GRID INTEGRATION AND WIND FARM MANAGEMENT

Thanks to their intelligent grid technology, ENERCON wind energy converters make a huge contribution to maintaining and improving grid stability. They can be easily integrated in grid structures the world over and meet the most demanding of grid requirements. In addition, ENERCON wind energy converters are also suitable for reducing the share of conventional power plants in large interconnected systems required for stability, as well as supplying remote grid areas and stand-alone systems.

The fundamental electrical design of all ENERCON wind energy converters is identical. The rotor is directly coupled to the multi-pole, electrically excited annular generator. The electrical power produced by the generator is fed onto the grid via a full-scale converter, which consists of a rectifier, a DC link and several inverters. In electrical terms, the use of the full-scale converter concept means the annular generator is decoupled from the grid. This enables a high level of rotor-speed variation and mechanically robust operation. Decoupling the generator from the grid has the effect that the electrical properties of ENERCON wind energy converters are determined solely by the inverters used and their control system.

To ensure that the power is fed into the grid properly, the voltage, current and frequency are recorded constantly at the point of reference (low-voltage side of transformer) and passed on to the WEC control system. The ENERCON grid feed system has the core function of feeding in the maximum possible power at all times, as well as meeting the relevant grid requirements. It enables reliable and stable operation, even in grids with strongly fluctuating voltage or frequency.

Depending on the grid, the ENERCON grid feed system can be flexibly configured for a nominal grid frequency of 50 Hz or 60 Hz. The possible voltage and frequency ranges for ENERCON wind energy converters surpass most of the international standards that apply today. This is also the case for their tolerance to high frequency gradients and their properties for riding through grid faults including dynamic grid support.

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**Fig. 1:** Electrical set-up of an ENERCON wind energy converter
GRID SUPPORT FROM ENERCON WECs

FREQUENCY STABILITY

Power-frequency control

In a power supply network, there needs to be an equilibrium between generation and consumption at all times. If this is not the case, the frequency will deviate from its nominal value. Due to the full-scale converter concept, the speed of the ENERCON generator is decoupled from the grid frequency to the greatest extent possible. The result is that, unlike with conventionally synchronous machines, frequency changes in the grid do not automatically have an impact on the WEC’s power output. The functions shown here allow ENERCON wind energy converters to contribute to frequency stability.

Inertia Emulsion – Synthetic flywheel mass for the grid

With its ‘Inertia Emulsion’ option, ENERCON offers a function that emulates the frequency-supporting behaviour of conventional power plants. If a significant drop in grid frequency is detected by the WEC at its point of reference, the active power feed is temporarily increased using the stored rotational energy in order to quickly help stabilise the frequency. Reserve power does not need to be held in curtailable form to do this. As the generator is not physically coupled to the grid frequency, a synthetic link is established via a fast data connection. This function is also known as ‘synthetic inertia’.

Power-frequency control with underfrequency

ENERCON wind energy converters also have the ability to reduce their power feed according to the grid operator’s requirements. Power-frequency control with underfrequency ENERCON wind energy converters can reduce their power feed according to the grid operator’s requirements.

Power-frequency control with overfrequency

If a power imbalance in the grid leads to temporary overfrequency, ENERCON wind energy converters can reduce their power feed according to the grid operator’s requirements.

Control reserve

ENERCON wind energy converters are already successfully participating in the control reserve market today. By providing control reserve, ENERCON wind energy converters make a contribution to stabilising frequency which goes further than the dynamic short-term range.

VOLTAGE STABILITY

Reactive power is required for voltage stability and to compensate operating equipment in transmission and distribution networks. The full-scale converter concept means ENERCON wind energy converters can provide reactive power very flexibly and dynamically.

Large reactive power range

Even in their basic configuration, ENERCON wind energy converters already have a large reactive power range when generating between 10 % and 100 % nominal active power. This reactive power can be fed dynamically into the grid as a system service. The reactive power range can be expanded by the ‘Q+’ option so that the reactive power requirements at more challenging grid connection points can also be met.

ENERCON wind energy converters can also be equipped with the ‘STATCOM option’. This expansion of the reactive power range enables reactive power to be provided irrespective of the active power – even when there is no wind. The ‘STATCOM option’ can be implemented with or without the ‘Q+’ option.

Abb. 6:

a) P/Q diagram of E-82 E2
b) P/Q diagram of E-82 E2 with expanded reactive power range (Q+ Option)
c) P/Q diagram of E-82 E2 with expanded reactive power range (Q+ Option and STATCOM option)

BEHAVIOUR DURING GRID FAULTS

The ability to ride through temporary grid faults is crucial for grid stability. The ‘Fault Ride Through function’ (FRT) available as standard on present-day ENERCON wind energy converters enables them to ride through grid faults such as undervoltage, overvoltage and automatic reclosing lasting up to five seconds. The ENERCON wind energy converter is capable of supplying active power to the grid during the fault. At the same time, the grid can be provided with voltage-supporting reactive current which can help to keep the affected grid area as small as possible. The feed-in of the reactive current can vary for each phase in order to balance out possible asymmetries during the fault and support the functioning of the protection systems. After successfully riding through the grid fault, the wind energy converter resumes its active power feed.

The FRT behaviour parameters can be configured flexibly, meaning the WEC behaviour in the event of a fault can be adapted to the grid operator’s specific requirements or the project’s framework conditions. The ENERCON FRT function is validated and certified according to the most stringent grid requirements.

Fig. 5:

Range of dynamic grid support FRT for an ENERCON WEC at the point of reference
The ENERCON SCADA system (Supervisory Control and Data Acquisition) is the platform for remote monitoring and control of wind energy converters. It has been established for many years and is an integral component of ENERCON’s service and maintenance programme. It offers numerous optional functions and interfaces for integrating ENERCON wind farms in the grid and ensuring compliance with technical grid connection criteria.

The ENERCON SCADA system has a modular set-up. The applications shown here can be easily and conveniently adapted to customer-specific requirements, or extended where necessary. Due to optimum adaptation to the technical and economic conditions of the respective wind farm project, the ENERCON SCADA system guarantees maximum yield.

**GENERATION MANAGEMENT SYSTEM**

**POWER CONTROL FOR MAXIMUM YIELD**

If the cumulative nominal power of the WECs in an ENERCON wind farm is greater than the grid connection capacity at the network connection point, a special power control system ensures that the available grid connection capacity is used to the fullest.

If one wind energy converter in the wind farm is generating less power, a higher capacity is released for the other wind energy converters accordingly. Optimal coordination of wind energy converters with varying operating loads within a wind farm is carried out fully automatically via the generation management system in the ENERCON SCADA RTU/ENERCON SCADA FCU E2.

**BOTTLENECK MANAGEMENT**

**MAXIMUM YIELD DURING GRID BOTTLENECKS**

ENERCON bottleneck management makes it possible to connect wind farms in regions where the grid does not have sufficient available transmission capacity. Continuous data exchange between the wind farm and the grid operator ensures that the maximum permissible wind farm output is adapted to the actual transmission capacity.

The maximum possible yield during grid bottlenecks means yield losses are minimised for wind farm owners and operators. The bottleneck management feature in the ENERCON SCADA system automatically adjusts the wind farm’s power output to the best possible setting in the case of a bottleneck.

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**ENERCON SCADA SERVER**

The ENERCON SCADA Server is part of the ENERCON program package, and represents the key component of every ENERCON SCADA system. It is connected to the wind energy converters in a wind farm via the wind farm’s internal optical fibre data bus system. The ENERCON SCADA Server performs various functions in the wind farm with regard to communication, data acquisition and control. This makes it the wind farm’s central repository for the current and archived operating data of the WECs and the ENERCON SCADA components.
ENERCON SCADA WIND FARM CONTROLLERS

On a wind farm consisting of multiple ENERCON WECs, the wind farm’s behaviour at the grid connection point can be controlled using an ENERCON SCADA wind farm controller, such as the ENERCON SCADA RTU or the ENERCON SCADA FCU E2. The local requirements determine which wind farm controller is suitable. This decision is made on a project-specific basis.

ENERCON SCADA RTU

The ENERCON SCADA Remote Terminal Unit (RTU) is a superordinate system for wind farm control and external communication. It has a modular design and is equipped with various hardware components and control options depending on the required functionality. In its basic version, the RTU takes on the function of a data interface with the possibility of providing setpoint values for the wind farm. The RTU can be optionally equipped with digital and/or analogue I/O modules for exchanging signals with the utility company or the operator/owner. There are a number of interfaces available for this purpose.

The RTU can also be used to control the wind farm at the grid connection point. It calculates control values using setpoints specified by the grid operator, for example, and actual values measured at the grid connection point. These control values are transferred to the ENERCON wind energy converters via the ENERCON SCADA Server. In this way, closed loop control can be established and various control properties such as P, Q, cosphi and Q(U) can also be set. These enable the wind farm to behave in accordance with the grid operator’s requirements and the local grid conditions.

ENERCON SCADA FCU E2

The ENERCON SCADA Farm Control Unit E2 (FCU E2) is a superordinate system for wind farm control and external communication. It has a modular design and is equipped with various hardware components and control options depending on the required functionality.

The FCU E2 offers a platform for sophisticated control functions. As it has its own fibre optic bus in the wind farm, the ENERCON SCADA FCU E2 offers a minimised reaction time and therefore presents a solution for rapid control purposes. Various interfaces are available for signal exchange with the utility company and the WEC operator or owner. To this end, the FCU E2 can be optionally equipped with digital and/or analogue I/O modules. The ENERCON SCADA FCU E2 not only provides fundamental control properties such as P, P(f), Q, cosphi and Q(U), but site-specific solutions as well. The controller can be optimally adapted for challenging grid connections, on the basis of simulations as well as the possibility to fine-tune parameters on site.

ENERCON SCADA REMOTE

ENERCON SCADA Remote is part of the ENERCON SCADA program package. It can be used to establish a connection to the ENERCON SCADA Server to allow users to view current and historical wind farm data online. The recorded WEC data such as operating hours, power, wind speed, technical availability and status messages can be visualised in a table or a graph. Historical data can be downloaded for offline analyses, enabling flexible further processing in external applications (e.g. spreadsheet).

ENERCON SCADA POWER CONSUMPTION MANAGEMENT

The ENERCON SCADA Power Consumption Management (PCM) can be used to limit the power consumption of ENERCON WECs at the grid connection point to an individually configurable value. This is especially useful for systems such as the blade heating and generator drying systems with large thermal loads, as these are often only used when the WEC is at a standstill, usually affect the entire wind farm, and can require considerable levels of power to be drawn from the grid.

ENERCON SCADA METEO

ENERCON SCADA METEO is used to acquire and analyse meteorological data in combination with ENERCON SCADA. The key component of the ENERCON SCADA METEO is the data logger installed in a weather data acquisition cabinet. It enables a wide range of sensors to be connected for the purpose of taking wind and weather measurements. Sensors and the meteorological mast are not standard components of ENERCON SCADA METEO, but can be included on request. This gives the customer the opportunity to design a weather measuring system that will suit their specific requirements.

ENERCON SCADA SYSTEM

Wind turbine operators, direct marketers, and grid operators are showing more and more interest in receiving online wind farm data in real time and sending setpoints to the wind farm. To make this possible, ENERCON offers a selection of interfaces including SCADA OPC and SCADA PDI-61400, 60870-5-104, Modbus and DNP3. These all comply with universally acknowledged industry standards. The ENERCON SCADA system can be adapted for each project to meet more far-reaching requirements, ensuring that all specifications put forward by the customer and grid operator can be fulfilled.

Fig. 8: ENERCON SCADA Remote

Fig. 9: Closed-loop wind farm control with ENERCON SCADA RTU

Fig. 10: Closed-loop wind farm control with ENERCON SCADA FCU E2
The ENERCON Service Info Portal (SIP) offers a high level of functionality and transparency regarding all relevant WEC data. In addition to ENERCON SCADA data, users can obtain quick and easy access to any service information they require for their own wind energy converters via the internet, without having to use additional software. A personal password and encrypted communications ensure double data protection according to the latest security standards.

A user-friendly menu in SIP allows for straightforward access to all monthly, weekly and daily analyses of the WECs. Customers can generate yield and availability overviews or consult maintenance and service reports in a matter of minutes.

The following information can be obtained through ENERCON SIP:

- Service orders and reports
- Maintenance orders and reports
- Availabilities
- Yield analyses
- Power curves
- Maps
- Service messages
- Status messages
- Master data of the wind energy converters
- Downloads
- Calculation of yield loss in the event that output is limited by the utility company (Germany only)

In order to ensure a high level of quality, functionality and reliability throughout the transmission substation’s operating lifetime, and avoid unnecessary service and maintenance costs, the components and equipment undergo a prequalification process specifically designed by ENERCON. In addition, prequalified suppliers are regularly audited to ensure high quality is sustained in the long term. Please contact the experts at ENERCON PLM High Voltage Systems for more information on ENERCON transmission substations.

ENERCON offers a full service package to deliver transmission substations and transmission lines for connecting ENERCON wind farms to high voltage and ultra-high voltage grids. This encompasses engineering and planning as well as implementation, commissioning and operation. The transmission substations provided by ENERCON offer cost-optimised and innovative solutions for grid connections from 38 kV to 500 kW with transformer ratings of 15 MVA to 600 MVA.

GRID INTEGRATION SERVICES

The technical requirements for connecting wind energy converters to the grid have increased significantly in recent years. ENERCON brings together all of the relevant specialist areas, and this enables the company to take a holistic approach to grid integration. ENERCON offers technical support for wind farm projects where required by the customer, beginning with the first theoretical simulations and then ranging from technical implementation and commissioning to compliance tests for the whole wind farm. Right at the start, during the early project phases, ENERCON assists the customer in determining the necessary WEC configuration for the project to ensure the required connection guidelines are fulfilled.

ENERCON customers can also count on our technical know-how and many years of experience if they intend to connect their wind energy converters to the grid together with photovoltaic or biomass systems, hydropower plants, or storage systems. The customer can also choose to have ENERCON take care of planning and delivering the entire electrical infrastructure of the wind farm, or connecting renewable projects to the grid as an EPC contractor.
Contact

Our experts from the Sales - Grid Integration team are happy to answer your questions on the grid properties and grid integration of ENERCON wind energy converters.

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