

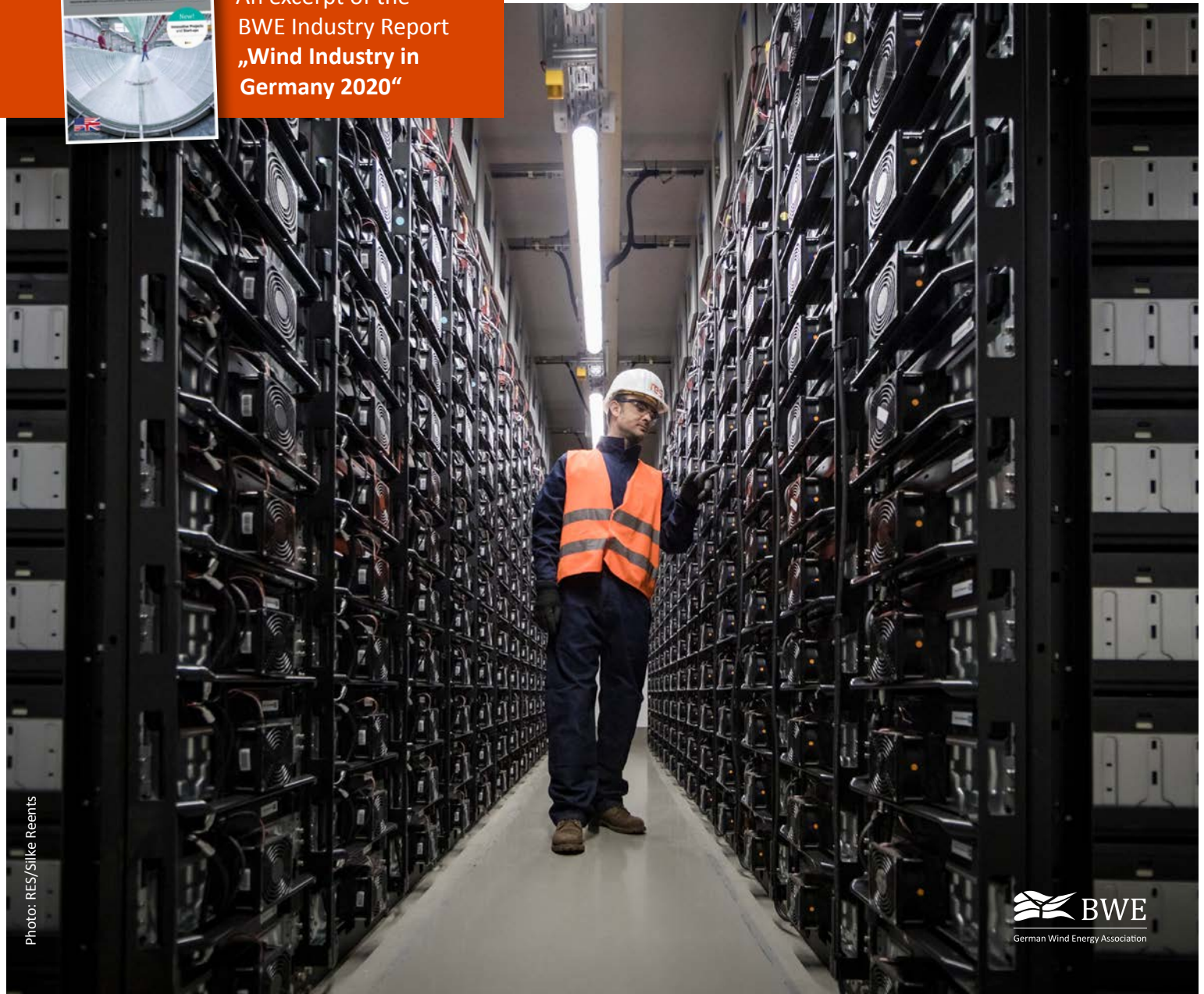


INNOVATIVE PROJECTS for the German wind market

The following pages are dedicated to companies whose new products, processes or methods ensure the continued development of the wind industry.



An excerpt of the
BWE Industry Report
„Wind Industry in
Germany 2020“



FLYING WIND MEASURING SYSTEM

Complex terrain and the resulting wind conditions can lead to unexpected yield losses at the wind farm. The WindLocator flying measuring system developed at the Center for Wind Power Drives in Aachen provides **planning security**.

Motivation

The annual wind energy yields of individual turbines within a wind farm in complex terrain can vary by up to 30%. One reason for this are wind phenomena, which can lead to local differences in the mean wind speed of up to 45%, e.g. due to steep ledges or obstacles (own measurement, Fig. 1). Increased planning reliability, therefore, requires a deeper understanding of the local wind conditions. Various methods are currently used to investigate these. Directive-compliant measuring systems (measuring mast, LIDAR, SODAR) offer statistical security, but are simply too immobile to produce spatially resolved insights. CFD simulations provide high spatial resolution, but are time-consuming and have large error potential due to complex boundary conditions.

The CWD WindLocator flying measuring system combines the advantages of both approaches by spatially resolving and statistically comparing the actual wind conditions.

The measuring system

The WindLocator consists of three main components: the flying carrier system, a 3D ultrasonic anemometer and an integrated analysis module.

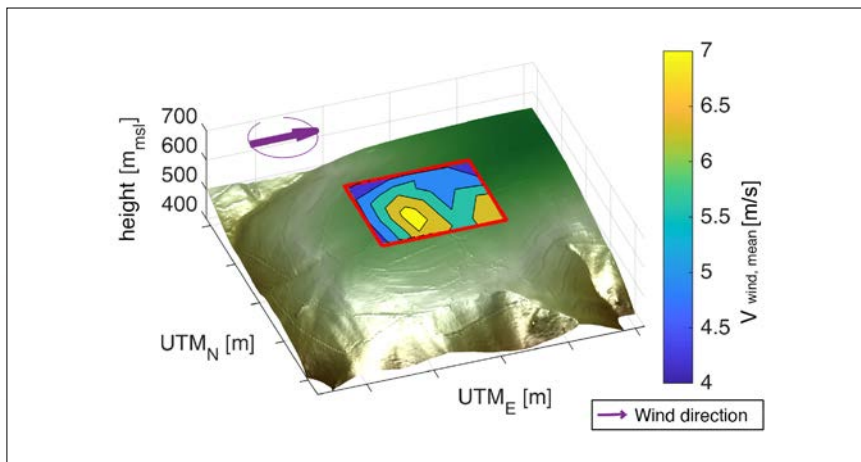
It is based on a high-performance carrier system, which enables accurate position control at all relevant wind speeds (at peak wind speeds of up to 25m/s). The GPS system facilitates the flexible planning of flight routes and measuring points, which can be approached autonomously and thus repeatedly.

„With our system, we want to provide better insight into the local wind conditions on a scientific basis. This enables us to make a quick and cost-effective contribution to optimising the yields of our customers' wind farms.“

*Christian Ingenhorst,
project manager in charge*



Fig. 1: Mean wind speed distribution across a 25ha area at 100m above ground at a complex location in the Eifel region



The measurement of wind speed and direction by means of the onboard anemometer is influenced by the flight system's own movements and tilting as well as by propeller induced winds. These disturbance variables are compensated for by means of sensor fusion via an analysis module, which was developed in house, with additional position and acceleration sensors. The standard uncertainty of the WindLocator is therefore only 0.37 m/s and is therefore comparable to the specified accuracy of the anemometer itself (0.18 m/s). Local wind conditions can, therefore, be recorded in a reliable and robust manner, as was successfully demonstrated in validation tests with stationary anemometers on the measuring mast and near the ground.

Conclusion

Significant differences in the spatial wind speed distribution lead to large uncertainties in park planning involving complex terrains. The CWD WindLocator provides a faster and more cost-effective insight into the local wind conditions compared to established methods. The validated measuring system can therefore be used profitably in almost all project phases of the park planning process.

Applications

The system can be used profitably in almost all project phases during the wind-farm planning process, starting with the preliminary evaluation of potential wind farm locations, through the analysis of the overall wind conditions in the planned wind farm to the targeted identification of high-yield turbine locations. In particular, the early definition of the specific turbine locations makes it possible to use expensive, directive-compliant measuring systems only where the wind conditions really require it, thus reducing the resulting uncertainty in the wind report. The flexibility of the measuring system also allows it to be used in various application scenarios, e.g. to validate simulation results or to investigate follow-up effects.

Project overview

Initiator	In-house initiated development
Implemented by	CWD Aachen GmbH in collaboration with IME Aachen GmbH and RWTH Aachen University
Facts and figures	Autonomous, position-controlled wind measuring system, up to 25m/s wind speed, standard uncertainty 0.37 m/s
Project status	Development phase completed, sales launch completed
Location	The project is not site-specific. The system can be used throughout Germany.



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www.windpower-aachen.de

DIGITISED FINANCIAL ASSET CONTROLLING

Renewable energy projects can now be financially **monitored and optimised** over the entire project lifetime with a new software package from greenmatch.

Last year, greenmatch, in collaboration with a major German asset manager, began developing a digital solution for monitoring the financial performance of renewable energies. The new product GM Asset Controlling will become available in 2019.

By channelling and processing the flood of information from various sources, the major challenge in asset management is addressed. Collecting and processing information is extremely time-consuming, and the process is complicated by the many manual interfaces involved. Until now, this process has mainly involved the use of spreadsheets, making it highly susceptible to human error. The new product enables asset managers to focus more on data analysis and the implementation of measures to sustainably improve the profitability of renewable energy plants.

The new product helps asset managers to meet their reporting obligations by enabling them to monitor and optimise financial performance and simplifying liquidity and distribution planning as well as the budgeting process. Establishing connections between planned and actual figures is a central challenge in the field of development.

Greenmatch is therefore integrating the new GM Asset Controlling product directly into the existing GM Valuation product which represent plan figures. Not only does this ensure a smooth transition between the financial plan and actual performance. It also enables on going impairment tests of your project directly within a single web-based app.

Monitor the financial performance of your assets

Thanks to the unique integration of financial planning and actual figures, the new product is the ideal tool for monitoring the financial performance of an investment. Apart from comparing planned and actual figures, GM Asset Controlling provides valuable information on the reasons for deviations from the plan. This allows

for statements to be made such as: The current return is 2% below the originally planned return. The higher revenues were more than offset by higher operating and investment costs. The biggest negative effect on the return was the increase in investment costs." (see Figure 1)

Year-to-date reporting

In addition to monitoring long-term financial performance, the short-term view in the form of year-to-date key figures also forms an integral component of the new asset controlling solution. The focus here is primarily on the controlling of operating figures such as production, revenues, operating costs and EBITDA. This information provides the basis for a reliable budgeting and forecasting process.

Figure 1: IRR deviation analysis

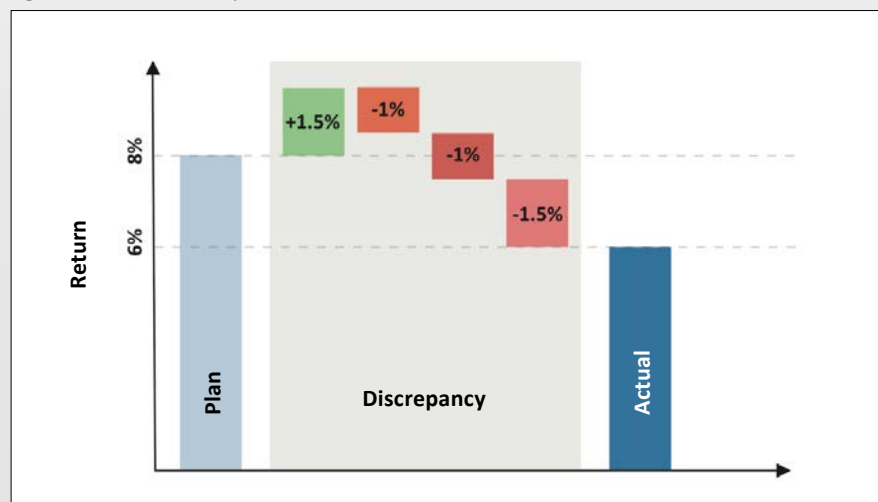
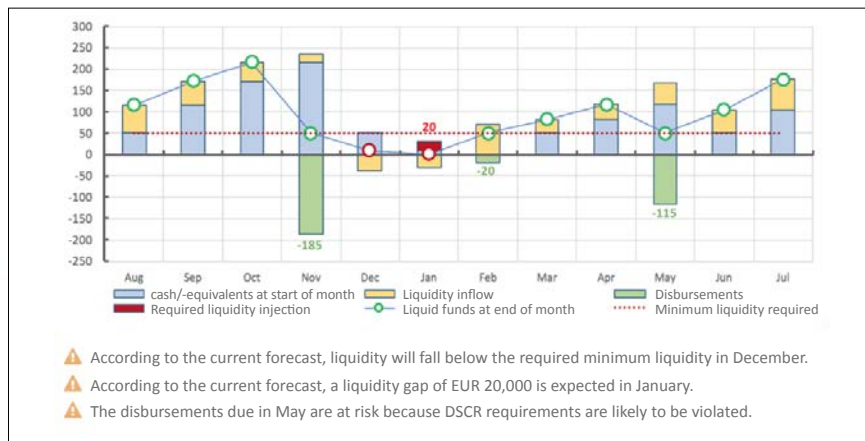


Figure 2: Liquidity planning



Liquidity and distribution planning

Another focus is rolling liquidity planning. GM Asset Controlling processes the latest available information and combines it into a liquidity plan. The system can derive hints and recommendations for action directly from the data and support the asset manager in optimally planning distributions and adapting them to the project-specific payment modalities. Figure 2 shows an example in which the planned distributions of EUR 186,000 will result in a planned liquidity gap of EUR 20,000 in the following months. The asset manager can make provisions and avoid unpleasant surprises.

Aggregation at portfolio level & benchmarking

In addition to the project-level view, the product will be extended in a subsequent step by a function for aggregation at the portfolio or investor level. This will enable monitoring of the financial performance of the overall portfolio and provide exciting opportunities for benchmarking. For example, the system will detect irregularities within the portfolio and derive indications for the asset manager using messages such as “the lease costs in Project A are 5% higher than the average”.

Conclusion

Thanks to the close link between financial planning and asset controlling in an integrated system, the new product from greenmatch offers the optimum solution for asset managers who wish to monitor and optimise the financial performance of their investments. The “Performance Monitoring” application is already developed and currently in an integration and test phase involving test customers. Collaborations with other test customers would be ideal for the further development, especially in the areas of portfolio aggregation and benchmarking.

“The new GM Asset Controlling product enormously increases both the transparency of investments in renewable energy projects and the efficiency of asset management.”

Tobias Bitterli, Co-CEO greenmatch AG



Project overview

Initiator	greenmatch AG & Deutscher Asset Manager
Implemented by	greenmatch AG
Project status	Market launch in 2019

green[::]match

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greenwind control: INDEPENDENT = INNOVATIVE

The company Green Wind has developed the state-of-the-art **24/7 control center** *greenwind control*, which, according to General Manager Manuel Lasse, owes its success primarily to its independence in conjunction with state-of-the-art technology.

As a result of its engagement by General Elekrtrics to assume responsibility for maintenance management of the DolWin3 offshore platform as one of two partners of ARGE O+M, Green Wind Offshore GmbH has entered a new level of technical operations management. Within the scope of the 900 MW project, the company invested in the design and construction of a state-of-the-art 24/7 control center that is now also available to other interested parties. A second major contract from Siemens Gamesa has proven to Green Wind General Manager Manuel Lasse that an independent control center like *greenwind control* meets a need in the industry.

On- and Offshore

According to Lasse, *greenwind control's* independence is what makes it truly special. There are only very few companies that offer such sophisticated technology for the 24/7 monitoring of on- and offshore wind turbines. But in contrast to large suppliers, Green Wind is not affiliated with or dependent on any manufacturers, operators, service providers, or investors: "This allows us to speak with everyone as equals – from the operations manager to the major energy supplier – without any conflicts of interest."



Digital Twin for "Albatros"

One of the company's major clients is Siemens Gamesa, which is installing 16 SWT-7.0-154 offshore turbines and the offshore transformer module with grid interfaces in EnBW's "Albatros" offshore wind farm. Green Wind Offshore GmbH was hired to organize and supervise all of the switching operations needed for the initial operation of the OTM and the wind turbines until the end of 2019. In addition, the entire grid structure has been reproduced as a digital twin in the control center software used by *greenwind control*, and is configured for both manual and optional remote control.



“In addition to all of the technical components and an exceptionally well-trained team, we also offer our customers something special – our independence.”

Manuel Lasse, General Manager of Green Wind



Control Center Sharing

But Lasse also believes the control center can be used in other ways. One of his main concepts is called control center sharing. This means that operators and independent service providers can use Green Wind technology, including 24/7 personnel, which would in turn allow them to offer their customers 24/7 monitoring and thus faster response times. This means that small and large onshore and offshore service providers can benefit from the system without having to bear the acquisition costs.

On the other hand, Green Wind can offer independent investor consulting services for complex onshore and offshore investments. This includes reviewing existing maintenance concepts to ensure that they are being carried out in accordance with the contract. Another option, according to Lasse, is to support large energy suppliers in setting up “monitoring and control systems” for infrastructure and personnel.



Two Connected Systems

All of this demands high safety standards, and one way to ensure compliance is by linking two control center systems that can replace each other if necessary. In addition, Green Wind stores all the data on servers in Germany and regularly backs it up to locally isolated and secure storage systems. To secure the systems, Green Wind relies on redundant and monitored networks consisting of select industrial-grade components. The *greenwind control* infrastructure is ISO 27001 certified.

Conclusion

***greenwind control* from Green Wind is one of the few 24/7 control centers that combines sophisticated technology and independence and can therefore be used by both small and large onshore and offshore service providers. Data security is guaranteed by the linking of two control center systems, among other measures. The infrastructure is ISO 27001 certified.**

Project overview

Initiator	Green Wind
Implemented by	Green Wind Operations GmbH and Green Wind Offshore GmbH
Facts and figures	General grid control, monitoring and management of substations, HVDC platforms, and onshore and offshore wind farms. Coordination and planning of service and maintenance. Switching authorisation up to 170 kV.
Project status	In operation since June 2018
Location	



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ENERGY PLANT MAINTENANCE IN OFFSHORE AREAS

The operation of 400 MW offshore wind power plants is ensured by maintenance, testing and servicing, as well as repair and 24/365 operational readiness, from a single competent source.



When a highly complex energy transmission system is installed, consisting of 36 medium-voltage switchgear panels (33 kV) with gas-insulated design, 2 155/33 kV transformers, a 155 kV GIS system and 86 medium-voltage switchgears on the wind turbine towers, supported and monitored by more than 200 digital protection and control technology devices with distance protection, differential protection and numerous OCP applications, an operating period begins in which the operator must test this complex system technology accordingly and, most importantly, ensure it remains functional. This task, in the normal environment of an application that has been tried and tested countless times, represents a real challenge for the operator in the offshore sector.

The availability of specialists with the appropriate offshore approval is one hurdle, but travel costs, local accommodation, and the limited capacity of overnight lodgings at sea also necessitate a concentration of specialist expertise in one person if possible, with appropriate redundancy.

“The process of implementation is determined by the requirement profile of the task.”

Martin Frangen, Managing Director, Koopmann Group



In addition, transport between the platform/hotel ship and the wind turbine towers is only possible in calm seas. Since, historically, technological boundaries exist in the German energy industry between the specialist areas of switchgear technology and protection technology as well as transformer know-how, this concentration of expertise on the basis of the requirements profile of the deployment site is the critical factor in being able to work successfully, cost-optimally and quickly.



The knowledge base of the employees must be broad as well as detailed, and the physical requirements for offshore work must be met.



- 01 | Koopmann in offshore operation
- 02 | Mobile equipment for flexible use
- 03 | Gas-insulated medium-voltage switchgear
- 04 | Reflection measurement on HV cables
- 05 | Testing the protective relays

Project overview

Initiator	Global Tech
Implemented by	Koopmann Group
Facts and figures	400 MW offshore wind power generation, 36 medium-voltage switchgear panels (33 kV) with gas-insulated design, 2 155/33 kV transformers, one 155 kV GIS system and 86 medium-voltage switchgear units
Project status	Ongoing maintenance cycle
Location	North Sea, approx. 180 kilometres off Bremerhaven



The bottom line

The development of the requirement profile marked the beginning of the Koopmann Group’s expansion into this demanding service sector. Through the development of employees and taking into account the optimisation of deployment capacities, this led to excellent results – the complex installation can be safely maintained and tested, and repaired with fast reaction times, thus securing the long-term contribution of this installed energy supply facility to the German power supply.



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PD DIAGNOSIS FOR CONDITION ASSESSMENT OF SWITCHGEAR

The reliability of medium voltage switchgear is an important basis for the safe operation of grids. PD measurement has emerged as a suitable method for detecting damage to insulation as early as possible.

Partial discharge (PD) measurement has proven itself as a reliable diagnostic method both for SF6 gas and air-insulated switchgear. Partial discharge is the localised, short-term electrical discharge of partial capacities, which can cause irreversible damage to insulation. The longer partial discharge occurs, the greater the level of damage; ultimately this can lead to dielectric breakdown and subsequent failure of the switching system.

Partial discharges are sub-divided into external and internal partial discharges. The following causes can be listed:

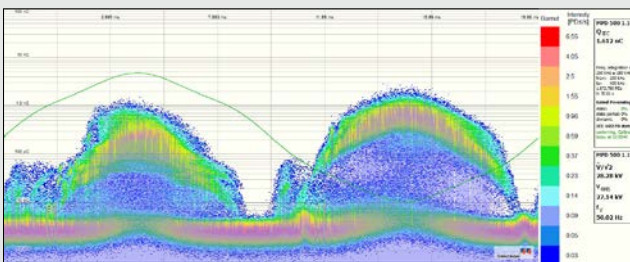
- Voids within solid insulating material
- Sliding discharges along two different mediums
- Inhomogenities of the electric field
- Potential-free metal objects
- Free particles within the electric field



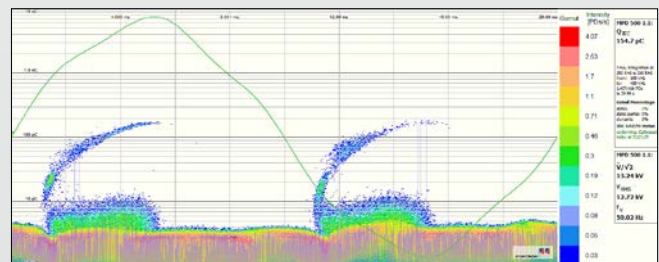
PD measuring system for up to 100 kV

In switching gear, PD can originate in screw connections, cracks, voids, free potentials on busbars, insulators, busbar glands or contact sockets with isolating contacts, as well as the cone for attaching energy cables.

Partial discharge testing has to be set up in line with IEC 60270 and IEC 62271 (DIN VDE 0671). Conventionally, PD measurement uses a PD-free coupling capacitor, a coupling device, and a PD measuring system.



PD measurement, 24 kV GIS (imperfection between bushing and fuse tube)



PD measurement, 12 kV switchgear of the defective capacitive insulator

“Using metrology in the preparation of maintenance is the basis of investment decisions“

Martin Frangen, Managing Director, Koopmann Group

PD measurement establishes a magnitude of PD that is usually expressed in picocoulombs (pC). However, this does not give any indication of the geometrical shape and quality of the electrical charge. In order to develop meaningful recommendations for action, not only the magnitude of PD needs to be established. The entire PD measurement results must be carefully analysed in order to reach a solid conclusion.

Measurements in the UHF range can do without a high voltage resistant coupling capacitor. Due to the very broad frequency range the radiation emitted by PD can be received by antennas and sensors. Since PD generates transversal electromagnetic (TEM), transverse electric (TE) or transverse magnetic (TE) waves, these signals can be detected by capacitive field sensors or antennas.

In the context of minimally invasive PD diagnostics, PD measurement takes place using a voltage detection system (VDS) interface. PD signals are extracted under operating voltage via the VDS interface of the enclosed switching gear.

The advantage of alternative PD measurement is that it can be done online, i.e. when the power equipment is in service. The plant does not have to be taken off the grid; customers therefore continue to receive electricity while measurement is taking place. Because of the tight requirements for alternative measurements with respect to background noise levels in the field, conventional PD measurement techniques are still the first choice in cases where these requirements are exceeded, as well as for measurements of PD with higher inception voltage than operating voltage.

Conclusion

The use of PD diagnostic techniques optimises maintenance efforts, tests operational safety, highlights any maintenance investment needs, and represents an additional, metrologically based decision criterion when it comes to the replacement, renewal or maintenance of equipment. Together with operational experience and manufacturer recommendations, these additional parameters can form the basis for any investment decision.



Defective capacitive insulator in 12 kV switchgear (see error pattern on the previous page)

Project overview

Initiator	EnBW Energie Baden-Württemberg AG
Implemented by	Koopmann Group
Facts and figures	Old switching gear constructed in 1986
Project status	completed
Location	Eastern Baden-Württemberg



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HIGH PERFORMANCE 2.0 – SECOND GENERATION HYBRID TOWER CONCEPT

Fully exploiting the potential of wind energy – this is the goal Max Bögl Wind AG wants to realise through the further development of its **modular tower concept**.

The new generation of the Hybrid Tower Bögl reaches hub heights of up to 190 meters and enables an even faster and more economical implementation of wind towers of the highest quality due to standardised processes.

Every meter a wind turbine gains in height can increase the annual electricity yield by up to 1 percent. As an efficient combination of steel and concrete, the Hybrid Tower with maximum hub heights ensures a quick return on investment for the entire project.

But it is not only the increased output that contributes to the economic efficiency of the new Hybrid Tower: the tower concept has also been optimised in terms of project management, which saves costs, simplifies logistics and improves the assembly process.

The new foundation design simplifies the prestressing at the entrance level of the wind turbine, thereby streamlining the work processes. Higher fatigue strengths are achieved and structural peak loads are further reduced. The conical Hybrid Towers 2.0 require significantly less pre-load force and have optimised power flow.

The internals are installed using a new process patented by the Max Bögl Group: lift and ladders are installed in parallel and concurrently with the erection of the concrete tower, which reduces the installation time considerably. The engineers have also focused on logistics and transport: almost no heavy load vehicles are required to transport the individual tower segments. The use of standard trucks makes the installation of the wind turbine more flexible, less risky and faster.

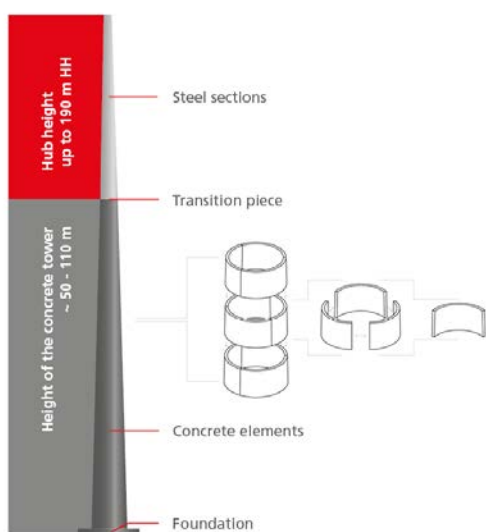


Photo: Max Bögl Wind AG / Reinhard Mederer

Production of the Hybrid Tower takes place in the Max Bögl Group’s prefabrication plants, where the segments are manufactured in serial production and ground to an accuracy of 1/10 of a millimetre with the aid of a CNC system. The benefit of this is that the individual elements can later be placed one on top of each other on the construction site without the use of mortar regardless of weather conditions.

Thanks to the Mobile Fabrication developed by Max Bögl, the Hybrid Tower can also be produced directly at the project location almost anywhere in the world – as was recently done in Thailand. The mobile production facility can produce Hybrid Towers directly on the construction site while maintaining the high quality standards of the German production plant, and increases local economic efficiency by involving local workers and raw materials.

This was one of the reasons why the trend-setting concept won this year’s bauma Innovation Award in the construction process category.



Photo: Max Bögl Wind AG / Reinhard Mederer



Photo: Max Bögl Wind AG

Conclusion

New technologies are essential to the efficient use of wind energy regardless of location, and especially important in terms of achieving current climate targets worldwide. Innovative and at the same time economical energy solutions such as the Max Bögl Hybrid Tower concept are paving the way to a more sustainable future.

Facts on Max Bögl Wind AG

- First hybrid tower prototype in 2010
- Start of serial production in 2011
- Over 1,850 towers manufactured and installed
- More than 4,800 MW installed
- More than 42 certified tower types
- Installation of the highest onshore wind turbine by hub height in Oct. 2017 in Gaildorf (178 m HH)
- More than 220 MW of developed wind projects
- 2017–2019 first project of the Mobile Fabrication in Thailand (90 turbines)
- Winner of the bauma Innovation Award in 2019 in the construction process category



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100 % RENEWABLE WITH BATTERY STORAGE SYSTEM

RES Deutschland GmbH is building one of the **most modern energy balancing power plants** in the world. The battery storage system will help Bordesholm achieve energy self-sufficiency and 100% renewable energy supply going forward.

Bordesholm is a small municipality with 8,000 inhabitants in the north of Schleswig-Holstein. Its municipal utility, Versorgungsbetriebe Bordesholm GmbH (VBB), generates about 75 % of the municipality's annual electricity demand from renewable energy. The municipality is aiming to cover 100 % of the electricity demand exclusively from regional renewables by 2020. VBB has been pursuing its "Vision 2020" with corresponding measures since 2008 and has set itself the ambitious goal of becoming completely independent of fossil fuels.

To make this possible, RES Deutschland GmbH has designed and built a battery storage system for VBB.

As a pilot project, the battery storage facility was supported by the state of Schleswig-Holstein and the Technical University of Cologne for research purposes. The aim of the project is to establish whether it is possible to operate a public power supply network, fed by 100 % renewable energy, as a frequency-stable standalone network.



One of the most modern balancing energy power plants in the world

The 10-MW battery storage system has been in operation as scheduled since May 2019 and is one of the most modern energy balancing power plants in the world. The battery storage system now reliably provides primary energy balancing for the Europe-wide electricity transmission network. Prequalification for participation in the energy balancing market was granted by the transmission system operator TenneT. In the event of a failure of the upstream power grid, the battery storage system acts as a "load spring" to ensure a stable grid frequency by balancing all consumers and intermittent energy production from renewable energy sources in less than 0.2 seconds.



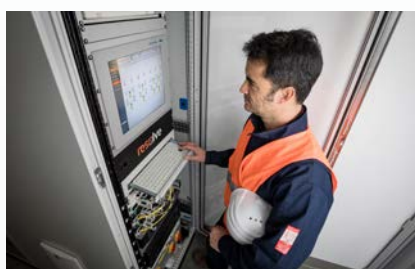
Photos: © RES / Silke Reents

“The battery storage facilities are now at the same point as the wind and solar energy were 30 years ago. Furthermore, we need visionaries who can think ahead in the future of energy supply, because this is the only way we will be able to bring about the energy transition.”

Dominique Guillou, Managing Director of RES Deutschland GmbH

Cellular network of many self-sufficient power grids – the first cell is Bordesholm

In addition to frequency stabilisation, two further features of the battery storage system are its “standalone network” and “black start” capabilities. Black start refers to the ability to start up a power plant independently of the power grid from the deactivated state. The battery storage system is thus also able to reactivate a deactivated power grid, a feat that was previously reserved for fossil-fuel power plants. Standalone connectivity means that the local network in Bordesholm can continue to operate in the event of a grid failure. VBB is thus in a position to provide the supply area with 100 % renewable and regionally generated energy completely independently as an independent cellular network.



Performance and energy management with RESolve®

The operation of the battery storage facility is optimised with aid of RESolve®, RES’s proprietary control and energy management system. 24/7 monitoring ensures the reliability and safety of the battery storage system. The control system is based on extensive experience with grid-connected generation plants and thus provides a spectrum of grid-support and grid-protection control functions. This protects the battery storage system from surge voltage and overheating, which increases the service life of the battery storage system and optimises its performance.



Conclusion

Full supply through renewable energy is already possible today thanks to intelligent and system-compatible battery storage. These are key solutions for future decentralised energy supply from 100% renewable energy. They offer communities such as Bordesholm the opportunity to build a cellular power grid comprising many small self-sufficient power grids, which together form a district power grid but are also capable of supplying a region reliably on their own.

Project overview

Initiator	Versorgungsbetriebe Bordesholm GmbH
Implemented by	RES Deutschland GmbH
Facts and figures	10 MW/ 15 MWh lithium-ion battery storage for frequency stabilisation with black start and standalone grid capability
Project status	Completion May 2019

Location



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CONTINUED OPERATION OF TURBINES OLDER THAN 20 YEARS

In the past, the German Renewable Energy Sources Act (EEG) guaranteed a fixed feed-in tariff to renewable energy assets. Action is now required in the case of assets whose subsidies expire after 20 years. Direct marketers such as Statkraft are using PPAs to ensure that continued operation is cost-effective.



PPAs are receiving increased attention, because the fundamental question is: How can both existing and new renewable energy assets be marketed and financed in the future? As a power off-taker, under PPAs, Statkraft can assume significant risks related to the operations of renewable energy assets that have until now been covered by the EEG subsidy or other support mechanisms.

Power purchase agreements (PPAs) enable wind farms to continue operating after their EEG subsidies expire. They are usually long-term power purchase agreements between an electricity producer as the seller and a power off-taker as the buyer. Private or public utilities, as well as large end consumers, power trading companies, or even direct marketers such as Statkraft can be considered as buyers. PPAs have existed since the beginnings of electrification, but they have not played a significant role in Germany in recent decades. However, this

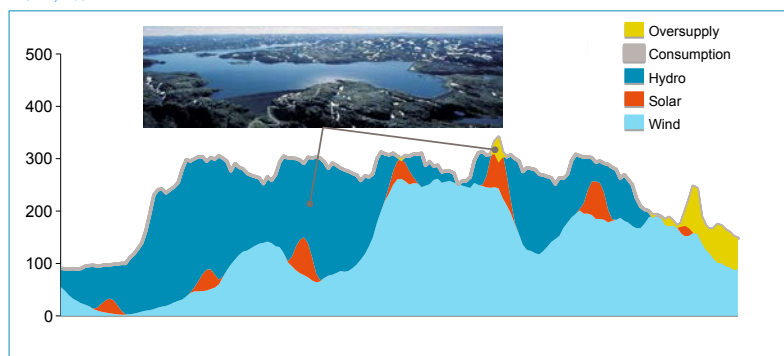
is changing, as both technology costs and feed-in tariffs are sinking, and EEG subsidies for existing plants are expiring: The demand for alternative marketing models for the continued commercial use of existing renewable energy assets, primarily wind farms, is increasing.

Until now, the EEG has hedged price- and volume-related risks as well as technical risks for renewable energy assets through a fixed feed-in tariff. Wind farms whose EEG subsidies expire after 20 years have to bear these risks themselves – if they decide to continue operating their plants. This is where direct marketers such as Statkraft come in, because as power off-takers, they assume at least some of the risks.

Without EEG subsidies, on the free market, the risks described above result in the following problem: If the operator of a wind farm sells their electricity on the stock exchange or to an end customer in the long-term in order to fix the unit value, the operator enters into a delivery obligation, which usually is a binding restriction on both the delivery quantity and the delivery period. However, if there is no wind, or if the plant has a major technical defect and the operator is unable to meet the delivery quantity or period, he must procure the contractually guaranteed electricity elsewhere – and possibly at higher prices.

How does it all fit together?

Example: Weekly energy consumption of an industrial company and the respective share derived from renewables GWh, week



“PPAs will receive increased attention, because the fundamental question is: How can both existing and new renewable energy power plants be marketed and financed in the future?”

On the other hand, excess generated electricity can also pose a considerable financial risk if energy prices are negative. If, on the other hand, the operator chooses a marketing channel via short-term trading, they will need to worry about high price fluctuations, which can at least partly lead to revenues that are below the operator’s marginal costs. This problem is present for both new installations that are not subsidised as well as old installations that stop receiving EEG subsidies after 20 years.

A power purchase agreement with a direct marketer enables the power plant’s operator to continue the commercial operation of their plant, even if it is not covered by EEG subsidies, and provides them with the security needed for planning.

Another significant aspect of the marketing of renewable energy assets that are outside the EEG is that once the EEG payment is withdrawn, the prohibition of multiple sales¹ will no longer apply, and the green added value of the electricity will be freely usable for the first time. This will allow power plant operators to market the green added value of their power plants in addition to the agreed electricity price. Statkraft can now offer green electricity to business and industrial clients to meet their sustainability targets. These end users may demand a steady supply of electricity, which must be provided. For this reason, intelligent portfolio management is necessary when marketing renewable energy to end users; the decisive factor here is the mix of technologies. Statkraft offers both: several years of experience in marketing renewable energy to end users and access to one of the largest renewable energy portfolios in Europe.

Wind farm	Number of turbines	Installed capacity
Schliekum	3	4.5 MW
Kunst und Wind	5	7.0 MW
Meerberg	6	9.0 MW
Rebenstein	3	4.5 MW
Bassum	13	19.5 MW
Sonne und Wind	1	1.5 MW

¹—Power plant operators who [...] market this electricity directly in the forms referred to in Article 33b (1) may not pass on proofs of origin, or other evidence proving the origins of this electricity, for this electricity.” Source § 56 EEG

Conclusion

Statkraft has concluded the first PPAs, which will enable the continued operation of renewable power plants after EEG subsidies expire, with six community wind farms. The contracts encompass 31 wind turbines with a total rated capacity of 46 MW and an operating time of three to five years. The electricity is purchased by Mercedes-Benz Cars and used to power the Mercedes Benz plant in Bremen, as well as German battery facilities such as the ones in Kamenz and Stuttgart-Untertürkheim.



Copyright: Windpark Kunst und Wind



Are you interested in the project and want to know how your community or your business can benefit from it? Contact us. Our contact can be found in the [company profile on page 179](#) ►

LIGHTER GENERATORS WITH SUPERCONDUCTORS

Within the EU EcoSwing project, for the first time ever a superconducting 3 MW generator fed power into the grid. Superconducting generators will enable a weight reduction of up to 50 % in the future.



Space savings become apparent when comparing the conventional PM generator to the superconducting one (right hand side)
Photo: ECO 5

Superconductors are able to transport electrical current without resistance when cooled to low temperatures. Then the current density can be hundredfold higher compared to other conductors. With high temperature superconductors, this state can be reached at higher temperatures which are much easier to realize. This enables applications in energy technology, e.g. generators. These applications profit from the high current density as their design can be smaller and more compact.

In 2015, the nine partners of the EU Horizon 2020 project EcoSwing started the development of the world's first superconducting wind power generator. THEVA's task was to develop and deliver the superconducting coils.

In March 2018, the generator was tested at IWES in Bremerhaven. After commissioning and installation in Thyborøn, Denmark, the last milestone of reaching 3 MW power output was reached. During the tests the superconducting coils as well as the cryogenic cooling system have proven to be particularly robust and reliable – under real conditions. The cooling system of the wind power generator as an example was stable over seven months of operation. This is a major step for series maturity.

Looked at in detail, the 3 MW generator has 40 coils. Each coil is about 1.4 meters long and 0.2 meters wide, which adds up to around 25 km of superconducting wire, explains Dr. Markus Bauer, VP Business Development at THEVA.



One of the superconducting EcoSwing coils.
Photo: THEVA

With the first series production of superconductors in Germany THEVA is pursuing the goal to decrease the cost of superconductors sufficiently to become competitive with copper. This will facilitate innovative new products that will become an important contribution to the energy transition in the future. Accordingly, THEVA has a portfolio of superconductors and coils tailored to the needs of various applications.

“Basically, anything is possible”, says Bauer. “Generator manufacturers can design and manufacture coils in different sizes, geometries and performance levels with our material”.

After the success in the EcoSwing project, the development of a generator for cost-efficient series production can begin. The EcoSwing design can be scaled up for nominal powers of 15 MW and above. The lower mass and bigger air gap coming from the specific properties of the superconductor result in less demanding construction and easy assembly. Due to the significantly reduced size and weight, costs are lower for foundation, supporting structures, installation space and logistics. Therefore, THEVA expects superconducting generators to reach a relevant market share for big wind turbines in the future.



Superconductor and copper cylinder with the same current carrying capacity. Photo: THEVA

Conclusion

THEVA and the EcoSwing consortium showed that a superconducting generator can be operated reliably. Mass reduction in the nacelle offers new perspectives especially for high power ranges and for offshore turbines. THEVA is open for a follow-up project to develop market maturity for superconducting wind power generators.



Envision's GC1-Turbine in Thyborøn, Denmark. The superconducting generator was mounted and tested on this turbine. Photo: THEVA

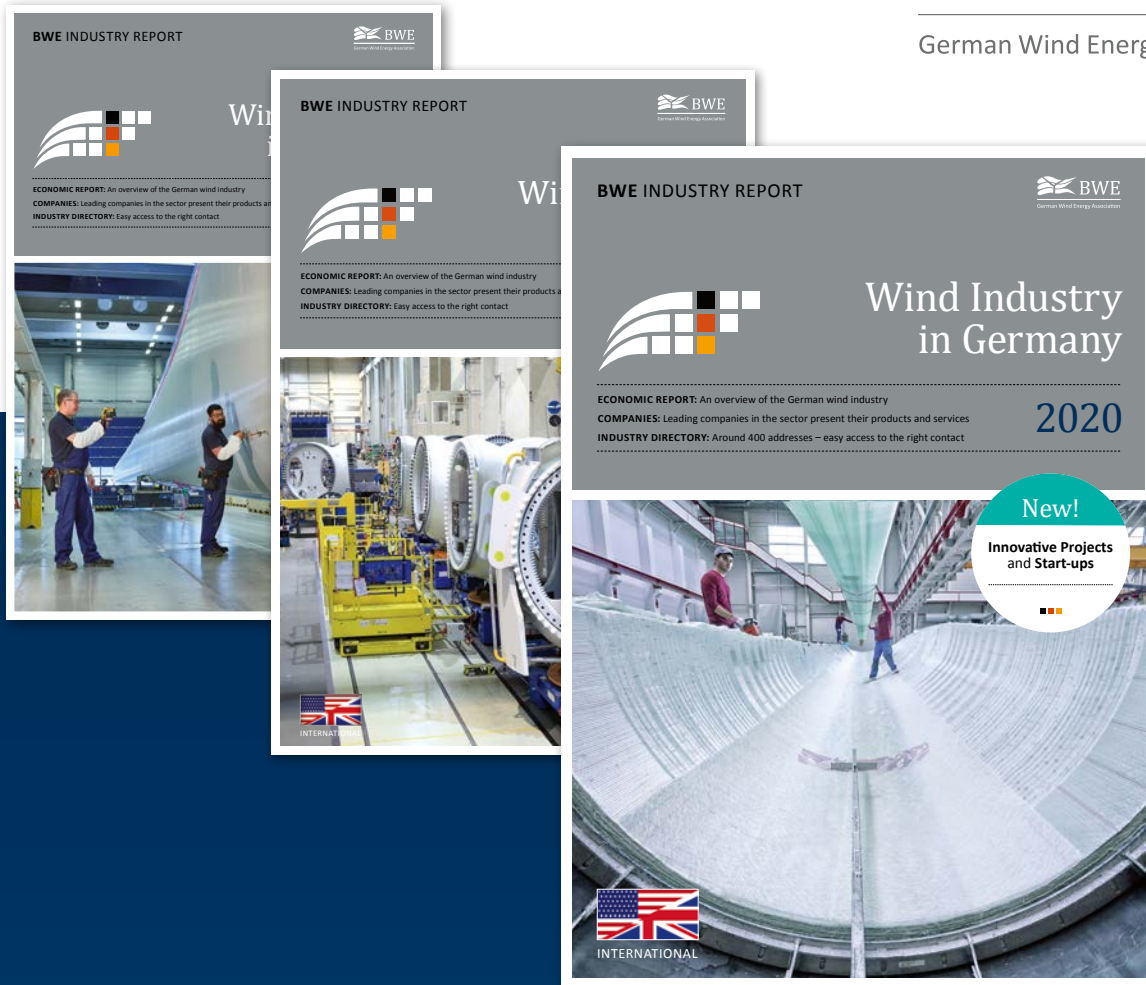
Project overview

Project	EU Horizon 2020 Projekt EcoSwing
Coordinator	Envision Energy
Partner	THEVA, Envision Energy, ECO 5, Jeumont Electric, Delta Energy Systems, Sumitomo Cryogenics of Europe, Fraunhofer IWES, Universiteit Twente, DNV GL
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THEVA

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