Technical Description

ENERCON Wind Energy Converter

E-138 EP3 E2

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ENERCON
ENERGY FOR THE WORLD

Publisher

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1 Overview of ENERCON E-138 EP3 E2

The ENERCON E-138 EP3 E2 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 of 4200 kW. It has a rotor diameter of 138.6 m and can be supplied with hub heights from 81 m to 160 m.

Fig. 1: Complete view of E-138 EP3 E2

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2 ENERCON wind energy converter concept

Gearless

The E-138 EP3 E2 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 are also minimised. 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 3 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 control drive for each rotor blade consists of two direct-current compositely excited motors with a gear. The pitch units limit the rotor speed and the amount of power extracted from the wind. This way, the maximum output of the E-138 EP3 E2 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 feed system. The ENERCON grid feed system, which consists of modular rectifier and inverter systems with a common DC link each, 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.

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3 E-138 EP3 E2 components

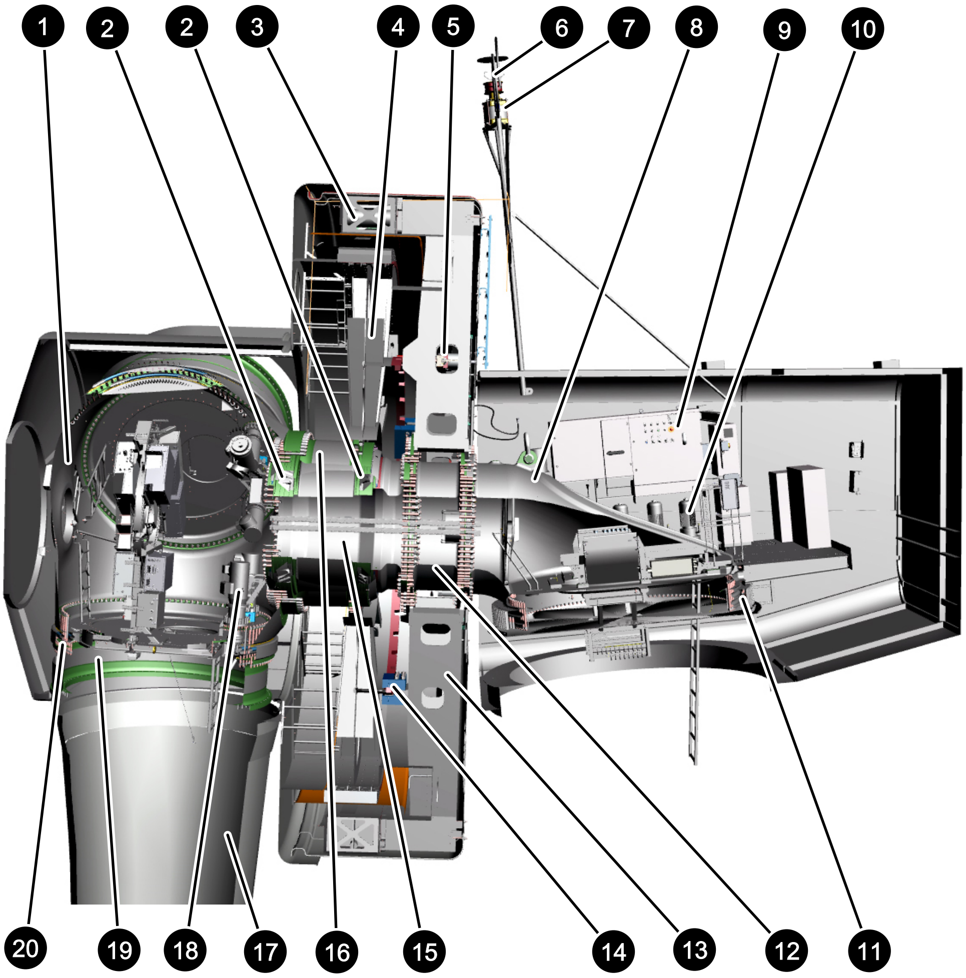

Fig. 2: Sectional view of nacelle

1	Hub	2	Rotor bearing
3	Generator stator	4	Generator rotor
5	Rotor lock	6	Wind measuring unit with lightning rods
7	Beacon system (optional)	8	Main carrier
9	Nacelle control cabinet	10	Yaw drive
11	Yaw bearing	12	Stator support star
13	Support	14	Rotor brake
15	Axle pin	16	Rotor support
17	Rotor blade	18	Pitch drives
19	Blade adapter	20	Blade flange bearing

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3.1 Rotor blades

The rotor blades made of glass-fibre reinforced plastic (GRP (glass fibre and epoxy resin)), balsa wood and foam have a major influence on the yield from the wind energy converter and its noise emission. The rotor blade is manufactured using half shells by the vacuum infusion method. The shape and profile of the E-138 EP3 E2 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

The rotor blades of the E-138 EP3 E2 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 3 rotor blades independently of each another. 2 blade angle measurements in each rotor blade constantly monitor the set blade angle and ensure blade angle synchronisation across all 3 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.

Vortex generators are mounted on the inside of the rotor blades on the suction face. The vortex generators delay the breakaway of the boundary layer flow from the rotor blade surface. Thus the aerodynamic properties of the WEC are less sensitive to temporary surface changes and wind conditions. The power of the WEC increases and the noise emissions decrease.

3.2 Nacelle

The hub rotates around the fixed axle pin on 2 rotor bearings. Among other components, the rotor blades and the generator rotor are attached to the hub. The slip ring unit is located at the tip of the axle pin. It transmits electrical energy and data between the stationary and the rotating parts of the nacelle via sliding contacts.
The stator support with its 6 jibs is the load-bearing element of the fixed generator stator. The stator support star connects the stator support to the main carrier. Mounted on the ends of the jibs is the stator support ring, which is fitted with the aluminium windings in which electric current is induced.
The main carrier is the central load-bearing element of the nacelle. All rotor and generator components are attached to it either directly or indirectly. The main carrier rotates on the tower head by means of the yaw bearing. The entire nacelle can be rotated by the yaw drives so that the rotor is always optimally aligned to the wind.
The nacelle casing consists of glass-fibre reinforced plastic (GRP). It is composed of multiple sections and attached to the generator stator, the nacelle floor and the hub by means of steel profiles.

3.2.1 Annular generator

ENERCON wind energy converters 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 several three-phase alternating current systems that are independent of each other. These systems are rectified independently of each other in the tower base. The inverters then reconvert them 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 E-138 EP3 E2 wind energy converter is a hybrid tower assembled from precast concrete segments and a steel section, or a tubular 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 defects or any transport damage. By default, the paintwork on the bottom of the tower has a graded colour scheme (can be omitted if desired).

Each tubular steel tower is a sheet steel tube that consists of few large sections. Depending on the tower variant, sections may be single-piece or subdivided into multiple longitudinal elements. First, the longitudinal elements are joined to form sections at the installation site. Flanges with drill holes for installation are welded to the ends of the sections. The tower sections are stacked on top of each other and bolted together at the installation site. They are linked to the foundation by means of a foundation basket.

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.

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4 Grid Management System

The annular generator is coupled to the grid through the ENERCON grid feed system. This system essentially consists of a modular rectifier and inverter system with a common DC link each.

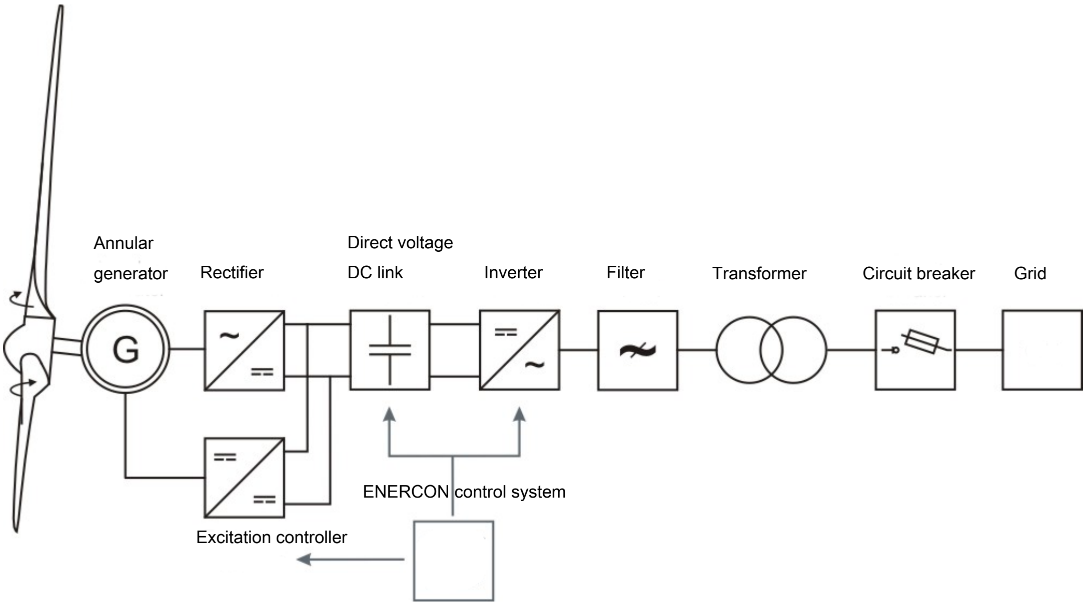

Fig. 3: Simplified electric diagram of an ENERCON WEC

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, possible grid faults have virtually no effect on WEC mechanics. The power fed in by the E-138 EP3 E2 can be precisely regulated from 0 kW to 4200 kW.

In general, the characteristics required for a specific WEC or wind farm to be connected to the receiving power grid with respect to the connection point and the power supply to be absorbed are predefined by the operator/owner of that grid. To be able 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 630 V low voltage to the desired medium voltage.

Reactive power

If necessary, an E-138 EP3 E2 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.

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FT configuration

By default, the E-138 EP3 E2 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.

FTS configuration

FACTS Transmission (FRT) with STATCOM option

Same as FT configuration; however, the STATCOM (**Stat**ic **Com**pensator) option additionally 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. Whether or not this configuration can be used needs to be determined for each individual project.

FTQ configuration

FACTS Transmission (FRT) with Q+ option

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

FTQS configuration

FACTS Transmission (FRT) with Q+ and STATCOM options

The FTQS configuration comprises all 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 E-138 EP3 E2 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

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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.

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5 Safety system

The E-138 EP3 E2 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. 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 wind energy converter continues running at limited power, or is stopped.

5.1 Safety equipment

Emergency stop button

In an ENERCON wind energy converter there are emergency stop buttons in the vicinity of 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 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 brake in addition to emergency pitching. This stops the rotor as quickly as possible. An emergency stop does not de-energise or only partly de-energises the wind energy converter.

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 at the WEC main distribution system (tower base) and at the nacelle control cabinet. When actuated, they de-energise almost 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

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.

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Redundant sensors

To be able to check plausibility by comparing the reported values, redundant sensors are installed for some operating states. This applies to temperature measurement in the generator, wind speed measurement or measuring the current rotor blade angle. Defective sensors are reliably detected and can be repaired or replaced by activating spare sensors. This way, the wind energy converter can safely continue its operation without having to replace 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 such that the speed does not significantly exceed nominal speed even during very high winds. However, pitch control 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 nominal speed is exceeded by more than 15 %, the control system stops the rotor. After 3 minutes the wind energy converter automatically attempts to restart. If this fault occurs more than 5 times within a 24 hour period, a defect is assumed. There are no further restart attempts.

In addition to the electronic monitoring system there are 3 electromechanical overspeed switches in the rotor head. They are spaced evenly along the circumference of the rotor. 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 %. 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.

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.

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Oscillation monitoring

Oscillation monitoring detects excessive oscillation or excursion of the wind energy converter tower top. 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 idle position.
In addition, excessive vibrations and shocks such as those that may occur e.g. in the event of a fault in the rectifier are detected by an integrated oscillation monitoring function. If the oscillations or excursion exceed the permissible limit, the wind energy converter stops. It restarts automatically after a short delay. If non-permissible vibrations are detected or if non-permissible tower oscillations occur repeatedly, the wind energy converter stops and does not make any further restart attempts.

Temperature monitoring

Some components in ENERCON wind energy converters are cooled. For this purpose, 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

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 sensors detect 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 matched 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.

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6 Control system

The E-138 EP3 E2 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-138 EP3 E2 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.

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6.2 Pitch control

Functional principle

The pitch 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 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 and to be converted by the generator, within or just slightly above the nominal limits.

Design

Each rotor blade is fitted with a pitch unit. The pitch unit consists of a pitch control box, a blade relay box, tow pitch motors and a capacitor unit. The pitch control box and the blade relay box control the pitch motors. 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 angles) of the E-138 EP3 E2:

A: 0° 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.

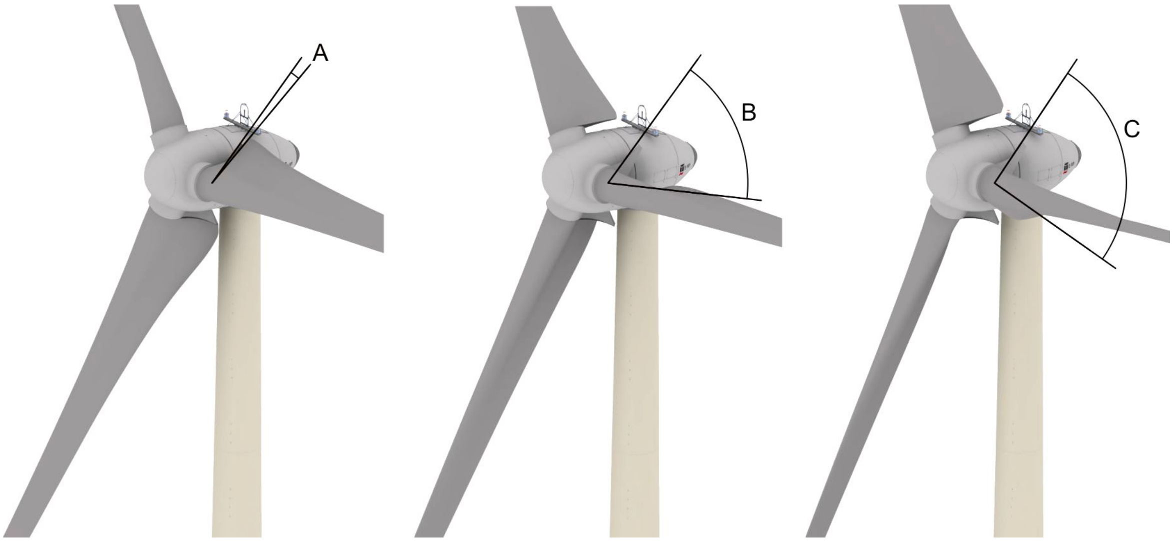

Fig. 4: Special blade positions

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 capacitor units 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.

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 average 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. 60 seconds after completing start lead-up the wind energy converter goes into idle mode. The rotor blades are slowly pitched in while a check is performed on the emergency pitching capacitor units.

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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 $P_{set} > 0$, the line contactors on the low-voltage side are closed and the E-138 EP3 E2 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 ENERCON wind energy converter type.

6.4 Operating modes

After completion of the E-138 EP3 E2 start-up procedure the wind energy converter switches to automatic mode (normal operation). While in operation, 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 3 operating modes, depending on the wind speed. In certain circumstances the wind energy converter stops if provided for by the configuration of the wind energy converter (e.g. 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 power feed.

The E-138 EP3 E2 switches between the following operating modes:

- Full load operation
- Partial load operation
- Idle mode

6.4.1 Full load operation

Wind speed
v ≥ 15 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. 11.1 rpm), thereby limiting the power to its nominal value of 4200 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. 22 m/s (12-second mean) and keep increasing, the rotational speed will be reduced linearly from 11.1 rpm to idle speed at about 28 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 28 m/s (10-minute mean) 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 28 m/s, the WEC restarts its power feed.

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

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6.4.2 Partial load operation

Wind speed
2.5 m/s ≤ v < 15 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. The 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.

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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.

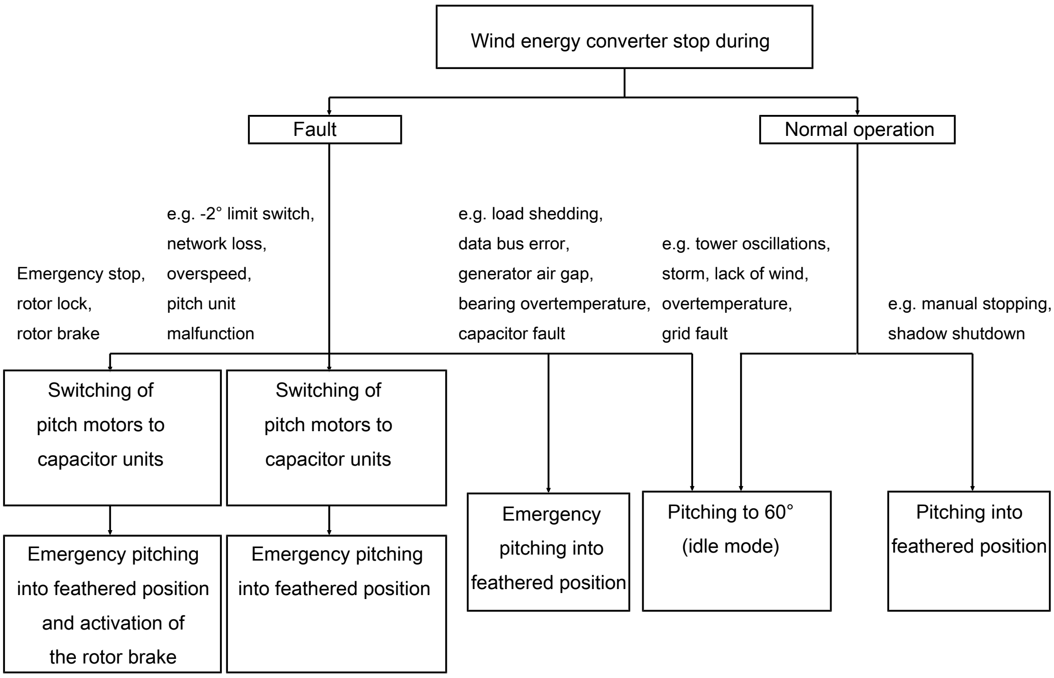

Fig. 5: Overview of shutdown procedures

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.

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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 the transmission substation 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.

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8 Maintenance

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

ENERCON 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 are checked on load-bearing joints (main components). All other components are visually inspected to check for any irregularities or damage. Lubrication systems are refilled.
Maintenance intervals may deviate, depending on regional regulations and standards.

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9 E-138 EP3 E2 Technical Specifications

General	
Manufacturer	ENERCON GmbH Dreekamp 5 26605 Aurich Germany
Type designation	E-138 EP3 E2
Nominal power	4200 kW
Hub heights	81 m, 111 m, 131 m, 160 m
Rotor diameter	138.6 m
IEC wind class (ed. 3)	IIIA
Extreme wind speed at hub height (10-minute mean)	37.5 m/s
	Corresponds to a load equivalent of approx. 52.5 m/s (3-second gust)
Annual average wind speed at hub height	7.5 m/s

Rotor with pitch control	
Type	Upwind rotor with active pitch control
Rotational direction	Clockwise
Number of rotor blades	3
Rotor blade length	66.89 m
Swept area	15085 m^2
Rotor blade material	GRP/epoxy resin/balsa wood/foam
Lower power feed rotational speed up to nominal speed	4.4 to 10.8 rpm (81 m and 131 m (hybrid tower) hub height); 5 to 10.8 rpm (111 m, 131 m (steel tower and modular steel tower) and 160 m hub height)
Speed setpoint	11.1 rpm
Tip speed at speed setpoint	Up to 80.5 m/s
Power reduction wind speed	22 to 28 m/s (with ENERCON storm control)
Conical angle	2.5°
Rotor axis angle	7°
Pitch control	One independent electrical pitch system per rotor blade with dedicated emergency power supply

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Drive train with generator	
Wind energy converter concept	Gearless, variable speed, full-scale converter
Hub	Rigid
Bearing	2 tapered roller bearings
Generator	Direct-drive ENERCON annular generator
Grid feed	ENERCON inverters with high clock speed and sinus-oidal current
IP Code/insulation class	At least IP 23/F

Brake system	
Aerodynamic brake	Three independent pitch systems with emergency power supply
Rotor brake	Hydraulic
Rotor lock	Latching every 10°

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

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

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Tower types			
Hub height	Total height	Type	Wind class
81 m	150 m	Tubular steel tower	IEC IIIA[1] DIBt WZ2 GK II[2]
111 m	180 m	Tubular steel tower	IEC IIIA[1] DIBt WZ2 GK II[2]
131 m	200 m	Tubular steel tower	IEC IIIA[1] DIBt WZ2 GK II[2]
131 m	200 m	Modular steel tower	IEC IIIA[1] DIBt WZ2 GK II[2]
131 m	200 m	Hybrid tower	IEC IIIA[1] DIBt WZ2 GK II[2]
160 m	230 m	Hybrid tower	IEC IIIA[1] DIBt WZ2 GK II[2]

[1]Edition 3
[2]Edition 2012

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