Technical Description

ENERCON Wind Energy Converter E-92 / 2000/2350 kW

ENERCON
ENERGY FOR THE WORLD

Publisher

ENERCON GmbH ▪ Dreekamp 5 ▪ 26605 Aurich ▪ Germany
Phone: +49 4941 927-0 ▪ Fax: +49 4941 927-109
E-mail: info@enercon.de ▪ Internet: http://www.enercon.de
Managing Directors: Hans-Dieter Kettwig
Local court: Aurich ▪ Company registration number: HRB 411
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List of abbreviations

FACTS	Flexible Alternating Current Transmission System
FT	FACTS transmission (electrical configuration with FACTS properties)
FTQ	FACTS Transmission with Q+ option
FTQS	FACTS Transmission with Q+ option and STATCOM option (electrical configuration with expanded reactive power range and STATCOM option)
FTS	FACTS Transmission with STATCOM option
GRP	Glass-fibre Reinforced Plastic
SCADA	Supervisory Control and Data Acquisition
STATCOM	Static compensator

1 Overview of the ENERCON E-92 wind energy converter

The ENERCON E-92 wind energy converter is a directly-driven wind energy converter with a three-bladed rotor, active pitch control, variable-speed operation and a nominal power of 2000/2350 kW. It has a rotor diameter of 92 m and is available with hub heights from 68.91 m to 138.38 m.

Fig. 1: ENERCON E-92 wind energy converter, overall view

2 ENERCON wind energy converter concept

Gearless

The WEC drive system comprises very few rotating components. The hub and the rotor of the annular generator are directly interconnected without a gear to form one solid unit. This reduces mechanical strain and increases technical service life. Maintenance and service costs are reduced (fewer wearing parts, no gear oil change, etc.) and operating expenses are also kept to a minimum. 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. This allows the maximum power to 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 grid feed system. The grid feed 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. This way, the energy contained in the wind can be optimally exploited even in the partial load range.

3 Components of the ENERCON E-92 wind energy converter

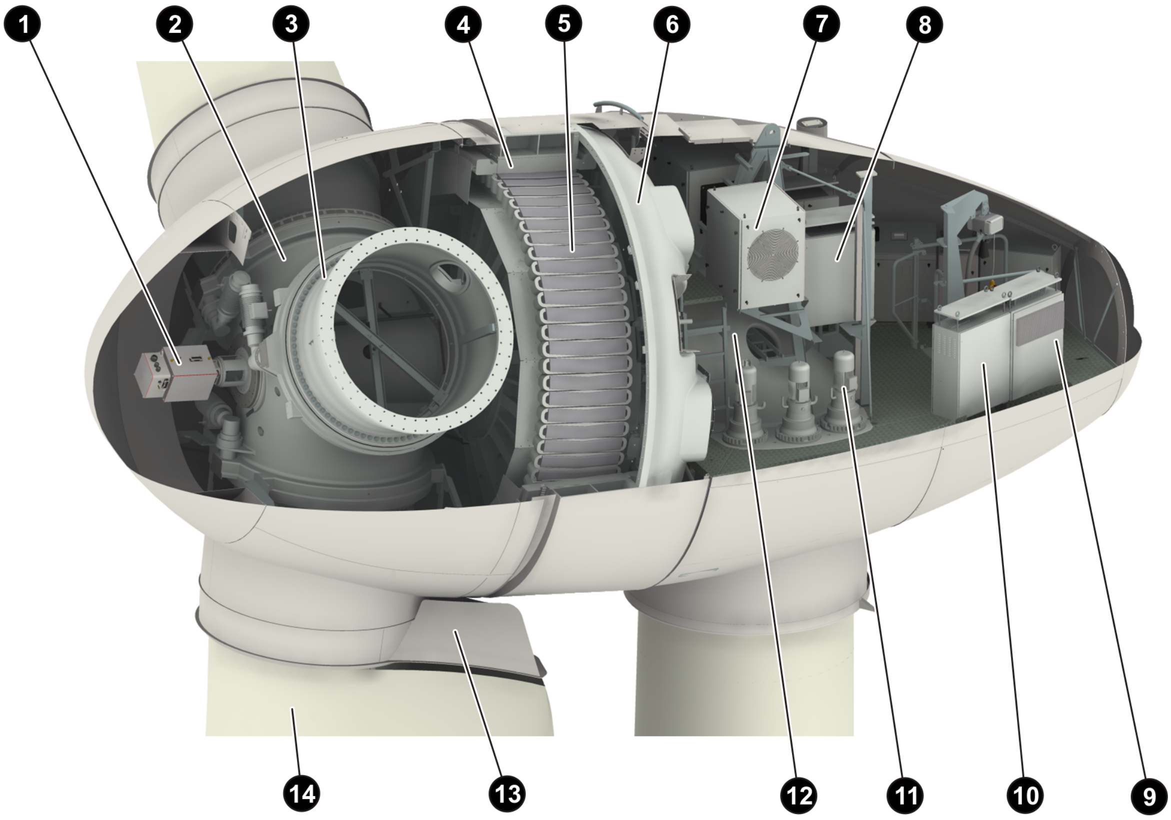

Fig. 2: Nacelle view of ENERCON E-92 wind energy converter

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

3.1 Rotor blades

The rotor blades made of GRP, balsa wood and foam have a major influence on the wind energy converter's yield and its noise emissions. The rotor blade is manufactured using half-ring segments by the vacuum infusion method. The shape and profile of the 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 deserving of emphasis is the rotor blade profile, which extends down to the nacelle. This design prevents the loss of the inner air flow experienced with conventional rotor blades. In combination with the streamlined nacelle, this significantly optimises utilisation of the wind supply.

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

Microprocessor-controlled pitch units adjust each of the three rotor blades independently of each another. An angle encoder in each rotor blade constantly monitors the set blade angle and ensures blade angle synchronisation across all three blades. This enables quick and precise setting of the blade angles according to the prevailing wind conditions.

Optionally, and in some cases as standard, the rotor blades have a serrated profile on part of the trailing edge. This trailing edge serration reduces the turbulence on the trailing edge and thus lowers the noise emission from the wind energy converter.

3.2 Nacelle

3.2.1 Annular generator

The wind energy converters are equipped with a multi-polar, externally excited synchronous generator (annular generator). The wind energy converter operates at variable speeds in order to fully exploit the wind energy potential at all wind speeds. The annular generator therefore produces alternating current with fluctuating voltage, frequency and amplitude.

The windings in the stator of the annular generator form 2 three-phase alternating current systems that are independent of each other. Both systems are rectified separately in the nacelle, combined in the DC distribution system and then reconverted by the inverters in the tower base 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 company; instead, it is completely decoupled from the grid by the full-scale converter.

3.3 Tower

The tower of the wind energy converter is a hybrid tower assembled from precast concrete tower segments and a steel section, or a steel tower.
All towers are painted and coated 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 outer paintwork on the bottom of the tower has a graded colour scheme (can be omitted if desired).

Steel towers are steel tubes that taper linearly towards the top. They are pre-fabricated 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 hybrid 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 bolted. As a final step, the top steel section is placed on the tower and bolted.

Hybrid towers are prestressed 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 economic reasons, the slender top part of the hybrid tower is made of steel. It is not possible, for example, to install the yaw bearing directly on the concrete elements 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 grid feed system. This system essentially consists of a modular rectifier and inverter system with a common DC link each.

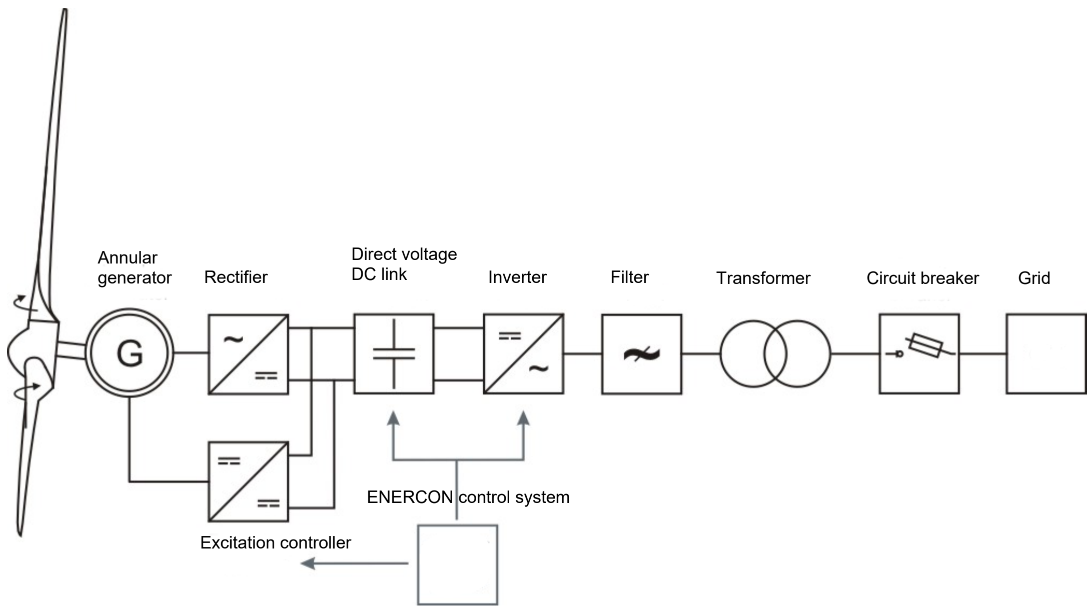

Fig. 3: Simplified electric diagram of a wind energy converter

The grid feed 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 provides for optimum power transmission. Sudden changes in the wind speed are translated into controlled changes in the power fed into the grid. Conversely, any grid faults that occur have virtually no effect on the mechanical side of the wind energy converter. The power fed in by the wind energy converter can be precisely regulated from 0 kW to 2000/2350 kW.

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

The inverter system in the tower base is dimensioned according to the particular configuration of the wind energy converter. 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, a wind energy converter equipped with a standard FACTS control system 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 configuration of the wind energy converter.

FT configuration

By default, the wind energy converter comes equipped with FACTS technology that meets the stringent requirements of specific grid codes. It is able to ride through grid faults of up to 5 seconds (undervoltage, overvoltage, automatic reclosing, etc.) and to remain connected to the grid during these faults.

If the voltage measured at the reference point exceeds a defined limit value, the wind energy converter changes from normal operation to a special 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 during the grid 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.

FTS configuration

FT configuration with STATCOM option
Same as FT configuration; however, the STATCOM option additionally enables the wind energy converter to output and absorb reactive power regardless of whether it is generating and feeding active power into the grid. It is thus able to actively support the power grid at any time, similar to a power plant. Whether or not this configuration can be used needs to be determined on a project-by-project basis.

FTQ configuration

FT configuration with Q+ option

The FTQ configuration has all of the features of the FT configuration. In addition, it offers an extended reactive power range.

FTQS configuration

FT configuration with Q+ and STATCOM options

The FTQS configuration has all of the features of the FTQ and FTS configurations.

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 wind energy converters is defined by a lower and upper frequency limit value. Overfrequency and underfrequency events at the reference point of the wind energy converter trigger frequency protection and cause the wind energy converter 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, the wind energy converter can reduce its power feed dynamically to contribute to restoring the balance between the generating and transmission networks.
As a pre-emptive measure, the active power feed 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 adapted to various specifications in a flexible manner.

5 Safety system

The wind energy converter comes with a large number of safety features whose purpose is to permanently keep the wind energy converter inside a safe operating range. In addition to components that ensure safe stopping of the wind energy converter, these include a complex sensor system. This system records on an ongoing basis all relevant operating states of the wind energy converter and makes the corresponding information available via the ENERCON SCADA remote monitoring system.

If any safety-relevant operating parameters are outside of the permitted range, the wind energy converter continues running at limited power, or is stopped.

5.1 Safety equipment

Emergency stop button

In wind energy converters there are emergency stop buttons on the control cabinet in the tower base, on the nacelle control cabinet and, as necessary, in the tower entrance area as well as at other locations. Actuating an emergency stop button in the tower base activates emergency pitching of the rotor blades. This brakes the rotor aerodynamically. Actuating an emergency stop button in the nacelle activates the rotor holding brake in addition to emergency pitching. This stops the rotor as quickly as possible. An emergency stop does not render the wind energy converter dead or renders it only partially dead.

The following are still supplied with power:

- Rotor holding brake
- Beacon system components
- Lighting
- Sockets

Main switch

In a wind energy converter, main switches are installed on the control cabinet and the nacelle control cabinet. When actuated, they render almost the entire wind energy converter dead.

The following are still supplied with power:

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

5.2 Sensor system

A large number of sensors 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 at the same time operating safety is ensured.

Redundant sensors

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 wind energy converter regulates the rotor speed by adjusting the blade angle in such a way that the nominal speed is not significantly exceeded, even if the wind is very strong. However, the pitch control may not be able to react quickly enough to sudden events such as a strong gust of wind or a sudden reduction in generator load. If nominal 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 a 24-hour period, a defect is assumed. There are no further restart attempts.

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 by means of emergency pitching. The switches respond if the rotor speed exceeds the nominal speed by more than 25 %. In order to restart the wind energy converter, the overspeed switches must be reset manually after the cause of the overspeed has been identified and eliminated.

Vibration monitoring

The vibration sensor detects 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 with 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 are 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.

2 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 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 system

Some components of wind energy converters are cooled. In addition, temperature sensors continuously measure the temperature of the components of the wind energy converter 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 wind energy converter stops. The wind energy converter cools down and generally 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 once the temperature exceeds a specific limit, in certain cases without an automatic restart after cooling down.

At low temperatures, some assemblies such as the hazard beacon energy storage and the generator are heated in order to keep them operational.

Nacelle-internal noise monitoring

There are sensors located in the rotor head of WECs with nacelle-internal noise monitoring that respond to loud knocking sounds such as might be caused by loose or defective components. If any of these sensors detect noise and there is nothing to indicate a different cause, the wind energy converter stops.

In order to rule out external 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 against each other. For stand-alone WECs, an additional noise sensor in the machine house is used. If the sensors in multiple WECs or the noise sensor in the machine house detect noise simultaneously, an exterior cause is assumed. The noise sensors are deactivated briefly so that none of the wind energy converters in the wind farm stop.

Cable twist monitoring

If the nacelle of the wind energy converter has turned around its own axis more than 3 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 twist monitoring feature is equipped with sensors that cut the power supply to the yaw motors if the permitted adjusting range is exceeded.

6 Control system

The wind energy converter 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 wind energy converter 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, that is 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 blade turns the rotor.

In automatic mode (normal operation) 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, pitch control is used to decelerate the rotor aerodynamically.

If the wind energy converter achieves nominal power output and the wind speed continues to increase, pitch control 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 nominal limits.

Installation

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

Blade angle

Special rotor blade positions (blade angle):

A: 2.5° Normal position during partial load operation: maximum exploitation of available wind.

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.

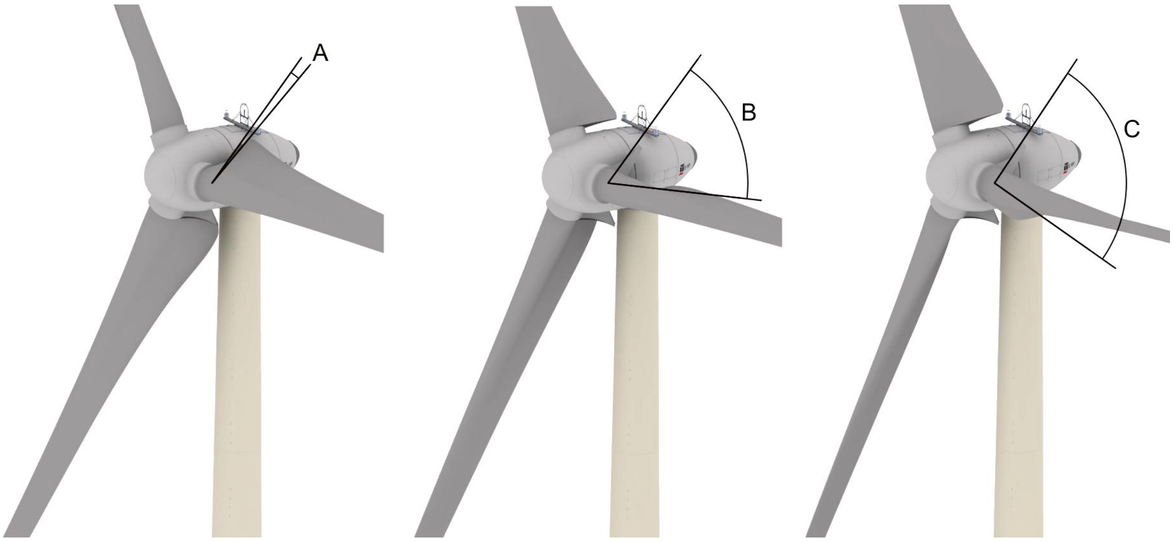

Fig. 4: Special rotor blade positions

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 wind energy converter is ready and the start-up procedure is initiated. If certain boundary conditions for start-up, e.g. charging of the emergency-pitching capacitor units, have not yet been fulfilled, status `0:3 Start lead-up` is displayed.

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

6.3.2 Wind measurement and nacelle alignment

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

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

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

If the mean wind speed during the wind measurement and alignment phase of 150 seconds is above the current cut-in 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`).

Power consumption

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

6.3.3 Generator excitation

Once the rotor reaches a certain rotational speed that depends on the wind turbine type, generator excitation is initiated. The electricity required for this purpose is temporarily taken from the grid. Once the generator reaches a sufficient speed the wind energy converter 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 > 0 kW, the line contactors on the low-voltage side are closed and the wind energy converter starts feeding power into the grid at approx. 5 rpm.

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 in the control system within a certain range. For more detailed information, see the grid performance data sheet for the particular wind energy converter type.

6.4 Operating modes

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

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

The wind energy converter switches between the following operating modes:

- Full load operation
- Partial load operation
- Idle mode

6.4.1 Full load operation

Wind speed
v ≥ 13/14 (2000/2350 kW) m/s

At wind speeds at and above the rated wind speed, the wind energy converter uses pitch control to maintain the rotor speed at the setpoint (approx. 17 rpm), thereby limiting 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 are reduced.

If wind speeds are above 28.42 m/s (12-second mean) and keep increasing, the rotational speed will be reduced linearly from 17 rpm to idle speed at 34 m/s (10-min mean) by pitching the rotor blades out of the wind accordingly. The power fed into the grid decreases in accordance with the speed/power characteristic curve in the process.

At wind speeds of above 34 m/s (10-minute average) the rotor blades are almost in the feathered position. The wind energy converter 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 wind energy converter restarts its power feed.

Storm control is enabled 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 mean) or 30 m/s (15-second mean). 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 < 13/14 (2000/2350 kW) 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 (blade angle ≥ 60°) and the rotor turns slowly or stops completely if there is no wind at all.

Slow movement (idling) puts less strain on the rotor 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 wind energy converter can be stopped by manual intervention or automatically by the control system.

The causes are divided into groups by risk.

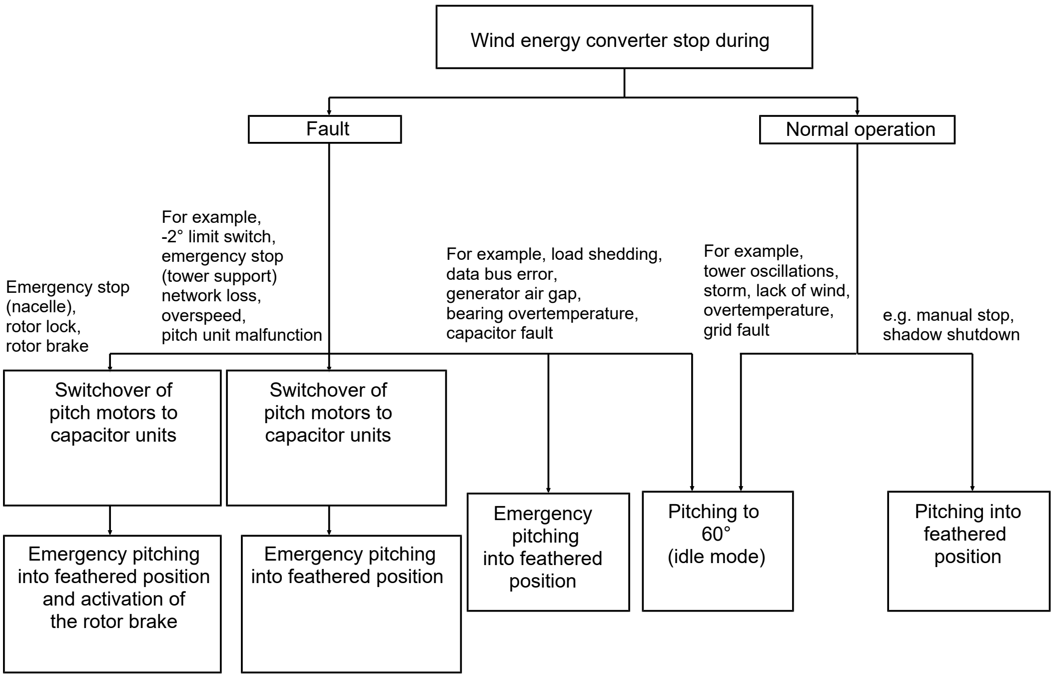

Fig. 5: Overview of wind energy converter stop

Stopping the wind energy converter by means of pitch control

In the event of a fault that is not safety-relevant, the wind energy converter 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

The pitch unit's energy storage system provides the energy required for emergency pitching. During operation of the wind energy converter, it is kept charged and continually tested. For emergency pitching, the drive units are supplied with power from the corresponding energy storage. 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 3 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 an emergency stop button is pressed in the nacelle, or if the rotor lock is actuated while the rotor is turning, the control system initiates an emergency braking procedure.

In this case, the rotor brake is applied in addition to emergency pitching of the rotor blades. The rotor decelerates from nominal 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 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 faults.

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 the ENERCON SCADA Server, which is typically located in the substation or the transmission substation of a wind farm. One ENERCON SCADA Server is installed 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 long-term safe and optimum operation of the wind energy converters, maintenance is required at regular intervals.

Wind energy converters are regularly serviced at least once a year, depending on requirements.

During maintenance, all safety-relevant components and features are inspected, e.g. pitch control, yaw control, safety systems, lightning protection system, anchorage points and safety ladders. The bolt connections on load-bearing joints (main components) are checked. All other components are visually inspected to check for any irregularities or damage. Lubrication systems are refilled.

Maintenance intervals and scope may vary, depending on regional guidelines and standards.

9 Technical specifications ENERCON E-92 wind energy converter

General	
Manufacturer	ENERCON GmbH Dreekamp 5 26605 Aurich Germany
Type designation	E-92
Nominal power	2000/2350 kW
Design service life	25 years
Rotor diameter	92 m
IEC wind class (ed. 3)	IIA
Extreme wind speed at hub height (10-minute mean)	42.5 m/s Corresponds to a load equivalent of approx. 59.5 m/s (3-second 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 m^2
Rotor blade material	GRP (glass fibre + epoxy resin)/balsa wood/foam
Maximum idle speed	3.3 rpm
Lower power feed rotational speed up to nominal speed	5 – 16.5 rpm
Speed setpoint	17 rpm
Tip speed at speed setpoint	Up to 81.89 m/s
Power reduction wind speed (with ENERCON storm control)	28.42 (12-second mean) – 34 m/s (10-minute mean)
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	
Wind energy converter concept	Gearless, variable speed, full-scale converter

Drive train with generator	
Hub	Rigid
Bearing	Double-row tapered/cylindrical roller bearing
Generator	Direct-drive ENERCON annular generator
Grid feed	ENERCON inverter with high clock speed and sinusoidal current
IP Code/insulation class	IP 23/F

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

Yaw control	
Yaw system	Electromechanical pitch system

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

Tower types			
Hub height	**Total height**	**Construction type**	**Wind class**
68.91 m	114.91 m	Steel tower with foundation basket	IEC IIA[1] DIBt WZ4 GK I+II[2]
78.33 m	124.33 m	Steel tower with foundation basket	IEC IIA/S[1] DIBt WZ4 GK I+II[2]
84.00 m	130.00 m	Hybrid tower (external prestressing)	IEC IIA[1]
84.58 m	130.58 m	Hybrid tower	IEC IIA[1] DIBt WZIII/WZ4 GK I[3]
84.58 m	130.58 m	Steel tower with foundation basket	IEC IIA[1] DIBt WZ4 GK I[2]
84.58 m	130.58 m	Steel tower with foundation basket	IEC IIA[1] (only for Japan)
98.38 m	144.38 m	Hybrid tower	IEC IIA[1] DIBt WZIII/WZ4 GK I[3]
98.38 m	144.38 m	Hybrid tower (external prestressing)	IEC IIA[1]

Tower types			
103.9 m	149.9 m	Hybrid tower (external prestressing)	IEC IIA[1]
103.9 m	149.9 m	Hybrid tower (external prestressing)	DIBt WZ4 GK I+II[2]
108.38 m	154.38 m	Hybrid tower	IEC IIA[1]
108.38 m	154.38 m	Hybrid tower	IEC IIA[1] (only for Brazil/Uruguay)
138.38 m	184.38 m	Hybrid tower	IEC IIA[1] DIBt WZIII/WZ4 GK I[3]

[1] Issue of the guideline Edition 3

[2] Issue of the guideline 2012

[3] Issue of the guideline 2004