Annexe B

Description technique d'une éolienne Enercon E-82 et des exigences quant à son implantation sur le territoire

Technical Description

E-82

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1 BRIEF DESCRIPTION

The E-82 is a wind energy converter with a three bladed rotor, active pitch controls, variable operating speed and a rated power of 2000 kW. Its 82 m rotor diameter and 78 – 138 m hub heights enable the turbine to make efficient use of the prevailing wind conditions at the respective sites to produce electrical energy.

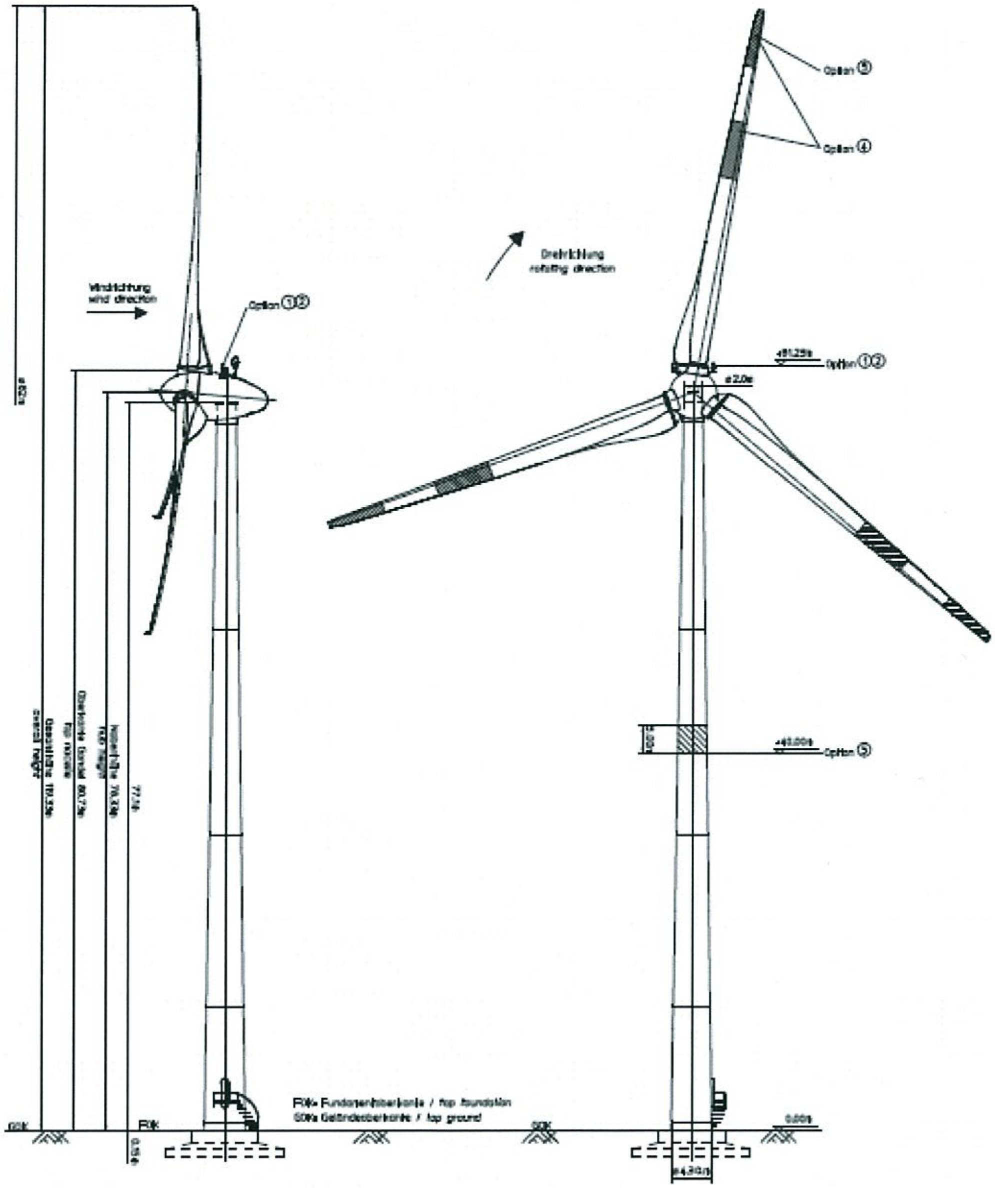


Figure 1: Illustration E-82

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

Output controlled by variable speed allows the E-82 to attain maximum operation efficiency without increasing operating loads in the full and partial load ranges and at the same time prevents undesirable output peaks thus guaranteeing excellent yield and a high quality of power fed into the grid.

1.1 The ENERCON Concept

ENERCON wind energy converters are characterised by the following features:

The inner ring of the ENERCON annular generator and the rotor of the E-82 form one unit. These two components are flanged directly to the hub so that they both rotate at the same low speed. Since there are no gears or other fast-rotating parts, energy loss between generator and rotor, noise emissions, the use of gear oil and mechanical wear are considerably reduced.

The output produced by the E-82 generator is fed via the ENERCON grid connection system into the power supply company's grid. The ENERCON grid connection system comprises a rectifier/inverter unit (converter). This system ensures that high-quality electricity is fed into the power supply company's network.

Using the converter, this grid connection concept permits the E-82's rotor to operate at variable speeds. The rotor rotates slowly at low wind speeds and quickly at high wind speeds. This optimises wind flow on the rotor blades. Moreover, variable speed also reduces loads caused by gusts.

Each of the three rotor blades is equipped with an electrical pitch system. The pitch system limits the rotor speed and the use of the wind's power thus allowing the output of the E-82 to be reduced to rated power, even within a short period. By pitching the rotor blades into the feathered position, the rotor stops without mechanical brakes exerting load on the drive train.

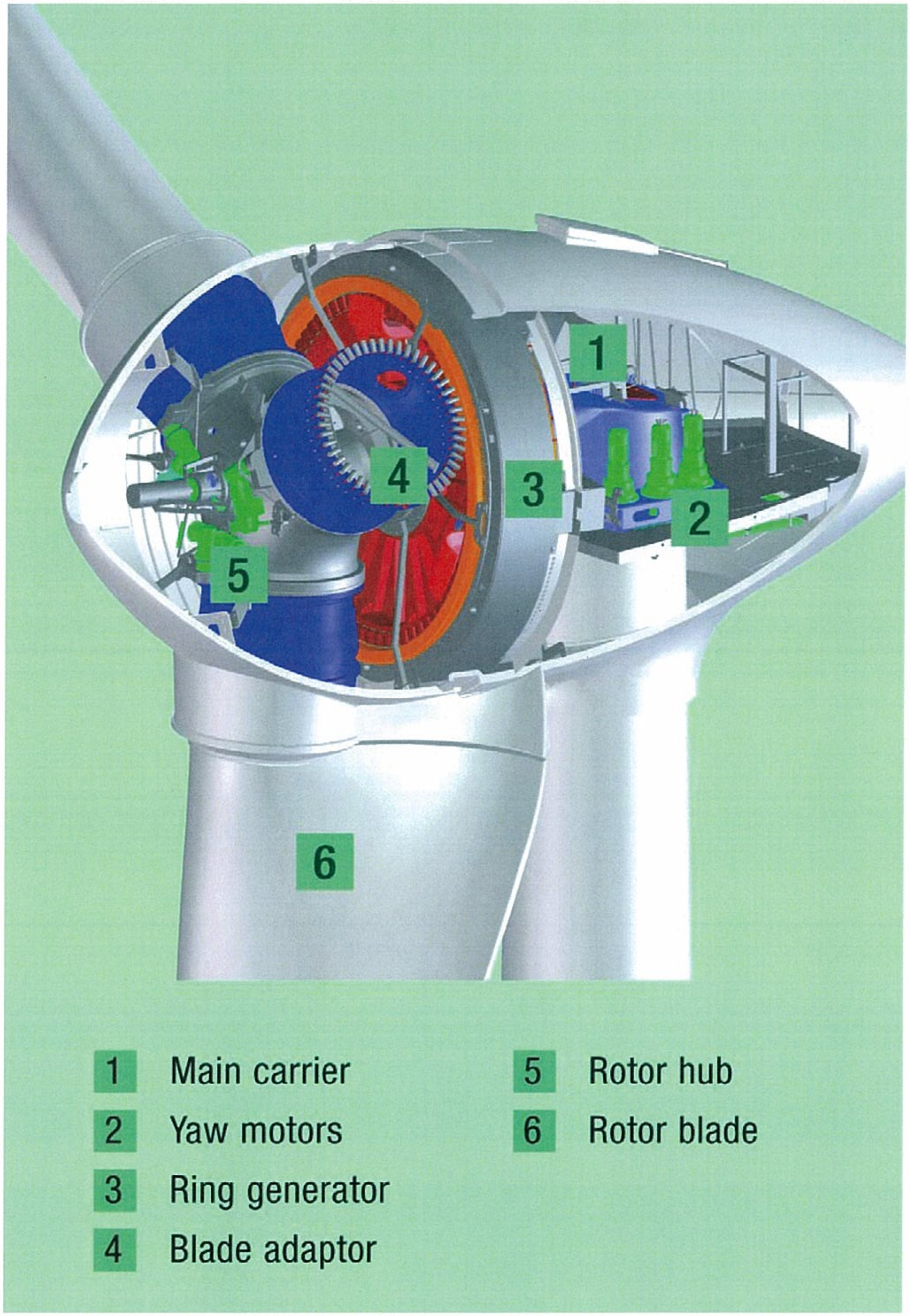


Figure 2: Illustration: Nacelle

1.2 Rotor

The E-82 rotor blades made of glass reinforced plastic (GRP) (epoxy resin) have a major influence on turbine output and its noise emission. Their shape and profile were developed according to the following criteria:

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

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

The rotor blades of the E-82 were specially designed to operate with variable pitch control and variable speed. Due to this special profile, the blades are not sensitive to turbulence and dirt on the leading edge. On the outside, a top coat protects the rotor blades against environmental factors. The polyurethane-based material employed is highly resistant to abrasion, durable, and highly resistant to chemical factors and solar radiation.

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

1.3 Generator

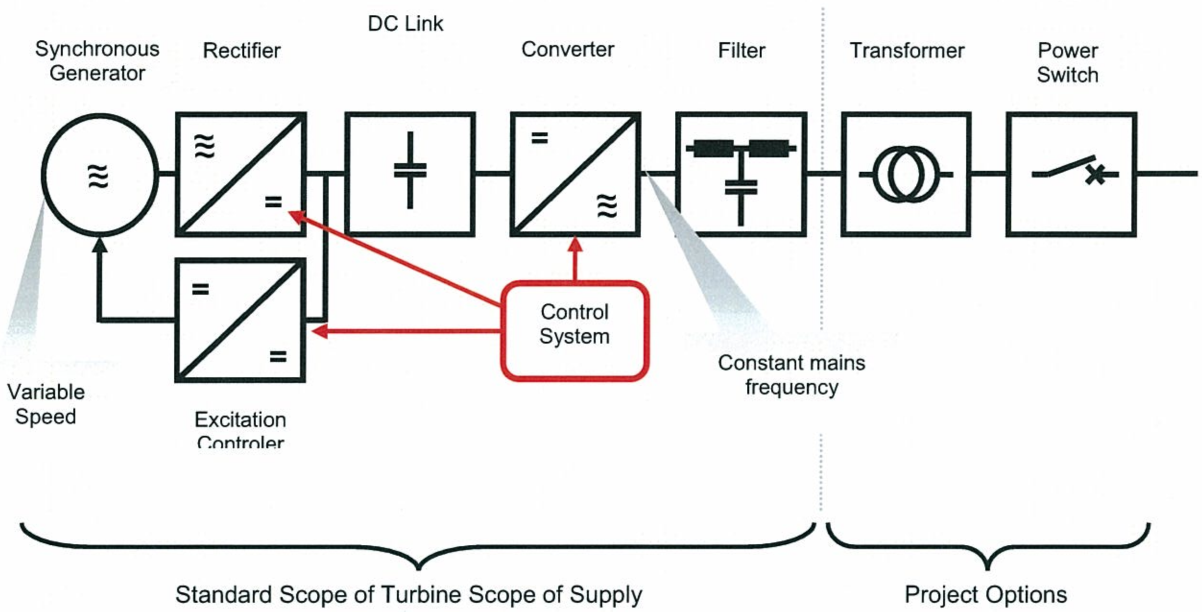
The air flow on the rotor blades drives the rotor which in turn is the direct drive for the E-82 annular generator. The multipole ENERCON generator is based on the direct drive synchronous machine principle.

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

1.4 Grid feed unit

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

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



Flexible coupling between the annular generator and the grid guarantees ideal output transmission conditions while reducing undesirable reactions between the rotor and the grid in both directions. Sudden changes in wind speeds are controlled in order to maintain stable grid feed. Concurrently possible grid failures have very little effect on the mechanics. The power fed from the E-82 can be exactly regulated between 0 kW to 2000 kW.

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

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

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

The range of operation parallel to the grid is limited by the minimum and maximum grid voltage. Both these values (undervoltage and overvoltage) can be set as the limit value for the E-82.

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

The E-82 is preset to a power factor of $\cos\varphi=1$. It does not require reactive power nor does it deliver reactive power to the grid within the entire power range from 0 to 2000 kW. Only active power is fed into the grid. Any equalization payments for reactive power demanded by some power supply network operators are not necessary.

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

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

If these voltage or frequency limits cannot be maintained, the E-82 control unit switches off all grid contactors in the inverter. This allows the E-82 to immediately disconnect from the grid on all phases.

1.5 Yaw control

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

1.6 Safety system

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

1.6.1 Brake System

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

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

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

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

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

1.6.2 Lightning protection system

The ENERCON lightning conductor system in the E-82 efficiently diverts almost all possible lightning strikes with no damage caused to the turbine.

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

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

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

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

1.6.3 Sensor System

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

1.7 Control system

The E-82 control system is based on a microprocessor system developed by ENERCON. Sensors query all turbine components and data such as wind direction and wind speed and adjust the operating mode of the E-82 accordingly.

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

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

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

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

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

2 Control System

2.1 Response to safety relevant sensor messages

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

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

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

2.2 Starting the turbine

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

When the turbine is switched on (main switch on control cabinet to “ON” and start/stop switch is set to start), "Turbine operational" appears on the LCD shortly afterwards (status 0:2), provided the E-82 control system has not detected any faults. Ninety seconds after start-up, the rotor blades are driven out of the feathered position (approx. 90°) and "idle mode" begins. The rotor starts turning slowly. The turbine begins the actual operations startup procedure when the average wind speed is greater than the required startup wind speed for three consecutive minutes.

2.3 Normal operation

Once the E-82 startup procedure is completed, the wind energy converter switches to normal operation. During operation, the wind conditions are continuously determined: rotor speed, generator excitation and output are optimised, the nacelle position is adjusted to the wind direction and all sensor messages are recorded. When outside temperatures are high and if the wind speeds are also elevated, the generator fan is switched on.

2.3.1 Operation at partial load

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

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

2.3.2 Automatic control mode

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

2.4 Idle mode

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

2.5 Stopping the turbine

The E-82 can be stopped by manually activating the start/stop switch and the EMERGENCY STOP button. The control system stops the turbine in the event of faults or unsuitable wind conditions (see Figure 3).

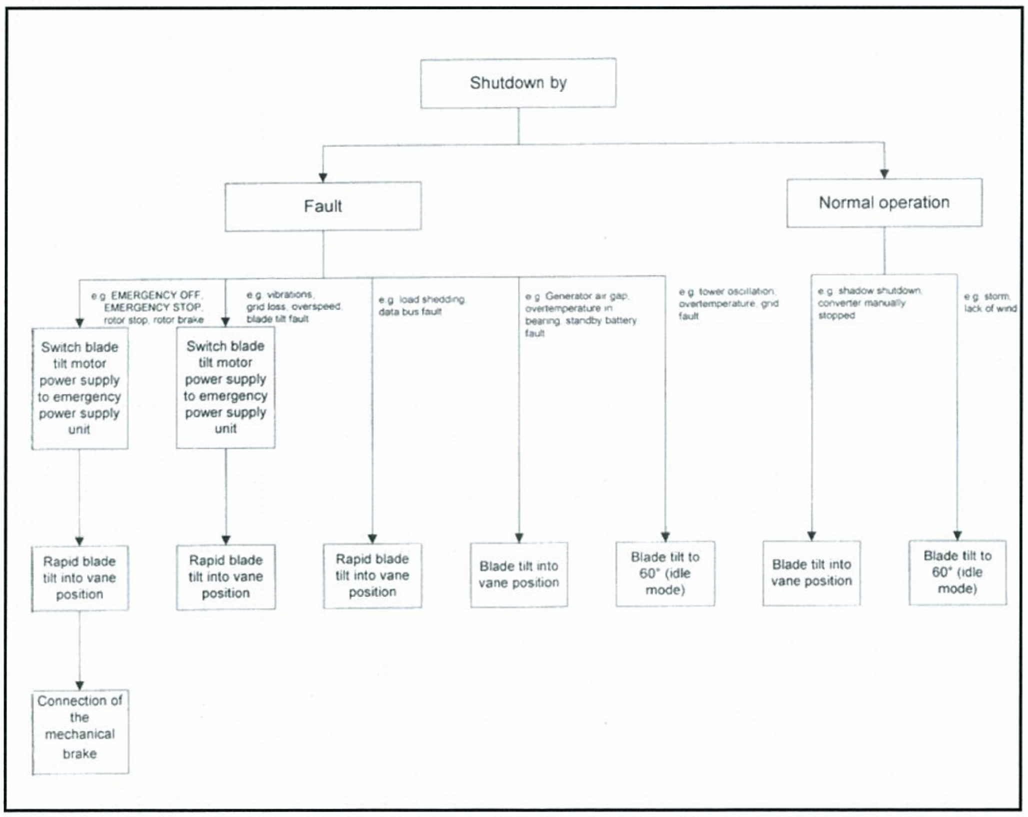


Figure 3: Shutdown procedures for the E-82

2.5.1 Automatic shutdown

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

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

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

2.5.2 Manual stop

The E-82 can be stopped via the start/stop switch on the control cabinet. The control system then pitches the rotor blades out of the wind and the turbine slows to a halt. The brake is not activated and yaw control remains in operation so that the E-82 can continue to optimally adjust to the wind.

2.5.3 Manual shutdown in emergency situations

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

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

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

2.6 Lack of wind

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

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

2.7 Storm

From the standstill position or idle mode the turbine does not start up at wind speeds over 31 m/s. If an average wind speed of 31 m/s or a top value of 34 m/s is exceeded, the E-82 automatic control mode stops. The turbine also stops if the maximum permissible blade angle is exceeded. A frozen anemometer therefore does not represent a safety risk. In all cases the turbine switches to idle mode.

The E-82 components, such as rotor blades, nacelle, tower and foundations are designed to withstand considerably higher wind speeds.

The turbine starts automatically if the wind speed drops below cut-out wind speed (31 m/s) for 10 consecutive minutes.

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

2.8 Yaw control

The E-82 has a combination wind sensor, which is installed on the top of the nacelle. The combined wind sensor comprises a wind vane, which constantly determines the wind direction, and an anemometer, which measures wind speed.

E-82 yaw control already starts to operate below the cut-in wind speed of 2 m/s. Even if the system shuts down (e.g. due to excessive wind speed), it adjusts according to the wind conditions. The angle and the period of measurement depend on the wind speed and turbine performance.

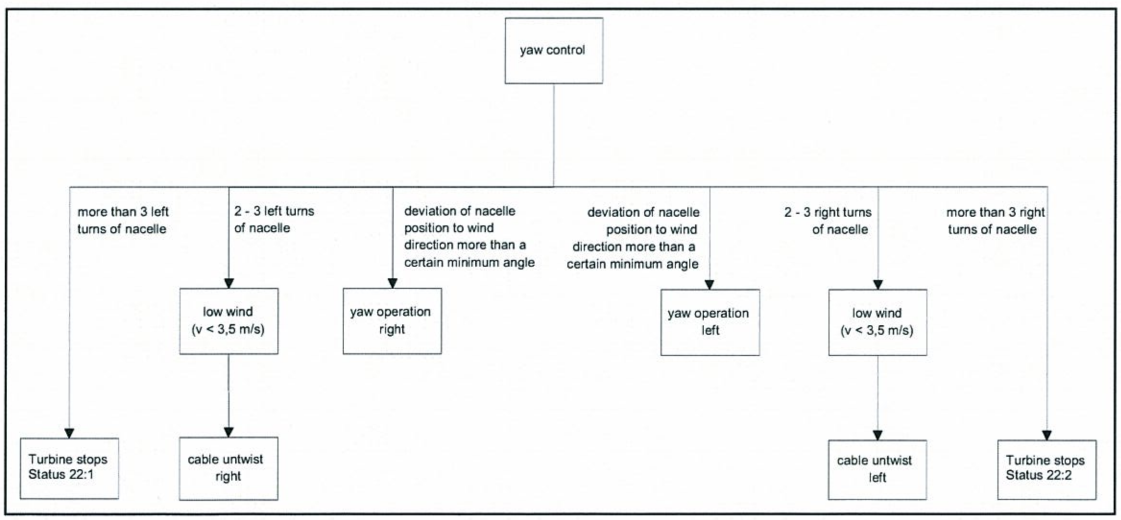


Figure 4: Illustration of yaw control

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

2.8.1 Untwisting power and control cables

The E-82 power and control cables located in the tower pass from the nacelle over a deflection pad and are then fastened to the tower wall. The cables have enough freedom of movement to permit the nacelle to rotate several times in the same direction about its axis. The cables gradually twist. The E-82 control system ensures that the twisted cables are automatically unwound.

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

The cable twist sensors can be found on the so-called cable twist switch, which in the E-82 is fitted near the access hatch. The sensor is connected via a gearwheel and gearbox to the yaw slewing ring. Changes in the nacelle direction are transmitted to the operation control system.

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

3 TECHNICAL SPECIFICATIONS:

Turbine type:	**ENERCON E-82**
Rated power:	2000 kW
Rotor diameter:	82 m
Hub height:	78 – 138 m (tower and foundation options)
Turbine concept:	Gearless, variable speed, single blade pitch control
Rotor	
Type:	Upwind rotor with active pitch control
Rotational Direction:	Clockwise
No. of blades:	3
Swept area:	5281 m²
Blade material:	Fibreglass (epoxy resin); integrated lightning protection
Speed:	Variable, 6 – 19,5 rpm
Tip speed:	25 - 80 m/s
Pitch control:	ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply
Drive train with generator	
Hub:	Rigid
Main bearing:	Dual row tapered / cylindrical roller bearings
Generator:	ENERCON direct-drive synchronous annular generator
Grid power feed:	ENERCON inverter

Braking system	- 3 independent pitch systems with emergency power supply - Rotor brake - Rotor lock
Yaw control:	Active via adjustment gear, load-dependent damping
Cut-in wind speed:	2.5 m/s
Rated wind speed:	12 m/s
Cut-out wind speed:	28 - 34 m/s
Remote monitoring:	ENERCON SCADA

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Subject to change without notice, status 04/08

E-33
E-44
E-48
E-53
E-70
E-82

ENERCON WIND TURBINES

PRODUCT OVERVIEW

E33

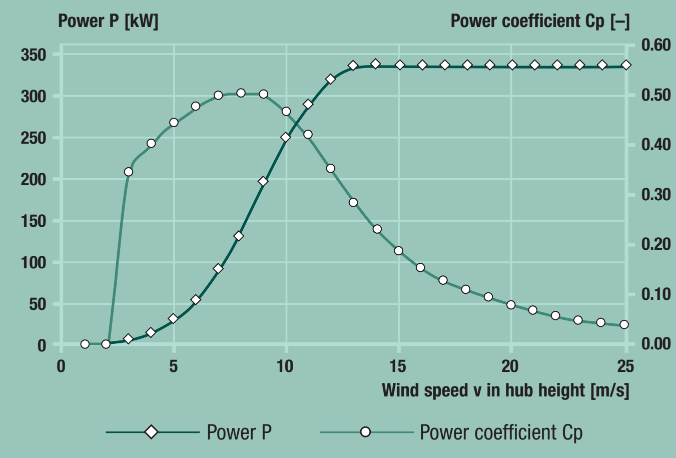
ENERCON's E-33 wind turbine makes it economically feasible to realise wind energy projects even at sites difficult to access. Their modular design allows for convenient container transport by ship and truck as well as efficient installation using one regular-sized lifting crane.

TECHNICAL DATA

Rated power:	330 kW
Rotor diameter:	33.4 m
Hub height:	36 m – 50 m
Wind class (IEC):	IEC/NVN I and IEC/NVN II (depending on hub height)
Turbine concept:	Gearless, variable speed, variable pitch control
Rotor	
Type:	Upwind rotor with active pitch control
Direction of rotation:	Clockwise
Number of blades:	3
Swept area:	876 m²
Blade material:	Fibreglass (epoxy resin); integrated lightning protection
Rotational speed:	Variable, 18 – 45 rpm
Pitch control:	ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply
Drive train with generator	
Hub:	Rigid
Main bearings:	Single-row cylindrical roller bearings
Generator:	ENERCON direct-drive synchronous annular generator
Grid feeding:	ENERCON converter
Braking systems:	– 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock
Yaw control:	Active via adjustment gears, load-dependent damping
Cut-out wind speed:	28 – 34 m/s (with ENERCON storm control)
Remote monitoring:	ENERCON SCADA

Details – ENERCON Storm Control – (see last page)

CALCULATED POWER CURVE



Wind [m/s]	Power P [kW]	Power coefficient Cp [-]
1	0.0	0.00
2	0.0	0.00
3	5.0	0.35
4	13.7	0.40
5	30.0	0.45
6	55.0	0.47
7	92.0	0.50
8	138.0	0.50
9	196.0	0.50
10	250.0	0.47
11	292.8	0.41
12	320.0	0.35
13	335.0	0.28
14	335.0	0.23
15	335.0	0.18
16	335.0	0.15
17	335.0	0.13
18	335.0	0.11
19	335.0	0.09
20	335.0	0.08
21	335.0	0.07
22	335.0	0.06
23	335.0	0.05
24	335.0	0.05
25	335.0	0.04

ρ = 1.225 kg/m³

Details – ENERCON power curve – (see last page)

E44

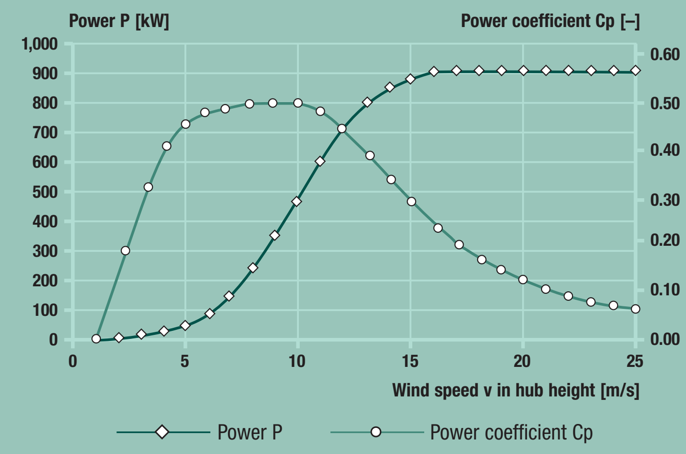
Developed as a strong-wind system for the international market, the E-44 wind turbine sets the benchmark in the medium power range. As all other ENERCON wind turbines, the E-44 is also provided with ENERCON's efficient rotor blade design. With a rated power of 900 kW, maximum use is made of prevailing winds at strong wind sites.

TECHNICAL DATA

Rated power:	900 kW
Rotor diameter:	44 m
Hub height:	45 m / 55 m
Wind class (IEC):	IEC/NVN I A
Turbine concept:	Gearless, variable speed, variable pitch control
Rotor	
Type:	Upwind rotor with active pitch control
Direction of rotation:	Clockwise
Number of blades:	3
Swept area:	1,521 m²
Blade material:	Fibreglass (epoxy resin); integrated lightning protection
Rotational speed:	Variable, 12 – 34 rpm
Pitch control:	ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply
Drive train with generator	
Hub:	Rigid
Main bearings:	Single-row cylindrical roller bearings
Generator:	ENERCON direct-drive synchronous annular generator
Grid feeding:	ENERCON converter
Braking systems:	– 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock
Yaw control:	Active via adjustment gears, load-dependent damping
Cut-out wind speed:	28 – 34 m/s (with ENERCON storm control)
Remote monitoring:	ENERCON SCADA

Details – ENERCON Storm Control – (see last page)

CALCULATED POWER CURVE

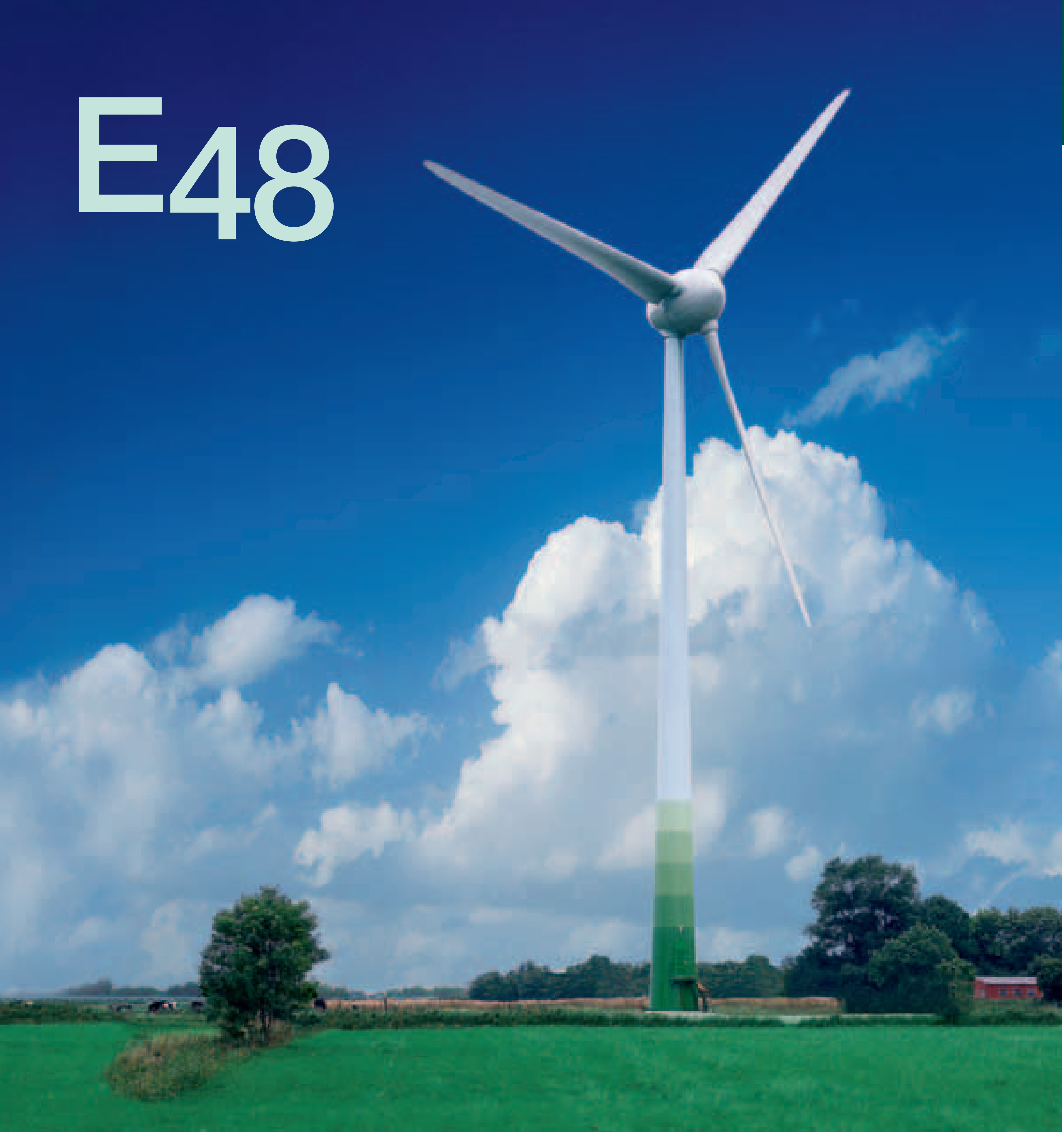


Wind [m/s]	Power P [kW]	Power coefficient Cp [-]
1	0.0	0.00
2	1.4	0.19
3	8.0	0.32
4	24.5	0.41
5	53.0	0.46
6	96.0	0.48
7	156.0	0.49
8	238.0	0.50
9	340.0	0.50
10	466.0	0.50
11	600.0	0.48
12	710.0	0.44
13	790.0	0.39
14	850.0	0.33
15	880.0	0.28
16	905.0	0.24
17	910.0	0.20
18	910.0	0.17
19	910.0	0.14
20	910.0	0.12
21	910.0	0.11
22	910.0	0.09
23	910.0	0.08
24	910.0	0.07
25	910.0	0.06

ρ = 1.225 kg/m³

Details – ENERCON power curve – (see last page)

E48



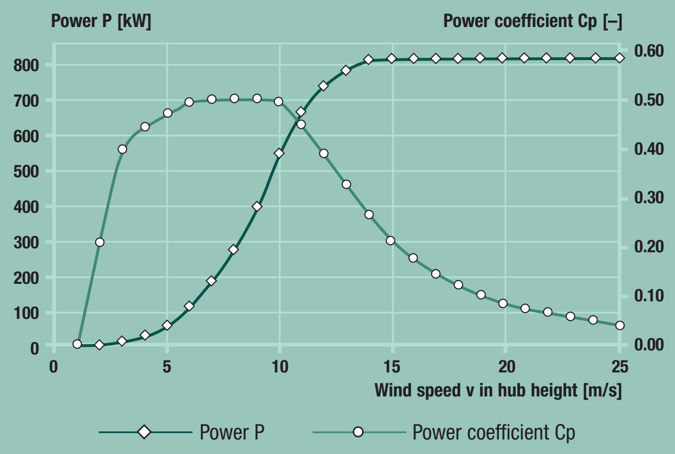
ENERCON's E-48 wind turbine is yet another success story in the company's medium class power range. With a rated power of 800 kW and a sophisticated rotor blade design, the E-48 wind turbine is the most profitable system within its class. Together with a choice of different tower versions up to 76 m, the E-48 offers an economically sound solution to complex sites worldwide.

TECHNICAL DATA

Rated power:	800 kW
Rotor diameter:	48 m
Hub height:	50 m – 76 m
Wind class (IEC):	IEC/NVN II
Turbine concept:	Gearless, variable speed, variable pitch control
Rotor	
Type:	Upwind rotor with active pitch control
Direction of rotation:	Clockwise
Number of blades:	3
Swept area:	1,810 m²
Blade material:	Fibreglass (epoxy resin); integrated lightning protection
Rotational speed:	Variable, 16 – 30 rpm
Pitch control:	ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply
Drive train with generator	
Hub:	Rigid
Main bearings:	Single-row cylindrical roller bearings
Generator:	ENERCON direct-drive synchronous annular generator
Grid feeding:	ENERCON converter
Braking systems:	– 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock
Yaw control:	Active via adjustment gears, load-dependent damping
Cut-out wind speed:	28 – 34 m/s (with ENERCON storm control)
Remote monitoring:	ENERCON SCADA

Details – ENERCON Storm Control – (see last page)

CALCULATED POWER CURVE



Wind [m/s]	Power P [kW]	Power coefficient Cp [-]
1	0.0	0.00
2	2.0	0.23
3	12.0	0.40
4	32.0	0.45
5	66.0	0.48
6	120.0	0.50
7	191.0	0.50
8	284.0	0.50
9	405.0	0.50
10	555.0	0.50
11	671.0	0.45
12	750.0	0.39
13	790.0	0.32
14	810.0	0.27
15	810.0	0.22
16	810.0	0.18
17	810.0	0.15
18	810.0	0.13
19	810.0	0.11
20	810.0	0.09
21	810.0	0.08
22	810.0	0.07
23	810.0	0.06
24	810.0	0.05
25	810.0	0.05

$\rho = 1.225\ kg/m^3$

Details – ENERCON power curve – (see last page)

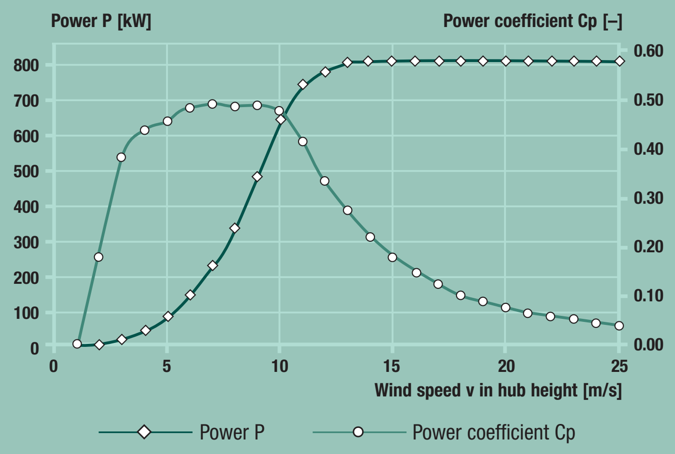
Developed for sites with medium wind speeds, the ENERCON E-53 wind turbine's expanded rotor diameter and newly designed rotor blades guarantee maximum yield even at low wind speeds.

TECHNICAL DATA

Rated power:	800 kW
Rotor diameter:	52.9 m
Hub height:	60 m / 73 m
Wind class (IEC):	IEC/NVN S (v_{av} = 7.5 m/s, v_{ext} = 57 m/s)
Turbine concept:	Gearless, variable speed, variable pitch control
Rotor	
Type:	Upwind rotor with active pitch control
Direction of rotation:	Clockwise
Number of blades:	3
Swept area:	2,198 m^2
Blade material:	Fibreglass (epoxy resin); integrated lightning protection
Rotational speed:	Variable, 12 – 29 rpm
Pitch control:	ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply
Drive train with generator	
Hub:	Rigid
Main bearings:	Single-row cylindrical roller bearings
Generator:	ENERCON direct-drive synchronous annular generator
Grid feeding:	ENERCON converter
Braking systems:	– 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock
Yaw control:	Active via adjustment gears, load-dependent damping
Cut-out wind speed:	28 – 34 m/s (with ENERCON storm control)
Remote monitoring:	ENERCON SCADA

Details – ENERCON Storm Control – (see last page)

CALCULATED POWER CURVE



Wind [m/s]	Power P [kW]	Power coefficient Cp [-]
1	0.0	0.00
2	2.0	0.19
3	14.0	0.39
4	38.0	0.44
5	77.0	0.46
6	141.0	0.48
7	228.0	0.49
8	336.0	0.49
9	480.0	0.49
10	645.0	0.48
11	744.0	0.42
12	780.0	0.34
13	810.0	0.27
14	810.0	0.22
15	810.0	0.18
16	810.0	0.15
17	810.0	0.12
18	810.0	0.10
19	810.0	0.09
20	810.0	0.08
21	810.0	0.06
22	810.0	0.06
23	810.0	0.05
24	810.0	0.04
25	810.0	0.04

ρ = 1.225 kg/m³

Details – ENERCON power curve – (see last page)

E70

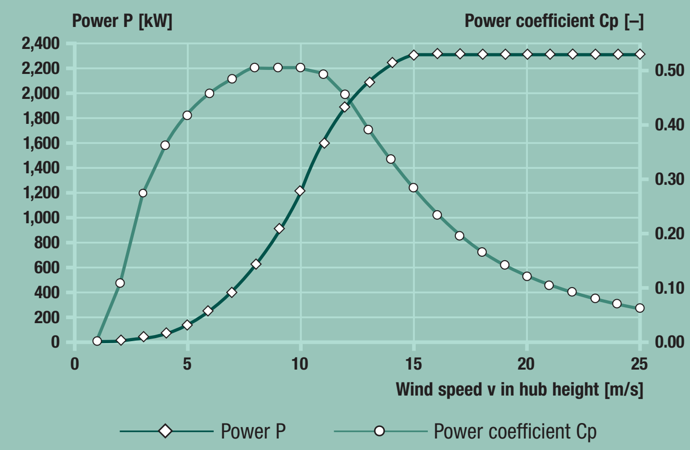
With the E-70 wind turbine ENERCON continues its longstanding reputation for reliability in the 2 MW class. Especially suitable for sites with high wind speeds, the E-70 wind turbine – with 2.3 MW rated power and numerous steel and precast concrete tower versions – is designed to ensure maximum yield in the upper power range.

TECHNICAL DATA

Rated power:	2,300 kW
Rotor diameter:	71 m
Hub height:	64 m – 113 m
Wind class (IEC):	IEC/NVN I and IEC/NVN II (depending on hub height)
Turbine concept:	Gearless, variable speed, variable pitch control
Rotor	
Type:	Upwind rotor with active pitch control
Direction of rotation:	Clockwise
Number of blades:	3
Swept area:	3,959 m²
Blade material:	Fibreglass (epoxy resin); integrated lightning protection
Rotational speed:	Variable, 6 – 21.5 rpm
Pitch control:	ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply
Drive train with generator	
Hub:	Rigid
Main bearings:	Dual-row tapered/single-row cylindrical roller bearings
Generator:	ENERCON direct-drive synchronous annular generator
Grid feeding:	ENERCON converter
Braking systems:	– 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock
Yaw control:	Active via adjustment gears, load-dependent damping
Cut-out wind speed:	28 – 34 m/s (with ENERCON storm control)
Remote monitoring:	ENERCON SCADA

Details – ENERCON Storm Control – (see last page)

CALCULATED POWER CURVE



Wind [m/s]	Power P [kW]	Power coefficient Cp [-]
1	0.0	0.00
2	2.0	0.10
3	18.0	0.27
4	56.0	0.36
5	127.0	0.42
6	240.0	0.46
7	400.0	0.48
8	626.0	0.50
9	892.0	0.50
10	1,223.0	0.50
11	1,590.0	0.49
12	1,900.0	0.45
13	2,080.0	0.39
14	2,230.0	0.34
15	2,300.0	0.28
16	2,310.0	0.23
17	2,310.0	0.19
18	2,310.0	0.16
19	2,310.0	0.14
20	2,310.0	0.12
21	2,310.0	0.10
22	2,310.0	0.09
23	2,310.0	0.08
24	2,310.0	0.07
25	2,310.0	0.06

ρ = 1.225 kg/m³

Details – ENERCON power curve – (see last page)

E82

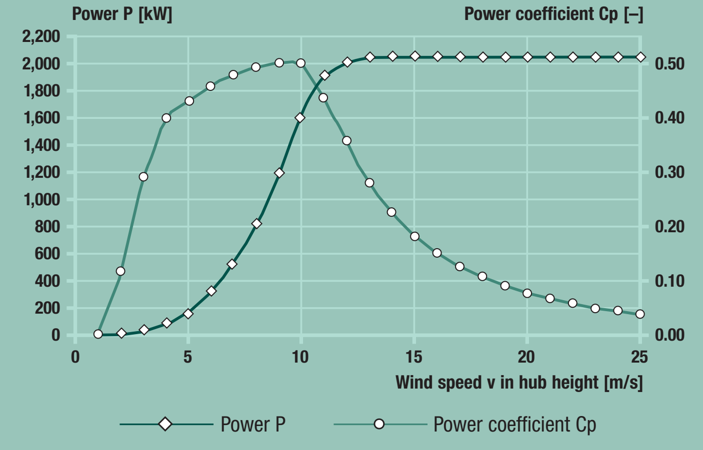
Specially designed for medium wind speeds, the ENERCON E-82 wind turbine – with the new rotor blade design and tower versions up to 138 m hub height – guarantees excellent yields in the 2 MW category, even at inland sites.

TECHNICAL DATA

Rated power:	2,000 kW
Rotor diameter:	82 m
Hub height:	78 m – 138 m
Wind class (IEC):	IEC/NVN II
Turbine concept:	Gearless, variable speed, variable pitch control
Rotor	
Type:	Upwind rotor with active pitch control
Direction of rotation:	Clockwise
Number of blades:	3
Swept area:	5,281 m²
Blade material:	Fibreglass (epoxy resin); integrated lightning protection
Rotational speed:	Variable, 6 – 19.5 rpm
Pitch control:	ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply
Drive train with generator	
Hub:	Rigid
Main bearings:	Dual-row tapered/single-row cylindrical roller bearings
Generator:	ENERCON direct-drive synchronous annular generator
Grid feeding:	ENERCON converter
Braking systems:	– 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock
Yaw control:	Active via adjustment gears, load-dependent damping
Cut-out wind speed:	28 – 34 m/s (with ENERCON storm control)
Remote monitoring:	ENERCON SCADA

Details – ENERCON Storm Control – (see last page)

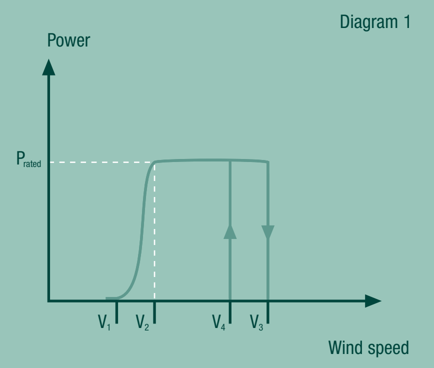
CALCULATED POWER CURVE



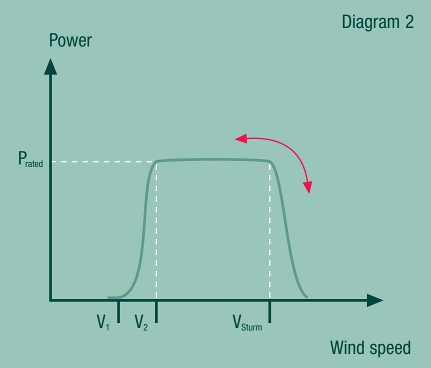
Wind [m/s]	Power P [kW]	Power coefficient Cp [-]
1	0.0	0.00
2	3.0	0.12
3	25.0	0.29
4	82.0	0.40
5	174.0	0.43
6	321.0	0.46
7	532.0	0.48
8	815.0	0.49
9	1,180.0	0.50
10	1,612.0	0.50
11	1,890.0	0.44
12	2,000.0	0.36
13	2,050.0	0.29
14	2,050.0	0.23
15	2,050.0	0.19
16	2,050.0	0.15
17	2,050.0	0.13
18	2,050.0	0.11
19	2,050.0	0.09
20	2,050.0	0.08
21	2,050.0	0.07
22	2,050.0	0.06
23	2,050.0	0.05
24	2,050.0	0.05
25	2,050.0	0.04

$\rho = 1.225\ kg/m^3$

Details – ENERCON power curve – (see last page)



Power curve of a wind turbine without ENERCON storm control



Power curve of a wind turbine with ENERCON storm control

ENERCON POWER CURVES

According to current standards at power curve measurement certain parameters such as turbulence intensity are not taken into consideration. The results are deviating measurements on the same type of wind turbine at different locations. Also when comparing yield using power curve measurements from different types of wind turbines, a clear picture cannot be obtained unless all measurement parameters are taking into consideration.

So in order to calculate power yield forecasts for its wind turbines, ENERCON does not use power curve measurements but calculated power curves.

These are based on the following:

- several different power curve measurements for the respective wind turbine type taken by accredited institutes with documented evidence of these measurements on the respective power curve certificates; or results from other turbine types if measurements have not yet begun or are still in progress
- average turbulence intensity 12 %
- standard air density – 1.225 kg/m^3
- realistic assumptions concerning anemometer behaviour
- wind turbine operation with ENERCON's storm control feature which enables operation without shutdown at high wind speeds.

Thus the power curves for ENERCON wind turbines provide highly reliable and realistic calculations for expected energy yield according to the wind conditions at the respective site.

DESCRIPTION WIND CLASSES

IEC I V_{av} = 10 m/s
V_{ext} = 70 m/s

IEC II V_{av} = 8.5 m/s
V_{ext} = 59.5 m/s

IEC S V_{av} and V_{ext} to be determined by the manufacturer

ENERCON STORM CONTROL

ENERCON wind turbines are operated with a special storm control feature. This system enables reduced turbine operation in the event of extremely high wind speeds, and prevents the otherwise frequent shutdowns and resulting yield losses.

Power curve without ENERCON storm control

The diagram 1 shows that the wind turbine stops at a defined shutdown speed V_3. The reason being that a specified maximum wind speed has been exceeded. In the case of a wind turbine without storm control this, for example, occurs at a wind speed of 25 m/s within the 20 second mean. The wind turbine only starts up again when the average wind speed drops below the shutdown speed or a possibly even lower restart speed (V_4 in the diagram; socalled strong wind hysteresis). In gusty wind conditions there may be a longer delay, which means that considerable yield losses are incurred.

Power curve with ENERCON storm control

The power curve diagram with ENERCON storm control (diagram 2) demonstrates that the wind turbine does not shut down automatically when a certain wind speed V_{Storm} is exceeded, but merely reduces the power output by lowering the rotational speed. This is achieved by turning the rotor blades slightly out of the wind. Once the wind speed drops, the blades turn back into the wind, and the turbine immediately resumes operation at full power. Yield-reducing shutdown and start-up procedures are thus avoided.

Safety systems in E-82 wind turbines to prevent water pollutants from leaking

Table of Contents:

General information:
Unlike conventional systems, only a minimum amount of water pollutants is required in our gearless E-82 wind turbines. In order to prevent these substances from leaking in the event of a fault, the following safety systems have been developed:

1. Gear: E-82 wind turbines have no main gear as their rotors are directly connected to an annular generator which does not require any increase in speed. For this reason, the usual amount of 200 l gear oil required in conventional systems is not necessary for our wind turbines.

2. Yaw gear: The E-82 turbine has 6 yaw gears which align the nacelle with the wind direction. Each gear contains approximately 7l of oil. The electric motors are seated directly on top of these gears. The gears are installed inside the main carrier which collects the entire amount of oil. In addition oil pans are fitted underneath the yaw drives.

3. Pitch control: A pitch motor activates the pitch gear of each of the three E-82 rotor blades. The pitch gears only contain 4 litres of gear oil. The entire nacelle and rotor head are enclosed in an aluminium casing which collects any oil leakage.

4. Roller bearing lubrication: The tooth flanks and bearings in E-82 wind turbines are greased with special lubricants. The lubricated parts are either encapsulated so that grease cannot leak out or excess lubricant is collected in special pouches fitted to the aluminium casing.

5. Lubricant supply for bearings:
Permanent lubricators supply the roller bearings and pivot bearings of the E-82 turbine with lubricant. Each of these sealed cartridges contains125 ml of lubricant. These are replaced during regular maintenance operations.
The E-82 turbine can be optionally equipped with a central lubrication system for the spinner area. This electronically controlled system comprises a leak monitoring feature and is refilled during maintenance.

6. Transformer oil: The transformer is located either at the base of the tower or in a station outside the tower. In the station, the concrete sump is completely sealed and deep enough to contain the entire amount of transformer oil (870 - 1500 litres depending on the type of transformer. If the transformer is inside the tower base, it is set on a steel floor sump able to contain the entire volume of oil. The oil sumps in the stations and tower bases are oil-tight in accordance with § 19 WHG (German Water Resources Act).

For further questions, do not hesitate to contact us.
i.A. R. Kelling

1	**Yaw gear**
Unit / component description	Yaw gear to align nacelle on top of tower with wind direction; fixed position in main carrier
Number	6 gears
Amount of oil per unit	**7 l**
Type of product	Gear oil, liquid
Product name	MOBILGEAR SHC 460, alternative: RENOLIN Unisyn CLP 220
Description	Synthetic hydrocarbons and additives
Water hazard class (German regulation)	1
Technical equipment / safety system	Closed cast metal housing; completely sealed; vertical position in main carrier; main carrier or aluminium sumps collect oil leakage
Inspection	Check for leaks during service inspections (twice a year)
Handling water pollutants	Not in wind turbine as delivered completely assembled
2	**Pitch gear**
Unit / component description	Pitch gear to control blade angle, installation on rotor hub, turns with hub
Number	**3**
Amount of oil per unit	4l (depending on type)
Type of product	Gear oil, liquid
Product name	MOBILGEAR SHC 460, alternative: RENOLIN Unisyn CLP 220
Description	Synthetic hydrocarbons and additives
Water hazard class (German regulation)	1
Technical equipment / safety system	Closed cast metal housing; completely sealed; aluminium rotor casing collects possible oil leakage
Handling water pollutants	No handling in wind turbine, unit already completely assembled on delivery
Inspection	Check for leaks during service inspections (twice a year)
3	**Gear wheel lubrication**
Unit / component description	Yaw and pitch control drive gear wheels (pinion and gear rim)
Number	9 pinions in total
Amount	Grease lubrication
Type of product	Automotive grease
Product name	MOBILGEAR OGL 461
Description	Hydrocarbons and additives
Water hazard class (German regulation)	Class 2 (in accordance with VwVwS dated 17 May 1999)
Technical equipment / safety system	Toothing in sealed housing
Handling water pollutants	No handling in wind turbine, unit already completely assembled on delivery
Inspection	During service inspections, check for conspicuous leaks (twice a year)
4	**Yaw bearing lubrication**

Unit / component description	Nacelle bearing on tower, cartridges for permanent lubrication; type: Perma
Number	1 pivot bearing
Amount	Grease lubrication
Type of product	Roller bearing grease
Product name	Mobillith SHC 460
Description	Synthetic hydrocarbons and additives
Water hazard class (German regulation)	Class 2 (in accordance with VwVwS dated 17 May 1999)
Technical equipment / safety system	Closed four-point bearing
Handling water pollutants	No handling in wind turbine, unit already completely assembled on delivery
Inspection	During service inspections, check for conspicuous leaks (twice a year)
5	Permanent lubricator
Unit / component description	Cartridges for permanent lubrication Type: PERMA, automatic lubricator
Number	24 greasing points in spinner area
Amount	125 ml
Type of product	Roller bearing grease
Product name	MOBILITH SHC 460 (see above)
Description	Synthetic hydrocarbons and additives
Water hazard class (German regulation)	Class 2 (in accordance with VwVwS dated 17 May 1999)
Technical equipment / safety system	Sealed cartridges
Handling water pollutants	Cartridges are ready for use on delivery and replaced as is; ENERCON disposes of used cartridges
Inspection	During service inspections, check for conspicuous leaks (twice a year)
6	Alternative for pos. 6 (permanent lubricator)
Unit / component description	Central lubrication system for spinner area
Number	1 system with 24 greasing points
Amount	4 kg max.
Type of product	Roller bearing grease
Product name	MOBILITH SHC 460 (see above)
Description	Synthetic hydrocarbons and additives
Water hazard class (German regulation)	Class 2 (in accordance with VwVwS dated 17 May 1999)
Technical equipment / safety system	Closed system
Handling water pollutants	Ready for use on delivery; refilled during maintenance (max. 4 kg/a)
Inspection	Leak monitoring via remote monitoring system; additional inspection during maintenance

7	**Transformer station / transformer unit**			
Unit / component description	Transformer station according to separate description (A separate transformer station description is available on request.)			
Number	1 transformer for each wind turbine			
Amount	870 litres – 1500 litres			
Type of product	Transformer oil according to IEC-296 or IEC 836 depending on type			
Product name	DOW-Corning 561	Rhodorsil-Öl 604 V 50	NYNAS-NYTRO 10GBN	MIDEL 7131
Description	Mixture of highly refined mineral oils			
Water hazard class (German regulation)	1	1	1	0
Technical equipment / safety system	Transformer in transformer station: oil sump on station floor collects oil; specialist company installs station in accordance with § 19 WHG (German Water Resources Act), station can also be installed in water protection zones Transformer in tower base: transformer is installed over galvanised steel sump which can collect entire amount of oil;			
Handling water pollutants	No handling in wind turbine, unit already completely assembled on delivery			
Inspection	Check for leaks during service inspections (twice a year)			

Access Roads and Crane Platforms

E-82

83 m Prefabricated Concrete Tower

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CONTENTS Page

1. Assembling the tower and wind energy converter

The tower and wind energy converter are installed in three stages (work steps):

Step 1
Preassembly of the first prefabricated concrete tower sections (supplied as half shells) in the location described in 6.2, with subsequent assembly on the foundation.
The 83 m prefabricated concrete tower consists of 5 half shells.

Step 2
Assembly of the remaining, one-piece, prefabricated concrete tower sections.

Step 3
Completion of the tower - achieved by assembling the top steel section, partial preassembly of the supplied converter components and subsequent assembly of the wind energy converter.

2. Crane technology

2.1. Details of crane technology

The following crane technology is required for the work steps described above:

	Step 1	Step 2	Step 3
Crane type	300t telescopic crane	500t telescopic crane	800t lattice tower crane
Length/basic unit	18 m	20 m	20 m
Width/basic unit	3 m	3 m	3 m
Track width	3 m	3 m	3 m
Supporting base	10 m x 10 m	10 m x 10 m	13 m x 13 m
Outreach	12 m	20 m	34 m

2.2. Supporting base and working radius

The **supporting base** describes the distance between the four support cylinders arranged in a square (in metres).

The **working radius** is the minimum distance between the crane hook and the crane's live ring.
Example: With a working radius of 34 m, the distance from the live ring to the centre of the foundation would be at least 34 m (see 6.2.).

2.3. Installing the lattice tower crane

The following work steps need to be performed:

- Drive crane into position
- Align the crane with the centre of the WEC (taking into account the working radius)
- Use approx. 20 trucks to transport the crane accessories to the crane
- Support the crane on the crane platform using load distribution plates and
- Assemble jib

2.4. Assembling the jib

The individual jib (lattice tower) components should be assembled across a span of 100 m with the aid of an auxiliary crane. It should then be installed. During this process, the auxiliary crane must be positioned to the side of the jib of the main crane.

In order to facilitate consecutive assembly of the individual jib components, a paved roadway will be required for the auxiliary crane to travel along. You are advised to make use of the existing access road for the wind energy converter. If the existing access road is not suitable, a temporary roadway has to be constructed for the purpose of assembling the jib; this roadway has to be agreed with the competent ENERCON Project Manager on a case-by-case basis.

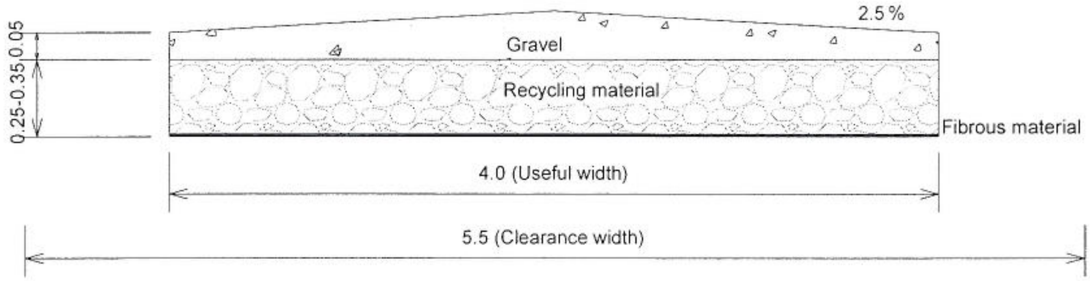
3. Access roads

Any roadways, bridges or access roads that are constructed have to be able to withstand the transportation of heavy loads up to a maximum axle load of 12t and a maximum overall weight of 120t. Access has to be kept clear at all times. The ENERCON Project Manager has to be informed of any failure to meet these requirements.

3.1. Minimum requirements of access roads

Useful width of carriageway	4 m
Clearance width	5.5 m
Clearance height	4.6 m
Radius of curve, external	28 m
Incline with loose surface	7%
Incline with fixed surface	12%
Ground clearance of transport vehicles	0.15 m

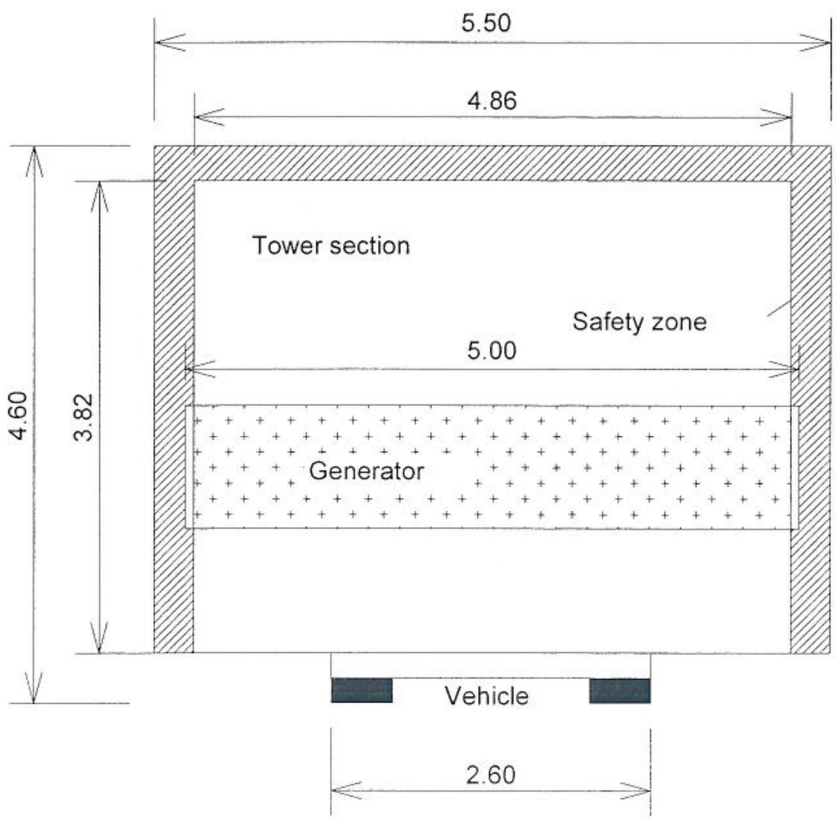
3.2. Example of access road construction



Caution:

The structure illustrated above is merely an example of average bearing soil. If the subsoil is soft (boggy soil, etc.), it may be necessary to use more backfill, install a geogrid and make use of gravel. ENERCON has always to be consulted prior to any construction work.

3.3. Transport structure clearance



3.4. Access road bearing capacity

In the case of cohesive soils, the use of a geotextile or geogrid is recommended, as this makes for better distribution of the load across the access road's subgrade. It will also increase the access road's service life and durability.
During construction, plate load bearing tests should be carried to ensure that the necessary bearing capacity is achieved.

Data for soil experts:

Subsoil	$E_{v2} \geq 45$ MN/m²
Base course	$E_{v2} \geq 100$ MN/m²
Maximum axle load of transport vehicles	10t
Maximum axle load of crane	12t
Maximum vehicle weight	120t

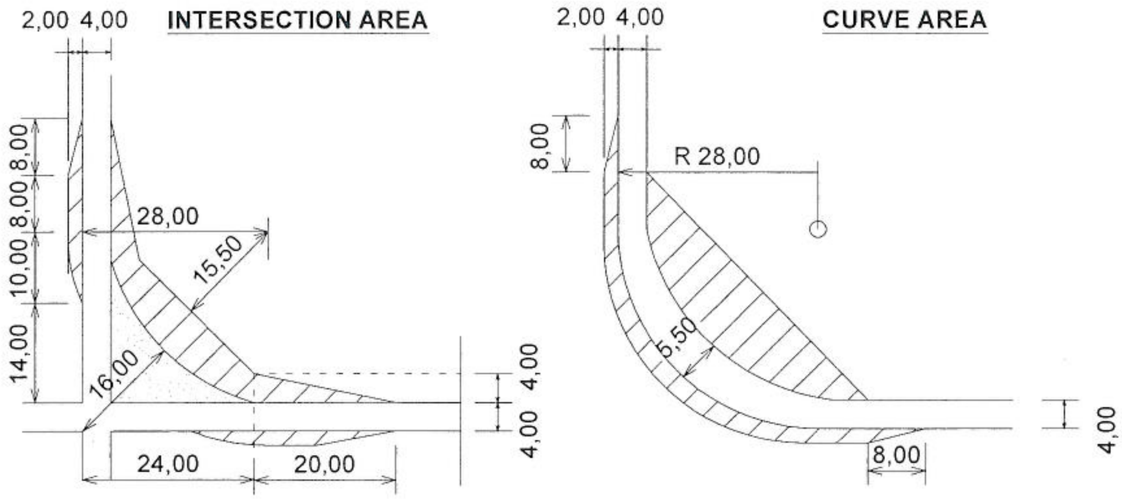
3.5. Basic principles of access road construction

- Useful carriageway width of 4 m
- Able to withstand an axle load of up to 12t
- Able to withstand an overall weight of up to 120t
- Carriageway width of 5.5 m on curves
- No obstacles on inside/outside of curves
- Clearance width of 5.5 m
- Clearance height of 4.6 m
- Checking of bridge bearing capacity
- Checking of outlets and pipework
- Checking of distances from graves, hollows and watercourses
- Checking of distances from high voltage/electrical/telephone cables and
- Inspection of inclines

4. Radii of curves

4.1. Minimum requirements of intersections and curves

In contrast to intersections, areas involving curves do not require the same degree of paving, as the squinch does not need to be constructed.



Intersections

The construction method for intersection areas as illustrated above should be used for existing intersections. The area indicated by the dotted line should already be paved; if not, it has to be paved.

The hatched areas have to be free of obstacles, as the load that is being transported may protrude into these areas (for example, rotor blades may protrude from the rear of the vehicle by 7 m during transport).

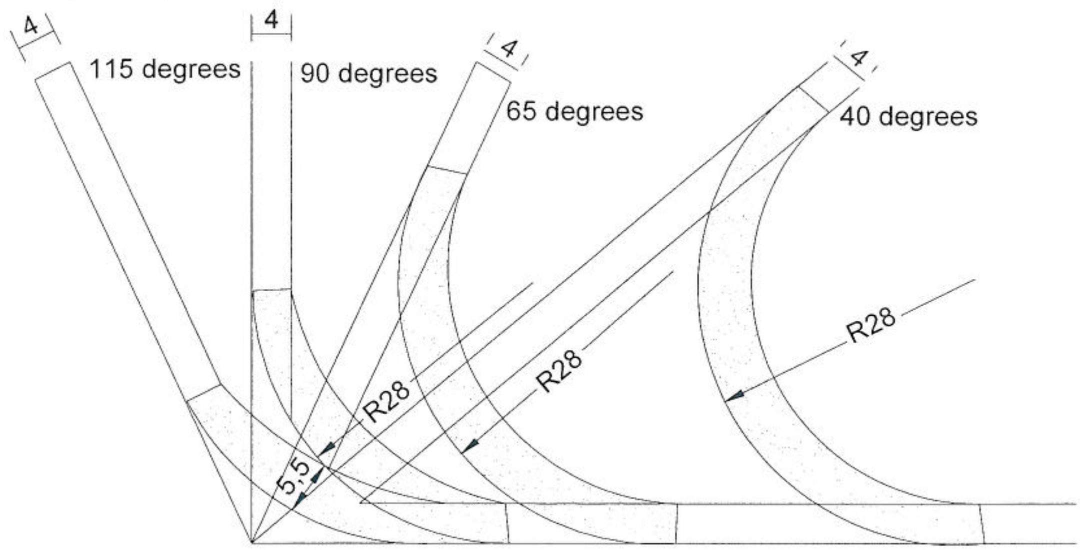
Curves

The construction method for curve areas as illustrated above should be used for new access roads within the context of any curves.

The hatched areas have to be free of obstacles, as the load that is being transported may protrude into these areas.

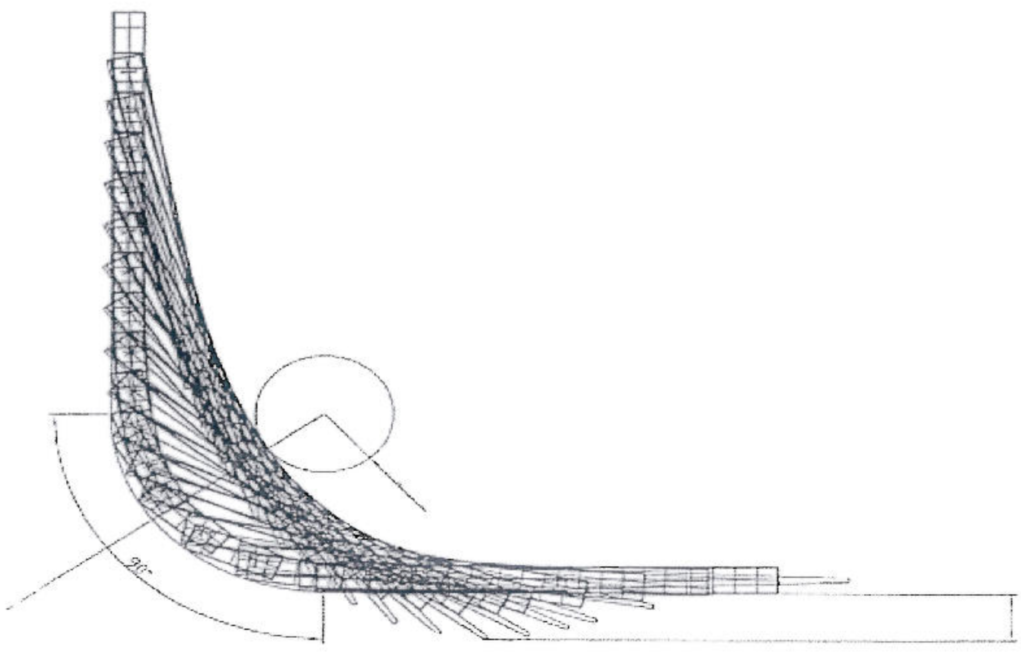
4.2. Radius of curve < 90 degrees

If the angle of the curve under construction is < 90 degrees, the curve moves outwards and the area associated with the necessary carriageway width of 5.5 m has to be enlarged accordingly (see marking). The load again protrudes into the inside and outside areas of the curve (see 4.1).



4.3. Road performance of vehicles in curves

The figure bellow illustrates the movement of blades as they are transported round a curve.



5. Transport and logistics

5.1. Basic principles of transport

It is a basic principle that transport vehicles should not exceed the maximum axle load of 10t. Thus, a transport vehicle with an actual overall weight of 100t must have at least 10 axles.

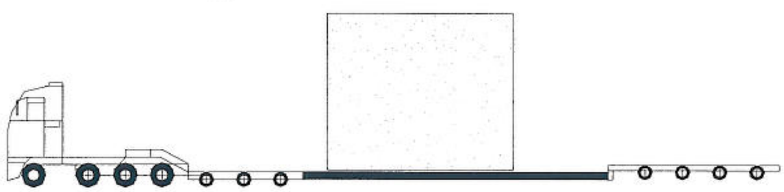
The following vehicles are used on ENERCON construction sites:

- Lowloader trailers
- Drop base vehicles
- Semi trailers and
- Adapter vehicles

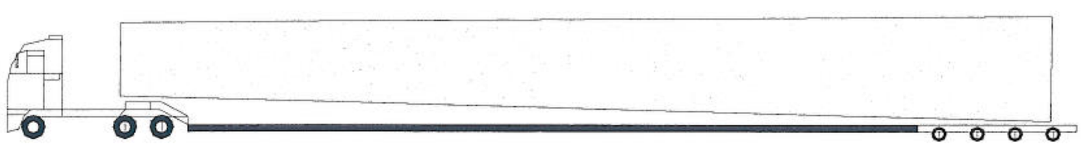
The vehicles vary to some extent in terms of length and width and can be shortened (pushed in) by several metres once they have been unloaded.

5.2. Overview of transport vehicles

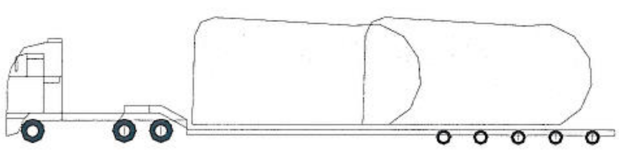
Lowloader trailer, prefabricated concrete tower section



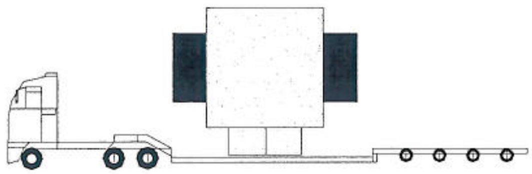
Semi trailer, steel section



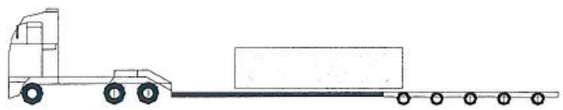
Telescopic semi, machine house components



Flatbed trailer, hub



8-axled semi, generator



Semi trailer, rotor blade

6. Crane platforms

6.1. Minimum requirements of crane platforms

The crane platform is the key to ensuring that everything runs smoothly and safely during the construction phase.
It should take the form of a coarse, level surface with a top surface made from recycled materials or mixed minerals with a grain size of 0 – 32 mm.
The crane platform should be located above ground level to ensure that surface water is properly dispersed.
During construction, plate load bearing tests should be carried out to ensure that the necessary bearing capacity is achieved.

Any cranes used have a maximum support pressure of 200t and are supported on the crane platform by means of load distribution plates. Pressures of up to 18.5t/m² may act on the platform as a result of this and the maximum surface pressure is therefore **185 kN/m²**.

The dimensions of the crane platform should be calculated so that all the work necessary for installing the wind energy converter (including tower) can be carried out in the optimum manner.
The example given in 6.2 provides a basic standard. This can be adapted to local conditions in consultation with the competent ENERCON Project Manager.
Depending on the foundation type the outer foundation edge always defines the boundary edge for the crane platform.
The preassembly area can be located to the left or to the right of the crane platform, but the access road must always be constructed on the side of the platform that adjoins the preassembly area.
To ensure that any components inside the tower can subsequently be replaced and to protect the wind energy converter against ingress of dirt, a 6 m wide, paved access has to be constructed between the crane platform and the tower once the foundation has been backfilled.

During foundation construction, the crane platform also serves as a storage area for material (e.g. reinforced steel) and machinery.

Any excess earth excavated during the construction phase should always be stored behind the foundation (see 6.2).

On completion of all the work, the preassembly area for the prefabricated concrete tower sections can be put back how it was before.

6.2. Standard crane platform