PC-based control technology from Beckhoff is in use in wind turbines up to a size of 5 MW.
With around 19,800 megawatts of newly installed wind power capacity, 2007 was a record year for the wind energy sector. The capacity installed worldwide increased to 94,000 megawatts. Germany was top of the international ranking list with 22,200 MW, followed by the USA with a total capacity of around 16,800 MW, Spain with approx. 15,200 MW and India with approx. 8,000 MW. China was in fifth position with an installed capacity of around 6,000 MW. The global wind power boom is a result of growing concern about climate change, security of supply and dwindling oil resources in combination with the fact that wind power is becoming increasingly cost-effective.

Few would have believed predictions made in the early 1980s that today Germany would produce approx. 40 billion kilowatt-hours – i.e. around 7 percent of total electricity consumption – from wind power plants. At the time, such figures appeared just as utopian as the idea that PC-based automation could become established as a worldwide standard in a wide range of industries. However, in both cases expectations were not only met, but exceeded. According to calculations produced by the German Wind Energy Association (BWE), an installed capacity of 45,000 MW onshore and 10,000 MW offshore is quite a realistic prospect for Germany by 2020. This would correspond to around 150 billion kWh of CO2-free electricity per year, equivalent to 25 percent of total electricity consumption. In order to achieve this ambitious target, existing wind power installations will have to be expanded and so-called first generation systems will have to be replaced with new, high-performance multi-megawatt systems (repowering), and new wind farms will have to be built.

In August, the go-ahead was given for the construction of “Alpha Ventus”, the first German offshore wind farm at sea, located around 45 kilometers off the coast of the island of Borkum. Beckhoff contributed its expertise as control equipment supplier for this pilot project consisting of six wind energy converters from the Multibrid M5000 5 MW class (see p. 17).

Beckhoff entered the wind power market as an automation supplier at an early stage, and today we have a wind power competence center at our Lübeck branch offering sound industry know-how.

Compared with a conventional solution, the Beckhoff PC-based control system has the advantage that only a single computer is required for control and data interfacing purposes. EtherCAT, our high-speed-fieldbus system, is able to demonstrate its strengths: maximum performance, flexible topology, integration of subordinate fieldbus systems (e.g. for the connection of autonomous pitch control systems), 200 kHz sampling rate in the field for future expansion of the control system to form a condition monitoring system, and cost-effective conversion between copper and optical fiber technology (e.g. for the fieldbus connection between the tower base and the nacelle). The Beckhoff system also offers superior safety performance: While previously, the nacelle and tower were “hard wired”, today all safety sensors and actuators are integrated in the Bus Terminal system via TwinSAFE technology. Beckhoff is probably the only supplier able to offer control systems, automation components, control cabinets and even system management software from a single source – a considerable advantage for customers.

In addition to Europe and the USA, we are also active in the Chinese market as an automation partner for producers of wind energy converters. The Chinese wind power market is also booming, which is not surprising in view of the voracious appetite for energy associated with the country’s rapid economic growth.

The Chinese government has an ambitious target of 30,000 MW installed wind capacity by 2020. This means that China is likely to become the leader in the wind power market over the coming years. Meanwhile, there are around 60 manufacturers of wind energy converters in China. The majority are currently still owned by foreign investors, although the number of Chinese business start-ups is increasing steadily. Beckhoff supplies control equipment for e.g. Mingyang (see p. 18) and Goldwind, the market leader in China. Goldwind supplied the wind energy converters for the recently opened Beijing Guanting Wind Farm, which is the first wind farm in Beijing and served as a showpiece for clean energy generation during the 2008 Olympics. The wind farm meets 5 percent of the electricity demand of the Olympic stadium.

On this note, we hope you enjoy reading our “Wind Special” and wish you high availability for your systems.

Dirk Kordtmeikel
Wind power expert and manager of the Lübeck branch
Special: PC Control for wind turbines
In the course of this development, besides the European markets which were dominant until recently, new markets such as China and India or – once again – the USA, are pushing themselves to the fore at terrific speed and placing new demands on wind turbines and their automation. Representative of these demands are the requirements made by different conditions for feeding the grid and by greatly extended climatic operating conditions. Whereas up until a few years ago the use of wind turbines under Arctic or desert climatic conditions was an exception for research purposes, nowadays the fulfillment of these extreme conditions has almost been elevated to an industry standard. Manufacturers of wind turbines therefore face the task of retaining maximum flexibility in face of the continually changing demands of the market in order to keep their products competitive.

Beckhoff PC-based control technology and automation components are nowadays in use in wind turbines up to a size of 5 MW – including cold climate regions such as the North Cape and extreme climatic regions such as Inner Mongolia.

**Continuity and flexibility using PC-based control**

Beckhoff implements open automation systems on the principle of PC-based control technology. This openness in relation to the software and hardware interfaces enables the turbine manufacturers to adapt their systems to varying demands both in the first draft design and also for later system expansion or modification at low cost.

The open, scalable TwinCAT automation software is a software PLC for PCs. Programming in accordance with the international IEC 61131-3 standard guarantees the turbine manufacturers high investment security. The utilization of technological standards based on the Windows operating system opens up numerous expansion options and allows the user to benefit from the rapid development of the computer industry. It also enables the universal use of one technology for all types of turbines.

Data provision and data management in particular occupy a key position for control and evaluation of turbine performance both vertically (from the machine to the central control room) and horizontally (between the individual intelligent components and sub-systems of the turbine and...
Advantages of Beckhoff technology for wind turbines

- advanced technologies, tried and tested in a wide range of industrial applications
- flexible, modular system, consisting of: Industrial and Embedded PCs, controllers, displays, Bus Couplers, Bus Terminals and fieldbus systems
- special terminals available as standard: 3-phase power measurement terminal, oscilloscope terminal, PWM, etc.
- straightforward integration with any relevant industrial bus system, no limits regarding combination options: EtherCAT, Ethernet, DeviceNet, CANopen, PROFIBUS, Modbus, Interbus, RS232, RS485, etc.
- integrated safety Bus Terminals (TwinSAFE)
- single software tool (TwinCAT) for all automation hardware platforms
- open industrial standards: (IEC 61131-3, Ethernet TCP/IP, PLCopen, OPC)
- genuine real-time characteristics (jitter < 10 µs)
- wind-specific customer know-how encapsulated in application software

also between the turbines within a wind farm). Local data banks as a basis for the higher ranking data backup and data preparation do not pose any problems for the PC whatsoever. Porting all functions to PC hardware also simplifies data transfer – generally via Ethernet – to the production databases and ERP systems.

**EtherCAT: High-performance communication system for the tower/nacelle and the control room**

Beckhoff supplies a complete range of fieldbus components for all common I/O and fieldbus systems. The Bus Terminals and EtherCAT Terminals available are sufficient for the complete range of signal types and fieldbuses that are of relevance for wind power. EtherCAT, the fast Ethernet-based fieldbus, offers optimum real-time properties for time-critical process requirements without the need for special hardware in the central processing unit. With XFC technology (eXtreme Fast Control Technology) a time resolution of < 100 ns is possible with the time stamp technique. Sensor signals can be read with sampling times of less than 10 µs.

**Integrated safety using TwinSAFE**

In recent years, operational safety and work safety have played an ever larger part in machine construction. With TwinSAFE, Beckhoff offers an integrated system solution with optimum synergy between automation technology and safety technology. TwinSAFE integrates safety functions in the existing control architecture and in particular helps to significantly reduce the wiring costs for the higher-level hard-wired safety chain in the wind turbine.

www.beckhoff.com/wind
Husum WindEnergy 2008 – leading international wind energy trade show

The Husum WindEnergy will be the scene of the world’s largest wind energy trade show from 9th to 13th September 2008. Around 700 companies, manufacturers of wind turbines and sub-suppliers from 35 countries will be presenting their solutions in four halls. Beckhoff is presenting its open automation solutions for wind turbines in Hall 4, Booth C23.

Robert Müller, Branch Management Wind Energy at Beckhoff, predicts healthy revenue growth in this segment: “A recent survey of manufacturers carried out by the German Wind Energy Institute (DEWI) indicated that last year the German wind industry clearly maintained its leading position in the world market. In 2007, German manufacturers and suppliers had a 28 percent share in worldwide sales totaling 22.1 billion euros. The export ratio increased from 74 percent in 2006 to more than 83 percent in 2007. With our PC- and EtherCAT-based control technology, we offer an integrated solution that has been tried and tested worldwide and covers pitch control, operation control for the tower and the nacelle, wind farm networking and the control room.”

The main information at a glance:
| Husum WindEnergy 2008, Germany |
| 9 – 13 September 2008 |
| Opening hours: Tuesday – Friday: 10 am – 6 pm |
| Saturday: 10 am – 4 pm |
| Beckhoff booth: Hall 4, Booth C23 |

www.beckhoff.com/husumwind
www.husumwind.com

Goldwind wind farm supplied electricity for the Olympics in Beijing. The company Goldwind is the market leader among wind energy converter manufacturers in China. Goldwind supplied the wind energy converters – equipped with Beckhoff control technology – for the recently opened Beijing Guanting Wind Farm, which is the first wind farm in Beijing and a showpiece for clean energy generation for the 2008 Olympics. The wind farm meets 5 percent of the electricity demand of the Olympic stadium.
On January 7, 2007 DeWind had cause for celebration. It was the day the new DeWind D8.2 was commissioned at Cuxhaven, Germany. It marked an energetic comeback to the wind sector by the Lübeck-based manufacturer with a fully revised design for its flagship model.

From the outside, the DeWind D8 seems unchanged. Only the windows in the nacelle roof provide a little more insight than in the past. Otherwise, the spectacular Porsche design has been retained: like all large modern wind turbines the system is pitch-controlled. The hub height (80 and 100 meters) and the rotor diameter (80 meters) are the same as in the previous model. With a rating of 2 megawatts, the capacity also remained unchanged.

However, almost everything changed inside. The reason is that DeWind, following the sale of the company to an English-American investor, repositioned its wind turbines primarily for the U.S. market. Accordingly, the special characteristics of the American energy supply system had to be taken into account. To start with, the U.S. grid is operated with 60 Hz, as opposed to 50 Hz in Europe. In addition, the American supplier General Electric has a patent on field-oriented converter systems for wind turbines and was blocking access to the U.S. market.

Breaking new ground for wind energy
DeWind therefore decided to use a radically new design, breaking with its own technological tradition. DeWind had used variable-speed systems since it was established in 1995. In such systems uniform voltage and associated high current quality is ensured by a double-fed induction generator and a converter. Strong variations in wind speeds on the rotor side must be converted to constant fre-
quency on the grid side. The design enables DeWind to build systems that can be used economically onshore in areas with relatively low wind speeds. Systems of this type are successfully sold in Europe.

The move into the U.S. market forced the company to find new solutions. These efforts led to a design that is unparalleled in the wind energy sector. At the core of the new design is a variable-speed hydraulic gearbox. The three-stage planetary spur gear unit used in the European DeWind D8 model was replaced with a two-stage gear unit. The third stage was replaced with a WinDrive® unit, a highly dynamic mechatronic drive system from Voith Turbo.

This proven technology has been used for decades in the energy sector, particularly in applications where the focus is on operational reliability, precise control dynamics and low operating and maintenance effort.

With the aid of WinDrive®, the DeWind D8.2 converts the variable speed of the wind rotor into constant speed for the synchronous generator, which is directly connected to the grid. The converter that deals with this task in a double-fed induction generator is no longer required. This means that a complex electronic component is replaced with a low-wear drive system without any power electronics. In this way, DeWind is presenting a technology that is vastly different than the GE patent and can position its systems freely and without additional costs in the United States. At the same time DeWind is able to fully – and more effectively than the competition – meet current and emerging grid connection regulations.

In Germany wind turbines fed nearly 40 billion kWh into the country’s electrical grid in 2007, equivalent to more than 7 percent of total German demand. This success leads to new challenges: wind turbines must be integrated into the grid
management arrangements, which becomes particularly relevant in the event of malfunctions, voltage drops or short circuits. Systems with synchronous generators are better suited for this purpose than systems with other generator systems. More than 95 percent of all electrical energy is generated with synchronous generators, which is why transmission and protection systems are designed for their inherent fault characteristics. Despite elaborate solutions, it is difficult for converter systems to reach the harmonic mains quality of a synchronous generator.

**EtherCAT and TwinSAFE help put a new spin on wind turbine control**

The redesign of the turbine system also required a redesign of the control and automation system. DeWind had developed the control system for the D8 in close cooperation with Beckhoff. It is based on a Beckhoff Industrial PC and TwinCAT automation software from Beckhoff. The application software was developed by DeWind. The control system analyzes around 350 I/Os. The real-time system requirements are within the range of a deterministic cycle time of 10 ms or around 1 ms with grid feeding and monitoring. The DeWind D8 already used flash drives for mass storage, not least in view of the harsh operating environment. The open Beckhoff control system permits connection via all commercially available PC interfaces.

EtherCAT was selected as the communication system: the DeWind D8.2 is equipped with two separate high-speed EtherCAT communication circuits for system and wind farm networking. The communication is based on optical fiber. System safety and availability are guaranteed via a redundant configuration. The safety chain, which is usually hard wired in wind energy applications, was integrated in the automation hardware with TwinSAFE, the safety solution from

A 60 Hz version of the DeWind D8.2 was built in Sweetwater, Texas, in March 2008.
DeWind D8.2: a proven solution thanks to real-time test environment

In order to complete the D8.2 project in such a short time, DeWind decided to take a new development route. The physical elements of the wind turbine and the drive system were simulated, tested and adapted to each other based on an advanced computer model. In this way, the turbine had already run in simulation for several hundred hours and mastered all conceivable operating situations before the power switch between the turbine and the grid was closed for the first time. As part of this development process WinDrive® was equipped with a separate Beckhoff control, into which controller systems were downloaded directly from the simulation during the trial phase. After the test phase, the WinDrive® control system was integrated into the turbine control system.

With support from Beckhoff, the development team also designed a real-time test environment for simulating the physical forces acting on the turbine and the real response of the turbine: the D8.x Real-Time Test Environment (RTSim). Both sides of RTSim consist of Beckhoff components and are, just like the real turbine, wired to the turbine control terminals. With RTSim it was possible to carry out detailed simulations of the dynamic system characteristics in advance of the installation and commissioning. The option of "dissecting" the model at any point in order to test various components and devices in the hardware loop is a tremendous advantage. The simulation not only replaces the actual test operation, it also enables existing turbine operation experience to be taken into account in advance of a new development in order to test the system characteristics and optimize the design. In this way, pilot production becomes much more reliable than in the past.

Besides its high performance and low system costs, EtherCAT also stands out due to its flexible topological characteristics. The maximum distance between two stations is 100 m (328 feet) using a standard Ethernet cable (100BASE-TX). With the new fiber-optic modules, greatly extended networking up to 2 km (1.24 miles) is possible (100BASE-FX).

Rapid development propels DeWind

The kick-off meeting between DeWind and Voith Turbo, the supplier of the WinDrive® drive system, took place in December 2005. Only twelve months later, in December 2006, a prototype was built at Cuxhaven, Germany, and commissioned in January 2007. DeWind is pleased: only one year passed between the decision to use Voith’s WinDrive® solution and commissioning of the system. This would not have been possible without a motivated, competent and bold team. In the meantime, DeWind built two additional systems of this type, one of which is installed at a record elevation of 4,300 meters (over 14,100 ft) in the Argentinean Andes. The third system, a 60 Hz version, was built and commissioned in Sweetwater, Texas, in March 2008.

This third system was built by DeWind’s strategic production partner Teco Westinghouse at Round Rock, Texas. Teco Westinghouse is currently setting up a production line with a capacity of five systems per week. The company expects to build and install up to 80 systems in the United States during 2008.

Voith Turbo Wind GmbH & Co. KG
www.voithturbo.de/windtechnologie.htm

DeWind Inc. www.dewind.de

Beckhoff. Beckhoff makes safety systems more flexible through streamlined expansion and adaptation options, without loss of reliability in the event of an emergency.

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Multibrid GmbH never bothered with onshore wind farms: the 5 MW M5000 turbine was designed for offshore wind energy applications from the outset. Multibrid revised the control scheme in close cooperation with Beckhoff and based it on an integrated platform for the mass production of these turbines.

PC Control for an offshore wind farm
Multibrid developed the first prototype of its wind turbine back in 2004, although it took another three years before it was ready for series production. Assembly of the Multibrid M5000 with a rotor diameter of 116 meters and a hub height of 90 meters started in mid-2007 at Multibrid’s own production facility at Bremerhaven, Germany.

When project manager Bernd Zickert joined the company in 2005, he found a typical technical situation: The control and automation systems for the turbine were not based on an integrated platform. The hardware components came from four different manufacturers, which meant that the Multibrid engineers had to familiarize themselves with diverse systems. Coordination of the components and data acquisition were also problematic.

For Multibrid’s prototype this internal diversity made sense, because it was intended to demonstrate resilience of the design and form a basis for the final decision on series production. To this end, the company had to test various options. The first field test for the M5000 took place two years earlier. This test showed that the approach basically passed. The next challenge for Multibrid was to prepare for series production and offshore operation.

The prototype was tested through detailed simulation of the complex environmental influences affecting a wind turbine, including a wide range of possible fault and malfunction scenarios (hardware-in-the-loop). “For the simulation we created an exact model of all system interfaces,” said Bernd Zickert. “We were able to implement further developments for improving system performance.” The focus was on system feasibility in terms of production, installation, operation and service. In 2008 Multibrid intends to build up to 13 systems, six of which are scheduled for the Alpha Ventus offshore wind farm (see page 17). Alpha Ventus is the first German offshore wind farm on the high seas. It is a pioneering joint project in which E.ON Climate & Renewables, EWE and Vattenfall Europe New Energy are all involved.

**Low-wear technology minimizes system failures**

The Multibrid design is ambitious. Unlike most other wind turbine manufacturers, Multibrid uses permanent magnet synchronous generators. While most electricity suppliers use synchronous generators, the wind industry tends to prefer asynchronous (induction) generators. Multibrid’s decision to use a multi-pole synchronous generator with a ring design means it is based on proven technology and has the additional advantage of significantly less wear. This provides major benefits, particularly for offshore operations where service, maintenance and repairs are much more difficult than onshore, especially during periods of poor weather. Any equipment or feature that is less prone to faults and failures helps make the turbines more reliable.

**Less weight facilitates construction and installation**

To facilitate transport and ensure safe and fast installation, a key design requirement for the M5000 was minimized weight of the nacelle and the rotor. Multibrid placed a single-stage gear unit between the rotor and the generator, which reduced the speed variance of the rotor by a factor of almost 10:1. The generator

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<td>Rotor diameter:</td>
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<td>Offshore hub height:</td>
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<td>Head weight/swept area:</td>
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is linked to the grid via a four-quadrant inverter, which enables variable-speed operation. At the same time it meets the requirements stipulated by grid operators for advanced wind turbines. With this design Multibrid reduced the total weight of the rotor, hub and nacelle to around 310 t. Despite the high rated capacity, Multibrid turbines are very compact: The two-level nacelle is only 7 meters high and 10 meters long, making the system significantly smaller and lighter than comparable units. This has several advantages: The tubular steel tower, which rests on tripod foundations, can be dimensioned differently. The nacelle can be pre-assembled on land and installed at sea as a complete unit.

A key requirement for offshore operation is hermetic sealing of the nacelle: an air treatment system separates salt and water particles from the ambient air and generates a positive pressure in the nacelle, which keeps out the aggressive sea atmosphere and protects the sensitive control elements from corrosion.

**Integrated control platform simplifies system management**

The revision of the control and automation system carried out by Bernd Zickert and his team simplified the system. The number of controllers was reduced from five to two. In addition to the main computer in the tower, there is a hub computer that provides redundancy and prevents data loss during transfer via the slip ring coupling. The complete hardware platform was converted to Beckhoff components, creating an integrated control system that offered coordinated and simpler handling, interfaces and data flows. The system processes no less than 500 digital and analog signals. This is particularly beneficial when it comes to service and maintenance: the service technicians only have to familiarize themselves with one operator guidance system, which drastically reduces the training and commissioning effort.
Multibrid was established in 2000. The company develops and builds the Multibrid M5000 offshore wind turbine. In collaboration with suppliers, a team of specialists for all key system components continuously develops and enhances the Multibrid technology. Through the affiliation of the Prokon Nord Group, Multibrid technology can draw upon long-standing experience with wind farm implementations.

The project design company Prokon Nord ventured into the offshore sector at an early stage and designed three wind farms in the North Sea and off the coast of Normandy, the latter featuring 181 turbines with a capacity of 5 MW each. Prokon’s involvement was very useful: backed by large demand, the new development was economically viable. The involvement of the French energy company Areva, which acquired 51 percent of the Multibrid shares in September 2007, provided a secure financial basis for Multibrid. The company was able to turn a good idea into good business. Meanwhile, Multibrid production is up and running.

M5000 control architecture

**Control system**
- Main computer: CX1020 Embedded PC with Windows XP
- Hub computer: CX9000 Embedded PC with Windows CE
- Automation software: TwinCAT PLC

**HMI**
- Built-in Control Panel CP6832

**I/O**
- Bus system: EtherCAT (PROFIBUS with EtherCAT Terminals)
- I/O systems: Bus Terminals/EtherCAT Terminals
- I/O terminals:
  - Various digital/analog I/Os
  - Power measurement terminal
  - Relay terminal
  - SSI angular measurement terminal
  - Incremental encoder interface
  - Serial interface
In order to minimize the effects of possible component failures, the sensors, actuators and auxiliary systems are also designed for redundancy. This particularly applies to the air treatment, oil supply and hydraulic systems, the battery chargers for the hub and the cooling system.

PC-based control technology ensures openness of the system. Multibrid engineer Zickert regards this as a particularly significant feature, because it offers scope for further development of the control and automation system: "After all, we operate in a highly dynamic sector that is constantly changing." Third-party equipment can easily be integrated via the available interfaces. The openness of the system also enables integration of I/O terminals with new functionalities.

The fact that the TwinCAT control software from Beckhoff is based on the Windows standard simplifies operator guidance and ensures compatibility with conventional user interfaces. This also has positive effects on the visualization of the data streams and information provided via a SCADA system. The control system offers secure access on site and in the control center by multiple users. Parameters can be modified and adapted to specific requirements. The error analysis capability of the system is improved. The system is monitored in real-time via the Internet Protocol over an optical fiber cable.

An integrated ORACLE database system can store data offline for up to 50 days (in the event of system communication malfunctions, for example) before forwarding them to the control center. The storage capacity depends on the size of the flash card used. The system stores all data that are relevant for managing the wind farm, including operational data (10-minute mean values, trace, counters), error log analysis, power curve, production, reactive power, internal consumption and mode.

**Comprehensive and complex simulation ensures quality**

Of particular significance is the quality of the simulation software developed by the Multibrid team in close cooperation with ISET (Institut für Solare Energiesversorgungstechnik, University of Kassel, Germany). It enables real-time simulation of the system states and data exchange via TwinCAT. Beckhoff supplied the associated hardware and was involved in the development of the SCADA system.

The test stand is used for initial plausibility checks for theoretical assumptions and concepts as well as staff and customer training. In addition, Multibrid developed it into an efficient and effective quality assurance tool: All system control components are mapped on the test stand. The system is able to simulate all actuators and sensors, as well as the communication with the turbine control equipment. In this way, the functionality of the control system and other systems can be fully tested in advance of installation. Rather than having to install components with unproven functionality under difficult conditions at sea, the quality of the components and subsystems can be ensured before delivery. This is also beneficial for the installation of updates and retrofit measures, which no longer have to be field-tested as beta versions, but can be installed with extensive function tests included.

Multibrid GmbH [www.multibrid.com](http://www.multibrid.com)
The Alpha Ventus offshore wind farm is a pioneering joint project in which E.ON Climate & Renewables, EWE and Vattenfall Europe New Energy are involved. It is located on the North Sea, around 45 kilometers (28 miles) north of the island of Borkum, at a water depth of 30 meters (98.4 feet). Alpha Ventus is the first German wind farm to be built on the high seas under real offshore conditions. The design, construction, operation and grid integration of the Alpha Ventus research project will provide highly valuable insights for the future commercial utilization of offshore wind farms.

The 2008 project schedule includes construction of the southern half of the wind farm with six Multibrid M5000 turbines and the offshore substation. The wind farm is expected to be connected to the grid in autumn 2008. Construction of the northern half of the wind farm with six further turbines of a different type is scheduled for summer 2009.

The wind turbines are prefabricated on land as individual components. The nacelle, rotor blades, tower segments and foundation structures are assembled at sea into a complete wind turbine.

The 12 turbines will be spread over an area of 4 square kilometers (1.5 square miles). They will be positioned in the form of a rectangle, with four parallel rows (from north to south) of three turbines each. Within this grid-like formation, the turbines are spaced with a distance of around 800 meters (approx 0.5 miles) from each other. The Multibrid M5000 turbines are anchored to the seabed with tripod-type foundations. The water depth at this location is around 30 meters (98.4 feet). To reach around the triangular 255 m² footprint of a tripod would require 56 men. The 1,000-ton weight of a turbine is equivalent to around 200 fully grown elephants or 22 railway wagons. The area swept by the rotor is equivalent to around 200 fully grown elephants or 22 railway wagons. The area swept by the rotor is equivalent to around 200 fully grown elephants or 22 railway wagons. The area swept by the rotor is equivalent to around 200 fully grown elephants or 22 railway wagons.

The maximum rotational speed of the rotor, the blade tips cut through the air with around 300 km per hour (186 mph). The average wind speed at the location is 10 meters per second (m/s), which corresponds to a 5 on the Beaufort scale of wind force (19 – 24 mph or 30 – 39 km/h). The designers expect the farm to operate at full capacity for around 3,800 hours per year. For comparison: good onshore locations offer around 5 m/s and 2,200 to 2,500 full-capacity hours.

**Alpha Ventus key data**

| No. of turbines: 12 |
| Total capacity: 60 MW |
| Expected energy yield/year: approx. 220 GWh (= annual consumption of approx. 50,000 3-person households) |

www.alpha-ventus.de
Wind energy helps keep the future bright for China

Mingyang relies on Beckhoff wind industry expertise

Meanwhile China has become the country with the world’s most wind farms. The reasons for using wind energy are obvious: With a population of more than 1.3 billion or approx. a quarter of the world’s population, China uses around 10 percent of the global primary energy resources. Coal is the main energy source for China, with all the consequences associated with generating electricity from coal. Existing coal-fired power plants have a very poor environmental balance, due to their high CO₂ emissions and other polluting attributes. Economic growth creates an incredible challenge: China must build new clean, advanced power plant capacities faster than the dramatic increase in energy consumption. Wind energy is becoming one of the assets in China’s dynamic energy market, with up to 40 GW of capacity expected to be installed by 2020. By the end of 2007, around 6 GW capacity had already been installed, of which approx. 3.3 GW were installed in 2007 alone.

Mingyang: wind turbines for the domestic market and abroad

Mingyang Electric Group Co., based in the southern Chinese province of Guangdong, was established in 1993 and became active in the wind energy sector several years ago. Last year the company built its first wind turbine with a nominal capacity of 1.5 MW at Zhanjiang in the far south of China. An additional 33 units are expected. Mingyang is currently establishing production capacities not only to satisfy the Chinese market, but also for export: In 2008 the company expects to export 72 systems to the USA. Over the coming years Mingyang intends to build systems with a total capacity of 2,000 MW, around half of which destined for the United States. In addition to the lower price, high system performance and reliability are further key arguments in favor of this wind energy market newcomer.

System design made in Germany

Mingyang relies on a tried and tested design originating from Aerodyn Energiestysteme GmbH, a firm of consulting engineers based in Rendsburg, Germany, who have been developing wind turbines since the early 1980s. Beckhoff supplies the control and automation system. “The basic design is proven and has been used successfully in the market for years,” said Robert Müller, Beckhoff project manager and wind power branch manager, commenting on the basic idea for the Mingyang system. The wind turbine has a nominal capacity of 1.5 MW, with a hub height and a rotor diameter of 80 meters. Mingyang offers the system in strong wind and light wind versions as well as a cold climate version. The pitch-controlled, variable-speed system is equipped with a double-fed induction generator. All these features are familiar and have been proven in the market. The project was nevertheless ambitious: The order for the development of the control system was issued in late autumn 2006. A prototype was built only a year later and commissioned in October 2007.
Control concept for extreme operating conditions

The specific operating conditions for automation components in the wind energy sector differ from other industrial applications and require special automation expertise: harsh, rapidly varying ambient temperatures and weather conditions such as wind speed and direction have to be mastered in order for the installation to meet the stringent electrical quality requirements.

While the wind quality in the southern Chinese province of Zhanjiang is generally high and uniform, the region is at risk from typhoons all year round. Two typhoons already passed through during the construction phase and left their mark. The wind turbines have to cope with wind speeds in excess of 50 m/s (180 km/h) in conjunction with strong precipitation. The South China Sea location just north of the 20° degree of latitude generally has a more extreme climate than Central European locations.

"The control system has to be adapted to such extreme conditions," said wind power expert Robert Müller. "It must be able to respond very quickly, the emergency systems must be designed with redundancy in mind, and the installation must meet stringent safety criteria." The automation system automatically responds to changes in environmental parameters. The operating states are monitored both locally and remotely via remote data communication in order to enable full control of the system. The data are stored for retrospective fault analysis, for example following disruptions in system communication.

PC-based control platform offers openness for future developments

The PC Control system in the tower is based on a CX1020 Embedded PC with TwinCAT automation software. The modular CX system is equipped with a CAN bus interface for communication with the autonomous converter for the double-fed induction generator and standard interfaces (USB, DVI and Ethernet TCP/IP). Further I/O stations for interfacing sensors and actuators are connected via the high-speed EtherCAT communication system. The autonomous pitch system with PROFIBUS master is integrated into the EtherCAT I/O system via suitable fieldbus terminals. The safety sensors and actuators in the nacelle and the tower base are also directly integrated into the EtherCAT system. Therefore, an additional safety bus system is not required.

Current and historic operational data can be displayed on Beckhoff Control Panels in the nacelle and the tower base. The individual units can be integrated into a wind farm communication system or a control master station for remote monitoring, although this has not yet been implemented in the Zhanjiang installation. This functionality can be retrofitted if required.

In addition to the automation components, Beckhoff also supplied the application software and provided support for Mingyang’s engineers during commissioning. The open nature of the application program enables Mingyang to adapt and refine the software. This is a big advantage of open, PC-based control technology.

The use of Windows as an operating system and Ethernet as the communication platform opens up new potential in terms of communication and data processing speed. Control or communication components such as laptops can be connected at any time. In the future, any component can be replaced with state-of-the-art modules as required.

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