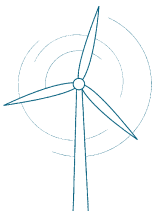


N90



Nordex N90/2500

New dimensions in the
3rd generation



NORDEX

We've got the power.



 **N90 wind farm "Ketzin"** near Potsdam, Germany.

20 YEARS OF ENGINEERING WITH WIND TURBINES.

Nordex was founded in Give, Denmark, in 1985. So today Nordex can look back on more than 20 years of experience in the development, construction and operation of modern wind turbines. In other words, we know what we are talking about when we design our turbines for a 20-year lifetime. Although Nordex has remained true to the Danish turbine concept, of

course much has changed in the field of engineering since the 80s. In the further development of our machines we have always been guided by the principle of continuous improvement. Our slogan is "Evolution instead of revolution". Although our engineers work with the latest computer-aided simulation models, nothing is more instructive than practical experience.



TURBINE CONCEPT OF THE N90/2500.

A good example of this is the new N90/2500. This turbine is a direct further development of our N80/2500 kW and N90/2300 kW series, which we have been producing and operating since 2000 and 2002 respectively. Around 600 N80, N90 and N100 machines are now* in operation worldwide, onshore and offshore. Some of these turbines have been installed at very challenging locations—thereby we have been

able to gain a great deal of experience. This wealth of experience has contributed to the optimised N90/2500. The deliberately generous overall design of the N80/N90 series made it possible to increase the nominal output of the new N90 to 2,500 kW. But the modifications also relate to many other details that have a positive effect on the turbines yield and reliability: some examples:

Optimisation of the N90 concept:

High level of availability in the pitch system:

- optimised emergency power supply for pitch drive
- further developed battery-charging management, which supplies the battery sets with a temperature-based charging voltage and conducts an automatic voltage test of the batteries every two hours. Each set of batteries is equipped with a charger
- automatic lubrication system for all three pitch systems
- ventilated water protection

Low-wear rotor brake

- active hydraulic rotor brake permits idling when separated from the network, relieving the drive train

Maintenance-friendly nacelle housing

- optimised nacelle casing provides better thermal properties, safer working and makes service and transport easier

Powerful yawing

- further developed brake and drive system
- intelligent control concept ensures low-strain yawing under extreme operating conditions

Automatic lubrication

- automatic greasing for components of the drive train and yaw and pitch system

All-location turbine concept for reliable yields

With the N90/2500 you opt for a mature product that has proven itself over and over again. And what is more, you have several options to choose from. The new N90/2500 is designed for locations with strong winds and locations with light winds, the HS-version (high-speed) is certified according to IEC 1b, the

LS-version (low-speed) according to IEC 2a (80 m tower). Nordex supplies the turbine as a 50 or 60 Hz version, depending on the country where you wish to connect your wind park to the grid. The HS version of the N90/2500 can also be employed offshore. The N90/2500 is our all-location turbine concept—your yield guarantee for every wind farm.

Our N90/2500 range at a glance

- ✓ N90/2500 LS 50 Hz
- ✓ N90/2500 HS 50 Hz
- ✓ N90/2500 HS Offshore 50 Hz
- ✓ N90/2500 LS 60 Hz
- ✓ N90/2500 HS 60 Hz

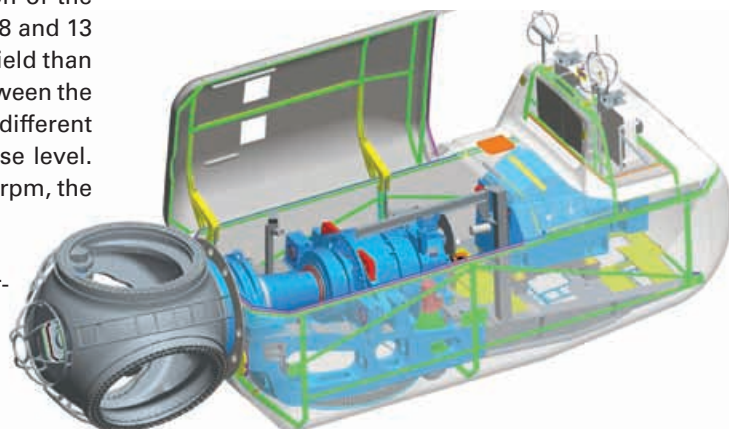


TECHNICAL SPECIFICATIONS	
Turbine concept	variable speed, single-blade adjustment
Nominal output:	2,500 kW
Rotor diameter:	90 m
Hub height:	70 m, 75 m, 80 m, 100 m, 120 m
Rotor	
Type:	upwind with active blade adjustment
Number of blades:	3
Swept area:	6,362 m ²
Speed range:	9.6–14.9 rpm (LS); 16.0 rpm (HS)
Tip speed:	approx. 70 m/s (LS); 75 m/s (HS)
Blade material:	glass fibre-reinforced plastic, integrated lightning protection
Tower	
Hub height:	70 m, 75 m, 80 m, 100 m, 120 m
Operating data	
Cut-in wind speed:	3 m/s
Nominal output wind:	approx. 13 m/s (HS), approx. 14 m/s (LS)
Cut-out wind speed:	25 m/s
Generator	
Type:	double-fed asynchronous generator
Nominal output:	2,500 kW
Nominal voltage:	660 V
Frequency:	50 or 60 Hz
Max. speed range:	740–1,310 rpm
Gearbox	
Type:	two-stage planetary gearbox with one spur-gear stage or differential gearbox
Nominal output:	2,775 kW
Transmission:	i = 71.9 to 92.9

TECHNICAL SPECIFICATIONS.

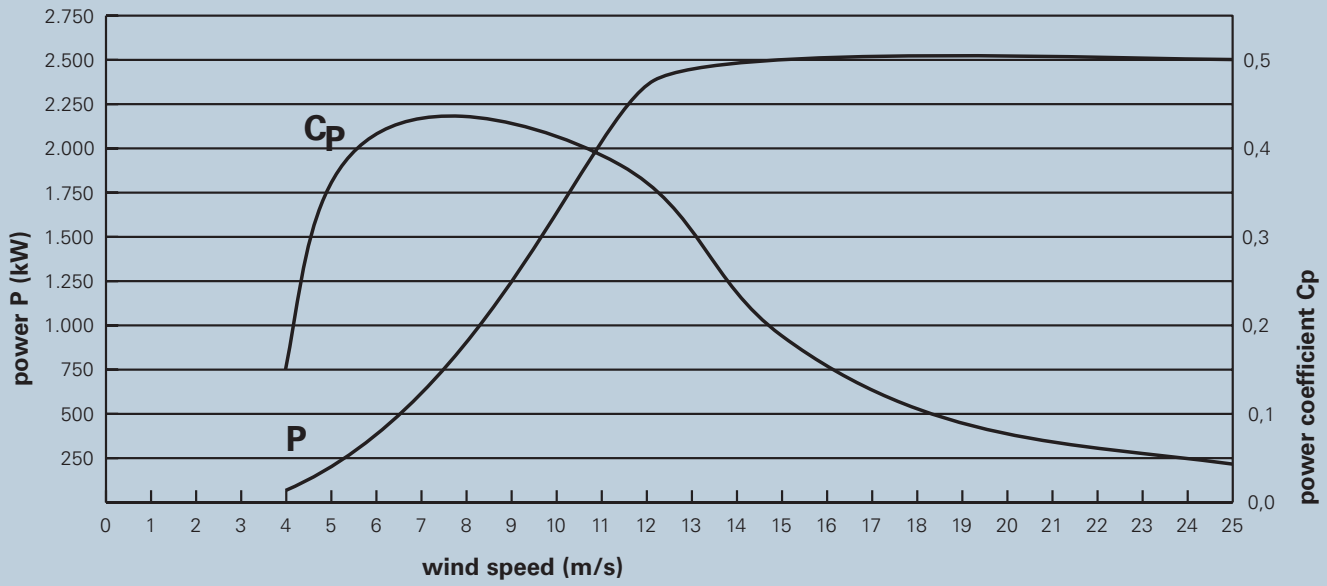
The higher speed at which the HS version of the N90/2500 rotates at wind speeds of between 8 and 13 m/s means that it produces a higher energy yield than the LS version. A further major difference between the HS and LS versions, apart from suitability for different locations (strong wind/light wind), is the noise level. While the HS has a nominal speed of up to 16 rpm, the LS is running at a maximum of 14.9 rpm.

This is reflected in the noise level. The reference output level at 95% nominal output is shown below:

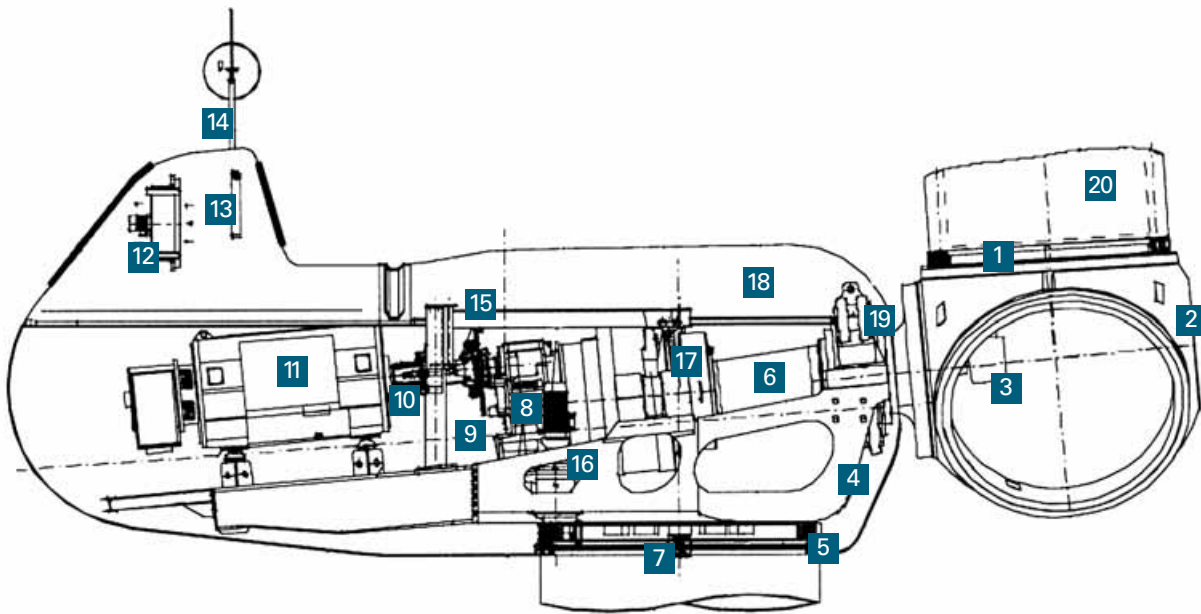


N90/2500 LS			N90/2500 HS	
reduced-noise operation at 95% red. nominal output			at 95% red. nominal output	
101.5 dB(A)	102.5 dB(A)	103.5 dB(A)*	104.5 dB(A)	107 dB(A)
1,600 kW	2,000 kW	Ca. 2,200 kW	2,500 kW	2,500 kW

*Calculated



N90/2500 LS power curve | High yield also at low wind speed.



- | | | | |
|-----------------|-----------------------|---------------------|---------------------|
| 1 Pitch bearing | 6 Rotor shaft | 11 Generator | 16 Yaw drive |
| 2 Rotor hub | 7 Yaw brakes | 12 Generator cooler | 17 Gearbox mounting |
| 3 Pitch drive | 8 Gearbox | 13 Gearbox cooler | 18 Nacelle cover |
| 4 Nacelle frame | 9 Safety brake | 14 Wind sensors | 19 Rotor bearing |
| 5 Yaw bearing | 10 Generator coupling | 15 Hoist | 20 Rotor blade |



Nordex rotor blade production | a N90 blade beside smaller blade generations.

NORDEX ROTOR BLADE CONCEPT.

One of the core components of the N90/2500 is the rotor with its diameter of 90 metres and a sweep of 6,362 square meters—equivalent to the area covered by a football pitch. With these dimensions, the N90 numbers among the largest onshore turbines, making it possible to exploit the maximum amount of energy from the wind supply.

But a rotor blade is also subjected to enormous strains. This is why only rotor blades fulfilling the highest standards in terms of manufacture and material quality are used for the N90/2500. For example, Nordex produces its blade by means of the vacuum-injection method, using a new type of VAP foil (Vacuum-Assisted Process; an EADS patent), which prevents even the smallest air pockets forming in component structures. In this process glass fibres are subjected to a vacuum in order to inject epoxy resin into the fibre material. The material used (glass fibre) is 10 per cent more resistant to tensile stress than conventional fibres. This is the result of a material test conducted by the Institut für Materialfor-

schung und Anwendungstechnik Dresden, which tests the material properties of airbus wings, among other objects. In addition to this, Nordex produces the supporting structures (struts, stays) separately from the aerodynamic shell in order to ensure a high degree of dependability in production and quality control.

Aviation industry as a benchmark

Thanks to the new geometry of the blade tip, Nordex has made major advances with regard to noise optimisation. The new profile has resulted in a significant reduction in noise emissions. One more special feature: the large proportion of aluminium in the tip ensures an extremely high level of protection against lightning, providing a safety bonus compared to many conventional rotor blades.

All the rotor blade types used by Nordex have withstood load tests above the design threshold. Furthermore, Nordex conducted extensive additional material tests when developing the rotor blade.



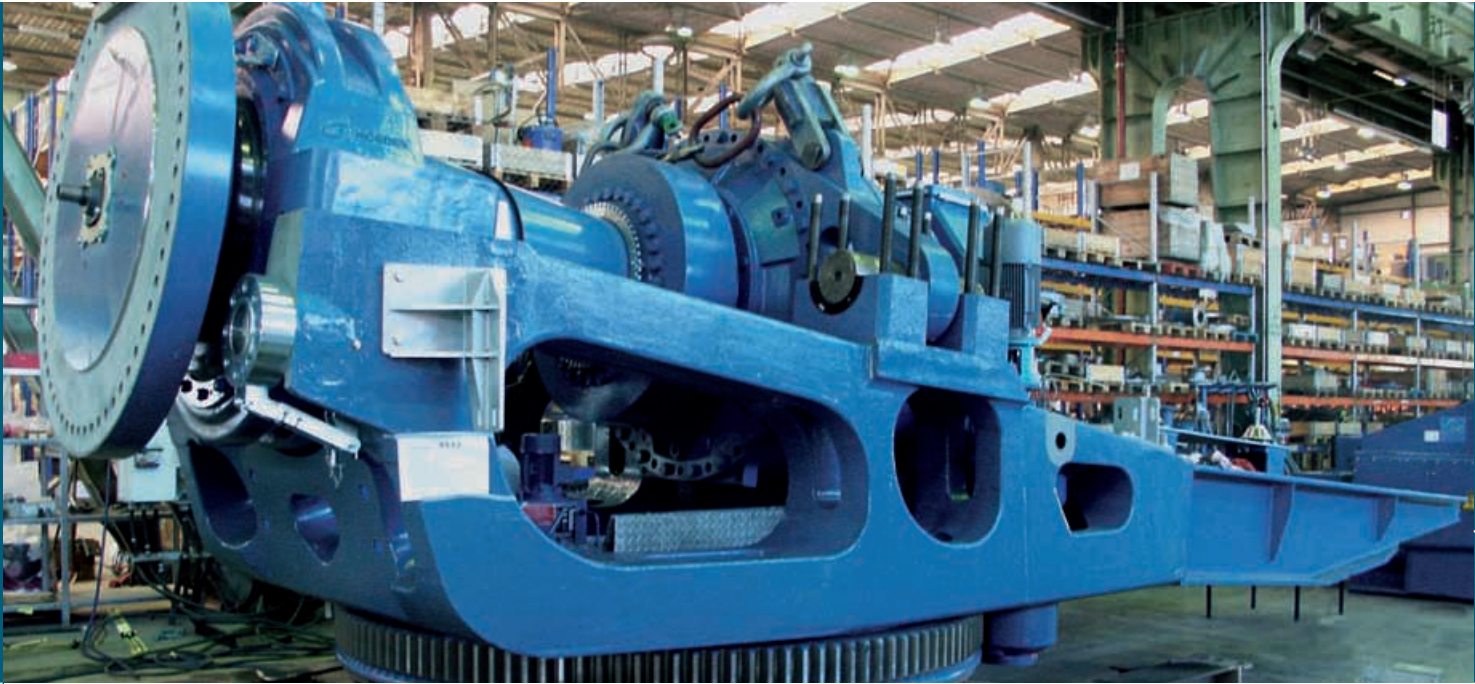
Component in the vacuum injection process.

Rotor blade installation.

Ready for take-off.

Your benefits at a glance:

- With a swept area of 6,362 m², one of the largest onshore serial-produced turbines
- High rotor blade quality thanks to vacuum-injection process using VAP foil
- 10% higher tensile strength of glass-fibre reinforced plastic
- Blade tip optimised for low noise
- High lightning protection thanks to aluminium blade tip



DRIVE CONCEPT.

For large turbines in the multi-megawatt class Nordex makes use of a gearbox-based drive concept. In this way it is possible to keep the tower-head mass low and so have dependable control of the loads in the system as a whole. The drivetrain consists of a rotor shaft, which is connected to the gearbox via a shrink-fit coupling. The speed is increased and transferred to the generator via a coupler with overload protection in order to be converted into correspondingly high electrical energy. This principle makes it possible to use very compact sub-assemblies. The relatively light weight and small volume for the N90/2500 power class also facilitates transport and installation of the turbine.

Gearbox with reliable torque split.

The N90/2500 can be supplied with different gearboxes. In addition to the two-stage planetary gearbox with a one-stage spur gear, the option of a differential gearbox is also offered. Both gearboxes are compact and reliably convert the high output (torque) of large turbines. This planetary gearbox was first used in the N80 in the year 2000 and has since established itself as the standard for large turbines on the basis of positive experience. Working principle: the power transmitted is split onto the planet wheels in order to ensure good transmission of the power torque. The power is brought together again on the spur wheel.

The torque split is slightly different in the differential gearbox. With this gearbox the rotor torque is transferred to two planetary stages and converted, and the two power lines are subsequently reunited in the third planetary stage. Here, the torque and speed are converted again and passed on to the generator by the spur-wheel stage.

Heat is removed from the gearbox through the oil circuit in an oil/air cooler. A pump with two pumping stages forces the gearbox oil through a combined filter element (coarse filter 50 μm , fine filter 10 μm) into the cooling circuit. The job of the coarse and fine filters is to remove solids from the gearbox oil. As an option, an additional ancillary flow filter system (ultrafine filter 5 μm) can be installed.

If the optimal operating temperature has not yet been reached, a thermo-bypass returns the oil directly to the gearbox. If the optimal operating temperature of the oil is exceeded, the active oil/air filter is switched on and the oil is cooled.

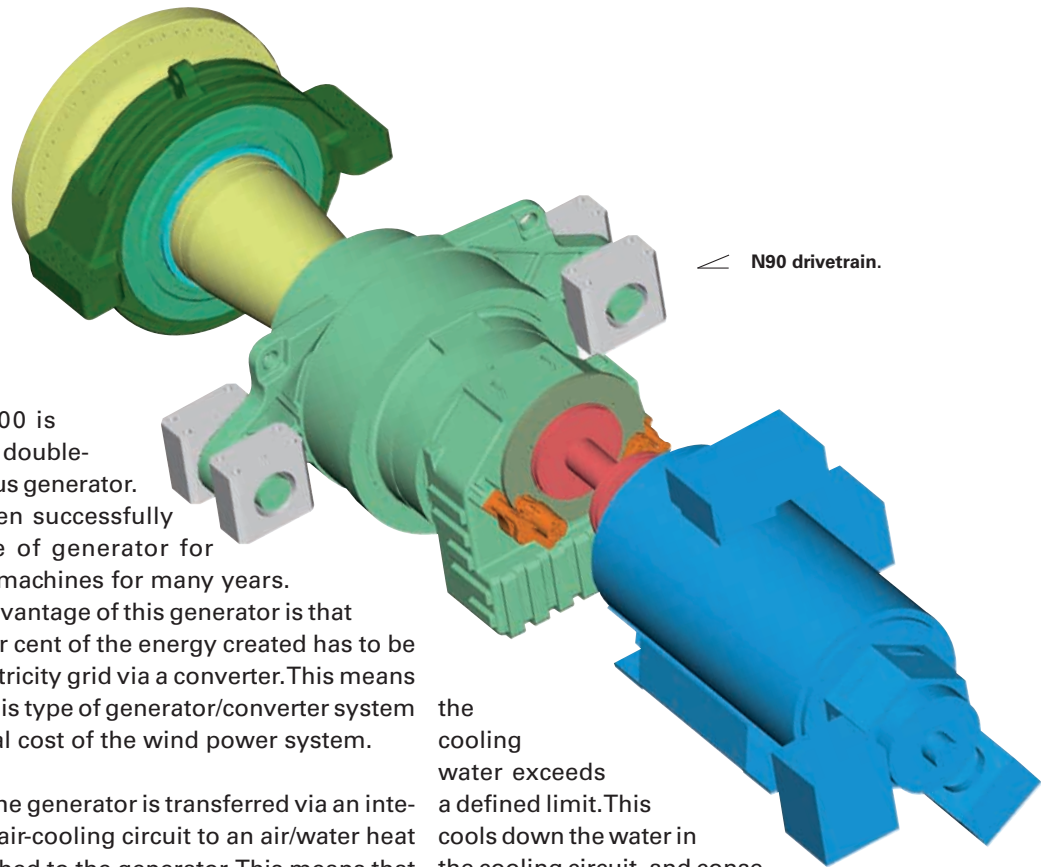
The cooled and filtered oil is carried specifically to those components subjected to high thermal loads and to all those points requiring lubrication (bearings, gear teeth, etc.).

Your benefits at a glance:

- Compact drive train
- Low tower-head mass
- Guaranteed installation quality
- Multi-megawatt gearbox design
- Reduced-load operation via drivetrain damping



▲ N90 drivetrain.



◀ N90 drivetrain.

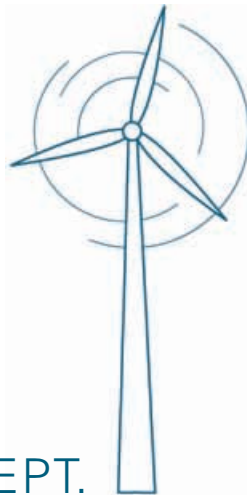
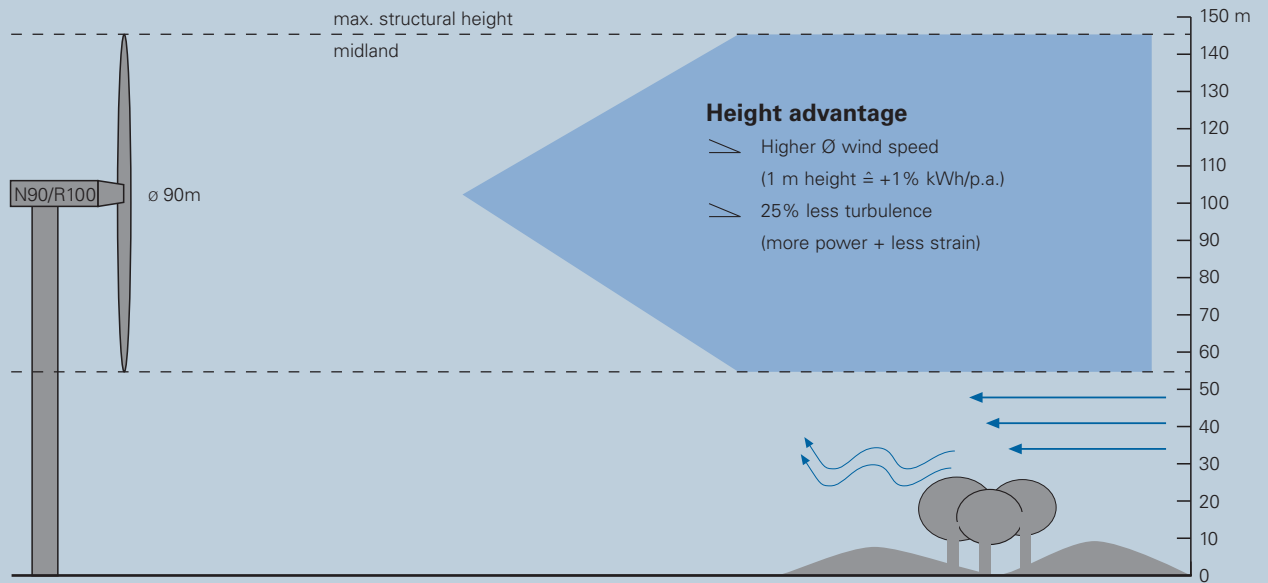
Generator

The N90/2500 is equipped with a double-fed asynchronous generator. Nordex has been successfully using this type of generator for variable-speed machines for many years. The principal advantage of this generator is that only 25 to 30 per cent of the energy created has to be fed into the electricity grid via a converter. This means that installing this type of generator/converter system reduces the total cost of the wind power system.

The heat in the generator is transferred via an integrated (closed) air-cooling circuit to an air/water heat exchanger attached to the generator. This means that the generator is more effectively cooled than in a water-jacket cooled generator as the air is able to flow through the rotor and safely and rapidly dissipate the heat generated there. The cooling water is then led to an active water/air heat exchanger outside the nacelle using a maintenance-free centrifugal pump. This pump is switched on as soon as the temperature of

the cooling water exceeds a defined limit. This cools down the water in the cooling circuit, and consequently that in the generator, to the optimal operating temperature.

The N90/2500 is operated using a newly developed active drivetrain damping system. This intelligent control system makes it possible to operate the machine at a reduced load.



TOWER CONCEPT.

Modern wind turbines are becoming taller and taller. There are good reasons for this: high above the ground the wind always blows more strongly and more constantly. Due to turbulence resulting from obstacles on the ground (roughness length) the wind quality improves with increasing height, above all inland. Apart from the tower costs, building permission often means that the limits for adjusting the hub height are very tight. Typical construction height limits are between 80 and 100 m. In Germany hub heights of more than 100 metres are becoming increasingly popular. This is why Nordex is initially offering the N90/2500 with hub heights of 80 and

100 metres. This puts the rotor sweep in the height range of 55 to 145 metres (100 m tower) or 35 to 125 metres (80 m tower). The 100-metre tower is ideal for inland locations whereas the 80-metre tower is more suitable for locations near the coast. Also a tower with a hub height of 120 metres is available.

Tower features:

Inside the 100 m tower there are the lift and working platforms. As an option it is possible to supply a tower with an integrated transformer. Corrosion protection of the tubular tower is achieved by means of an epoxy resin coating on the surface.



High energy yield also in midland due to large hub heights.



View into a tower at the installation phase.



Remote monitoring in Rostock.



SYSTEM CONTROL.

Operation control of the N90/2500 is effected using Nordex Control 2 (NC2). This software and hardware controls individual wind turbines as well as wind farms or the interconnected power plants of decentralised power utilities. NC2 continuously evaluates all the operating and climatic data measured, ensuring that the turbine operates with optimum yield. To do this, Nordex adapts each control system with parameters specific to the machine and location. The wind turbine works with two measuring instruments to record the wind speed and direction. The first is used for control while the second monitors the first unit. If one of the measuring instruments breaks down, the other is used for controlling.

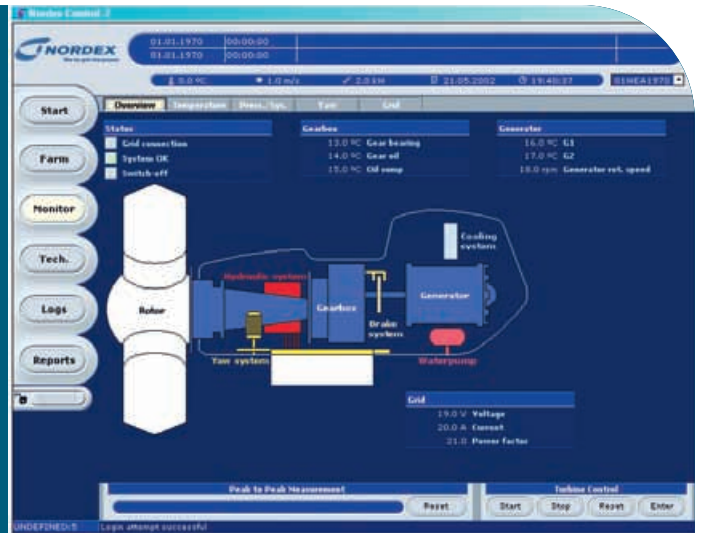
What does this mean in practice? If there is no wind, the turbine remains at rest (energy-saving mode) and only the control computer works, collecting the climatic data. The other systems are only switched on when required, meaning that no electricity is used. The exceptions are those functions of relevance to safety, such as the brake system. Once the cut-in

wind speed (3 m/s) is reached, the turbine changes to "operation" mode. Now all the systems are tested and the nacelle aligns itself with the wind direction. The rotor blades are pitched to the starting position so that the wind can start the rotor rotating. As the wind gets stronger, the rotor begins to turn faster. Once the defined synchronisation speed has been achieved, the generator is connected to the grid and the turbine produces electricity. During operation the nacelle constantly follows the wind direction. If the cut-out wind speed (25 m/s) is exceeded, the system is stopped by turning the rotor blades through 90° in the direction of the wind. Then the rotor slows down.

The operation control system offered can easily be integrated in the Nordex modular SCADA system. On request, all existing wind farm management systems can also be implemented. This system level also has the same user interface as all other turbines with an NC2 control system and is ideally suited for its own modular overall system.

Your benefits at a glance:

- Location-specific control for individual turbines or wind farms
- Security due to redundant systems
- 24-hour remote monitoring
- Autonomous safety systems (emergency off in the event of power cut)

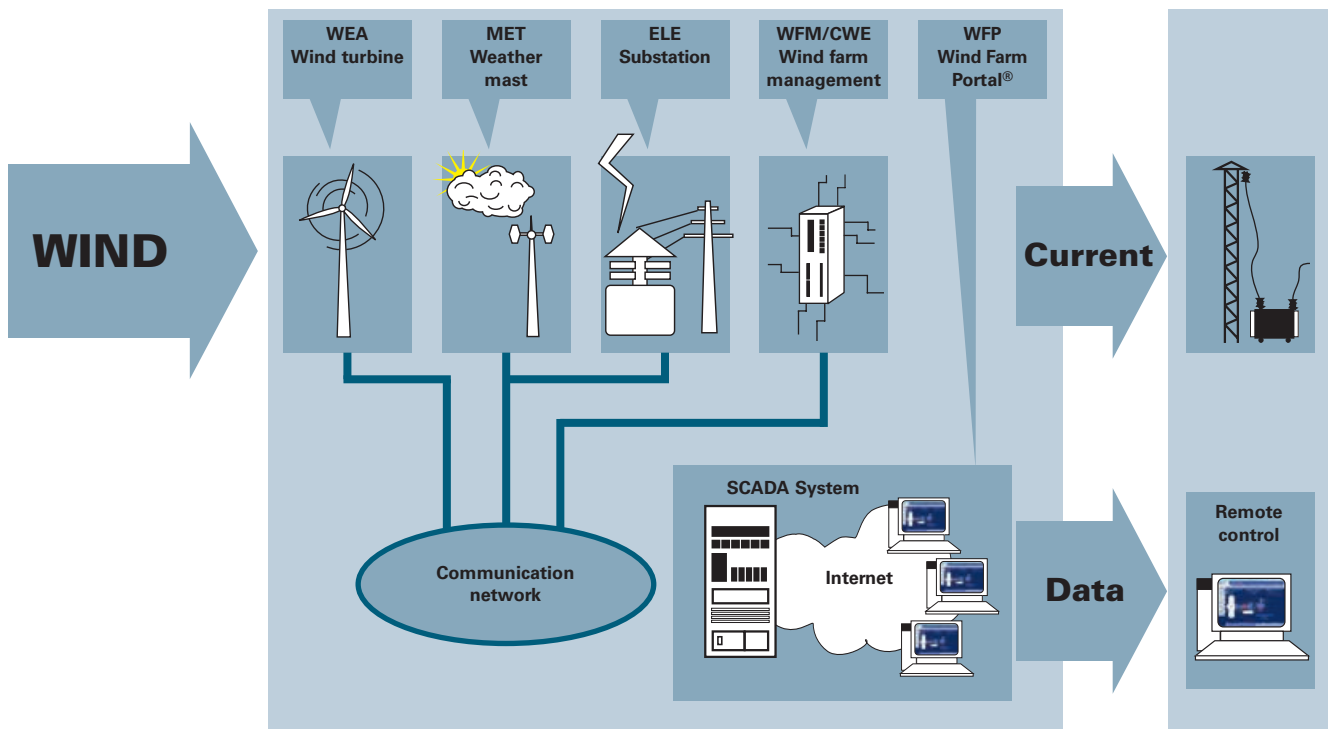


Visualisation of a turbine in the NC2 control system.

On watch round the clock

The control system of each turbine is equipped with components (hardware and software) for remote data monitoring. All data and signals are transmitted via an ISDN connection and are accessible through an Internet browser. This makes it possible to monitor data as well as active remote control (such as starting and switching off) of every turbine operating worldwide from the Nordex ser-

vice centre in Rostock. In the remote control centre experienced staff check the operating data from the connected wind farms round the clock as well as any automatic alarms received—if operating data deviate from the reference value. In the event of an emergency the turbines have an interruption-free power supply. Together with the batteries in the pitch system, the system is safely run down in the event of a power cut.



The Wind Farm Portal® Nordex Control 2 | registers all the data concerning individual wind turbines, the meteorological and management systems, the substation as well as the complete wind park.



Your benefits at a glance:

- Secure annual yields thanks to the full-service concept
- Short reaction time ensured by service network and expert remote monitoring
- High level of staff qualification thanks to company's own academy



NORDEX SERVICE.

A secure and high level of technical availability is the key to every operator's investment in a wind turbine. After all, the machine should produce high yields over a useful life of at least 20 years, ensuring a high return on capital. Nordex ensures this by means of high product and manufacturing standards (ISO 9001). On the other hand, Nordex offers a comprehensive range of services. This multistage service range is divided into three packages: Premium, Extended and Basic. Premium customers have the highest degree of security that they will be able to realise the technically possible annual yield. Only the risk of poor

wind conditions or damage resulting from force majeure are not covered by Nordex. And if a customer does not wish to be responsible for technical operation of the turbines, he can assign this task to Nordex. Nordex then takes direct charge of operation management and supplies all the commercially relevant data. The Service division looks after the majority of the wind turbines erected by Nordex in the past 20 years: by means of remote monitoring and for local maintenance work and rapid service activities using a dense global network of service stations geographically located to be close to the wind farms they

are responsible for. In this way the service network grows with the number of turbines installed and supported. The service staff are continuously trained in the company's own academy. This academy has also achieved success in training new staff or teaching technical innovations and developments.

PERFORMANCE	PREMIUM	EXTENDED
Service/maintenance of all components, incl. the tower	yes	yes
24-hour remote monitoring	yes	yes
Repair work	all repairs excl. damage by third parties or force majeure	up to EUR 2,000 per annum (net)
Availability guarantee	96% (wind farm) or 95% (individual turbine in GER)	96% (wind farm) or 95% (individual turbine in GER)
Technical operation management	optional	no
Lifetime	9 + 3 years	6 + 3 years

Service contracts for N90 customers.



EQUIPMENT, OPTIONS AND ACCESSORIES.

The N90/2500 can be ideally adapted to the respective location by means of additional equipment.

Condition Monitoring

Nordex offers a condition monitoring system for the N90/2500 in order to continuously monitor changes in components. This early-warning system informs the operator if a component of the machine needs to be upgraded in the foreseeable future. This makes it possible to avoid unscheduled machine downtimes and expensive service work.

Grid access options

The N90/2500 is always supplied as grid-compatible. In other words, Nordex makes sure that the machine complies with the local grid-access requirements (e.g. according to the E.on directive, Version 8/03).

Spinner

The offshore version of the N90/2500 is equipped with a spinner. This provides the hub with additional protection against the weather which makes service work easier especially in "heavy weather". The spinner is also available as an option for onshore machines.

Service platform

Nordex also offers a service platform for offshore turbines. This makes it possible to land service staff on the nacelle by helicopter if the machine cannot be reached by boat.



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