E53 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.

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.

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.

Sales
ENERCON GmbH
Dreekamp 5 · 26605 Aurich · Germany
Phone +49 4941 9270 · Fax +49 4941 92 76 69
vertrieb@enercon.de

ENERCON GmbH · Dreekamp 5 · 26605 Aurich · Germany · Phone +49 4941 92 70 · Fax +49 4941 92 71 09 · www.enercon.de

Subject to change without notice, status 03/07.

ENERCON WIND TURBINES

TECHNOLOGY & SERVICE

ENERCON
ENERGY FOR THE WORLD

CONTENTS

MARKET LEADER THROUGH INNOVATION

ENERCON began its road to economical/ecological success when graduate engineer Aloys Wobben founded the company in 1984. A small team of engineers developed the first E-15/16 wind turbine with a rated power of 55 kW. In the beginning ENERCON systems still featured gearboxes. The changeover to gearless technology was made in 1992 with the first ENERCON E-40/500 kW. The innovative drive system with few rotating components enables almost friction-free energy flow. The performance and reliability of this system is exemplary. Mechanical stress, operating costs and maintenance costs are reduced, and the service life of the systems is increased.

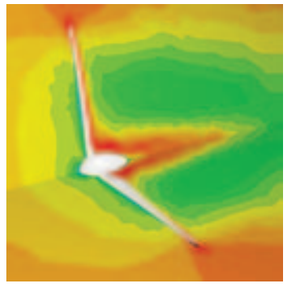
Today, all ENERCON wind energy converters are based on this tried and tested turbine concept. New system generations emerge through continuous further development of all components, in order to provide customers with technologically sophisticated products. One example of these technological innovations is the new rotor blade geometry introduced in 2004. It significantly increases revenue, reduces noise emission and stress on the wind energy converter.

All ENERCON installations feature a grid feed system that meets the latest grid connection requirements and can therefore be easily integrated in any supply and distribution structures. ENERCON's concept offers solutions such as reactive power management and voltage control for normal operation as well as for critical situations resulting from network short-circuits or bottlenecks.

ENERCON has been setting new standards for technological design for more than 20 years. As one of the world's leading companies in the wind energy sector and the longstanding leader in the German market, ENERCON directly or indirectly employs over 8,000 people worldwide.

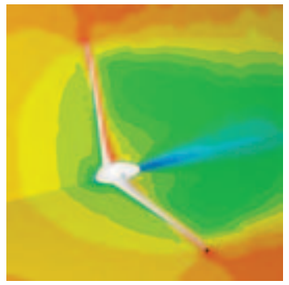
With more than 9,000 wind turbines installed in over 30 countries, ENERCON is also amongst the leading manufacturers on an international level. Research and Development, as well as Production and Sales are continuously being expanded. The company's objective for 2006 is an export share of more than 45 %, gradually increasing over the years to come.

DRIVE SYSTEM



The new ENERCON rotor blade design also makes use of the inner part of the swept area

Old rotor blade design

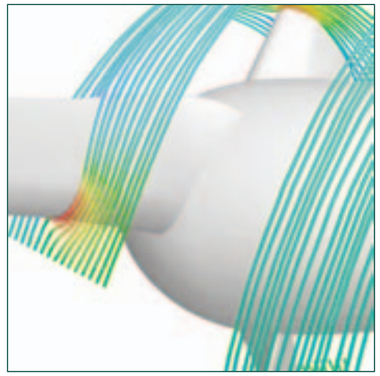


New rotor blade design

ROTOR BLADE CONCEPT

ENERCON's rotor blade concept sets new standards with regard to yield, noise emission and stress minimisation. Because of their modified design, the blades not only draw energy from the outer edges but also use the inner part of the swept area considerably increasing power output. The new rotor blades are also less susceptible to turbulence and provide an even flow along the entire length of the blade profile.

The blade tips have also been improved to reduce noise emission and power output. Turbulences at the blade tips due to overpressure and underpressure are effectively eliminated in the rotor plane. The entire length of the blade is therefore utilised without any loss of energy caused by turbulences.



Even airflow around the nacelle increases energy yield

ENERCON rotor blades set new standards with regard to yield, noise emission and stress minimisation

ADVANTAGES OF ENERCON ROTOR BLADES

- Higher efficiency due to modified blade design
- Less noise emission due to optimised blade tips
- Longer service life due to reduced stress
- Easier transport due to streamlined blade design

ENERCON rotor blades are manufactured with a vacuum infusion process using the so-called sandwich method. Glass fibre mats placed in the mould are vacuum-impregnated with resin via a pump and a hose system. This method eliminates air pockets in the laminate.

A paint robot paints components of up to 35 m in length in one operation, thus providing efficient rotor blade surface protection against the elements, UV radiation as well as erosion and bending loads

In order to efficiently protect the rotor blade surface against elements such as wind and water, UV radiation, as well as erosion and bending loads, the rotor blade finish protection system includes gel coat, filler, edge protection and top coat. ENERCON only uses solvent-free two component polyurethane compounds in the entire system.

In order to effectively withstand wind stress over the entire usage period, ENERCON rotor blades have an extremely large blade flange diameter. The double-row bolt connection specially developed by ENERCON for large wind turbines also provides additional strength by creating even load distribution. This is an important factor, particularly at sites with extreme winds and large stress fluctuations.

An ENERCON E-70 rotor blade with a double-row bolt connection guarantees additional security through even load distribution

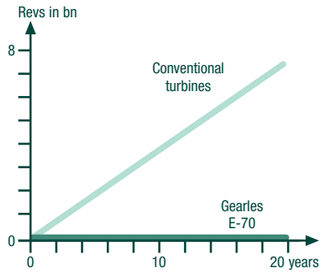
DIRECT DRIVE

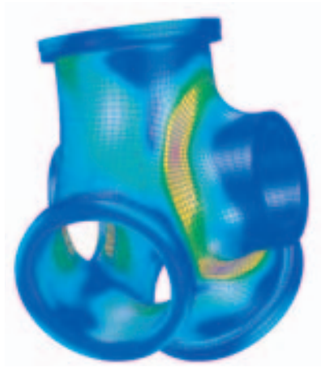
The drive system for the ENERCON wind energy converters is based on a simple principle: Fewer rotating components reduce mechanical stress and at the same time increase the technical service life of the equipment. Maintenance and service costs for the wind turbine are lower (fewer wearing parts, no gear oil change, etc.) and operating costs are reduced.

The rotor hub and annular generator are directly connected to each other as a fixed unit without gears. The rotor unit is mounted on a fixed axle, the so-called axle pin. Compared to conventional geared systems that have a large number of bearing points in a moving drive train, ENERCON's drive system has only two slow-moving roller bearings. The reason for this is the low speed of the direct drive.

ENERCON direct drive – few rotating components increase lifespan

Annular generator of ENERCON E-70 undergoes same number of rotations in 20 years as the generators in conventional wind turbines in three months





Strain examination of cast components using the finite element method

A few years ago only the rotor hub was made of cast steel, nowadays the use of modern spheroidal graphite cast iron makes it possible to manufacture other major components such as blade adaptors, axle pins and main carriers with this process.

ENERCON carries out advanced development of cast components in close collaboration with the foundries. All cast components are drawn on a 3D CAD system and calculated using the finite element method to test strain increases at critical points. During the entire prototype phase, the designer tests and optimizes performance. In order to guarantee the identification and traceability of each cast component when the goods are received at ENERCON, each part is given a specific barcode, from which the serial number can be obtained in the event of quality matters for example. Cast components are not released for further steps in ENERCON's manufacturing process until comprehensive quality testing has taken place, thus guaranteeing high ENERCON quality standards in the cast component supply sector.

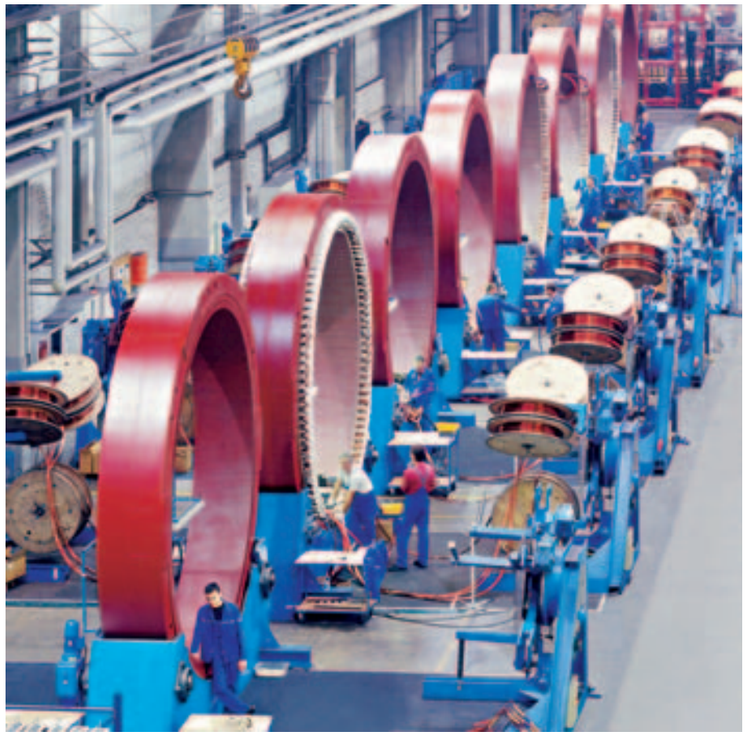
ENERCON'S QUALITY TESTING PROCEDURES FOR CAST COMPONENTS

- Structural inspection on component
- Ultra sound test
- X-ray test

All major ENERCON components such as rotor hubs, blade adaptors, axle pins and main carriers are made of spheroidal graphite cast iron

ANNULAR GENERATOR

In order to guarantee ENERCON's high quality, the annular generators are all manufactured in the company's own production facilities



ANNULAR GENERATOR

The annular generator is of primary importance in the gearless system design of ENERCON wind turbines. Combined with the rotor hub it provides an almost frictionless flow of energy, while the gentle running of fewer moving components guarantees minimal material wear. Unlike conventional asynchronous generators, the ENERCON annular generator is subjected to minimal mechanical wear, which makes it ideal for particularly heavy loads and a long service life.

ENERCON's annular generator is a low-speed synchronous generator with no direct grid coupling. Output voltage and frequency vary with the speed and are converted for output to the grid via a DC link and an converter achieving high speed variability.

ADVANTAGES OF ENERCON'S ANNULAR GENERATOR

- No gear
- Low wear due to slow machine rotation
- Low machine stress due to high level of speed variability
- Yield-optimised control
- High level of grid compatibility

STATOR AND ROTOR

According to ENERCON's service life requirements the copper winding in the stator, the stationary part of the annular generator, known as closed, single-layer basket winding is produced in insulation class F (155°C). It consists of individual round wires that are gathered in bundles and varnish insulated. ENERCON does the copper winding by manually. In spite of increasing automation in other manufacturing areas, preference has been given to manual labour in this case for good reason. It ensures that the materials used are fully tested. Furthermore, a special processing method allows continuous windings to be produced. Each wire strand is continuous from start to finish.

ADVANTAGES OF CONTINUOUS WINDING

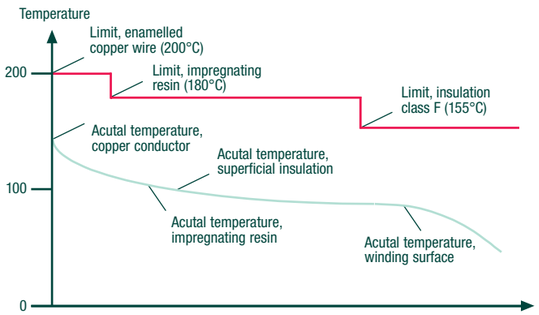
- Prevents processing faults in the production of electrical connections
- Maintains high-quality copper wire insulating system
- No contact resistance
- No weak points susceptible to corrosion or material fatigue

Stator (stationary part) of an ENERCON E-33 annular generator

The magnetic field of the stator winding is excited via so-called pole shoes. These are located on the disk rotor, the mobile part of the ENERCON annular generator. Since the shape and position of the pole shoes have a decisive influence on the noise emission of the annular generator, ENERCON's Research & Development Department has dedicated particular attention to this aspect. The result: Improved adaptation of the pole shoes to slow rotation of ENERCON's annular generator means that no noise is generated.

TEMPERATURE BEHAVIOUR

ENERCON's annular generator features optimised temperature control. The hottest areas in the annular generator are constantly monitored by a large number of temperature sensors. The sensors activation temperature is well below constant temperature resistance of the insulating materials used in the generator. This prevents temperature overload.

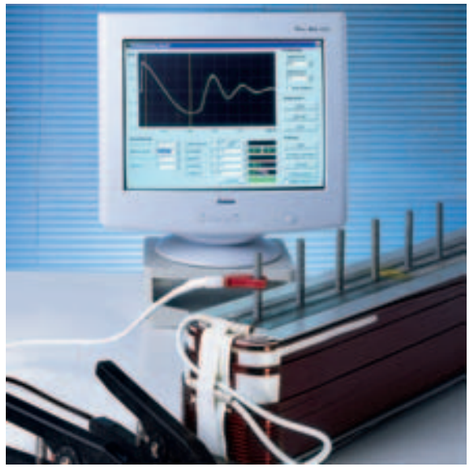


Maximum operating temperature in an ENERCON annular generator is considerably below limit values of the processed materials

— Limits for the insulating materials used
— Operating temperatures in the annular generator

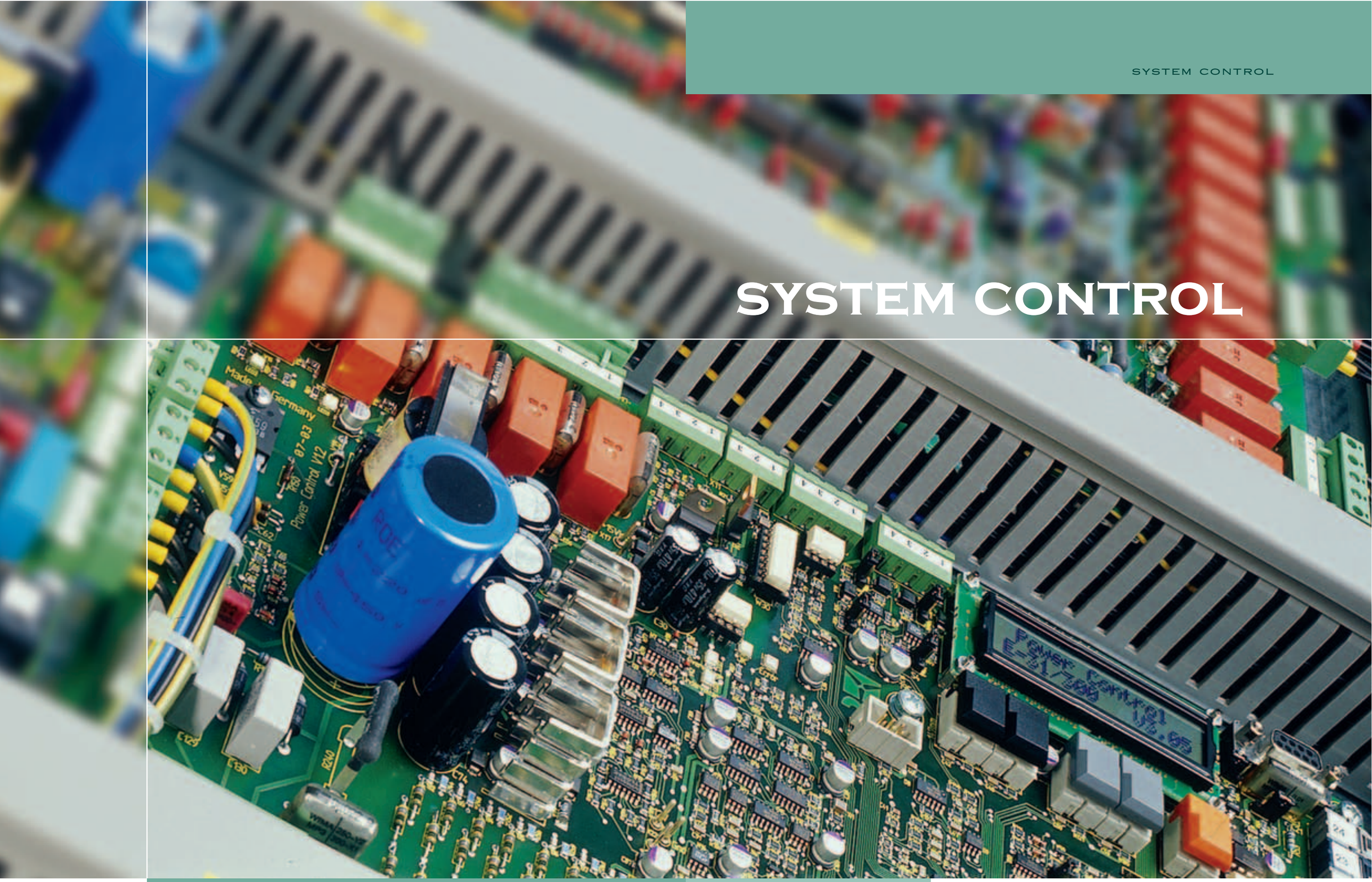
QUALITY ASSURANCE

In order to guarantee ENERCON's high quality, all annular generators are manufactured in the company's own production facilities. Superior quality materials are always used. Close collaboration with supplier companies has proven to be the most reliable way of providing maximum material quality. For example, the enamelled copper wires are subjected to more testing than is specified in the standard and samples are archived, while surge voltage tests are performed on the pole shoes and then documented in the computer system.



ENERCON quality assurance – surge voltage test on pole shoes and chokes

SYSTEM CONTROL



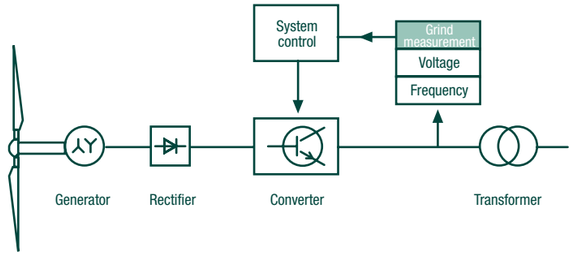
SYSTEM CONTROL

ENERCON wind turbines are equipped with state-of-the-art micro-electronic control technology developed in-house. The MPU (main processing unit), the central element of ENERCON's control system, constantly registers information from the peripheral control elements, such as the yaw control and active pitch control systems. Its function is to adjust the individual system parameters to ensure that ENERCON wind turbines achieve maximum output under all weather conditions.

ENERCON CONTROL SYSTEM

- Constant evaluation of measurement data from wind sensor for adaptive nacelle yaw control
- Variable speed for maximum wind turbine efficiency at all wind speeds, and elimination of undesirable output peaks and high operating load
- Active pitch control system to obtain ideal angle of flow on the rotor blades ensures maximum output and stress reduction on the entire wind turbine
- ENERCON brake system for maximum turbine reliability by means of three independently operated pitch mechanisms with standby power supply (batteries) in case of supply failure
- Tower and generator monitoring by means of vibration and acceleration sensors to check tower oscillation
- Temperature and air gap sensors between rotor and stator ensure dependable annular generator operation

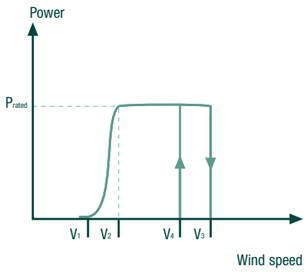
Wind sensor on an ENERCON wind turbine



Monitoring grid feeding on ENERCON wind turbines

MONITORING GRID CONNECTION

Ensuring proper power feed from ENERCON wind turbines into the grid requires grid connection monitoring. Grid parameters such as voltage, current and frequency are measured on the low-voltage side between the ENERCON converter and the system transformer. The measured values are continuously transmitted to the control system, enabling the turbine to react immediately to changes in grid voltage or frequency. If the defined limit values for system or grid protection are exceeded, the wind turbine is securely shut down and the service teams informed. As soon as voltage and frequency return within the permissible tolerance range, the wind turbine is automatically started up again. Prolonged downtimes are thus avoided.



Power curve without ENERCON storm control – The wind turbine is shut down at a defined maximum wind speed

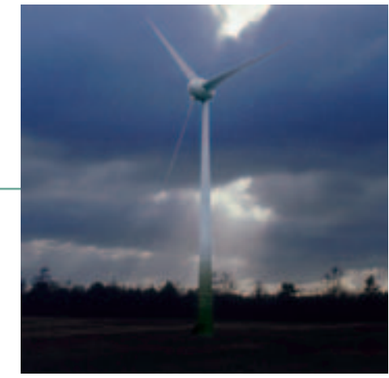
ENERCON STORM CONTROL

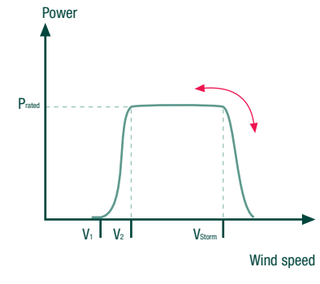
ENERCON wind turbines are equipped with a special storm control system, which enables reduced turbine operation in the event of extremely high wind speeds. This prevents the otherwise frequent shutdowns and the resulting yield losses.

The diagram of a power curve of a wind turbine without ENERCON storm control 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 with the 20 second mean. The wind turbine only starts up again when the average wind speed drops below the shutdown speed or possibly even lower restart speed (V_4 in the diagram; so-called strong wind hysteresis). In gusty wind condition, this may take a while, which means that considerable yield losses are incurred.

ENERCON wind turbines run on a different principle at high wind speeds. They are equipped with special storm control software which prevents sudden shutdowns.

The power curve diagram with ENERCON storm control demonstrates clearly 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.





Power curve with ENERCON storm control – The wind turbine merely reduces the power output at a certain wind speed without shutting down

Output loss of ENERCON E-70 without storm control due to 2 stormy days/year

2 days x 2,300 kW = 110,400 kWh

2 – 4 % of yearly income

GRID CONNECTION

ENERCON GRID CONNECTION SYSTEM

ENERCON installations feature a grid feed system that meets the latest grid connection requirements and can therefore be easily integrated in any supply and distribution structures. ENERCON's concept offers solutions such as reactive power management and voltage control for normal operation as well as for critical situations resulting from network short-circuits or bottlenecks. Wind turbine behaviour is essentially comparable to conventional power plants. ENERCON is the first manufacturer worldwide to have received a certificate confirming these power plant properties.

Energy generated in the ENERCON annular generator is fed to an inverter via a rectifier and a so-called DC link, It ensures that output power is regulated according to grid specifications. This is where stipulated requirements, such as voltage frequency and reactive power for each individual turbine in a wind farm, are implemented. The system transformer makes the conversion from 400 V to medium voltage.

ELECTRICAL GRID COMPATIBILITY

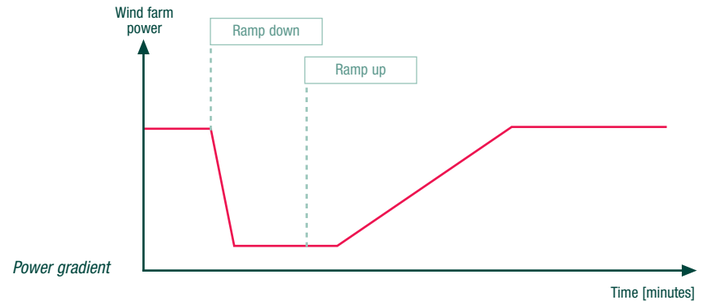
The wind turbines offer maximum grid compatibility due to their control and operating mode. Output peaks do not occur due to the closed-loop and open-loop control concept. Almost no reactive power is required in normal operation.

WIDE VOLTAGE AND FREQUENCY RANGES

ENERCON's grid feed system allows the wind turbine to operate within a wide range promoting reliable operation in weak grids. This enables ENERCON wind energy converters to support the electrical grid even at complex locations.

COORDINATED GRID FEED IN NETWORK

In order to provide reliable economical grid operation, power feed timing has to be regulated. To ensure that this takes place, variable set point values for maximum permitted power gradients can be specified for ENERCON grid feed systems. For example, when the wind turbine or wind farm is started up, power feed can be controlled according to requirement. This allows the grid operator to optimise load flow and grid voltage stability as well as the interaction between power supply companies and consumers.

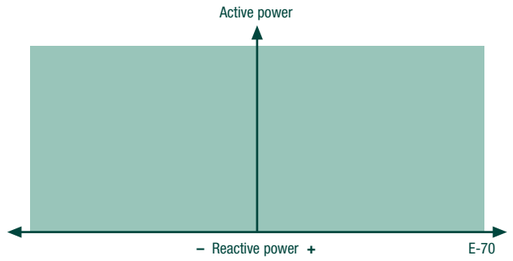


Regulation of power feed for reliable economical grid operation.

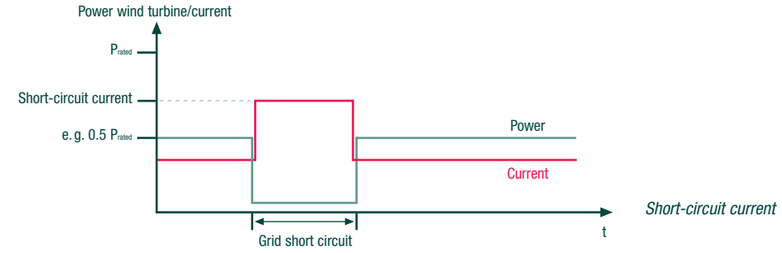
REACTIVE POWER MANAGEMENT

Reactive power must be regulated when operating transmission and distribution grids. It is necessary to compensate transmission equipment such as cables and transformers, and to maintain voltage stability. ENERCON wind turbines have a wide operating range for reactive power exchange which can be provided to the grid as a system service.

In many regions of the world conventional power plants alone are not sufficient to meet highly complex requirements for stable grid operation. In these cases, dynamic reactive power sources such as a so-called SVC or STATCOM (Static Compensator) must be integrated into the grid to guarantee adequate power supply quality for the consumer. As an option, ENERCON wind turbines are able to provide the grid with the performance properties of a STATCOM. Irrespective of power feed, the entire reactive power range is at the disposal of the grid operator even if active power is not being fed into the grid. These STATCOM properties are a crucial requirement to connect to weak and heavily loaded networks operating on the edge of stability.



Reactive power management for an E-70 E4 with STATCOM properties



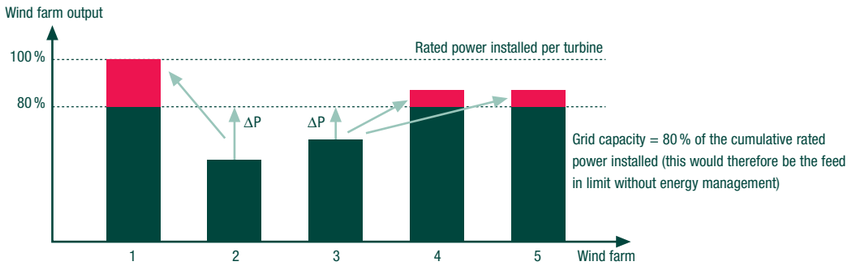
ENERCON wind turbines staying connected to the grid when short circuit occur.

STAYING CONNECTED WHEN GRID PROBLEMS OCCUR

Similar to power station behaviour, wind turbines in transmission grids should not immediately disconnect from the grid when short circuits occur. During voltage dips due to grid problems they should be able to remain connected to the grid. ENERCON wind turbines have this capacity. If necessary, the turbines also support grid voltage when problems arise. This is achieved by feeding reactive power. After the problem has been remedied and grid voltage has been restored, the wind turbine immediately continues feeding power.

ENERCON SCADA

ENERCON SCADA has been a proven system for remote wind farm control and monitoring for many years and is also a vital element of ENERCON's service and maintenance concept. Introduced in 1998, this dependable system is now used in more than 6,500 wind turbines worldwide. It offers a number of optional functions and interfaces to connect ENERCON wind farms to the grid while meeting demanding grid connection regulations. Due to its modular design ENERCON SCADA expansion is simple and flexible and can be adapted to customer-specific applications. Since adaptation to the respective technical and economic conditions of wind farm projects is excellent ENERCON SCADA assures maximum output values.



Without energy management the available grid capacity could not be used to 100% in this case.

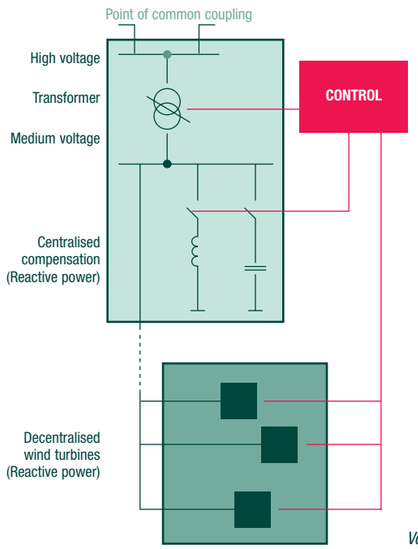
Energy management

ENERGY MANAGEMENT – POWER REGULATION FOR MAXIMUM YIELD

If the cumulative (nominal) output of a wind farm is greater than the grid connection capacity at the point of common coupling, ENERCON wind farm power regulation ensures that the capacity is used to the fullest at all times. If a wind turbine in the wind farm generates less power, the other turbines are appropriately adjusted to run at a higher capacity. The optional ernergy management system in ENERCON SCADA handles this automatically.

VOLTAGE CONTROL

As an option, ENERCON's SCADA system can be expanded to provide ENERCON wind farms with a voltage control feature. This feature, which is a mandatory requirement by utilities in many countries, enables large wind farms to be integrated into relatively weak grids. The reactive power range of ENERCON wind turbines is in this case usually used to control voltage at the point of common coupling. Voltage can be controlled by the grid operator according to predefined conditions or via additional interfaces.

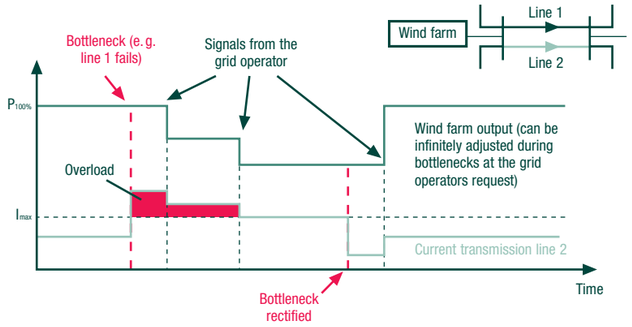


Voltage control

There are various requirements concerning wind farm voltage control. If a wind farm is for example connected to a substation, automatic voltage regulators can be integrated into the control concept. In large wind farms with respective cable lengths, a control system can be used to improve reactive power demand for the contractually agreed point of common coupling with centralised compensation equipment and decentralised wind turbines. ENERCON offers a large number of solutions.

INTERFACES

In many countries, integration of wind farms into grid control systems and connection to grid control stations are today standard requirements for wind farms. ENERCON SCADA offers different optional modules which act as interfaces between the various systems. This enables ENERCON's SCADA system to communicate via analogue or digital interfaces depending on requirements. Certain wind farm target values can be preset and status messages or wind farm measurement values transmitted to the grid operator. If desired, ENERCON METEO offers the possibility of integrating wind masts in farm into the permanent data transfer system.



Bottleneck management

BOTTLENECK MANAGEMENT – FEEDING INTO WEAK GRIDS

Not all regions have sufficient transmission capacity available to manage each low-load and strong wind situation. ENERCON's bottleneck management offers the possibility of connecting wind farms to this type of grid. Constant data exchange between the wind farm and the grid operator ensures that transmission capacity is well adapted to the highest permissible wind farm output.

WIND FARMS WITH SUBSTATIONS

More and more wind farms are feeding power into the grid via substations specially constructed for this purpose. Remote monitoring and control of these substations are often required in order to receive continuous information on switchgear assemblies and, as the case may be, carry out switching operations. ENERCON's SCADA system features special optional modules for remote monitoring and control of switchgear units and entire substations. Representation and operation are carried out by proven remote monitoring system ENERCON SCADA REMOTE.

ENERCON MAIN CONTROL UNIT (MCU) – FOR WIND POWER PLANTS

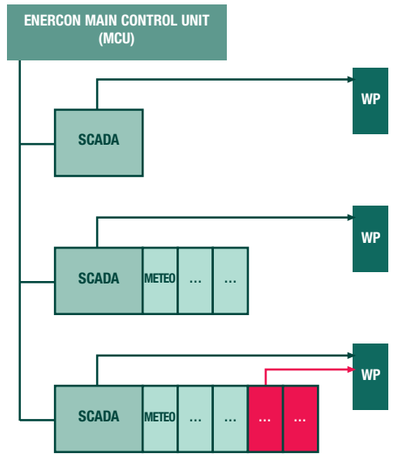
Individual ENERCON wind farms functioning similar to conventional power plants have successfully been in operation and integrated in existing grid structures for many years. It is more and more common to find several wind farms connected to a central point of common coupling to form wind power plants. Since installed power output is high, these plants usually feed power into high-performance transmission grids. ENERCON's MAIN CONTROL UNIT (MCU) assumes centralised open-loop and closed-loop control of a wind power plant. It takes over typical communication and data transfer tasks to grid control systems and load dispatching centres fulfilling complex technical grid connection regulations for wind power plants.

ENERCON's MAIN CONTROL UNIT (MCU) comes a as module. Each application is customised with features best suited to the project. Depending on requirements ENERCON's MAIN CONTROL UNIT (MCU) has different interfaces to connect to the grid control systems. Bottleneck management for wind power plants is yet another feature part in addition to reactive power management, or the integration of switchgear assemblies or entire substations into the wind power plant.

Grid connection of ENERCON wind power plants (combination of several wind farms)

TYPICAL REQUIREMENTS FOR WIND POWER PLANTS IN TRANSMISSION GRIDS

- Wind turbines should be able to remain connected to the grid without power reduction even if considerable voltage and frequency deviations occur
- If voltage dips occur due to grid problems, wind turbines should remain connected to the grid for a defined period
- Short circuit current feeding may be demanded during a grid failure
- After a fault has been remedied, a wind farm should resume power feed as quickly as possible within a specified maximum time range
- Wind farms should be able to be operated with reduced power output without any time restrictions
- For coordinated load distribution in the grid, the increase in power output (power gradient), for example when the wind farm is started up, should be able to be restricted in accordance with the grid operator's specifications
- Wind farms should be able to contribute reserve energy within the grid. If grid frequency increases, the power output of a wind farm should be reduced
- If necessary, wind farms should be able to contribute to maintaining voltage stability in the grid by supplying or accepting reactive power
- Wind farms should be able to be integrated in the grid control system for remote monitoring and control of all wind turbines in the grid



TOWER AND FOUNDATION

TOWER CONSTRUCTION

The load dynamic design of materials and structure used in ENERCON towers provide the best conditions for transport, installation and use. Over and above the binding national and international norms (e.g.: DIN and Eurocode) ENERCON sets its own standards which surpass quality and safety norms.

Virtual 3D models of the tower designs are produced during the development phase using the finite element method (FEM). All possible stress on the wind turbine is then simulated on the model. This means that accurate predictions concerning tower stability and service life are not left to chance before building a prototype. ENERCON continuously evaluates additional measurements on existing turbines providing further verification of the calculated data. ENERCON's calculations are supported by results produced by specially commissioned certification bodies, research institutes and engineering firms.

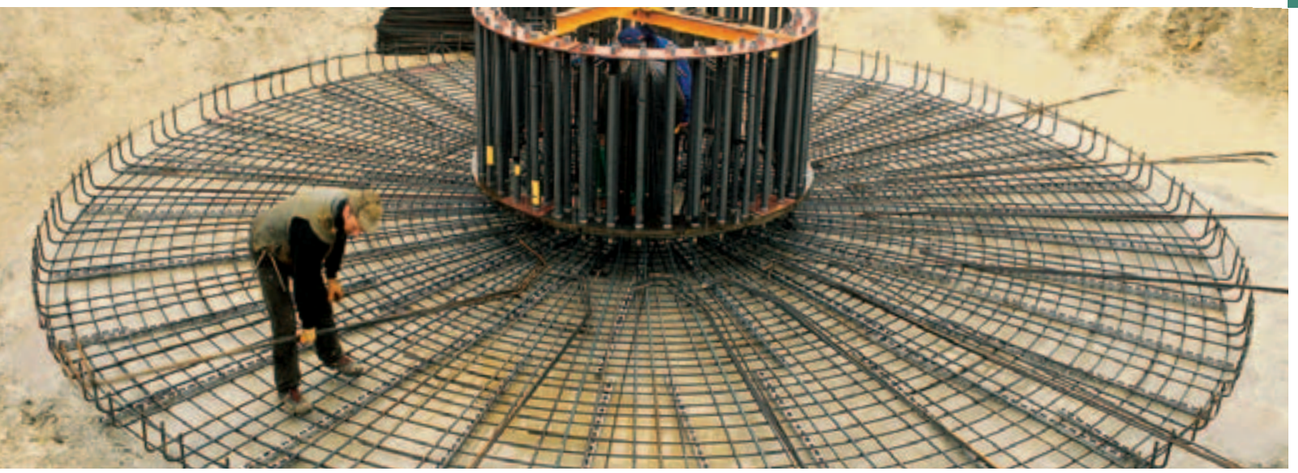
The aesthetic aspect is also a decisive factor during tower development, which is obvious in the finished product. The streamlined gradually tapered design offers a visibly sophisticated concept which has next to nothing in common with the huge and bulky conventional cylindrical structures.

TUBULAR STEEL TOWER

ENERCON tubular steel towers are manufactured in several individual tower sections connected using stress reducing L-flanges. Unlike conventional flange connections (such as those used in steel chimney construction), the welding seam of the L-flange is outside the stress zone.

OTHER ADVANTAGES OF THIS CONNECTING TECHNOLOGY ARE

- Dispenses with complicated and costly welding work on site
- Quick, reliable assembly with the highest quality standard
- Full corrosion protection, applied under best production engineering conditions



Foundation connection of small ENERCON steel towers

Due to their relatively small circumference, shorter ENERCON tubular steel towers are mounted on the foundations using a so-called foundation basket, which consists of a double rowed circular array of threaded steel bolts. A retainer ring, fitted to the tower flange dimensions, is used to hold the individual bolts in position. When the foundation is completed, the lower tower section is placed on the bolts protruding out of the concrete surface and then bolted with nuts and washers.

A specially developed foundation connection system is used for taller ENERCON steel towers. A cylindrical structural element is set on the blinding layer and precisely aligned with adjusting bolts. Once the foundation is completed, the tower is flanged together with the foundation section.

Like all other components, tubular steel towers are subject to strict ENERCON quality standards. Quality assurance begins already in the design development stages to ensure that the prototype meets all requirements before going into series production.

PRECAST CONCRETE TOWER

ENERCON precast concrete towers are made using specially developed prestressed steel reinforcement. The individual tower sections and foundation are fastened together to form an inseparable unit with stay cables running through jacket tubes in the core of the concrete tower wall. The tower sections themselves are manufactured entirely in the precasting plant. Specially constructed steel moulds assure manufacturing precision for each individual concrete section. This manufacturing process minimises dimensional tolerances which assures a high degree of fitting accuracy. Here again, ENERCON's Quality Assurance Department carries out strict inspections. Detailed procedural and work instructions are available for each manufacturing sector. This ensures that each individual manufacturing stage as well as the materials used can be completely retraced.

Production of ENERCON precast concrete towers

Reinforcement steel in ENERCON round foundation with foundation section for tall steel towers

FOUNDATION CONSTRUCTION

The foundation transmits the wind turbine's dead load and wind load into the ground. ENERCON foundations are always circular.

ADVANTAGES OF ENERCON ROUND FOUNDATIONS

- The forces are equal in all wind directions, whereas asymmetrical foundation pressure is possible with square bases or cross-shaped foundations
- The circular design has proven to reduce the amount of reinforcement and concrete required. The circular design reduces the size of the formwork area
- Backfilling the foundation with soil from the excavation pit is included in the structural analysis as a load. This means that less reinforced concrete is needed for foundation stability

Depending on the site, the ground can only absorb a certain amount of compressive strain so the foundation surfaces are adapted accordingly. ENERCON's circular foundations are designed based on this elementary realisation and as a rule are installed as shallow foundations. If necessary, (in soft soil for example) a special deep foundation distributes the load down to deeper load-bearing soil strata. The piles, symmetrically arranged, are slightly inclined so that the imagined extended pile centre lines meet at a point above the centre of the foundation. This provides maximum force/load distribution over the entire surface.

SERVICE-MANAGEMENT

More than 1,300 ENERCON service technicians worldwide provide high degree of technical wind turbine availability

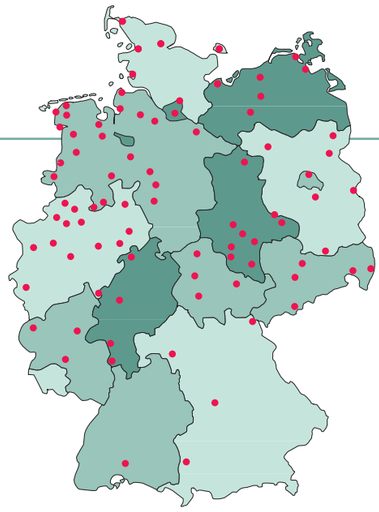
SERVICE-MANAGEMENT

The aim of ENERCON's Service Department is to ensure and maintain operational readiness for all ENERCON wind turbines. In accordance with the "Speedy service through local presence" principle, more than 1,300 employees worldwide expedite wind turbine maintenance and servicing. This means shorter distances for service technicians and ensures a high degree of technical availability (average in the last years more than 98.5 %).

A well-coordinated dispatch team is another important factor for efficient field service organisation. ENERCON has more than 100 employees coordinating global service operations, from both a technical and commercial point of view. Each operator has a designated point of contact in their service centre. Operators can be confident that the technician knows the site but also has detailed knowledge of the local conditions surrounding the wind turbines.

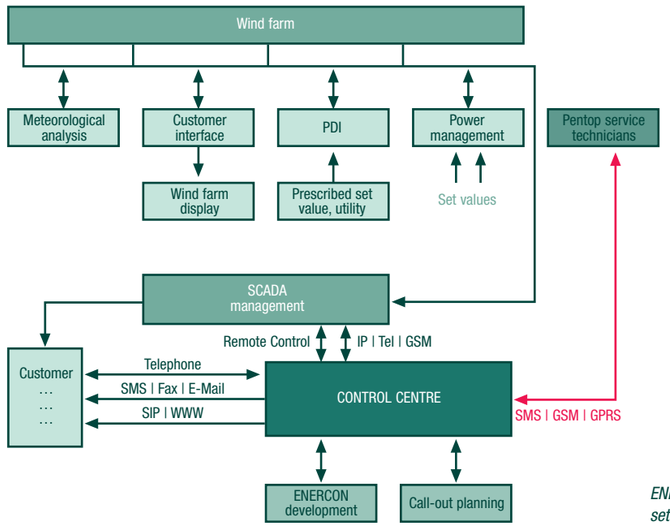
ENERCON SERVICE PERFORMANCE PROFILE

- Servicing and maintenance of all wind turbines installed by ENERCON
- Wind turbine monitoring via remote data transmission
- Maintaining technical availability of wind turbines serviced by ENERCON
- Customer care in all technical and commercial matters
- Operator training

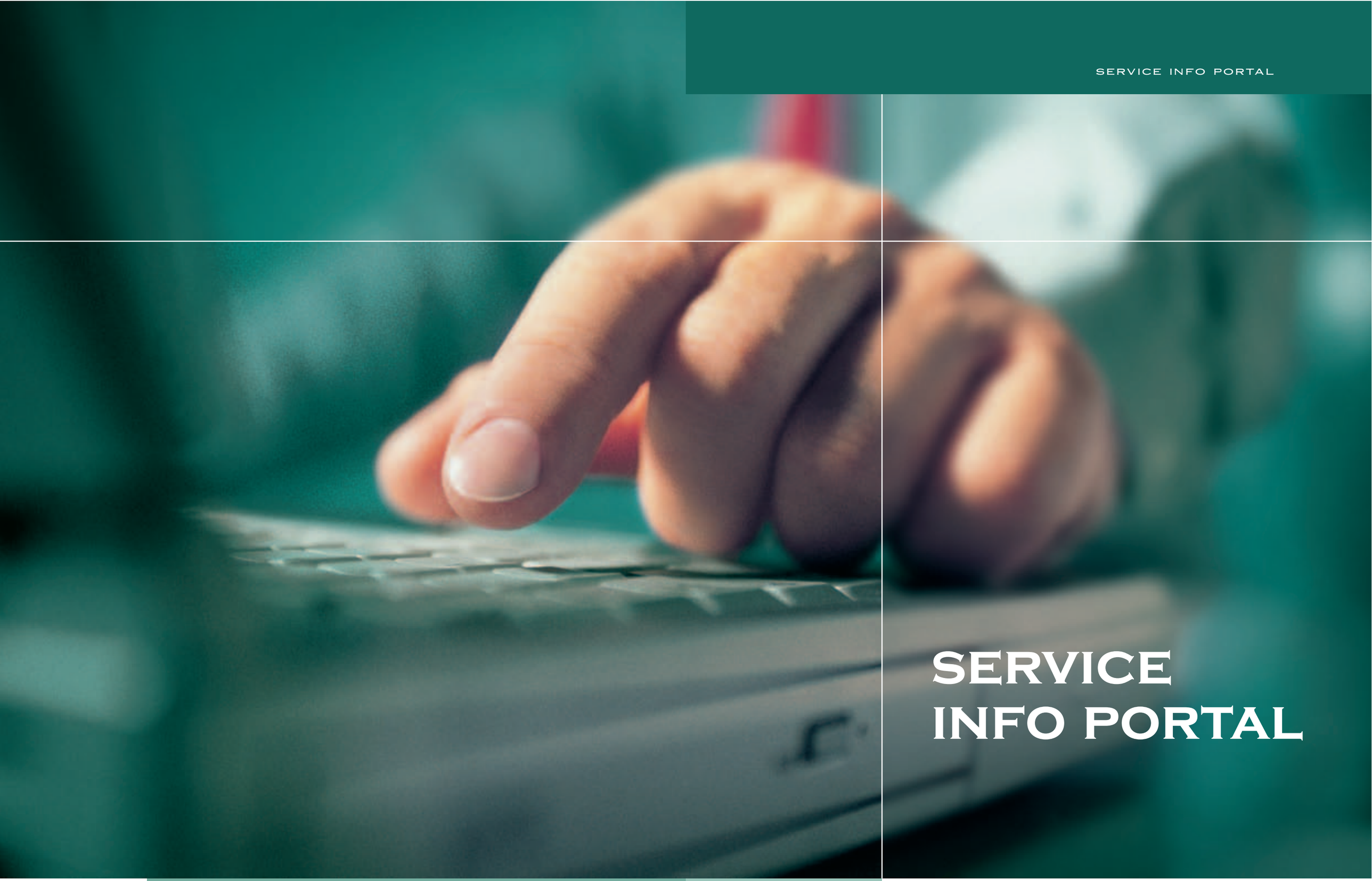


Service at a local level – decentralised ENERCON service structure in Germany

Each ENERCON wind turbine has a modem link to the central remote data transmission facility. If wind turbine signals malfunction, the service centre and the service branch in charge are notified via the SCADA remote monitoring system. The message is automatically transferred to the ENERCON deployment planning software and displayed on the dispatchers screen. With the aid of a specially developed locating system (GIS – Geoinformation System), the deployment planning system automatically locates the service team closest to the wind turbine. Service teams are able to access all turbine-specific documents and data using so-called pentops (robust, portable computers with a link to the service centre) ensuring that all maintenance is dealt with as quickly and efficiently as possible: A new standard in Service-Management.



ENERCON Service-Management sets new benchmarks



SERVICE INFO PORTAL

SIP enables customers to obtain any desired information on their own wind turbine via the internet

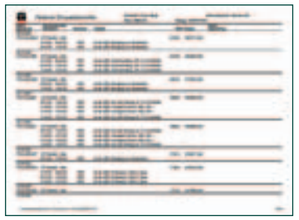
SERVICE INFO PORTAL

The Service Info Portal (SIP) offers customers simple and effective access to information concerning their own wind turbines via the Internet from anywhere in the world. The only requirement is a computer with a Web browser (e. g. Microsoft Internet Explorer) and an Internet connection. A changing PIN code, personal password and encrypted transmission routes ensure triple data protection security.

Since the SIP menu structure is clear and simple to use, customers have quick and easy access to all wind turbine data. Work processes, such as producing wind turbine analyses, checking maintenance logs or producing up-to-date yield overviews, which normally take hours, can be done in a matter of minutes using SIP: A boost in efficiency which not only increases customer satisfaction but also improves the flow of information (between partners in a wind farm, for example).

The Service Info Portal is available for ENERCON customers as basic, standard and premium versions. The basic package is included for all wind turbine owners without ENERCON PartnerKonzept (EPK; ENERCON Partner Concept). Customers with EPK can use the standard version free of charge. The premium package is provided to EPK customers for a fee and offers the possibility of performing more extensive technical and commercial evaluations.

SERVICE	SIP-Basic	SIP-Standard	SIP-Premium
Data from ENERCON service operations	●	●	●
Maintenance data	●	●	●
Availability evaluations		●	●
Yield comparisons			●
Activity evaluations			●
Technical master data			●
SCADA data evaluation			●
Power purchase price report/limited partner report			●
Next ENERCON maintenance/Fault message monitoring			●



Easy access to all wind turbine data such as service reports, maintenance data and availability evaluations

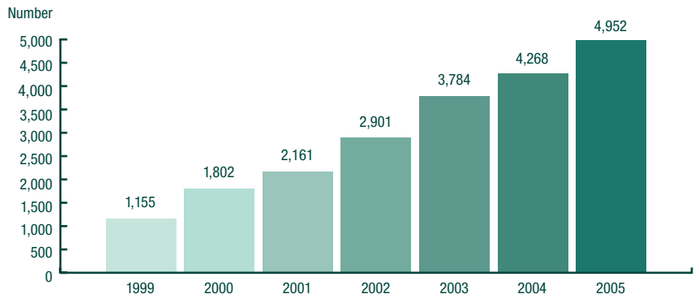
ENERCON PARTNERKONZEPT

The ENERCON PartnerKonzept (EPK) guarantees economical service reliability

ENERCON PARTNERKONZEPT

The ENERCON PartnerKonzept (EPK) gives customers the assurance of consistently high wind turbine availability for the first twelve years of operation with calculable operating costs. From servicing to safety inspections, maintenance and repairs, all eventualities are covered by a single contract. Because of its economical service reliability, the EPK has long since become an acknowledged ENERCON quality feature. More than 85 % of the international customers and 90 % of domestic customers sign an EPK agreement.

Damage caused by unforeseeable events such as acts of nature and vandalism can be covered by a specially developed additional EPK insurance policy. Significantly cheaper than conventional machine failure insurance, the additional EPK insurance policy is now available through all well-known insurance companies.



ENERCON wind turbines with EPK in Germany

YIELD-ORIENTED COST STRUCTURE

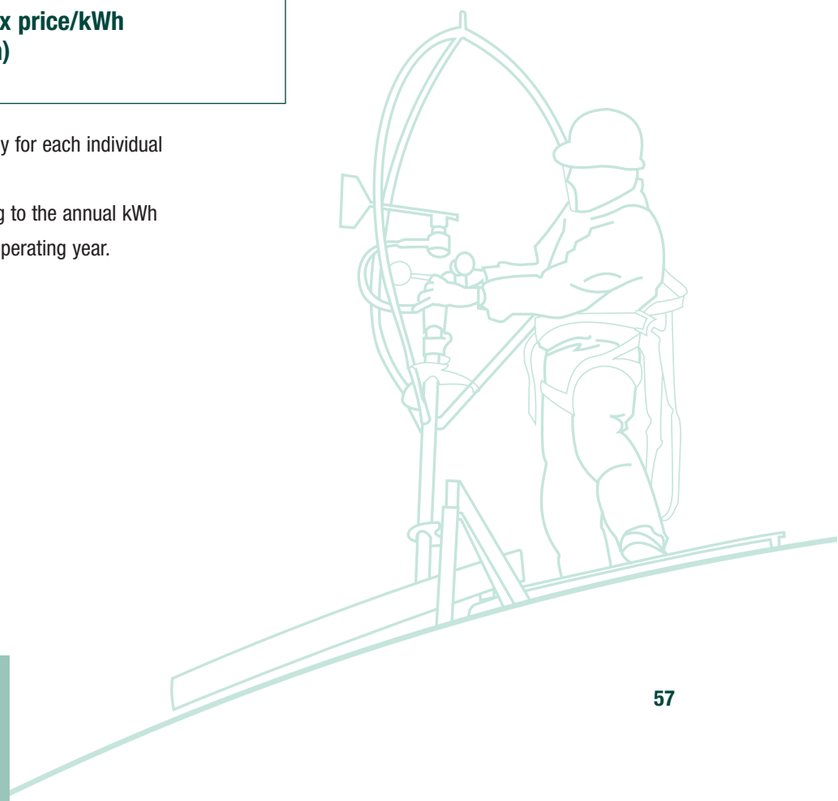
The costs for the ENERCON PartnerKonzept contract are based on the annual wind turbine output. The customer pays a minimum fee depending on the respective wind turbine type and a yield-oriented surcharge. This means that the customer pays more in good wind years with good yield and less in bad wind years with less output thus stabilising annual wind turbine profit.

In order to keep customer charges as low as possible, ENERCON assumes half of the EPK fee during the first five year operational period. The customer is then obliged to assume the entire fee starting from the sixth year of operation. This is a definite advantage for the operator.

Calculation formula

Fee = produced kWh x price/kWh (SCADA System)

1) The fee is calculated separately for each individual wind turbine/year.
2) The fee is calculated according to the annual kWh produced during the elapsed operating year.



SERVICE SAFETY WORLDWIDE

Spare part delivery depends on the wind turbine location. ENERCON offers two EPK variants: In Europe (EPK I) ENERCON bears any costs for maintenance, servicing and repair. Outside Europe, (EPK II) ENERCON and the customer share the risk for potential defects on the wind turbine's main components. ENERCON pays for material costs and the replacement on site, and the customer bears the cost for transport, crane provision and possible yield losses. This is the reason why the annual fee for EPK II is considerably lower than the fee for EPK I.

SERVICE	EPK I	EPK II
Guarantee of a technical availability of up to 97 %*	●	●
Yield-oriented cost structure	●	●
Agreement term of twelve years (with possible extension)	●	●
Maintenance		
Four maintenance operations per year	●	●
Delivery of all required materials	●	●
Material transport to site	●	●
Servicing**		
Performance of servicing operations	●	●
Delivery of all required materials	●	●
Material transport to site	●	●
Repair		
Performance of all repairs	●	●
Delivery of all required materials and main components (tower, rotor blades, hub, machine house, generator, etc.)	●	●
Main component transport to site	●	
Providing crane for main component replacement	●	
Remote monitoring (24 hours) by ENERCON SCADA	●	●

**Percentage individually defined in EPK contract and for EPK II: not valid during main component breakdowns*
***Excluding damage caused by customer or third parties*

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.

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.

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.

CONTENTS

TECHNICAL DATA

	Rated power	Rotor diameter	Swept area	Hub height	Rotational speed	Cut-out wind speed	Wind class (IEC)
 E33	330 kW	33.4 m	876 m²	44 – 50 m	variable, 18 – 45 rpm	28 – 34 m/s	IEC/NVN I and IEC/NVN II
 E44	900 kW	44 m	1,521 m²	55 m	variable, 12 – 34 rpm	28 – 34 m/s	IEC/NVN I A
 E48	800 kW	48 m	1,810 m²	50 – 76 m	variable, 16 – 30 rpm	28 – 34 m/s	IEC/NVN II
 E53	800 kW	52.9 m	2,198 m²	73 m	variable, 12 – 29 rpm	28 – 34 m/s	IEC/NVN S (V_{av} = 7.5 m/s, V_{ref} = 57 m/s)
 E70	2,300 kW	71 m	3,959 m²	58 – 113 m	variable, 6 – 21.5 rpm	28 – 34 m/s	IEC/NVN I
 E82	2,000 kW	82 m	5,281 m²	70 – 138 m	variable, 6 – 19.5 rpm	28 – 34 m/s	IEC/NVN II