

Efficient turbine foundation monitoring in Dutch offshore wind farm

CX2020 Embedded PC ensures high availability of wind turbines

Following a two-year construction period, the Dutch energy company Eneco opened the Luchterduinen offshore wind farm in September 2015. The order for monitoring the foundations of the wind turbines, situated 23 kilometers off the North Sea coast between Zandvoort and Noordwijk, was placed with Zensor, a specialist for intelligent monitoring solutions. A Beckhoff CX2020 Embedded PC processes the data acquired from sensors distributed in the wind turbine foundations and enables the transmission of measured data into the cloud.

Offshore wind energy is a booming business; however, specific requirements must be satisfied. Regular inspection and maintenance of offshore wind farm turbines is necessary to ensure reliable operation, particularly as they are exposed to extremely harsh weather conditions and a highly corrosive environment. However, dispatching a technician for on-site service of the turbines is very time-consuming and costly. Another problem is the subsidence, the gradual caving in or sinking of land around the wind turbine over the course of time. "In some offshore wind farms, the turbine pylon is fastened by means of a transition piece to the monopile on the sea bed," explains Yves Van Ingelgem, Business Development Manager at Zensor. "The space between transition piece and monopile is filled with a specially-developed concrete just for this application. Due to the force of the wind, however, the concrete can loosen from the steel, which ultimately leads to subsidence around the turbine. Further potential problems in the structure of the wind turbines can arise from corrosion, material fatigue, the elongation of bolts and walls, and cracks in the concrete."

High computing power in a compact design

Zensor – a spin-off company of the Vrije Universiteit Brussel – specializes in the monitoring of concrete and steel construction projects. The company initially concentrated on the development of specific sensors for the detection of material fatigue; today, Zensor offers all-inclusive monitoring solutions, which include data acquisition and reporting in addition to the sensor systems.

The company has installed around 30 sensors in four of the wind turbines at the Luchterduinen wind farm. They monitor not only the most diverse parameters of the structure itself, but also the environment inside the foundation as well as indirect indications of the level of the seabed through the tower dynamics. The CX2020 Embedded PC collects all measured data, pre-processes it and transmits the compressed data to the mainland via a fiber-optic cable integrated into the main power transmission line from the wind farm. "We utilize the performance potential of PC-based control to the fullest," Yves Van Ingelgem stresses. "The

PermaZEN sensor, a proprietary development from Zensor that is used in other offshore wind farms to measure corrosion on the inside of the steel foundation, requires high computing power." Zensor performs the calculations in software written in Python that runs on the PC.

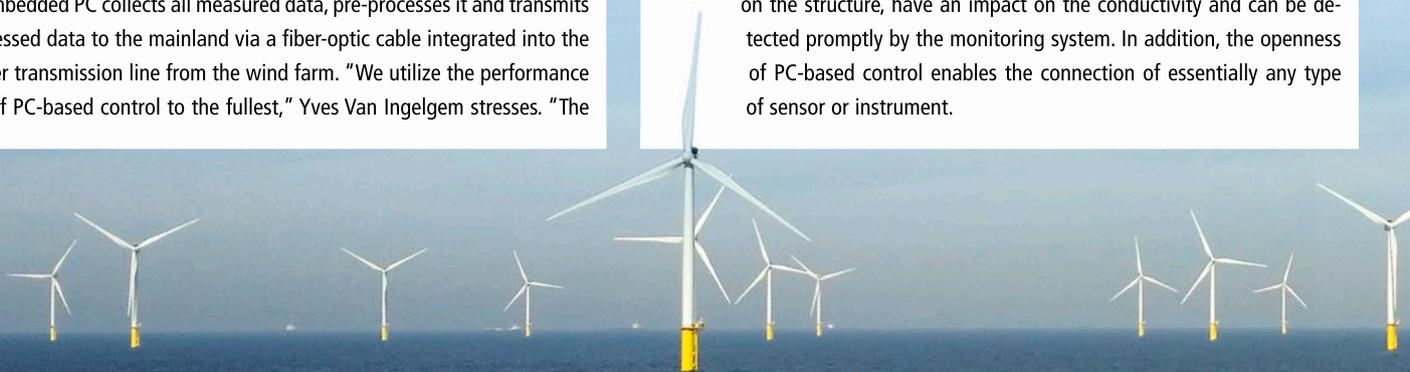
Voltage pattern delivers a picture of corrosion activity

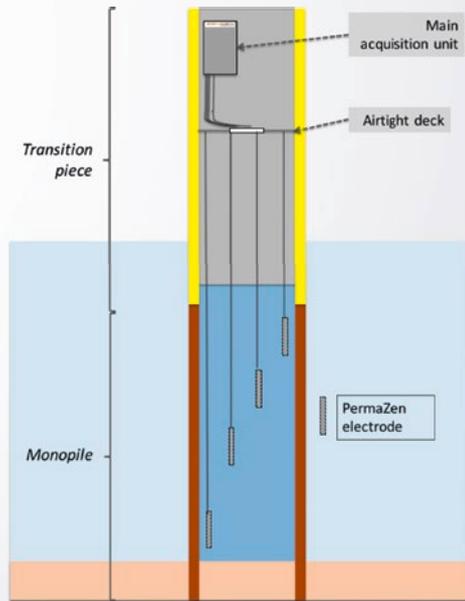
The PermaZEN sensors consist of a series of electrodes suspended at different heights in the water inside the foundation of the wind turbine. Gori Nieubourg, Product Development Engineer at Zensor says: "Voltage is generated between the electrodes and the wall of the foundation according to a certain pattern. By comparing this pattern with the measured voltage and current values, we can obtain a picture of the corrosion activity on the surface."

"The performance of the PLC, integrated via software, was a major factor in our decision in favor of Beckhoff," Gori Nieubourg states. "With PC-based automation, there was no need for further hardware, since not only the PLC, but also visualization and data storage can be executed on the Beckhoff platform. The decrease in the number of components, as well as the elimination of additional interfaces, ultimately makes the system more reliable. The pylons of the wind turbines are 100 meters high; with the aid of EtherCAT technology, however, it is easy to use even very remote fieldbus 'islands' to transmit the sensor signals to the controller over long distances without signal losses."

No limitations in the connection of peripheral devices

In addition to controlling the PermaZEN sensors, the CX2020 also takes care of the control and readout of IntegrIZEN, a system that can track the current state of concrete structures on the basis of conductivity measurements. All relevant factors, such as moisture content, crack sizes or changes in the pressure on the structure, have an impact on the conductivity and can be detected promptly by the monitoring system. In addition, the openness of PC-based control enables the connection of essentially any type of sensor or instrument.





Electrodes are suspended at different heights in the water inside the wind turbine foundation. Between the electrodes and the wall of the foundation, voltage is generated according to a certain pattern. By comparing this pattern with the measured voltage and current values, a picture can be obtained of the corrosion activity on the surface.

"We are offering a modular solution," explains Yves Van Ingelgem. "This allows us to implement the ideal application for every project without the PC platform imposing any restrictions. For some measurements, we make use of standard sensors connected to the PLC via analog or digital I/Os or via Modbus. Regardless of whether we are dealing with a simple temperature sensor or a sonar measuring instrument that scans the seabed, it is sufficient just to add the corresponding terminal to the system for each additional measurement type."

XFC terminals with high sampling rate secure competitive advantage

The majority of the measured values are read via EL3602 24-bit analog I/O terminals. "Zensor uses the eXtreme Fast Control (XFC) terminals with integrated oversampling technology, which are available with a sampling frequency of up to 100 kHz. The performance of these terminals reaches the level of high-end measurement technology applications, which is not a typical offering in the PLC world," as Gori Nieubourg emphasizes. "The resolution with which the measured values can be read, coupled with the high sampling rates, account for the competitive advantage of our solution. Another advantage is that Beckhoff offers this performance in a standard automation system that features all the robustness necessary for industrial applications. On top of that, the properties of the PLC software running on PC-based hardware were a strong argument for us: on the PLC side, we have the flexibility of the I/Os and the XFC terminals. On the PC side, we use the computing power to filter and process data, to carry out frequency analyses and to compare measured values with threshold values defined beforehand."



CX2020 Embedded PC provides high computing power in a compact device

- Integration of PLC, visualization and data storage
- High-frequency sampling of approx. 30 sensors
- Filtering and pre-processing of the data, calculation of frequency analyses, and comparison of the measured values with threshold values defined beforehand on the basis of the application software developed by Zensor
- Transmission of compressed data into a cloud system

Early detection of potential problems maximizes availability

However, the monitoring solution installed by Zensor goes beyond the equipment in the wind turbines: all measured values are compressed in the CX and transmitted via optical fiber links to a server on the mainland. There, a cloud solution is available through which the wind farm operator can monitor the system. All measured values can be retrieved in real-time; trends and deviations are illustrated by means of graphs. In addition, Zensor can carry out ad-hoc analyses of the available data in order to answer specific questions regarding the structure of the wind turbines. This allows regular checking and determination of preventive measures if required.

"Since an offshore wind turbine is sometimes not even accessible due to changing weather conditions at sea, it is not possible to quickly solve a problem," Yves Van Ingelgem adds. "However, the fact that we can identify possible problems early on gives our customer the time to prepare and plan for maintenance or repair work well in advance and determine the most suitable time." Intensive monitoring therefore also helps save costs and guarantee maximum availability of the wind turbine.

Further information:

<http://projecten.eneco.nl/eneco-luchterduinen>

www.zensor.be

www.beckhoff.be