PROVINCIA DI GENOVA

COMUNE DI BARGAGLI

PARCO EOLICO MONTE TRASO

PROGETTO DEFINITIVO



DOCUMENTAZIONE TECNICA AEROGENERATORI ENERCON E53

PROFESSIONISTA

PROPONENTE

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Technical Description

E-53

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1 BRIEF DESCRIPTION

The E-53 is a wind energy converter with a three bladed rotor, active pitch control, variable operating speed and a rated power of 800 kW. Its 53 m rotor diameter and 73 m hub height enable the turbine to make efficient use of the prevailing wind conditions at the respective sites to produce electrical energy.

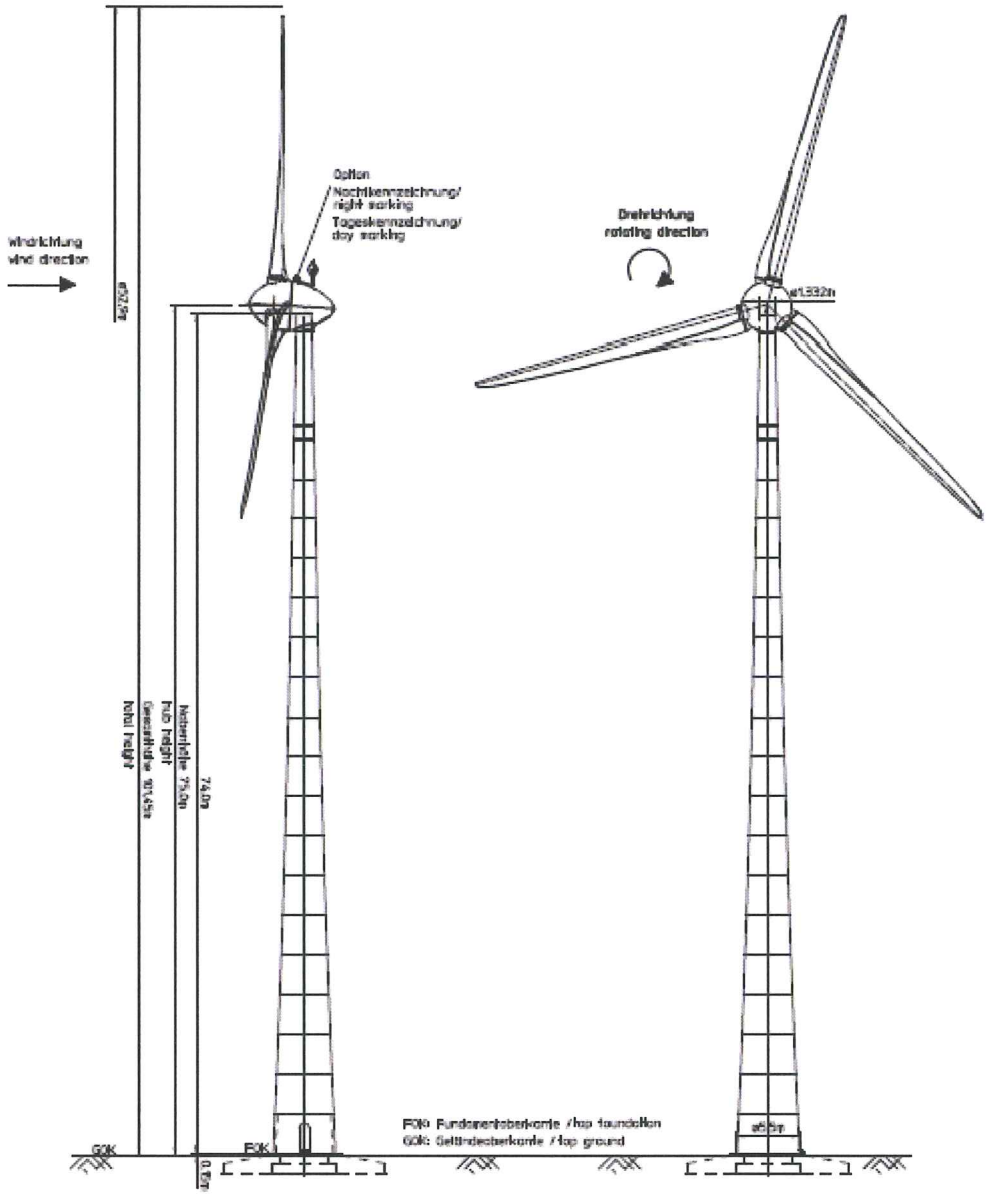


Figure 1: Illustration E-53

The main objective of ENERCON design and engineering is to minimise loads. All turbine components are developed and constructed accordingly. The result is a turbine which is, amongst other things, convincing due to its low load level and long service life.

Output controlled by variable speed allows the E-53 to attain maximum operation efficiency without increasing operating loads in the full and partial load ranges and at the same time prevents undesirable output peaks thus guaranteeing excellent yield and a high quality of power fed into the grid.

1.1 The ENERCON Concept

ENERCON wind energy converters are characterised by the following features:

The inner ring of the ENERCON annular generator and the rotor of the E-53 form one unit. These two components are flanged directly to the hub so that they both rotate at the same low speed. Since there are no gears or other fast-rotating parts, energy loss between generator and rotor, noise emissions, the use of gear oil and mechanical wear are considerably reduced.

The output produced by the E-53 generator is fed via the ENERCON grid connection system into the power supply company's grid. The ENERCON grid connection system comprises a rectifier/inverter unit (converter). This system ensures that high-quality electricity is fed into the power supply company's network.

Using the converter, this grid connection concept permits the E-53's rotor to operate at variable speeds. The rotor rotates slowly at low wind speeds and quickly at high wind speeds. This optimises wind flow on the rotor blades. Moreover, variable speed also reduces loads caused by gusts.

Each of the three rotor blades is equipped with an electrical pitch system. The pitch system limits the rotor speed and the use of the wind's power thus allowing the output of the E-53 to be reduced to rated power, even within a short period. By pitching the rotor blades into the feathered position, the rotor stops without mechanical brakes exerting load on the drive train.

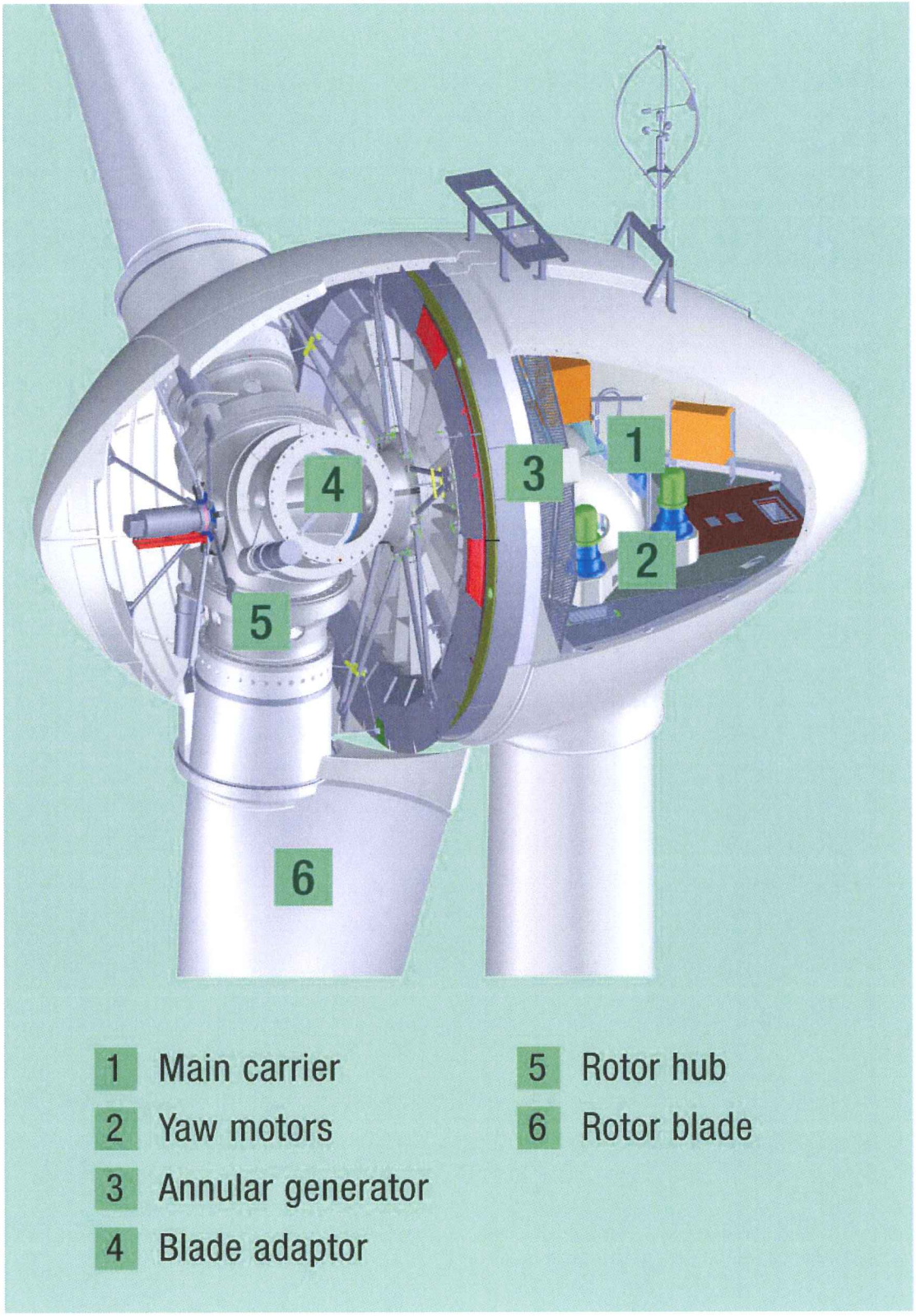


Figure 2: Illustration: Nacelle

1.2 Rotor

The E-53 rotor blades made of glass reinforced plastic (GRP) (epoxy resin) have a major influence on turbine output and its noise emission. Their shape and profile were developed according to the following criteria:

- high power coefficient
- long service life
- low noise emissions
- low loads and
- less material

One special feature to be pointed out is the new rotor blade profile which extends down to the nacelle. This innovative design eliminates the loss of the inner air flow experienced with conventional rotor blades. Together with the streamlined nacelle, the use of prevailing winds is considerably optimised.

The rotor blades of the E-53 were specially designed to operate with variable pitch control and variable speed. Due to this special profile, the blades are not sensitive to turbulence and dirt on the leading edge. On the outside, a top coat protects the rotor blades against environmental factors. The polyurethane-based material employed is highly resistant to abrasion, durable, and highly resistant to chemical factors and solar radiation.

Each of the three rotor blades is adjusted by independent microprocessor-controlled pitch systems. Angle encoders constantly monitor the set angle on each blade and ensure that the three blades are synchronised. This permits quick and accurate adjustment according to the prevailing wind conditions.

1.3 Generator

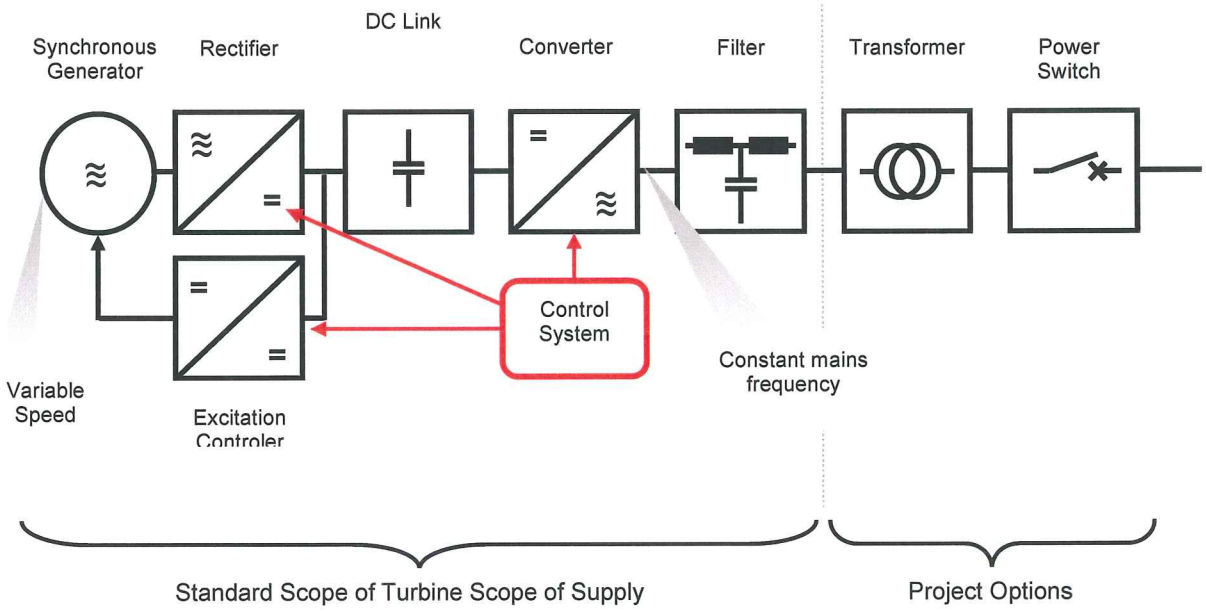
The air flow on the rotor blades drives the rotor which in turn is the direct drive for the E-53 annular generator. The multipole ENERCON generator is based on the direct drive synchronous machine principle.

Due to the low rotational speed and a large generator cross-section, temperature levels are comparatively low during operation and are only subject to minor fluctuations. Slight temperature fluctuations and comparatively few load changes during operation significantly decrease mechanical stress and the associated wear on generator material and insulation. Furthermore, variable speed and the connection to the electrical grid via converters contribute to reducing speed peaks.

1.4 Grid feed unit

The annular generator is coupled with the grid via the ENERCON grid connection unit. The main components in this system are a rectifier, a DC link and modular inverters.

The grid feed unit, generator and pitch unit are all controlled to achieve maximum output and excellent grid compatibility.



Flexible coupling between the annular generator and the grid guarantees ideal output transmission conditions while reducing undesirable reactions between the rotor and the grid in both directions. Sudden changes in wind speeds are controlled in order to maintain stable grid feed. Concurrently possible grid failures have very little effect on the mechanics. The power fed from the E-53 can be exactly regulated between 0 kW to 800 kW

Depending on the WEC configuration, different numbers of identical converter modules are available. They feed three-phase current from output on the low voltage side into the grid. Generally, a transformer directly in or near the turbine converts 400V to the desired high voltage.

With this converter technology, the wind energy turbine can be considered as a regulated source of power As long as the voltage at the output terminals is within the permissible range, the converters feed symmetrical, sinusoidal current. The voltage at the output is affected by the feed but it is not actively controlled. If desired, a voltage regulator can be installed at the wind farm's point of common coupling.

Depending on the grid voltage phase angle and generator output, a target value for the current to be fed is generated. Three-phase current is then generated according to this target value with the power available in the DC link. This target value is compared to the actual current flow (actual value) every 100 µs and corrected in the event of deviations. The current fed is sinusoidal and largely free of disruptive harmonic oscillations. A high frequency filter further reduces harmonics. No significant flicker emissions occur. Momentary current peaks are excluded with this converter technology.

The range of operation parallel to the grid is limited by the minimum and maximum grid voltage. Both these values (undervoltage and overvoltage) can be set as the limit value for the E-53.

Furthermore, ENERCON provides turbines as "transmission" versions on request. This means that the wind turbine can ride though voltage dips (grid failures) from one to several seconds instead of immediately disconnecting from the grid. As soon as voltage is re-established maximum possible active power is fed into the grid. During a grid failure, active power is fed into the grid depending on the remaining voltage, the maximum converter current and the actual wind conditions. In addition, the wind turbine can support the grid by feeding reactive current in the event of a grid failure. With this feature ENERCON wind turbines are able to provide wind farms with power plant properties often demanded and at the same time contribute to maintaining stable network operation.

The E-53 is preset to a power factor of $\cos\varphi=1$. It does not require reactive power nor does it deliver reactive power to the grid within the entire power range from 0 to 800 kW. Only active power is fed into the grid. Any equalization payments for reactive power demanded by some power supply network operators are not necessary.

However, if requested by the power supply network operators, it is also possible to run the turbine with an output factor of $\neq 1$. This enables the wind turbine to contribute to reactive power balance and to maintain the voltage in the grid. The maximum reactive power range varies depending on the turbine configuration. The active power being fed is not affected by reactive power being fed simultaneously.

The range of operation parallel to the grid is also determined by a lower and upper frequency limit value. The range between these frequency limits is much wider than in conventional energy production units thanks to ENERCON's flexible IGBT converter technology. ENERCON wind turbines can be used in grids with a rated frequency of 50 Hz or 60 Hz.

If these voltage or frequency limits cannot be maintained, the E-53 control unit switches off all grid contactors in the inverter. This allows the E-53 to immediately disconnect from the grid on all phases.

1.5 Yaw control

The yaw bearing is mounted directly at the top of the tower with an externally geared ring. The yaw bearing allows the nacelle to rotate, thus facilitating yaw control. Six adjustment drives (yaw gears) engage in the geared ring in order to adjust the nacelle to the wind direction. The yaw bearing also transmits the load of the nacelle to the tower. The main carrier is mounted directly on the yaw bearing.

1.6 Safety system

The safety system guarantees safe turbine operation in accordance with international standards and independent test institutes.

1.6.1 Brake System

Halting ENERCON turbine operation is done completely aerodynamically by pitching the rotor blades into the feathered position. The three independent pitch drives move the rotor blades into the feathered position within seconds (i.e. they are "driven out of the wind"). The speed of the turbine is diminished without applying additional load to the drive train. In order to reduce the rotor speed to a safe level, it would be sufficient to drive only one of the three rotor blades out of the wind.

The rotor is not locked in place even when the WEC is shut down. It idles freely at a very low speed. The rotor and drive train remain practically without load. While idling, fewer loads are placed on the bearings than when the rotor is locked.

The rotor is only completely locked in place for maintenance purposes or when the EMERGENCY STOP button is activated. In this case, an additional brake is employed. It does not engage until the rotor has already been partially braked with the pitch controls. The rotor lock is only used as a final safety mechanism for maintenance purposes.

In the event of an emergency (e.g. if the utility's mains fails), each rotor blade is safely brought into the feathered position via its own back-up pitch unit. The backup power units are monitored and automatically charged to guarantee availability. The backup pitch units, which are electromechanically linked, trigger simultaneous pitch control.

The pitch control system is equipped with parallel power supply in the case of emergencies (mains or backup power unit). Together with three fully independent pitch drives this safety concept more than fulfils the requirements for a fail safe braking system.

1.6.2 Lightning protection system

The ENERCON lightning conductor system in the E-53 efficiently diverts almost all possible lightning strikes with no damage caused to the turbine.

The leading edge of the rotor blade and the blade tip are equipped with aluminium profiles which are attached to an aluminium ring at the blade connection point. Strikes are safely absorbed by these profiles and the lightning current is conducted via a spark gap and cables into the ground surrounding the foundation. The rear of

the nacelle casing is also fitted with a lightning conductor which diverts the current into the ground.

In the event of a lightning strike or an abnormal increase in voltage (overvoltage), the entire electrical and electronic equipment is protected by built-in energy-absorbing components. All main conductive turbine components are connected to the equipotential busbar with an adequate wire cross-section. Furthermore, overvoltage surge arresters are installed with low impedance grounding at the mains connection point.

The turbine electronics located in metal housing are electrically isolated. The remote monitoring system is protected by a special protection module for data interfaces.

1.6.3 Sensor System

A comprehensive monitoring system guarantees turbine safety. All safety related functions (e.g. rotor speed, temperature, loads, oscillations) are monitored by electronic media. If the electronics fail, a mechanical safety function takes over. If one of the sensors registers a serious fault, the turbine shuts down immediately.

1.7 Control system

The E-53 control system is based on a microprocessor system developed by ENERCON. Sensors query all turbine components and data such as wind direction and wind speed and adjust the operating mode of the E-53 accordingly.

When wind speeds suitable for turbine operation are measured over three consecutive minutes, the automatic startup process is initiated. Once the lower speed range limit is reached, power output is fed to the grid. Elevated making current does not occur at start-up since the grid connection is performed through the DC Link and the converter.

During operation at partial load, speed and rotor blade angle are continuously adjusted to the changing wind conditions. Power is controlled through generator excitation. If rated wind speed is exceeded, the blade angle is adjusted to maintain rated speed.

When the storm control system (optional) is deactivated, the turbine stops as soon as an average wind speed of 25 m/s in the 10-minute-mean or a peak value of 30 m/s is exceeded. The turbine restarts when the wind speed constantly remains below the shutdown wind speed. The rotor is permitted to idle freely at a very low speed even in the shutdown mode.

Yaw control begins even before the start-up speed has been reached. The wind vane constantly takes wind direction measurements. If the deviation between the direction of the rotor axis and the measured wind direction is too great, the yaw adjustment drives correct the nacelle position. The deviation angle and the time it takes for the nacelle position to be corrected vary depending on the wind speed.

Whether the turbine is stopped manually or via the turbine controls, the blade is pitched into the feathered position to reduce the actual contact surface of the wind flow on the blade. The turbine gradually slows down to idle mode.

2 CONTROL SYSTEM

2.1 Response to safety relevant sensor messages

Turbine response to messages received from individual sensors is explained in the following sections. If a safety relevant sensor responds, the turbine initiates an automatic shutdown. The nature of the shutdown and whether it is followed by a restart depends on the fault in question.

Turbine fault occurrences are displayed on the LCD. Minor faults can be reset by pressing the "Acknowledge fault" button once their cause has been established. Afterwards, the turbine automatically starts up again. Some faults may only be rectified by Service technicians and then deleted. The respective status text flashes on the LCD. These messages are also marked with an asterisk.

Furthermore, sensor reliability is constantly monitored by the control system. If the sensors respond, a fault message is sent via the remote monitoring system. Depending on the sensor, the turbine may continue to operate for a certain amount of time. If certain sensors respond, the turbine has to be stopped immediately and the fault rectified.

2.2 Starting the turbine

Unless expressly stated otherwise, these instructions apply to startup after an automatic shutdown and for operation start up with the start/stop switch.

When the turbine is switched on (main switch on control cabinet to "ON" and start/stop switch is set to start), "Turbine operational" appears on the LCD shortly afterwards (status 0:2), provided the E-53 control system has not detected any faults. Ninety seconds after start-up, the rotor blades are driven out of the feathered position (approx. 90°) and "idle mode" begins. The rotor starts turning slowly. The turbine begins the actual operations startup procedure when the average wind speed is greater than the required startup wind speed for three consecutive minutes.

2.3 Normal operation

Once the E-53 startup procedure is completed, the wind energy converter switches to normal operation. During operation, the wind conditions are continuously determined: rotor speed, generator excitation and output are optimised, the nacelle position is adjusted to the wind direction and all sensor messages are recorded. When outside temperatures are high and if the wind speeds are also elevated, the generator fan is switched on.

2.3.1 Operation at partial load

During operation at partial load, the speed and power output are continuously adjusted to the changing wind conditions. In the upper partial load range, the rotor blades are pitched a few degrees to avoid flow interruption (stall effect).

As wind speed increases, the rotor speed and power output increase.

2.3.2 Automatic control mode

When the wind speed exceeds the rated wind speed, the blade angle is adjusted to maintain the rotor speed at / or around its rated value and to limit the use of the wind's power ("automatic control mode"). The required blade angle adjustment is determined by evaluating speed and acceleration measurement data which is then transmitted to the pitch drives. This maintains power output at its rated value.

2.4 Idle mode

If the turbine is shut down (e.g. due to lack of wind or faults), the rotor blades are normally positioned at a 60° angle in relation to the operating position. The turbine then rotates at a slow speed. If this speed (approx. 3 RPM) is exceeded the rotor blades are pitched further into the feathered position (approx. 90°). This operating mode is called "idling". Idling reduces load and enables the turbine to be restarted in the shortest possible time. The reason for turbine shutdown or idle mode is indicated by the status message.

2.5 Stopping the turbine

The E-53 can be stopped by manually activating the start/stop switch and the EMERGENCY STOP button. The control system stops the turbine in the event of faults or unsuitable wind conditions (see Figure 3).

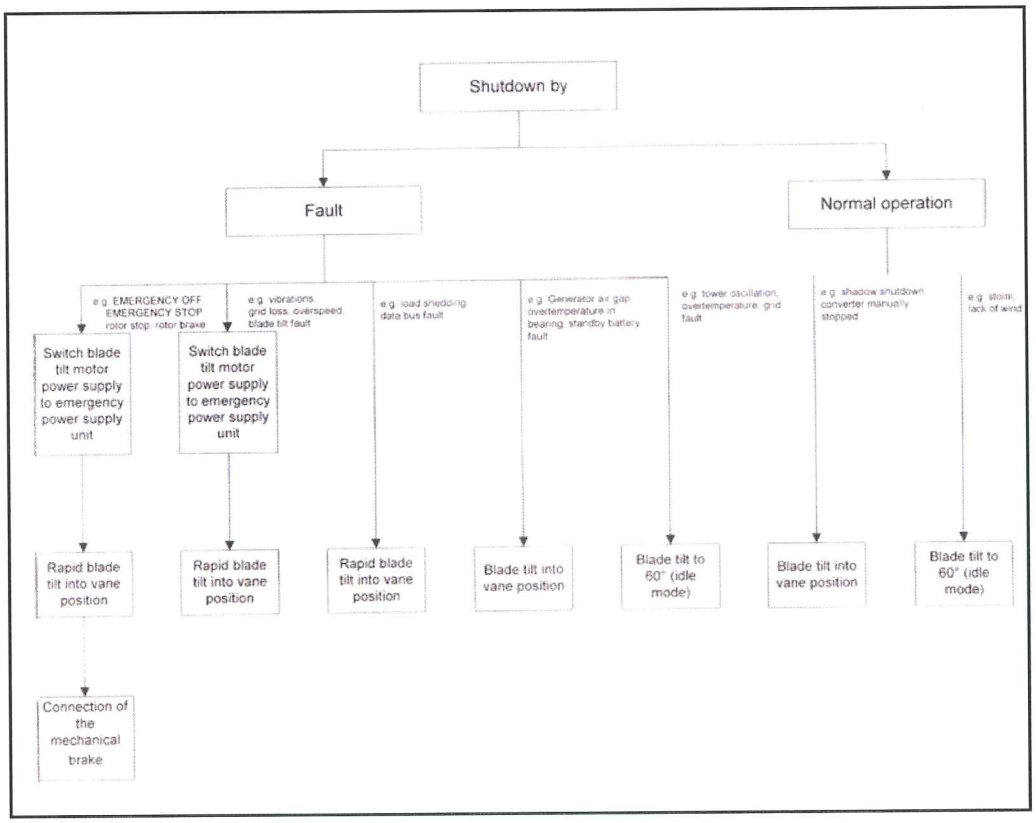


Figure 3: Shutdown procedures for the E-53

2.5.1 Automatic shutdown

In automatic mode, ENERCON wind energy converters are only brought to a standstill aerodynamically by pitching the rotor blades. Pitching the rotor blades reduces the aerodynamic lift force which slows the rotor down. The pitch control devices can drive the rotor blades out of the wind (i.e. into the feathered position) within seconds.

The turbine also stops automatically when certain faults or operating events occur or under certain wind conditions. Some faults cause rapid shutdown to occur. This happens via the rotor blades' backup power units. Other faults result in a normal shutdown.

Automatic restart may be possible depending on the type of fault. In each case the converters are electrically isolated from the grid during shutdown.

2.5.2 Manual stop

The E-53 can be stopped via the start/stop switch on the control cabinet. The control system then pitches the rotor blades out of the wind and the turbine slows to a halt. The brake is not activated and yaw control remains in operation so that the E-53 can continue to optimally adjust to the wind.

2.5.3 Manual shutdown in emergency situations

If individuals or turbine parts are at risk, the turbine can be stopped by pressing the EMERGENCY STOP button. An EMERGENCY STOP button is located on the control cabinet. Pressing it will induce immediate emergency braking on the rotor with rapid pitch control via the emergency pitch and brake units. At the same time the mechanical brakes are activated. All components continue to be supplied with power.

The buttons are latched and have to be pulled back to their original position once the emergency has passed and the turbine is to be restarted.

If the main switch on the control cabinet is set to the OFF position, all turbine components, except for tower and control cabinet lighting and individual light switches and sockets, are switched off. The turbine activates rapid pitch control via the emergency pitch devices. The mechanical brake is not activated when the main switch is used.

2.6 Lack of wind

If the turbine is in operation and the rotor speed drops too low due to lack of wind, the turbine is switched to idle mode by slowly pitching the rotor blades towards the 60° angle. The turbine then restarts automatically when the cut-in wind speed is reached.

If the anemometer freezes due to low temperatures (<3°C), the turbine attempts to start at hourly intervals to test whether the wind speed is sufficient for operation when the wind vane is functioning. If the turbine starts and produces power, it goes into normal operation. However, the correct wind speed does not appear on the display since the frozen sensor cannot provide accurate wind speed data.

2.7 Storm

From the standstill position or idle mode the turbine does not start up at wind speeds over 25 m/s. If an average wind speed of 25 m/s or a top value of 30 m/s is exceeded, the E-53 automatic control mode stops. The turbine also stops if the maximum permissible blade angle is exceeded. A frozen anemometer therefore does not represent a safety risk. In all cases the turbine switches to idle mode.

The E-53 components, such as rotor blades, nacelle, tower and foundations are designed to withstand considerably higher wind speeds.

The turbine starts automatically if the wind speed drops below cut-out wind speed (25 m/s) for 10 consecutive minutes.

When wind speeds surpass 28 m/s the ENERCON Storm Control System does not shut down the turbine abruptly, but rather reduces the power by continuously pitching the rotor blades. The output is only reduced to zero at wind speeds of approx. 34 m/s. This strategy improves electrical behaviour in the grid at the same time increases output.

2.8 Yaw control

The E-53 has a combination wind sensor, which is installed on the top of the nacelle. The combined wind sensor comprises a wind vane, which constantly determines the wind direction, and an anemometer, which measures wind speed.

E-53 yaw control already starts to operate below the cut-in wind speed of 2 m/s. Even if the system shuts down (e.g. due to excessive wind speed), it adjusts according to the wind conditions. The angle and the period of measurement depend on the wind speed and turbine performance.

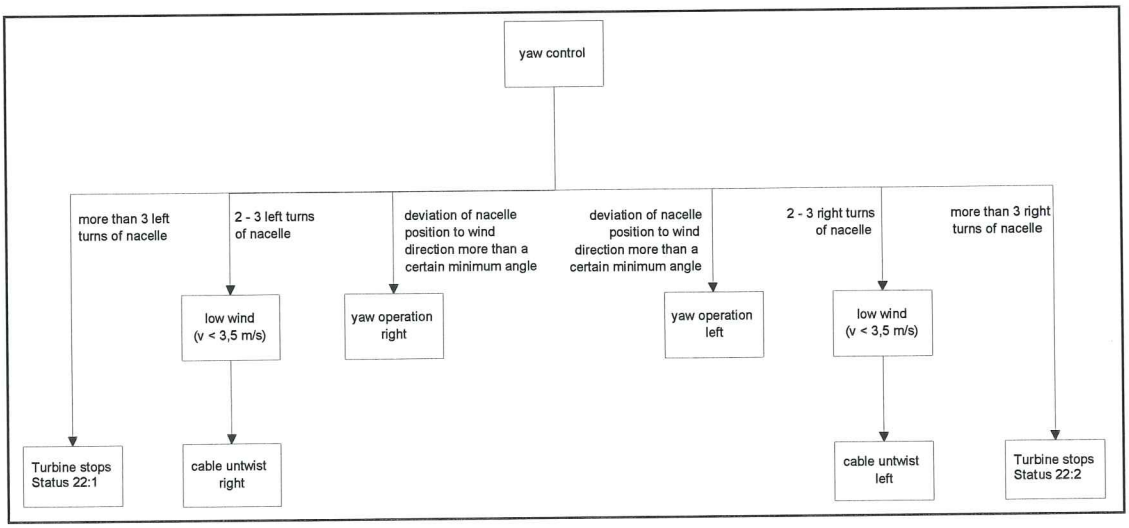


Figure 4: Illustration of yaw control

Yaw procedure is determined by counting the pitch motor rotations and the required pitch time is checked for plausibility. If the control system detects irregularities in yaw control or cable untwisting (See following), shutdown procedure is initiated.

2.8.1 Untwisting power and control cables

The E-53 power and control cables located in the tower pass from the nacelle over a deflection pad and are then fastened to the tower wall. The cables have enough freedom of movement to permit the nacelle to rotate several times in the same direction about its axis. The cables gradually twist. The E-53 control system ensures that the twisted cables are automatically unwound.

Once the cables have been twisted two and three times, the control system uses the next low-wind period to untwist the cables. If, however, high wind conditions continue and the cables have twisted more than 3 turns, the turbine stops and the cables untwist irrespective of wind speed. The cables take about half an hour to untwist. Once the cables have untwisted, the turbine automatically restarts.

The cable twist sensors can be found on the so-called cable twist switch, which in the E-53 is fitted near the access hatch. The sensor is connected via a gearwheel and gearbox to the yaw slewing ring. Changes in the nacelle direction are transmitted to the operation control system.

Furthermore, clockwise and anti-clockwise limit switches transmit whether the permissible limit has been exceeded in either direction (cable twist limit switch clockwise or anti-clockwise). This prevents the tower cables from twisting further. The turbine stops and cannot be restarted automatically.

3 TECHNICAL SPECIFICATIONS:

Turbine type:	**ENERCON E-53**
Rated power:	800 kW
Rotor diameter:	52,9 m
Hub height:	73 m
Wind class (IEC):	IEC / NVN S
	(v_{av} = 7.5 m/s, v_{exr} = 57 m/s)
Turbine concept:	Gearless, variable speed, single blade pitch control
Rotor	
Type:	Upwind rotor with active pitch control
Rotational Direction:	Clockwise
No. of blades:	3
Swept area:	2 198 m²
Blade material:	Fibreglass (epoxy resin); integrated lightning protection
Speed:	Variable, 12-29 rpm
Pitch control:	ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply
Drive train with generator	
Hub:	Rigid
Main bearing:	Single row cylindrical roller bearings
Generator:	ENERCON direct-drive synchronous annular generator
Grid power feed:	ENERCON inverter

Braking system	- 3 independent pitch systems with emergency power supply - Rotor brake - Rotor lock
Yaw control:	Active via adjustment gear, load-dependent damping
Cut-out wind speed:	28 - 34 m/s (with ENERCON Storm Control)
Remote monitoring:	ENERCON SCADA

WEC CHARACTERISTICS

E-53

Rotor	
Type	E-53-1
Rotor diameter	52,9 m
Swept area	2198 m²
Power regulation	Pitch
RPM	12-29 min^{-1}.
Cut in wind	2,5 m/s
Cut out wind	28-34 m/s (ENERCON Storm control)
Survival wind speed	57 m/s

Gear box	
Not applicable	No gearbox

Blades	
Manufacturer	ENERCON
Blade length	25,25 m
Material	GRP (Epoxy)
Lightning protection	included

Generator	
Manufacturer	ENERCON
Nominal power	800 kW
Type (model)	Synchronous, direct-drive ringgenerator
Protection classification	IP 23
Insulation class	F

Yaw System	
Type	4 electrical motors
Yaw control	Active (based on wind vane signal)
Yaw rate	0,5°/s

Controller	
Manufacturer	ENERCON
Type	microprocessor
Grid connection	Via ENERCON inverter
Remote communication	ENERCON Remote Monitoring System
UPS	included

Braking System	
Aerodynamic brake	- three independent blade pitch systems with emergency supply - rotor brake - rotor lock, locking at 30°

Tower		
Hub height	60 m	73 m
Tower	Steel (3 + B)	Steel (3 + B)
Design Wind Class IEC	**S**	**S**
Definition of Wind Class S	Annual average wind speed: 7,72 m/s Survival wind speed: 57 m/s	

Weights	
Nacelle, excl. Rotor and hub	Approx. 5,5 to
Rotor incl. Hub/Main pin	Approx. 16,5 to
Generator	Approx. 16,5 to
Total weight	**Approx. 38,5 to**

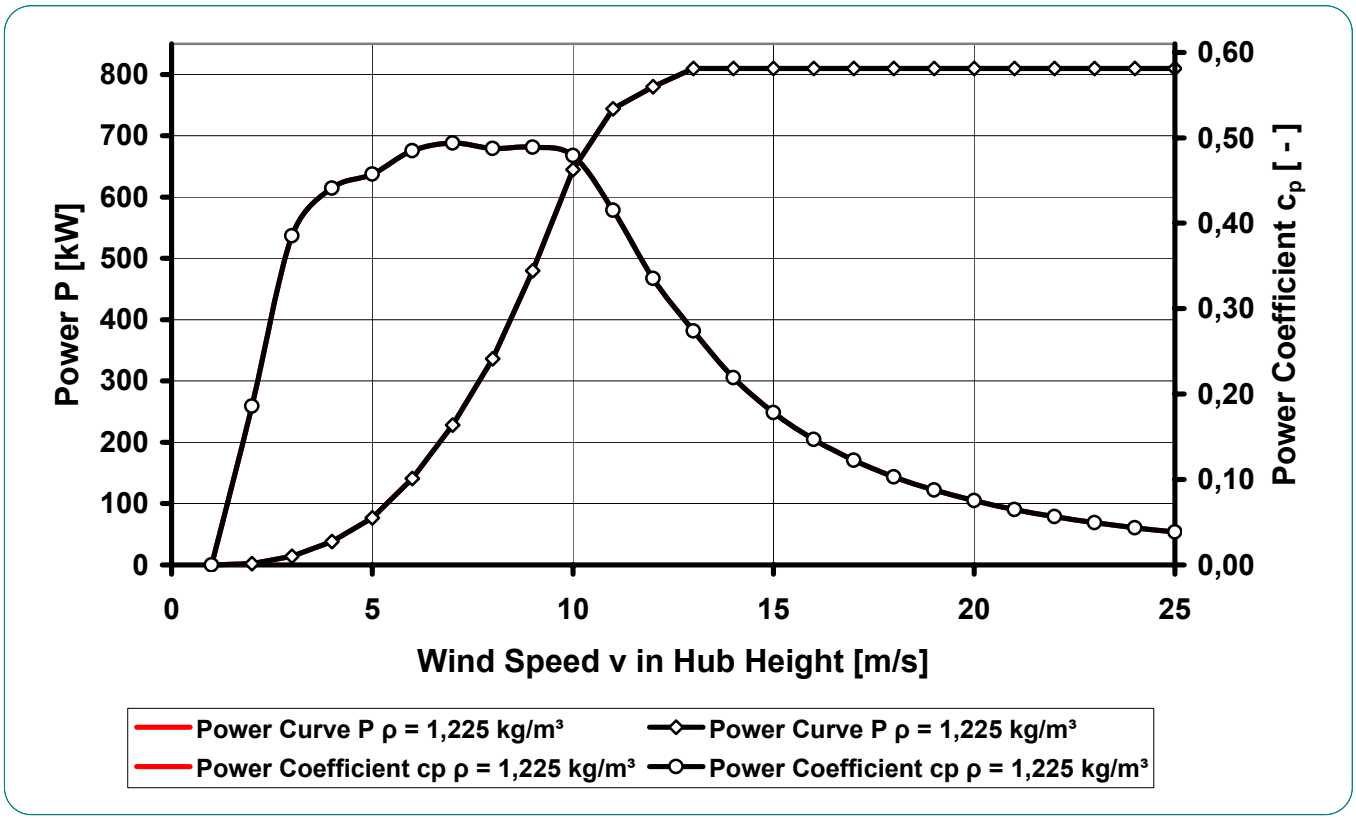
Sources: Design Assessment, Manufacturers certificate

Power Curve E-53

(In dependence of Air Density)

	Standard Air Density ρ = 1,225 kg/m³		*Modified Air Density ρ = 1,225 kg/m³*	
Wind [m/s]	Power Curve P ρ = 1,225 kg/m³ [kW]	Power Coefficient c_p ρ = 1,225 kg/m³ [-]	Power Curve P ρ = 1,225 kg/m³ [kW]	Power Coefficient c_p ρ = 1,225 kg/m³ [-]
1	0,0	0,00	0,0	0,00
2	2,0	0,19	2,0	0,19
3	14,0	0,39	14,0	0,39
4	38,0	0,44	38,0	0,44
5	77,0	0,46	77,0	0,46
6	141,0	0,48	141,0	0,48
7	228,0	0,49	228,0	0,49
8	336,0	0,49	336,0	0,49
9	480,0	0,49	480,0	0,49
10	645,0	0,48	645,0	0,48
11	744,0	0,42	744,0	0,42
12	780,0	0,34	780,0	0,34
13	810,0	0,27	810,0	0,27
14	810,0	0,22	810,0	0,22
15	810,0	0,18	810,0	0,18
16	810,0	0,15	810,0	0,15
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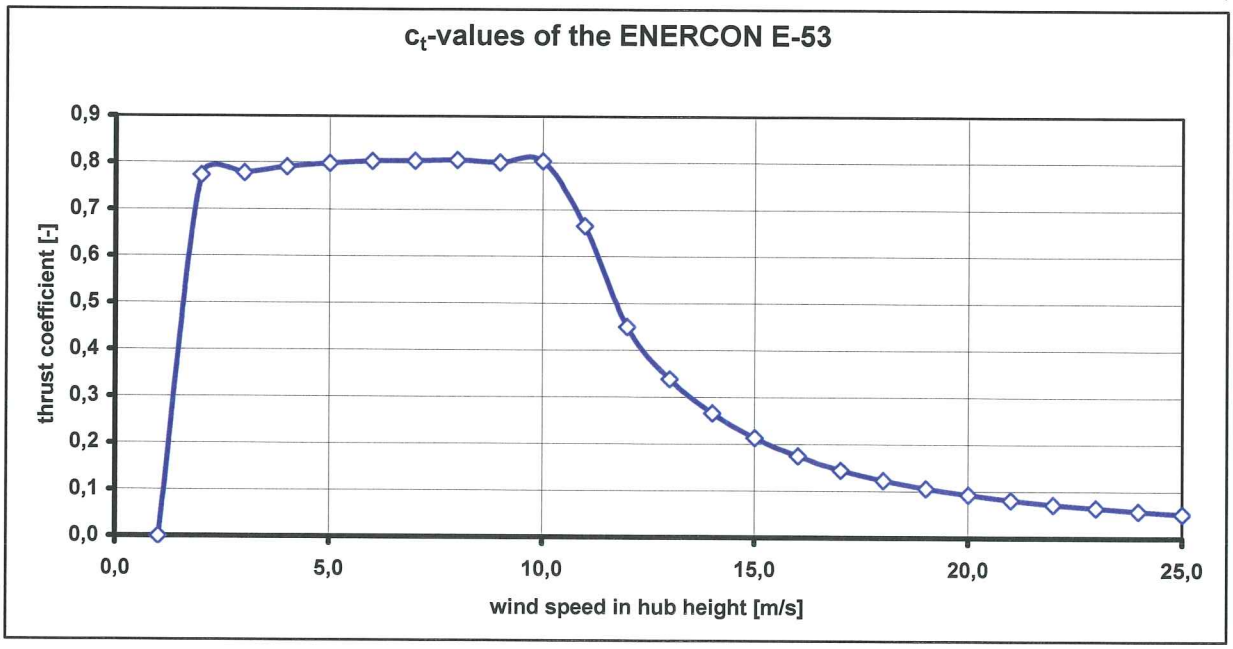
Power Curve E-53 with Standard Air Density



Rated power output: 800 kW
Power curve: calculated power curve (June 2005)

Wind Speed [m/s]	Power Output [kW]	c_t [-]
1,0	0,0	0,000
2,0	2,0	0,773
3,0	14,0	0,778
4,0	38,0	0,791
5,0	77,0	0,798
6,0	141,0	0,803
7,0	228,0	0,804
8,0	336,0	0,806
9,0	480,0	0,801
10,0	645,0	0,804
11,0	744,0	0,665
12,0	780,0	0,450
13,0	810,0	0,339
14,0	810,0	0,266
15,0	810,0	0,214
16,0	810,0	0,175
17,0	810,0	0,145
18,0	810,0	0,123
19,0	810,0	0,106
20,0	810,0	0,093
21,0	810,0	0,081
22,0	810,0	0,072
23,0	810,0	0,065
24,0	810,0	0,058
25,0	810,0	0,052

(Simulation ENERCON)



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ENERCON DATA SHEET

GRID PERFORMANCE

ENERCON E-53

Configuration: FD

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

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For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

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For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

1 INTRODUCTION

All data refer to the reference point shown in Chapter 12.
The performance can only be achieved with the CS48 control system with FACTS power cabinets.
In addition to the Grid Performance Data Sheet an extract of the power quality measurement according to IEC 61400-21 (NR 06010.112) is available on request.

2 MAIN TECHNICAL DATA

Nominal Frequency:	f_n =	50 / 60 Hz	**Nominal Voltage:**	U_n =	400 V
Rated Apparent Power:	S_n =	800 kVA	**Rated Current at P_n:**	I_n =	1155 A
Rated Active Power:	P_n =	800 kW			
Max. Permanent Apparent Power:	S_{max} =	900 kVA	**Max. Permanent Current:**	I_{max} =	1425 A
			Short Circuit Current	$I_k{}''_{,max}$ =	1500 A
			Number of power cabinets:		3
Reactive Power is adjustable:					
Default value:	Q =	0 kvar	**Corresponding to cos φ =**	1,0	

For further information regarding short circuit current see Chapter 8.1.

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

3 REACTIVE POWER CAPABILITY

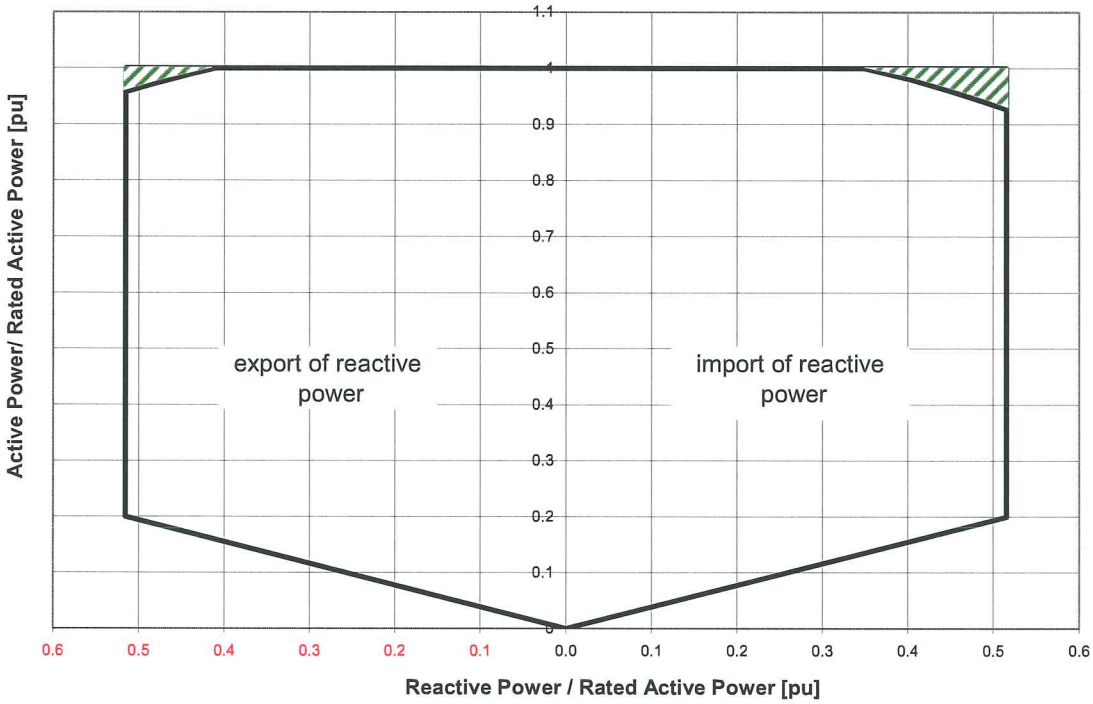


Fig. 3.1: Reactive power capability: Left side with red numbers refers to export of reactive power. Right side with black numbers refers to import of reactive power. Orientation is according to IEC 60034-3

Max. reactive power: $Q_{max\ export}$ = 410 kvar $Q_{max\ import}$ = 410 kvar

Any operating point within the area marked with the solid black lines can be ensured for the continuous voltage range, as shown by the black line in diagram 4.1. Additionally, the operating points within the green hatched area can be ensured for a voltage range from U_n up to the maximum voltage U_{max}.

The reactive power of the WT is adjustable. You may choose a value either for reactive power (Q = const. within the limits of the diagram above) or for the power factor (cos φ = const. within the limits of the diagram above). A higher-level control for Q or cos φ or voltage can be installed on request, always with reference to the point of common coupling (PCC) of the wind farm, using the ENERCON SCADA System.

The reactive power at the individual WT can be ensured within a tolerance < ± 2.5% of the rated active power for the 10-minute average values.

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

4 POWER-VOLTAGE DIAGRAM

Maximum Continuous Voltage:	U_{max} =	120% = 480 V
Nominal Voltage:	U_n =	100% = 400 V
Minimum Continuous Voltage:	U_{min} =	90% = 360 V
Temporary Minimum Voltage:	$U_{min,temp}$ =	80% = 320 V

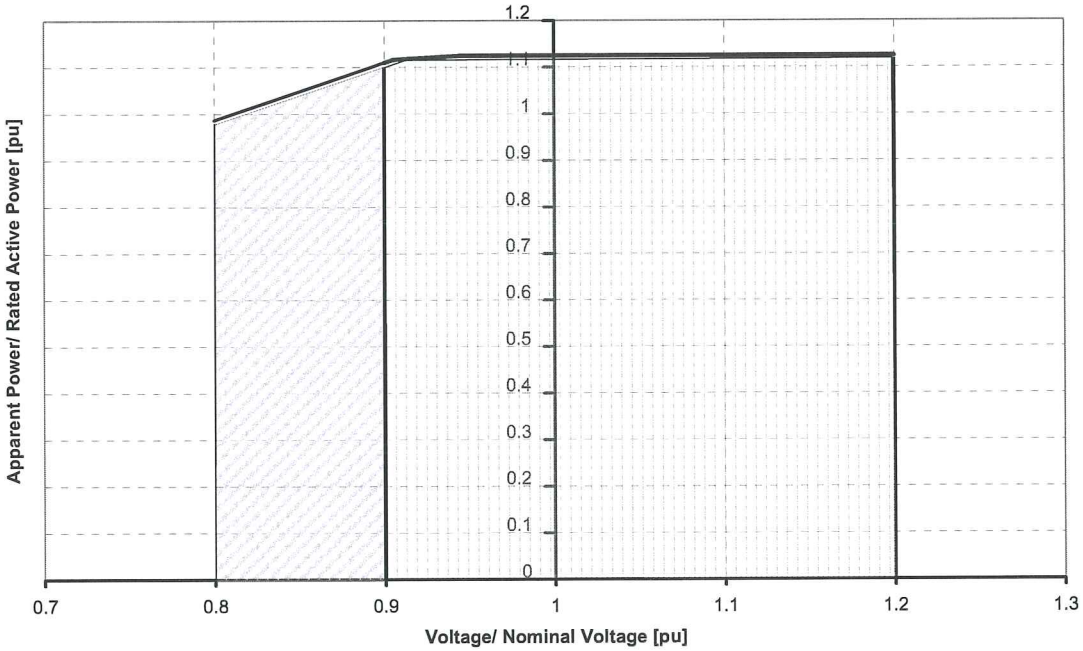


Fig. 4.1: Power-voltage diagram

Temporary operation limits: In the hatched area only temporary operation is possible for up to 60 seconds.

If the voltage drops while the WT is in an operation point injecting a certain apparent power, this may lead to a new operating point that does not allow the same apparent power any more. To keep within the limits given in figure 4.1, the WT will by default give priority to active power as long as possible and reduce the reactive power accordingly. The priority of P over Q can be altered on request.

See also Chapter 8 if the voltage is below the temporary minimum value or above the maximum value.

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

5 POWER-FREQUENCY DIAGRAM

Rated Mains Frequency:		**50 Hz**		**60 Hz**
Maximum Frequency:	f_{max} =	57 Hz	f_{max} =	67 Hz
Nominal Frequency:	f_n =	50 Hz	f_n =	60 Hz
Minimum Frequency:	f_{min} =	43 Hz	f_{min} =	53 Hz

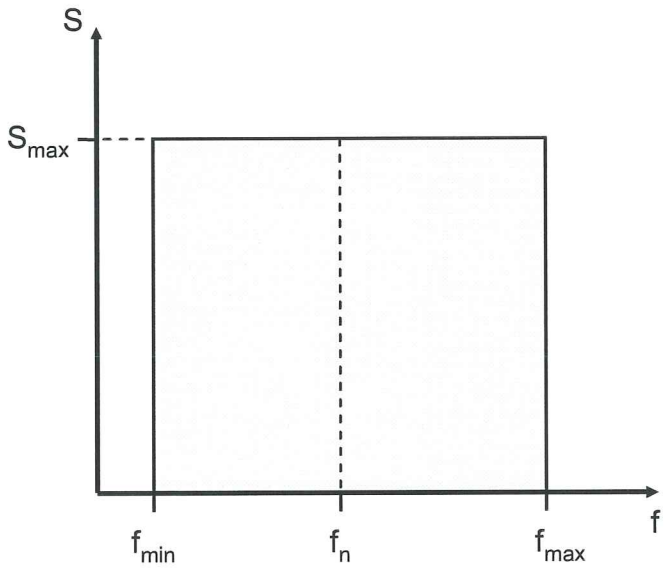


Fig. 5.1: Power-Frequency Diagram

Regarding changes of the power system frequency the ENERCON E-53 can operate without interruption during disturbances with frequency gradients up to 4 Hz/s.

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

6 FREQUENCY PROTECTION

6.1 Frequency protection for 50 Hz grid

Over frequency protection setting data:	50 Hz ≤ f_{of} ≤ 57 Hz
Step width:	0.1 Hz
Factory default:	52 Hz
Under frequency protection setting data:	43 Hz ≤ f_{uf} ≤ 50 Hz
Step width:	0.1 Hz
Factory default:	47 Hz
Delay time for over frequency protection:	0.070 s ≤ t_{dof} ≤ 60 s
Step width:	0.010 s
Factory default:	0.070 s
Delay time for under frequency protection:	0.070 s ≤ t_{duf} ≤ 60 s
Step width:	0.010 s
Factory default:	0.070 s

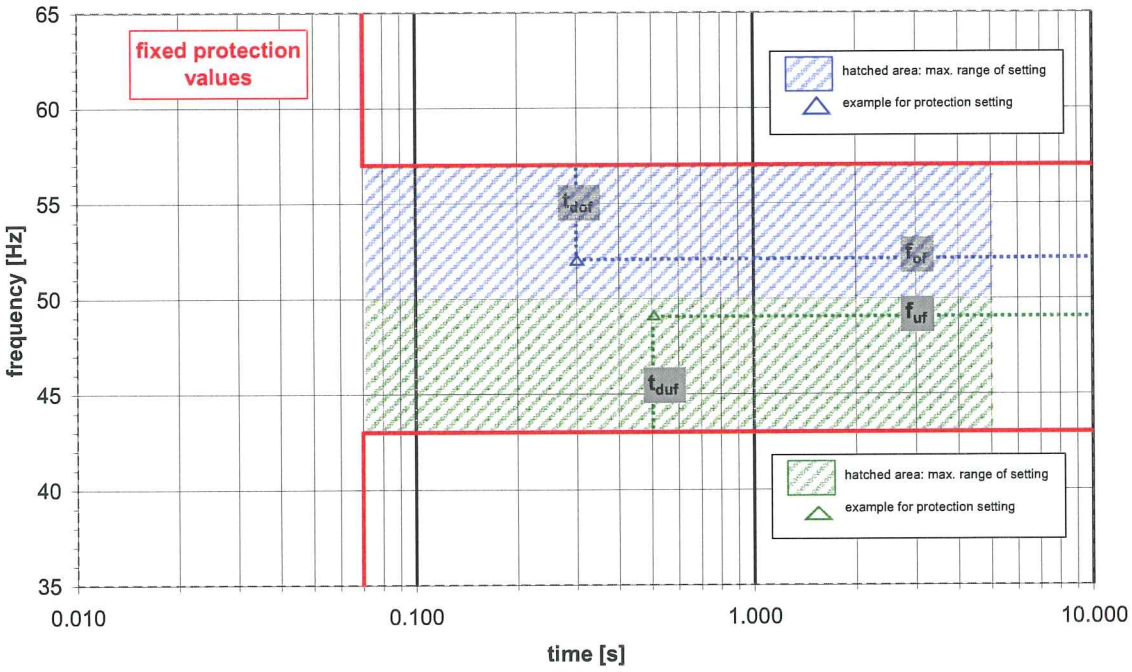


Fig. 6.1.1: Frequency Protection for 50 Hz grid

For effective tripping time see end of Chapter 6.2.

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

6.2 Frequency protection for 60 Hz grid

Over frequency protection setting data:	60 Hz ≤ f_{of} ≤ 67 Hz
Step width:	0.1 Hz
Factory default:	62 Hz
Under frequency protection setting data:	53 Hz ≤ f_{uf} ≤ 60 Hz
Step width:	0.1 Hz
Factory default:	57 Hz
Delay time for over frequency protection:	0.070 s ≤ t_{dof} ≤ 60 s
Step width:	0.010 s
Factory default:	0.070 s
Delay time for under frequency protection:	0.070 s ≤ t_{duf} ≤ 60 s
Step width:	0.010 s
Factory default:	0.070 s

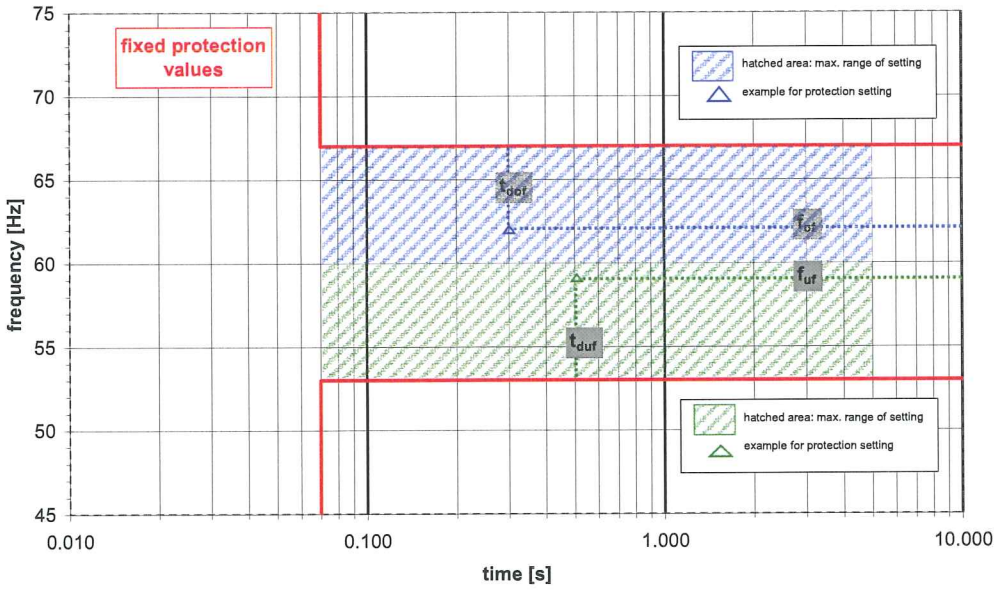


Fig. 6.2.1: Frequency Protection for 60 Hz grid

The delay time of the protection is shown. The effective tripping time is longer, due to the switch-off time of the power contactors.

Switch-off time of power contactors:	T_{pc} ≤ 0.040 s	(fixed value)
Tripping time of over frequency protection:	$t_{ofp} = t_{dof} + T_{pc}$	
Tripping time of under frequency protection:	$t_{ufp} = t_{duf} + T_{pc}$	

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

7 VOLTAGE PROTECTION

7.1 Over voltage protection (for each phase)

Over voltage protection 1:	U_{ovp1} : 145% of $\sqrt{2}xU_n/\sqrt{3}$	(fixed value)
Detection of over voltage 1:	$U_{Grid} \geq U_{ovp1}$	
Detection time 1:	$T_{detect1}$ = 0.001 s	(fixed value)
	$t_{dovp1} = T_{detect1}$	

This protection leads to tripping of the WT. This serves to protect the WT.

Over voltage protection 2:	U_{ovp2} : 120% of $U_n/\sqrt{3}$	(fixed value)
Detection of over voltage 2:	$U_{ovp2} < U_{Grid} < U_{ovp1}$	
Detection time 2:	$T_{detect2} \leq$ 0.040 s	(fixed value)
Delay time for over voltage protection 2:	$t_{dovp2} = T_{detect2}$	

This protection leads to tripping of the WT. This serves to protect the WT.

Over voltage protection 3:	u_{ovp3} : 100% ... 120% of $U_n/\sqrt{3}$
Detection of over voltage 3:	$U_{Grid} > u_{ovp3}$
Step width:	1 V
Factory default:	u_{ovp3}= 116% of $U_n/\sqrt{3}$
Delay time for over voltage protection 3:	0.070 s ≤ $t_{dovp3} \leq$ 60 s
Step width:	0.010 s
Factory default:	t_{dovp3} = 0.100 s

This protection leads to tripping of the WT. This parameter can be used to protect the grid.

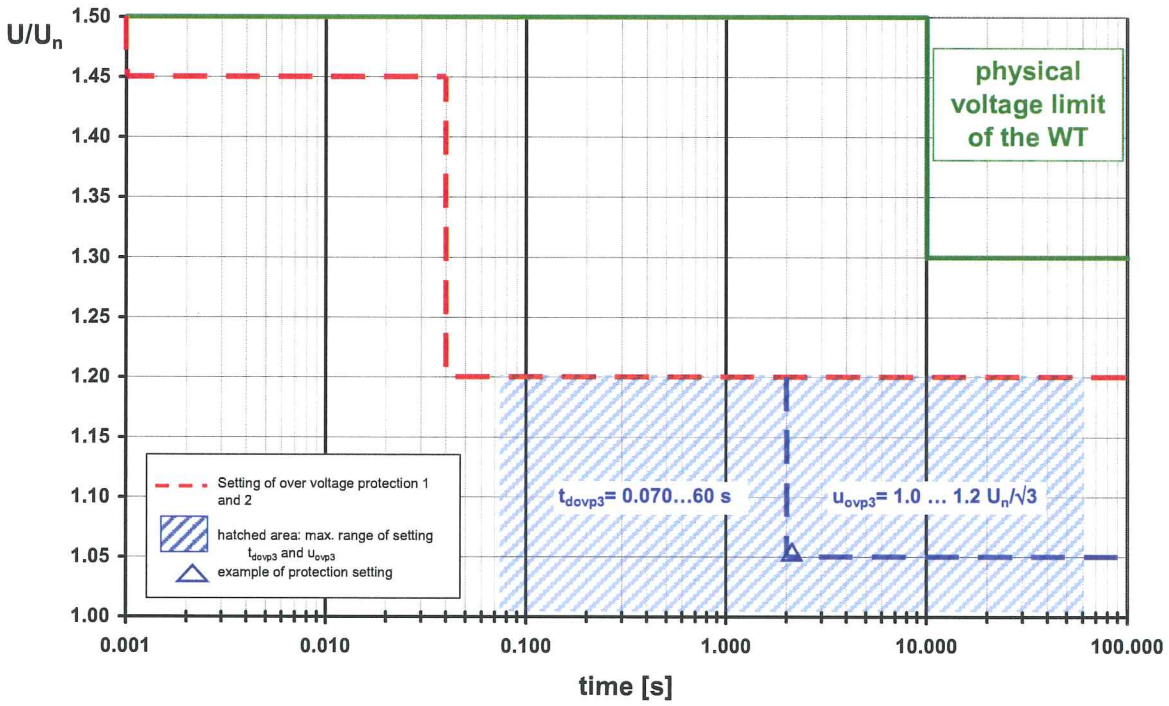


Fig. 7.1.1: Over voltage protection

Optionally, an additional over voltage protection can be set:

Over voltage protection 4:	u>> : 100% ... 120% of $U_n/\sqrt{3}$
Detection of over voltage 4:	U_{Grid} > u>>
Step width:	1 V
Delay time for over voltage protection 4:	0.070 s ≤ $t_{du>>}$ ≤ 60 s
Step width:	0.010 s

This protection leads to tripping of the WT. This parameter can be used to protect the grid.

The delay time of the protection is shown. The effective disconnection/ tripping time is longer due to the switch-off time of the power contactors.

Switch-off time of power contactors:	T_{pc} ≤ 0.040 s	(fixed value)
Tripping time for over voltage protection 1:	$t_{ovp1} = t_{dovp1} + T_{pc}$	
Tripping time for over voltage protection 2:	$t_{ovp2} = t_{dovp2} + T_{pc}$	
Tripping time for over voltage protection 3:	$t_{ovp3} = t_{dovp3} + T_{pc}$	
Tripping time for over voltage protection 4:	$t_{u>>} = t_{du>>} + T_{pc}$	(optionally)

At voltage levels >145% of $\sqrt{2}xU_n/\sqrt{3}$ the power contactors always open within 1 ms + T_{pc}.

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

7.2 Under voltage protection (for each phase)

Under voltage protection 1:	U_{uvp1} : 80% of $U_n/\sqrt{3}$	(fixed value)
Detection of under voltage 1:	$U_{Grid} \leq U_{uvp1}$	
Detection time 2:	$T_{detect2} \leq 0.040$ s	(fixed value)
Delay time for under voltage protection 1:	$t_{duvp1} = T_{detect2}$	

Under voltage protection 2:	u_{uvp2} : 80% … 100% of $U_n/\sqrt{3}$
Detection of under voltage 2:	$U_{uvp1} < U_{Grid} \leq u_{uvp2}$
Delay time for under voltage protection 2:	0.070 s ≤ t_{duvp2} ≤ 60 s
Step width:	0.010 s
Factory default:	t_{duvp2} = 0.100 s
Step width:	1 V
Factory default:	u_{uvp2} = 80% of $U_n/\sqrt{3}$

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

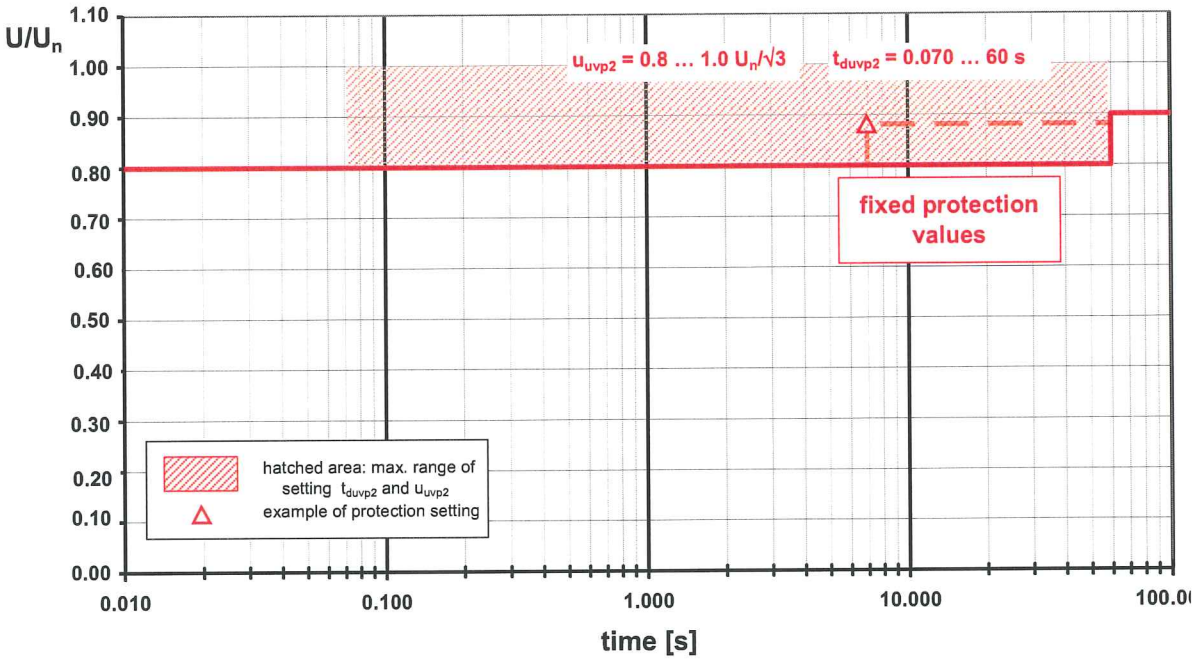


Fig. 7.2.1: Under-voltage protection

Optionally, an additional under voltage protection can be set:

Under voltage protection 3:	u<< : 0% ... 100% of $U_n/\sqrt{3}$
Detection of over voltage 3:	U_{Grid} < u<<
Step width:	1 V
Delay time for over voltage protection 3:	0.070 s ≤ $t_{du<<}$ ≤ 60 s
Step width:	0.010 s

This protection leads to tripping of the WT. This parameter can be used to protect the grid.

The delay time of the protection is shown. The effective tripping time is longer, due to the switch-off time of the power contactors.

Switch-off time of power contactors:	T_{pc} ≤ 0.040 s	(fixed value)
Tripping time for under-voltage protection 1:	$t_{uvp1} = t_{duvp1} + T_{pc}$	
Tripping time for under-voltage protection 2:	$t_{uvp2} = t_{duvp2} + T_{pc}$	
Tripping time for under-voltage protection 3:	$t_{u<<} = t_{du<<} + T_{pc}$	(optionally)

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

8 FAULT RIDE THROUGH PERFORMANCE

8.1 General Performance

There is no Fault Ride Through Performance available in this configuration.

Maximum Short Circuit Current in all three phases (even in case of unsymmetrical faults):

1. $I_k"_{,max}$: 1500 A (Maximum Initial Symmetrical Short Circuit Current)
2. $I_{P\,max}$: 2121 A (Maximum Peak Short Circuit Current: $\sqrt{2} * I_k"_{,max}$)
3. $I_{b,max}$: 1500 A (Maximum Short Circuit Breaking Current)
4. $I_{k,max}$: - (Maximum Steady State Short Circuit Current)

Further details and explanations concerning the short circuit currents are provided in the document "Steady State Short Circuit Calculations" (available on request).

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

9 POWER RAMPS

9.1 Active Power Ramp-up

Normal start power gradient:

maximum value:	$dP/dt_{start,max}$ =	80	kW/s
minimum value:	$dP/dt_{start,min}$ =	1	kW/s
Factory default:	dP/dt_{start} =	15	kW/s

Power gradient after loss of voltage:

maximum value:	$dP/dt_{power,max}$ =	80	kW/s
minimum value:	$dP/dt_{power,min}$ =	1	kW/s
Factory default:	dP/dt_{power} =	15	kW/s

Operating power gradient:

maximum value:	$dP/dt_{oper,max}$ =	210	kW/s
minimum value:	$dP/dt_{oper,min}$ =	1	kW/s
Factory default:	dP/dt_{oper} =	50	kW/s

9.2 Active Power Ramp-down

Intervention of grid operator: The active power output may be limited via ENERCON PDI[1]. After a WT has received the signal to reduce the active power output the new value is reached within a period not longer than 10 seconds.
Communication delay from ENERCON PDI via SCADA to the WT is not included and depends on the configuration in the wind farm.

9.3 Reactive Power Ramp

Time delay during normal operation: τ = 0.160 s

[1] See ENERCON Process Data Interface documentation
For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

10 POWER-FREQUENCY CONTROL

In over frequency grid situations the active power output can be reduced by using the implemented power-down ramp. You may choose between a "static" and a "dynamic" reduction of active power due to over frequency. Ex factory, the WT is adjusted to static reduction.

Moreover, with both options the ramp-down can be related to the actual generated active power or to the rated active power of the WT.
The ramp-down related to the *actual generated* active power leads to immediate ramp-down when the over frequency limit f_{limit} is exceeded.
Alternatively, the ramp-down can be related to the *rated* active power, which may lead to delayed ramping-down in case the actual active power is less than the rated active power.

10.1 "Static" power-frequency control

The active power is ramped down related to the current frequency.

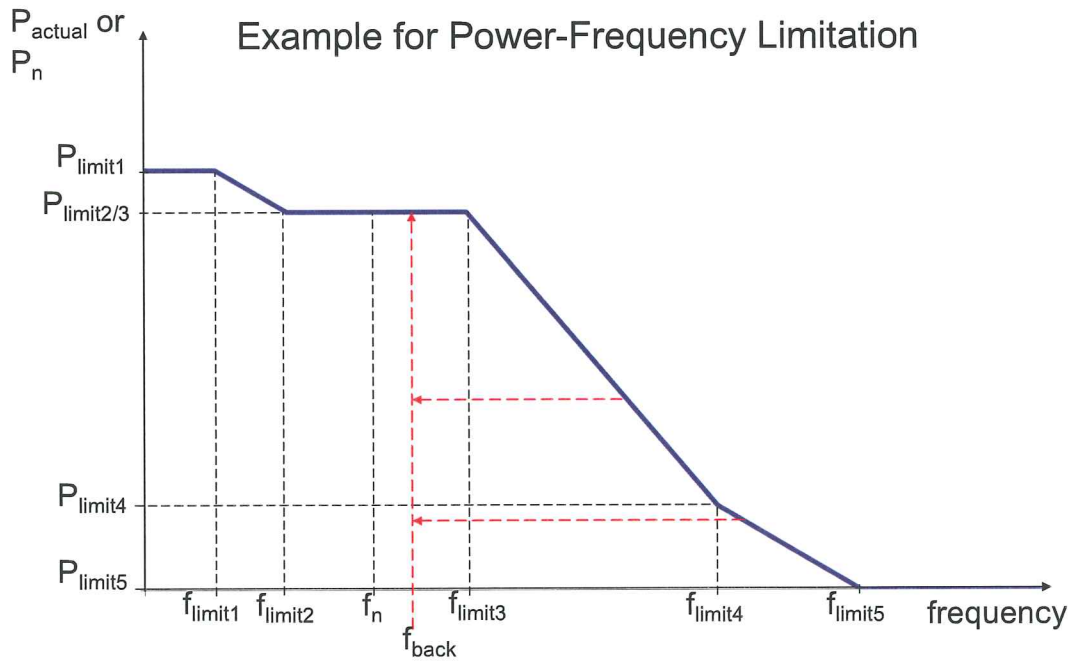


Fig. 9.1.1: "Static" Power-frequency control

By default there is no power limitation set at f_n ($P_{limit2/3}$ = 100% P_n respectively 100% P_{actual}). If required, the limitation at f_n can be set via ENERCON SCADA-System.

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

Setting	Description	Default value	Minimum setting value	Maximum setting value
P_{actual}	Active power depending on present wind conditions and power curve of WT	-	-	-
P_n	Rated Active power of the WT		-	-
f_n	Nominal frequency	-	-	-
f_{limit1}	Frequency limit 1	49 Hz	-	$f_{limit1} < f_{limit2}$ - 0.1Hz
P_{limit1}	Max. available active power (in %) at $f_{Grid} \leq f_{limit1}$	100%	-	-
f_{limit2}	Frequency limit 2	49.75 Hz	$f_{limit2} > f_n - 2$ Hz	$f_{limit2} < f_n$
$P_{limit2/3}$	Limitation of the active power (in %) related to P_{actual} or P_n between f_{limit2} and f_{limit3}	100%	0%	100%
f_{limit3}	Frequency limit 3	50.25 Hz	$f_{limit3} > f_n$	$f_{limit3} < f_{limit4}$
f_{limit4}	Frequency limit 4	51.5 Hz	$f_{limit4} > f_{limit3}$	$f_{limit4} < f_{limit5}$ -0.1Hz
P_{limit4}	Limitation of the active power (in %) related to P_{actual} or P_n at f_{limit4}	0%	0%	$P_{limit4} < P_{limit2/3}$
f_{limit5}	Frequency limit 5	51.6 Hz	$f_{limit5} > f_{limit4}$	$f_{limit5} < 70$ Hz
P_{limit5}	Limitation of the active power (in %) related to P_{actual} or P_n at f_{limit5}	0%	0%	$P_{limit5} \leq P_{limit4}$
f_{back}	Turn back frequency	50.05 Hz	0 Hz	$f_{back} < 70$ Hz

If the frequency decreases after it has exceeded f_{limit3}, the power will remain limited until the actual frequency $f_{Grid} \leq f_{back}$. The WT will then ramp in maximum available active power and reactive power as set before the fault.

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

10.2 "Dynamic" power-frequency control

The active power of the WT is ramped down once an over frequency limit f_{limit} has been exceeded. The power ramp-down continues as long as the over frequency limit f_{limit} is exceeded.
In case the frequency falls below the frequency limit again, active power is ramped up again with the same gradient as the previous ramp-down (given sufficient wind speed).
Reactive power will be ramped down or ramped up with the same gradient.

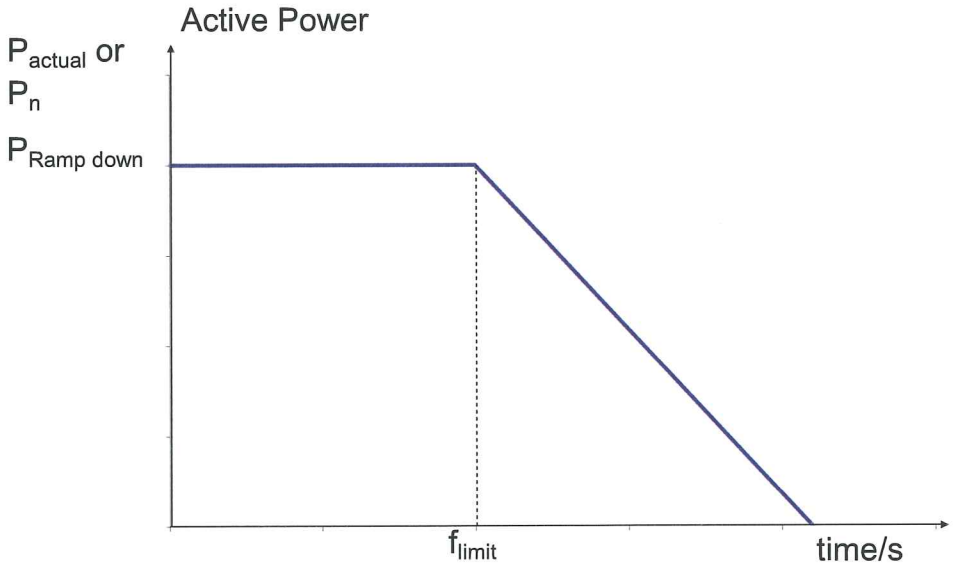


Fig. 10.2.1: "Dynamic" Power-frequency control

Setting	Description	Default value	Minimum setting value	Maximum setting value
P_{actual}	Active power depending on present wind conditions and power curve of WT	-	-	-
P_n	Rated Active power of the WT		-	-
f_{limit}	Over-frequency limit for start of ramp-down	50.5 Hz	f_n – 2 Hz	f_n + 5 Hz
Ramp-down	Reduction of active power related to P_{actual} or P_n	5%/s	0%/s	25%/s

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

11 CONSUMPTION OF WT DURING STANDBY

In case the wind speed is too low to supply the WT-internal auxiliary devices, the WT may consume the following power from the grid:

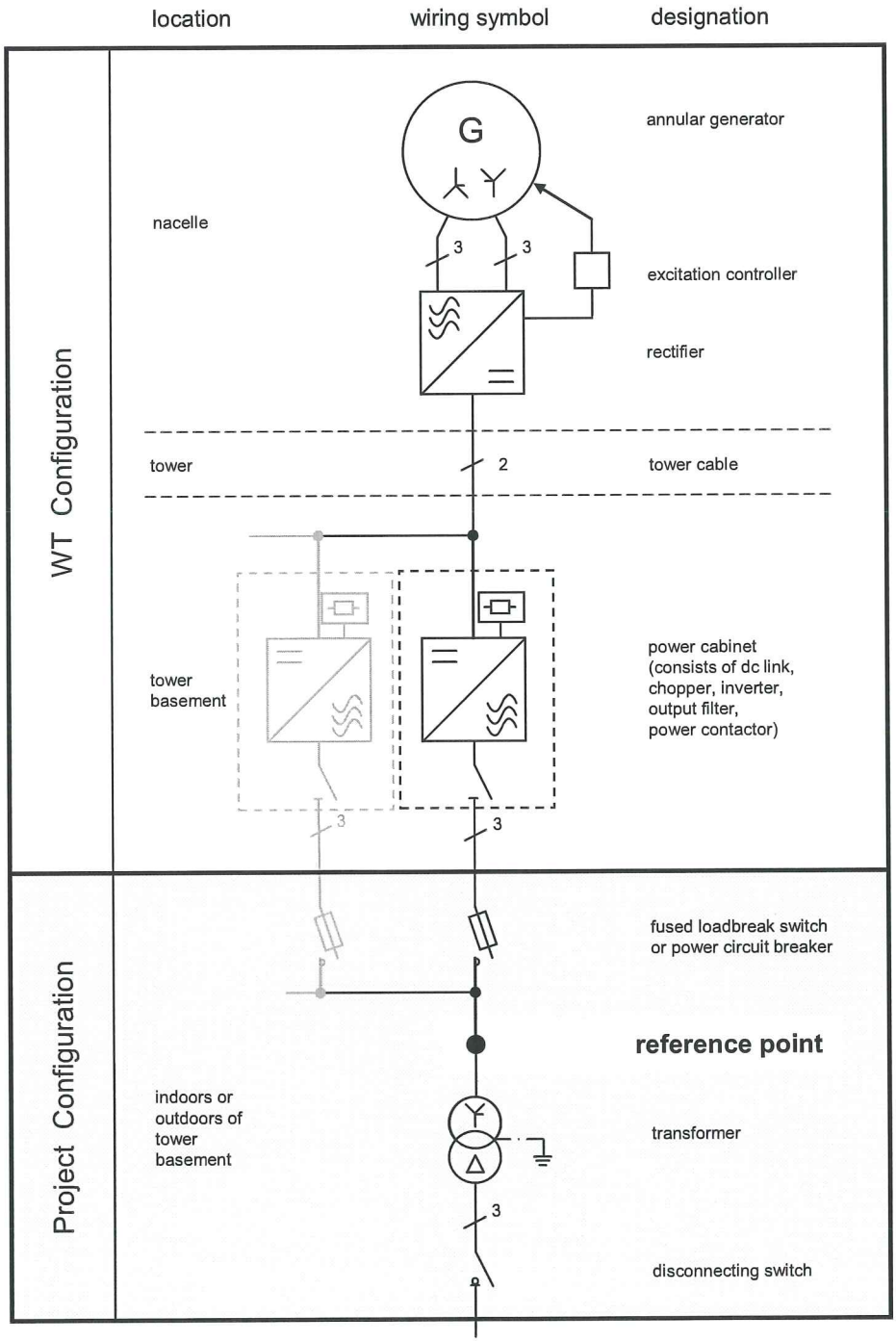
Max. active power (10-minute-average): $P_{aux\ max\ 10\ min}$ = 2 kW

Max. reactive power (10-minute-average): $Q_{aux\ max\ 10\ min}$ = 0.1 kvar inductive

Energy consumption depends on the project-specific wind conditions.

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

12 REFERENCE POINT



For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

13 GLOSSARY

Export of reactive power	According to Standard IEC 60034-3, export of reactive power is equivalent to the behaviour of an overexcited synchronous machine
f_n	Nominal grid frequency according to Standard IEC 61400-21, 7.1.1
f_{Grid}	Actual frequency of the grid
FRT	Fault Ride Through: Ability of the wind turbine to stay connected during temporary voltage drops or peaks. One distinguishes between Under Voltage Ride Through Mode (UVRT) and Over Voltage Ride Through Mode (OVRT).
G	ENERCON annular generator
I_{max}	Max. Permanent Current
Import of reactive power	According to Standard IEC 60034-3, import of reactive power is equivalent to the behaviour of an underexcited synchronous machine
Maximum Apparent Power (S_{max})	Maximum Apparent Power of the WT: Apparent power related to the maximum active and reactive power (compare reactive power capabilities).
PCC	**P**oint of **C**ommon **C**oupling: According to Standard IEC 61400-21, 3.10: Point of a power supply network, electrically nearest to a particular load, at which other loads are, or may be, connected.
Rated Active Power (P_n)	Rated Active Power output of the WT: According to IEC 61400-21, 3.14: Maximum continuous electric output power which a turbine is designed to achieve under normal operating conditions.
Rated Apparent Power (S_n)	Rated Apparent Power of the WT: According to IEC 61400-21, 3.12: Apparent power from the wind turbine while operating at rated power and nominal voltage and frequency: $S_n = \sqrt{3}\, U_n\, I_n.$ ENERCON comment: In this data sheet S_n is related to reactive power of 0 kVAr.
Rated current (I_n)	Rated current of the WT: According to Standard IEC 61400-21, 3.13: Maximum continuous electric output current which a wind turbine is designed to achieve under normal operating conditions. ENERCON comment: The current at rated active power and rated voltage at the terminals of the WT.
Switch-off time	The switch-off time is the time that the power contactor needs to open or close its contacts.

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

Temporary operation	Operation in under voltage situations may cause great stress on the inverters. Due to internal WT protection of the devices, the operation at under voltage conditions is limited in time.
Tripping	Tripping of an ENERCON wind turbine takes place in several stages: - No current is fed into the grid (IGBT pulses are blocked) - Excitation of the generator is stopped - Power contactors are opened - Rotation of the generator is stopped The WT does not stay in operation.
U_{Grid}	Actual voltage of the grid at the reference point of the WT
U_{max}	Maximum Continuous Voltage
U_{min}	Minimum Continuous Voltage
U_n	Nominal Voltage
$U_{min,temp}$	Temporary minimum voltage of the WT. Temporary operation is possible for up to 60 seconds. See also Chapter 8 if the voltage is continuously below the minimum value.
WT	**W**ind **T**urbine: According to IEC 61400-21, 3.21: System which converts kinetic wind energy into electric energy.
WT terminals	**W**ind **T**urbine terminals: According to IEC 61400-21, 3.22: Point being a part of the WT and identified by the WT supplier at which the WT may be connected to the power system. ENERCON comment: This point is related to the *reference point* on the low voltage side, see Chapter 12.
Zero Power Mode (ZPM)	In Zero Power Mode the WT blocks the IGBTs but stays in operation. No current is fed into the grid.

For explanations of the terms and abbreviations used, please refer to Chapter 13 Glossary.

E-44, E-48, E-53 - Standard 1
Transformer station inside the steel tower

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1 Introduction

The E-44, E-48, E-53 offer the possibility to locate the transformer and medium-voltage switchgear inside of the tower. This eliminates the need of an external housing. ENERCON calls this tower integrated transformer station "Standard 1". Most of ENERCON's customer prefer this Standard 1 option for their windturbines (WEC). The Standard 1 option will be fully described in this document.

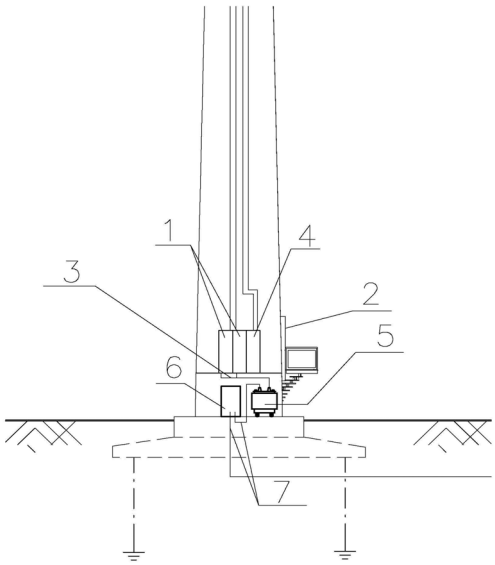


Fig. 1: Arrangement of the equipment of the electrical components: 1. Power cabinets, 2. door, 3. low voltage cable, 4. control cabinet, 5. transformer, 6. medium-voltage cabinet, 7. medium-voltage cable

2 Arrangement of electrical equipment inside the tower

The entrance to the tower is located approx. 2,5m above the ground level and can be reached via an external stairway. The control and power cabinets are located on the first (entrance) floor.

The complete transformer station is integrated in the cellar of the turbine. The access to the transformer station is provided by means of a tower ladder through a locked hatch in the first floor. Only authorised persons are allowed to access the cellar.

The medium-voltage cables, part of the internal wind farm cabling are conducted through dummy tubes in the foundation to the corresponding panels of the medium-voltage switchgear. The transformer is connected to the medium-voltage switchgear by using medium-voltage cable and touch proof medium voltage plugs. The transformer is placed in a way that there is enough space for service and maintenance. The low-voltage connection between transformer and power cabinets one the first floor is made by using flexible copper low-voltage cables.

The tower integrated transformer station is designed to assure optimal safety for the service staff. Some examples are the pressure channel for the medium-voltage switchgear, enclosures and touch proof equipments as well as adequate space for operation, service and maintenance.

The arrangement of the equipments in the tower base of the turbine is shown in figure 2.

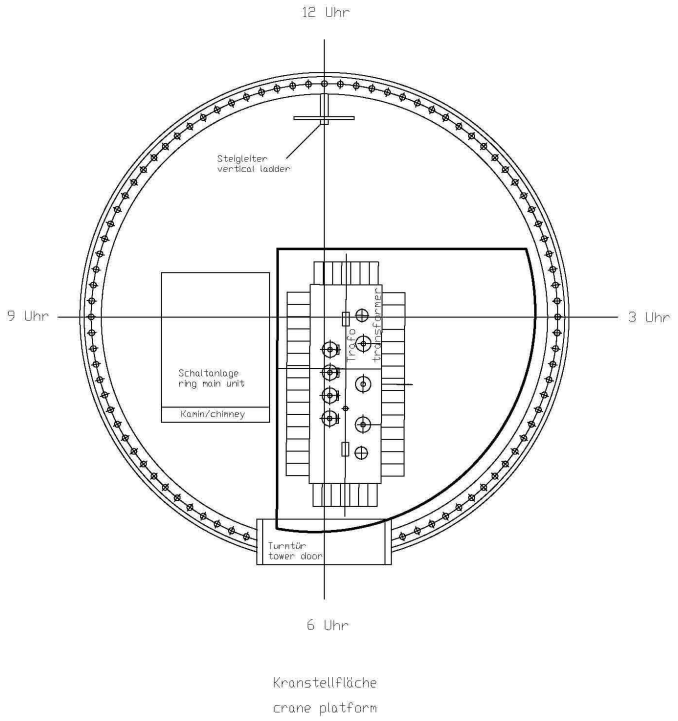


Fig 2: Arrangement of electrical components of the transformer station inside the cellar

3 Single line diagram and scope of supply

It is important to define the scope of supply during the planning phase in order to avoid eventual missing or wrong material, that can delay the commissioning of the wind energy converter (WEC).

ENERCON provides all necessary electrical equipment between the generator and the MV switchgear. **Everything up to the medium-voltage switchgear is included in ENERCON's scope of supply**. The contractor for the electrical infrastructure of the windfarm provides and installs the medium voltage and data cables. He conducts the cables through the corresponding foundation dummy tubes and connects the MV cables to the MV switchgear and the control cables to the corresponding connection box or splice box.

The delivery, installation and termination of the medium-voltage cables must be performed by an authorised expert company only.

The single line diagram of the turbine in figure 3 shows the scope of supply with a red line between the switchgear and the plugs of the medium-voltage cables.

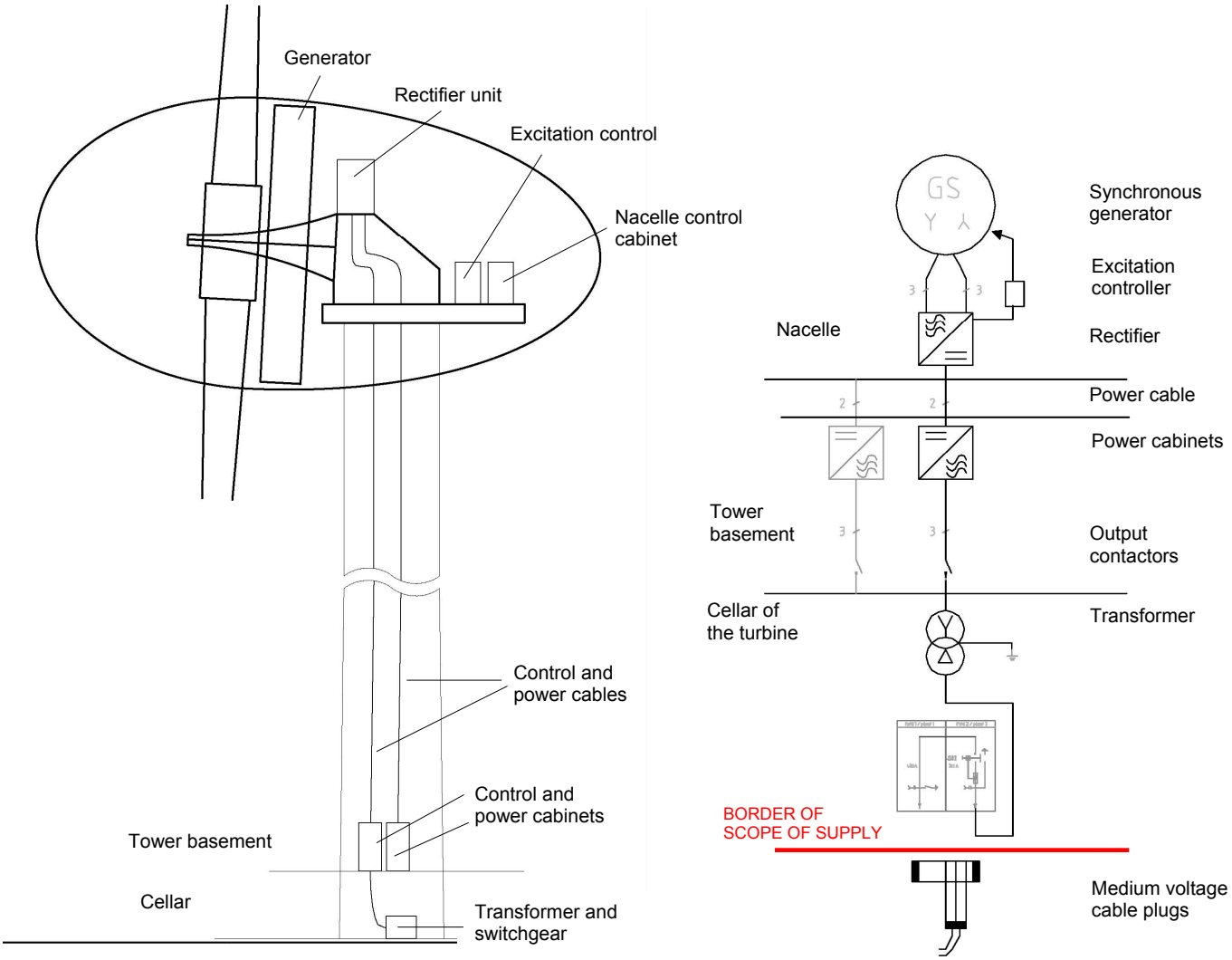


Fig 3: Single line diagram

4 Definition of the electrical equipments included in ENERCON's scope of supply

In this chapter, you can find a definition of the electrical components in the tower-integrated transformer station, including photos, technical data tables, and special comments.

4.1 Low voltage installation

ENERCON provides all necessary equipment between the generator and the transformer. This includes the low-voltage connection between transformer and power cabinets with 3 copper cables 300mm² per phase and 1 copper cable 300mm² for the neutral conductor. For metering the generated energy a set of current transformers is installed within the connection between transformer and power cabinets on the LV bushings of the transformer (see figures 4 and 5).



Fig. 4: Current transformers installed at transformer

To enable the installation of the current transformers, the distance between the centre of the LV transformer bushings has to be at least 180mm. The connection to the energy meter inside the control cabinet is done via cable Y-JZ 7x6mm^2 copper.

Without these current transformers it is not possible to operate the WEC.

Current transformers	
Secondary current (A)	5
Primary current (A)	1500
Rated power (VA)	10
Class	0,5
Insulation (kV)	3
Frequency (Hz)	50
Supplier	RITZ or similar
Thermal Current (kA)	60*In

Fig. 5: Technical data of low-voltage current transformer

4.2 Transformer

The transformer steps up the WEC voltage from 400V to medium voltage. ENERCON installs 3-phase-hermetic-silicone-oil transformers, which can be replaced through the tower entrance door, in case of an eventual damage.
The combustion point of the transformer is higher than 300°C.

Figure 6 shows the technical data of the ENERCON "standard" transformers. For tensions higher than 36kV please contact the ENERCON electrical project manager.
ENERCON does not allow the installation of dry transformers. The reasons for this decision (advantages of oil transformers compared to a dry transformer) are listed in the following:

- Compact and touch proof construction
- Smaller iron losses
- Better cooling due to bigger surface
- Less sensitivity to overloads and fast load changes
- Less sensitivity to over voltages
- Less sensitivity to mechanical stress

Power transformer		
Supplier	Pauwels, Areva, Siemens or similar	
Type	3 phase-hermetic	
Rated power (kVA) - E-48 & E-53 - E-44	 900 1000	
Rated frequency (Hz)	50/60	
Rated high voltage (kV)	According to grid (1<U<24)	According to grid (24<U<36)
Rated low voltage (V)	400	
Tappings	+4x2,5%	
Vector group	Dyn5	
Impedance	6%	
No load current at 110% rated voltage (A)	<5	
Iron losses at rated voltage (W)	<1.100	
Copper losses at rated current and 75°C (W)	<10.000	
BIL between phase and earth (kV)	125	170
Temperature rise: Oil/windings (K)	50/55	
Ambient temperature (°C)	40	
Temperature monitoring - alarm level (C)	90	
Temperature monitoring - trip level (C)	95	
Cooling material	Silicone oil	
Cooling type	KNAN	
Installation height over sea level (m)	max 1000	
Noise level LwA dB(A)	60	
Service	Continuous	
External dimensions (approx.) (mm)	1600x770x2040	
Weight approx. (t)	2,4	2,6

Fig. 6: Technical data of the transformer

The hermetically-closed and earthed housing, the touch-proofed medium-voltage bushings and the insulated low-voltage terminations (see also figure 4) guarantee safety for the service personnel.

The transformer coating is based on zincflakes, which is coated with additional layers of watercolor RAL7033.

For ordering the correct transformer, it is important to know the value of the voltage at the point of common coupling. This data has to be provided by the utility and is essential to define the transformer.

Please make sure that this data is shown in the contract before signing.

4.3. Medium voltage switchgear

The SF_6 insulated medium voltage switchgear is type-tested and complies to the common IEC norms.

Medium voltage switchgear		
Use	Inside tower	
Rated voltage (kV)	24	36
Rated frequency (Hz)	50/60	
Supplier	ABB, Siemens or similar	Driescher or similar
Number of cells	2	
Standard configuration (4)	1 connection panel, 1 transformer panel	
Insulating gas	SF_6	
Type of construction	Compact	
Type of service	Continuous	
Rated current busbar (A)	630	
Rated current transformer switch (A)	200	
Rated short-time current 1s (kA)	16	20
Rated short-circuit making current (kA)	50	40
Withstand voltage to earth and between phases 1 min. (kV)	50	70
Withstand voltage across the isolating distance (kV)	60	80
BIL between phase and earth (kV)	125	170
BIL between open contacts (kV)	145	195

Fig. 8: Technical data medium-voltage switchgear



Fig. 7: 2-panel medium voltage switchgear, Driescher

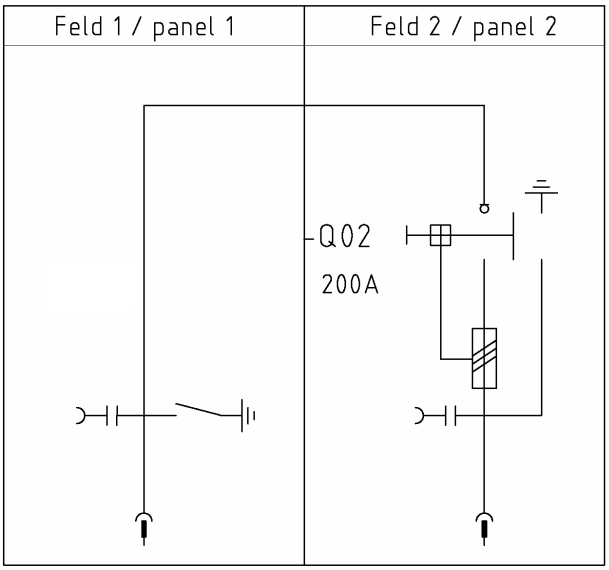


Fig 9: Scheme of the type 2-panel medium-voltage switchgear
(1 connection panel, 1 transformer panel)

The reasons for the installation of SF_6 switchgears are the compact construction, the high operational safety and the protection against external influences, such as humidity and dust. All metal parts alive are hermetically sealed inside the gastank. The switchgear is equipped with a pressure release diaphragm and a pressure channel. In case of an internal failure and the occurance of an internal arc, the pressure channel comes into play. The pressure channel conducts hot gases through metallic cooling lattices, reduces the gas pressure to a minimum and escapes it out of the top of this absorber. Thus danger for service staff is reduced to a minimum.

Because of the complete enclosure of the switchgear, the customer gets a safe, nearly maintenance free and longlife product that will do long-term duty.

The 30kV standard type of the MV switchgear is shown in figure 7, the technical data are shown in the table (figure 8) and the SLD is shown in figure 9.

4.4 Cables

The power cables that ENERCON use, are designed according to IEC 60502-603 for low voltage cables and IEC 60502-620 for medium voltage cables.

In order to explain the specifications for each cable, they are classified in three groups:

1. Low voltage power cables
2. Medium voltage power cables
3. Control cables

4.4.1 Low voltage power cable

The cable used to connect the power cabinets to the transformer is H07RNF-O 1x300. It is a flexible copper cable with rubber insulation 0,6/1kV without shield. 3 cables (each approx 8m) are installed for each power cabinet.

Standard cable lugs 300*10 are installed to connect this cable to the power cabinets (refer also to figure 10). Cable lugs 300*12 are installed to connect the cables to the transformer.

Each power cabinet is earthed at the earthing bar via a 95mm^2 copper cable, type H07VK



Fig. 10: Low voltage cable lugs for the connection to the power cabinet

4.4.2 Medium voltage power cables

The medium voltage cables between the power transformer and the switchgear are type N2XSY 1x50. The copper conductor has a XLPE insulation. The cable has a 16mm^2 copper shielding and an outer PVC insulation cover.

To connect the transformer to the MV switchgear ENERCON installs one 6m long cable per phase.

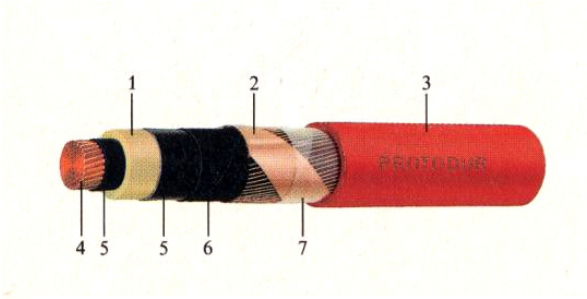


Fig 11: Medium-voltage cable between transformer and medium-voltage switchgear

4.4.3 Control cables

ENERCON's scope of supply includes the following 0,6/1kV control cables for the tower integrated transformer station:

- Y-JZ 7x6 with copper conductor, PVC conductor insulation and PVC external cover. This cable is used between the energy meter inside the control cabinet of the WEC and the current transformers.
- Y–JZ 3x1,5 with copper conductor, PVC conductor insulation and PVC external cover. This cable is used between the control cabinet of the WEC and the temperature sensor inside the thermometer pocket of the transformer, to constantly monitor its temperature.

5 Instructions for the construction of the electrical infrastructure of the windfarm

According to this standard 1, the subcontractor for the electrical infrastructure of the windfarm is responsible for:

- Delivery of MV - and data cables
- Trenching
- Installation of medium voltage and data cables (including conducting the cables through the tubes of the foundation)
- Connection of data cable to termination box, respectively splice box
- Delivery of medium-voltage cable plugs and joints and connection of medium-voltage cables to the bushings of the MV switchgear.
- Testing of installed electrical components

All work to be performed by an authorised company only.

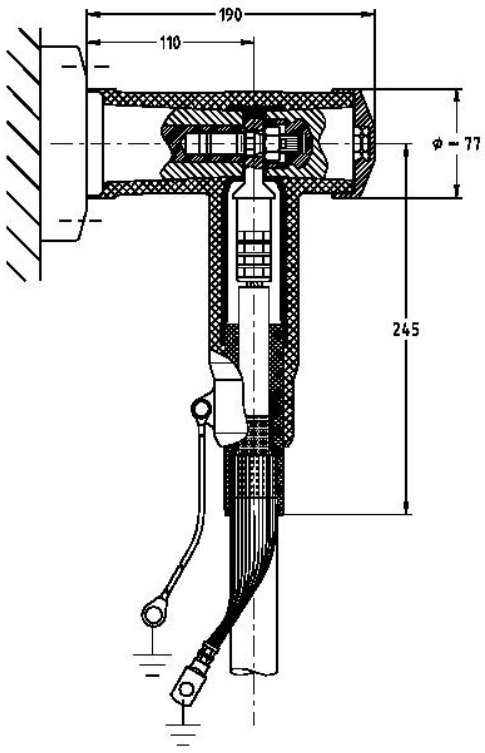


Fig 12: Dimensions of cable plug CB24-630 company nkt

Further technical requirements:

- For medium voltage, XLPE single core cables have to be used. Cross sections higher than 300mm² should be avoided as they could cause problems during installation (in case bigger cross sections are intended, please contact the responsible electrical project manager).
- Suitable MV plugs and joints have to be chosen. Please refer to figure 12 and the table, figure 13, showing ENERCON recommendations.
- It is possible to install a double connector inside the cable panels of the MV switchgear.
- Before commissioning, suitable MV cable tests have to be performed to assure that the cable is not damaged and joints and plugs are correctly mounted.

MV cable plugs		
Maximum voltage (kV)	24	36
Cable section (mm²)	25<S<300	50<S<300
Diameter over cable isolation (mm)	12,7<D<34,6	22,4<D<42,8
Rated current (A)	630	
BIL between phase and earth (kV)	125	170
Recommended supplier and type	nkt CB 20-630 CC 20-630	nkt CB 30-630 CC 30-630

Fig 13: Technical data of medium-voltage plugs

Sound Power Level

of the

ENERCON E-53

Operational Mode I

(Data Sheet)

Imprint

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Revision

Revision: 1.0

Department: ENERCON GmbH / Site Assessment

Glossary

WEC	means an ENERCON wind energy converter.
WECs	means more than one ENERCON wind energy converter.

Sound Power Level for the E-53 with 800 kW rated power

in relation to standardized wind speed v_S at 10 m height					
hub height / V_S in 10 m height		60 m	73 m	75 m	
5 m/s		92.0 dB(A)	92.5 dB(A)	92.8 dB(A)	
6 m/s		93.7 dB(A)	94.2 dB(A)	94.5 dB(A)	
7 m/s		97.2 dB(A)	97.7 dB(A)	97.9 dB(A)	
8 m/s		99.7 dB(A)	100.1 dB(A)	100.3 dB(A)	
9 m/s		101.3 dB(A)	101.5 dB(A)	101.8 dB(A)	
10 m/s		102.5 dB(A)	102.5 dB(A)	102.5 dB(A)	
95% rated power		102.5 dB(A)	102.5 dB(A)	102.5 dB(A)	

Measured value at 95% rated power			*101.4 dB(A) WT 6263/08* *101.9 dB(A) M87 748/1*	*100.7 dB(A) M69 915/2*	

in relation to wind speed at hub height									
wind speed at hub height [m/s]	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Sound Power Level [dB(A)]	**93.1**	**94.8**	**97.3**	**99.3**	**100.7**	**101.8**	**102.5**	**102.5**	**102.5**

1. The relation between the sound power level and the standardized wind speed v_S in 10 m height as shown above is valid on the premise of a logarithmic wind profile with a roughness length of 0.05 m. The relation between the sound power level and the wind speed at hub height applies for all hub heights. During the sound measurements the wind speeds are derived from the power output and the power curve of the WEC.

2. A tonal audibility of $\Delta L_{a,k} \leq 2$ dB can be expected over the whole operational range (valid in the near vicinity of the turbine according to IEC 61 400 -11 ed. 2).

3. The sound power level values given in the table are valid for the **Operational Mode I** (defined via the rotational speed range of 6 – 29 rpm). The respective power curve is the calculated power curve E-53 dated June 2005 (Rev. 1.x).
4. The values displayed in the tables above are based on official and internal measurements of the sound power level. If available the official measured values are given in this document as a reference (in italic print). The extracts of the official measurements can be made available upon request. The values given in the measurement extracts do not replace the values given in this document. All measurements have been carried out according to the recommended German and international standards and guidelines as defined in the measurement reports, respectively.
5. Due to the typical measurement uncertainties, if the sound power level is measured according to one of the accepted methods the measured values can differ from the values shown in this document in the range of +/- 1 dB.

   Accepted measurement methods are:

   a) IEC 61400-11 ed. 2 („Wind turbine generator systems – Part 11: Acoustic noise measurement techniques; Second edition"), and

   b) the FGW-Guidelines („Technische Richtlinie für Windenergieanlagen – Teil 1: Bestimmung der Schallemissionswerte", published by the association "Fördergesellschaft für Windenergie e.V.", 18th revision).

   If the difference between total noise and background noise during a measurement is less than 6 dB a higher uncertainty must be considered.
6. For noise-sensitive sites it is possible to operate the E-53 with reduced rotational speed and reduced rated power during night time. The sound power levels resulting from such operational mode can be provided in a separate document upon request.
7. The sound power level of a wind turbine depends on several factors such as but not limited to regular maintenance and day-to-day operation in compliance with the manufacturer's operating instructions. Therefore, this data sheet can not, and is not intended to, constitute an express or implied warranty towards the customer that the E-53 WEC will meet the exact sound power level values as shown in this document at any project specific site.

Extract of test report

page 1/2

Master Sheet "Noise", according to "Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte"
Extract of test report according to Annex C of [1]

Extract of test report M69 915/1
regarding noise emission of wind turbine (WT) Enercon E-53

General		Technical specifications (manufacturer)	
Manufacturer:	Enercon GmbH	Rated power (generator):	800 kW
	Dreekamp 5	Rotor diameter:	53 m
	26605 Aurich	Hub height above ground:	76 m
Serial number:	53001	Tower design:	tube tower
WT-location:	RW: 34.22.780	material:	steel
	HW: 59.40.691	Power control:	pitch
Complementations of rotor (manufacturer)		**Complementations of gear and generator (manufacturer)**	
blades:	Enercon GmbH	Manufacturer of gear:	---
Type of blades:	E53/1	Type of gear:	---
Pitch angel:	variabel	Manufacturer of generator:	Enercon GmbH
Number of blades:	3	Type of generator:	E-53
Rated speed(s)/speed ra	12 - 29 rpm (mode I)	Rated speed(s)/speed range:	12 - 29 rpm (mode I)

test report of power curve: Enercon GmbH: Calculated output curve of the E-53 from February 2007

	Reference		Noise emission parameter	Remarks
	Standardized wind speed at 10 m above ground	Electric power		
Sound Power level $L_{WA,P}$	6 m/s	377,9 kW	96,7 dB(A)	
	7 m/s	591,0 kW	99,3 dB(A)	
	8 m/s	746,0 kW	100,8 dB(A)	
	9 m/s	793,1 kW	101,0 dB(A)	
	10 m/s	810,0 kW	100,6 dB(A)	
	8,3 m/s	*760,0* kW	100,9 dB(A)	[3]
Tonality (close-up range) K_{TN}	6 m/s	377,9 kW	--- dB	
	7 m/s	591,0 kW	--- dB	
	8 m/s	746,0 kW	--- dB	
	9 m/s	793,1 kW	--- dB	
	10 m/s	810,0 kW	--- dB	
	8,3 m/s	*760,0* kW	--- *dB*	[3]
Impulsivity (close-up range) K_{IN}	6 m/s	377,9 kW	--- dB	
	7 m/s	591,0 kW	--- dB	
	8 m/s	746,0 kW	--- dB	
	9 m/s	793,1 kW	--- dB	
	10 m/s	810,0 kW	--- dB	
	8,3 m/s	*760,0* kW	--- dB	[3]

one third octave sound power level at reference point v_{10} = 6 m/s

frequency	50	63	80	100	125	160	200	250	315	400	500	630
$L_{WA,P,\ 1/3\ octave}$	69,0	73,2	74,4	77,1	79,4	81,7	80,7	82,4	83,0	82,6	85,8	85,6
frequency	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
$L_{WA,P,\ 1/3\ octave}$	87,2	88,3	88,5	86,4	84,7	81,9	77,3	74,7	72,4	69,6	67,5	64,5

octave sound power level at reference point v_{10} = 6 m/s

frequency	63	125	250	500	1000	2000	4000	8000
$L_{WA,P,\ octave}$	77,5	84,6	86,9	89,7	92,8	89,5	80,0	72,4

one third octave sound power level at reference point v_{10} = 7 m/s

frequency	50	63	80	100	125	160	200	250	315	400	500	630
$L_{WA,P,\ 1/3\ octave}$	72,0	74,3	77,1	80,0	81,9	84,5	83,2	84,8	86,0	85,8	88,5	88,4
frequency	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
$L_{WA,P,\ 1/3\ octave}$	89,8	90,6	90,8	89,1	87,5	84,6	80,4	77,6	75,0	71,2	68,8	64,7

octave sound power level at reference point v_{10} = 7 m/s

frequency	63	125	250	500	1000	2000	4000	8000
$L_{WA,P,\ octave}$	79,7	87,3	89,6	92,5	95,2	92,2	83,0	73,8

one third octave sound power level at reference point v_{10} = 8 m/s

frequency	50	63	80	100	125	160	200	250	315	400	500	630
$L_{WA,P,\ 1/3\ octave}$	77,6	76,5	79,5	82,4	84,0	86,9	85,6	87,3	88,0	87,7	89,8	89,4
frequency	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
$L_{WA,P,\ 1/3\ octave}$	90,8	91,4	91,8	90,7	89,5	86,9	82,8	81,0	78,1	73,2	69,8	64,7

octave sound power level at reference point v_{10} = 8 m/s

frequency	63	125	250	500	1000	2000	4000	8000
$L_{WA,P,\ octave}$	82,8	89,6	91,8	93,8	96,1	94,1	85,8	75,2

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one third octave sound power level at reference point v_{10} = 9 m/s

Frequenz	50	63	80	100	125	160	200	250	315	400	500	630
$L_{WA,P,Terz}$	76,6	78,1	80,6	83,1	84,8	87,9	86,6	87,8	88,1	87,5	89,5	89,2
Frequenz	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
$L_{WA,P,Terz}$	90,7	91,3	91,7	90,9	89,6	87,7	84,0	83,0	80,0	75,9	70,2	64,9

octave sound power level at reference point v_{10} = 9 m/s

	63	125	250	500	1000	2000	4000	8000
$L_{WA,P,Terz}$	83,5	90,5	92,3	93,6	96,0	94,4	87,4	77,2

one third octave sound power level at reference point v_{10} = 10 m/s

Frequenz	50	63	80	100	125	160	200	250	315	400	500	630
$L_{WA,P,Terz}$	74,5	77,4	79,7	82,0	83,8	86,6	85,6	86,8	87,1	87,0	89,1	89,2
Frequenz	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
$L_{WA,P,Terz}$	90,5	91,0	91,3	90,6	89,6	87,7	84,1	83,2	80,4	76,6	70,3	64,8

octave sound power level at reference point v_{10} = 10 m/s

	63	125	250	500	1000	2000	4000	8000
$L_{WA,P,Terz}$	82,5	89,3	91,3	93,3	95,7	94,2	87,6	77,7

This test report extract is only valid with the manufacturer's certificate from 14.3.2007.
The declarations in this extract are only valid in combination with the test report M69 915/1 from 7.8.2007 [4] (especially for calculations of sound propagation).

Remarks:

[1] Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte
Rev. 17 vom 01. Juli 2006 (Herausgeber: Fördergesellschaft Windenergie e.V., Stresemannplatz 4, D-24103 Kiel)
[2] IEC TS 61400-11 Wind turbines. Part 11: Acoustic noise measurement techni-ques. November 2002
[3] The working point of 95% of the rated power, for which the maximum sound power level was stated, is according to the reference power curve and the hub height of the measured WT under standardized meteorological conditions v10= 8,3 m/s
[4] Müller-BBM testreport M69 915/1 from 7.8.2007

measured by: Müller-BBM GmbH
brand office Gelsenkirchen
Am Bugapark 1
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MÜLLER-BBM GMBH
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Schallemission FGW Fördergesellschaft Windenergie 2007 Konformitätssiegel

date: 07.08.2007

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Accredited Test Laboratory
according to ISO/IEC 17025

Deutscher Akkreditierungs Rat DAR
DAP-PL-2465.10

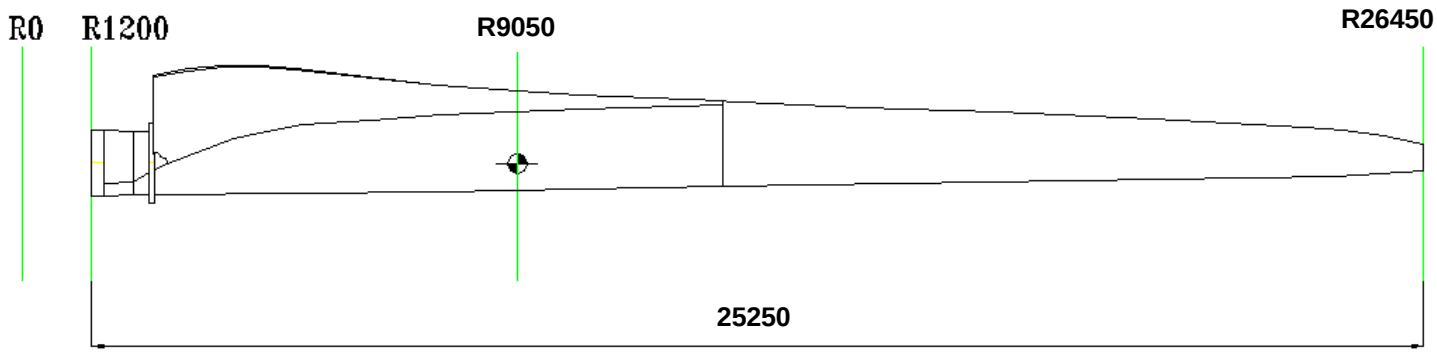
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ENERCON
GmbH
Dreekamp 5 Tel.: +49 49 41- 927 - 0
26605 Aurich Fax: +49 49 41 927 - 109

Blattdaten E53/1 / Main data rotorblade E53/1

Radius / radius [mm]	Tiefe / depth [mm]
1200	1150
1800	2439
3600	2393
4800	2244
6000	2053
7200	1871
8400	1733
9600	1623
10800	1538
12000	1464
13200	1393
14400	1326
15600	1260
16800	1193
18000	1125
19200	1054
20415	977
21060	934
21770	885
22610	826
23610	753
25070	636
25900	550
26450	445

Gewicht Blatt / blade weight	approx.	2600 kg
Schwerpunkt / center of mass position	approx.	at R 9050
Länge Rotorblatt / length rotorblade	approx.	25250 mm



ENERCON wind energy converters obtain active power for the control system, pitch motors, azimuth motors, transformer loss, obstruction lights etc. from the grid. This own consumption is heavily dependent on the location and the existing wind data. Therefore ENERCON cannot state definite values regarding active and reactive power consumption.

This document defines the average energy needs of the ENERCON wind turbine types as follows:

E-33:
- Active power P = 5kW, 15 minutes average without rotor blade heating
- Active energy depending on location and number of converters between W = 500kWh and 2000kWh per year without rotor blade heating

E-40/6.44:
- Active power P = 5kW, 15 minutes average without rotor blade heating
- Active power P = 19kW, 15 minutes average with rotor blade heating
- Active energy depending on location and number of converters between W = 500kWh and 2000kWh per year without rotor blade heating

E-48:
- Active power P = 5kW, 15 minutes average without rotor blade heating
- Active power P = 19kW, 15 minutes average with rotor blade heating
- Active energy depending on location and number of converters between W = 500kWh and 2000kWh per year without rotor blade heating

E-53:
- Active power P = 5kW, 15 minutes average without rotor blade heating
- Active power P = 19kW, 15 minutes average with rotor blade heating
- Active energy depending on location and number of converters between W = 500kWh and 2000kWh per year without rotor blade heating

E-58:
- Active power P = 8kW, 15 minutes average without rotor blade heating
- Active power P = 40kW, 15 minutes average with rotor blade heating
- Active energy depending on location and number of converters between W = 500kWh and 3500kWh per year without rotor blade heating

E-66/18.70:
- Active power P = 10kW, 15 minutes average without rotor blade heating
- Active power P = 42kW, 15 minutes average with rotor blade heating
- Active energy depending on location and number of converters between 500kWh and 3500kWh per year without rotor blade heating

E-66/20.70:
- Active power P = 10kW, 15 minutes average without rotor blade heating
- Active power P = 43kW, 15 minutes average with rotor blade heating
- Active energy depending on location and number of converters between W = 800kWh and 4000kWh per year without rotor blade heating

E-70/E4:
- Active power P = 10kW, 15 minutes average without rotor blade heating
- Active power P = 43kW, 15 minutes average with rotor blade heating
- Active energy depending on location and number of converters between 800kWh and 4000kWh per year without rotor blade heating

E-82:
- Active power P = 10kW, 15 minutes average without rotor blade heating
- Active power P = 43kW, 15 minutes average with rotor blade heating
- Active energy depending on location and number of converters between 800kWh and 4000kWh per year without rotor blade heating

E-112:
- Active power P = 30kW, 15 minutes average without rotor blade heating
- Active power P = 63kW, 15 minutes average with rotor blade heating
- Active energy depending on location and number of converters between 800kWh and 4000kWh per year without rotor blade heating

WINDTEST
Kaiser-Wilhelm-Koog GmbH

Durch das DAP Deutsches Akkreditierungssystem Prüfwesen nach DIN EN ISO/IEC 17025 akkreditiertes Prüflaboratorium. Die Akkreditierung gilt für die in der Urkunde aufgeführten Prüfverfahren.
Deutscher Akkreditierungs Rat
DAP-PL-1556.00

Auszug aus dem Prüfbericht
Excerpt of the test report
„Bestimmung der Leistungen des Eigenverbrauchszweiges an der Windenergieanlage vom Typ E-48“
„Determination of the performances of the consumption of auxiliaries at the wind turbine typ E-48“

Prüfbericht Nr./ *Report No.* : 5030/06 Seite 1 von 1 *Page 1 of 1*

„Technische Richtlinie für Windenergieanlagen Teil 3“ Rev./Version 18 vom/from 01.03.2006
(Herausgeber/publisher: Fördergesellschaft Windenergie e. V.)

Anlagentyp/*Installation type*:	E-48	Herstellerangaben/*Manufacturer´s specifications*:	
Anlagenhersteller/ *Manufacturer*:	Enercon GmbH	Anlagenart/ *Kind of installation*:	Pitch/synchronous
	Dreekamp 5	Nennleistung/ *Rated power* P_{nG}:	800 kW
	D – 26605 Aurich	Nennspannung/ *Nominal voltage* U_{nG}:	400 V
Prüfbericht/*Report*:	WT 5024/06	Messzeitraum/ *Period of measurement*:	2006-01-23 – 2006-03-17

Leistung bei Stillstand der Windenegieanlage /Performance at interruption of the wind turbine:[1)]

Mittelungszeitraum / *Average time*	Max. Wirkleistung / *Max. active power* [kW]	Max. Blindleistung / *Max. reactive power* [kvar]	Leistungsfaktor / *Power factor*
600 sec	1,9	0,10	0,995
60 sec	4,3	0,35	0,996
0,2 sec	6,9	0,68	0,996

Besonderheiten/*Exceptional details*:

1) **Der Betriebsbereich Stillstand enthält alle Werte bei der die WEA keine Leistung in das Netz eingespeist, sondern ausschließlich aus dem Netz bezieht.**/ *The operating range interruption contains all values if the WEA doesn't supply power to the grid but exclusive from the grid.*

Dieser Auszug aus dem Prüfbericht gilt nur in Verbindung mit dem Prüfbericht WT 5024/06.
This excerpt of the report is only valid in conjunction with the report WT 5024/06.

Gemessen durch: WINDTEST Kaiser-Wilhelm-Koog GmbH
measured by: Sommerdeich 14b
25079 Kaiser-Wilhelm-Koog
Bearbeiter/*Operative*: Dipl.-Ing. Andreas Müller
Tel. / Phone: +49 (0)4856/901 36/ - 859

Datum/date: 2006-05-12

Dipl.-Ing. Andreas Müller
(Gruppe Netz,
Messingenieur)

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Gruppenleiter)

Dieser Auszug aus dem Prüfbericht enthält 1 Seiten.
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