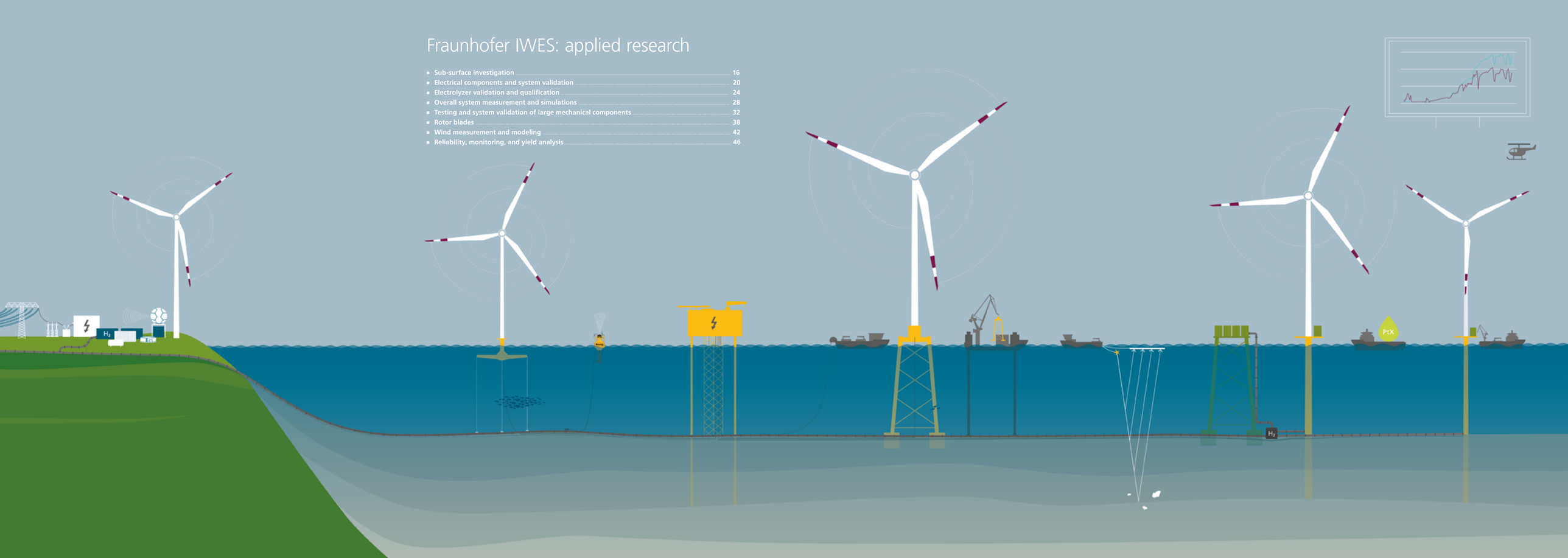
Fraunhofer
IWES

Wind energy and hydrogen

Applied research for a sustainable future

Fraunhofer IWES: applied research



The management team (from left to right): Prof. Dr.-Ing. Jan Wenske, Deputy Managing Director and Chief Technology Officer, Jenny Kuball, Chief Financial Officer, Dr. Bernhard Lange, Deputy Managing Director and Chief Technology Officer, Prof. Dr.-Ing. Andreas Reuter, Managing Director and Christian Broer, Chief Operating Officer

Dear readers,

Optimal utilization of the wind is a forward-looking but also complex task. At Fraunhofer IWES, experts from a wide range of disciplines are putting their extensive knowledge to use to improve both performance and cost-efficiency. Our key areas of expertise of Offshore, Hydrogen, Test Infrastructure, and Digitalization open up opportunities for customers to delve deep into specific issues together. For us, the specific interests of our customers are the measure of all things: pushing boundaries and making it technically possible for them to move forward.

Our unique testing infrastructure and measurement technology have been adapted to the rapid growth in the wind energy industry and expanded to include digital testing methods. New measurement methods support the rapid development of offshore wind energy utilization. As a result, we are now ready to develop unconventional solutions and take the next steps together with you. From the analysis of wind conditions to grid feed-in and hydrogen production, you benefit from our globally unique testing infrastructure and many years of experience to guarantee a resilient and sustainable energy supply.

We are by your side as you explore the possibilities for the future and break new ground. Applied research is an important driver and can identify and even overcome systemic challenges.

Let's reach the next level together and turn our vision of an environment worth living in into reality. We are driven by an innovative wind energy and hydrogen industry.

I hope you enjoy reading!

Prof. Dr.-Ing. Andreas Reuter
Managing Director

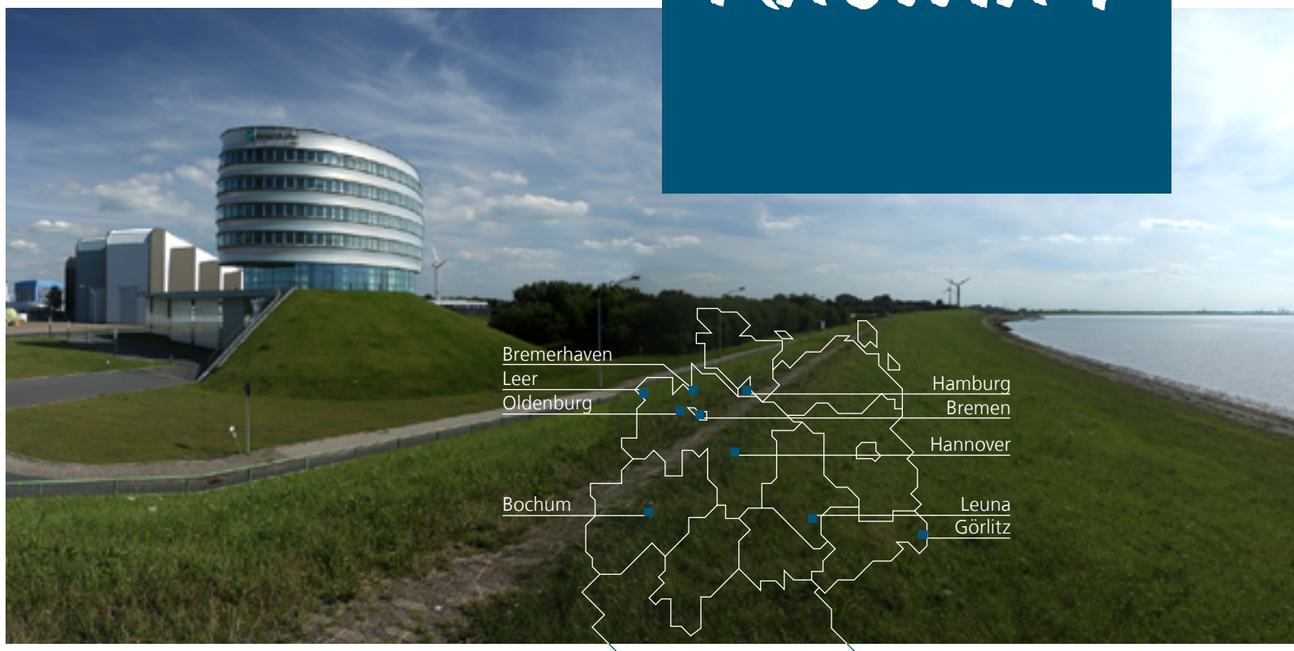
Short portrait

Fraunhofer IWES develops innovative methods to accelerate the expansion of the wind energy and hydrogen economy, minimize risks and increase cost efficiency. Innovations in technological developments are validated and innovation cycles are shortened. Planning and development of offshore wind farms are accelerated and made more precise. At present, there are more than 300 scientists and employees as well as more than 100 students employed at the nine sites: Bochum, Bremen, Bremerhaven, Görlitz, Hamburg, Hannover, Leer, Leuna, and Oldenburg.

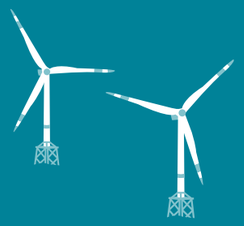
The combination of a globally unique testing infrastructure with methods expertise distinguishes Fraunhofer IWES as a research partner for companies all over the world. Participation in international expert committees makes the institute an active trailblazer for technological developments and quality assurance in the wind industry.

MORE INFO

worth KNOWING



Test infrastructure 2009 to 2024



Assessment of Soil Conditions Bremen

2009

70m Rotor Blade Hall

2011

90m Rotor Blade Hall Bremerhaven

2012

Engineering Building

1st Lidar Measuring Buoy Bremerhaven

2013

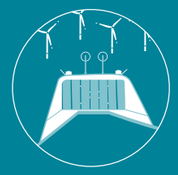
Test Center Support Structures Hannover

2014

DyNaLab Bremerhaven

2015

Application Center for Field Measurements Bremerhaven



BladeMaker Bremerhaven

2016

Research Windturbine Bremerhaven

2017

Large Bearing Laboratory Hamburg

2019

Application Center for Integration of Local Energy Systems Hamburg

HiL-GridCoP Bremerhaven

2020

Hydrogen Lab Leuna

2021

Hydrogen Lab Bremerhaven

2023

115m+ Rotor Blade Test Rig Bremerhaven

Mobile Grid Bremerhaven

2024

PQ4Wind Bremerhaven

Since Fraunhofer IWES was founded in 2009, our testing infrastructure has grown steadily. Large-scale tests can be used to validate models of new rotor blades, nacelles, support structures and bearings as well as for electrical grid integration.

With the construction and operation of Hydrogen Labs, a digitally networked infrastructure with test and qualification capacities for the necessary electrolysis and fuel cell systems of up to 26 megawatts (MW) is being created for the first time. They are used to test the efficiency and reliability of the operation of electrolyzers in combination with renewable energies.

With our expertise in wind farm development, site investigation, wind measurement and the production and use of green hydrogen, we are making an important contribution to a sustainable energy supply.

MEASUREable

Fraunhofer IWES focus topics

Promising potential for optimization

The greatest potential for further improvements in the field of technological efficiency and reliable energy supply in the medium and long term lies in the more consistent utilization of wind energy. Policymakers have set the course here – not least through research funds, which are as necessary as they are well invested. In the future, the focus will particularly be on the expansion of offshore wind turbines and the increasing utilization of green hydrogen. Fraunhofer IWES is well equipped for the future. With a goal-oriented overall strategy, we are facing the challenges of dynamic policies and focusing on additional specialist personnel, New Work concepts, and cross-site cooperation among other things.

Focus topic Offshore

Greater success with sound site investigations

Designing and constructing offshore wind farms demands comprehensive knowledge of the environmental conditions at the selected location. This is the only way for the project to be a financial success. Fraunhofer IWES carries out wind measuring and modeling campaigns as well as the investigation of geological sub-surface characteristics and seismic surveys of the subsoil for offshore wind farms. Innovative technologies tried and tested in feasibility studies, data analyses, and actual offshore deployments are employed for sound site investigations.

Offshore wind farm development with innovative measurement methods

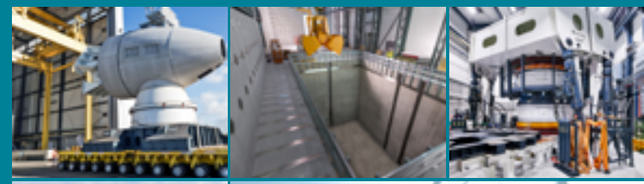
Fraunhofer IWES has extensive experience in the development of offshore wind farms, from modeling wind conditions and wind measurements to sub-surface investigation and geological ground models. CFD (computational fluid dynamics) models are employed to simulate the offshore wind conditions according to relevant atmospheric characteristics. The effects of existing wind farms are also included. Floating lidar systems are employed for the offshore wind measuring campaigns. They meet the highest international standards and also offer innovative services for wind farm development.

For sub-surface investigation, Fraunhofer IWES has developed 2D and 3D geological investigation technologies with ultra-high-resolution multichannel seismics and brought them to market maturity. All wind farm areas in Germany that were centrally pre-investigated were measured by Fraunhofer IWES using this method. A further special field of application is boulder detection performed with the aid of of patented refraction seismic methods.

With Fraunhofer IWES:
Cost-efficient planning and development

Effective project and risk management forms the basis for the successful and cost-efficient planning, construction and operation of offshore wind farms. During the planning and implementation phase, Fraunhofer IWES offers project planning and weather risk analyses in order to identify and assess potential risks at an early stage. In addition, Fraunhofer IWES supports partners in the development of new technologies to effectively exploit the potential of direct offshore generation of green hydrogen and other Power-to-X products.

Focus topic Test Infrastructure



Fraunhofer IWES' trademark

Large-scale test rigs for realistic and accelerated life testing of wind turbines are Fraunhofer IWES' trademark. Alongside test rigs for rotor blades, blade segments, blade bearings, nacelles, the grid integration of electrical systems, and support structures, testing facilities for electrolyzer systems and components also form part of IWES' portfolio.

Continuous investment in new test rigs

Large composite components and mechanical components are being considered as well as complex environmental influences, more reliable, power electronics in the megawatt range, and the electrical system properties. Different operating scenarios, damage mechanisms, and adapted protection concepts are being investigated and models validated through comparison with experimental tests. Fraunhofer IWES is not only continuously investing in new test rigs for increasing component sizes, but also offers segment tests, scaled tests and virtualized tests.

Cost reduction through earliest possible validation

The growth in size and the further expansion of wind turbines mean that the demands on technical reliability are continuing in general. Accelerated introduction on the market, the use of one platform for multiple turbine models, the professionalization of wind farm operators, and higher costs in the event of offshore turbine failures all speak in favor of comprehensive validation prior to initiating operation. Added to this comes the increasing complexity from the coupling with systems in the hydrogen value chain. Modular testing and the precise characterization of multi-domain properties as well as experimental validation - across sectors - are possible thanks to the many years of accumulated expertise and the unique equipment at Fraunhofer IWES. Our experts are already using all the technological possibilities of advancing digitalization to support this.

In addition to the classic 1:1 tests of subsystems and components, scaled 1:X tests are realized. We are also working on new hybrid test methods with measurements and model validations only in the partial load range, which are then used for experimentally verified extrapolation over the entire operating range.

Focus topic Hydrogen

Achieving climate goals with reliable operation

The production of green hydrogen for the decarbonization and defossilization of industrial processes will make a decisive contribution to the achievement of the climate goals. The reliable operation of electrolyzers and systems all along the H_2 value chain is key to minimizing the risks of upscaling hydrogen production.

The rapid ramp-up and the associated immense increase in demand for electrolysis capacity pose challenges not only for manufacturers but also for future operators, as not only production processes, but also measurement and monitoring procedures are not easy to scale up from the factory to industrial dimensions.

Three hydrogen labs with different focuses

Embedding in the energy system and in industrial processes also poses challenges in terms of deployment behavior and operating models. This is why Fraunhofer IWES operates hydrogen labs for the testing and validation of hydrogen-relevant components along the value chain: from production via electrolysis to storage and use in power-to-X processes or fuel cells – with a total connected power of up to 26 MW. In doing so, Fraunhofer IWES is helping the industry to establish a sustainable hydrogen economy. The hydrogen labs have different focuses:

- At the Hydrogen Lab Leuna, the integration in a chemical hub allows testing of the defossilization of processes in the chemical industry under practical conditions.
- The coupling of hydrogen production and wind energy generation as well as the grid compatibility of electrolyzers is being investigated in Bremerhaven. This makes it possible to ensure the security of supply even with a high proportion of renewable energies in the grid.
- The focus at the Hydrogen Lab Görlitz is on the defossilization of the manufacturing industry. Prototypes of every step of the power-to-X-to-power value chain can be tested and supplemented with conclusions about corresponding production processes thanks to the collaboration with Fraunhofer IWU.

Testing offers of different scales and loads

The range extends from cell and stack testing in the 3.5 kW range up to a test capacity of several MW for operation under real conditions through to complete system testing with all the necessary auxiliary units. Dynamic loads are simulated, as are environmental conditions and mechanical loads. Digital simulations accompany the process, describe procedures, and serve to optimize techno-economic key figures. Analyses are carried out across the board in order to develop methods and test procedures for electrolyzer materials and components and to apply them on a laboratory scale. The services offered include real-time monitoring of H_2 and O_2 purity, GC-MS trace analysis of material flows, electrochemical evaluation of components, and fault diagnostics.

Fraunhofer IWES can draw on many years of expertise in validation and standardization in the wind industry. The partnerships with and expertise of pioneering institutions and companies enable Fraunhofer IWES to also develop standardized test procedures for hydrogen technologies.

Focus topic Digitalization

Solutions for all research areas

Digitalization is a dynamic and clearly noticeable process in industry – including the wind energy and hydrogen sectors. Through its complex research topics, Fraunhofer IWES offers digital solutions in all areas. In addition to standards such as data monitoring, topics such as big data and the digital twin have also found their way into research. They are being utilized and further developed in a wide range of different scientific fields.

Virtual test rigs for non-physical testing methods

Virtual test rigs are a major focus at Fraunhofer IWES among other things. The physical test rigs are used to develop numerical models and validate them fully with experimental tests. This enables the development of new test methods which are not physical.

At the Dynamic Nacelle Testing Laboratory (DyNaLab), for example, it is possible to describe a mechanical test. The parallel developed virtual nacelle test rig represents a nacelle, the surrounding test infrastructure, and the auxiliary systems. The virtual nacelle test rig can also map the effects of electrical tests on the mechanical structure.

Optimization scenarios with open source software from Fraunhofer IWES

In addition to a range of software used in-house, Fraunhofer IWES also makes open source fluid dynamics software available to external users. FOXES, a modular wind farm simulation and wake modeling toolbox, and iwopy, a framework for coupling different optimization modules, together form the basis for calculating different optimization scenarios of wind energy utilization.

Use cases range from wind farm optimization (e.g., layout optimization or wake steering) to post-construction analyses, studies, comparisons, and wake model validations. Further open source releases are also planned for the future.

DISCOvery

high PERFORMANCE

Fraunhofer IWES: applied research

Fraunhofer IWES operates test rigs for rotor blades, bearings, support structures, nacelles and material test laboratories, to experimentally analyze new designs and compare them with computer models. In addition, the scientists also carry out measurements on turbines in operation and record wind, waves waves, flows, current yields and the resulting loads using innovative methods.

The institute supports the necessary market ramp-up of hydrogen technologies and has testing and qualification capacities for the necessary electrolysis and fuel cell systems of up to 26 MW. Fraunhofer IWES is shaping the future through technological progress and stands for sustainable development for the benefit of society.

in DEPTH

Sub-surface investigation

Efficient sub-surface investigation for offshore wind farm projects

The planning and installation of foundations for offshore wind turbines account for a significant proportion of the total costs of wind farms. A detailed understanding of the offshore sub-surface is the basis for the choice of foundation type, design, and installation planning of the foundations.

The optimal mapping of the geological structures in the top 100 to 200 m below the sea floor using geophysical technologies is the first priority. Geotechnical sampling of the strata is then employed to create an integrated ground model by linking seismic and geotechnical data. The identification and reduction of the installation risks, for example due to boulders in glacial deposits, is also crucial for the installation.

Fraunhofer IWES is the world's leading institute in the development and performance of ultrahigh-resolution seismic surveys for wind farm projects as well as data processing and interpretation up to the creation of ground models.

Our services:

- Offshore 2D/3D seismic sub-surface surveys
- Offshore seismic surveys for the detection of boulders in the sub-surface (Manta Ray system)
- Creation of integrated ground models on the basis of geophysical and geotechnical data
- Processing and evaluation of multichannel seismic data sets
- Comprehensive support and advice on issues regarding sub-surface investigation

Optimized ground models reduce the risks in offshore wind turbine installation.

Multichannel seismic surveys as the basis for sub-surface investigation

The creation of a ground model begins with the detailed mapping of the sub-surface by means of geophysical technologies. The basis for this is a first-rate surveying campaign employing multichannel seismic methods.

Fraunhofer IWES has its own specialized surveying system for ultrahigh-resolution (UHR) seismic data acquisition, which comprises adapted and modular seismic streamer systems, high-frequency seismic signal sources (sparkers), and high-precision positioning solutions. Seismic technology and measuring techniques are being continuously optimized at Fraunhofer IWES.

We process data using algorithms specially developed by us for UHR seismics. Increasing computing capacities permit improved data processing routines and higher mapping quality. One of our focuses is on high-resolution seismic data sets from shallow sea areas: high-precision reconstruction of the acquisition geometry, compensation for wave motion, optimized signal characteristics, and suppression of multiple reflections. The result is an initial sub-surface model of the wind farm areas. The practical suitability of our system has been proven in many commercial surveys of wind farm areas; in particular, all wind farm areas in Germany that have been centrally surveyed by the BSH have been measured by Fraunhofer IWES using this method.

Visualizing sub-surface complexity with data and models

MORE INFO

Local geotechnical in situ data are integrated into this initial sub-surface model to produce a geological ground model. Profiled seismic data are then combined with geotechnical data (e.g., cone penetration testing (CPT)) for lateral mapping of the geological structures. The result is a clear representation of the sub-surface conditions as well as a detailed characterization of the ground properties.

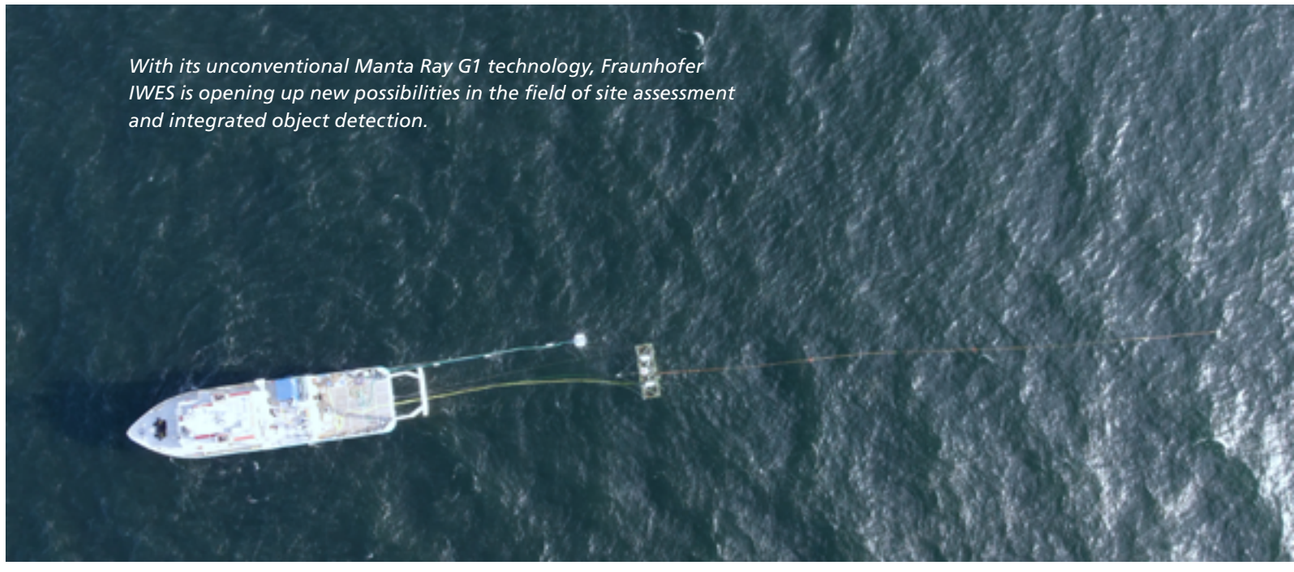
These models are key planning principles for the development of offshore wind farms. Local geotechnical parameters can be modeled comprehensively in an integrated ground model. In contrast, methods of inversion allow the derivation of geotechnical parameters directly from the geophysical data sets.

Synthetic CPT profiles are generated for the planning and technical design application. Geotechnical lab results can also be integrated into this model via so-called site-specific correlation functions. In this way, it is then possible to generate further design-relevant geotechnical parameters. This provides the offshore wind industry with reliable geotechnical ground properties for the technical design of the wind turbine foundations. The creation of synthetic CPT profiles to support the repositioning of wind turbine sites has been commercially performed and accepted by the certification body.

Boulder detection: minimization of installation risks in the sub-surface

Geological risks to the installation of foundations come in many forms. Among other things, large boulders from glacial deposits are a significant obstacle to installation. Fraunhofer IWES developed a patented system based on diffraction seismics for the reliable mapping of such boulders in the sub-surface. The innovative surveying system utilizes multichannel seismic methods to detect objects via the mapping of diffraction energy.

The identified and localized objects are integrated into a local ground model and documented for risk mapping in the close range of planned turbine locations and cable corridors (approx. 100 m) via micrositing. Fraunhofer IWES has successfully performed this kind of survey in commercial projects in the Baltic Sea. The boulders in the sea floor are mapped in accordance with the respective project requirements.



With its unconventional Manta Ray G1 technology, Fraunhofer IWES is opening up new possibilities in the field of site assessment and integrated object detection.

highly DRIVEN

Electrical components and system validation: ensuring grid compatibility with IWES research

Continuously growing offshore wind turbines are pushing existing test facilities for testing their grid properties to their limits. Fraunhofer IWES has therefore developed a mobile grid emulator with an installed converter capacity of 88 MVA to determine electrical properties in the multi-megawatt range. Fraunhofer IWES also operates the HiPE-LAB in cooperation with the IALB of the University of Bremen. This unique facility is used for multimodal testing of converters of up to 10 MVA under superimposed climatic and electrical loads to demonstrate or optimize the necessary technical reliability.

Mobile test facility for grid compliance tests

System technology

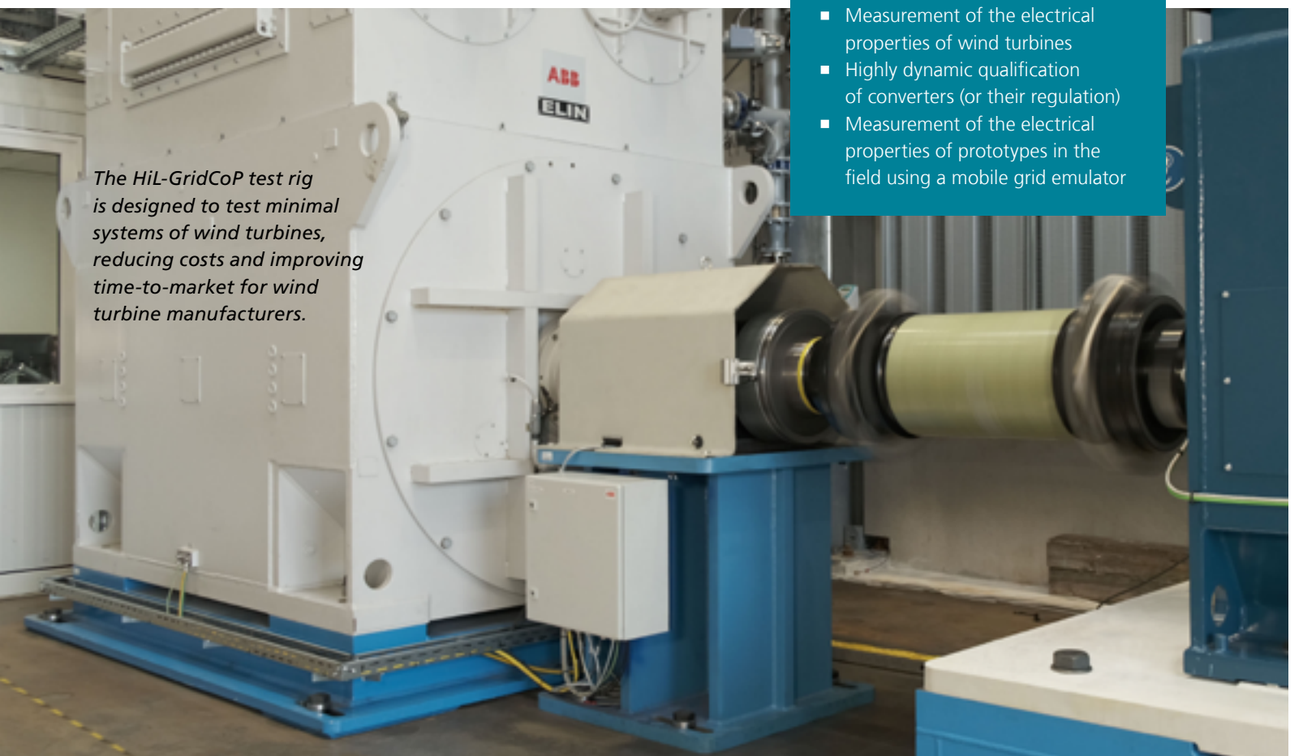
Determination of electrical properties in the multi-megawatt range

MORE INFO

Fraunhofer IWES offers grid compatibility testing for the certification of the electrical properties of new wind turbines (e.g., FRT) and their components. It does so employing a one-of-a-kind virtual grid and low and medium voltage grid emulators in the power range between 4 to 44 MVA. The use of a virtual grid enables the simulation of all typical grid faults. This approach also makes it possible to conduct static tests, for example to record the active and reactive power output under different grid conditions and to emulate transient grid events.

2015 saw the opening of Germany's biggest large-scale test rig for complete wind turbine nacelles. The Dynamic Nacelle Testing Laboratory (DyNaLab) offers a realistic test environment for nacelles. The HiL-GridCoP test rig, opened in 2021, allows generator-converter tests in the multi-megawatt range performed as meaningful, certifiable laboratory tests. One-off test services for prototype validation, here specifically for onshore wind turbines, are offered with a drive power of 10 MW.

In addition, Fraunhofer IWES also has the capacity to analyze the electrical properties of frequency converters. The so-called PQ4Wind test rig is employed to measure the high-frequency power quality. As offshore wind turbines continue to grow in size, the current facilities for testing grid characteristics are being pushed to their limits. For this reason, Fraunhofer IWES has developed a mobile grid emulator with an installed converter capacity of 88 MVA. With its help, the electrical properties of wind turbines and their ability to support the power grid in the event of faults can be tested in the field (e.g. at prototype installation locations).



The HiL-GridCoP test rig is designed to test minimal systems of wind turbines, reducing costs and improving time-to-market for wind turbine manufacturers.

Our services:

- Measurement of the electrical properties of wind turbines
- Highly dynamic qualification of converters (or their regulation)
- Measurement of the electrical properties of prototypes in the field using a mobile grid emulator

A better understanding of the causes of failure is essential to develop effective protective measures and thus improve the economic efficiency of system operation.

Our services:

- Derivation of test procedures from comprehensive field measurements
- Identification of relevant test cycles and parameters
- Analysis of field data from converters of more than 10,000 wind turbines and many climates
- Independent assessment and laboratory analysis

MORE INFO

Technical reliability

Application-specific reliability testing of power-electronic systems

Power converters should be designed to withstand their typical operating conditions. In the field, however, they are exposed to a wide variety of influences which can induce early failure. In wind energy, for instance, the failure rate of power converters is as high as 0.5 damage-related failures per wind turbine and year.

As humidity has been found to be a major driver of failures, we set up a laboratory to validate clients' products from power modules to entire converter systems under the most realistic, site-specific conditions possible. Fraunhofer IWES cooperates closely with the laboratory operator, the IALB at the University of Bremen, to run the HiPe-LAB - a unique facility for testing converters up to 10 MVA under a superposition of application-specific climatic and electrical loads.

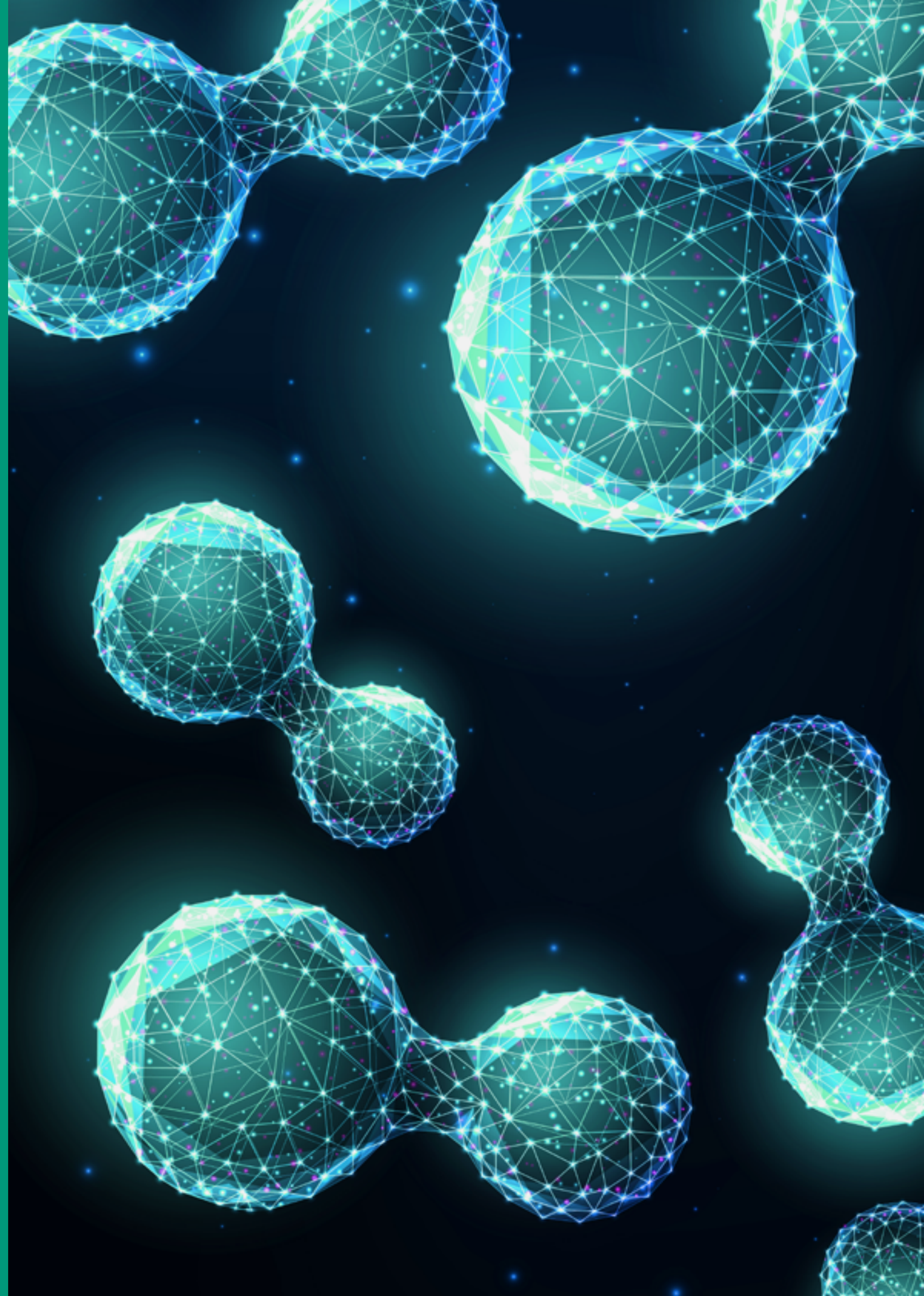
FORWARD looking

Electrolyzer validation and qualification: thinking wind and hydrogen together

Fraunhofer IWES operates technology-independent test platforms (hydrogen labs) for the qualification and optimization of electrolyzers – from the cell to the industry stack right up to full system level – with a total connection power of up to 26 MW. In addition to electrolyzers, hydrogen-consuming units and parts of the peripheral infrastructure are also tested here. Among other things, the long-term stability of materials and components in the dynamic operation of electrolyzers coupled with wind turbines is being tested.

Furthermore, the world's leading facility for grid integration tests is available at the Dynamic Nacelle Testing Laboratory (DyNaLab) to examine the grid properties. As future electrolyzers will be connected to the power grid as large consumers, their grid-supporting properties are very important, which is why their measurement and optimization is a focus of research and development. We provide the manufacturers with support in the further development of their products accordingly.

There is also a test platform for coupled power-to-X processes available, allowing mapping of the entire value chain from renewable, load-flexible energy production to hydrogen production right up to material use as well as corresponding testing and researching on an industrial level.



Upscaling in new performance classes – safe and sound!

The market ramp-up of green hydrogen requires reliable, safe, and cost-optimized systems and components along the entire value creation chain for widespread use in industry and business. In addition to operational safety, costs play a central role here. The development of high-performance, cost-effective, and reliable components and the establishment of series production for electrolyzers and fuel cells generate savings potential.

Experimental testing and modeling based on it significantly reduce the risk associated with the upscaling of electrolyzers to new performance classes and areas of application, which are essential for offshore applications among other things. Fraunhofer IWES boasts core competences in the field of electrochemical analysis and tests cells and stacks at microscopic level. Stack tests and systems tests up to industrial scale can be performed in the hydrogen labs, making it possible to transfer knowledge acquired on a microscopic scale to large-scale systems. Work in the opposite direction, the feedback of effects observed in the whole system to the microscopic level, is also conceivable. This interplay of system and individual component tests allows holistic optimization.

Mapping of the entire value chain

Fraunhofer IWES considers the entire hydrogen value creation chain from production through to usage. The competencies and infrastructures of related institutes are called in for specific issues. Our customers include both globally operating groups and small and medium-sized enterprises in the region.

Model processes of sector coupling can also be demonstrated and tested. This is particularly important in the case of fluctuating energy supply from renewable sources in order to ensure security of supply and to enable the storage of power surpluses. Operating strategies for stand-alone solutions will be developed across systems and optimized under techno-economic aspects.

The Fraunhofer IWES Hydrogen Labs support the market ramp-up of green hydrogen for a CO_2-neutral industry.

The Hydrogen Lab Leuna offers the capacity for testing of industrial-scale electrolyzers of any type – PEM, AEL, AEM, or SOEC – in 24/7 continuous operation.

Core competence: grid integration tests

A stable grid is a fundamental requirement for security of supply. The grids are not always designed for highly decentralized feed-in points with grid-side inverter connection and fluctuating energy supply.

When there is an oversupply of renewable energies in the grid at present, wind turbines are often switched off so as not to overload the grid – or the electricity is sold abroad below price. One option is to utilize this “excess electricity” to produce hydrogen, which serves as a chemical energy store. With increasing grid-connected electrolyzer capacity, these “consumers” will need to provide grid system services in the future, just like on the production side. Performing grid integration tests in the hydrogen labs will help to validate these system properties prior to large-scale market integration.

Co-simulation of usage scenarios

Key components of the hydrogen value chain will be modeled. A coherent data and model space will also be created for the co-simulation of usage scenarios for a future hydrogen economy.

We are working to expand a reference architecture for digital twins in such a way that it can represent the modularity of renewable energy systems and take registered changes to the system into account. This will create the basis for a comprehensive, generic digital twin of wind and hydrogen energy systems.

Our services:

- Comprehensive validation of stack components through to whole electrolysis systems, peripheral infrastructure, and downstream power-to-X processes
- Accelerated lifetime tests and investigation of dynamic operating behavior
- Independent efficiency measurement
- Validation of desalination plants
- Modeling of systems, assistance with the design and operational management of electrolyzers in combination with renewable energy sources
- Analysis of electrolytes used and resulting product gases
- Techno-economic assessment of the whole system

Modeling and control of decentralized and local energy systems

Beyond this, the Fraunhofer Application Center for the Integration of Local Energy Systems (ILES) at Fraunhofer IWES is investigating systematic aspects of the production of green hydrogen using electrolysis in cooperation with its partners, the Competence Center for Renewable Energies and Energy Efficiency (CC4E) and the Hamburg University of Applied Sciences (HAW Hamburg). The focus of this research is on the modeling and control of decentralized and local energy systems. These assessments help to improve technical reliability and system efficiency, thus saving costs.

MORE INFO

MULTIfaceted

Overall system measurement and simulations: how Fraunhofer IWES optimizes wind energy systems and makes shipping more sustainable

Reliable statements on the efficiency, functionality, and service life of wind turbines are essential for their realization. To this end, Fraunhofer IWES performs measurements on turbines in operation, tests mechanical loads and determines their performance behavior at the Application Center for Wind Energy Field Measurements (AWF). To research the aero-servo-hydro-elastic simulation of wind turbines, Fraunhofer IWES programs the so-called MoWiT overall system simulation model for load calculation and real-time simulation. MoWiT is used to optimize wind energy systems and develop AI models. Fraunhofer IWES is also supporting the development of sustainable shipping. In cooperation with the University of Applied Sciences Emden/Leer, the focus is on wind propulsion systems, design concepts, and emission reduction.

Extensive measurement and modeling data help improve system designs.

MORE INFO

Our services:

- Measurement of wind turbines
- Accredited mechanical load and power performance measurements (IEC 61400-12 and IEC 61400-13) in acc. with ISO 17025
- Customer-specific measurements on individual components of wind turbines

Wind energy field measurements

Customer-specific and accredited measurement of wind turbines

The dynamically increasing competition in the wind energy sector demands high-quality, efficient processes with which prototypes and old turbines in the field can be measured, analyzed, and optimized. As with banks and insurance companies, developers, manufacturers, operators, and technical service providers require reliable information about the efficiency, functionality, and service life prospects of their turbines.

The Application Center for Wind Energy Field Measurements (AWF), a cooperation between Fraunhofer IWES and fk-wind at Bremerhaven University of Applied Sciences, carries out measurements of running systems in the field, in particular as a partner in research and development projects. AWF boasts highly qualified scientific and technical staff and is an accredited testing and calibration laboratory in accordance with ISO 17025 for the measurement of mechanical loads and the assessment of the power performance characteristics of wind turbines. In addition, it also has the unique testing infrastructure of the entire Fraunhofer IWES at its disposal.

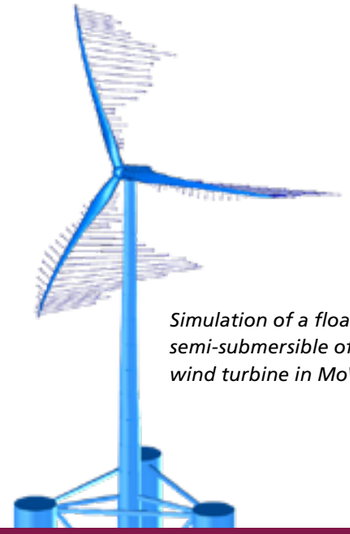
AWF at Fraunhofer IWES plans and conducts measurements of wind turbines, applying the relevant national and international standards and guidelines in consultation with the customer. The data recorded include meteorological variables and the power performance in accordance with IEC 61400-12 and/or load parameters in accordance with IEC 61400-13. In addition to standard-specific measurements of the full wind turbine, measurements are also conducted on specific components of wind turbines (e.g., bearings, rotor blades, etc.) in particular. The most important operating data of the wind turbine, such as the azimuth position and speed, are also recorded for the evaluation and interpretation of the measurement data.

Global turbine dynamics

Simulative analysis of the system dynamics, loads, and frequencies of wind turbines

The Global Systems Dynamics group at Fraunhofer IWES conducts research in the field of aero-servo-hydro-elastic simulations of wind turbines with a focus on improving simulation and validation methods for onshore, offshore, and floating wind turbines. The MoWiT simulation model (Modelica library for Wind Turbines) for load calculations and real-time simulation was programmed specifically for this purpose. MoWiT forms the basis for the optimization of wind energy systems using a proprietary Python-based optimization and automation framework as well as for the development of AI models.

Questions such as the capacity of floating wind turbines to self-align and the resulting effect on the energy yield are answered utilizing customer-specific simulation studies, and new methods are employed to verify the validity of current simulation models.

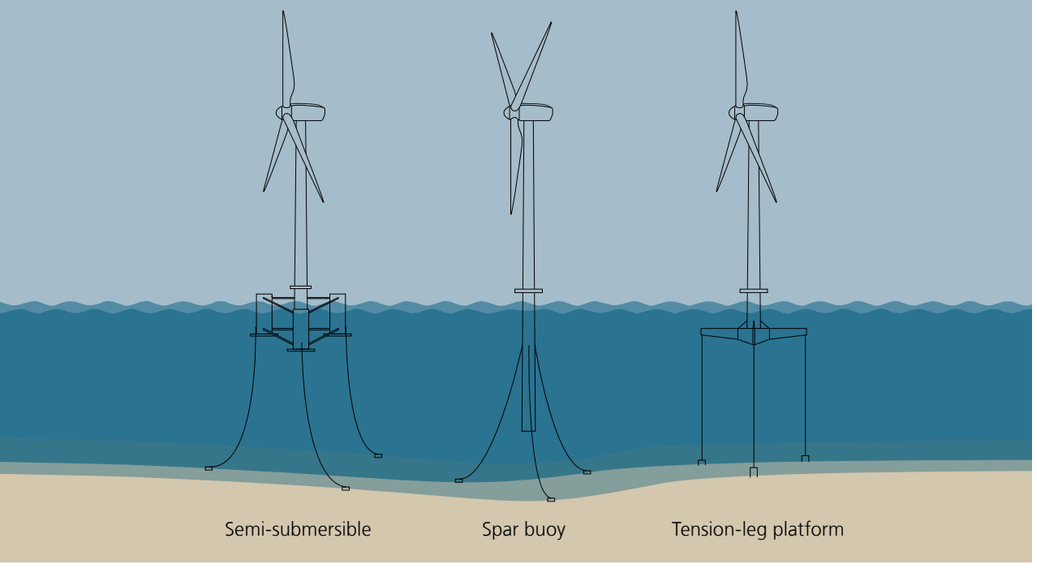


Simulation of a floating semi-submersible offshore wind turbine in MoWiT

Our services:

- Customer-specific simulation studies on onshore and offshore wind turbines
- Analysis of the coupled system dynamics, loads, and frequencies, including for future turbine sizes
- Evaluation of the validity of simulation models
- Creation of real-time capable system models

Fraunhofer IWES conducts research in the field of floating wind turbines and offers services from the modeling to the validation of numerical simulation models.



MORE INFO

Given the current climate protection targets, the shipping industry needs to reduce its emissions too. This can be achieved with hybrid vessels with sail systems and hydrogen-based drives.

Sustainable maritime mobility

Development, construction, and operation of trendsetting wind propulsion systems for the shipping industry

MORE INFO

The Fraunhofer Working Group Sustainable Maritime Mobility (SMM) at Fraunhofer IWES is boosting research and development for sustainable shipping. Under the joint leadership the teams from University of Applied Sciences Emden/Leer in Leer and from Fraunhofer IWES in Bremerhaven are focusing on wind propulsion systems, design concepts, and scientific studies for emission-free shipping.

System-independent research and consulting services for the commercial shipping industry
The SMM working group provides system-independent research and consulting services spanning all discussed wind propulsion systems for the commercial shipping industry. The spectrum ranges from Flettner rotors, wing rigs, and DynaRigs to membrane sails and classic cloth sails. The Maritime Experimental Center in Leer is at the core of the experimental field.

The unique test infrastructure of the other Fraunhofer IWES sites complement the validation options up to full scale. The many years of experience in the field of offshore wind energy create synergies in the working group.

Expertise through crossover and upscaling effects
The joint methodological focal points are in the fields of maritime hydro- and aerodynamics, automation and systems technology, and materials technology. Hybrid model concepts result from the intersection of powerful modeling and simulation with measurement technology both in the laboratory and at sea. One special joint area of expertise lies in the utilization of crossover and upscaling effects between wind propulsion technology for vessels and classic wind energy systems.

Our services:

- In-depth modeling expertise (CFD, FEM, FSI, MBS)
- Availability of large-scale laboratories for all conceivable engineering questions in the field of shipping and maritime technology
- Hybrid modeling concepts for the performance prediction of sailing systems
- Ship handling simulation for vessels with wind propulsion systems
- Technical risk analysis for investors, banks, and insurance companies

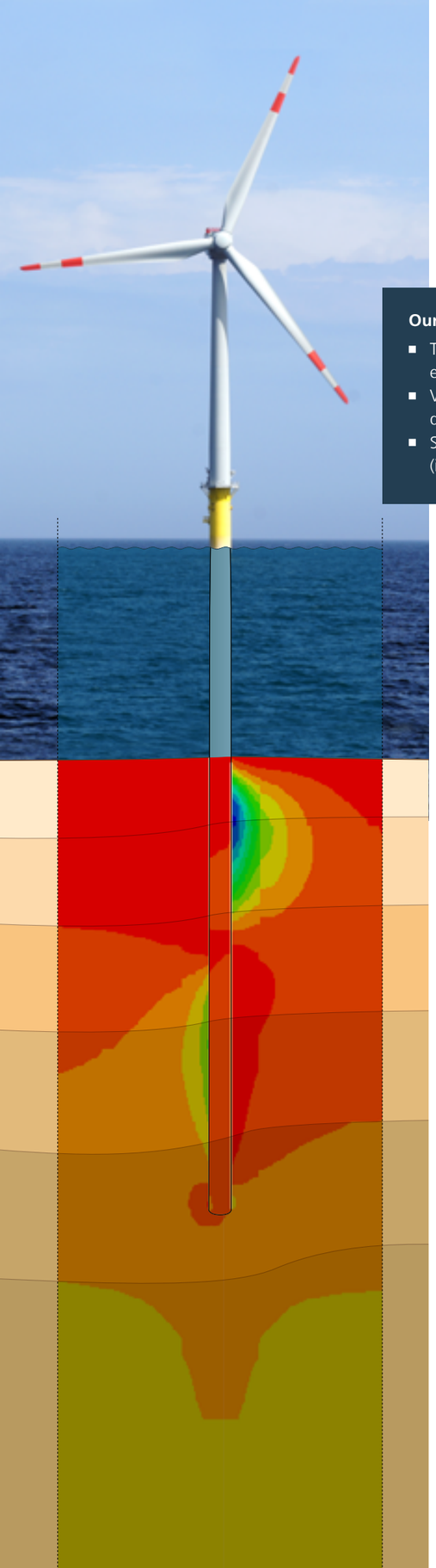
Testing and system validation of large mechanical components: IWES increases the reliability of large wind turbine components

Stochastic loads, lubricant properties, varying speeds, interfaces with complex stiffness profiles: the service life of rolling bearings in wind turbines depends on numerous influences. With the Large Bearing Laboratory (LBL), Fraunhofer IWES has unique methodological expertise as well as testing and research infrastructure for increasing the reliability of drive train components. Fraunhofer IWES develops and realizes validation strategies, test concepts, test rigs, measurement methods, test campaigns, CAE models, and much more to ensure the product characteristics of complete mechanical wind turbine drive trains. To ensure the stability of the turbine, the design and manufacturing of the wind turbine support structures – e.g. tower, foundations and necessary attachments – must be optimized in line with the increasing operating loads. Fraunhofer IWES is developing proposals to reduce the economic and technical risks of future support structures.

For large-scale wind turbine nacelle testing, Fraunhofer IWES has a test rig, the Dynamic Nacelle Testing Laboratory, which is functionally unique in the world. It contains, among other things, a powerful load application system (LAS), which is equipped as a hexapod with a large moment bearing, and enables a realistic test environment in the multi-megawatt range for meaningful laboratory tests.

Failures of drive train components are one of the main causes of downtimes. Virtualized tests using simulation models and validated measurement data allow critical loads to be identified as early as during the development process. Fraunhofer IWES has exceptional experience in the collection and processing of corresponding measurement data.

POWERfull



Support structures

Testing and validation of support structures and methods

Our services:

- Testing of support structures and components – experimentally and virtually
- Validation of dimensioning approaches and design methods
- Support in the development and market launch (incl. certification) of new technologies

The support structures of a wind turbine include all components ensuring the statics of the turbine: the tower, foundations, and secondary steel elements. The mechanical dimensions and rated powers of both onshore and offshore turbines continue to increase, and consequently so do the operating loads that have to be absorbed by the support structures. The components making up these structures are now among the largest steel components of all. Manufacturers and designers are confronted with an array of challenges: for example, vibration-resistant welded joints with very high wall thicknesses (> 100 mm) must be reliably produced and the subsoil behavior must be predicted over the service life of a system – at least 25 years. Fraunhofer IWES is developing a wide range of solutions with the potential to reduce the economic and technical risk of the next and future generations of support structures significantly.

Along with the increasing rated powers of wind turbines, the requirements on their support structures are also growing constantly. Manufacturers are required to adapt the design and production of the necessary components to accommodate the increasing operating loads. Fraunhofer IWES is developing a wide range of methodical approaches for this purpose with the potential to reduce the economic and technical risks of future support structures significantly.

The focus here is on design suitable for both production and use, for example investigations into the specific load-bearing behavior of suction caissons as well as the development and validation of material models utilized to model, for example, the subsoil in the North Sea. The massive dimensions of these components mean that the design and production of a wind turbine support structure is always challenging. We offer customers support in onshore and offshore installations.

Structural analysis of components and large-scale models

MORE INFO

Rolling bearings

Large rolling bearings: Higher reliability thanks to innovative test methods and system understanding

Rolling bearings achieve a very high service life in the majority of industrial applications. However, the operating conditions for and the requirements placed on rolling bearings in wind turbines differ significantly from standard applications: high stochastic loads, oscillating movements, constantly varying speeds, and interfaces with complex stiffness profiles complicate the design and can lead to failures well before the end of the calculated service life.

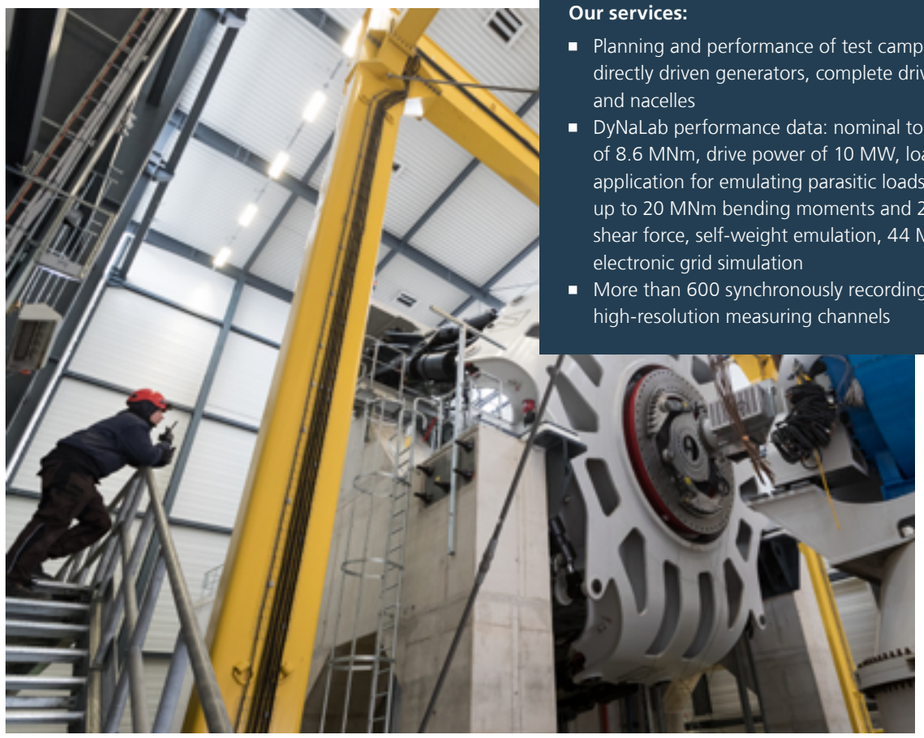
Particularly in the field of rotor blade bearings, the Fraunhofer IWES team operates a unique research infrastructure with the Large Bearing Laboratory and has accumulated corresponding methodological expertise. From validated calculation methods, from failure cause analysis up to scaled, real-scale, and always application-oriented tests, the Large Bearing Laboratory offers everything to support the wind energy industry in the design, operation, and validation of the properties of these sophisticated components.

Our services:

- Applied research and development in the field of large rolling bearings of wind turbines
- Planning and performance of test campaigns on proven test infrastructure with more than 300 tested bearings from 0.2 m to 6 m in diameter
- Development of customized solutions and test methods for large rolling bearings
- Support in the development of the whole blade pitch mechanism, calculation methods, data analysis, and modeling

MORE INFO

Fraunhofer IWES uses the BEAT 6.1 test rig to test rolling bearings with a diameter of 6 m.



Superconducting generator on the test rig

Our services:

- Planning and performance of test campaigns for directly driven generators, complete drive trains, and nacelles
- DyNaLab performance data: nominal torque of 8.6 MNm, drive power of 10 MW, load application for emulating parasitic loads, up to 20 MNm bending moments and 2 MN shear force, self-weight emulation, 44 MVA electronic grid simulation
- More than 600 synchronously recording high-resolution measuring channels

Mechanical and electrical nacelle properties

MORE INFO

Investigation and testing

Competitive pressure and increasing professionalization of the sector are increasing the requirements on wind turbine nacelles. Wind turbines with a new design must must run reliably right from the start of series production.

Investors mostly demand proof of extensive operating experience before financing is approved. For manufacturers, modifications and new developments mean considerable economic risks. Experimental validation of prototypes and zero-series systems on large-scale test rigs reduces these risks, speeds up certification, and ensures better planning.

The higher share of renewable sources in the distribution and transmission grid structures is increasing the requirements for the grid integration of wind turbines even further. Standards and guidelines must take this development into consideration. Mandatory system certificates for new and further developments ensure grid-compliant operation and guarantee permanent grid connection and receipt of feed-in tariffs.

Fraunhofer IWES provides turbine manufacturers with support in meeting increasing requirements with efficient test methods. DyNaLab offers realistic testing conditions in the multi-megawatt range, making it possible to validate and optimize existing and future wind turbine concepts. The combination of mechanical tests with a grid emulator for testing wind turbines with a rated output of up to 10 MW is the only one of its kind in the world in this configuration.

Drive train

Model development, model validation, and virtual testing of wind turbine drive trains

Wind turbine drive trains are subjected to complex dynamic loads when in operation; their failure in this complex subsystem is one of the main causes of downtimes. Modern simulation tools such as multi-body simulations (MBS), finite element method (FEM), and the integration of multi-domain models increase system understanding. This allows design processes to be improved and the reliability of the drive train increased.

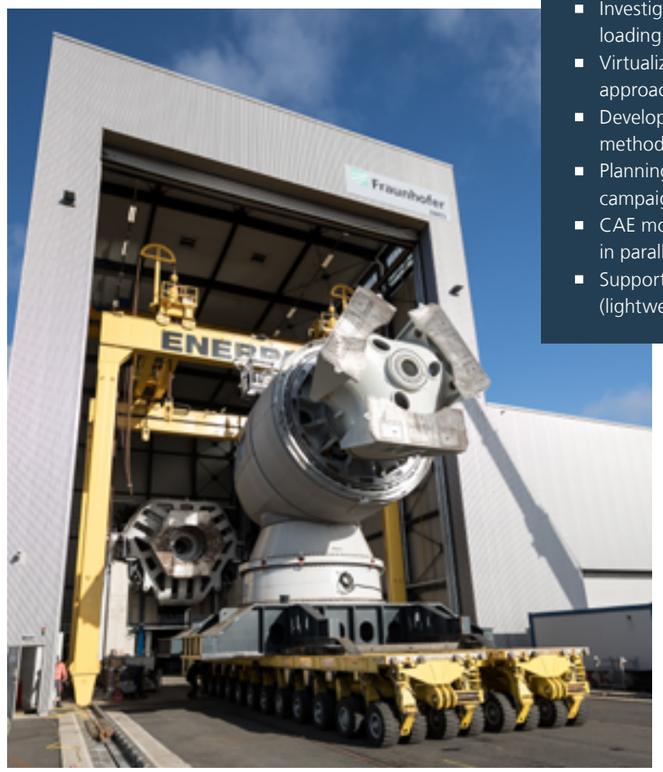
Virtual tests using simulation allow loads to be identified as early as during the development process. Cost-intensive physical tests can thus be supplemented, extended if necessary and optimization approaches can be checked with the aid of parameter variations.

Validation with measurement data is important to ensure the validity of the models used. Fraunhofer IWES can draw on many years of experience in the collection and processing of relevant measurement data. Only validated simulation models allow reliable statements to be made about both existing and new drive train concepts.

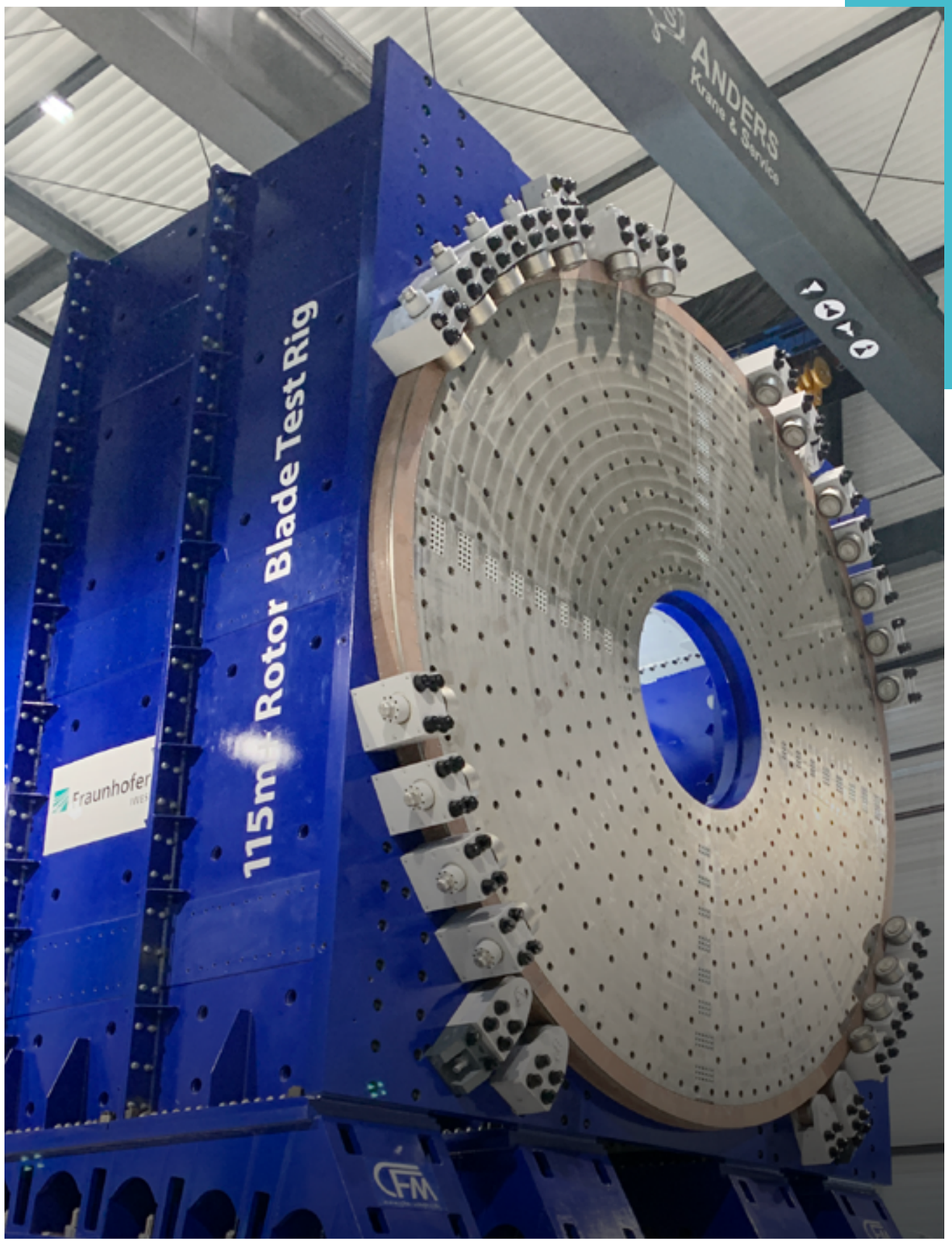
Due to the constant growth in performance and size of turbines and their drive trains, many of the system test rigs still in use today are no longer sufficient in some of their technical parameters to fully test future turbines in their entire operating range in ever shorter periods of time. To address this challenge, we at Fraunhofer IWES are developing the methodical approach of hybrid testing. It combines physical tests with innovative simulation methods to enable, for example, the complete testing of drive trains even above the maximum load of the test rig.

Our services:

- Development and validation of detailed simulation models of wind turbine drive trains
- Investigation of drive train dynamics and loading on the basis of virtual tests
- Virtualization of tests and innovative testing approaches such as hybrid testing
- Development of new test rigs and measuring methods
- Planning and implementation of testing campaigns and metrological evaluations
- CAE model development and validation in parallel to testing
- Support in component optimization (lightweight construction, etc.)



A precise understanding of the dynamic loads and operating conditions is essential for increasing the reliability of drive trains.



The state-of-the-art test rig offers comprehensive testing possibilities for rotor blades with a length of more than 115 meters.

LARGEscale

Rotor blades

From innovative test methods to an efficient manufacturing process

The rotor blades of large offshore wind turbines have now clearly exceeded the 100-meter mark and continue to increase in size. This growth is pushing the structural load-bearing capabilities of the designs to their limits, rendering a thorough understanding of the complex mechanical behavior of composite materials under fatigue loading indispensable. At the same time, the reliable and efficient production of wind turbine blades of this scale is a task which demands advances in production techniques and in automation.

With the help of unique research infrastructure, Fraunhofer IWES can support the wind industry across scales and in all technical domains. Fraunhofer IWES is your one-stop shop for everything you need for the research on and development of wind turbine blades: from micro-CT scans of fiber orientation to full-scale testing of the rotor blades, from innovative production technologies to the recycling of end-of-lifetime (EoL) blades and much more.

High reliability thanks to intensive validation

Intensive validation across scales is necessary to ensure the reliable operation of wind turbine blades for 20, 25, or even 40 years. Fraunhofer IWES operates an IECRE-recognized laboratory for the testing of wind turbine blades with three test rigs for certification tests according to IEC 61400-23. The largest test rig is designed for a maximum amplitude of 140 MNm for the fatigue bending moment.

With a track record of more than 40 completed full-scale blade test campaigns, Fraunhofer IWES is known throughout the industry for its high levels of reliability and flexibility as well as its ability to react. Among the leading research institutes, Fraunhofer IWES is a pioneer in the employment of innovative approaches for the testing of rotor blades. For example, biaxial testing in a 1:1 elliptical excitation is available for commercial tests, and the same applies for the sequential approach to segmented testing of very long rotor blades.

Modular test rigs which can accommodate a large range of tip segment and 1:1 subcomponent tests complete the service portfolio. To develop new test methods, Fraunhofer IWES relies on a proprietary software tool for the preparation and optimization of test setups, and also offers this tool to customers.

Deep understanding of the materials and manufacturing processes

The accurate prediction of the fatigue behavior of composite materials requires a deep understanding of both the materials themselves and also the manufacturing processes. Fraunhofer IWES operates a DAkkS-accredited materials laboratory. Standard material tests are, of course, available, but our real strength shines through when developing new test setups for special requirements. Systems are tested for rain erosion and ice accretion in the Leading Edge Lab.

Fraunhofer IWES is the only institute capable of manufacturing specimens from coupon size to full wind turbine blades. This helps with the testing of the manufacturability of novel materials and supports a seamless market introduction. At the same time, processing large-scale components enables us to validate manufacturing-centered material models, such as advanced curing kinetics models.

Support of customer-specific solutions

Automated production processes are always a case-by-case decision for wind turbine blades. Achieving the optimal balance between investment costs, production rate, flexibility of production, operational costs, and the in-field reliability of the blade is particularly important.

Fraunhofer IWES provides support in the search for optimal solutions for manufacturing challenges. To do so, we combine and integrate existing commercial products, taking customized, customer-specific technological developments into consideration. The BladeMaker demonstration center is an ideal development environment for both us and our customers. In addition, Fraunhofer IWES also works independently on process developments such as the variable paste shoe.

Our services:

- Research, development, validation, process development
- IECRE-recognized laboratory
- DAkkS-accredited materials laboratory
- Test rigs for necessary (certification) tests
- Solutions for customized manufacturing processes

MORE INFO

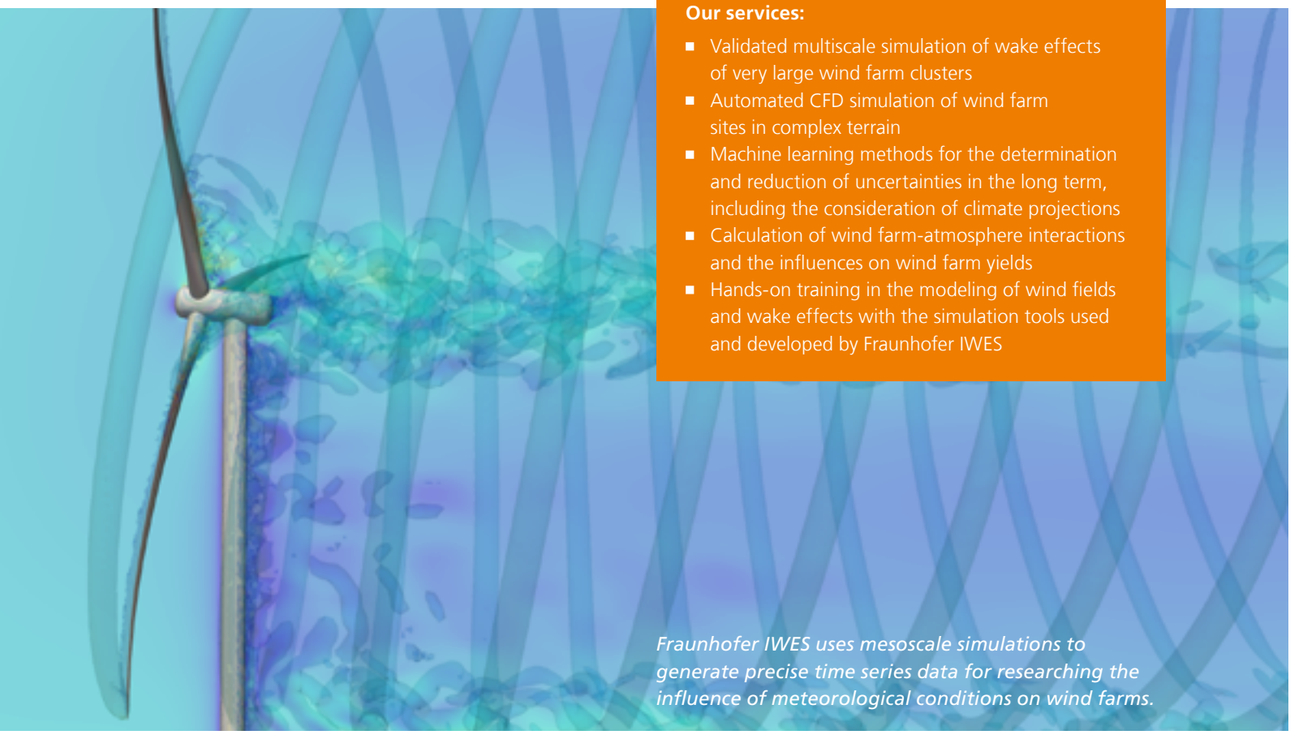
Rotor blade manufacturing at Fraunhofer IWES

AERO dynamic

Wind measurement and wind modeling: assessment of wind turbine sites – from the measurement of wind at specific points up to the modeling of large-scale wind fields

Wind turbines are exposed to complex conditions both onshore and offshore. The challenges for the numerical simulation and assessment of potential sites are correspondingly different, making precise modeling of wind fields indispensable. Fraunhofer IWES is active in the optimization of numerical methods and data sets on all relevant scales in order to meet the industry's requirements. For example, during the construction of offshore wind farms, the wind parameters influence the design and layout of the turbines as well as their components, including the foundations and towers. Fraunhofer IWES conducts offshore lidar surveys in order to customize the numerical models for the sites. To this end, it has developed lidar measuring buoys, which record meteorological and oceanographic measurement data on the high seas. Fraunhofer IWES employs innovative measurement concepts – using a variety of remote sensing technologies – to document the wind conditions.

The lidar buoy provides quick, reliable, and cost-effective measurement data for offshore wind farm planning.



Our services:

- Validated multiscale simulation of wake effects of very large wind farm clusters
- Automated CFD simulation of wind farm sites in complex terrain
- Machine learning methods for the determination and reduction of uncertainties in the long term, including the consideration of climate projections
- Calculation of wind farm-atmosphere interactions and the influences on wind farm yields
- Hands-on training in the modeling of wind fields and wake effects with the simulation tools used and developed by Fraunhofer IWES

Fraunhofer IWES uses mesoscale simulations to generate precise time series data for researching the influence of meteorological conditions on wind farms.

Aerodynamics

Wind field modeling: multiscale simulation of wind and wake effects

MORE INFO

The expansion of wind energy is taking place under different environmental conditions all around the world. Whereas wind farms are increasingly being planned and constructed in very complex terrain on land (onshore), large "power plants" with hundreds of wind turbines are being installed at sea (offshore), where they interact with the marine atmospheric boundary layer (MABL). The challenges in the numerical simulation and assessment of the sites are correspondingly different.

The modeling of wind fields is primarily required to supplement wind measurement and yield data in space and time as well as for the simulation of future planning conditions. Fraunhofer IWES has been active in the further development, improvement, and application of numerical methods and data sets on all relevant scales for more than a decade, employing open source models and methods in particular.

The numerical simulation of wind energy sites requires the application of different methods in order to satisfy the industry's requirements on precision and speed as well as to adapt precisely to the various associated scales. To this end, Fraunhofer IWES has developed a range of different numerical site assessment tools for the calculation of wind fields and wind farm yields in complex terrain geometries and the calculation of wind turbines and wind farm wakes in recent years.

Wind measurements

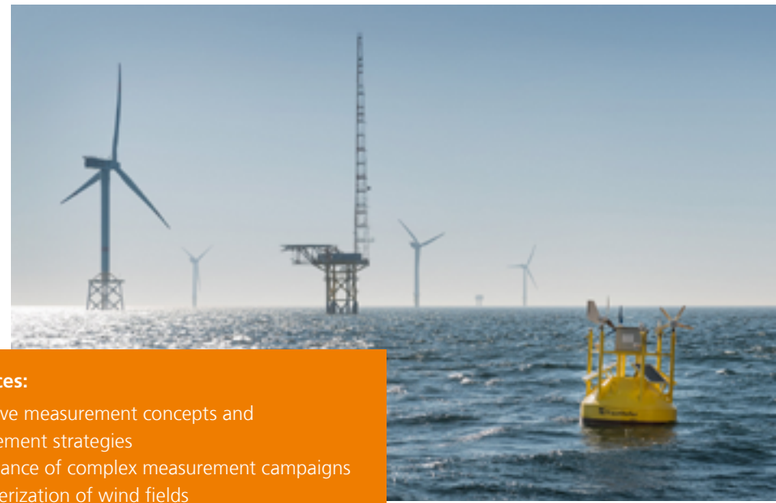
Wind measurements at specific points

Offshore wind farms are increasingly being constructed at sites mostly far away from the coast, where the wind conditions are not known with sufficient accuracy. Even at locations surveyed in the past, subsequently constructed wind farms with their wake effects can lead to a change in the prevalent wind resource. The different wind parameters are required not only for determination of the wind potential, and thus for calculating the profitability of a wind farm, but also for the design/layout of the wind turbine and its components, including the foundations and towers. Accurate measurement data, low measurement uncertainties, and, additionally, high availability are generally indispensable. To this end, Fraunhofer IWES has developed its own measurement buoy, which records meteorological and oceanographic measurement data relevant for the wind industry on the high seas. Fraunhofer IWES also creates innovative measurement concepts utilizing a wide range of different remote sensing technologies.

Fraunhofer IWES has been working on the development of floating lidar systems (FLS) and methods for the correction of measurement data corrupted by the movements of the lidar buoy itself since 2009. The first prototype of the Fraunhofer IWES wind lidar buoy was tested for the first time offshore in 2013 and has also been in use in commercial measurement campaigns to determine offshore wind potential since 2017. In addition to the data analysis, Fraunhofer IWES also takes care of the planning of the measurement campaigns as well as the installation, operation, and maintenance of the lidar buoy.

Measurement campaigns with wind lidar buoys for determining wind potential

MORE INFO



Our services:

- Innovative measurement concepts and measurement strategies
- Performance of complex measurement campaigns
- Characterization of wind fields
- Lidar buoy technology

FAR reaching

Reliability, monitoring, and yield analysis: how IWES significantly boosts the efficiency of offshore wind farms

In cooperation with other stakeholders, Fraunhofer IWES has supported the installation and operation of numerous wind turbines. In addition to unique experience in this sector, this has also resulted in an unrivaled collection of field data. This collection makes a major contribution to boosting the reliability of wind turbine components significantly, reducing costs and risks effectively as well as performing OPEX modeling and cost-benefit analyses. We develop coupled physical and field data-based models and methods for early failure detection and remaining service life estimation. In addition, IWES runs computational fluid dynamics (CFD) simulations for the protection of flexible rotor blades, which make it possible to identify and reduce the blades' susceptibility to vibrations – for example when the turbine is at a standstill or in trundle mode. For highly efficient project and risk management, IWES also offers project plan and weather risk analyses in order to assess potential risks at an early stage. IWES evaluates the performance and efficiency of existing offshore wind farms by means of post-construction and performance analyses. The portfolio also encompasses optimized maintenance concepts, the assessment of existing concepts, and the optimization of the O&M logistics, in order to develop tailored, cost-efficient solutions.

Technical reliability

Better understanding and improvement of O&M activities

MORE INFO

Fraunhofer IWES boasts many years of success in publicly funded projects on the topics of the reliability of power converters, root cause analysis, condition monitoring, and the digitalization of O&M data. In addition, IWES also has considerable experience in O&M modeling, cost-benefit analysis, and the optimization of O&M strategies on the basis of field data.

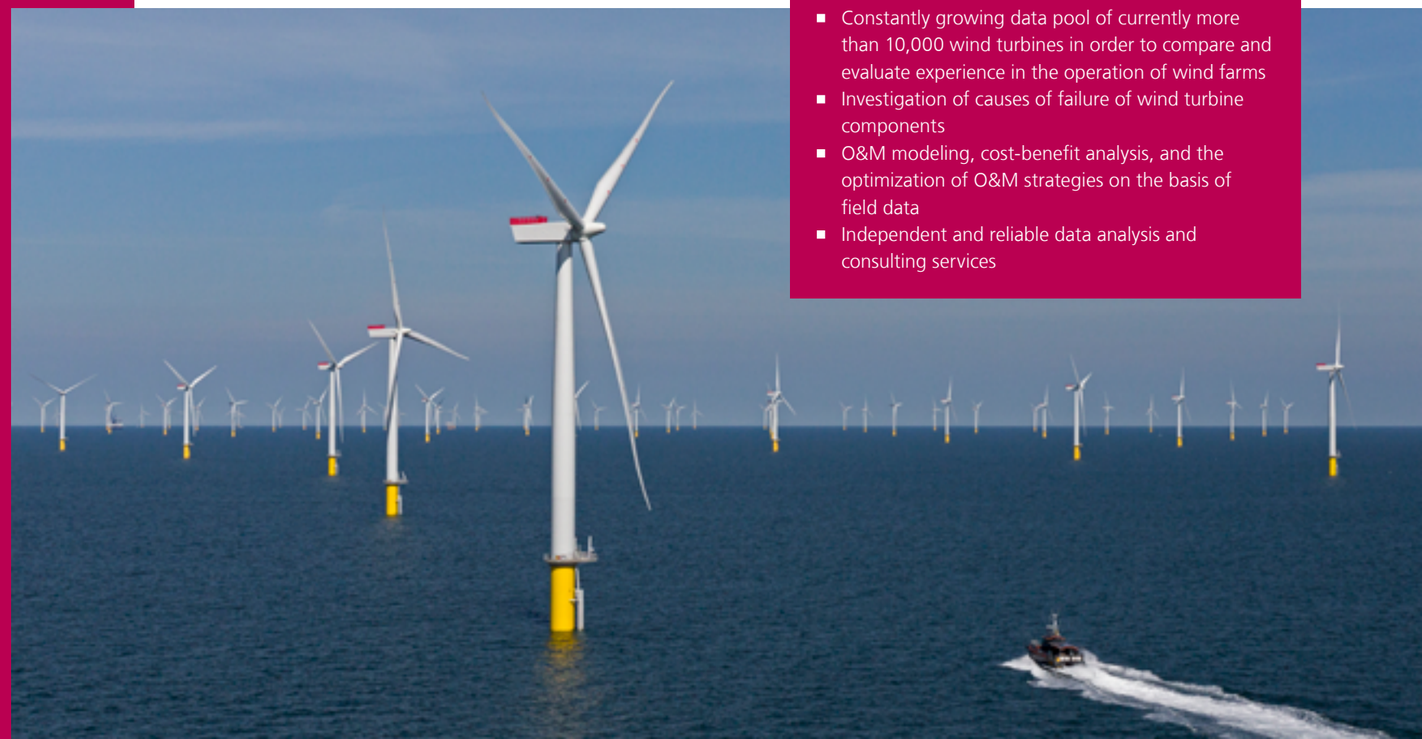
More reliable wind turbine components thanks to unrivaled collection of field data
Many years of research have enabled Fraunhofer IWES to build up extensive expertise in the investigation of causes of failure of wind turbine components. This is performed in close cooperation with stakeholders from all areas of the value chain. The aim when doing so is to improve reliability and reduce both costs and the associated risks.

Fraunhofer IWES has generated an extensive, continuously growing collection of field data from more than 10,000 wind turbines in projects. Thanks to its size, diversity, and up-to-dateness, this data set is unique and it spans a wide range of turbine age classes, manufacturers, and installation sites. On the basis of this data set, Fraunhofer IWES supplies reliability data for OPEX modeling and cost-benefit analysis. In addition, Fraunhofer IWES also offers solutions for early failure detection and conducts failure cause analyses.

The post-construction analysis provides information on yield and performance. The combination of wind farm yield data analyses with numerical methods and models makes it possible to consider the causes for the performance of a wind farm individually.

Our services:

- Constantly growing data pool of currently more than 10,000 wind turbines in order to compare and evaluate experience in the operation of wind farms
- Investigation of causes of failure of wind turbine components
- O&M modeling, cost-benefit analysis, and the optimization of O&M strategies on the basis of field data
- Independent and reliable data analysis and consulting services



The intelligent and optimized condition monitoring leads to higher energy yields in the wind farm.

Fraunhofer IWES utilizes its many years of expertise in the field of high-performance computing on appropriate computers to carry out the calculations in an optimized and efficient manner.

Our services:

- Complex aeroelastic system analyses
- Simulation of rotor blades vibrating at standstill
- Investigations of vibrations on trundling turbines
- Simulation-based validation of technical concepts for vibration reduction
- Comprehensive, practical training on the use of OpenFoam for flow analyses in coupled systems

MORE INFO

Numerical yield and site assessment

Countermeasures against too intense vibrations: identifying the susceptibility of rotor blades

When a turbine is at a standstill or fails, it can begin trundling. In turn, this can result in the wind reaching the rotor blades at very high angles of attack. This leads to vortex shedding, which triggers heavily alternating loads on the blades and can cause them to vibrate. Depending on the intensity of the vibrations, they can damage or even destroy the blade or the turbine. As there are no reliable models currently available for this process, Fraunhofer IWES performs computational fluid dynamics (CFD) simulations on flexible rotor blades. This makes it possible to identify a rotor blade's susceptibility to such vibrations in certain scenarios and implement countermeasures where appropriate.

Computational fluid dynamics as a solution

Wind turbine rotor blades are currently designed to be slender and flexible. This has a range of advantages, including aerodynamic ones. One disadvantage is that the flexibility can result in the development of undesirable vibrations. In blade design, it is possible to determine and calculate the behavior of the rotor blades well for standard turbine operation. However, this is not the case if the flow behavior on the blades becomes highly unsteady, e.g., due to vortex shedding. This happens with high wind speeds or in cases where the turbine is not in operation or, in extreme cases, can no longer be controlled. Computational fluid dynamics makes it possible to investigate precisely this problem with a physics-based approach to flow calculation. Fraunhofer IWES has created the possibility of a flow structure-coupled simulation with the open source code OpenFoam.

Offshore logistics

Project and risk management for offshore wind farms: minimizing costs and boosting efficiency

Our services:

- Project plan analyses and qualitative assessment of schedules in project logistics
- Identification, analysis, and evaluation of weather risks
- Post-construction and performance analyses as well as KPI evaluation of offshore wind farms and their assets
- Assessment and optimization of the O&M processes of an offshore wind farm
- Consulting services in the bidder and claim management of offshore projects

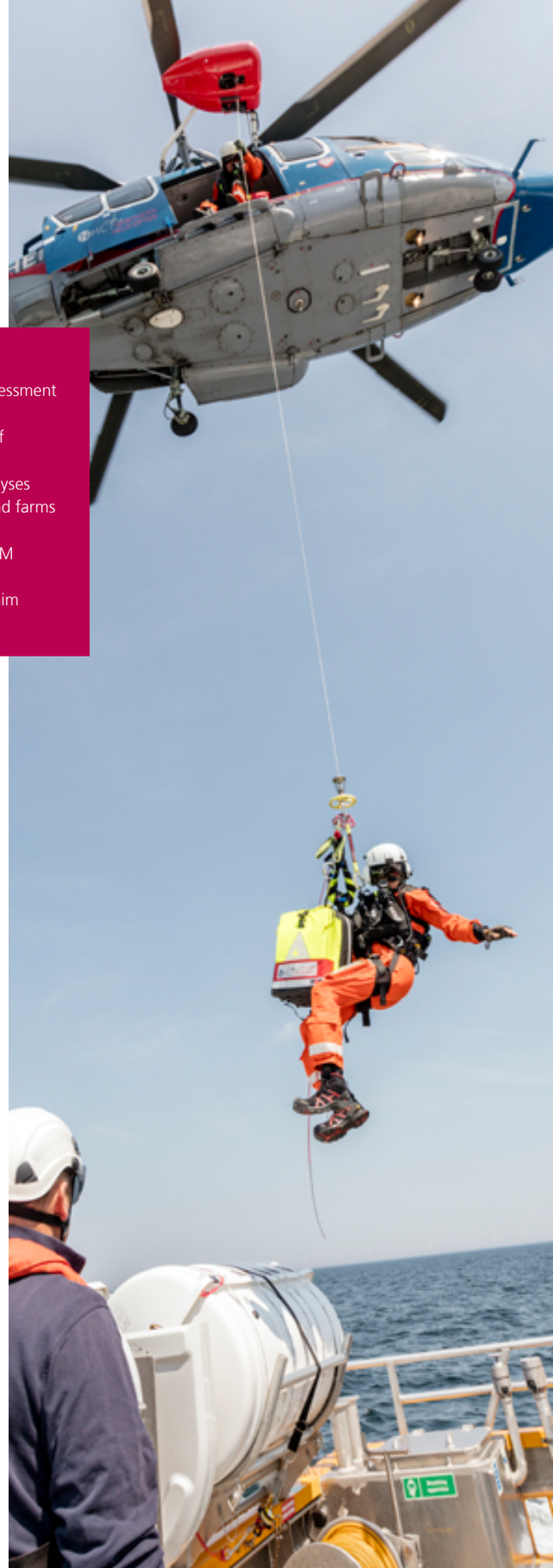
Efficient project and risk management forms the basis for the successful and cost-efficient planning, installation, and operation of offshore wind farms. In the planning and execution phase, Fraunhofer IWES offers project plan and weather risk analyses for early identification and assessment of potential risks. Its expertise means that Fraunhofer IWES can help to minimize risks and optimize the efficiency of the project logistics.

Post-construction and performance analyses allow assessment of the performance and efficiency of already installed offshore wind farms. Fraunhofer IWES can then make suggestions for optimization on the basis of the results. With the conceptual design of maintenance concepts for offshore wind farms and the evaluation of existing concepts, Fraunhofer IWES contributes to finding the optimal operating strategy for wind farms and minimizing costs.

In addition, Fraunhofer IWES offers the optimization of the O&M logistics in order to render the operation and maintenance of the offshore wind farms more efficient. Fraunhofer IWES analyzes the logistics processes and develops customized solutions for maximizing the availability of the turbines and optimizing the O&M costs.

MORE INFO

Project and risk management of offshore wind farms helps minimizing costs and increasing efficiency.



»Fraunhofer IWES boasts a unique infrastructure, expertise, and innovative spirit under one roof, making it fit for all the challenges of the wind energy and hydrogen industry!«

Prof. Dr.-Ing. Andreas Reuter
Managing Director

Applied research for customers

Fraunhofer IWES stands for strong cooperation and collaboration. We always aim to solve the problem and introduce the innovation into operation or the market. Our strength lies in developing suitable solutions for companies facing technological challenges. We are happy to support you in all aspects of planning, implementation and optimization of wind turbines or hydrogen production. Get in touch with us!

Find the matching pairs of cards. Cut them out and start playing.
At Fraunhofer IWES every match is a hit.

KNOWING	able
high	DISCO
MEASURE	in
ful	DRIVEN
AERO	very

dynamic	FORWARD
MULTI	looking
faceted	FAR
PERFORMANCE	scale
worth	POWER
LARGE	reaching
highly	DEPTH

Publication details

Publisher

Fraunhofer Institute for Wind Energy Systems IWES
Am Seedeich 45 | 27572 Bremerhaven | Germany
info@iwes.fraunhofer.de
www.iwes.fraunhofer.de

Fraunhofer Institute for Wind Energy Systems IWES
is a constituent entity of the Fraunhofer-Gesellschaft,
and as such has no separate legal status.

Fraunhofer-Gesellschaft zur Förderung der
angewandten Forschung e. V.
Hansastraße 27 c | 80686 München | Germany
www.fraunhofer.de

Published: August 2024

Responsible editor

Inna Eck, Head of Communications

Design

Fraunhofer IWES

Printing

UmweltDruckhaus Hannover GmbH
30851 Langenhagen | Germany
www.umweltdruckhaus.de
Printed in offset printing with organic inks
on Circle Offset Premium White 100% recycled paper

www.blauer-engel.de/uz195
- ressourcenschonend und umweltfreundlich hergestellt
- emissionsarm gedruckt
- hauptsächlich aus Altpapier

HO3

Photo credits

Pages 1:	Paul Langrock
Pages 2-5:	Fraunhofer IWES
Page 6:	Timo Lutz
Page 7:	Jens Meier
Pages 8/9:	Fraunhofer IWES/gobasil
Page 10:	Fraunhofer IWES/Gerrit Wolken-Möhlmann
Page 11:	Frank S. Bauer, small left to right: Jan Meier, Hermann Kolbeck, Marcus Heine, Fraunhofer IWES/Thomas Viergutz, Frank S. Bauer
Page 12:	Fraunhofer IWES
Pages 13:	Brazhyk - stock.adobe.com
Pages 14/15:	Paul Langrock
Pages 17-19:	Frank S. Bauer
Pages 20/21:	Fraunhofer IWES
Page 22:	Frank S. Bauer
Page 23:	Wind turbine - istockphoto instamatics, diagram - Pixabay Buffik
Page 25:	iStock_inkoly
Page 26:	Wenger Engineering GmbH
Page 27:	Till Schuster/Linde GmbH - Anlage in Leuna, Hydrogen Lab Fraunhofer IWES
Page 29:	Jens Meier
Page 30:	Fraunhofer IWES
Page 31:	HSEL/Tobias Trapp
Pages 32/33:	Fraunhofer IWES/Gerrit Wolken-Möhlmann
Page 34:	Fraunhofer IWES
Page 35:	Marcus Heine
Pages 36/37:	Jan Meier
Page 38:	Fraunhofer IWES
Pages 40/41:	PORT OF ESBJERG-CHRISTER HOLTE
Page 41:	Jan Meier
Page 43:	Fraunhofer IWES
Page 44:	Fraunhofer IWES, created with ParaView
Page 45:	Fraunhofer IWES
Page 47:	Paul Langrock
Page 48:	Fraunhofer IWES
Page 49:	Paul Langrock
Pages 51+54:	taviphoto/photocase

Certification

Our quality, occupational health and safety, and environmental management system is certified in accordance with ISO 9001, ISO 45001, and ISO 14001.

Accreditation

Our accredited laboratory with the laboratory areas of rotor blade, material laboratory, and field measurements is accredited by Deutsche Akkreditierungsstelle (German National Accreditation Body – DAkkS) in accordance with ISO/IEC 17025 with a flexible scope of accreditation per Category III* and Category I**.

This provides our accredited laboratory areas with objective and internationally recognized proof of their competence.

DAkkS Deutsche Akkreditierungsstelle D-PL-11140-21-00

IECRE

* Category III: In this area, the laboratory is permitted, without being required to obtain prior approval from DAkkS, to use the testing methods listed on the certificate with different issue dates of the standards.

** Category I: This next-highest category allows the laboratory – without prior approval from DAkkS – to select standardized or equivalent test methods freely within the defined test area.

The Fraunhofer-Gesellschaft

Fraunhofer IWES is one of 76 institutes and research facilities of the Fraunhofer-Gesellschaft based in Germany and is one of the leading applied research organization. It plays a crucial role in the innovation process by prioritizing research in key future technologies and transferring its research findings to industry in order to strengthen Germany as a hub of industrial activity as well as for the benefit of society.

The Fraunhofer-Gesellschaft is one of the most popular employers in Germany
Current studies conducted by Randstad, trendence, and Universum confirm that Fraunhofer doesn't just lead the field when it comes to research, but is also one of the most popular employers in Germany. Fraunhofer is proud to have ranked so highly and continues to do everything in its power to become even better.

Top 2023 Company kununu

1. PLATZ Attraktivste Arbeitgeber 2023 Für Absolventen Forschung trendence

2. PLATZ Attraktivste Arbeitgeber 2023 Für Professionals Forschung trendence

There are plenty of good reasons to work at Fraunhofer IWES!

Exciting research questions await you at Fraunhofer IWES. The institute is home to one-of-a-kind test rigs and a unique measuring infrastructure as well as state-of-the-art technologies. Here, you will conduct experimental trials and tests and enjoy freedom when it comes to designing your projects. Together, we find solutions to current and future challenges in the fields of wind and hydrogen technologies. To this end, you will work together closely with our customers and partners, applying innovative solutions with your colleagues.

Change starts with us.

MORE INFO

Contact

Fraunhofer Institute for Wind Energy Systems IWES
Am Seedeich 45 | 27572 Bremerhaven | Germany

Phone: +49 471 14290-100
E-Mail: info@iwes.fraunhofer.de

www.iwes.fraunhofer.de/en.html