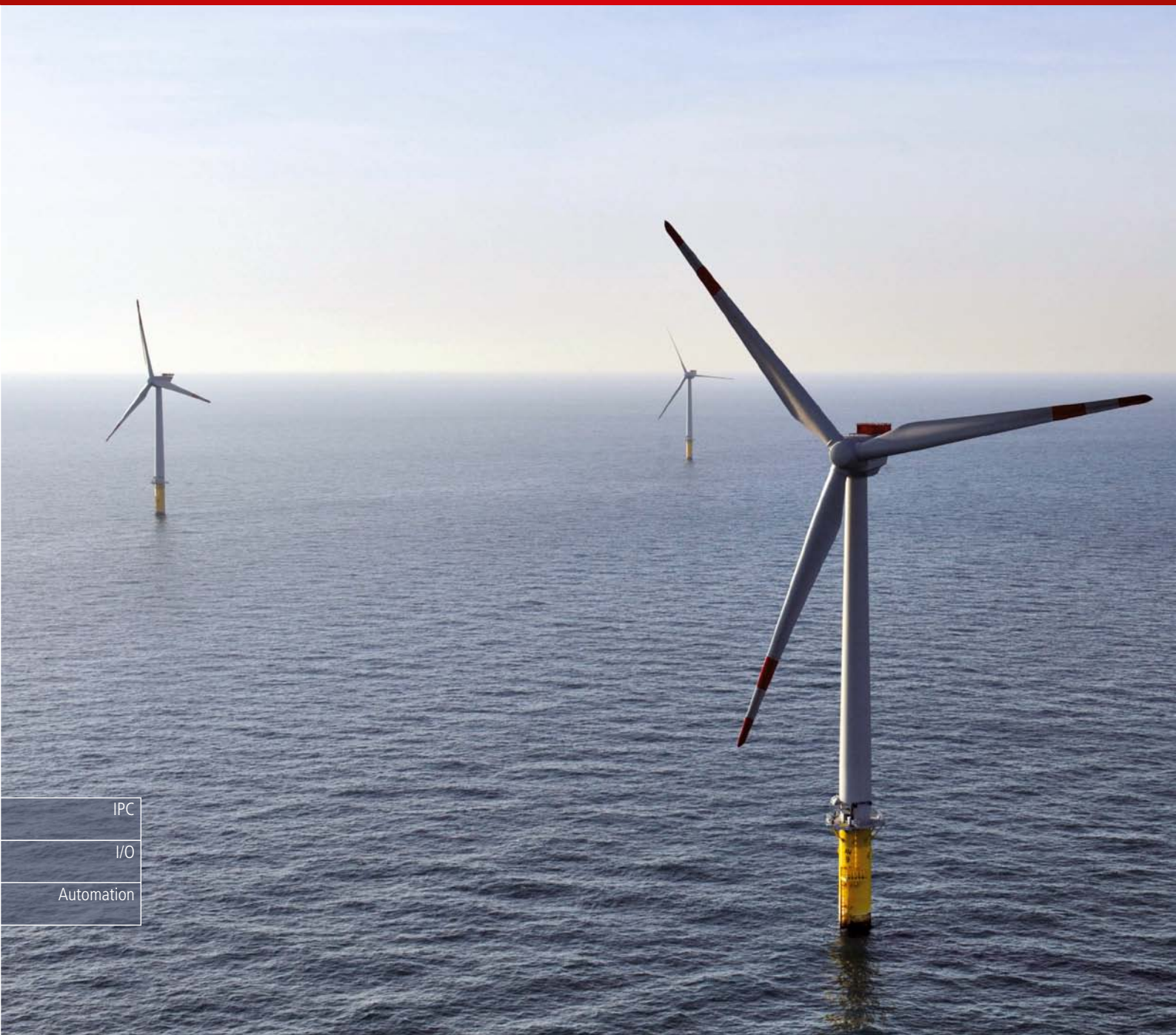**BECKHOFF** New Automation Technology

PC-based Control
for Wind Turbines

IPC

I/O

Automation

Beckhoff technological expertise …

For over 30 years Beckhoff has been implementing automation solutions on the basis of PC-based control technology, which have been proven in the most diverse industries and applications. The globally operative company, with headquarters and production site located in Verl, Germany, employs over 2100 people worldwide*. With 30 subsidiary companies* as well as distributors, Beckhoff is represented in over 60 countries. Beckhoff achieved a total turnover of 465 million Euros in 2011.

Thanks to constant technological innovations and economic growth as well as a high vertical integration and large production capacities, Beckhoff guarantees long-term availability and reliability in product delivery. Robust, industry-proven components and more than 12 years of expertise in wind power make Beckhoff a competent and reliable partner. A global team of experts ensures worldwide support, with local service and support to customers.
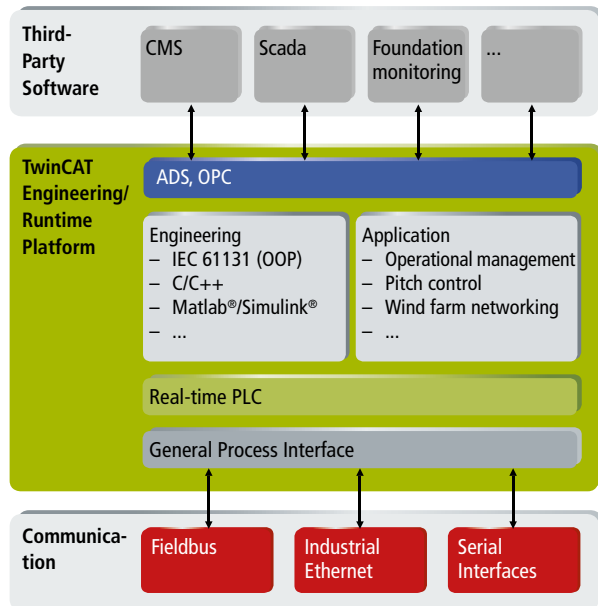
* (as of 03/2012)

BECKHOFF New Automation Technology

We reserve the right to make technical changes.

… enables higher wind turbine efficiency and availability.

Automation technology from Beckhoff is used in over 20,000 wind turbines worldwide up to a size of 5 MW – both onshore and offshore. The high degree of integration as well as the use of IT and automation standards make PC-based control technology a powerful and efficient solution with an optimum price-to-performance ratio. In addition to the hardware platform, Beckhoff also supplies a complete software solution for operational management. Further software function blocks, e.g. for Condition Monitoring, braking, obstruction lighting or SCADA systems, are integrated into the controller via standard interfaces. The range of services from Beckhoff is supplemented by control cabinet construction, from the creation of the circuit diagrams to the manufacturing of prototypes or series production. This way, the wind turbine manufacturer is supported by the Beckhoff experts from the design phase to final commissioning. The complete documentation of the project, including the application software in the open source code, means that no dependencies arise for the user.

Reference
AREVA Wind GmbH
Germany

Third-Party Software	CMS	Scada	Foundation monitoring	...

TwinCAT Engineering/ Runtime Platform

ADS, OPC

Engineering – IEC 61131 (OOP) – C/C++ – Matlab®/Simulink® – ...	Application – Operational management – Pitch control – Wind farm networking – ...

Real-time PLC

General Process Interface

Communica-tion	Fieldbus	Industrial Ethernet	Serial Interfaces

The openness of the Beckhoff control technology …

PC- and EtherCAT-based control technology from Beckhoff is characterised by its variety of hardware and software interfaces. Openness is the basis of the system concept at Beckhoff which facilitates the easy integration of functions such as visualisation, safety technology, measuring technology, and third-party software. For all product families, from Industrial and Embedded PCs, Control Panels and I/O components to automation software, Beckhoff offers modular solutions with scalable performance. The user can configure a performance-scaled controller for wind turbines from standard components as if from an automation kit. Future extensions and modifications are also possible without great expense. In addition, the reliance of the Beckhoff technology on industrial communication standards such as IEC 61400-25, Ethernet TCP/IP or OPC guarantees high investment security for the user.

CANopen

PROFIBUS
PROCESS FIELD BUS

EtherCAT®

4
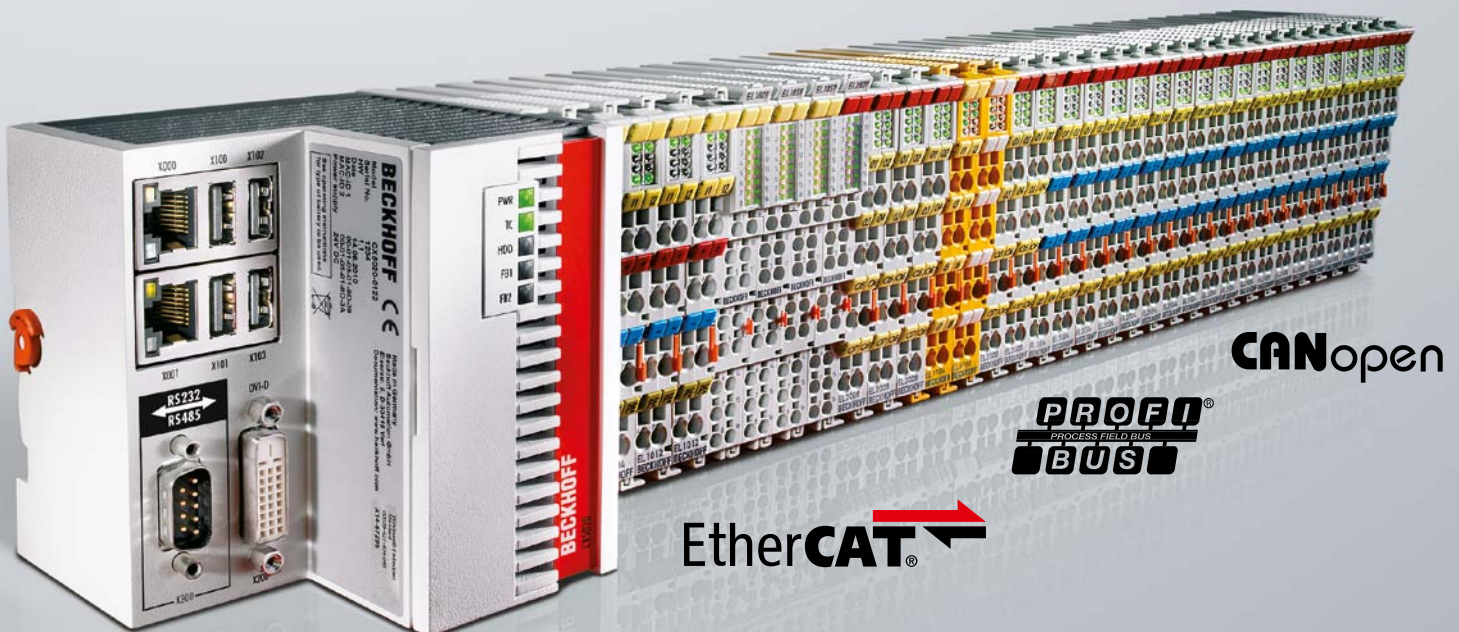
… offers investment security and reduces hardware and engineering costs.

The openness of the Beckhoff control architecture fits the requirements of the wind power industry perfectly: performance-focused scalability, maximum flexibility in controller design and a high degree of integration. The functional range of the control platform, which, apart from sequence control, also encompasses visualisation, safety infrastructure and Condition Monitoring, ensures the efficient interaction of all system components and optimises the performance of the wind turbine. Beyond that, dispensing with special hardware leads to a leaner control architecture and to lower engineering expenditures. This results in a significant reduction in costs and offers corresponding competitive advantages. Interfaces for all common fieldbus systems and the large product variety within the Beckhoff I/O systems cover all types of signals and fieldbuses that are relevant to wind power.

Reference
Xinjiang Goldwind Science & Technology Co., Ltd.
China

BECKHOFF New Automation Technology
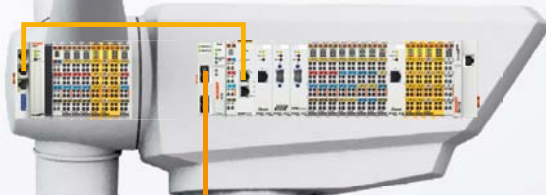
Control

- pitch control
- operational management
  - integration of brake, gearbox, converter and Scada

PC-based automation technology with a high degree of integration …

Based on PC and EtherCAT technology, Beckhoff supplies a universal plat-form for all control requirements in wind turbines. All procedures are auto-mated on the Industrial PC with the directly connected Beckhoff I/O sys-tem and TwinCAT automation software: from the operational management and control of pitch, converter, gearbox and brakes to the visualisation and farm networking. The real-time Ethernet system, EtherCAT, offers full Ethernet compatibility and outstanding real-time characteristics. Beyond that, the fast communication system is characterised by flexible topology options and simple handling. Lower-level fieldbuses such as CANopen, PROFIBUS and Ethernet TCP/IP can be relocated to the field via fieldbus master or slave terminals for the control of subsystems. Software libraries and hardware components specially developed for the wind power indus-try round off the wide range of solutions from Beckhoff.
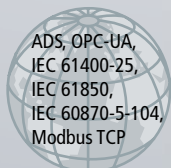
ADS, OPC-UA,
IEC 61400-25,
IEC 61850,
IEC 60870-5-104,
Modbus TCP

EtherCAT.

Monitoring

- condition monitoring
- foundation monitoring

Communication

- wind farm networking

EtherCAT.

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We reserve the right to make technical changes.
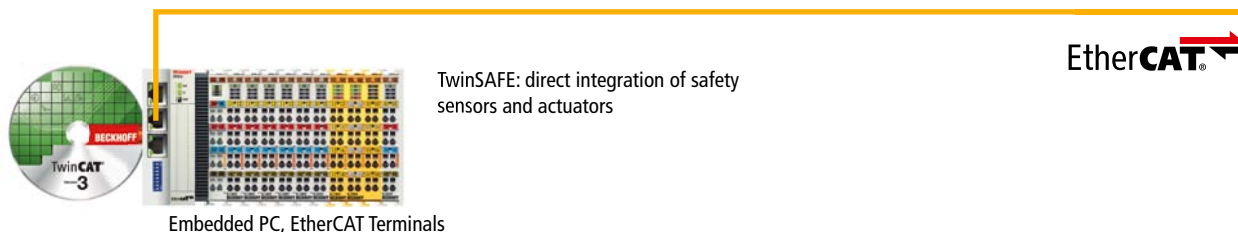
… optimises wind turbine control and lowers operating costs.

The standard Beckhoff controller for a wind turbine consists of an Embedded PC as the master computer, EtherCAT as the communication system, Bus Terminals or EtherCAT Terminals as the I/O system and TwinCAT automation software. The converter, the I/O system in the nacelle and the pitch controller in the hub are connected to the master controller via EtherCAT or another fieldbus system. Safety technology and Condition Monitoring are integrated seamlessly into the terminal node via corresponding I/O modules. A separate CPU can be eliminated as a result. Through the use of EtherCAT as the universal fieldbus system, communication becomes much faster and simpler while the project engineering, programming and cabling of the wind turbine are simplified. The central Embedded PC acquires and processes all data, checks the feed-in and communicates with the central control room via Ethernet.

Reference
DeWind Europe GmbH
Germany

BECKHOFF New Automation Technology

Pitch control

Collective control

TwinSAFE: direct integration of safety sensors and actuators

Embedded PC, EtherCAT Terminals

EtherCAT

Individual pitch control

EtherCAT

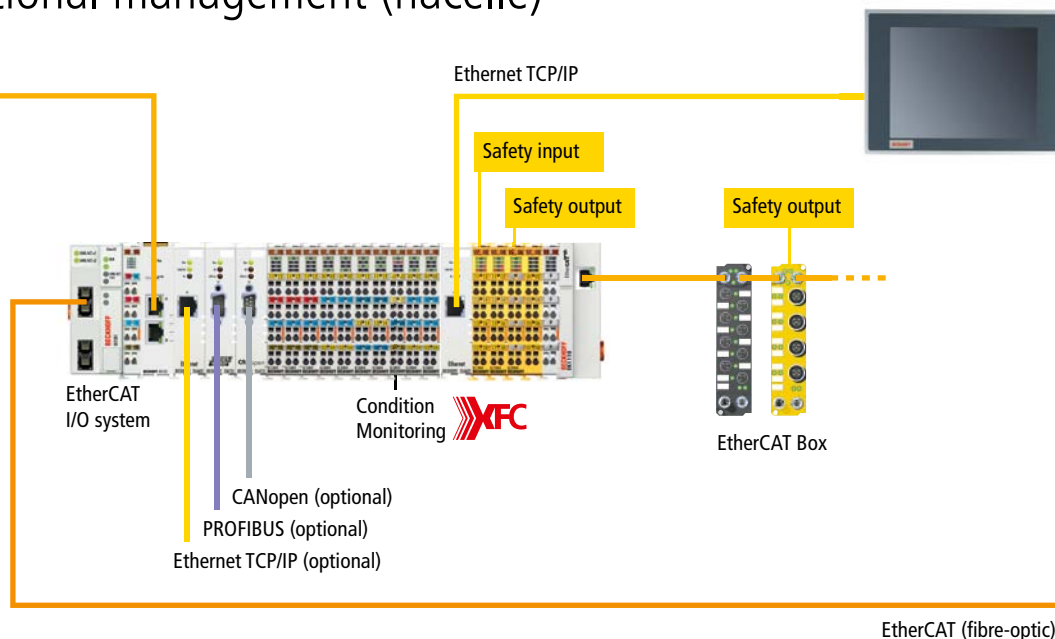Embedded PC, EtherCAT Terminals

Pitch control

Beckhoff also offers the complete control solution for pitch systems. On account of their scalability and modularity, the DIN-rail-mounted Beckhoff Embedded PCs from the company's CX series are ideally suited to collective or individual pitch adjustment of the rotor blades. Encoder terminals for all types of blade angle sensors are available from Beckhoff as standard. Intelligent control routines in the individual pitch controller enable reduction of the loads acting on the system.
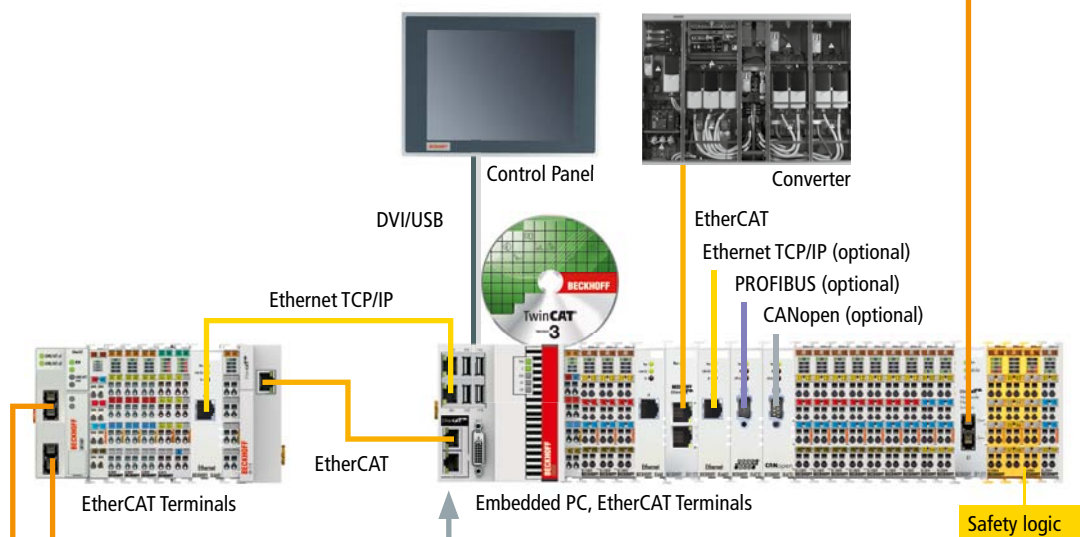
Operational management

In PC Control, a complete solution is available in hardware and software for operational management, including safety technology and Condition Monitoring. The operational management is programmed under IEC 61131 using TwinCAT; interfacing with higher-level control systems is based on internationally standardised telecontrol protocols. A web server for remote user access is integrated in the PC. TwinSAFE handles the integration of the traditionally hard-wired,

higher-level safety infrastructure into the automation system. In addition, TwinCAT offers comprehensive libraries for control and filter algorithms. Communication between the tower base and nacelle takes place inexpensively and flexibly via fibre-optic cables using EtherCAT. Interface modules permit the simple integration of lower-level bus systems.

Operational management (nacelle)

Ethernet TCP/IP

Safety input

Safety output

Safety output

EtherCAT
I/O system

Condition
Monitoring **XFC**

EtherCAT Box

CANopen (optional)

PROFIBUS (optional)

Ethernet TCP/IP (optional)

EtherCAT (fibre-optic)

Operational management (tower base)

Control Panel

Converter

DVI/USB

EtherCAT

Ethernet TCP/IP (optional)

PROFIBUS (optional)

CANopen (optional)

Ethernet TCP/IP

EtherCAT

EtherCAT Terminals

Embedded PC, EtherCAT Terminals

Safety logic

Wind farm networking

EtherCAT.

ADS, OPC-UA,
IEC 61400-25,
IEC 61850,
IEC 60870-5-104,
Modbus TCP

BECKHOFF New Automation Technology
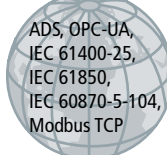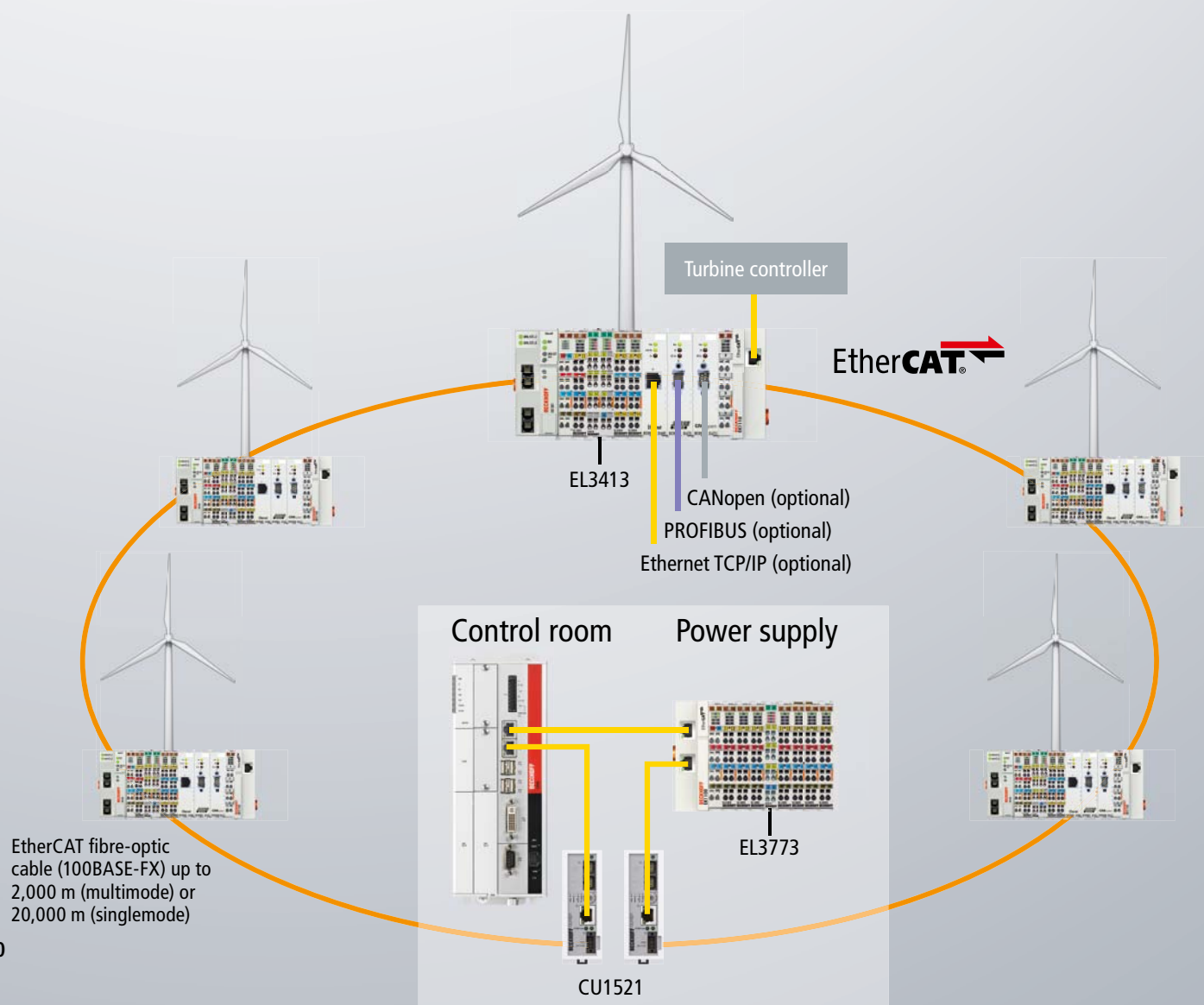
EtherCAT optimises wind farm networking and transforms …

Wind farm networking with EtherCAT is not only faster compared to conventional IP solutions, but also reduces costs by saving the use of switches and hubs. With the EL3773 EtherCAT power measurement terminal integrated in the automation system, momentary current and voltage values can be measured at up to 10,000 samples/s. Using the EtherCAT distributed clocks, the measured values of all wind turbines and the measurement at the point of common coupling can be synchronised to a timeframe smaller than 1 µs. The physical layer can be used for both Ethernet TCP/IP and for EtherCAT. The existing Ethernet infrastructure (fibre-optic technology) can be used over distances of up to 20 km without loss of speed. TwinCAT supports the standardised IEC 61400-25 communication protocol for wind turbines, which simplifies the monitoring and control of heterogeneous wind farms, including the connection to the electricity supplier.

Turbine controller

EtherCAT

EL3413

CANopen (optional)

PROFIBUS (optional)

Ethernet TCP/IP (optional)

Control room   Power supply

EL3773

EtherCAT fibre-optic cable (100BASE-FX) up to 2,000 m (multimode) or 20,000 m (singlemode)

CU1521

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… the wind farm into a grid-supporting power station.

The producers of renewable energies are faced with the challenge of supporting grids in the case of voltage drops (Low Voltage Ride Through). Measurement of the current at the point of common coupling using the EtherCAT power measurement terminal ensures the early diagnosis of voltage drops. Unlike the current solution, it is possible to generate a reaction of an entire wind farm to an LVRT case in this way. If a voltage drop is diagnosed at the point of common coupling, this can be broadcast to all turbines in the entire farm network within 1 ms. With these data, the current, voltage and frequency can be controlled accordingly and the grid can be supported. The existing fibre-optic-based Ethernet infrastructure can be used. Even the synchronisation of the IGBTs of converters within a wind farm is conceivable with this technology. The use of one cable for Ethernet TCP/IP and for EtherCAT represents an inexpensive solution for cable redundancy.

Reference
WinWinD Ltd.
Finland

TwinCAT, the universal control platform …

TwinCAT, the open, scalable automation software from Beckhoff, forms the centrepiece of the PC-based control platform. It consists of runtime systems for real-time execution of control programs and development environments for programming, diagnostics and configuration. The programming of TwinCAT in accordance with the international IEC 61131-3 standard guarantees the power plant manufacturers high investment security. In addition, open interfaces supplemented by the latest technological standards based on Windows operating systems introduce numerous extension options. TwinCAT 3 offers the users a high degree of freedom in choosing their programming language: In addition to the object-oriented extensions of IEC 61131-3, C and C++ are now also available as programming languages for real-time applications. Matlab®/Simulink® have also been integrated, with which the load calculation, for example, can be simulated.

▶ **www.beckhoff.com/TwinCAT**
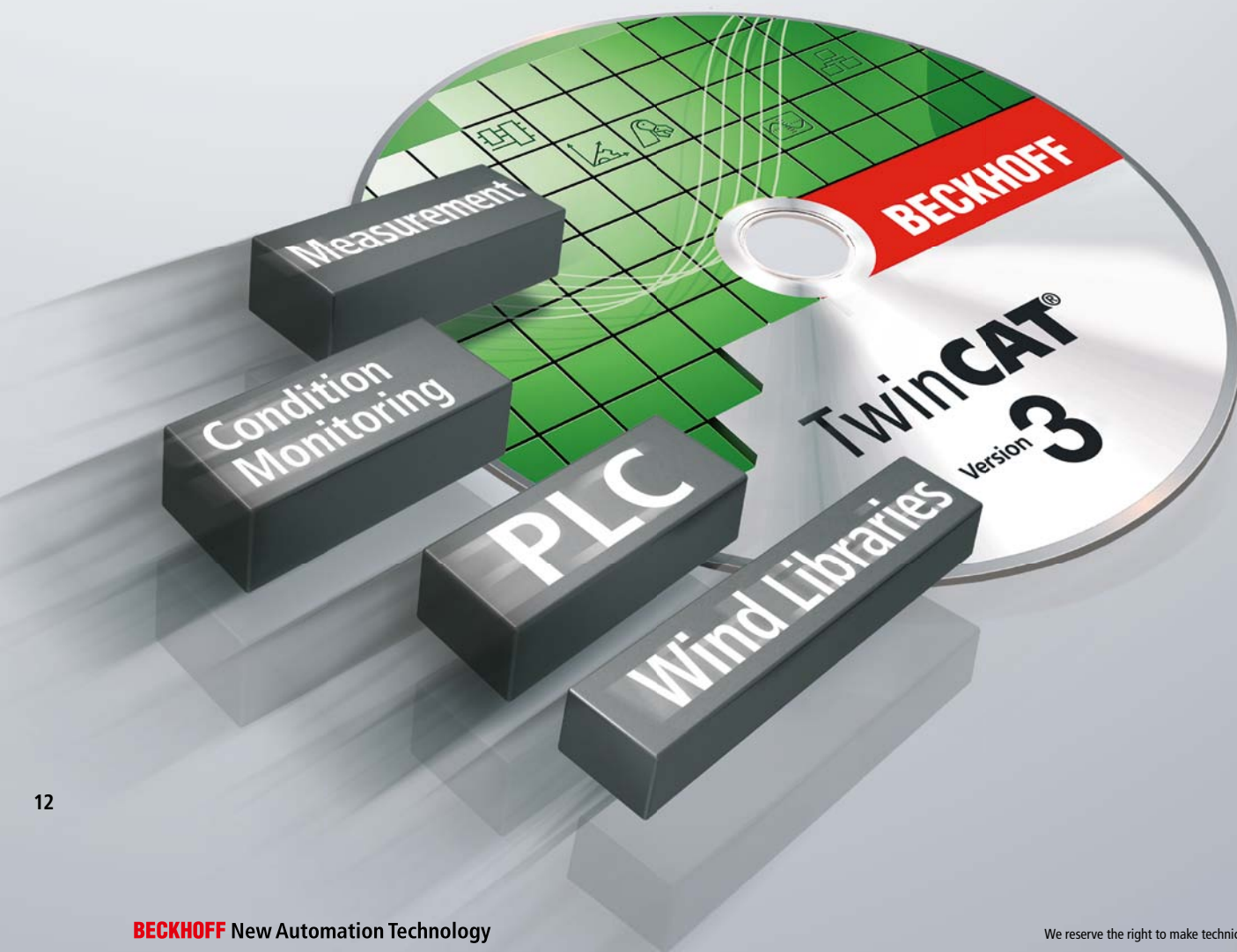
… simplifies
power plant engineering.

With TwinCAT the power plant manufacturer needs only one tool for programming and configuration. Through the integration of Matlab®/Simulink® into the development environment, TwinCAT also represents a convenient tool for the design of the control software and for plant simulation. The Beckhoff product range is supplemented by wind turbine-specific application software, into which the knowledge base developed from over a decade in the wind industry flows. Its structure corresponds to the automation process stages, enabling rapid familiarisation of the programmer with the application. It encompasses: flexible modification of the brake programs and operational states of the wind turbine; visualisation and parameterisation; simple simulation of the plant operation, including the subsystems and internal communication; logging of events, trends and performance curves; event and alarm; online modifications, including by remote access.

Reference
AREVA Wind GmbH
Germany
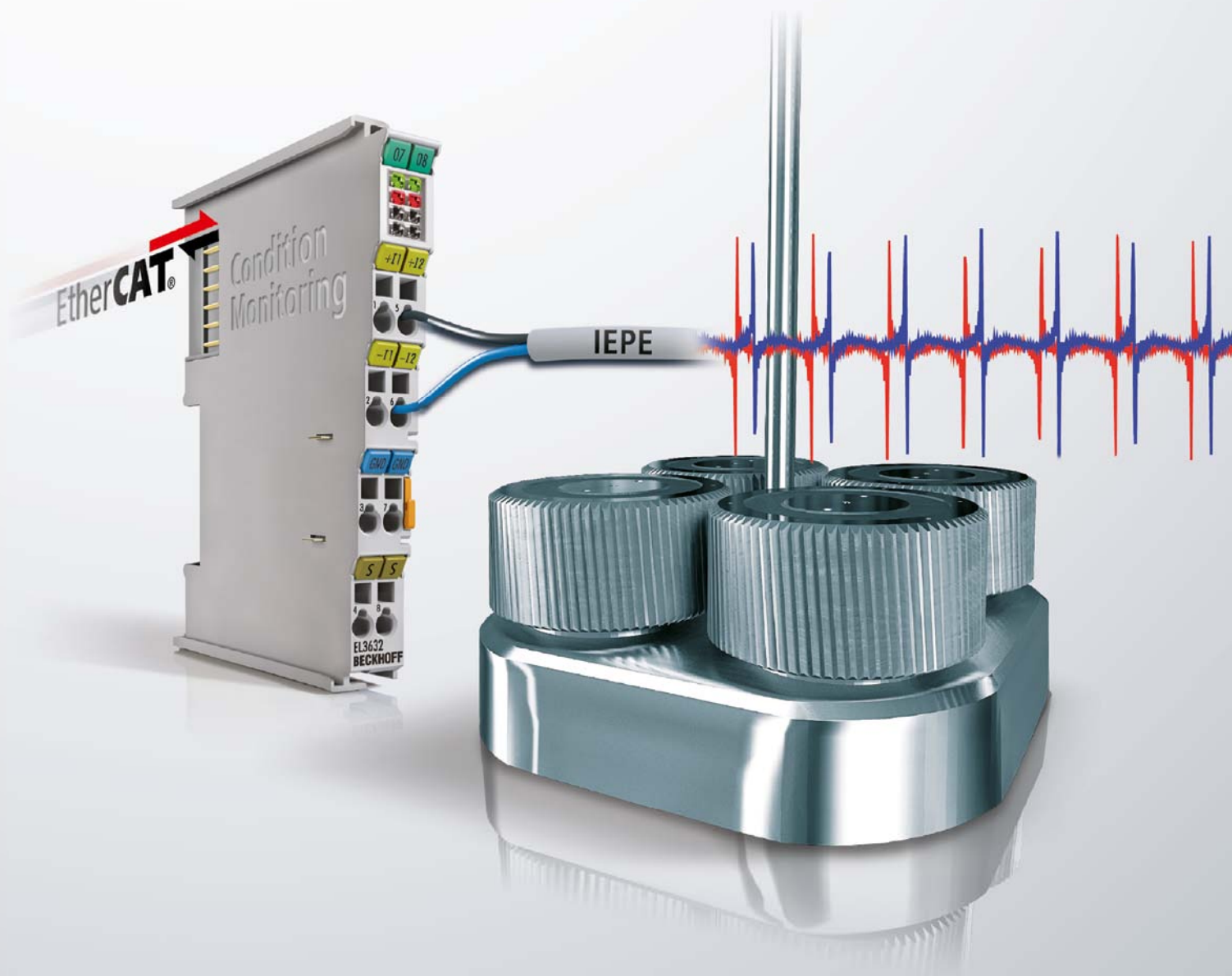
Integration of Condition Monitoring into the controller …

The high-performance processors of modern PCs together with EtherCAT as the fast communication system provide the conditions necessary for the control platform to perform advanced measuring tasks – virtually "on the side." In this way, special functions such as the condition monitoring of the gearbox or foundation monitoring can be integrated seamlessly into the existing automation system. Using this approach it is possible to dispense with the complex coupling of the plant controller with traditional condition monitoring systems in the form of separate hardware modules. In addition to the optimised interaction of all components and reduced hardware costs, engineering is also simplified: configuration, programming and diagnostics take place on one system using TwinCAT. Standard EtherCAT Terminals for 3-phase power measurement, oscilloscope functionality and PWM represent an inexpensive solution. These terminals can be used for network analysis or for monitoring the rechargeable batteries in the pitch system, for example.

▶ **www.beckhoff.com/Condition-Monitoring**

14

… extends the service life of wind turbines.

Condition Monitoring helps to avoid plant failures and optimises the service life of wind turbines through the early diagnosis of approaching damage. The sensors record vibrations in a bearing or a gearbox so that, by means of analysis of the measured values, damage can be detected well before a breakdown occurs. The acquired status data are conveyed over EtherCAT to the controller, where the signal analysis takes place. Until now Condition Monitoring has primarily been used for the diagnosis of gearboxes and generators. However, the integrated solution makes the monitoring of the complete wind turbine and its foundation economically feasible. The integration of Condition Monitoring into the automation system additionally offers the advantage that all information about current conditions, e.g. the rotor speed, is available synchronously and can be evaluated, thus avoiding false alarms.

Reference 15
Vensys Energy AG
Germany

BECKHOFF New Automation Technology

Remote control optimises operational management …
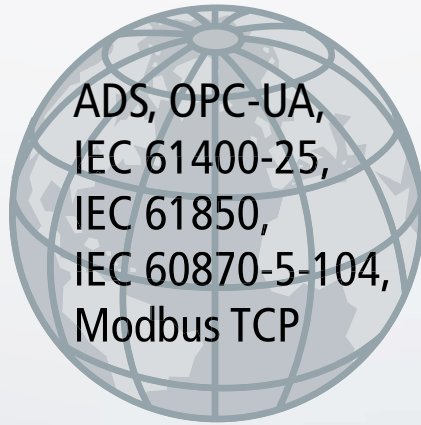
A wide range of Beckhoff Panel PCs and Control Panels in various formats – from touch screen to touchpad to multi-touch panel – is available for comfortable operation and monitoring of wind turbines. The central Embedded PC collects and processes the operational management, pitch controller and converter data, controls the grid feed-in and communicates with the control room via Ethernet. A webserver for remote user access is integrated into the PC, permitting remote access to the controller. Apart from their function as communication interfaces, the Embedded PCs also log all necessary process data. Virtually unlimited storage capacity is available for the data capture via extendable card slots for industrial flash cards. Powerful diagnostic tools integrated into TwinCAT contribute to cost reductions and increase the quality of the algorithms.

ADS, OPC-UA,
IEC 61400-25,
IEC 61850,
IEC 60870-5-104,
Modbus TCP

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… and ensures high energy yields.

Capabilities for remote supervision and maintenance are a must, especially for wind turbines in remote regions, in order to ensure proper operation and to react immediately in case of alarms from anywhere in the world. The provision and management of data occupy a key position in the monitoring and evaluation of the operational behaviour of wind turbines: both vertically – from the turbine to the central control room – and horizontally – between the components and subsystems of a turbine as well as between the individual turbines within a wind farm. Local databases as the foundation for higher level data backup and data preparation do not pose any problems for the PC. The consolidation of all functions into one piece of PC hardware additionally simplifies the data transfer to production databases and ERP systems. The user can configure complex data models comfortably using the Beckhoff Telecontrol Configurator, which is the TwinCAT PLC library for IEC 61400-25.

Reference
Xinjiang Goldwind Science & Technology Co., Ltd. China

Xinjiang Goldwind Science & Technology Co., Ltd., Urumqi, China

PC-based control of gearless 1.5 and 2.5 MW wind power plants, including pitch control and safety technology

Industrial PC: CX1020 Embedded PC
I/O system: BK3150 PROFIBUS Bus Coupler,
BC3150 PROFIBUS Bus Terminal Controller,
Bus Terminals
Software: TwinCAT PLC

www.goldwind.com.cn

Guandong Mingyang Wind Power Technology Co. Ltd, China

PC- and EtherCAT-based control platform for 1.5 MW wind power plant with double-fed asynchronous generator

Industrial PC: CX1020 Embedded PC,
CP6901 built-in Control Panel
I/O system: EtherCAT Terminals, Bus Terminals,
TwinSAFE Terminals
Software: TwinCAT PLC

en.mywind.com.cn

BECKHOFF New Automation Technology

AREVA Wind GmbH, Bremerhaven, Germany

PC- and EtherCAT based control platform of the M5000 5 MW wind turbine for the first German offshore wind farm (Alpha Ventus) on the high seas

Industrial PC: CX1020 and
                CX9000 Embedded PCs,
                CP6832 built-in Control
                Panel
I/O system: EtherCAT Coupler,
                Bus Terminals
Software: TwinCAT PLC

www.areva-wind.com

WinWinD Ltd., Espoo, Finland

PC- and EtherCAT-based control of a 3 MW wind power plant with permanent magnet technology; conversion of the automation system of a 1 MW plant to Beckhoff technology

Industrial PC: CX1020 Embedded PC
I/O system: EK1501 EtherCAT Coupler
                with EtherCAT Terminals
Software: TwinCAT PLC,
                TwinCAT ADS,
                TwinSAFE

www.winwind.com

Further references

China
- Guodian United Power Technology Co., Ltd, Jiangsu Province

Germany
- DeWind Europe GmbH, Lübeck

BECKHOFF New Automation Technology

Pitch

Brakes

Moog GmbH, Unna, Germany

PITCHmaster® II pitch control for wind turbines

Industrial PC: CX9000 or CX1010 Embedded PC,
             alternatively CP6008 Control Panel
I/O system: EtherCAT Terminals,
             EL3403 power measurement terminal
Software: TwinCAT PLC

www.moog.com

Further suppliers

- Atech Antriebstechnik GmbH, Mehring, Germany

Svendborg Brakes A/S, Vejstrup, Denmark

SOBO®-Control (Soft Braking Option) for controlled and precise deceleration of the rotor

I/O system: BX8000 RS232/RS485 Bus Terminal Controller,
             various Bus Terminals,
             incremental encoder terminal
Software: TwinCAT PLC

www.svendborg-brakes.com
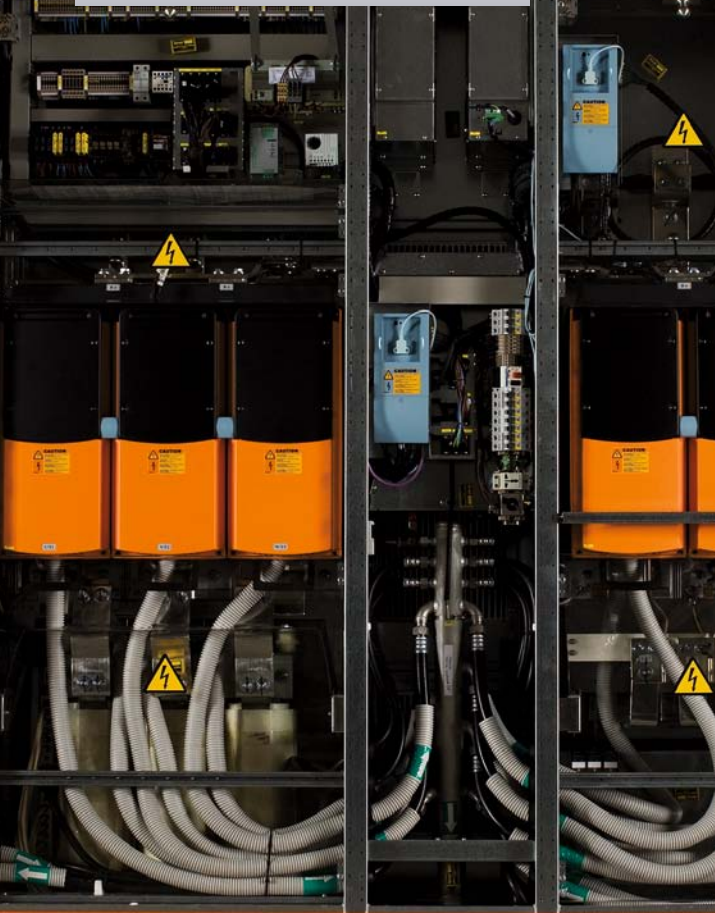
TheSwitch, Vantaa, Finland

PC-based control of The Switch-Drive™ converter unit for gearless wind turbines

Industrial PC: CX9000 or CX1010 Embedded PC
I/O system: EtherCAT Terminals
Software: TwinCAT PLC

www.theswitch.com

Further suppliers

- Renergy Electric Tianjin Ltd (REE), Tianjiin, China
- Vensys Energy AG, Neunkirchen, Germany

Wind farm communication
- Enertrag AG, Dauerthal, Germany

Obstacle light
- Enertrag AG, Dauerthal, Germany

Condition monitoring
- 8.2 Monitoring GmbH, Hamburg, Germany
- DMT GmbH & Co. KG, Essen, Germany
- Ortosense Wind Power, Birkerød, Denmark
- Hermos AG, Mistelgau, Germany
- Končar Inc., Zagreb, Croatia

BECKHOFF New Automation Technology

Beckhoff – New Automation Technology

Beckhoff implements open automation systems based on PC Control technology. The product range covers Industrial PCs, I/O and Fieldbus Components, Drive Technology and automation software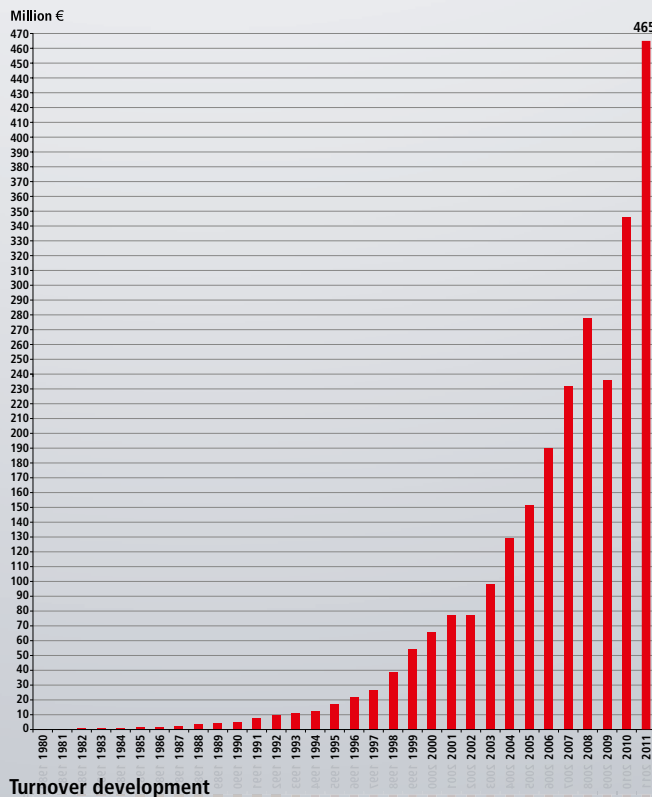. Products that can be used as separate components or integrated into a complete and seamless control system are available for all industries. The Beckhoff "New Automation Technology" philosophy represents universal and open control and automation solutions that are used worldwide in a wide variety of different applications, ranging from CNC-controlled machine tools to intelligent building automation.

▶ **www.beckhoff.com**

Beckhoff at a glance

- Headquarters Verl, Germany
- Sales 2011: 465 million €
- Staff worldwide: over 2,100
- Branch Offices Germany: 11
- Subsidiaries/Branch Offices worldwide: 30
- Distributors worldwide: in more than 60 countries (as of 03/2012)

Million €

465

470
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Turnover development

Seattle
North Fond du Lac
Laval
Minneapolis
London
Toronto
Detroit
Chicago
Denver
Indianapolis
Coplay
Baltimore
San Francisco
NORTH AMERICA
Los Angeles
San Diego
Rogers
Raleigh
Charlotte
Atlanta
Dallas
Austin
San Luis Potosí
Bogotá
La Paz
Santiago

22

Worldwide presence on all continents

The central divisions of Beckhoff, such as development, production, administration, distribution, marketing, support and service are located at the Beckhoff Automation GmbH headquarters in Verl, Germany. Rapidly growing presence in the international market is taking place through 30 subsidiaries. Through worldwide co-operation with partners, Beckhoff is represented in more than 60 countries.

Further information

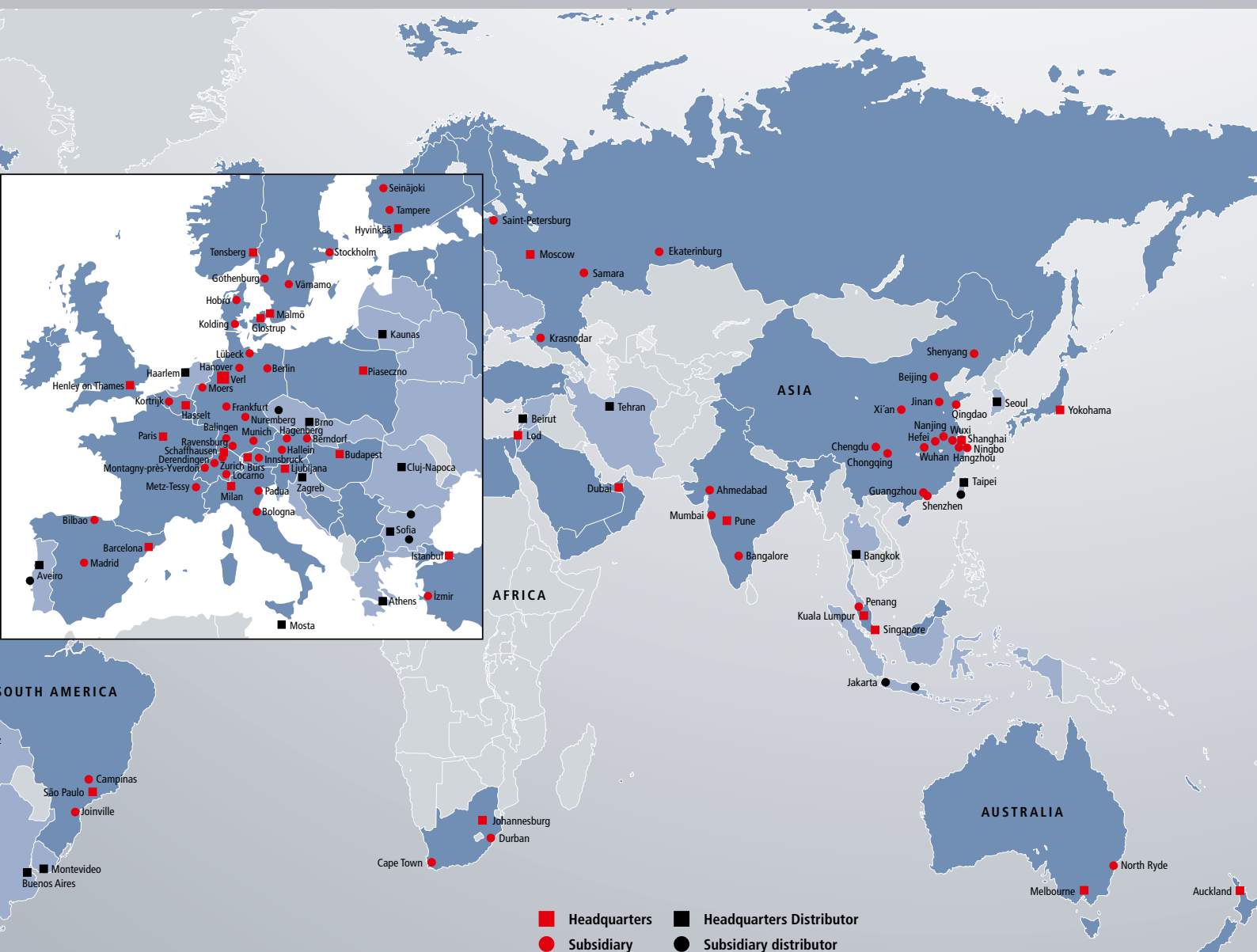The web pages "PC-based Control for Wind Turbines" offer further information, e. g. application reports or industry-specific solutions. ▶ **www.beckhoff.com/wind**

The Beckhoff catalogs and flyers are available for download on the Internet.
▶ **www.beckhoff.com/media**

🟥	**Headquarters**	⬛	**Headquarters Distributor**
🔴	**Subsidiary**	⚫	**Subsidiary distributor**

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DK3572-0812

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