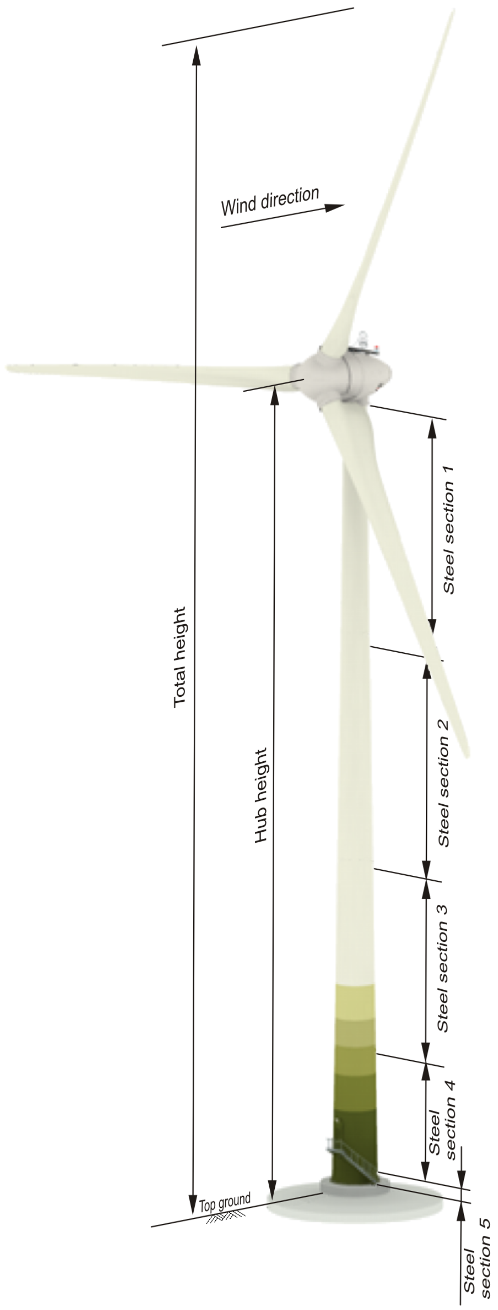
Bijlage 10a: Technische gegevens Enercon



Parameter	Value
Total height above top ground (GOK)	130.580 m
Hub height above top ground (GOK)	84.580 m
Tower height above top foundation	82.990 m
Design	Steel tower
Wind zone (DIBt, DIN 1055-4)	WZ4 GK I
WTC (IEC 61400-1)	WTC IIA
Number of sections	5 Steel

	Length (m)	D_{Top} (m)	D_{Bottom} (m)	Weight ca. (t)
Section 1	28.460	2.245 / 2.490 [1]	2.850	44
Section 2	24.005	2.850	3.480	57
Section 3	16.135	3.480	3.950	58
Section 4	11.330	3.950	4.300	62
Section 5	3.000	4.300	4.600 / 4.900 [1]	21
Foundation basket	1.800	4.960 [1]	4.890 [1]	10
Total tower weight				252

[1]) Outside flange diameter

Technical specifications E-92 2 MW/2.35 MW

General	
Manufacturer	ENERCON GmbH Dreekamp 5 26605 Aurich
Type designation	E-92
Nominal power	2000/2350 kW
Hub heights	78.3 m; 83.8 m; 84.6 m; 98.4 m; 103.9 m; 108.4 m; 138.4 m
Rotor diameter	92 m
IEC wind class (ed. 3)	IIA
Extreme wind speed at hub height (10-min. mean)	42.5 m/s
	Corresponds to a load equivalent of approx. 59.5 m/s (3-sec. gust)
Annual average wind speed at hub height	8.5 m/s

Rotor with pitch control	
Type	Upwind rotor with active pitch control
Rotational direction	Clockwise (downwind)
Number of rotor blades	3
Rotor blade length	43.8 m
Swept area	6648 m²
Rotor blade material	GRP/epoxy resin/wood
Lowest power feed speed to nominal speed	5 - 16.5 rpm
Tip speed	Up to 81.89 m/s
Power reduction wind speed	28 - 34 m/s (with optional ENERCON storm control)
Conical angle	0°
Rotor axis angle	5°
Pitch control	One independent electrical pitch system per rotor blade with dedicated emergency power supply

Drive train with generator	
WEC concept	Gearless; variable speed; full-scale converter
Hub	Rigid
Bearing	Double-row tapered/cylindrical roller bearing
Generator	Direct-drive ENERCON annular generator
Grid feed	ENERCON inverters with high-frequency IGBT switching and sinusoidal current
IP Code/insulation class	IP 23/F

Brake system	
Aerodynamic brake	Three independent pitch systems with emergency power supply
Rotor brake	Electromechanical
Rotor lock	Latching every 15°

Yaw control	
Type	Electrical with yaw motors
Control system	Active via yaw gears

Control system	
Type	Microprocessor
Grid feed	ENERCON inverter
Remote monitoring system	ENERCON SCADA
Uninterruptible power supply (UPS)	Integrated

Tower variants

Hub height	Total height	Design	Wind class
78.3 m	124.3 m	Steel tower with foundation basket	IEC IIA DIBt WZ4 GK I
83.8 m	129.8 m	Precast concrete tower with steel section (external prestressing)	IEC IIA
84.6 m	130.6 m	Precast concrete tower with steel section	IEC IIA DIBt WZ4 GK I
84.6 m	130.6 m	Steel tower with foundation basket	IEC IIA DIBt WZ4 GK I
98.4 m	144.4 m	Precast concrete tower with steel section	IEC IIA DIBt WZ4 GK I

Tower variants			
98.4 m	144.4 m	Precast concrete tower with steel section (external prestressing)	IEC IIA
103.9 m	149.9 m	Precast concrete tower with steel section (external prestressing)	IEC IIA
103.9 m	149.9 m	Precast concrete tower with steel section (external prestressing)	DIBt WZ4 GK IA DIBt WZ4 GK IIA
108.4 m	154.4 m	Precast concrete tower with steel section	IEC IIA DIBt WZ4 GK I (for BR/UY only)
138.4 m	184.4 m	Precast concrete tower with steel section	IEC IIA DIBt WZ4 GK I

Technical Description

ENERCON Wind Energy Converter
E-92 2000/2350 kW

Legal notice

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Table of contents

1 Overview of ENERCON E-92 2 MW/2.35 MW

The ENERCON E-92 wind energy converter is a direct-drive wind energy converter with a three-bladed rotor, active pitch control, variable speed operation, and a nominal power output of 2000/2350 kW. It has a rotor diameter of 92 m and can be supplied with hub heights of 78 m to 138 m.

Fig. 1: Complete view of ENERCON E-92

2 ENERCON wind energy converter concept

ENERCON wind energy converters are characterised by the following features:

Gearless

The E-92 drive system comprises very few rotating components. The rotor hub and the rotor of the annular generator are directly interconnected to form one solid unit. This reduces the mechanical strain and increases technical service life. Maintenance and service costs are reduced (fewer wearing parts, no gear oil change, etc.) and operating expenses also decrease. Since there are no gears or other fast rotating parts, the energy loss between generator and rotor as well as noise emissions are considerably reduced.

Active pitch control

Each of the three rotor blades is equipped with a pitch unit. Each pitch unit consists of an electrical drive, a control system, and a dedicated emergency power supply. The pitch units limit the rotor speed and the amount of power extracted from the wind. In this way, the maximum output of the E-92 can be accurately limited to nominal power, even at short notice. By pitching the rotor blades into the feathered position, the rotor is stopped without any strain on the drive train caused by the application of a mechanical brake.

Indirect grid connection

The power produced by the annular generator is fed into the distribution or transport grid via the ENERCON Grid Management System. The ENERCON Grid Management System, which consists of a rectifier, a DC link and a modular inverter system, ensures maximum energy yield with excellent power quality. The electrical properties of the annular generator are therefore irrelevant to the behaviour of the wind energy converter in the distribution or transport grid. Rotational speed, excitation, output voltage and output frequency of the annular generator may vary depending on the wind speed. In this way, the energy contained in the wind can be optimally exploited even in the partial load range.

3 E-92 components

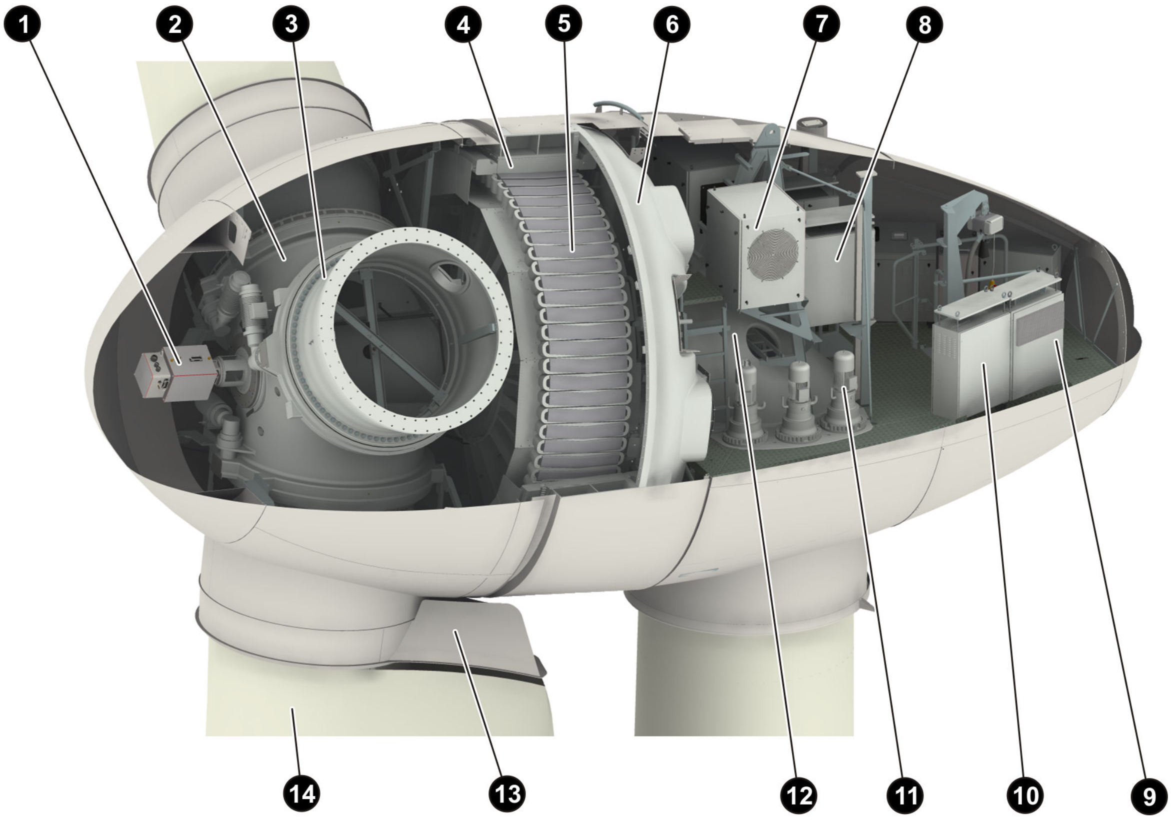

Fig. 2: View of ENERCON E-92 nacelle

1	Slip ring unit	8	Generator filter cabinet
2	Rotor hub	9	Excitation controller box
3	Blade adapter	10	Nacelle converter cabinet
4	Generator stator	11	Yaw drives
5	Generator rotor	12	Main carrier
6	Stator shield	13	Blade extension
7	Rectifier cabinet	14	Rotor blade

3.1 Rotor blades

The rotor blades made of glass-fibre reinforced plastic (glass fibre + epoxy resin) have a major influence on the wind energy converter's yield and its noise emission. The shape and profile of the E-92 rotor blades were designed with the following criteria in mind:

- High power coefficient
- Long service life
- Low noise emissions
- Low mechanical strain
- Efficient use of material

One special feature to be pointed out is the new rotor blade profile, which extends down to the nacelle. This design eliminates the loss of the inner air flow experienced with conventional rotor blades. In combination with the streamlined nacelle, utilisation of the wind supply is considerably optimised.

The rotor blades of the E-92 were specially designed to operate with variable pitch control and at variable speeds. The PU-based surface coating protects the rotor blades from environmental impacts such as UV radiation and erosion. This coating is highly resistant to abrasion and visco-hard.

Microprocessor-controlled pitch units that are independent of one another adjust each of the three rotor blades. An angle encoder in each rotor blade constantly monitors the set blade angle and ensures blade angle synchronisation across all three blades. This provides for quick, accurate adjustment of blade angles according to the prevailing wind conditions.

3.2 Nacelle

3.2.1 Annular generator

ENERCON wind energy converters (WECs) are equipped with a multi-polar, separately excited synchronous generator (annular generator). The WEC operates at variable speeds so as to optimally utilise the wind energy potential. The annular generator therefore produces alternating current with varying voltage, frequency and amplitude.

The windings in the stator of the annular generator form two three-phase alternating current systems that are independent of each other. Both systems are rectified independently of each other in the nacelle and combined by the direct-current distribution system. In the tower base the inverters reconvert the current into three-phase current whose voltage, frequency, and phase position conform to the grid.

Consequently, the annular generator is not directly connected to the receiving power grid of the utility/power supply company; instead, it is completely decoupled from the grid by the full-scale converter.

3.3 Tower

The tower of the E-92 wind energy converter is either a steel tower or a concrete tower made of precast segments. Towers with different heights are available.
All towers are painted and equipped with weather and corrosion protection at the factory. This means that no work is required in this regard after assembly except for repairing any defects or transport damage. By default, the bottom of the tower comes with graduated paintwork (can be dispensed with if desired).

Steel towers are steel tubes that taper linearly towards the top. They are prefabricated and consist of a small number of large sections. Flanges with drill holes for bolting are welded to the ends of the sections.

The tower sections are simply stacked on top of each other and bolted together at the installation site. They are linked to the foundation by means of a bolt cage.

The concrete tower is assembled from the precast concrete elements at the installation site. As a rule, segments are dry-stacked; however, a compensatory grout layer can be applied. Vertical joints are closed by means of bolt connections.

Towers are pre-tensioned vertically by means of prestressing steel tendons. The prestressing tendons run vertically either through ducts in the concrete elements or externally along the interior tower wall. They are anchored to the foundation.

For technical and financial reasons, the top slender part of the E-92 concrete tower is made of steel. For instance, installing the yaw bearing directly on the concrete elements is unfeasible, and the considerably thinner wall of the steel section provides for more space in the tower interior.

4 Grid Management System

The annular generator is coupled to the grid through the ENERCON Grid Management System. The main components of this system are a rectifier, a DC link, and several modular inverters.

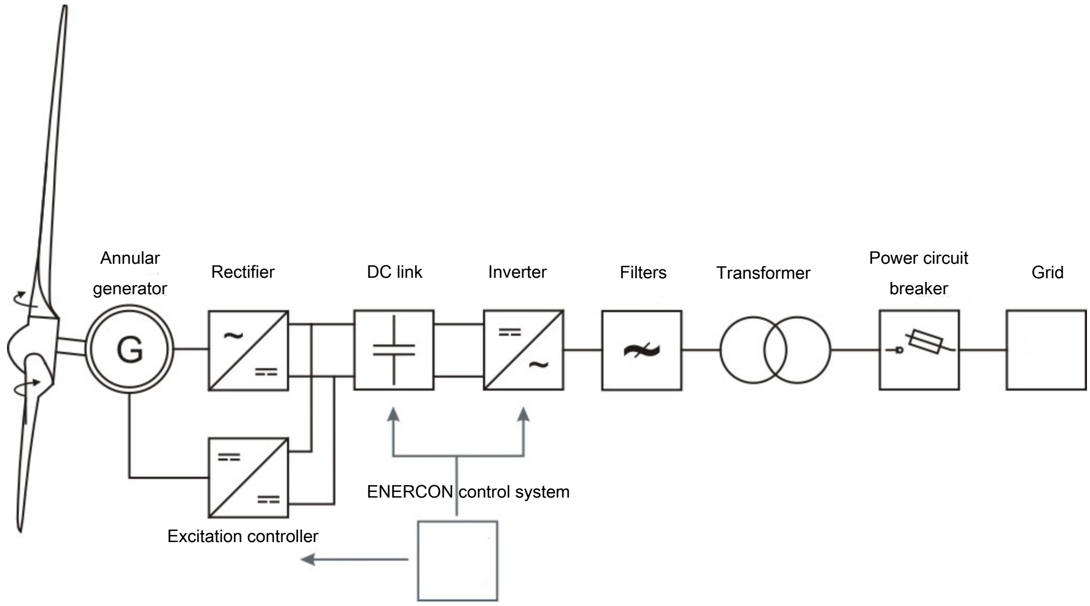

Fig. 3: Simplified electric diagram of an ENERCON WEC

The Grid Management System, generator excitation and pitch control are all managed by the control system to achieve maximum energy yield and excellent power quality.

Decoupling the annular generator from the grid guarantees ideal power transmission conditions. Sudden changes in wind speed are translated into controlled change in order to maintain stable grid feed. Conversely, possible grid faults have virtually no effect on WEC mechanics. The power injected by the E-92 can be precisely regulated from 0 kW to 2000/2350 kW.

In general, the features required for a certain wind energy converter or wind farm to be connected to the receiving power grid are predefined by the operator of that grid. To meet different requirements, ENERCON wind energy converters are available with different configurations.

The inverter system in the tower base is dimensioned according to the particular WEC configuration. As a rule, a transformer inside or near the wind energy converter converts 400 V low voltage to the desired medium voltage.

Reactive power

If necessary, an E-92 equipped with standard FACTS (Flexible AC Transmission System) control can supply reactive power in order to contribute to reactive power balance and to maintaining voltage levels in the grid. The maximum reactive power range is available at an output as low as 10 % of the nominal active power. The maximum reactive power range varies, depending on the WEC configuration.

FT configuration

By default, the E-92 comes equipped with FACTS technology that meets the stringent requirements of specific grid codes. It is able to ride through grid faults (undervoltage, overvoltage, automatic reclosing, etc.) of up to 5 seconds (FT = FACTS + FRT [Fault Ride Through]) and to remain connected to the grid during these faults.

If the voltage measured at the reference point exceeds a defined limit value, the ENERCON wind energy converter changes from normal operation to a specific fault operating mode.

Once the fault has been cleared, the wind energy converter returns to normal operation and feeds the available power into the grid. If the voltage does not return to the operating range admissible for normal operation within an adjustable time frame (5 seconds max.), the wind energy converter is disconnected from the grid.

While the system is riding through a grid fault, various fault modes using different grid feed strategies are available, including feeding in additional reactive current in the event of a fault. The control strategies include different options for setting fault types.

Selection of a suitable control strategy depends on specific grid code and project requirements that must be confirmed by the particular grid operator.

FTQ configuration

The FTQ configuration (FT plus Q+ option) comprises all features of the FT configuration. In addition, it has an extended reactive power range.

FTQS configuration

The FTQS configuration comprises all features of the FTQ configuration and has been expanded to include the STATCOM (Static Synchronous Compensator) option. The STATCOM option enables the wind energy converter to output and absorb reactive power regardless of whether it generates and feeds active power into the grid. It is thus able to actively support the power grid at any time, similar to a power plant.

Frequency protection

ENERCON wind energy converters can be used in grids with a nominal frequency of 50 Hz or 60 Hz.

The range of operation of the E-92 is defined by a lower and upper frequency limit value. Overfrequency and underfrequency events at the WEC reference point trigger frequency protection and cause the WEC to shut down after the maximum delay time of 60 seconds has elapsed.

Power-frequency control

If temporary overfrequency occurs as a result of a grid fault, ENERCON wind energy converters can reduce their power feed dynamically to contribute to restoring the balance between the generating and transmission networks.
As a pre-emptive measure, the active power feed of ENERCON wind energy converters can be limited during normal operation. During an underfrequency event, the power reserved by this limitation is made available to stabilise the frequency. The characteristics of this control system can be easily adapted to different specifications.

5 Safety system

The E-92 comes with a large number of safety features whose purpose is to permanently keep the WEC inside a safe operating range. In addition to components that ensure safe stopping of the wind energy converter, these include a complex sensor system. It continuously captures all relevant operating states of the wind energy converter and makes the relevant information available through the ENERCON SCADA remote monitoring system.

If any safety-relevant operating parameters are out of the permitted range, the WEC will continue running at limited power or it will stop.

5.1 Safety equipment

Emergency stop button

In an ENERCON wind energy converter there are emergency stop buttons next to the tower door, on the control cabinet in the tower base, on the nacelle control cabinet and, if required, on further levels of the E-module. Actuating an emergency stop button activates the rotor brake. Emergency pitching of the rotor blades takes place.

The following are still supplied with power:

- Rotor brake
- Beacon system components
- Lighting
- Sockets

Main switch

In an ENERCON wind energy converter, main switches are installed on the control cabinet and the nacelle control cabinet. When actuated, they de-energise virtually the entire wind energy converter.

The following are still supplied with power:

- Beacon system components
- Service hoist
- Sockets
- Lighting
- Medium-voltage area

5.2 Sensor system

There is a large number of sensors that continuously monitor the current status of the wind energy converter and the relevant ambient parameters (e.g. rotor speed, temperature, blade load, etc.). The control system analyses the signals and regulates the wind energy converter such that the wind energy available at any given time is always optimally exploited and operating safety is ensured at the same time.

Redundant sensors

In order to be able to check plausibility by comparing the reported values, more sensors than necessary are installed for some operating states (e.g. for measuring the generator temperature). Defective sensors are reliably detected and can be replaced by activation of a spare sensor. In this way, the wind energy converter can safely continue its operation without the need for replacement of major components.

Sensor checks

Proper functioning of all sensors is either regularly checked by the WEC control system itself during normal WEC operation or, where this is not possible, in the course of WEC maintenance work.

Speed monitoring

The control system of the ENERCON wind energy converter regulates the rotor speed by adjusting the blade angle in such a way that the speed does not significantly exceed rated speed even during very high winds. However, this pitch control system may not be able to react quickly enough to sudden events such as strong gusts of wind or a sudden drop of the generator load. If rated speed is exceeded by more than 15 %, the control system stops the rotor. After three minutes, the wind energy converter automatically attempts to restart. If this fault occurs more than five times within 24 hours, the control system assumes a defect and does not attempt any further restarts.

In addition to the electronic monitoring system, each of the three pitch control boxes is fitted with an electromechanical overspeed switch. Each of these switches can stop the wind energy converter via emergency pitching. The switches respond if the rotor speed exceeds the rated speed by more than 25 %. To enable the wind energy converter to restart, the overspeed switches must be reset manually after the cause of the overspeed has been identified and eliminated.

Vibration monitoring

The vibration sensor serves to detect excessive vibrations and shocks such as might be caused by a malfunction in the rectifier. It is mounted on the bottom of the main carrier of the wind energy converter and consists of a limit switch with a spring rod that has a ball attached to one end by a chain. The ball sits on top of a short vertical pipe. In the event of strong vibrations, the ball falls from its seat on the pipe, activates the switch by pulling the chain and thereby initiates emergency pitching of the rotor blades that stops the rotor.

Air gap monitoring

Microswitches distributed along the rotor circumference monitor the width of the air gap between the rotor and the stator of the annular generator. If any of the switches is triggered because the distance has dropped below the minimum distance, the wind energy converter stops and restarts automatically after a brief delay.

If the fault recurs within 24 hours, the wind energy converter remains stopped until the cause has been eliminated.

Oscillation monitoring

Oscillation monitoring detects excessive oscillation or excursion of the wind energy converter tower top.

Two acceleration sensors detect the acceleration of the nacelle along the direction of the hub axis (longitudinal oscillation) and perpendicular to this axis (transverse oscillation). The WEC control system uses this input to calculate the tower excursion compared to its resting position. If the excursion exceeds the permissible limit, the wind energy converter stops. It restarts automatically after a short delay. The acceleration sensors are mounted on the same support as the vibration sensor. If multiple out-of-range tower oscillations are recorded within a 24-hour period, the wind energy converter does not attempt any further restarts.

Temperature monitoring

The components of the ENERCON wind energy converter are cooled by an air cooling system. In addition, temperature sensors continuously measure the temperature of WEC components that need to be protected from excessive heat.

In the event of excessive temperatures, the power output of the wind energy converter is reduced. If necessary, the WEC stops. The wind energy converter cools down and typically restarts automatically as soon as the temperature falls below a predefined limit.

Some measuring points are equipped with additional overtemperature switches. These also initiate a stop of the wind energy converter, but without an automatic restart after cooling down, once the temperature exceeds a specific limit.

At low temperatures, some assemblies such as the pitch system emergency power supply and the generator are heated in order to keep them operational.

Noise monitoring

Sensors located in the rotor head respond to loud knocking sounds such as might be caused by loose or defective components. If any of these sensor detects any noise and there is nothing to indicate a different cause, the wind energy converter stops.

In order to rule out exterior causes for the noise (mainly the impact of hail during a thunderstorm), the signals from all wind energy converters in a wind farm are compared with each other. If the sensors in multiple WECs are detecting noise at the same time, an exterior cause is assumed. The noise sensors are deactivated briefly so that none of the wind energy converters in the wind farm stops. For wind energy converters outside of wind farms, the signal from a noise sensor in the machine house is used for reference.

Cable untwisting

If the nacelle of the wind energy converter has turned around its own axis up to three times and twisted the cables running down inside the tower, the WEC control system uses the next opportunity to automatically untwist the cables.

The cable untwisting system includes a sensor system with an angle encoder with two programmable relays that travel along in the yaw bearing gear rim. If outside the permitted range, the power supply to the yaw motors is cut.

6 Control system

The E-92 control system is based on a microprocessor system developed by ENERCON and uses sensors to query all WEC components and collect data such as wind direction and wind speed. Using this information, it adjusts the operating mode of the E-92 accordingly. The WEC display of the control cabinet in the tower base shows the current status of the wind energy converter and any fault that may have occurred.

6.1 Yaw system

The yaw bearing with an externally geared rim is mounted on top of the tower. The yaw bearing allows the nacelle to rotate, thus providing for yaw control.

If the difference between the wind direction and the rotor axis direction exceeds the maximum permissible value, the yaw drives are activated and adjust the nacelle position according to the wind direction. The yaw motor control system ensures smooth starting and stopping of the yawing motion. The WEC control system monitors the yaw system. If it detects any irregularities it deactivates yaw control and stops the wind energy converter.

6.2 Pitch control

Functional principle

The pitch control system modifies the angle of attack, i.e., the angle at which the air flow meets the blade profile. Changes to the blade angle change the lift at the rotor blade and thus the force with which the rotor blade turns the rotor.

During normal operation (automatic mode) the blade angle is adjusted in a way that ensures optimal exploitation of the energy contained in the wind while avoiding overload of the wind energy converter. Wherever possible, boundary conditions such as noise optimisation are also fulfilled in the process. In addition, blade angle adjustment is used to decelerate the rotor aerodynamically.

If the wind energy converter achieves nominal power output and the wind speed continues to increase, the pitch system turns the rotor blades just far enough out of the wind to keep the rotor speed and the amount of energy extracted from the wind, i.e., the energy to be converted by the generator, within or just slightly above the rated limits.

Assembly

Each rotor blade is fitted with a pitch unit. The pitch unit consists of a pitch control box, a blade relay box, a pitch motor and a capacitor box. The pitch control box and the blade relay box control the pitch motor. The capacitor box stores the energy required for emergency pitching; during WEC operation, it is kept charged and tested continually.

Blade angle

Special rotor blade positions (blade angles) of the E-92:

A: 2.5°	Regular position during partial load operation: Maximum exploitation of available wind energy.
B: 60°	Idle mode (wind energy converter does not feed any power into the grid because the wind speed is too low): Depending on the wind speed, the rotor spins at low speed or stands still (if there is no wind at all).
C: 92°	Feathered position (rotor has been stopped manually or automatically): The rotor blades do not generate any lift even in the presence of wind; the rotor stands still or moves very slowly.

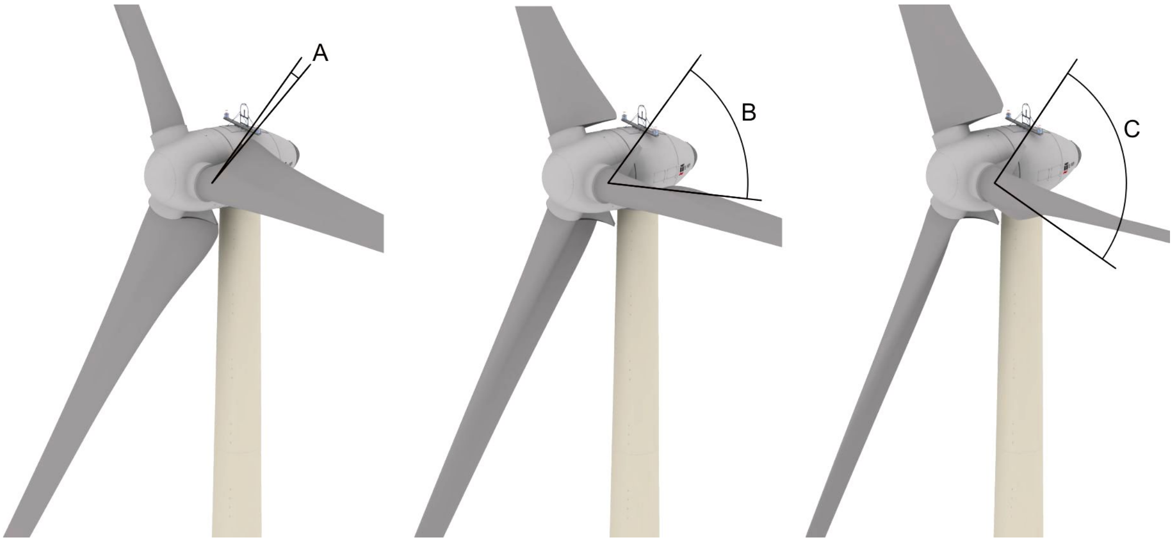

Fig. 4: Special blade positions

6.3 WEC start

6.3.1 Start lead-up

As long as the main status is > 0, the wind energy converter remains stopped. As soon as the main status changes to 0, the WEC is ready and the start-up procedure is initiated. If certain boundary conditions for start-up, e.g. charging of the emergency pitching capacitors, have not been fulfilled yet, status `0:3 - Start lead-up` is displayed.

During the start lead-up, a wind measurement and alignment phase of 150 seconds begins.

6.3.2 Wind measurement and nacelle alignment

After completing the start lead-up, status `0:2 - Turbine operational` is displayed.

If the control system is in automatic mode, the average wind speed is above 1.8 m/s and the wind direction deviation is sufficient for yawing, the WEC will start alignment with the prevailing wind direction. 60 seconds after completing the start lead-up the WEC goes into idle mode. The rotor blades are slowly pitched in as a check is performed on the emergency pitching capacitors.

If the WEC is equipped with load control sensors, the rotor blades will stop at an angle of 70° and adjust the load measurement points, which might take several minutes. During this time, status `0:5 - Calibration of load control` is displayed.

If the average wind speed during the wind measurement and alignment phase of 150 seconds is above the current start wind speed (about 2.0 m/s), the start-up procedure is initiated (status `0:1`). Otherwise, the wind energy converter remains in idle mode (status `2:1 - Lack of wind : Wind speed too low`).

Auxiliary power supply

As the wind energy converter does not supply any active power at that moment, the electrical energy consumed by the WEC is taken from the grid.

6.3.3 Generator excitation

Once the rotor reaches a certain rotational speed that depends on the WEC type (for instance, approx. 3 rpm with the E-82), generator excitation is initiated. The electricity required for this purpose is temporarily taken from the grid. Once the generator reaches a sufficient speed the WEC supplies itself with power. The electricity for self-excitation is then taken from the DC link; the energy taken from the grid is reduced to zero.

6.3.4 Power feed

As soon as the DC link voltage is sufficient and the excitation controller is no longer connected to the grid, power feed is initiated. After the rotational speed has increased due to sufficient wind and with a power setpoint $P_{set} > 0$, the line contactors on the low-voltage side are closed and the WEC starts feeding power into the grid.

The number of activated inverters is gradually increased, depending on the number necessary for the power generated by the generator. Power control regulates the excitation current so that power is fed according to the required power curve.

The power increase gradient (dP/dt) after a grid fault or a regular start-up can be defined within a certain range in the control system. For more detailed information, see the *Grid Performance* data sheet for the particular ENERCON WEC type.

6.4 Operating modes

After completion of the E-92 start-up procedure the wind energy converter switches to automatic mode (normal operation). While in operation, the WEC constantly monitors wind conditions, optimises rotor speed, generator excitation and generator power output, aligns the nacelle position with the wind direction, and captures all sensor statuses.

In order to optimise power generation in highly diverse wind conditions when in automatic mode, the WEC changes between three operating modes, depending on the wind speed. In certain circumstances the WEC stops if provided for by the WEC configuration (e.g. shadow shutdown). In addition, the utility company into whose grid the generated power is fed can be given the option to directly intervene in the operation of the wind energy converter by remote control, e.g. in order to temporarily reduce the power feed.

The E-92 switches between the following operating modes:

- Full load operation
- Partial load operation
- Idle mode

6.4.1 Full load operation

Wind speed
v ≥ 13 (2 MW) / 14 (2.35 MW) m/s

With wind speeds at and above the rated wind speed, the wind energy converter uses pitch control to maintain rotor speed at rated (approx. 16.5 rpm) and thus limits the power to its nominal value of 2000/2350 kW.

Storm Control enabled (normal case)

Storm Control enables WEC operation even at very high wind speeds; however, the rotor speed and the power output are reduced.

If wind speeds exceed approx. 28 m/s (12-second average) and keep increasing, the rotational speed will be reduced linearly from 16.5 rpm to idle speed at about 34 m/s by pitching the rotor blades out of the wind accordingly. The power fed into the grid decreases in accordance with the speed/power curve in the process.

At wind speeds above 34 m/s (10-minute average) the rotor blades are almost in the feathered position. The WEC runs in idle mode and without any power output; it does, however, remain connected to the receiving grid. Once the wind speed falls below 34 m/s, the WEC restarts its power feed.

Storm control is activated by default and can only be deactivated by remote control or on site by ENERCON Service.

Storm control disabled

If, by way of exception, storm control is disabled, the wind energy converter will be stopped for safety reasons if the wind speed exceeds 25 m/s (3-minute average) or 30 m/s (15-second average). If none of the above events occurs within 10 minutes after stopping, the wind energy converter will be restarted automatically.

6.4.2 Partial load operation

Wind speed
2.5 m/s ≤ v < 13 (2 MW) / 14 (2.35 MW) m/s

During partial load operation (i.e., the wind speed is between the cut-in wind speed and the rated wind speed) the maximum possible power is extracted from the wind. Rotor speed and power output are determined by the current wind speed. Pitch control already starts as the WEC approaches full load operation so as to achieve a smooth transition.

6.4.3 Idle mode

Wind speed
v < 2.5 m/s

At wind speeds below 2.5 m/s no power can be fed into the grid. The wind energy converter runs in idle mode, i.e., the rotor blades are turned almost completely out of the wind (60° blade angle) and the rotor turns slowly or stops completely if there is no wind at all.

Slow movement (idling) puts less strain on the hub bearings than longer periods of complete standstill; in addition, the WEC can resume power generation and power feed more quickly as soon as the wind picks up.

6.5 Safe stopping of the wind energy converter

The ENERCON wind energy converter can be stopped by manual intervention or automatically by the control system.

The causes are divided into groups by risk.

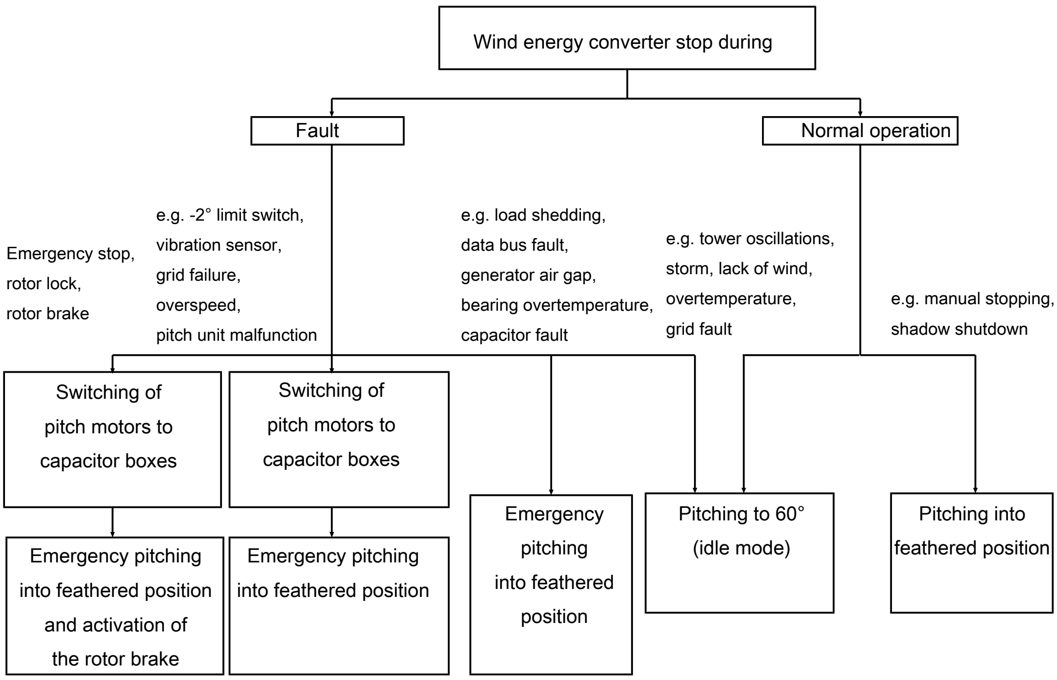

Fig. 5: Overview of stopping procedures

Stopping the wind energy converter by means of pitch control

In the event on a fault that is not safety-relevant, the WEC control system pitches the rotor blades out of the wind, causing the rotor blades not to generate any lift and bringing the wind energy converter to a safe stop.

Emergency pitching

For emergency pitching, the pitch motors are supplied with power by the capacitor boxes. The rotor blades move automatically and independently of each other into a position in which they do not generate any lift; this is called the feathered position.

Since the three pitch units are interconnected but also operate independently of each other, if one component fails, the remaining pitch units can still function and stop the rotor.

Emergency braking

If a person presses an emergency stop button, or if the rotor lock is used while the rotor is turning, the control system initiates an emergency braking procedure.

This means that in addition to the emergency pitching of the rotor blades, the rotor brake is applied. The rotor is decelerated from rated speed to a standstill within 10 to 15 seconds.

7 Remote monitoring

By default, all ENERCON wind energy converters are equipped with the ENERCON SCADA (Supervisory Control And Data Acquisition) system that connects them to Technical Service Dispatch. Technical Service Dispatch can retrieve each wind energy converter's operating data at any time and instantly respond to any irregularities or malfunctions.

The ENERCON SCADA system also transmits all status messages to Technical Service Dispatch, where they are permanently stored. This ensures that the practical experience gained through the long-term operation of ENERCON wind energy converters is taken into account for their continued development.

Connection of the individual wind energy converters is through a dedicated personal computer (ENERCON SCADA Server), which is typically located in one of the wind farm wind energy converters or in the associated substation. There is one ENERCON SCADA Server in every wind farm.

The ENERCON SCADA system, its properties and its operation are described in separate documentation.

At the operator/owner's request, monitoring of the wind energy converters can be performed by a third party.

8 Maintenance

In order to ensure the long-term safe and optimum operation of the wind energy converter, maintenance is required at regular intervals.

Frequency

One mechanical maintenance, one visual maintenance, one grease maintenance and one electrical maintenance are carried out per year. The maintenance activities are spread out over the year so that every wind energy converter is being serviced once per quarter. The first maintenance is carried out at 300 operating hours after commissioning.

Visual maintenance

During visual maintenance – as during the other maintenance activities – technicians check the wind energy converter for damage (for example, damaged cables or rotor blades) and listen for unusual noises during operation (for example, noise from the bearings).

Grease maintenance

During grease maintenance, technicians not only perform visual maintenance but also top up or replace lubrication components, and apply lubrication to seals.

Mechanical maintenance

In addition to grease maintenance, mechanical maintenance includes checks or tests of the following items:

- Fasteners (in particular of rotor blades) and weld seams
- Tightening torques (300-h maintenance)
- Yaw gears and pitch gears
- Safety ladders
- Tower cooling system
- Load-bearing parts
- Rotor brake
- Rotor blades (visual check from nacelle roof)

Electrical maintenance

Electrical maintenance includes checks or tests of the following items:

- Sensors, detectors, measuring equipment, push buttons, switches, and fuses
- Shadow shutdown and noise optimisation (depending on equipment)
- Overspeed switch and emergency pitch system
- Transmission (depending on equipment)
- Accuracy of yaw angle and blade angle
- Start-up procedure and software version
- Release circuits and safety circuits
- Cables and connections
- Lightning protection and earthing

9 Technical specifications E-92 2 MW/2.35 MW

General	
Manufacturer	ENERCON GmbH Dreekamp 5 26605 Aurich
Type designation	E-92
Nominal power	2000/2350 kW
Hub heights	78.3 m; 83.8 m; 84.6 m; 98.4 m; 103.9 m; 108.4 m; 138.4 m
Rotor diameter	92 m
IEC wind class (ed. 3)	IIA
Extreme wind speed at hub height (10-min. mean)	42.5 m/s
	Corresponds to a load equivalent of approx. 59.5 m/s (3-sec. gust)
Annual average wind speed at hub height	8.5 m/s

Rotor with pitch control	
Type	Upwind rotor with active pitch control
Rotational direction	Clockwise (downwind)
Number of rotor blades	3
Rotor blade length	43.8 m
Swept area	6648 m²
Rotor blade material	GRP/epoxy resin/wood
Lowest power feed speed to nominal speed	5 - 16.5 rpm
Tip speed	Up to 81.89 m/s
Power reduction wind speed	28 - 34 m/s (with optional ENERCON storm control)
Conical angle	0°
Rotor axis angle	5°
Pitch control	One independent electrical pitch system per rotor blade with dedicated emergency power supply

Drive train with generator	
WEC concept	Gearless; variable speed; full-scale converter
Hub	Rigid
Bearing	Double-row tapered/cylindrical roller bearing
Generator	Direct-drive ENERCON annular generator
Grid feed	ENERCON inverters with high-frequency IGBT switching and sinusoidal current
IP Code/insulation class	IP 23/F

Brake system	
Aerodynamic brake	Three independent pitch systems with emergency power supply
Rotor brake	Electromechanical
Rotor lock	Latching every 15°

Yaw control	
Type	Electrical with yaw motors
Control system	Active via yaw gears

Control system	
Type	Microprocessor
Grid feed	ENERCON inverter
Remote monitoring system	ENERCON SCADA
Uninterruptible power supply (UPS)	Integrated

Tower variants			
Hub height	**Total height**	**Design**	**Wind class**
78.3 m	124.3 m	Steel tower with foundation basket	IEC IIA DIBt WZ4 GK I
83.8 m	129.8 m	Precast concrete tower with steel section (external prestressing)	IEC IIA
84.6 m	130.6 m	Precast concrete tower with steel section	IEC IIA DIBt WZ4 GK I
84.6 m	130.6 m	Steel tower with foundation basket	IEC IIA DIBt WZ4 GK I
98.4 m	144.4 m	Precast concrete tower with steel section	IEC IIA DIBt WZ4 GK I

Tower variants			
98.4 m	144.4 m	Precast concrete tower with steel section (external prestressing)	IEC IIA
103.9 m	149.9 m	Precast concrete tower with steel section (external prestressing)	IEC IIA
103.9 m	149.9 m	Precast concrete tower with steel section (external prestressing)	DIBt WZ4 GK IA DIBt WZ4 GK IIA
108.4 m	154.4 m	Precast concrete tower with steel section	IEC IIA DIBt WZ4 GK I (for BR/UY only)
138.4 m	184.4 m	Precast concrete tower with steel section	IEC IIA DIBt WZ4 GK I

ZERTIFIKAT ◆ CERTIFICATE ◆ 認証証書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

TÜV SÜD Industrie Service

Type Certificate

Subject:	**Wind Turbine Enercon E-92 CCV, 2.35 MW** **Hub Heights above Ground Level** **78m, 84m, 98m, 104m, 108m and 138m** **WTC II$_A$ with Rotor Blade E92-1**
Registration no.:	002.19.2.01.16.01
Applicant:	**ENERCON GmbH** **Dreekamp 5** **26605 Aurich** **Germany**
Confirmation:	It is hereby certified that the above mentioned subject has been assessed by TÜV SÜD Industrie Service GmbH concerning the design, the prototype testing and the manufacturing.
Assessment procedure:	The conformity evaluation was carried out according to IEC 61400-22:2010 'Wind turbines – Part 22: Conformity testing and certification' in combination with IEC 61400-1:2005 including amendment 1:2010 'Wind turbines – Part 1: Design requirements'.

The evaluation is based on the following reference documents:

Registration No.:	dated	Statements of Compliance / Reports
002.19.2.03.16.04	2016-04-22	Design Evaluation E-92 CCV by TÜV SÜD
002.15.2.04.14.02	2014-12-17	Type Testing E-92 by TÜV SÜD
02.15.14.42.02	2014-12-17	Manufacturing Evaluation E-92 by TÜV SÜD
2483183-6-e	2016-04-25	Final Evaluation Report E-92 CCV by TÜV SÜD

This Certificate is valid until **2020-10-08**

if the validity of the certification of the quality management system is maintained.

Munich, 2016-05-11

Dr.-Ing. M. Webhofer
Head of Certification Body Wind Turbines
TÜV SÜD Industrie Service GmbH

DAkkS Deutsche Akkreditierungsstelle D-ZE-14153-01-02
Certification Body for products according to DIN EN ISO/IEC 17065:2013 accredited by DAkkS. The accreditation is only valid for the scope mentioned in the accreditation certificate.

Dipl.-Ing. A. Trunz
Head of Department Wind Turbines
TÜV SÜD Industrie Service GmbH

ZERTIFIKAT ◆ CERTIFICATE ◆ 認証証書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

TÜV SÜD
Industrie Service

Type Certificate

Subject:	**Wind Turbine Enercon E-92, 2.35 MW** **Hub Heights above Ground Level** **78m, 84m, 98m, 104m, 108m and 138m** **WTC II_A with Rotor Blade E92-1**
Registration No.:	002.15.2.01.16.04
Applicant:	**ENERCON GmbH** **Dreekamp 5** **26605 Aurich** **Germany**
Confirmation:	It is hereby certified that the above mentioned subject has been assessed by TÜV SÜD Industrie Service GmbH concerning the design, the prototype testing and the manufacturing.
Assessment procedure:	The conformity evaluation was carried out according to IEC 61400-22:2010 'Wind turbines – Part 22: Conformity testing and certification' in combination with IEC 61400-1:2005 including amendment 1:2010 'Wind turbines – Part 1: Design requirements'.

The evaluation is based on the following reference documents:

Registration No.:	dated	Statements of Compliance / Reports
02.15.16.22.09	2016-03-23	Design Evaluation E-92 by TÜV SÜD
002.15.2.04.14.02	2014-12-17	Type Testing E-92 by TÜV SÜD
02.15.14.42.02	2014-12-17	Manufacturing Evaluation E-92 by TÜV SÜD
2026676-8-e Rev.4	2016-03-24	Final Evaluation Report E-92 by TÜV SÜD

This Certificate is valid until **2019-12-16**

if the validity of the certification of the quality management system is maintained.

Munich, 2016-03-24

Dr.-Ing. M. Webhofer
Head Certification Body Wind Turbines
TÜV SÜD Industrie Service GmbH

DAkkS
Deutsche Akkreditierungsstelle
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