# 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 2024'**



Photo: ENERTRAG/Silke Reents

BWE German Wind Energy Association

# Higher yields through retrofitting

It only took two working days for Bachmann to make three Mitsubishi MWT-1000A wind turbines fit for continued operations. This was made possible by an innovative retrofit technology that provides the operator with a significant revenue increase.

Fig. 1: Retrofitting can extend the service life of wind turbines beyond the ten-year limit. Bachmann has won awards for its retrofit solutions.

**"Bachmann's retrofit technology enables energy suppliers to remain competitive by increasing productivity and extending the service life of their wind turbines."**

*Gabriel Schwanzer, Director of the Business Wind / Energy Unit at Bachmann*

Operating older wind turbines is complex and expensive: technical failures result in unproductive downtimes and necessary maintenance tasks accumulate in addition to which spare parts may no longer be available. Access and parameterisation options are also limited resulting in dwindling yields. As Gabriel Schwanzer, Director of the Business Wind / Energy Unit at Bachmann, explains: "Bachmann's retrofit technology enables energy suppliers to remain competitive by increasing productivity and extending the service life of their wind turbines."

For the upgraded Mitsubishi systems, the retrofit ensured that a complete shutdown is no longer necessary by precisely controlling each individual system. At a required wind farm capacity of 30 per cent, the electricity yield of each modified turbine increases by a remarkable 44 per cent, and even at 70 per cent of required capacity it still increases by 17 per cent.

Bachmann's retrofit technology is focused on scalability and customer-oriented optimisation: **CMSadvanced** is an expandable modular system that provides the full range of condition monitoring for all wind turbine components. **CMScompact** provides customers with a cost-effective solution for the basic monitoring of mechanical drive train components.

**CMScompact** is also used for data aggregation and data transfer to the Bachmann WebLog interface, where all the necessary calculations take place. **CMSadvanced,** by contrast, performs the relevant calculations onboard, so that status information can be used directly to control the systems, for example for rapid intervention to protect the components.

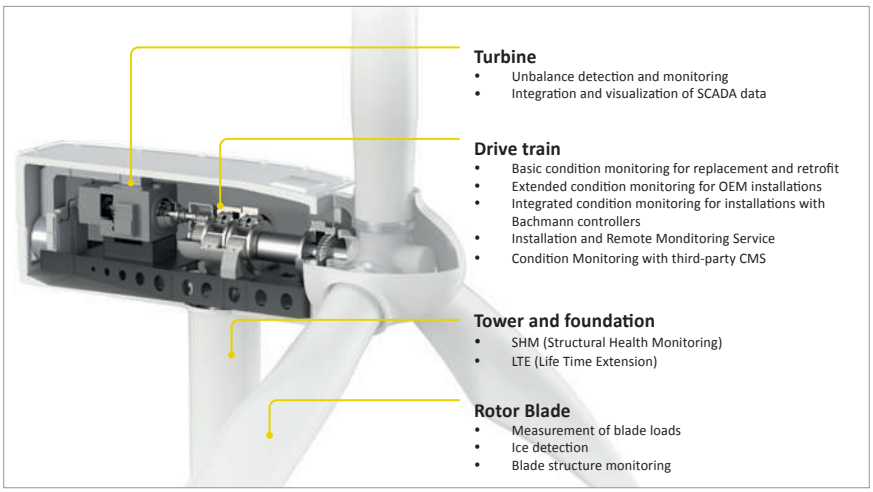


Fig. 2: Following a retrofit, Bachmann can monitor the operating parameters of a wind turbine on the turbine itself, the drive train, the tower, the foundations, and the rotor.

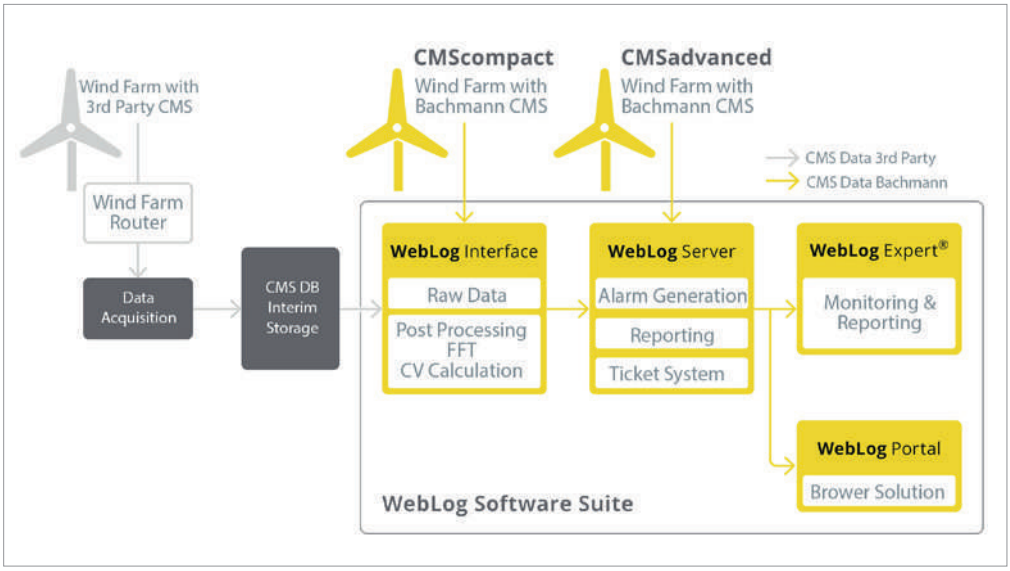


Fig. 3: **CMScompact** processes the collected raw data in the WebLog interface whereas **CMSadvanced** pre-processes the data on the system enabling the WebLog server to generate an alarm or a report immediately.

For this modular approach to control retrofit technology Bachmann was awarded the **WEU O&M Excellence Award** for the best technological innovation for wind turbines.

The basic retrofit process involves compiling an inventory of the wind turbine and measuring its performance, then analysing the data and communication interfaces followed by identifying any optimisation potential. Following this, the control software, I/O, and event lists as well as load calculations are implemented using the Bachmann Wind Turbine Template (WTT). Once various test procedures have been carried out using software in the loop (SIL) and hardware in the loop (HIL) technology, the prepared system is installed on site and put into operation.

The use of the existing turbine infrastructure is optimised during the retrofit: to the greatest extent possible, existing sensors and actuators are used whilst failure-prone or obsolete components are replaced. Bachmann's standard practice is to subject the new controller modules to a 48-hour factory test under the most extreme conditions.

The drive train fault detection rate is an impressive 99 percent following the retrofit. Operational downtime for implementation is limited to just a few days, as all hardware retrofits and software adaptations are planned and configured in advance.

## Conclusion

**Facilities in a competitive manner to which end the wind turbines are equipped with the latest control technology resulting in increased productivity and an extended system service life. Bachmann was awarded the WEU O&M Excellence Award for the best technological innovation for wind turbines for this innovative approach.**

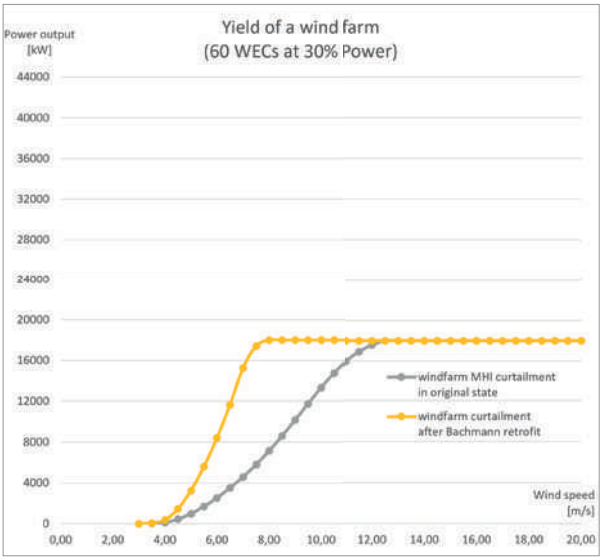


Fig. 4: This diagram shows the output of 60 Mitsubishi MWT-1000A wind turbines as a function of wind speed at 30 percent park output. The retrofit results in a 44 percent higher electricity yield, based on an average wind speed of 8.5 m/s in accordance with the IEC standard.

### Project overview

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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 126 ►**

# In 365 days to series production

Norra Hunna wind farm: The rotor blades of the Siemens SWT 4.1 are in Mercedes Star position, the 2in1 LPS Inspection is being prepared. Matrice 300 is the name of the new employee at German company ENERTRAG Operation, and she has no fear of heights.

Initialization successful: visual drone inspection creates images in high definition quality, allowing for identification of damaged areas in the 1–2 mm range. © ENERTRAG / Silke Reents

**Multi Stop becomes Single Stop**
Introduced in the accredited inspection department (competence confirmed by the Accreditation Body of the Federal Republic of Germany) of ENERTRAG Operation and validated by the technical inspection association TÜV Nord Group in 2022, the system is being further developed at full speed in close coordination with the company's own inspectors.

Until now, each blade has been scanned individually while in the 6 o'clock position. With the new single-stop variant, the rotor star is aligned at 12 o'clock and all rotor blades are scanned one after the other. The new HP variant of the SSL drone has changed the position of the camera and field strength meter and a new flight algorithm has been developed. This makes flying in single-stop mode possible. The direct inspection time can thus be reduced from approximately one hour per wind turbine to just 15 minutes. As a result, the time-consuming turning of the rotor until the next rotor blade is in the 6 o'clock position is eliminated, as is the multiple take-off and landing of the drone.

**Connection complexity simplified**
Another important component was to reduce the connection complexity, because there are countless variants depending on the technology orientation and the wind turbine manufacturer. Currently, the company differentiates between flat and ring adapters as well as connection via test probe, so that the application in the wind field can be carried out as quickly and user-friendly as possible.

In addition, the adapter insert is aligned with the drone's new single stop flight procedure. This requires three adapters per wind turbine, as they are then in use at the same time. For this purpose, a new cable separation point will be included in

**“We are continuously developing the system based on lessons learned from our day-to-day business. Our most important development partners are our own inspectors to whose needs we adapt the new system. The result of this work is easily seen in our three new developments: Single stop flight, LPS box and LPS adapter. These represent precisely this maxim. With these end products, we are also well equipped to develop a licensing model, as these three components are now compact and user-friendly.”**

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

For easy use in the wind field. Here you see a ring adapter. © ENERTRAG / Silke Reents

No more cable tangle: The new LPS box impresses with its robust yet slim design and simple operation. © ENERTRAG / Silke Reents

the system in order to keep the material to be transported to a minimum and at the same time save costs. The tested adapter types are currently being prepared for series production and combined into a handy LPS adapter set.

**Hardware scopes reduced**

In a further step, the focus was on robust design, user-friendly operation and efficient integration into existing work processes. For improved transport logistics, the hardware has also been shrunk. For example, the drone was equipped with a new field strength meter. In addition, a smaller frequency converter has been created, which is part of a new, fully integrated LPS box that includes all other functions. The necessary equipment can thus be carried along with the team in the lift and the use of a crane in a separate work step is no longer necessary.

## Conclusion

**What started as an innovative concept now offers wind farm operators the more efficient and accurate way to standardize rotor blade inspection, including lightning protection testing, and still ensure compliance for the insurer. For Matthes Schachtner and his team, after completing more than 300 drone flights within a year, one thing is clear: With the prototypes presented here, the final product of the 2in1 LPS Inspection is clearly emerging. It is convenient to use, integrates excellently into inspection activities when working on wind turbines, and offers solutions to problems for large turbines for which there were previously no answers.**

## Project overview

| | |
|---|---|
| Initiator | **ENERTRAG Betrieb GmbH** |
| Implementation: | **ENERTRAG Betrieb GmbH + Sulzer & Schmid Laboratories AG** |
| Numbers, data, facts: | **The 2in1 LPS Inspection has been offered as a service on the market since May 2022. As of fall 2023, the procedure and hardware have been further optimized and more than 300 drone flights have already been completed. Since then, the drone inspection has also been offered as a license model.** |
| Project status | **Completed** |
| Location | **Dauerthal** |

ENERTRAG
One energy ahead
Operation

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 **business directory on page 250.** ▶

# New age for local power

Local electricity tariffs are becoming a central instrument of social participation models in the renewable energy sector. In collaboration with Naturstrom, REZ has developed a new, simple, and easily transferable concept.

REZ and Naturstrom have developed a comprehensive concept that adequately involves local residents. © Jörg Weusthoff

The aim of REZ' innovative concept is to minimise red tape and costs even for major projects.

Since 2015, Regenerative Energien Zernsee GmbH & Co. KG has implemented a number of local power supply projects for the MLK Group. This includes local electricity tariffs, i.e., green electricity tariffs that people living close to wind farms were able to sign up for and that were sponsored by MLK's local wind farms. Since then, some 300 residents around the Prenzlau site and just over 100 residents at the Jacobsdorf site near Frankfurt/Oder are being supplied with subsidised power. This made it possible to offer low tariffs at these sites which were competitive with low-cost providers even prior to the energy cost explosion. Originally, the various stakeholders resorted to a rather complex contractual structure in order to be able to make such projects as attractive as possible for neighbouring residents.

Naturstrom and REZ have now developed a new concept to streamline these projects and make them more flexible. This enables an expedited start of new projects, a flexible subsidy design as well as a simplified management concept for the beneficiaries and the participating wind farms.

> **"Community participation must have a direct local impact and must take the form of a public project, which takes all stakeholders into account."**
>
> *Prof. Dr. Walter Delabar, REZ*

**Simplified management process**

Within the novel structure, Naturstrom, as the supplier, and REZ, as the manager, enter into a contract for the implementation of neighbourhood electricity tariffs, which can be located anywhere in the country. The wind farms conclude contracts with REZ, which can be suspended or even terminated at short notice enabling them to manage their commitment much more easily. Vis-à-vis local residents, REZ and Naturstrom operate as partners on behalf of the respective wind farms. REZ is primarily responsible for marketing activities. The beneficiaries can also be defined in more simple terms. As such, REZ is responsible for the entire organisational effort; the wind farms only provide their framework and guidelines according to which the respective measures can be implemented.

This makes it possible to get neighbourhood projects underway at an early stage. The refinancing of subsidies, for example, can be secured by the initiators or even from the construction costs.

In addition to this, simple control mechanisms can be built in to limit expenditure, which could be relevant in difficult years or at the start of operations. The number of


This structured concept connects regional stakeholders without being limited to specific regions. © Jörg Weusthoff

local electricity contracts available could be limited for example: given a subsidy of 180 euros and a maximum of 100 contracts, the annual costs would then be 18,000 euros. On top of this, there will be expenses for advertising and administration, which could amount to the same in total, especially in the start-up years. REZ charges 10 per cent of the funding amount as basic remuneration, whereas projects such as advertising campaigns are charged separately.

**Maximum flexibility and cost control**

Another approach to cost limitation is to allow only the immediate neighbours to benefit. To this end, distance parameters can be specified or postcodes can be used, depending on their practicability. REZ then decides whether applications meet the criteria and supervises the implementation on behalf of the wind farms. In addition, the subsidy amounts can be staggered so that residents in the immediate vicinity receive higher subsidies on their electricity costs than those who live further away. By the same token, social tariffs can be embedded, as is already the case at the Jacobsdorf site, which are easy to manage.

The concept is easily transferable and is no longer limited to specific regions. Operators interested in neighbourhood electricity models can have them implemented in a lean and flexible manner in their areas whilst keeping an eye on the costs.

## Conclusion

**Involving neighbouring residents in a way that really benefits everyone, even low-income residents and those living further away, requires a well thought-out concept where red tape is kept to a minimum and the costs are manageable. REZ as a manager has developed a transferable concept in collaboration with Naturstrom, which is not tied to any particular region, and which sensibly connects stakeholders in the sector for the benefit of consumers and with a view to the expansion of renewable energies.**

Excellent: REZ has analysed its experience and invested in optimisation. © Jörg Weusthoff

### Project overview

| | |
|---|---|
| Initiator | **Regenerative Energien Zernsee GmbH & Co. KG** |
| Project overview | **Public participation in RE projects: REZ and Naturstrom have identified local resident electricity tariffs as a key instrument for this. A novel concept is enabling interested operators to introduce flexible implementations throughout Germany with very little effort. The associated costs are manageable but there is plenty of scope for bespoke solutions.** |

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REZ

If you're interested in this project and wish to find out more about how your own municipality or company could benefit from it then talk to us. Our contact details are listed under **company profile on page 202 ▶**

# RESEARCH IN GERMANY

## Insight into the industry of tomorrow

Germany occupies an outstanding position in international wind energy research. The following pages present some research results of industry-related science, which can provide you with valuable insights into the latest technology trends.

# Wind power plant inspection using thermography and AI

BAM (German Federal Institute for Materials Research and Testing) is conducting research on how thermography and AI can be used to inspect wind turbine blades in order to prevent breakdowns and operate wind farms more economically.

**Inspection of turbines while in operation**

Rain erosion reduces wind turbine power and increases maintenance costs. Modern technologies such as infra-red thermography, combined with AI, make it possible to detect rain erosion on rotor blades efficiently, minimise maintenance effort, reduce operating costs and help to avoid efficiency losses. BAM has developed a method by which thermographic images of wind turbine blades can be taken from ground level while the respective turbine is in operation (Fig. 1). The wind turbine does not have to be stopped in order to allow the images to be taken, thus down-times are avoided.

**Thermographic images are evaluated using AI**

It is possible to detect thermal turbulence patterns in high-quality thermographic images of rotating wind turbine blades. Such turbulences are mostly caused by damage along the leading edges (Fig. 2). The objective of the present project is to use AI to accurately identify the thermal characteristics induced by erosion damage to the blades' leading edges. In order to assess AI performance, the models were subjected to image classification. Areas with real, existing characteristics were marked in test images (Fig. 3, green) and the predictions by the AI model (Fig. 3, red) were then validated on the basis of these test images.


Fig. 1: Visual depiction of the internal structure, based on thermal inspection of rotating wind turbine blades. Source: BAM

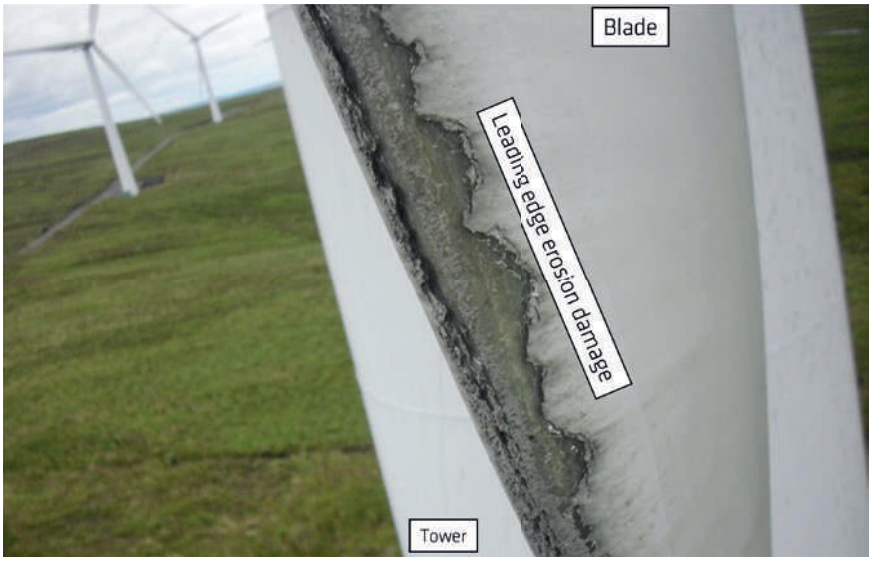


Fig. 2: Rain erosion damage of the leading edge of a wind-turbine blade

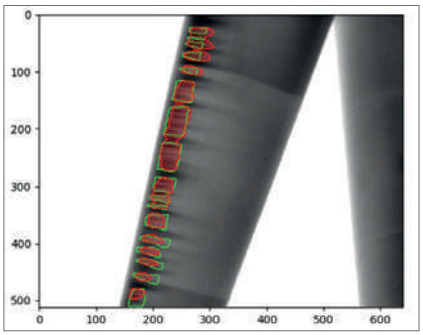


Fig. 3: Validation of the AI model: The green areas show visually detected characteristics, the red areas were detected using AI. Source: BAM

**"At present, wind turbine inspection is carried out by professional industrial climbers. This is a complicated, expensive method and, in view of the planned expansion of wind energy generation, is not viable for the future. We are developing a digital monitoring method that will eliminate down-times."**

*Dr. Michael Stamm (BAM), thermography expert and head of the research project.*

## Conclusion

**With the assistance of the LATODA start-up company from Marburg, BAM has developed a method which combines infrared thermography with AI-based image evaluation. In contrast to the inspection methods which have been used up to now, these being mainly visual and manual, this method allows damage to be detected and repairs to be made at an early stage, thus avoiding long down-times and efficiency losses.**

## Project overview

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|---|---|
| Status | **The feasibility study has been concluded. A follow-up project as part of the QI-Digital initiative is due to start in October 2023.** |
| Location | **Berlin-Adlershof** |

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# Corrosion research under real-life conditions

In order to allow corrosion prevention for offshore foundations to be tested under real-life conditions, the German Federal Institute for Materials Research and Testing (Bundesanstalt für Materialforschung und -prüfung – BAM), has set up a new sea-water laboratory near the Eider barrage.

**More accurate prediction of corrosion and corrosion prevention**

Research on corrosion in sea water and sediments can be conducted in this sea-water laboratory, which has an area of 50 m² and has been constructed with the help of the Elbe-North Sea waterways and shipping authority (Wasserstrassen- und Schifffahrtsamt Elbe-Nordsee).

The transition zone between sea water and sediment, along with biofouling, is considered to be critical for corrosion prevention on offshore foundations, since particularly heterogeneous conditions are to be found there. Up to now, it has not been possible to adequately describe the effectiveness of protection measures in these zones. The corrosion laboratory will be operated using a sea-water circulation system with the sediments found on site since testing in artificial sea water and sediments is not able to recreate a realistic marine biofouling situation.

Continued on page 80 →

Moving the corrosion protection metrology container from BAM TTS to the Eider barrage location
Source: BAM

**"Thanks to this sea-water laboratory for corrosion research – the only one of its kind in Germany up to now – it will be possible to determine the characteristics of complex corrosion systems, plan targeted protective measures and thus reliably achieve the planned service lives."**

*Gino Ebell (BAM), Corrosion prevention expert and head of the research facility*

**Five test basins**

The laboratory encompasses five test basins each with a volume of 500 litres and using artificial daylight, as well as a large test cylinder holding 4000 litres and exposed to natural daylight. The entire laboratory is climate-controlled and has a supply storage basin and a fresh-water connection. All test basins are equipped with extensive metrology systems with remote control capability.

**Innovative exploration tools**

The items being developed by BAM in this laboratory include exploration tools which can be used to describe the corrosiveness of ocean-floor sediments. The purpose of these tools is to allow the planners of future offshore structure foundations to avoid highly corrosive regions and/or adapt corrosion prevention measures more precisely to the ambient conditions of the site.

The interior of the container. Source: BAM

The new sea-water-laboratory at the Eider barrage location. Source: BAM

## Conclusion

**The aim of research work in the BAM's new sea-water laboratory is to improve the safety of offshore foundations. It focusses on predicting corrosion stresses and the effectiveness of protective measures. This will increase planning confidence for offshore wind farm operators and ultimately increase the contribution of wind energy to the energy transition process.**

## Project overview

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|---|---|
| Status | **The sea-water laboratory is to be commissioned at the end of 2023. Research on protection measures will commence in 2024 and the results will be continuously evaluated.** |
| Location | **Eider barrage / Berlin-Steglitz** |

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# WiValdi wind energy research farm

The German Aerospace Center (DLR) and its partners from the Research Alliance Wind Energy have set up the “Wivaldi” wind energy research farm.


View of the WiValdi wind energy research farm

> **“More than 2000 sensors are collecting a constantly growing treasure-trove of data for wind energy research.”**
>
> *Dr.-Ing. Jakob Klassen*
> *DLR, Wind energy experiments*


WiValdi OPUS 1

With partners from the Research Alliance Wind Energy (FVWE), DLR has developed and built the research wind farm. The FVWE consolidates the expertise of more than 600 researchers to provide impulses for the energy supply of the future. The three partners are: DLR, ForWind – Center for Wind Energy Research at the Universities of Oldenburg, Hannover, and Bremen, and the Fraunhofer Institute for Wind Energy Systems. This research farm enables holistic wind energy research on full-scale systems. Four metrology masts with extensive instrumentation and two modern wind power plants are already available on site for use by the research partnership. The masts and the wind turbines are aligned in a row in the direction of the prevailing wind. Using this constellation, which is otherwise commercially unfavourable, the interactive effects between individual turbines in wind farms can be investigated. In WiValdi over 2,000 sensors measure, for example, temperature, humidity, wind speed, pressure, or even the slightest deformations of the rotor blades. All these sensors collect synchronized and time-stamped high-resolution data non-stop, 24 hours data will become a constantly growing data treasure-trove for the wind energy research sector.

WiValdi is being sponsored by the Federal Ministry for Economic Affairs and Climate Action and the Ministry of Science and Culture of Lower Saxony.

## Conclusion

**WiValdi will enable the creation of a unique original-scale infrastructure in real-life conditions for the industrial and academic research community, making future power-plant generations more efficient and intelligent, allowing optimum utilisation of the areas suitable for wind power and contributing to increased acceptance of this technology.**

## Project overview

| | |
|---|---|
| Location | **Landkreis (county) Stade**<br>**21732 Krummendeich** |

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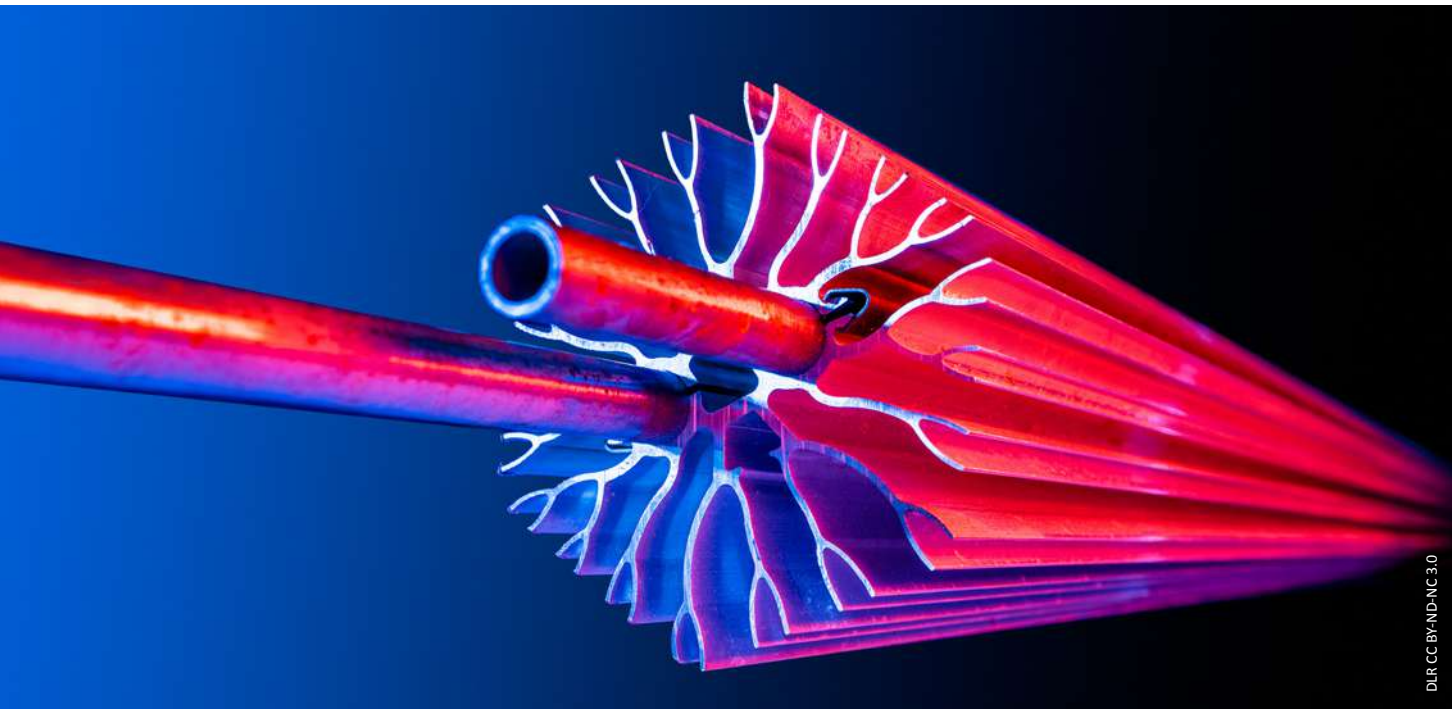
aufgrund eines Beschlusses des Deutschen Bundestages

Niedersächsisches Ministerium für Wissenschaft und Kultur




# Using salt to bridge blackouts and peak loads in a climate-neutral manner

In collaboration with stakeholders from the industrial and research sectors, the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) has successfully built and tested a Carnot battery. **Carnot batteries are able to store electricity in the form of heat and then reverse the process to generate electricity.**

The EU research project CHESTER (Compressed heat energy storage for energy from renewable sources) uses a latent heat storage system, which was developed by the DLR Institute of Technical Thermodynamics as the core element of the pilot plant. It contains around two cubic metres of nitrate salt which is heated by the electricity to be stored via a high-temperature heat pump and melts during the process. This is referred to as a latent heat storage system because part of the heat appears to be hidden, i.e., it is latently stored in the loosening of the bonds between the salt crystals, which acts like a kind of supplementary store.

To discharge the storage tank at a later stage, a cooling circuit transfers the heat to a heat engine coupled with a turbine and generator. The electricity generated in this climate-neutral manner can then be fed back into the grid. Under test operation conditions, the pilot plant achieved a total electrical output of just under 10 kilowatts.

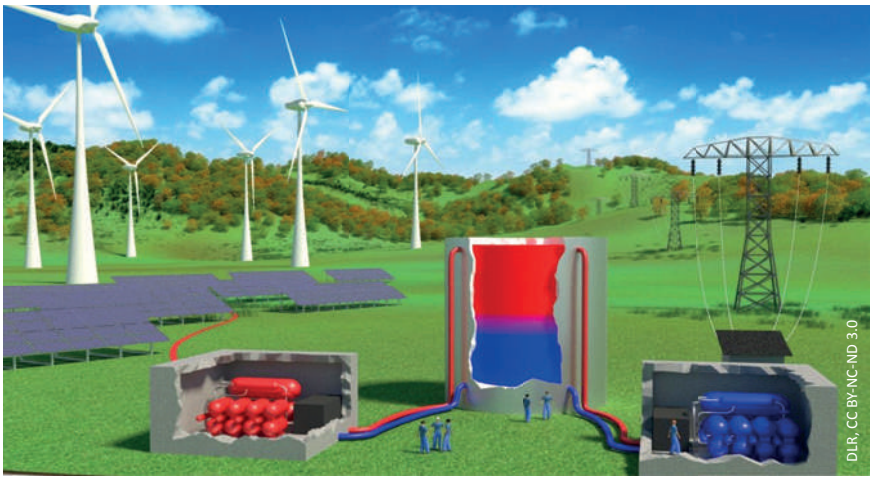
**One of the major benefits of Carnot batteries is that they can supply electricity and heat at the same time.** Their size and capacity can be easily adapted to the respective requirements, which makes them ideally suited for sector coupling set ups. As a result, they are particularly interesting for industrial processes as well as for local electrical grids and so-called smart district heating networks.

## Conclusion

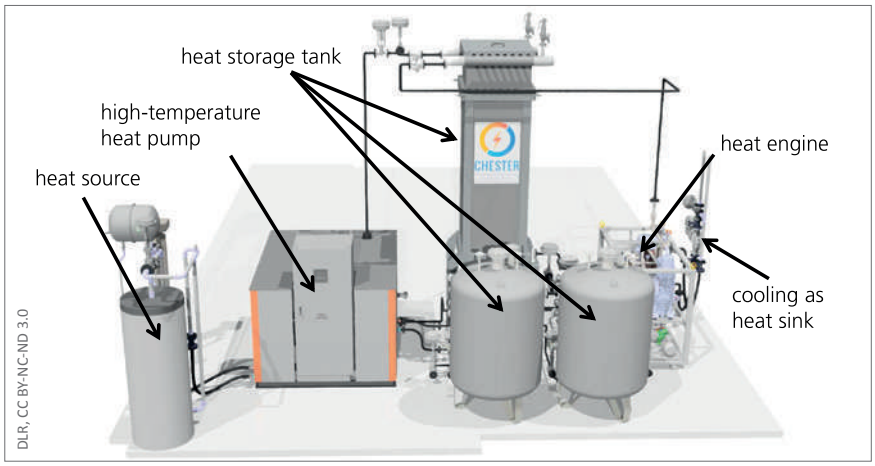
**Carnot batteries can be used to compensate for fluctuations in solar and wind energy, which means that this storage technology is capable of contributing to a controllable and secure renewable energy supply.**


**"This technology could potentially be used to store electricity generated from renewable sources on an industrial scale, which means that blackouts and peak loads can be bridged in a climate-neutral manner when there is no wind and no sunshine."**

*Maike Johnson of the DLR Institute of Technical Thermodynamics*




Carnot batteries are able to store electrical energy in the form of heat.




A Carnot battery pilot plant at the DLR site in Stuttgart: the main components of the storage system are a high-temperature heat pump, a heat accumulator filled with nitrate salts, and a thermal engine, which can generate climate-neutral electricity on demand via a turbine and generator combination.

## Project overview

| | |
|---|---|
| Implementation | **2018 Project launch**<br>**2022 Pilot plant successfully tested** |
| Location | **Pilot plant in Stuttgart** |

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**DLR Deutsches Zentrum für Luft- und Raumfahrt**

# Cognitive Energy Systems Competence Centre Artificial intelligence in the energy sector

The aim of the „Cognitive Energy Systems (CES) Competence Centre" project is to lay the foundations for the successful use of artificial intelligence (AI) in the energy system as well as to promote the development of cognitive energy systems.


> **"The use of AI in the energy system offers the potential for a more affordable and cleaner energy supply."**
>
> *André Baier, Project Manager*

The complexity of the energy system is increasing both on the generation and consumption sides yet electrical power should not become more expensive and should always be reliably available everywhere. Artificial intelligence (AI) can utilise self-learning systems and automation to help manage increasing complexity and reduce operating costs. A wide range of applications along the entire value chain can be automated through the use of AI.

Introducing AI into the energy system will be a multi-step process. Cognitive energy systems are energy systems that can independently determine and forecast the status of their assets on the basis of the available information and that are adaptive enough to learn how to achieve predefined energy management goals. The energy system of the future will need to develop an awareness of its own condition and be able to react automatically, whereby so-called AI agents can take over complex control processes that would not be possible with the current staffing and technology in the respective companies.

Tests have been carried out in 44 so-called spotlights projects to examine which AI processes would be useful in the energy sector, in particular for grid operation, forecasting, resilience, power electronics, energy management, and energy trading.

Forecasts are important for maximising the use of wind power in the energy supply. For example, what are the consumption behaviour factors that most influence consumption forecasts – time of day, day of week, season? Temporal Fusion Transformers (TFTs) are able to forecast different time horizons whilst taking account of probabilities. Forecasting power flows in the electrical grid enables grid operators to make predictive grid calculations and detect bottlenecks early on. TFTs enable a single model to be trained for several locations at the same time (multi-task learning), which means that lessons learned at other locations, as well as spatial and temporal dependencies, can be incorporated into the forecast in order to improve it.

Trading on the power markets is either done by humans or with automated rule-based systems, which, in many respects, will be unsatisfactory in the highly decentralised energy system of the future because of the expertise required, the fact that a large part of the complexity of the electricity market is ignored in rule-based systems, and due to the loss of flexibility. Machine learning (ML) and especially reinforcement learning (RL) are capable of counteracting potential excessive or

## Project overview

| | |
|---|---|
| Implementation | **completed** |
| Location | **Kassel** |
| Project Manager | Dipl.-Math André Baier, M.Sc.<br>Business Unit Manager Digital Portfolio Management |

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insufficient power supply capacities. An automated trading agent for energy trading from the perspective of wind power operators was created in the Deep Energy Trade project based on the use of wind power forecasts of Fraunhofer IEE. The outcome is a prototype in the form of a demonstrator that generates positive trading results from a small data set.

The Hessian Ministry of Science and the Arts provided 5.8 million euros in funding from 2019 to 2023 for the „Cognitive Energy Systems" start-up project.

## Conclusion

**The CES project has created the necessary foundation for the successful use of AI in the energy system by building up the necessary competences and tools and demonstrating its potential in a number of 44 spotlight projects.**

# Deep Bird Detect

Artificial intelligence is used to automatically record sensitive bird species in order to reconcile species protection and wind energy.

Wind farm construction is often delayed because the authorities require project developers to carry out comprehensive nature conservation assessments before they can be approved. The Fraunhofer IEE is collaborating with the universities of Kassel, Kiel, and Chemnitz, as well as industry partners to develop a system that can automatically recognise and classify birds and other animals on the wind farm sites using audio signals. The process is based on artificial intelligence (AI) whereby the researchers use deep-learning technology to make temporal and spatial recording of the respective species possible.

They record sound files to classify endangered species and those likely to be harmed by wind turbines. But analysing this data is extremely laborious, which is why AI-supported, automated data processing is so important. Another disadvantage of manual analysis is that it does not always capture all of the animals' audio signals – the effort required for a complete manual assessment would be far too great. This is why analyses are only conducted on a sample basis, which means some species may remain undetected, which in turn makes expert opinions contestable in a court of law. One of the results of a pilot project run by the Cognitive Energy Systems Competence Centre (see above) is a tool for classifying endangered bird species on the basis of sound recordings.

The standardised recording methodology of the „Deep Bird Detect" system also enables comparisons to be made with other ecosystems, which sheds light on long-term developments on these sites, e.g., via a monitoring network that can automatically detect geographic species-specific changes at an early stage. The technology used in the Deep Bird Detect project will also be adapted to other species groups, such as bats, amphibians, and insects, in order to broaden the scope of the ecosystem inventory.

> **"We need to make neural network decisions transparent and comprehensible, which will provide additional legal certainty."**
>
> *Dr. Christoph Scholz, Project Manager*

## Conclusion

**The aim of the Deep Bird Detect consortium is to help create legal certainty through AI-supported, efficient, and legally secure specialist assessments of fauna and to speed up approval procedures with a view to contributing to the expansion of wind power.**

## Project overview

| | |
|---|---|
| Implementation | **Project implementation started** |
| Location | **Kassel** |
| Project Manager | Dr. Christoph Scholz<br>Scientific Director of the Cognitive Energy Systems Competence Centre<br>Fraunhofer IEE |

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# Subsurface investigation using multichannel seismic and hydroacoustic methods

Fugro and Fraunhofer Institute for Wind Energy Systems secure survey work for wind farm sites in the German exclusive economic zone on behalf of the Federal Maritime and Hydrographic Agency.

Fugro Pioneer running lines with seismic equipment deployed to perform a geophysical survey. ©Fugro

Fugro are collaborating with the Fraunhofer Institute for Wind Energy Systems IWES to undertake a geophysical survey contract for two offshore wind farm sites in the German exclusive economic zone (EEZ) in the North Sea, for Germany's Federal Maritime and Hydrographic Agency, the Bundesamt für Seeschifffahrt und Hydrographie (BSH).

The project started in May 2023, with Fugro mobilising a dedicated survey vessel to perform high-precision positioning, sub-bottom profiling recording and interpretation. Additionally, Fraunhofer IWES took responsibility to conduct the multichannel seismic survey, followed by dedicated data processing and interpretation. A dense data raster was generated totalling 2393 km survey lines. The sub-bottom profiler data provides detailed structural imaging of sediments up to 15 m below the seafloor while the ultra high resolution multichannel seismic data (UHR MCS) penetrates more than 100 meters to capture images of small sedimentary bodies as well as deep sediment filled valley structures.

The collaboration of know-how and resources between both teams, guarantees a safe and efficient survey that meets BSH's stringent planning schedule. The final result will be a preliminary subsurface model that can be used as the basis for future geotechnical survey campaigns as well as to reduce the risk for the future installation of the windfarms.

## Conclusion

**The sites are to be auctioned in the coming years and play an important role in Germany's energy transition, which aims to achieve the target of 30 GW of installed offshore wind power capacity by 2030.**

## Project overview

| | |
|---|---|
| Implementation | **May 2023 to November 2023 with delivery of the ground model and final report** |
| Location | **North Sea** |

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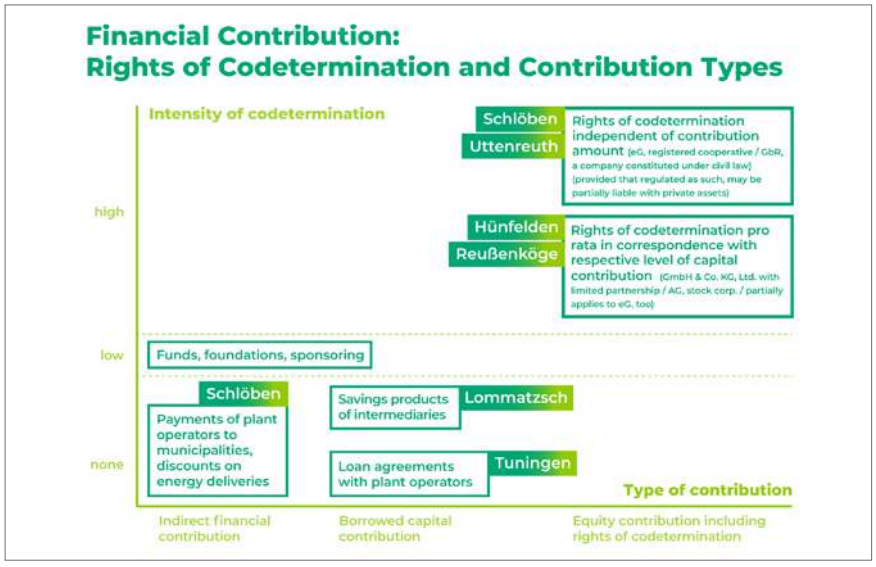
# Regional value creation, participation, and acceptance

The ReWA research project: Focus on the importance of regional value creation and financial participation opportunities for the acceptance of local RE projects.

The ReWA research project, which was funded by the Federal Ministry for Economic Affairs and Climate Action (BMWK), involved a collaboration between the Institute for Future Energy and Material Flow Systems (IZES), the Renewable Energy Agency (AEE), and the Institute for Ecological Economy Research (IÖW) and investigated the relationship between regional value creation, financial participation opportunities, and local acceptance of renewable energies in six selected German communities. Various RE projects (wind, PV, biomass) had been implemented with different participation approaches in the communities analysed. The overall finding was that the more that local stakeholders are involved in the respective value creation steps, the more value is retained within the community in which the project is implemented.

Whereas the proportion of the business taxes paid by the operating companies is regulated by law for the local community, other participation potentials (profit sharing, lease income, jobs, contracts) have to be addressed proactively. When it comes to wind farms, it is particularly important that citizens, the local authority, and local companies participate in the investment in the turbines so that the operator's profits remain local and citizens have a say in the process. For example, a wind farm based in Reußenköge, which is one of the world's largest publicly owned wind farms, has a policy of "earning with the wind farm, not exploiting the wind farm". The study results also show that the value created has to be communicated actively and made visible in order to have a positive effect on public acceptance.




Various forms of financial participation in the municipalities investigated in the project.
© Project ReWA/Graphic AEE

## Conclusion

**The acceptance of renewable energy projects is strongly influenced by regional value creation and participation opportunities, which, in turn, provide a basis for the successful and swift implementation of further renewable energy projects. In this context, local authorities have an important role to play: they should make use of their scope for action, e.g., by allocating municipal land as a basis for the managed control of this technology.**

## Project overview

| | |
|---|---|
| Implementation | **completed, duration 06.2020 – 03.2023 Funding by the Federal Ministry for Economic Affairs and Climate Action (BMWK)** |
| Location | **six communities in Germany; 3 of them with wind turbines** |

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**Results brochure**
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ReWA Regionale Wertschöpfung. Akzeptanz. Beteiligung.

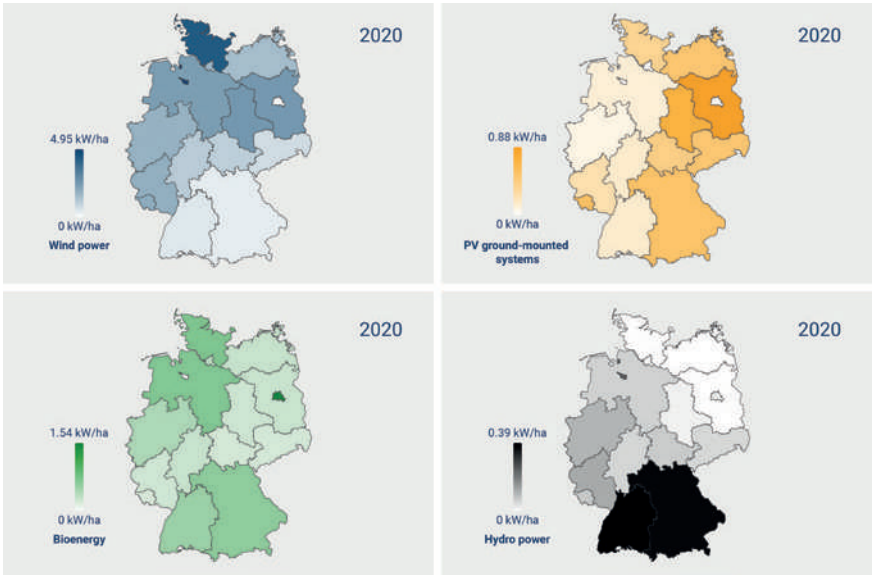
# How to assess the environmental compatibility of the energy transition

The Helmholtz Centre for Environmental Research (UFZ) developed the RE (renewable energies) Monitor (https://ee-monitor.de) to identify and evaluate the environmental compatibility and goal conflicts of the energy transition.

Facilities for renewable energy generation, such as wind turbines or ground-mounted photovoltaic plants, have become an integral part of the landscape. However, in addition to their contribution to protecting the climate, they can also have a negative impact on the environment if, for example, they pose collision risks for animals or result in land use changes.

The RE-Monitor is a publicly accessible web application that uses 41 indicators to quantify the expansion of renewable energy production and to measure impacts this has on nature and the landscape. For example, there is evidence that the expansion of wind turbines and ground-mounted photovoltaic systems is mainly taking place on agricultural land and that the number of turbines in environmentally protected areas, nature parks, and forests is steadily increasing. A positive trend is that the area efficiency of ground-mounted photovoltaic systems is rapidly increasing.

> "An energy transition that is environmentally friendly can only succeed if both the available land and the energy generated from it are used efficiently"
>
> *Prof. Dr.-Ing. Daniela Thrän, UFZ*




There are significant regional differences in the power densities of renewable energy production facilities.


The accelerated energy transition is exacerbating conflicts between the expansion of renewable energies and nature conservation.

## Conclusion

**The RE Monitor provides the public with detailed data on current areas of conflict between the energy transition and nature conservation. Regional comparisons can be made, and the temporal development of conflicts can be traced. Nature conservation-related indicators of the RE Monitor show both technology-specific and cross-technology trends.**

## Project overview

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|---|---|
| Implementation | **completed, the web application is updated and extended ever year** |

**Helmholtz Centre for Environmental Research (UFZ), Leipzig**
**Funded by the Federal Agency for Nature Conservation**

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UFZ HELMHOLTZ Centre for Environmental Research

# Offshore wind farms sequester carbon in sediment

Researchers at the University of Hamburg's Department of Biology have been studying the impact of offshore wind farms on sedimentary carbon deposits in the North Sea.

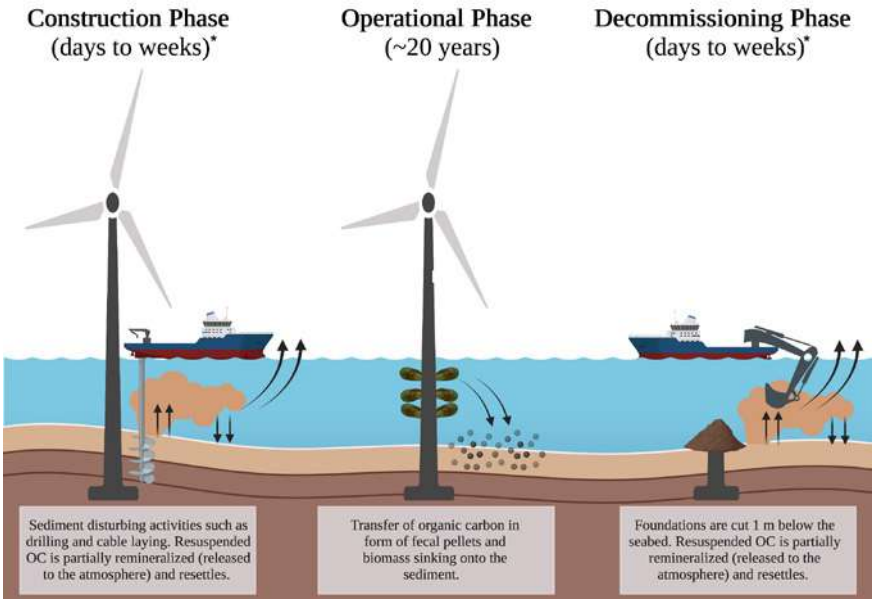
Around the world, the sediment beds in which offshore wind farms are installed harbour significant levels of carbon dioxide. Initial studies have shown that offshore wind farms affect the properties of the sediment in their immediate surroundings, increasing the natural carbon levels in the sediment during the operational phase and decreasing them during construction and decommissioning.

To find out whether the sediments in which offshore wind farms are located sequester more carbon than they release, researchers at the University of Hamburg have calculated the net carbon effect in the sediment over the entire life cycle of offshore wind farms in the southern North Sea, which includes the construction, operational, and decommissioning phases.

The results suggest that some 481,000 tonnes of carbon dioxide are additionally bound in the top ten centimetres of sediment surrounding the offshore wind farms in the respective area. By contrast, the total amount of carbon released during sediment-altering activities during construction and decommissioning is only about 100,000 tonnes. However, the intensity of carbon release in the disturbed areas is about 44 times higher than that of carbon sequestration throughout the entire offshore wind farm area. But, as the overall area that is disturbed is only about 0.50 per cent of the total area of the offshore wind farms (60 km²), it means that, in absolute terms, about **five times more carbon is subsequently trapped in the sediment than is released during construction.**

## Conclusion

**The relevant calculations show that five times more carbon is trapped than released by the wind turbines. Further research is needed, due to the limited nature of the data, so these results are only suggestive of orders of magnitude.**




Impacts of different life cycles (construction phase, operational phase, decommissioning phase) of offshore wind farms on the sediment and the resulting trapped and released organic carbon in the upper 1 m of the sediment. © 2023 Heinatz and Scheffold

## Project overview

| | |
|---|---|
| Implementation | **completed** |
| Location | **Southern North Sea** |

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Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

# Green hydrogen more competitive than expected

Researchers at the Wuppertal Institute conducted a meta-study to determine the demand, costs, and development paths of hydrogen in Germany.


According to a study conducted by the Wuppertal Institute on behalf of the North Rhine Westphalian Renewable Energy Association, domestically produced green hydrogen will be able to compete with imports in many cases. This is because of the expected decrease in production costs for green hydrogen in Germany and the higher transport costs for imports, which can offset the lower production costs abroad.

However, the production cost of a future hydrogen economy is not the only factor to be considered; demand will also play a major role. The researchers argue that in order to maximise the efficiency of the hydrogen production that is possible by 2030, the focus should be on the use of hydrogen in core industries such as the steel and chemical sectors. As study author Frank Merten, co-head of the Systems and Infrastructures Research Unit at the Wuppertal Institute, points out, „This will help to limit the future demand for hydrogen and therefore also the required production and import volumes and could simultaneously reduce the need to import blue hydrogen (to support the ramp-up), which, depending on the technology used and the origin of the natural gas, emits significantly to considerably more greenhouse gases than green hydrogen.

## Conclusion

**The production costs of domestically produced hydrogen need not be higher than those of imports, which means that a greater effort should be made in this sector than has been the case to date. Import and production volumes could and should be limited during the ramp-up phase by focusing on crucial applications in industry and the transformation sector.**

## Project overview

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|---|---|
| Implementation | **from 03/2023 to 05/2023** |
| Location | **Wuppertal** |

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Wuppertal Institut

# BirdRecorder – Collision-prevention system for wind energy turbines

The Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) deploys artificial intelligence for this system.


The cameras can identify endangered bird species at a distance of 700 metres.


BirdRecorder reconciles species conservation and climate protection.

Machine learning and artificial intelligence are the core elements of the "BirdRecorder" collision-prevention system developed by ZSW. AI experts at ZSW are using cutting-edge AI methods to detect birds and identify the species. As Anton Kaifel, head of ZSW's artificial intelligence team explained: "with our AI solution we are giving a new impetus to the further expansion of wind energy plants". This system can prevent birds of prey such as red kites from colliding with wind turbine blades. To achieve this aim, we need reliable detection and identification at distances where it is still possible to intervene in the control system.

**Birds can already be identified at distances of 700 metres**

The intervention zone of wind turbines must be at least 500 metres so that they can be put into stall mode in time to match the typical flight speed of red kites. BirdRecorder, however, can already identify bird species at distances of up to 700 metres. The collision-prevention system generates a signal causing the wind turbines to be switched into stall mode as soon as a kite enters the intervention zone. A signal to resume normal operation is then sent to the wind energy plant as soon as the bird leaves the intervention zone. The system, equipped with twelve cameras, is modular and can be adapted to all types of wind farm layout. BirdRecorder is due to be validated at ZSW's recently-opened wind energy research site near Geislingen early in 2024 in accordance with a standard developed by the Swiss Ornithological Institute. Following this, several pilot projects in wind farms are planned. Use of this system avoids complete shutdowns and thus improves the performance of wind farms. The Baden-Württemberg Ministry of the Environment, Climate Protection and the Energy Sector is funding the project.

## Conclusion

**In the years ahead, an increasing number of wind energy plants will be set up in forested areas. For reasons of species conservation, this will only be possible if collision-protection systems are deployed.**

## Project overview

| | |
|---|---|
| Implementation | **validation in 2024** |
| Location | **Schwäbische Alb (Swabian Jura)** |

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