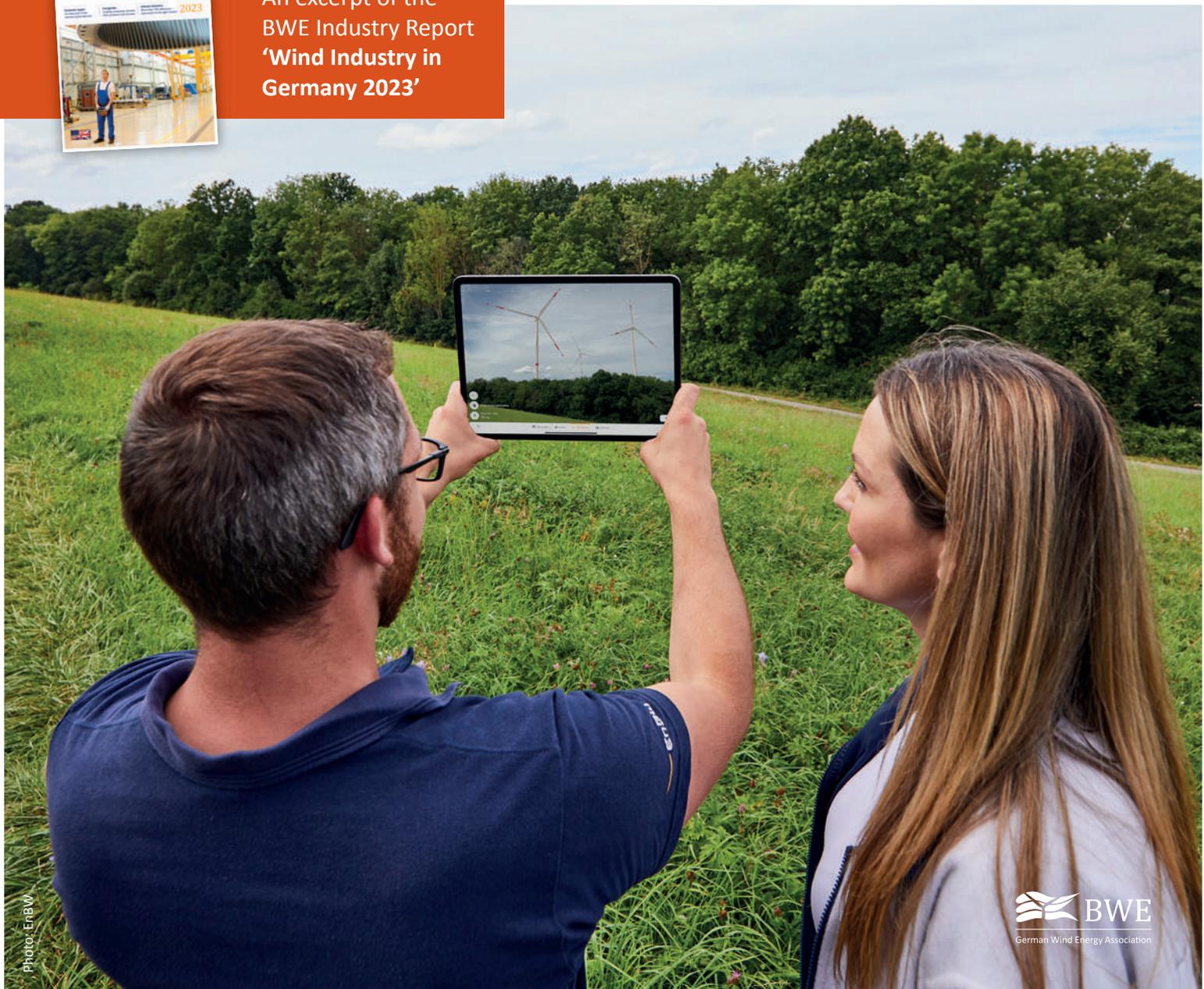


**ip**  **INNOVATIVE PROJECTS**  
for the German wind market

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 2023'



# AUTONOMOUS ACCESS SOLUTIONS FOR SENVION WIND TURBINES

To ensure the successful operation of wind turbines, it is essential for owners, operators, and the service companies they commission to have access to the facilities at all times.

**T**he requirements for access software can be summarised as follows:

- the wind turbine operator gets (renewed) access to their turbines, with the appropriate authorisation levels;
- the operator can manage these independently;
- no changes are made to the operation management software nor is there any violation of intellectual property (IP) rights.

Bachmann has developed a software package based on precisely these requirements, which operators can use independently to manage the user rights for appropriately trained and authorised personnel. New users can be created, and obsolete ones deleted. Access levels can be assigned based on the training level achieved and the tasks to be performed. Another feature is that password durations can be set as desired.

Many installations in various wind farms have now been completed successfully (cf. Case Study “KS energy systems”), and customer feedback indicates that

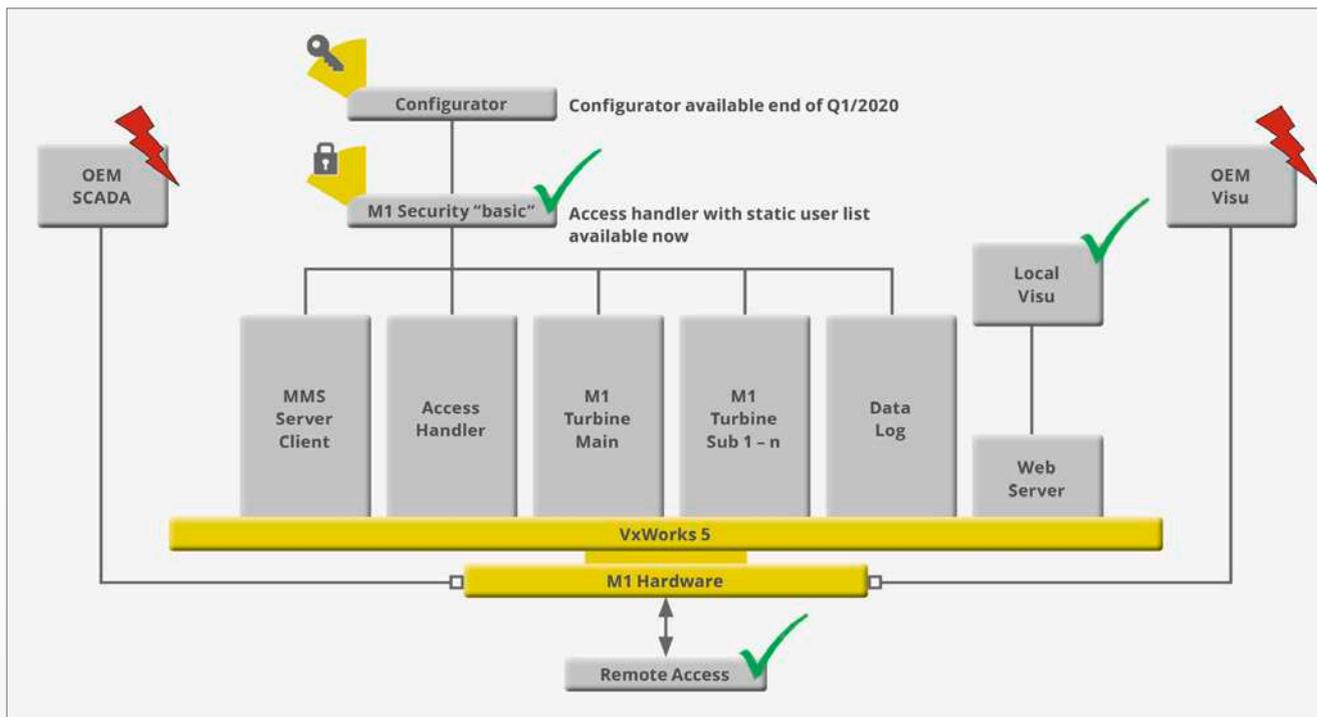
Bachmann has created a solution that meets the needs of both wind turbine owners and/or operators in terms of determining who is able to access wind turbines when, how, and with what permissions.

When it comes to managing access rights for wind turbine control purposes, having to depend on the turbine manufacturer is a risk for owners and operators that should not be underestimated. Even service contracts offer no guarantee that access will be granted throughout the entire service life of the turbine.



## SenAccessBasic in a nutshell:

- Basic solution for system access protection
- Operator-specific access management feature as an add-on for the existing controller
- Dynamic access management (customer configurable users, passwords, and security levels (all encrypted) up to level 3.20 (“Service Level”))
- Access to non-safety critical operational functions
- Unrestricted remote access to the controller system (using Bachmann electronic GmbH’s diagnostic tools such, e.g., SolutionCenter, ServiceCenter)
- Pure software add-on, no hardware modification required
- Can be upgraded to SenAccessSCADA (WindPowerSCADA and level 1.20)



The software concept of the system is supplemented by the „Access Handler“, with which the operator himself has full access to his system.

New software solutions, such as the Bachmann “Access Solution”, (once again) give wind turbine operators full access to their plant after just a few hours, irrespective of the turbine type and park controller. Existing turbine software with load and safety control features is retained in its entirety, which eliminates tedious validation periods and avoids time- and resource-consuming re-certification processes.

In addition to managing individual users and access, the turbine operator gains complete and unrestricted access to all turbine parameters. The flexibility of the solution also allows an update to SenAccessSCADA. This provides the customer with an innovative SCADA system from Bachmann (“Wind Power SCADA”) and the possibility of accesses up to level 1.20. Thanks to its use of SSL/ TSL encryption, the access software also increases IT security, which is essential given the increased demands for data security on the Internet.

## Conclusion

Following the successful market launch of the basic “SenAccessBasic” system, Bachmann has expanded the application, which grants extensive administrator rights to wind turbine owners and operators and gives full access to the data interface without violating existing intellectual property rights.

## Project overview

Location	<b>Bachman electronic GmbH</b> Kreuzäckerweg 33 A-6800 Feldkirch
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E-Mail	info@bachmann.info
Web	www.bachmann.info

# bachmann.

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 94. ▶

# REVisAR: VISUALISATION WITH THE AID OF AUGMENTED REALITY

EnBW's innovative app REVisAR (**Renewable Energy Visualisation with Augmented Reality**) now enables project planners to proceed even more precisely in real time and interactively when planning and implementing projects of all kinds.

This is because Europe's leading app features an integrated web portal for detailed visualisations of objects that characterise the landscape. How do wind turbines or a solar park fit into the existing landscape? Are the residents affected by the shadow cast by the wind turbines and how far are they from the designated protected zone? Over what area does the solar park extend? Project planners can use the REVisAR app's visualisation feature to clarify these and many other questions early on in the project development process.

## What is the app capable of?

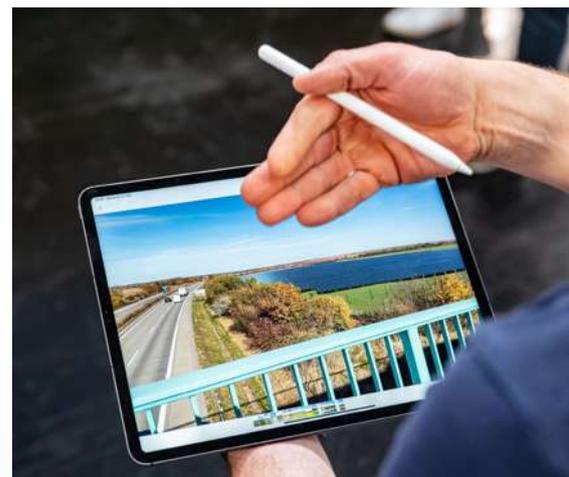
Up to now, project planners have used simple 2D maps with the turbine locations marked on them to illustrate their plans, especially in the early stages of development. But especially in the case of large construction projects that have a significant impact on the landscape, it is often difficult for those involved to assess the effects on the landscape. In addition, because of the considerable effort involved, static photomontages have only been produced at an advanced stage of the project, which cannot take many factors into account, such as rotating wind turbines.

REVisAR, an app for visualising projects such as wind turbine farms or solar parks, changes all that. Augmented reality adds a dynamic element to project development because the app enables wind turbines or solar parks, grid, or power plant projects to be displayed in a geographically correct, realistic, and fully animated manner. The app can also be used to display the position of the sun at certain times and thus the shadows cast by the turbines, or the orientation of a nacelle and rotor blades. The time-consuming processing steps required for conventional photographic visualisations are completely eliminated.



REVisAR can also visualise plants in real time in the early stages of project planning.





**Transparency from the start**

This means that the app creates transparency for all stakeholders, such as residents, mayors, and community representatives, right from the start because projects such as a wind farm or solar park can be presented to stakeholders from different angles directly on site at the planned location, quickly and easily. So REVisAR facilitates a completely new form of direct communication with the stakeholders of any project directly at the site in question. The visual and other impacts from any location are displayed immediately and realistically, giving stakeholders, who do not have any idea of the planned facility, an accurate impression of it from multiple angles and in different potential layouts, which helps to foster local acceptance, which is important for expediting the energy transition.

**“We originally developed REVisAR for our wind power projects,” says Philipp Hölscher, Product Owner REVisAR, “but we are continuously developing it to the point that our project developers are now using it in the solar sector as well. EnBW subsidiary Netze BW is also using it for project planning, as well as for planning conventional power plant projects. On top of that, we are constantly optimising the functionality of the fully animated display and hope to be able to make it available to third parties soon.”**

*Philipp Hölscher,  
Product Owner REVisAR*

**Conclusion**

**The benefits of the REVisAR app**

- Visualisation creates transparency early on in the project development process.
- The app provides a dynamic, rapid, and realistic representation of planned projects and even works offline.
- It includes an extensive asset portfolio and is always up to date.
- The app provides considerable support in the context of augmented reality projects.
- It can be used anywhere in the world and is intuitive to operate.

Not only wind turbines or solar parks, but also grid or power plant projects can be shown realistically and fully animated with REVisAR.

**Project overview**

Initiator	EnBW Energy Baden-Württemberg AG
Implementation	EnBW Energy Baden-Württemberg AG
Figures and facts	With around 26,000 employees, EnBW Energie Baden-Württemberg AG is one of the largest energy suppliers in Germany and Europe. We supply around 5.5 million customers with electricity, gas and water as well as energy solutions and energy-related services.
Project status	Test and optimisation phase
Location	Stuttgart



If you're interested in this project and would like to find out more about how your own municipality or company could benefit from it then please do get in touch: Philipp Hölscher, p.hoelscher@enbw.com; www.enbw.com/revisar. For more information, please click on company profile on page 140. ►

# DRONE INSPECTION SETTING NEW STANDARDS

Wind turbine yields can be optimised through the combination of machine intelligence and human expertise. **ENERTRAG Operation** provides a **drone inspection** solution that **enables smarter, safer, and faster inspections**.

**W**ind turbines have long been an integral part of the energy supply. New turbine models produce well over 100,000 kWh of electricity on windy days, and it is becoming increasingly clear that every kWh counts, which means that turbine downtimes must be kept to a minimum. Unavoidable inspection and maintenance work is time-consuming and routinely results in downtime. To ensure the best possible yields, it is important to use the latest technologies. ENERTRAG Operation has been offering an innovative solution to this problem since 2022, namely **rotor blade inspection including Lightning Protection System measurement (LPS measurement) by drone**.

## Drone inspection setting new standards

Ensuring the integrity of a wind turbine and all its components, including of course the rotor blades, is fundamental for securing good yields. Rotor blades must be inspected regularly to ensure that they remain in good condition. Whereas in the past inspectors had to abseil down the rotor blades by means of time-consuming and risky rope-climbing work, drones now offer a technologically innovative and time-saving method of carrying out visual inspections.<sup>1</sup>

<sup>1</sup>—Whenever an inspector is in the nacelle of the plant, the internal blade inspection is also carried out.

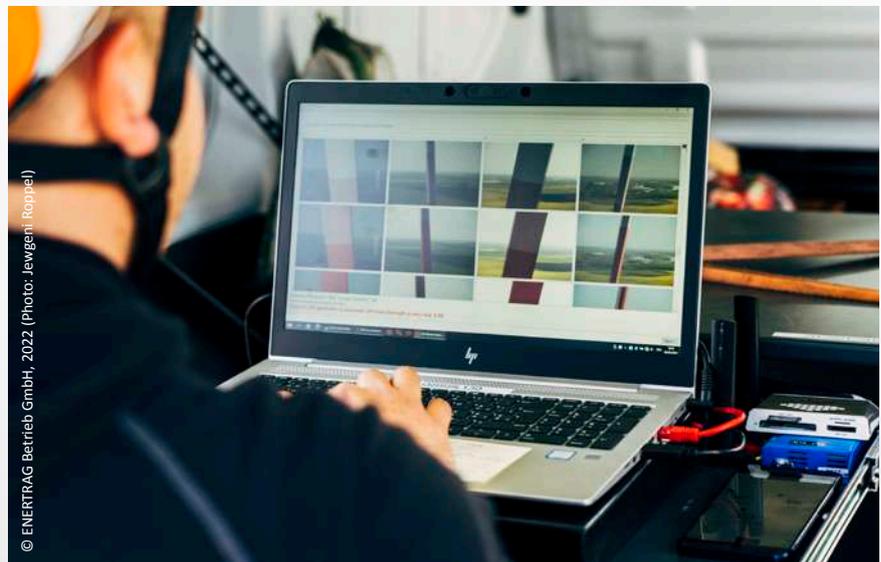


Image above: Complete documentation: The drone documents its entire flight and uploads the images directly to specially developed software.

Image below: Everything under control: the process is always monitored by an experienced drone pilot.

The benefits are obvious and include **time savings**, which means **shorter downtimes**, high-quality **photographic documentation** of the results, which enable comparisons between completed inspections and thus long-term **tracking** of the condition, as well as increased **occupational safety** through a **smart symbiosis** of humans and technology.

The drone also carries out **LPS measurements** at the same time as inspecting the rotor blades. The functionality of the lightning protection system can be tested, and it is possible to determine the location of a defect to within a few centimetres by means of a high-voltage generator connected to the lightning protection system at the root of the blade and a field strength meter attached to the drone.

**“Having recognised the potential, we are delighted to be able to offer optimised drone inspection as early as the end of 2022 followed later by a licensed product as of 2023.”**

*Matthes Schachtner,  
Head of Technical Services at ENERTRAG Operation*

**Practical field trials confirm quality of drone inspection – further development steps planned by 2023**

Not only are many of our customers convinced by the quality of the drone inspection: **TÜV NORD** took a close look at the procedure for LPS measurement

**Conclusion**

The drones have been in use since May 2022. Michael Dahm, Managing Director at ENERTRAG Operation, draws a positive interim balance: “What we have learned from the first few months of operation is that we have chosen the right technology: the benefits of drone inspection are particularly obvious for turbines with diameters in excess of 66m.” ENERTRAG Operation offers drone inspections as a service or (starting in 2023) also under a licence model.



Drone in action: initial practical applications delivered good results.

by drone as part of an audit and certified the quality of the service in a final report.

As Matthes Schachtner, Head of Technical Services at ENERTRAG Operation, explains, “We are satisfied with how our drones have been used so far, but it goes without saying that we are always on the lookout for optimisation potential to make drone-based inspections even more efficient.”

For example, he continues, it has become clear that the next stage of development could reduce the current number of three flight phases per inspection to just one. Our experience to date has also shown that optimising the hardware of the field strength meter could reduce the susceptibility to wind and increase battery life. An optimised process will be in use as early as the end of 2022.

**Project overview**

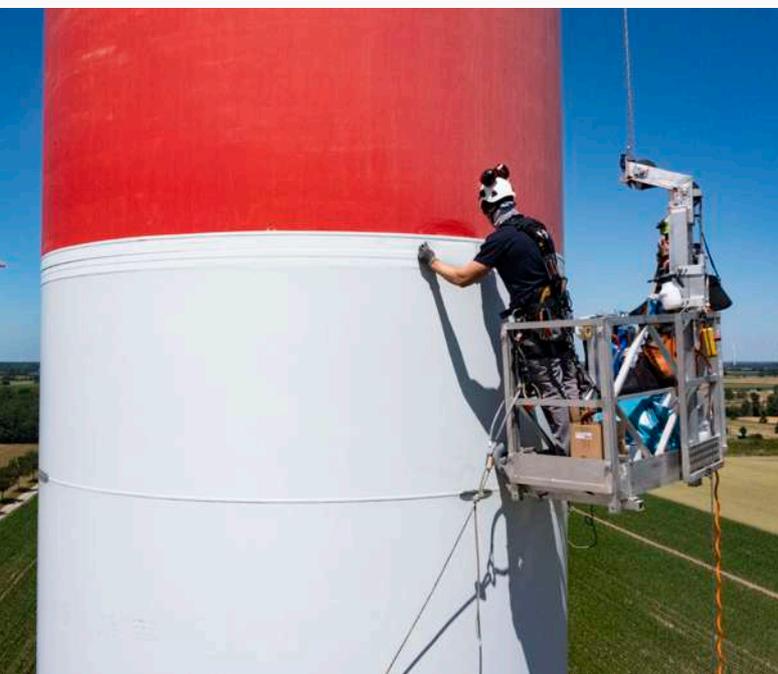
Initiator	ENERTRAG Betrieb GmbH
Implementation	ENERTRAG Betrieb GmbH + Sulzer & Schmid Laboratories AG
Figures and facts	Drone inspection with lightning protection measurement has been offered as a service on the market since May 2022. The procedure was optimised again in autumn 2022. From 2023, the drone inspection will also be offered as a licence model.
Project status	Completed
Location	Dauerthal



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 146. ►

# NEW CORROSION PROTECTION FOR WIND TURBINES

The film specialist **Renolit** has developed an innovative high-performance film that provides effective long-term corrosion protection for wind turbines while minimizing downtime and maintenance.

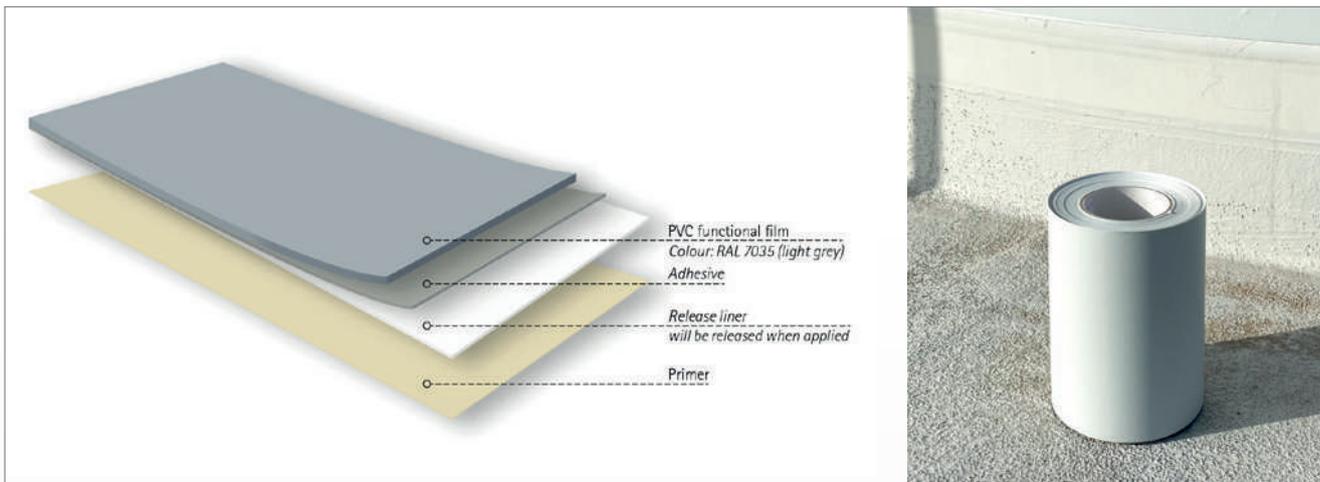


RENOLIT CP application project.

**W**ind turbines are exposed to natural forces every day: Wind, sun, rain and frost sooner or later lead to corrosion damage on the metal surfaces. Long-lasting steel towers therefore need protection – this can be environmentally friendly films or paint. Renolit has developed the corrosion protection film Renolit CP with the aim of providing the wind energy industry with an efficient tool to protect their wind turbines better. By law, wind turbines must be inspected for safety reasons every four years.

Among the biggest weak points of towers are bolted and flanged areas as well as weld seams. Especially at the flange areas and bolts, water ingress into the tower is possible – a breeding ground for corrosion. If flange corrosion progresses unchecked, it can damage the bolts. Replacing bolts is extremely cost-intensive: As a rule, all bolts have to be replaced after an expert assessment, which may involve costs of up to 35,000 euros. The better the flange areas are sealed, the more sustainable is the corrosion protection.

Although the towers are coated with a layer of paint at the factory, corrosion damage often results from the coating already being damaged during the installation of the wind turbine, for example by bumping it with a tool. Spalling occurs – the moisture stays in the gap for a longer period of time and works its way through the metal as rust. In this way, even small areas of damage cause considerable corrosion damage. In the worst case, the stability of the system is at risk.



RENOLIT CP film structure

“Renolit CP can also be applied on wind turbines as a preventive measure - ex works or when the plant is still young. Wherever there are gaps, the danger of corrosion lurks. Especially in the flange areas, it makes sense to apply the film as a preventive measure: This significantly prevents water ingress and saves high repair costs,” explains Ralph Gut, General Manager at Renolit.

**Film instead of Paint**

To validate the product, an independent testing institute was commissioned with the elaborate corrosion test according to the CX standard. The results show that Renolit CP is on a par with a certified three-coat anti-corrosion paint. The advantage of the film is that it can be applied in just a few steps.

When using anti-corrosion paint, three coats including the respective intermediate drying time are necessary for the same protection. Renolit CP, on the other hand, can be applied directly after the surface cleaning, application and drying time of the primer. In addition, the material can be applied with the same layer thickness throughout all areas; there are no paint noses. Thanks to only one drying time of the primer, Renolit CP can be applied faster and more weather-independently. This enables more flexible repairs, reduces wind turbine downtimes and thus saves costs. Renolit CP has been available since 2020 and is distributed by Renolit’s exclusive partner WP Energy, who is also responsible for the application of the corrosion protection film on the wind turbines.

**Conclusion**

Renolit CP was specially developed for the use on wind turbines. The high-performance film efficiently protects the steel and metal coatings of the towers from corrosion and offers an environmentally friendly alternative to paint. No volatile organic compounds (VOCs) are produced during the application, nor is hazardous waste generated. Thanks to the high quality standards during production, Renolit CP can be offered according to ISO 12944-9 CX certification with a durability of 10 years.

**Project overview**

Initiator	<b>RENOLIT SE</b>
Implementation	<b>RENOLIT SE and WP Energy</b>
Figures, data, facts	<b>RENOLIT SE has been on the market for more than 75 years and employs around 5,000 people at more than 30 production sites and sales units in over 20 countries.</b>
Projektstatus	<b>completed</b>
Location	<b>Worms</b>

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 Ernst-Abbe-Straße 2  
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 Web [www.wp-group.com.de](http://www.wp-group.com.de)



*Rely on it.*

Are you interested in the project and want to find out how your community or your company can benefit from the project? Get in touch with us. Our contact can be found in the company profile on page 171. ►

# FIRMER COMMITMENT IN TIMES OF CRISIS

War in Europe and dramatic increases in energy costs: times like these require the full commitment of the wind industry, both in terms of expanding the renewable power supply and when it comes to community participation.

Community participation is not an attractive topic, and discussing money is disagreeable to many, and sometimes even causes trouble. Yet in times such as these, the wind industry must focus on both. The high market values that have prevailed since the end of 2021 have resulted in unplanned windfall revenues for projects, which in many cases are also urgently needed as companies in the wind power sector have suffered from several bad wind years.

Since then, the picture has changed completely: tariffs of up to almost 28 cents/kWh mean that months with poor results can be balanced out and that it has been possible to compensate for some of the losses incurred in previous years.

However, energy costs for consumers have also risen sharply and are expected to continue to rise. In some cases, companies are charging over 50 cents per kilowatt hour for electricity for new contract customers.

**What can wind farm operators do for local residents?** For one thing, they can intensify their commitment and increase their support for local projects.

Working closely with Regenerative Energien Zernsee (REZ), the MLK Group has developed and tested various participation options over the past few years. Participating by investing directly in a wind farm did not prove to be particularly successful. After all, only a few, if any,

can make such a commitment, and investors have to bear the risk of losing their investment. Similarly, attempts to enable local participation through crowdfunding with small sums of money were largely unsuccessful.

By contrast, local resident electricity tariffs, where green electricity providers supply local residents with power directly from the local facilities, are a different story. This could involve a municipal utility, as in the MLK/REZ project, or a nationwide operator such as Naturstrom. In the current projects, it is residents in the immediate vicinity who are entitled to receive benefits. The electricity tariff offered by the supplier is subsidised by the wind farm. Several wind farms would have to collaborate to cover the costs if the group of beneficiaries were to be expanded.

With subsidies of up to 200 euros and about 100 residents who avail themselves of the local power offer, wind farms may face costs of 20,000 euros per year. Communication and marketing costs must also be taken into account, which can be as high as 20,000 euros in the initial phase, but then tail off to just a fraction of that. Where the number of customers is expected to increase significantly, it makes sense for several wind farm operators to join forces.



Ten MLK wind farms share the costs in the Jacobsdorf region, making them almost negligible for each individual company. Several years ago, MLK and Enertrag agreed to combine their subsidies in the Prenzlau region, which has once again significantly improved the benefits for local consumers.

Given the current revenue rates, such cost sharing could provide an incentive to increase subsidies at least temporarily, especially under the prevailing conditions and in view of the massively rising energy costs. This is precisely the step taken by MLK for the second half of 2022, increasing the subsidy in Jacobsdorf to 276 euros per year.

Another 60 euros has been added to the social tariff, which is granted to low-income families and families with many children. Initially, this measure is limited until the end of 2023.

These large subsidy volumes will at least alleviate the most severe hardship caused by the electricity price increases. Over 500 euros would have to be made available to compensate for the full amount, but even then, it would not be possible to reach the level of 2021.



**“In times of crisis, such as the one we are currently experiencing, all hopes for the future are centred on the wind industry: we want to show everyone, especially our closest neighbours, that they can rely on us.”**

*Heinrich Lohmann,  
Founder and managing director of the MLK Group*



## Project overview

Initiator	MLK Gruppe and Regenerative Energien Zernsee (REZ)
Project outline	MLK Group projects have been offering ecological neighbourhood electricity products and savings products in the Prenzlau area and near Frankfurt/ Oder since 2017. The plan is to transfer this concept to other locations in North Rhine-Westphalia and the Rhineland-Palatinate. We would welcome collaborations with other operators. The REZ has been playing an advisory, structuring, and operational role in these projects.

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E-Mail info@mlk-consult.de  
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**Regenerative Energien Zernsee GmbH & Co. KG (REZ)**  
Seesenerstraße 10–13  
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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 170 (REZ) and 162 (MLK).** ▶

# INSPECTIONS WITH AN AUTONOMOUSLY FLYING DRONE

For the first time, **TOPseven** is offering an AI-based ECO system with autonomously flying drones, special sensor technology and analysis software that allows every user to carry out independent inspections yielding results of the highest quality.

**D**rones have long been seen as a promising innovation for inspecting wind turbines, due to the latter's size and difficult accessibility. Until now, professional pilots have had to carry out drone-based inspections by flying manually which is very inaccurate and the visual material being difficult to evaluate and irreproducible. In addition, experienced drone pilots constitute a bottleneck when it comes to deploying a technology that could in principle be scaled up.

TOPseven, a developer of AI solutions and special sensor technologies, is for the first time now, offering a complete ECO system with autonomously flying drones that, by means of visual and patented non-contact lightning protection measurement as well as analysis software, enables any assessor, operator, or service company of a turbine to independently use drones for inspection purposes after only a short training course. The system's autonomous flight capability not only enables a scalable deployment framework, but also high-quality results.

The autonomously flying drones controlled by TOPseven's software can move along a turbine at a constant distance and with high precision without overlooking even the slightest anomaly.

The AI-based control software, the globally patented solution for non-contact lightning protection measurement and the cloud-based application software for wind turbines all contribute to highly automated drone deployment. From inspection flight planning in the cloud to operational execution with the autonomously flying





drone to evaluation and long-term results management, the TOPseven solution supports all phases of an inspection. What's more, the system tracks the complete life cycle of a turbine throughout the inspections and allows the continual monitoring of any detected damage and how it develops – from the tower to the rotor blades to the lightning protection system.

**Many customers around the world are already successfully using TOPseven's drone-based system.**

## Conclusion

The automated process of this innovative solution supports the operations before, during and after the inspection of a wind turbine. The drone's autonomous flight at close range generates highly precise and complete visual and sensory data material of the rotor blades, tower, and lightning protection. TOPseven's ECO system thus allows assessors, operators, and service companies to independently inspect and monitor each turbine over its entire life cycle.

We aim to make all sorts of difficult-to-access infrastructures regularly and completely inspectable to detect and contain damage development at an early stage, minimise damage levels and consequences, avoid downtimes and extend service life. The state of Lower Saxony is funding the further development of the technology with almost five million euros.

The first concrete result of this further development is a new AI-controlled high-performance camera that will be available in autumn 2022.

**“TOPseven is pursuing drone-based infrastructure analysis of bridges, ships, and wind turbines. We are thus making use of artificial intelligence, digitalisation, and drone technology for the future of our infrastructures. It's the creation of a fantastic and innovative project that we are providing with the appropriate funding. This will have a very positive long-term impact, not only for Lower Saxony, but also for Germany as a whole.”**

*Dr. Bernd Althusmann,  
Minister of Economic Affairs of the State  
of Lower Saxony*

Location	<b>TOP seven GmbH &amp; Co.KG</b>
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E-Mail	info@TOPseven.com
Web	www.TOPseven.com

**TOP7**<sup>®</sup>  
MAKING DRONES SMARTER.

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 178.** ▶

# RESEARCH IN GERMANY:

## HOW THE WIND CAN BE USED EVEN MORE EFFICIENTLY

The **German Aerospace Center (DLR)** by no means only conducts research on flying objects. Neighbouring areas such as wind flow, networking and Artificial Intelligence are also part of its activities. In the field of wind energy, the DLR is currently working on rotor blades, flow phenomena and the conversion of wind into heat.

### 1 | INSIGHTS INTO THE NERVOUS SYSTEM OF ROTOR BLADES

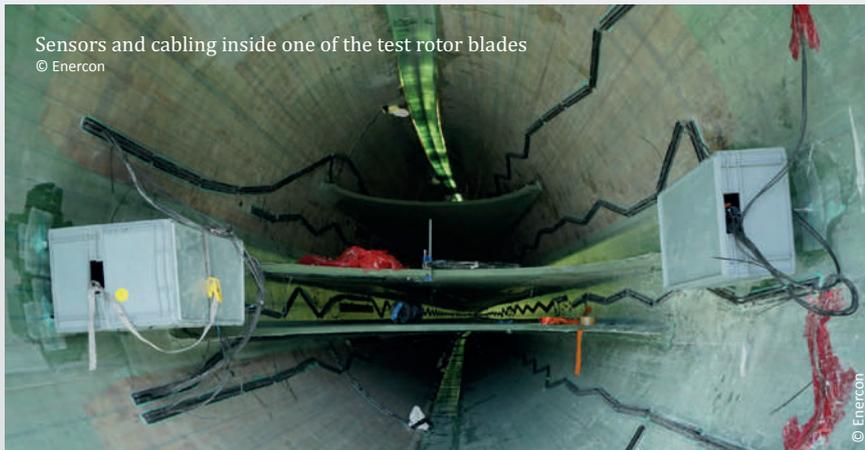
Six rotor blades were equipped with 1,500 sensors for the **DLR Wind Energy Research Park**. This makes it possible to study the vibration, load, aerodynamics and statics of the turbines in operation.

Rotor blades are one of the core components of a wind turbine. In order to operate them more efficiently in the future, even larger and at the same time lighter blades are needed. For the wind energy research park WiValdi (Wind Validation) of the German Aerospace Center (DLR) in Krummendeich, 2022 rotor blades with around 1,500 sensors were manufactured. State-of-the-art

measurement technology is now available from the blade tip to the blade root.

**Vibrations, material stress, stability: comprehensive data for better simulation and design**

Electrical and optical sensors are installed inside the rotor blades. They measure, for example, the acceleration at different points of the blades and thus enable



Sensors and cabling inside one of the test rotor blades  
© Enercon

**“You can think of the sensors as being like the human nervous system. They collect information, monitor and provide indications of where a problem might arise.”**

*Dr.-Ing. Yves Govers  
from the DLR Institute of Aeroelastics*

#### Project overview

Implementation **under construction, nearing completion**

Location **Krummendeich, Germany**

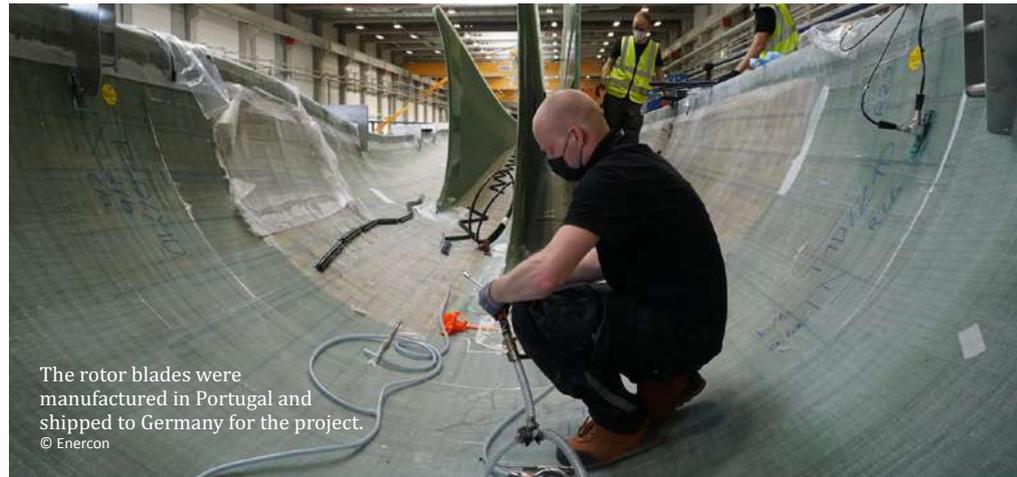
**German Aerospace Center (DLR)**  
Institute of Aeroelasticity  
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Web [www.dlr.de/ae](http://www.dlr.de/ae)



statements to be made about the vibration behaviour. “Until now, it has hardly been possible to record the vibration behaviour and thus also the material stress during operation. This is where we will collect valuable data with our comprehensive sensor technology,” describes Yves Govers from the DLR Institute of Aeroelastics.

After production of the rotor blades in Portugal in the summer of 2022, they will spend two months at the Fraunhofer Institute for Wind Energy Systems (IWES) for comprehensive material tests before continuing with practical testing at the DLR Research Park in the autumn.



The rotor blades were manufactured in Portugal and shipped to Germany for the project.  
© Enercon

## Conclusion

**Long and light rotor blades become very elastic and flexible. They bend under wind load. DLR wants to comprehensively test and analyse these new technical challenges with the help of such sensors**

## 2 | MEASURING WIND CURRENTS WITH “DRONE SWARM”

Wind is not just wind – but a complicated structure of turbulent structures. In the ESTABLIS-UAS project, **DLR** is researching flow phenomena with the help of a swarm of drones.

With regard to the energy transition, understanding turbulent wind structures plays an important role. “This allows us to understand the loads to which wind turbines are exposed during their life cycle and to predict what power they will feed into the energy grid,” says project leader Dr Norman Wildmann from DLR’s Institute of Atmospheric Physics. Up to 100 drones take off from the ground in a fixed formation for the ESTABLIS-UAS project (Exposing spatio-temporal Structures of Turbulence in the Atmospheric Boundary Layer with In-Situ measurements by a fleet of Unmanned Aerial Systems). They measure wind characteristics, temperature and humidity with high resolution.

### Tests also in the wind tunnel and in the wind energy research park

Wind turbines also generate their own vortices. DLR therefore wants to develop a model that clearly shows the effects on turbines in the second or third row. In addition to measurements on wind turbines themselves, experiments are planned in the wind tunnel at the University of Oldenburg and at DLR’s Wind Energy Research Park in Krummendeich. Ultimately, a comprehensive model for the representation of turbulent flow will be created.



Measurements of flow phenomena at a wind turbine.  
© DLR (CC BY-NC-ND 3.0)

**“The ESTABLIS-UAS measurements fill an observational gap between very small, local processes near the ground and large-scale observations by remote sensing, research aircraft and satellites.”**

*Prof. Markus Rapp,  
Head of the Institute of Atmospheric Physics, Oberpfaffenhofen*



Measurement drone in launch position.

## Conclusion

By combining ground-based sensors with remote sensing, the ESTABLIS-AUS measurements are expected to provide completely new insights into the interaction of complex flow phenomena.

### Models for the atmospheric boundary layer complement knowledge from remote sensing

Flows can differ greatly. Some eddies are a few millimetres small, others over a kilometre in size. Physical models for the lowest layer of the atmosphere, which extends from the ground to an altitude of about 2000 metres, are not yet very accurate: vortices from interconnected structures such as cities, wind turbines or aircraft are difficult to capture. DLR wants to address this challenge with its project.

## Project overview

Implementation	Implementation has started, first tests completed
Location	Oldenburg, Germany Krummendeich, Germany

German Aerospace Center (DLR)  
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## 3 | HOW WIND BECOMES CLIMATE-FRIENDLY HEAT

Wind turbines can generate more than just electricity. With a project, **DLR** shows how wind energy can be converted directly into heat.

In order for the energy sector to meet climate targets and become as CO<sub>2</sub>-free as possible, heat must also be produced in renewable ways. DLR is therefore researching the technological and economic possibilities of windthermal energy with the help of a small test facility. “The decisive advantage of windthermal energy is that we generate heat directly. This increases the efficiency because we save ourselves a conversion step,” describes project leader Malte Neumeier from the Institute of Flight Systems.

Windthermal prototype system of the DLR at the test site in Celle.



### Windheat: climate-friendly and efficient for heating and industrial processes

The scientists see possible applications for windthermal energy wherever heat is needed in the low and medium temperature range up to around 200 degrees Celsius. This includes the local and district heating supply of buildings as well as many processes in the paper, cardboard or food industry. Windthermal plants could be realised as decentralised small wind energy plants that provide heat up to 100 degrees Celsius, but also as large wind farms that could provide medium-temperature heat at 200 degrees Celsius, and theoretically up to 600 degrees Celsius.

**“We are optimistic that this technology can thus be scaled up comparatively easily – i.e., transferred to a size that is needed in practice.”**

*Malte Neumeier,  
Project Manager at the DLR Institute  
of Flight Systems*

### Conclusion

For rapid development towards industrial application, the DLR researchers are working as far as possible with components already available on the market. “We are optimistic that this technology can thus be scaled up comparatively easily - in other words, transferred to a size that is needed in practice,” says Neumeier.



Hydrodynamic retarder that converts the wind energy generated into heat.

### First practical test: Generating heat, storing it and collecting measurement data

The DLR pilot plant is located in Celle on the manufacturer’s premises and consists of a commercially available 22-metre-high wind turbine and a container. The latter contains all the components needed to convert the kinetic energy of the wind into heat. The main part of the “thermal platform” in the container is a special brake, known technically as a hydrodynamic retarder. It generates and regulates the heat depending on the application. A hot water basin serves as a heat reservoir. The pilot plant generates heat up to 70 degrees Celsius, and can be interconnected as it is to any space-heating application.

### Project overview

Implementation	Implementation has started, first tests completed
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Location	Celle, Germany
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# ROTOR BLADE RECYCLING AND MEGA TEST BENCH

Fraunhofer IWES is developing concrete concepts for rotor blade recycling and is testing Vestas' XXL rotor blade in the new test bench.



The design of a closed-loop, economically feasible disposal strategy is essential for establishing scientifically mature processes for the recycling of rotor blades in the future.

In collaboration with the Institute for Energy, Recycling and Environmental Protection (IEKrW) at Bremen University of Applied Sciences, the Fraunhofer Institute for Wind Energy Systems IWES is developing comprehensive concepts aimed at making it possible to recycle and reuse rotor blades considerably better in the future. The aim of the "Concept for recycling and reuse of rotor blades made of plastic composite materials" project – KoReNaRo for short – is to set up an economically feasible disposal strategy allowing as high a recycling quota as possible and thereby enabling a sustainable circular economy. The project was launched in October 2021. To date, almost 30,000 wind turbines with a total output of more than 50 gigawatts (GW) have been erected in Germany. For



GRP balsa wood mixture.

end-of-life (EOL) wind turbines no longer in operation, the recycling concepts currently available on the market are to be optimized or further developed towards a more circular economy. The focus here is in particular on how rotor blades can be recycled more efficiently, economically, and ecologically.

## High-quality recycling for fiber composite materials

The scientists are aiming to develop a higher-quality recycling system for the entire EOL rotor blade. The important aspect is first of all to design an automated initial treatment for this, whereby the rotor blade can be more effectively dismantled and separated into its individual components. This creates recycling

**"Holistic conceptualization is important to create a sustainable recycling concept for rotor blades that gives the wind industry a clear framework to create a competitive market for secondary products and disposal."**

*Project coordinator Dr.-Ing. Steffen Czichon,  
Head of Department Rotor Blades at  
Fraunhofer IWES*

loops, increases the recycling rate, and saves costs. One possible location for a recycling station would be Bremerhaven. Another goal of the research project is to reuse the spar caps – which give the rotor blade its stability – from the rotor blades for other workpieces, preserving the existing good material characteristics as far as possible. That represents a challenge, as they are made up of centimeter-thick layers of glass fiber and carbon fiber composites. The approach of recovering the high-quality glass fibers from the thick-walled flange and cap materials by means of slow-batch pyrolysis is also to be pursued further. The synthesis gases generated in this process can then be further utilized, among other things for energy or hydrogen production.

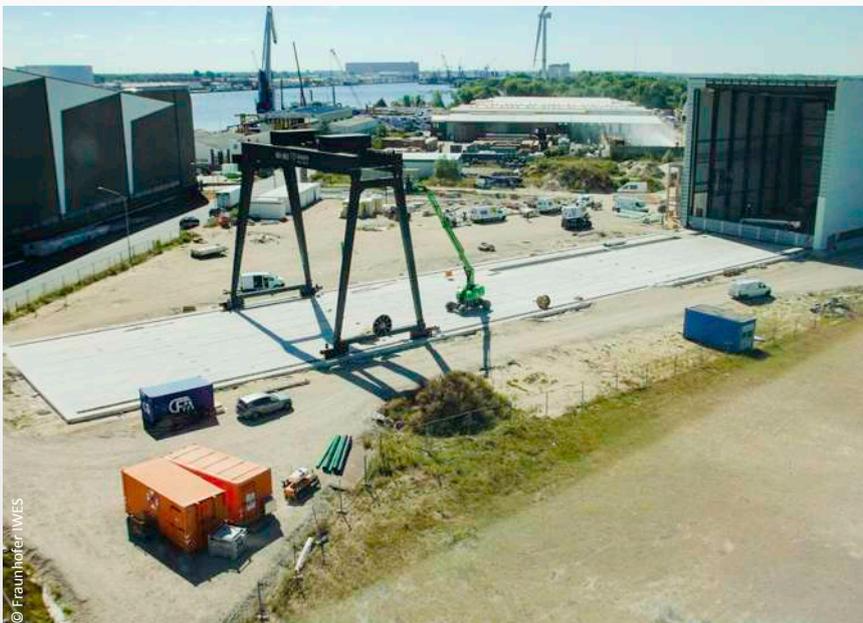
The cost-efficiency and feasibility of this special process should be verified in the project using a test system.

For the sandwich components in the rotor blade, balsa wood and plastic foams, already known methods are to be rolled out on a large scale, in particular for recycling the balsa wood as wood foam.

## New test bench for rotor blades

The Danish wind turbine manufacturer Vestas will be testing the rotor blade of the new V236-15.0 MW™ prototype in Bremerhaven later this year. The state-of-the-art test bench offers comprehensive testing possibilities for rotor blades measuring up to more than 120 meters. In addition to biaxial full-scale blade tests, manufacturers also have the option of testing individual segments of a rotor blade. The modular and adaptable design of the test

bench allows the scientists at Fraunhofer IWES to react flexibly to requirements and further develop intelligent test methods. Rotor blades are growing ever larger and more powerful, which sees the wind industry faced with new challenges, since the testing options for these prototypes are limited. Fraunhofer IWES is now filling this gap with the new large-scale rotor blade test bench currently under construction in Bremerhaven.



Rotor blades with a length of more than 120 meters will be tested on the new test stand.

## Conclusion

Currently, the initial treatment and recycling of rotor blades is largely based on the experience gained by dismantling companies: the first specific dismantling projects have been under way since 2019. A market for new secondary products now has to be developed or tapped. This is precisely where the KoReNaRo research project comes in.

The concept phase is followed by the implementation phase, where the research partners Fraunhofer IWES and IEKrW hope to realize the individual work steps together with cooperation partners. The planning of a recycling station should also be advanced in collaboration with an industry consortium.

**“Our test environment is the only one of its size in the world. However, the infrastructure is not the only decisive aspect – the test methods are also being continually further developed so as to be able to conduct the tests more realistically and faster!”**

*Dr.-Ing. Steffen Czichon, Head of Department Rotor Blades at Fraunhofer IWES.*

## Project overview

Implementation • Rotor blade recycling: concept phase, shortly before implementation phase  
• Rotor blade test bench: under construction, nearing completion

Location • Rotor blade recycling: still to be decided  
• Rotor blade test bench: Bremerhaven, Germany

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