for STV and LTV

5.4 Hydraulic system

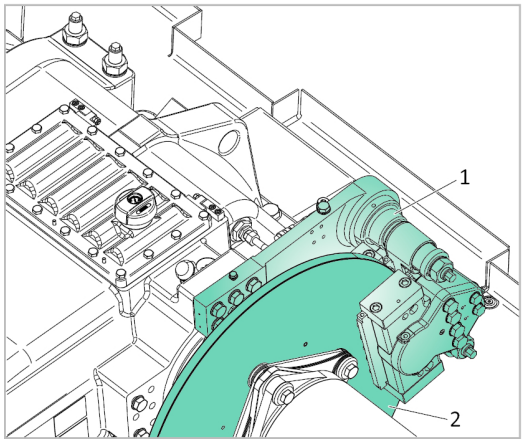
The hydraulic power unit provides the oil pressure that is required to actuate the mechanical brake and the rotor lock. It can be operated with the operation box or the hydraulic hand pump.



Description	Information	
Voltage (phase to phase)	50 Hz: 3 × 400 V	60 Hz: 3 × 400 V (IEC), 3 × 208 V (UL)
Power	0.75 to 1.5 kW	
Maximum hydraulic pressure	Mechanical brake: 10.3 MPa (103 bar) Rotor lock system: 70.0 MPa (700 bar)	
Oil capacity	Max. 6 l	
Heating	STV (light), HTV: LTV:	No heating One fan heater, power: 9 kW

Mechanical brake

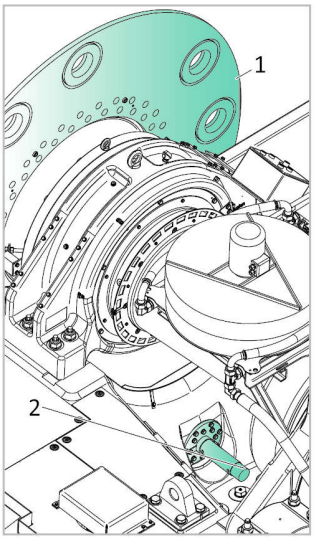
The mechanical brake is located on the high speed shaft between gearbox and coupling. It is used in addition to the aerodynamic brake [▷ 27]. The mechanical brake is applied by hydraulic pressure (active brake). The brake pads are pressing against the brake disc, thus braking the high speed shaft (HSS). The mechanical brake is only used to stop the WTG when it has already been slowed down by the aerodynamic brake (pitch system [▷ 27]). The mechanical brake operates at a very low rotor speed. It is only used as a parking brake to apply the rotor lock or in case of an emergency in the nacelle.
[1] Brake caliper
[2] Brake disc



Description	Information
Type	Hydraulic disc brake, activated by hydraulic pressure (active brake)
Brake disc	Material: steel Position: mounted on high speed shaft (HSS)

Rotor lock

The rotor lock stops the rotation of the rotor and the drive train mechanically. To prevent the rotation, the rotor lock pin moves into a defined hole in the rotor lock disc.
The rotor lock is applied e.g. during service and maintenance work. It provides additional personal safety when working inside the hub and on the nacelle/rotor roof.
The rotor lock disc is mounted on the main shaft inside the nacelle. The rotor lock pin is located underneath the main bearing and is operated by the hydraulic power unit. It is only allowed to apply the rotor lock under certain circumstances.
The rotor lock proximity sensor detects the status of the rotor lock. Only in case the rotor lock is not applied the WTG is able to start.
[1] Rotor lock disc
[2] Cylinder within rotor lock pin



5.5 Cooling/heating system

Several independent cooling/heating systems exist in the WTG e.g.:

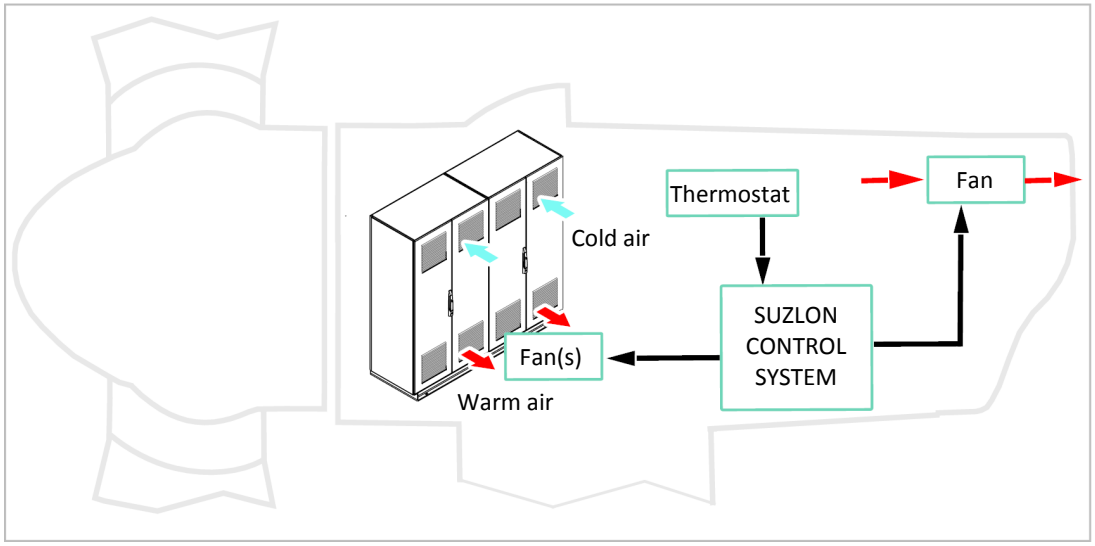
- Cabinets
- Nacelle
- Generator
- Converter
- Gearbox

The components to be cooled or heated are monitored by sensors which process the information to the SCS.

Cabinets and nacelle

The cabinets and nacelle are cooled by fans.

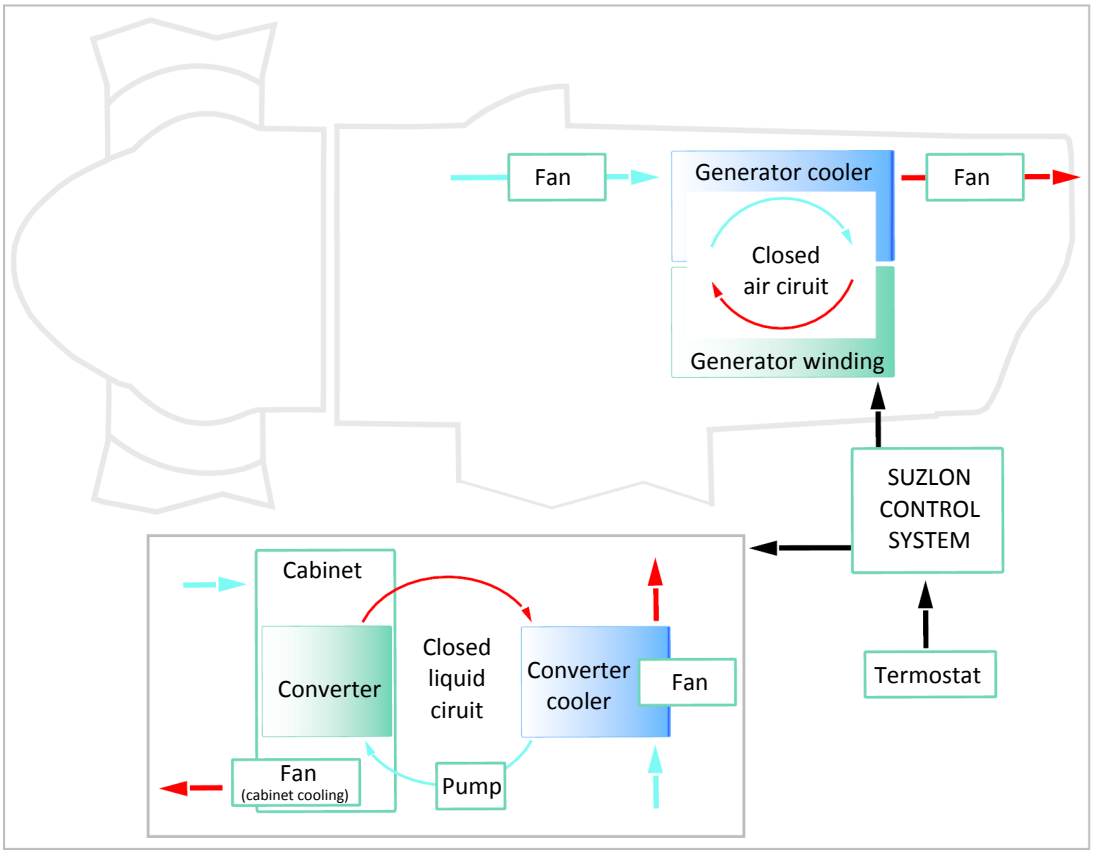
For cabinets the fans take cool air through filters into the cabinets. Warm air escapes the cabinets via filtered outlets. Thermostats and humidistat activate fans and where required heaters if the temperature/humidity inside the cabinets reaches a certain limit.
For nacelle the fan blows the warm air inside the nacelle out.



Generator and converter

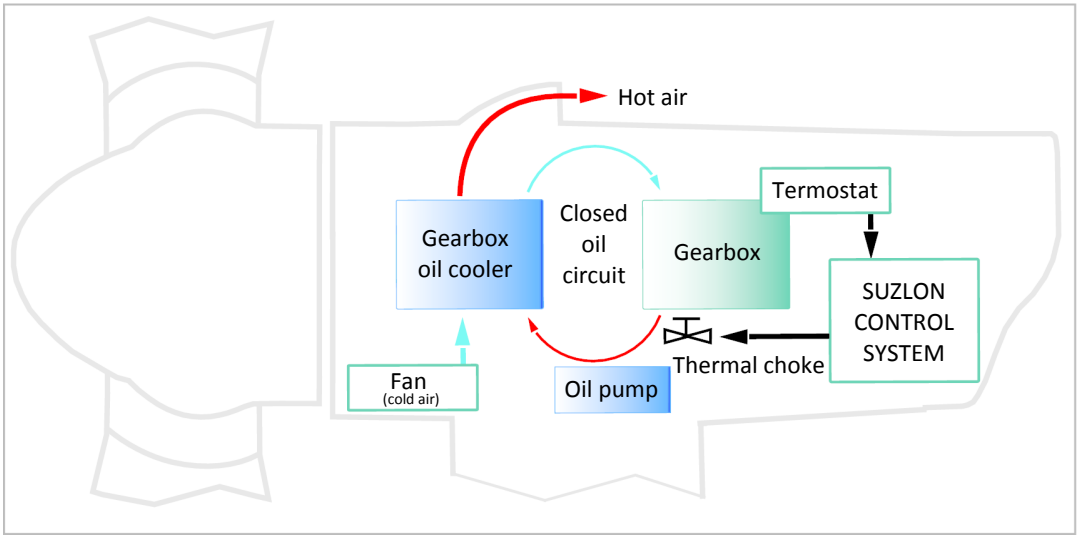
Two separate air cooling circuits cool the generator. Air ducts feed the inner closed cooling air circuit to provide all moving parts with cool air. A heat exchanger, a part of the stator housing, transfers the heated air to the outer cooling circuit. The air intake of the outer cooling circuit is located at the drive end side. One axial-flow bladed fan, located at the drive end side, takes the air in, carries it through the axially placed cooling tubes and discharges at the generator air duct.

The converter [▷ 37] is cooled via the coolant flow (water-glycol mix) that is passed through the converter cooler. If required it is possible to heat the converter with the same circulation.



Gearbox

The gearbox Drive train is cooled via the oil flow that is passed through the gearbox oil cooler. A thermal choke shuts off the oil circulation during start-up until the minimum operating temperature of the oil has been reached. An oil pump carries the oil directly to the relevant gearbox components.

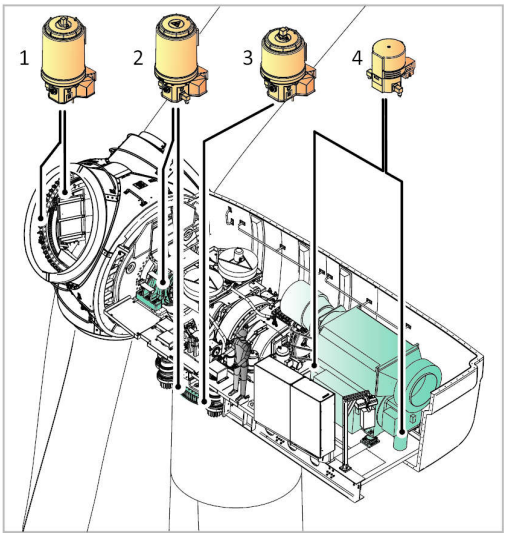


5.6 Lubrication system

Lubrication systems ensure permanent and essential operation of moving parts of the WTG due to a sufficient lubrication supply for determined components. Different types of lubrication systems are installed inside the WTG.

Centralised automatic lubrication system (CALS)

CALS generally comprises a control, a pump and reservoir, metering devices and fittings as well as supply and feed lines. It delivers a defined amount of lubricant to multiple, specific lubrication points on the WTG (e.g. generator bearings) while it is operating at defined times from a central location.
The CALS can be implemented as closed and opened lubrication system.
[1] CALS for blade bearings and blade bearing gear teeth
[2] CALS for main and yaw bearing
[3] CALS for yaw bearing gear rim
[4] CALS for generator bearings



Open lubrication system
Open systems supply the components with lubricant at all times using tanks. Such systems are used e.g. for the pitch system (blade bearing gear teeth) and have to be refilled at determined intervals.

Closed lubrication circuit
Closed lubrication circuits contain lubricant as part of a component. Within the component, e.g. gearbox, the lubricant is reused and filtered during operation and does not get in contact with the environment. The lubricant has to replaced in defined time frames (maintenance).

Lifetime lubrication
Lifetime lubrication, e.g. used for special roller bearings, contain lubricant for the whole service life of a the component. Those systems do not have to be refilled or maintained.

6 Electrical design

6.1 Generator

The WTG is equipped with a doubly-fed induction generator (DFIG) with a converter in the rotor circuit of the generator.

During operation, the stator side of the generator is permanently connected to the grid. The rotor windings are connected to the grid via slip rings and a converter that controls both the rotor and the grid current. Thus, rotor frequency can freely differ from the grid frequency. By controlling the rotor current with the converter it is possible to adjust the active and reactive power fed to the grid from the stator and rotor.

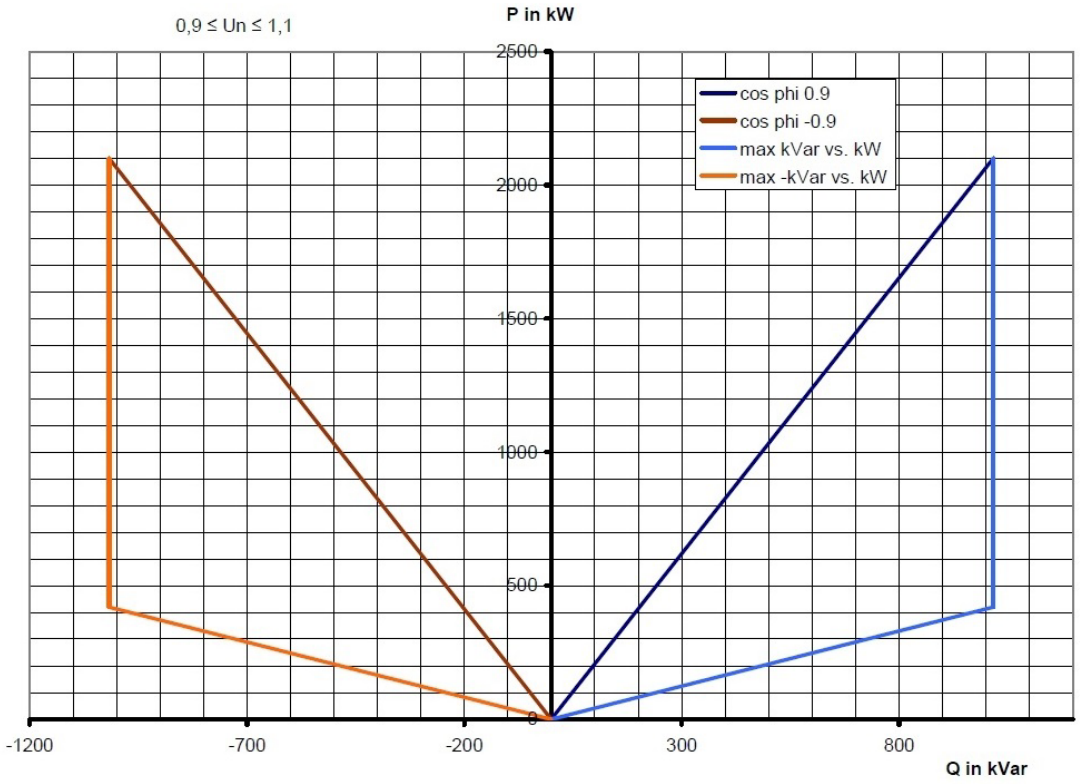
An air cooling system keeps the generator at an optimal operating temperature [▶ 32].

The generator is equipped with anti-condensation heaters which are activated when the generator is not in operation (generator switched off or rather is disconnected from the grid) and vice versa. This is done to keep the air temperature inside the generator (not in operation) slightly higher than the surrounding ambient temperature to prevent condensation of moisture inside generator on active parts.

The generator bearings are equipped with a time-controlled CALS.

Description	Information	
Type	Slip ring asynchronous generator	
Rated frequency	50 Hz/60 Hz (–6 to +5% continuously)	
Rated voltage	690 V	
Rated power	2.17 MW (under DFIG operation with rotor circuit inverter system)	
Max. rotor slip	±30.0%	
Number of poles/synchronous speed	50 Hz: 6/1000 rpm	60 Hz: 6/1200 rpm
Sub-synchronous speed for DFIG	50 Hz: 680 to 1000 rpm	60 Hz: 816 to 1200 rpm
Operation speed range	50 Hz: 700 to 1166 rpm (max. 1300 rpm) 60 Hz: 840 to 1399 rpm (max. 1560 rpm)	
Worst case continuous current rotor	650 A	
Worst case continuous current stator	1810 A	
Power factor with compensation	0.90 cap. to 0.90 ind.	
Protection class	IP 54 (slip ring IP 23)	
Thermal classification	Class H (stator and rotor)	
Cooling	IC616 as per IEC 60034 part 6	
Lubrication	Centralised automatic lubrication system (CALS) Tank capacity: 2 l	

Description	Information
Reactive power curve as a function of active power	See following figure.



6.2 Converter section

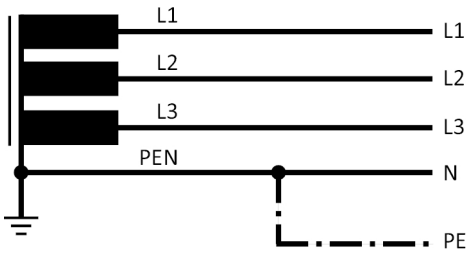
Description	Information	
Technology	DFIG (4Q-4Q)	
Rated frequency	50 Hz	60 Hz
Frequency variation capability	–6 to +5%	
Switching frequency	Line side converter: 4500 Hz, machine side converter: 2250/1125 Hz	
Rated voltage	690 V	
Voltage range	50 Hz: 621 to 759 V (±10%); except India –15% 60 Hz: 540 to 660 V (±10%); 621 V to 759 V (±10%)	
Operation range of converter/ generator: slip range	±30%	
Nominal slip	-16.6%	
Maximum IGBT power loss in form of heat during continuous operation	4% + 5 kW	
Worst case continuous current	Line side converter: 600 A, machine side converter: 650 A	
Protection class	IP 54	
Cooling	Liquid	
Temperature range of coolant inlet	Max. 50 °C	
Maximum flow of coolant	Approx. 95 l/min at 50 °C and 0.8 bar	

6.3 Grid connection

The WTG is connected to the grid through the generator. A transformer is used to transform medium voltage to high voltage.

When the WTG starts up the blades turn to a determined blade angle depending on the wind speed, thus accelerating the rotor. As soon as the generator speed has reached synchronous speed, the WTG is connected to the grid.

Find further and more detailed information in "Grid connection".

Description	Information	
TN-C-S System		
Voltage range (operation)	90 to 110% (continuously)	
Current range (nominal)	Overcurrent protection via SUZLON CONTROL SYSTEM and air circuit breaker	
	50 Hz: ≈2100 A	60 Hz: ≈2300 A
Frequency range (operation)	–6 to +5% (continuously)	
	50 Hz: 47 Hz ≤ f ≤ 52.5 Hz	60 Hz: 56.4 Hz ≤ f ≤ 63 Hz
Voltage harmonics	Total harmonic content of the grid voltage has to be less than 3% of fundamental frequency and less than 1% for any single harmonic	
Low Voltage Ride Through (LVRT)	Applicable	
HVRT (High Voltage Ride Through)	Applicable	

6.3.1 Medium voltage (MV) cabinet and transformer

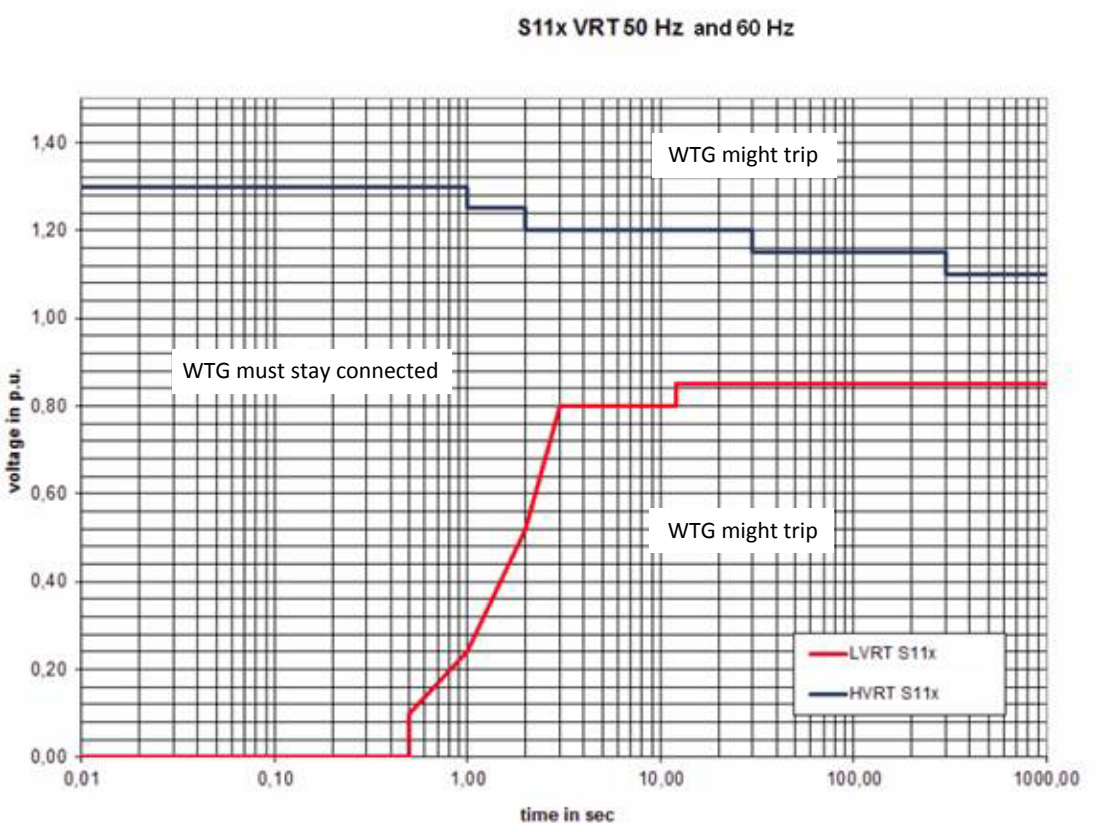
The MV cabinet and transformer are located outside the WTG and are within the responsibility of the owner. The transformer transforms electric energy from one voltage level to another, e.g. from the grid to the WTG or vice versa.

Description	Information
Type	Dry transformer
Winding connection	Delta (Δ)/Star (Y)
Vector group	Dyn5/Dyn11 (grid-dependent)
Rated apparent power	2500 kVA (tbd)
Tapping	At HV ±5% in 2.5% steps | India: At HV ±6% in 3.0% steps (tbd)
Reactance	6.00% | India: 6.25% (tbd)
No-load losses	≈2500 W (tbd)
Full load losses	≈22500 W (tbd)
Total losses	≈25000 W (tbd)
Rated winding ratio	Voltage level at line side depends on supply voltage level.
	50/60 Hz: IEC: (XX) kV/0.69 kV 60 Hz: UL/CSA: (XX) kV/0.60 kV

6.3.2 *Voltage ride through (LVRT/HVRT)*

In status "Operation" the WTG is able to perform a low voltage ride throughLVRT in case a low voltage dip is detected. For a defined period of time (fault clearance time) the voltage dip alarms are suppressed. The WTG remains connected to the grid during LVRT. After the LVRT event, the WTG reverts back to its previous status "Operation". The SUZLON CONTROL SYSTEM (SCS) writes all grid alarms in fast logs - even those that have been suppressed (for detailed information see the SUZLON software documentation).

If the voltage at the WTG terminals exceeds the normal operating range for a short period of time, this is called high voltage ride through HVRT. The maximum HVRT capability is determined by the converter capability. To make full use of this capability the SCS default settings are adjusted to values exceeding the converter capability.



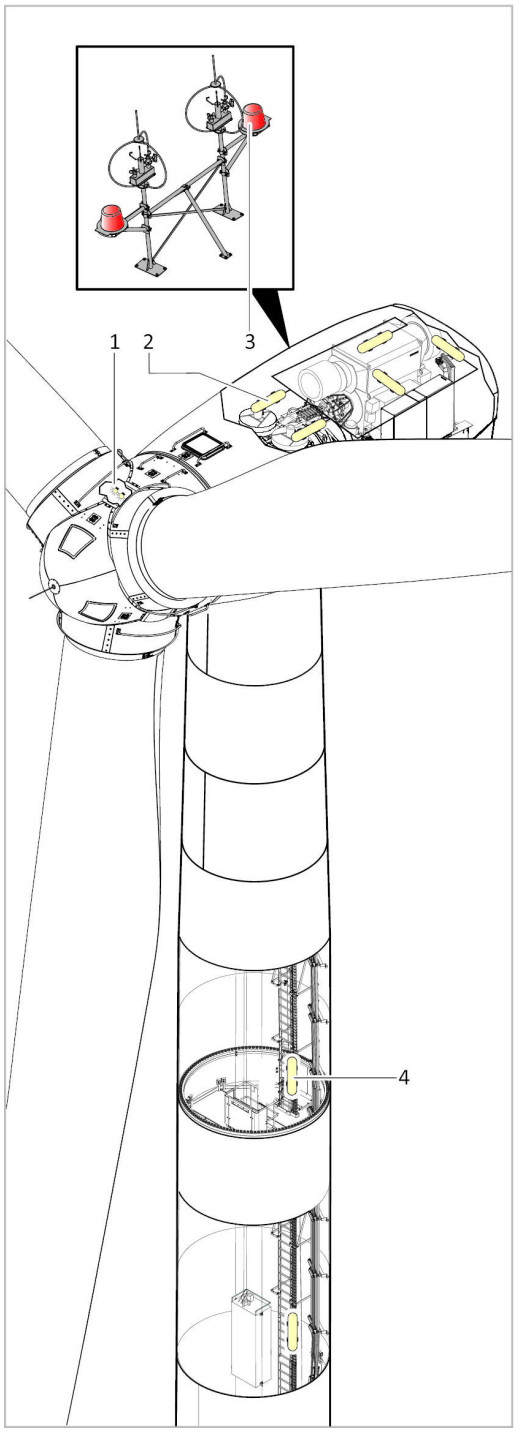
6.4 Lighting and aviation light

Tower
Tower lights [4] are mounted inside the tower at certain intervals next to the tower ladder. All tower lights are switched on and off by a single toggle switch located at the entrance of the WTG. The tower lights have a battery backup to ensure safe working conditions in case of emergency.

Nacelle
Overhead lights [2] are located inside the nacelle. Toggle switches are located at the right side (view to the rotor) of the nacelle cover.

Hub
The hub light [1] is located above the hub entry, inside the hub body. The corresponding switch is fixed right next to the light.

Aviation light (optinal)
Aviation lights [3] can be fitted on top of the nacelle at the equipment frame. The aviation lights have to be realised according to the national requirements.
Blinding can be avoided by covering the aviation lights but allowing the lights to be visible for e.g. pilots.



6.5 Uninterruptible power supply (UPS)

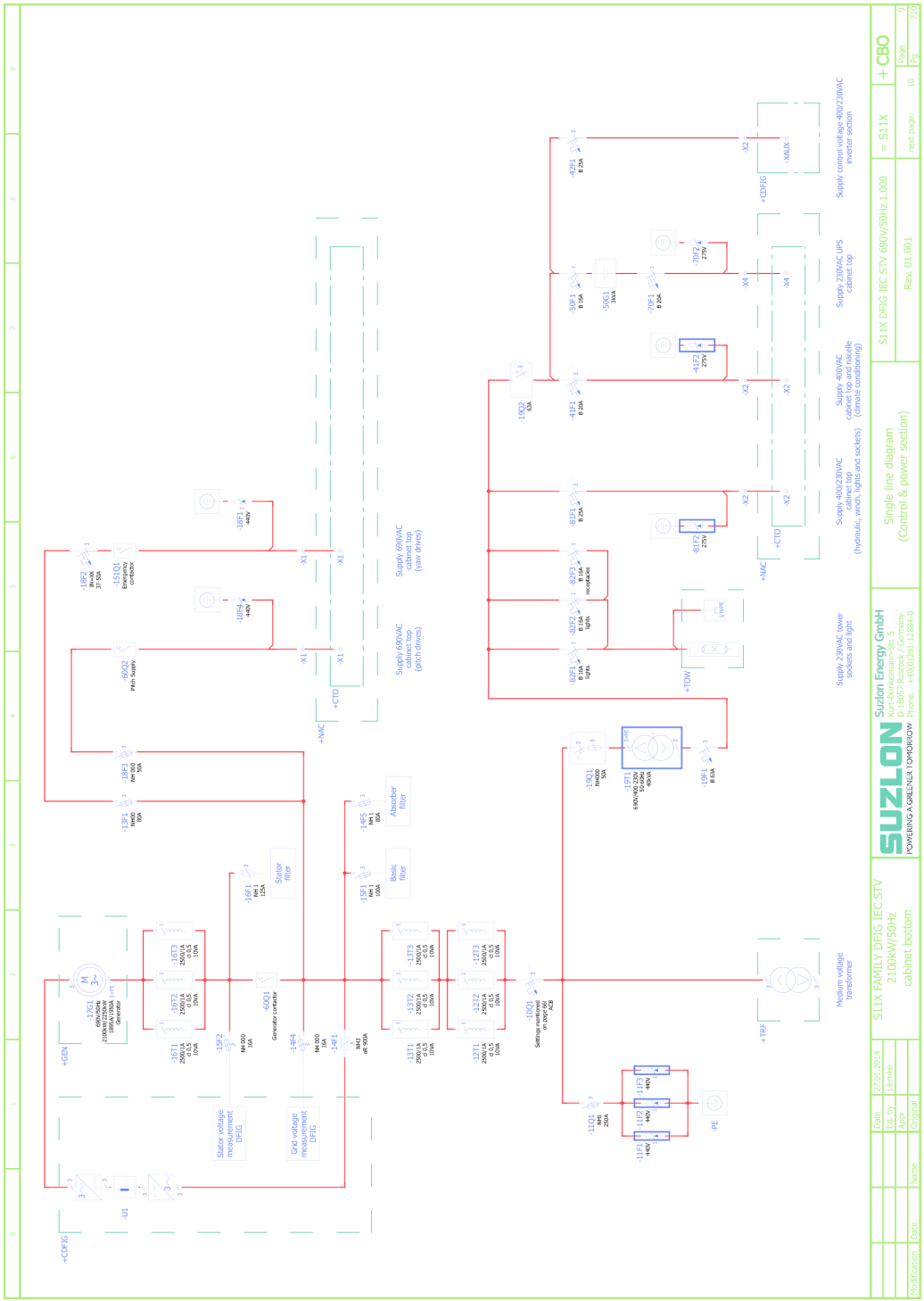
Description	Information
Battery type	Maintenance-free sealed lead-acid battery with suspended electrolyte: leakproof
Output power capacity	2100 W/3000VA
Nominal output voltage	230 V
Output frequency	50/60 Hz
Nominal input voltage	230 V
Input frequency	50/60 Hz
Typical recharge time	3 hours

6.6 Sensors

Sensor type	Description/use
Thermostats and humidistat	Temperature and humidity sensors observe the temperatures and humidity at several components inside and outside the WTG. In case the defined settings are exceeded fans and heater turn on or off, alarms are triggered and/or the safety chain of the WTG opens. (Used: e.g. gearbox, generator, nacelle inside and outside)
Vibration sensor	Mechanical and electric vibration sensors detect dynamic unbalances. In case the defined settings are exceeded, the safety chain opens. (Used: e.g. at main bearing, gearbox mounts)
Oil/grease sensor	Several sensors observe the function of the automatic lubrication system and the filling level of the grease and/or oil tanks at different observation points. These sensors pass the information to the SCS. (Used: e.g. yaw system, pitch system, gearbox, generator)

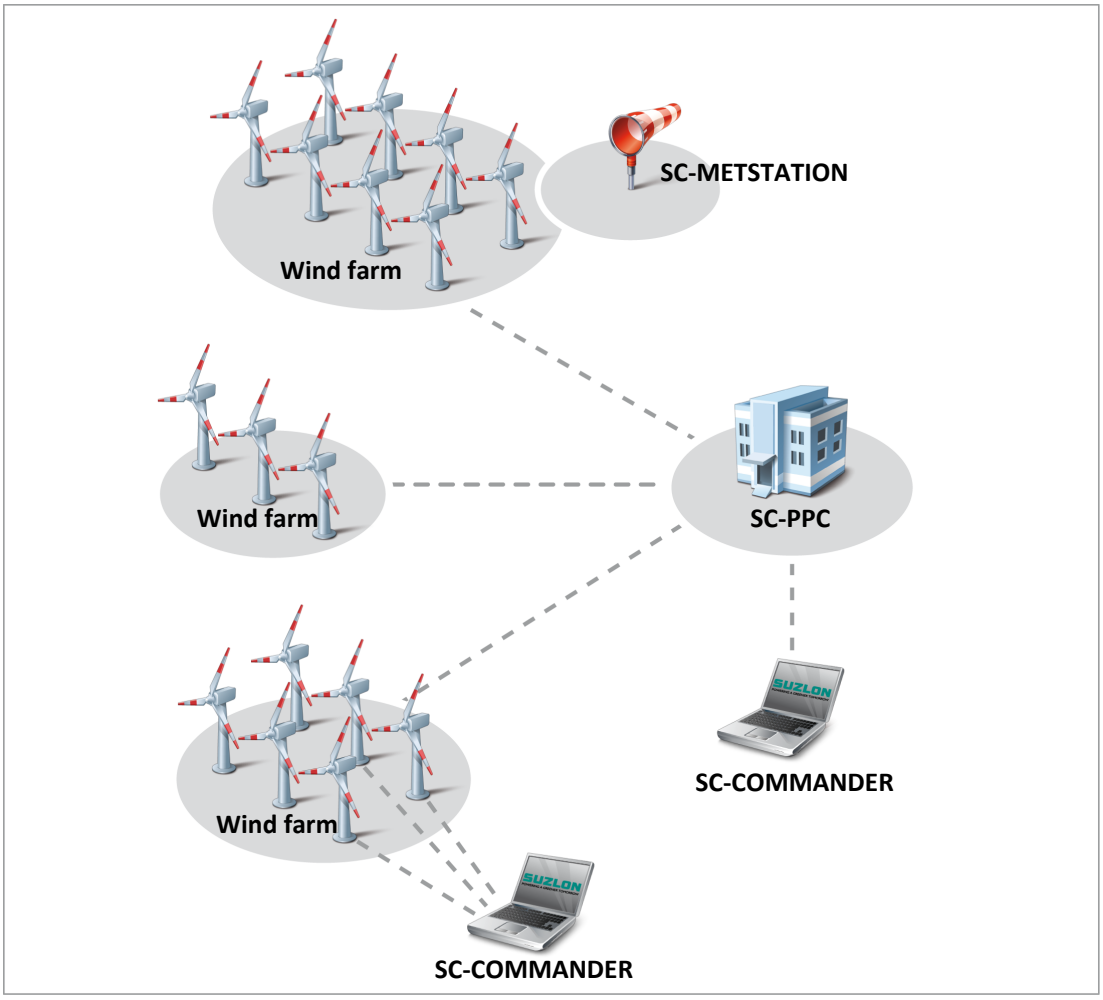
2D ultrasonic wind sensor (LTV)	The wind measurement equipment is mounted on top of the nacelle roof and measures the wind direction and the wind speed. It consists of two 2D ultrasonic wind sensors. The sensors are surrounded by a protection cage to protect them against electromagnetic fields. The sensors are equipped with integrated heaters. The SCS works with one of the sensors to receive a wind speed value. It permanently tests the plausibility of the sensors and chooses the highest wind speed. The wind direction is averaged between the two wind sensors. (Used: pitch system Pitch system, yaw system Yaw system)
Anemometer and wind vanes (STV, HTV)	The wind measurement equipment is mounted on top of the nacelle roof and measures the wind direction and the wind speed. It consists of two anemometers and two wind vanes. The sensors are surrounded by a protection cage to protect them against electromagnetic fields. The SCS works with one of the anemometers to receive a wind speed value. It permanently tests the plausibility of the sensors and chooses the highest wind speed. The wind direction is averaged between the two wind vanes. (Used: pitch system Pitch system, yaw system Yaw system)
Speed sensor	Proximity sensors and counter modules observe the speed at rotating WTG components. The measured values are used to optimise the WTG output and to to react in case of overspeed. (Used: main shaft, high speed shaft)
Angle sensor	Angle sensors detect the position of the belonging component and pass the position to the SCS. The user is able to move the component to a required position (e.g. for maintenance works). (Used: pitch system Pitch system, yaw system Yaw system)

6.7 Single line diagram



7 SUZLON CONTROL SYSTEM

The SUZLON CONTROL SYSTEM (SCS) controls and monitors WTGs as well as wind farms.



Interaction of the components of the SCS

Description	Information
Type	Programmable Logic Controller with SUZLON CONTROL SYSTEM software
Communication system	Internal: CAN-bus External: Ethernet
Access	Multi-level, user authenticated

7.1 SC-TURBINE

SUZLON CONTROL-TURBINE (SC-TURBINE) is the control system of a single WTG. It ensures safe and stable operation and power production of the WTG via different sensors and measurements (e.g. electrical grid data, wind speed and direction, rotor speed, yaw and blade angle and component temperatures). A flash memory stores statistical and operational data.

The SC-TURBINE software runs on a programmable logical controller (PLC).

SC-TURBINE can be monitored and controlled with a normal laptop (SC-COMMANDER) directly at the WTG. In close interaction with SC-COMMANDER it is possible to communicate with the WTG and to create reports and logs of stored WTG data or the whole wind farm.

7.2 SC-COMMANDER

SUZLON CONTROL-COMMANDER (SC-COMMANDER) is designed as a user interface to WTGs. It manages access for customers, service staff and other persons according to defined access levels to all wind farm devices, such as WTGs, meteorological masts and also to SC-PPC. At the same time it collects, stores and distributes all required data. SC-COMMANDER is required to see the WTG status, carry out simple operations like start, stop, reset and to create reports. SC-COMMANDER is the gate to SC-TURBINE and SC-PPC.

The SC-COMMANDER can be installed on any kind of operating system. The laptop/PC has to comply with defined requirements.

7.3 SC-PPC (optional)

The SUZLON CONTROL-POWER PLANT CONTROLLER (SC-PPC) is designed to control a complete wind farm according to specific requirements. The wind farm is controlled as a power plant. It is possible to e.g. reduce the power output of the wind farm which is in certain cases necessary to meet the requirements of the utilities or to stop individual WTGs to avoid shadow flicker effects at particular areas.

The software runs on a PLC in close interaction with SC-TURBINE. Visualisation and remote control of SC-PPC is possible via SC-COMMANDER.

7.4 SC-METSTATION (optional)

SUZLON CONTROL-METSTATION (SC-METSTATION) is introduced to provide a detailed and correct representation of actual weather conditions of a wind farm. Additional forecasts and calculations are possible.

The measured data are used for:

- Production forecast
- Free wind speed
- Wind direction
- Production loss calculation
- Air density calculation
- Turbulence intensity

SC-METSTATION is located inside its belonging wind farm. It is equipped with anemometers and wind vanes that are installed at hub height. The maximum number of wind measurement equipment can be extended to four anemometers and four wind vanes.

8 Turbine protection systems

8.1 Over-power / short circuit protections

Monitoring of the power output by the control system

The control system monitors the grid permanently. If the current in one of the phases is too high the control system will cut off the connection between the grid and the generator.

To fulfil a redundant configuration for power measurement two sets of three CTs for grid current measurement are installed. The two completely independent measurement systems are MFR360 and the DFIG-Inverter system. Each system uses three current transformers to continually measure the phase currents. The voltages of the phases are measured directly by the devices. The real power, reactive power and grid frequency are all calculated.

The multifunction relay is connected to the control system through a CAN bus interface. Furthermore, phase vector skipping and grid voltage asymmetry are transmitted through 24 V digital input signals to the control system.

All measured, as well as all calculated grid values, are transmitted cyclically to the control system. Over-power, over-voltage, under-voltage, over-frequency and under-frequency are calculated by the control system from the electrical values measured by the multifunction relay. By setting the appropriate parameters, the relevant alarms can be set in the control system.

Monitoring of the power output by the safety system

The main air circuit breaker (ACB) monitors the wind turbine output for over-current, short circuit and ground faults.

Over-current

The nominal current of the main ACB can be found in the fault situations and reactions table. If this is transgressed than the main switch will release and open the safety chain. The control system will detect this and initiate the appropriate brake programme to stop the wind turbine.

Short circuit

The short circuit current of the main ACB can be found in the fault situations and reactions table in the appropriate manual. If a short circuit is detected, the main switch will release and open the safety chain. The control system will detect this and initiate the appropriate brake programme to stop the wind turbine.

Ground fault

The main ACB is equipped with ground fault monitoring. If a ground fault current of more than 300 A for 0.3 s occurs the main switch will release and open the safety chain. The control system will detect this and initiate the appropriate brake programme to stop the wind turbine.

8.2 Overspeed protection

Overspeed monitoring by the control system

The control system measures the rotor speed by a proximity switch, which takes the measurements from a toothed wheel attached to the rotor. The pulses are analyzed and calculated into a speed signal by a counter module in the control system (PLC). By a transgression of the speed parameterized in the control system the alarm “Mech_Rotor_PeakSpeedStop” is set and the appropriate brake programme is activated. The control system measures the generator speed with an incremental encoder. The pulses are analyzed and calculated into a speed signal by a counter module in the control system. By a transgression of the speed parameterized in the control system the alarm “Mech_Generator_PeakSpeedStop” is set and a brake programme is activated.

Overspeed monitoring by the safety system

The speed monitor FR1, which is independent from the control system, measures the rotor speed with its own proximity switch mounted adjacent to the toothed wheel attached to the rotor. This speed monitor will release the safety chain and set the alarm “Mech_RotorFR_OverSpeedStop” if the rotor speed transgresses a set limit.

Plausibility check

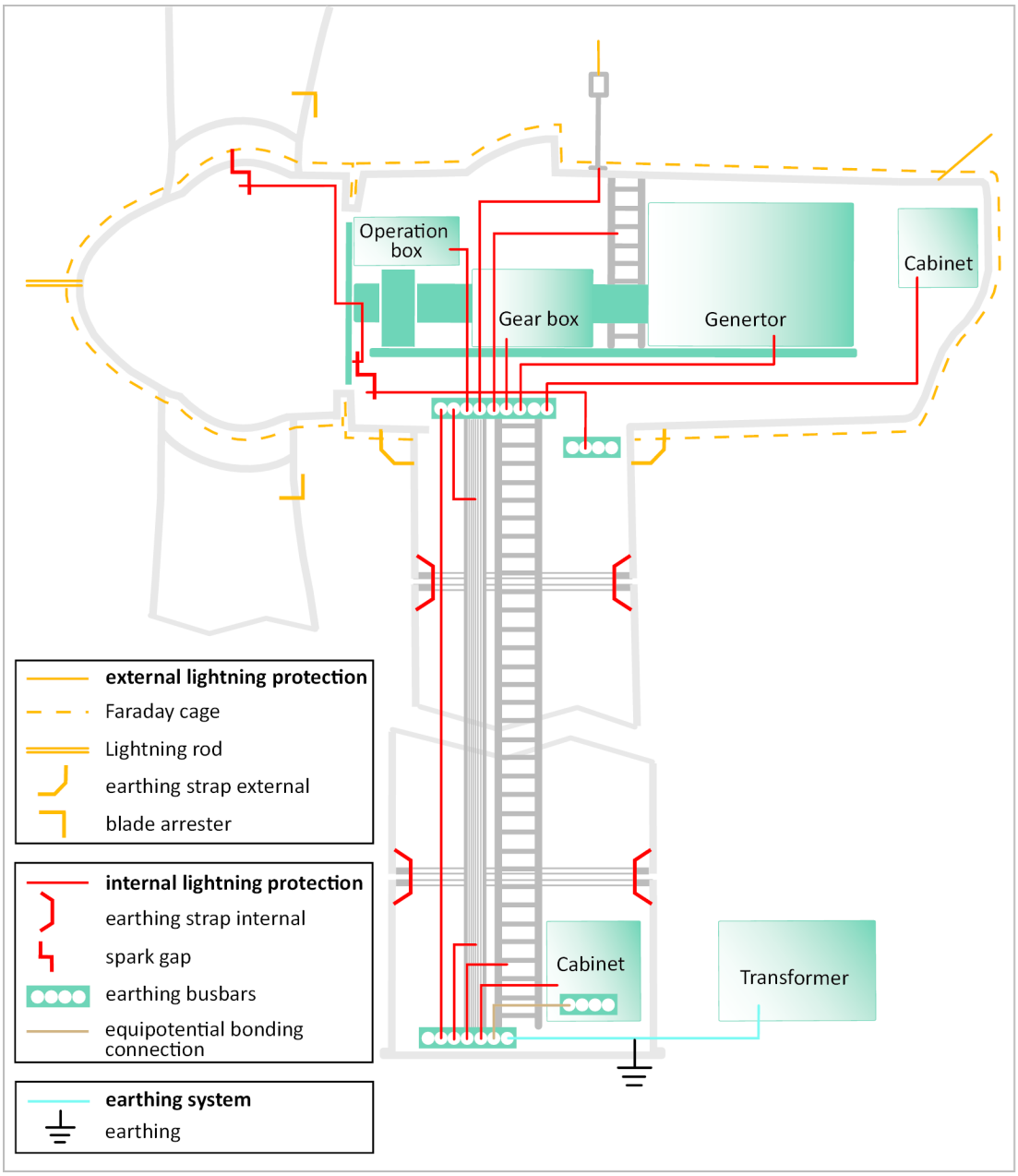
The analogue output signal of the speed monitor FR1 is also transferred to the control system. The control system compares the measured speed from the FR1 speed monitor with the speed measured by the control system itself. If the deviation between the speed measurements is higher than a set value, the alarm “Mech_RpmFR1_CNT_DiffStop” will be generated and a brake programme will be activated.

8.3 Lightning and surge protection

The lightning protection applies to lightning protection level I in accordance with relevant standards. The lightning protection system is based on the lightning protection zone concept. It consists of three main parts:

– External lightning protection
– Internal lightning protection
– Earthing system

Description	Information
Standard	DIN 18014, IEC 61140, IEC 61400-24, IEC TR 62066, IEC 62305-1, 2, 3, 4
Tower	Redundant lightning protection system (RLCTS) for protection of yaw bearing as well as optimized equipotential bonding and lightning down conduction
Nacelle	Redundant lightning current tapping system (RLCTS) for protection of drive train bearings as well as optimized equipotential bonding
Blades	Lightning receptors at blade tip and down conductor spark gap for insulation and protection of blade bearings



8.3.1 External lightning protection

The nacelle housing consists of three parts. Each part is provided with a mesh of galvanised steel. The meshes are interconnected to each other in order to build a Faraday cage. The meshes are attached to the tower using lightning cable. The equipment frame on top of the nacelle is equipped with a lightning rod.

The hub is made of cast iron. All electric components have the required distance to the nose cone, which is equipped with a lightning rod. The hub complies with the requirements for a Faraday cage.

The blades are equipped with a lightning arrester. In case of a lightning strike, the lightning is guided from the arresters to the hub and via spark gaps to the main shaft. The main shaft conducts the lightning to the earthed tower via earthing straps.

The blade bearings and the drive train are protected against lightning current by means of spark gaps. This ensures the lightning is earthed risk-free.

8.3.2 Internal lightning protection

Surge protection device (SPD)

SPDs protect cabinet internal electrical components against dangerous surge voltages which can be inducted into connected cables during lightning event. The inducted voltage can will be bypassed to earth conductor.

Equipotential bonding system

The task of the equipotential bonding system is the potential equalisation of all metal system components like housings, handrails, ladders and cabinets. The potential equalisation avoids the generation of dangerous voltages that endanger people and technical systems.

The equipotential bonding system connects all metal components of the WTG. As a result, the electric potential of all components is the same. In case of contacting two components, staff is not exposed to danger caused by high voltage.

Cable shielding and routing

Cables within the nacelle and hub are shielded or protected by SPDs. Cables from tower to nacelle are guided with metal cable ducts. Both ends have to be connected to earthing busbar. The tower is a closed steel body, so the cables inside the tower are shielded trough the tower body dependent on material parameters and thickness. The cables to the outside transformer station are protected by SPDs.

8.3.3 Earthing system

The earthing system is the basis to protect the WTG against damages, to protect people against electric shock and to operate the electrical system safely.

The earthing system connects the WTG with the foundation earthing electrodes, the metal reinforcement, all metal parts, the transformer, substation and all components outside the WTG.

8.4 Safety equipment

The WTG has been designed and certified in accordance with the latest international standards. A safe operation without any danger for the health and safety of the operator is given if the WTG is used in accordance with the relevant instructions.

Access, escape and working areas

Access to the WTG from the outside is through the bottom of the tower. The door is equipped with a lock.
A ladder with a fall arrest system is mounted through the tower. There are anchorage points in the tower, nacelle and hub, and on the roof for attaching fall arrest equipment. Anchorage points are coloured yellow.
In case of emergency alternative escape routes are described in addition to the normal access routes. The emergency escape and rescue plan is placed in the tower bottom and nacelle.
All operating elements can be easily and safely reached and have been clearly identified. The tower and nacelle are equipped with power sockets for electrical tools for service and maintenance.
Moving parts in the nacelle are equipped with protective covers. The covers can only be detached and removed by means of tools. These protective covers may only be removed by qualified staff to carry out maintenance measures.

Emergency stop

The WTG is fitted with emergency stop buttons. The emergency stop buttons are marked with the usual international symbols and trigger the safety chain.

Fire extinguisher and first aid kit (optional)

Two fire extinguishers and first aid kits are optionally available. Each of them will be located in the nacelle and next to the tower door of the WTG.

Warning signs and manuals

Basic safety related signs placed inside and outside on the WTG.
The documentation set consists of separate chapters for safety, operation, maintenance, troubleshooting and service with additional rules and information on health and safety when working in or around the WTG.

8.5 Condition Monitoring System (CMS)

The intention of the CMS is to prevent damage and loss of components. It forecasts damage and allows a minimum time for maintenance works. Additionally, it is possible to analyse damage, increase the reliability and mean time between failures (MTBF).

CMS is an advanced diagnostic system. A CM-device measures vibrations at drive train components and automatically detects relevant changes. These detections have to be signalled to the CMS surveillance centre for further analysis and additional investigations if necessary. In CMS surveillance centre experts can diagnose damage and prepare instructions for operating staff. The analysis of damage causes can help to develop possibilities of damage prevention. CMS information is only available if communication between CM-device and surveillance centre is established.

The CMS acts as follows:

- Measurement of vibration on drive train (main bearing, gearbox, generator)
- Communication to PLC
- Communication to CMS surveillance centre (remote control)

List of abbreviations

ACB
Air Circuit Breaker

CALS
Centralised Automatic Lubrication System

CMS
Condition Monitoring System

DFIG
Doubly-Fed Induction Generator

HTV
High Temperature Variant

HVRT
High Voltage Ride Through

LTV
Low Temperature Variant

LVRT
Low Voltage Ride Through

MV
Medium Voltage

PLC
Programmable Logic Controller

SC-PPC
SUZLON CONTROL-POWER PLANT CONTROLLER

SCS
SUZLON CONTROL SYSTEM

SPD
Surge Protection Device

STV
Standard Temperature Variant

STV light
Standard Temperature Variant light

UPS
Uninterruptible Power Supply

WTG
Wind Turbine Generator

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Summary: Application to Amend -- Exhibit A (Part 2) electronically filed by Mrs. Gretchen L. Petrucci on behalf of Hardin Wind LLC