Technical description

ENERCON E-160 EP5 E3 R1 / 5560 kW wind energy converter

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ENERCON
ENERGY FOR THE WORLD

Publisher

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List of abbreviations

SCADA	Supervisory Control and Data Acquisition

1 Overview of the ENERCON wind energy converter

The ENERCON 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 5560 kW. It has a rotor diameter of 160 m and is delivered with a hub height of 99.00 m, 119.83 m, 160.00 m or 166.60 m.

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2 Components of the ENERCON wind energy converter

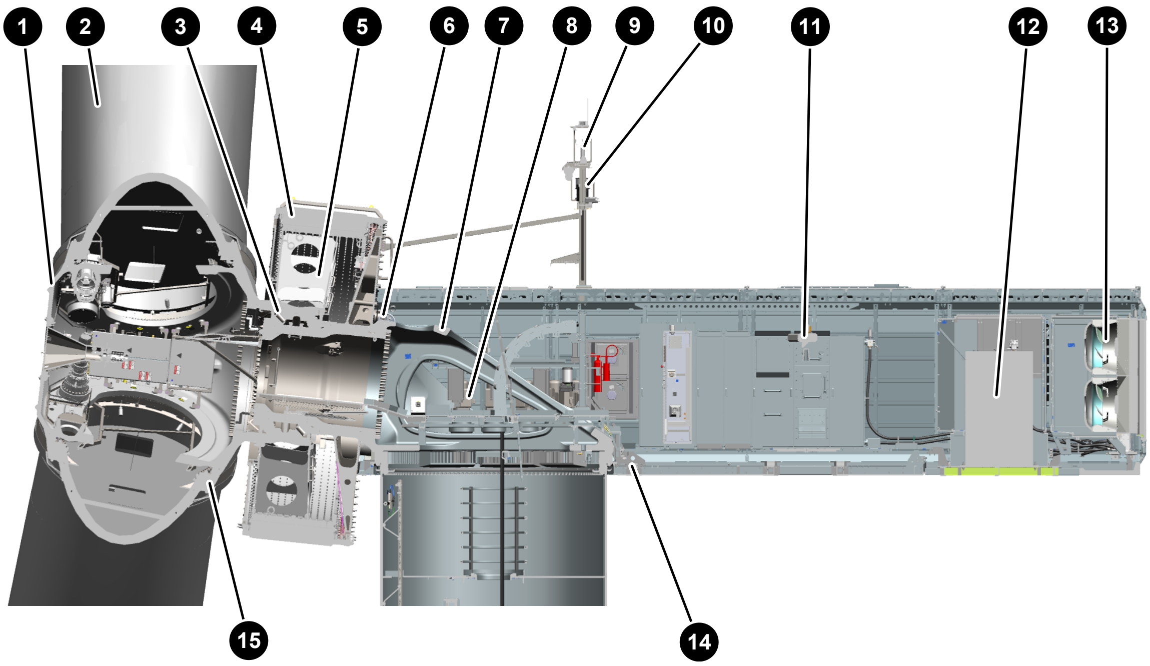

Fig. 1: Nacelle section

1	Hub	2	Rotor blade
3	Rotor bearing	4	Generator stator
5	Generator rotor	6	Rotor lock
7	Main carrier	8	Yaw drive
9	Wind measuring unit with lightning rods	10	Beacon system components
11	Nacelle crane	12	Transformer
13	Liquid cooling system	14	Yaw bearing
15	Blade flange bearing		

2.1 Nacelle

The supporting structure of the machine house is made of cast iron (EN-GJS-400-18-LT). The nacelle casing is made of steel. The nacelle is connected to the tower head by a yaw bearing.

The transformer and the converter are housed in the nacelle.

The entire nacelle can be rotated by the yaw drives so that the rotor is always optimally aligned with the wind.

2.2 Generator

The direct-driven generator is a multi-pole generator. Excitation occurs by way of permanent magnets on the generator rotor. The generator is air cooled, with a passive external air cooling system via the air flow and active internal air gap cooling. The generator is designed for a nominal power of 5560 kW. For maintenance purposes, the generator has a rotor lock and a rotor holding brake.

2.3 Tower

The tower of the wind energy converter is a tubular steel tower, hybrid steel tower or hybrid tower.

The tubular steel tower is a sheet steel tube consisting of a small number of large steel sections. Depending on the tower version, the lowermost steel section may be in one piece or subdivided into several longitudinal elements. The longitudinal elements are first joined at the installation site to form a single steel section. Flanges with drill holes for assembly are welded onto the ends of the steel sections. The steel sections are stacked on top of one another and bolted together at the installation site. They are linked to the foundation by means of a foundation basket.

The hybrid steel tower consists of bevelled steel section plates plus tubular steel sections. The tower sections are bolted together at the installation site. They are linked to the foundation by means of a foundation basket.

The lower part of the hybrid tower is made of concrete segments and the upper part of steel sections. The concrete segments are assembled from precast elements that are stacked on top of each other at the installation site. The upper steel sections are placed onto the concrete segments and bolted in place. The concrete segments are prestressed vertically by means of prestressing steel tendons. The prestressing tendons run either vertically through ducts in the concrete segments or externally along the interior tower wall. They are anchored to the tower foundation.

All towers receive the final paint top coat or weather and corrosion protection at the factory. This means that ideally no further work is required on the tower surface after installation.

2.4 Rotor blades

The rotor blades have a major influence on the wind energy converter's yield and its sound emission. The shape and profile of the rotor blades were designed with the following criteria in mind:

- High power coefficient
- Long service life
- Low sound emissions
- Low mechanical loads
- Efficient use of material

The rotor blades of the wind energy converter have been specially designed to operate with pitch unit and at variable speeds.

The rotor blades are elastic and bend slightly backwards when exposed to wind loads. The rotor blades are hollow and reinforced from the inside by webs. All components of the rotor blade structure consist of glass-fibre reinforced polyester or multi-layer constructions with foam and balsa wood as core materials. The rotor blade is connected to the hub by a bolt connection.

The rotor blade surface is coated. The coating protects the surface from dirt and environmental influences. Various aerodynamic components are attached to the surface for increasing the power or for reducing the sound emissions.

To reduce sound emissions during operation, the rotor blade is equipped with an optional segmented trailing edge serration. This trailing edge serration reduces the turbulence at the trailing edge and thus lowers the sound emissions from the wind energy converter. Vortex generators are used on the suction side of the rotor blades for passive flow control. To increase the aerodynamic lift of the rotor blades, T-spoilers are installed on the pressure side in the vicinity of the trailing edge.

2.5 Full-scale converter

The variable-frequency generator power is rectified, converted to a constant frequency of 50 Hz or 60 Hz (AC-DC-AC conversion) and fed into the grid. A full-scale converter is used to optimise the quality of the electrical power.

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3 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. These include components that enable the wind energy converter to be stopped safely and a complex sensor 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.

3.1 Safety equipment

Emergency stop buttons in the tower base and machine house

In an emergency, the wind energy converter (or rather, the rotor) can be stopped quickly by pressing an emergency stop button.

In the wind energy converter, there are emergency stop buttons at the following points:

- On the wind energy converter control console in the tower base
- On the nacelle control cabinet in the machine house

Emergency stop buttons latch when pressed. Provided the cause of the emergency stop has been eliminated and the emergency stop button has been reset, the wind energy converter can be restarted after an emergency stop.

Emergency stop buttons in the rotor head

Emergency stop buttons are located in the following positions in the rotor head:

- On all three pitch cabinets via a plug-in pendant controller

Pressing the emergency stop button on the pendant controller causes the pitch drive to stop immediately.

Main switches in the machine house

Main switches are located at the following points in the machine house:

- On the low-voltage distribution system

The main switch on the low-voltage distribution system can be used to interrupt the power supply to the rotor, the yaw drives and the cooling.

3.2 Sensor system

A large number of sensors continuously monitor the current status of the wind energy converter as well as the relevant ambient parameters. The sensor system provides the relevant information via the ENERCON SCADA remote monitoring system. The wind energy converter control system analyses the signals and regulates the wind energy converter to optimally exploit the available wind energy at any given time and to ensure operating safety at the same time.

Redundant sensors

To be able to check plausibility by comparing the reported values, redundant sensors are installed for some operating states. This applies, for example, to the measurement of the generator temperature, the wind speed or the current rotor blade angle. Defective sensors are reliably detected and can be repaired or replaced through activation of a reserve sensor. The wind energy converter is thus usually able to continue safe operation without the need for immediate service work.

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Checking the sensors

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

Speed monitoring

The wind energy converter control system 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. The pitch unit, however, may not be able to react quickly enough to sudden events such as a strong gust or a sudden reduction in generator load. If the nominal speed is exceeded by a defined value, the wind energy converter control system stops the wind energy converter. The wind energy converter can be restarted via the remote monitoring system.

If a fault occurs, the wind energy converter is stopped by an emergency pitching motion.

Temperature monitoring system

Some components of the wind energy converter are cooled. Temperature sensors also continuously measure components that need to be protected from high temperatures.

In the event of high temperatures, the wind energy converter's power is reduced or the wind energy converter is stopped, if necessary.

Some measuring points are equipped with additional overtemperature switches. The overtemperature switches similarly cause the wind energy converter to be stopped once a certain temperature has been exceeded. When it has cooled down, the wind energy converter can be put back into operation once the reason for the overtemperature has been investigated.

Cable twisting monitoring

The tower cables have so much slack in the upper tower area that the nacelle can be turned left and right by 1.5 turns without damaging and/or overheating the tower cables. Depending on the degree of twisting and level of the wind speed, the wind energy converter open-loop control system decides when the tower cables require untwisting.

The cable twisting monitoring is equipped with sensors that prevent further twisting if the permitted adjusting range is exceeded.

Air gap monitoring

The air gap between the rotor and stator of the generator must not be less than a specified width. The air gap is monitored by dedicated sensors arranged around the rotor circumference. If the air gap falls below a specified value, the wind energy converter is stopped. The wind energy converter can be restarted as soon as the cause has been eliminated.

3.3 Earthing and lightning protection

The rotor blades’ lightning protection system consists of metal receptors that transmit the lightning from the outer skin of the rotor blade to the inner discharge device. In the flange area of the rotor blade, the lightning current is further transmitted to the bolts that are connected to the lightning protection system of the wind energy converter.

The main earthing line leads from the lightning protection devices in the rotor blades through the non-rotating generator carrier to the nacelle and tower and then into the foundation earth electrodes. The foundation reinforcement and earthing electrodes to-

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gether form the central earthing point of the wind energy converter to which all earth lugs are connected. The wind measuring station and the nacelle also have lightning protection devices that are connected to the supporting structure of the machine house.

4 Control system

The wind energy converter control system is based on a programmable logic controller that uses sensors to query all wind energy converter 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 wind energy converter control console in the tower base and on the nacelle control cabinet show the current status of the wind energy converter and any faults that may have occurred.

4.1 Yaw system

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

When the difference between the wind direction and the rotor axis direction exceeds the maximum permissible value, the yaw drives are switched on and align the nacelle with the wind direction. The control system of the yaw motors ensures smooth starting and stopping. The wind energy converter control system monitors the yawing. If the wind energy converter control system detects any irregularities, yaw control is deactivated and the wind energy converter is stopped.

4.2 Pitch unit

The pitch unit changes the position of the rotor blades and thus the angle of attack at which the air strikes the rotor blade profile. Changes to the rotor blade angle change the lift at the rotor blade and, thus, also the force with which the blade turns the rotor.

In automatic mode (normal operation), the rotor blade angle is adjusted in such a way as to ensure optimum exploitation of the energy contained in the wind while avoiding overloading of the wind energy converter. Boundary conditions such as noise optimisation are also fulfilled in the process. In addition, the pitch unit serves to brake the rotor aerodynamically.

If the wind energy converter achieves its nominal power and the wind speed continues to increase, the pitch unit turns the rotor blades just far enough out of the wind to keep the rotor speed and the amount of energy generated by the generator from the wind within or just slightly above the nominal values.

4.3 Torque control

The wind energy converter is speed-controlled. The difference between the aerodynamic and electromechanical torque determines the rotor speed under partial load. The counter-torque is optimised in relation to the wind speed and incoming torque and follows an optimum tip speed ratio. Under full-load conditions, the output power is maintained by the torque control. The counter-torque produced by the generator is controlled by the converter.

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5 Remote monitoring

As standard, the wind energy converter is connected to the Technical Service Dispatch via a remote monitoring system (ENERCON SCADA System or ENERCON SCADA Edge System). The wind energy converter is connected via the server of the remote monitoring system that is typically located in the substation or the high-voltage substation of a wind farm. A server is installed in every wind farm.

Technical Service Dispatch can retrieve the operating data of the wind energy converter at any time and immediately react to any irregularities or faults. All status messages are also sent via the remote monitoring system to a Technical Service Dispatch, where they are permanently stored. Practical experience gained from long-term operation can thus be incorporated into the further development of ENERCON wind energy converters. At the operator/owner’s request, the wind energy converter can be monitored by a third party.

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6 Maintenance

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

The wind energy converter is regularly maintained at least once a year, depending on requirements.

During maintenance, all safety-relevant components and functions are checked, e.g. pitch control, yaw control, safety systems, lightning protection system, anchorage points and safety ladder. The bolt connections on load-bearing joints (main components) are checked. All other components are subjected to a visual inspection to check for any irregularities or damage. Any lubricants that have been used up are refilled.

The maintenance intervals and scope may vary, depending on regional directives and standards.