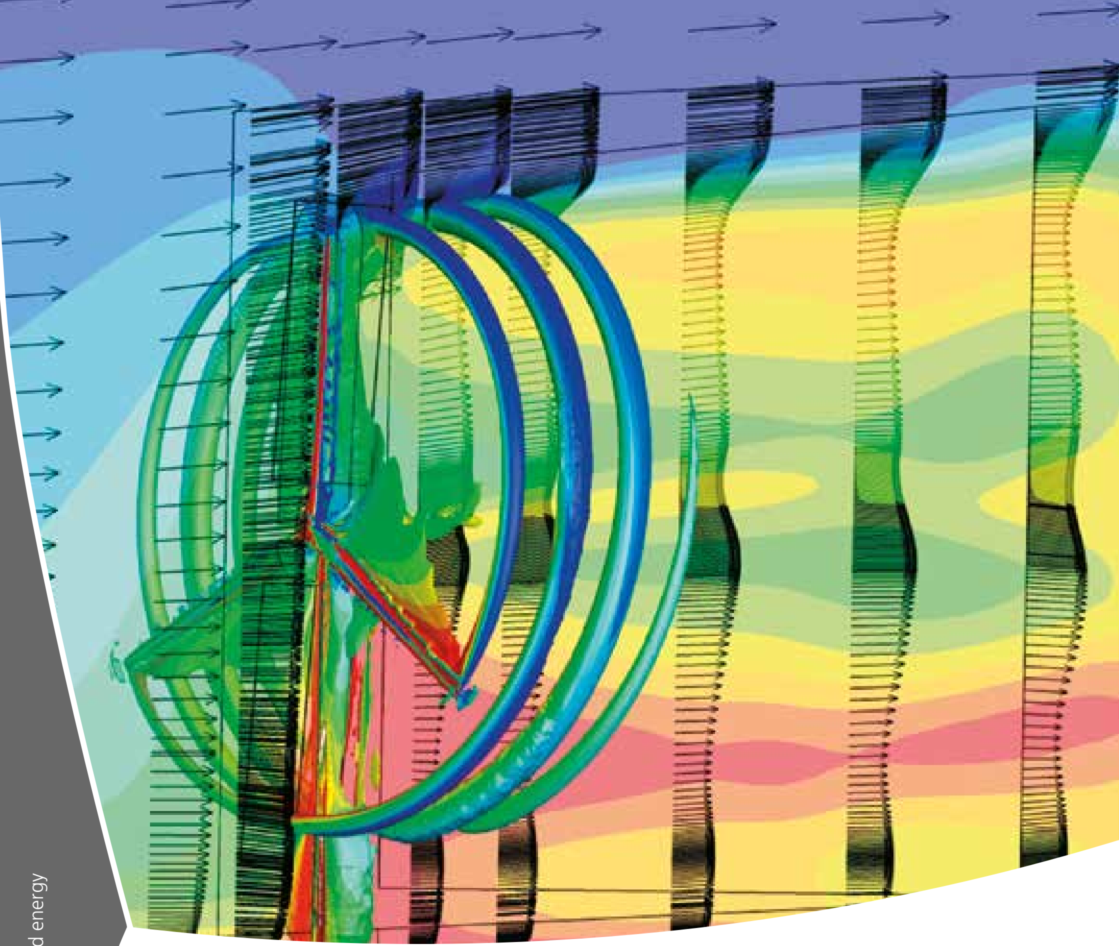


Wind energy

The rotor of the future

Wind energy research at DLR

DLR

Image: Rainer Sturm/pixelio.de

»German companies, universities and research institutions play leading roles worldwide in the field of wind energy. Innovations ensure that they keep this leading international position in the field of renewable energy technologies. Research plays a decisive role here.«

Sigmar Gabriel,
German Federal Minister for Economic Affairs and Energy

Foreword

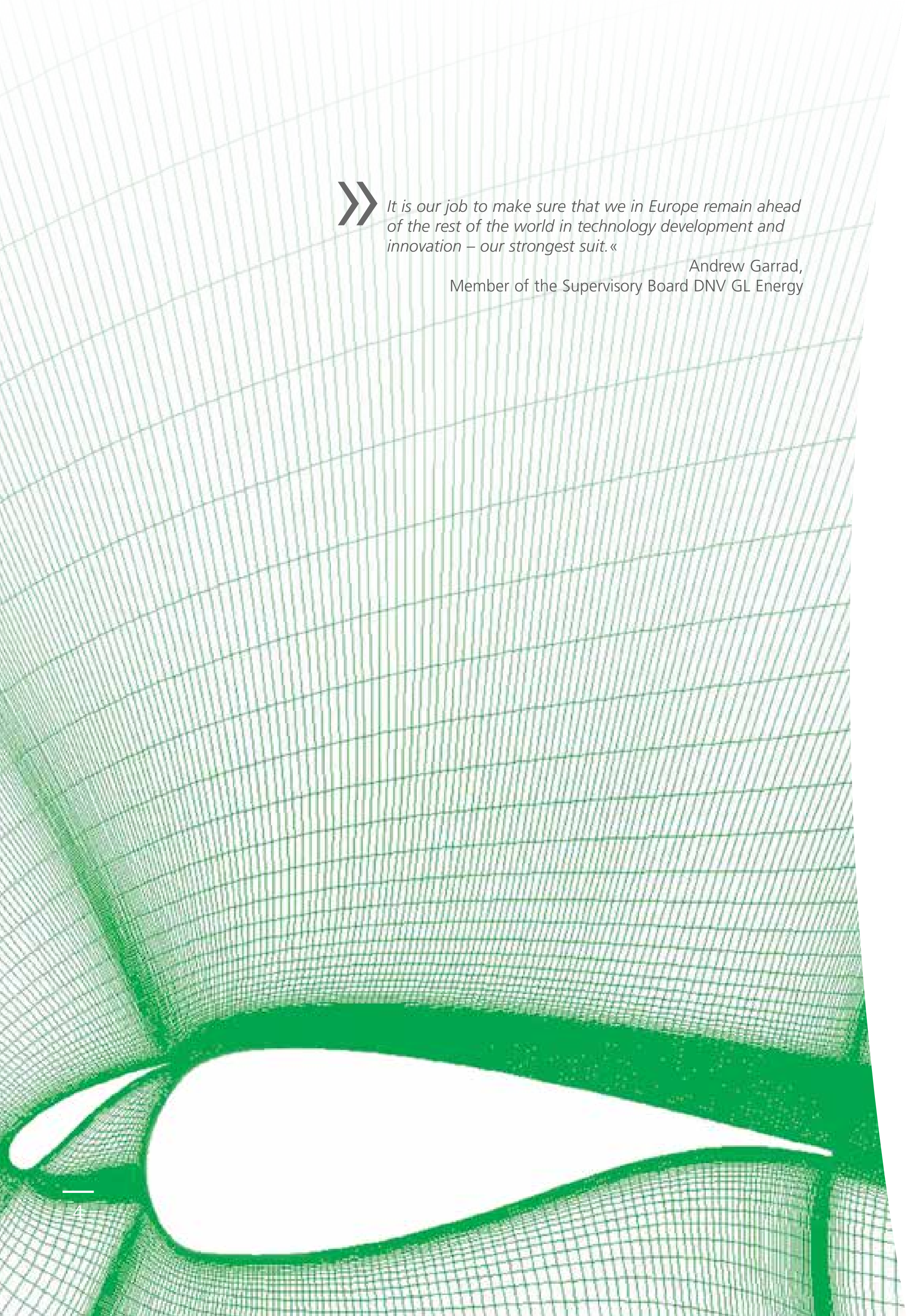
Energy is an essential part of our lives. The most widely used energy sources continue to be limited natural resources such as oil, coal and gas. This not only contributes to climate change, but also increases dependency on imports. In order to supply the population and industry with energy in the long term and in a sustainable fashion, our energy system must be transformed.

Various technologies play a major role in such a novel energy system. In particular, renewable sources like wind and solar power are going to make major contributions to our future energy supply. The continuously increasing size of wind turbines demonstrates that diverse and extensive technology developments await us.

Research can and must contribute to this endeavour. DLR wind energy research has emerged from decades of experience in aeronautics and space research. Currently, we benefit from these synergies to enable major technology leaps in wind energy.

I would like to invite you to read through the following pages so you can get an overview of the wind energy research conducted at DLR.

Jan Teßmer
Coordinator for Wind Energy Research



»It is our job to make sure that we in Europe remain ahead of the rest of the world in technology development and innovation – our strongest suit.«

Andrew Garrad,
Member of the Supervisory Board DNV GL Energy

Introduction

At DLR, researchers from various disciplines are working on developing the next generation of wind turbines. The industry sector faces the challenge of developing larger and more efficient systems at low costs, and with less environmental impact. Major issues arising from this can be recognised by looking at some basic technical rules:

With increasing rotor radius R

- aerodynamic forces increase as the square (R^2),
- the weight increases with the cube (R^3) and
- noise increases with the fifth power of blade tip speed (U_{Tip}^5).

This is why simply scaling up today's technologies and construction techniques is not appropriate. What is needed are innovative technology leaps that simultaneously offer lower costs; weight reduction concepts can balance aerodynamic and structural forces. Lightweight construction helps to reduce weight thanks to its novel materials and structures. Noise emissions are lowered with active and passive noise reduction measures. The overall operation is leveraged through accurate planning and awareness of external factors affecting the wind power plant.

Researchers at DLR continuously work on all these topics and benefit from decades of experience in the related fields of aeronautics and space. Our portfolio of expertise ranges from basic research through to further development of individual components in cooperation with industry. As part of the Helmholtz Association, we are experienced in the validation and verification of new methodologies in laboratories, in field tests or in our numerous wind tunnels. The planned full-scale DLR research platform, with its highly instrumented wind energy testing facilities, will make a decisive contribution to building a bridge between research and industry.

Smart rotor – design, new production methods and intelligent control

Expanding wind energy brings about various technical challenges. There is a tendency to combine ever-larger rotor blades with an efficient use of the wind potentials and reduced maintenance costs. Today's up to 85-metre-long rotor blades must cope with fluctuating winds – and thus changing loads – representing a high stress for the structure and difficult requirements for the control of a wind turbine.

To overcome the problems, innovative concepts such as 'smart blades' can help. These rotor blades stand out because they react to changing inflow with various active and/or passive mechanisms to reduce structural strains. As a consequence, longer rotor blades can be constructed, and negative effects on their safety and life cycle fatigue avoided. These lightweight rotor blades limit the stress and susceptibility to damage of the entire plant.

In addition to laying out a design in line with the applicable load, DLR researchers develop highly accurate simulation and test methods, as well as automation and quality assurance for the production of large fibre composites. In particular, the production monitoring and component assessment using appropriate contactless sensor systems and testing technology lead to manageable tolerance thresholds and a higher reproducibility. This reduces process times, manufacturing waste and risks within the operation. Structural health monitoring systems and load measurements made during operation will additionally increase plant security.

Good to know

The material properties of fibre composites develop during the production process. The slightest deviation of process parameters, such as temperature or fibre alignment, will cause major changes in material characteristics and geometric shape. This is why DLR researchers develop methods for the production of highly accurate and cost-effective fibre composite components.

Research infrastructure

Test Facility for Ground Vibration Testing and Structural Dynamics Experiments
Marc Böswald, Marc.Boeswald@dlr.de

Cryogenic Wind Tunnel for High Reynold Numbers
Rüdiger Rebstock,
Ruediger.Rebstock@dlr.de

High Pressure Wind Tunnel in Göttingen for High Reynold Numbers
Markus Jacobs, Markus.Jacobs@dlr.de

Center for Lightweight Production Technology

Flexible Dynamic Test Bed for Component Tests in the Field of Structural Analysis

45-metre rotor blade mould

Dynamic and Static Testing Facility for Material Science
Birgit Wieland,
Birgit.Wieland@dlr.de

Smart Blades – Design and construction of intelligent rotor blades

The ‘Smart Blades’ project explores opportunities for load reduction in rotor blades by active and passive means. The purpose is to prove the feasibility, efficiency and reliability of smart blades. Passive smart blades have a design that reacts by twisting if bent by heavy aerodynamic loads. This modifies the angle of attack; thus, the rotor blades can automatically avoid an overload. Active smart blades achieve the same effect with adjustable trailing edges on the rotor blade. In addition, active slats are being investigated; these shift the stall limit when needed.

The major task here is to prevent the rotor blades and the associated pitch control and hub construction equipped with active mechanisms from being prone to more defects and requiring more frequent maintenance. The Smart Blades project is a collaboration between the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES), the Centre for Wind Energy Research of the Universities of Oldenburg, Hannover and Bremen (ForWind) and DLR.

Johannes Riemenschneider
Institute of Composite Structures and Adaptive Systems
Johannes.Riemenschneider@dlr.de

LARS – Optimisation of wind turbines – Load reduction of wind turbines by implementation and control of system degrees of freedom

In the LARS project, DLR is developing a controller to reduce dynamic loads on a two-bladed wind turbine using the excitation of certain nacelle degrees of freedom in addition to the conventional pitch control system. For this purpose, DLR’s S4 rotor simulation program has been modified for dynamic simulation and analysis of wind turbines and is coupled with the multi-body simulation software SIMPACK. The coupled software allows for more accurate analysis of the aeroelastic interactions under excited degrees of freedom.

An analysis of the linearised system behaviour in the frequency domain is used to develop a controller for load reduction (for example, by means of individual blade pitch control or active rotor head tilt). In addition to testing the controller in the non-linear simulation, a system evaluation and validation with the results of a test campaign in a technology test rig will be performed.

Rainer Bartels
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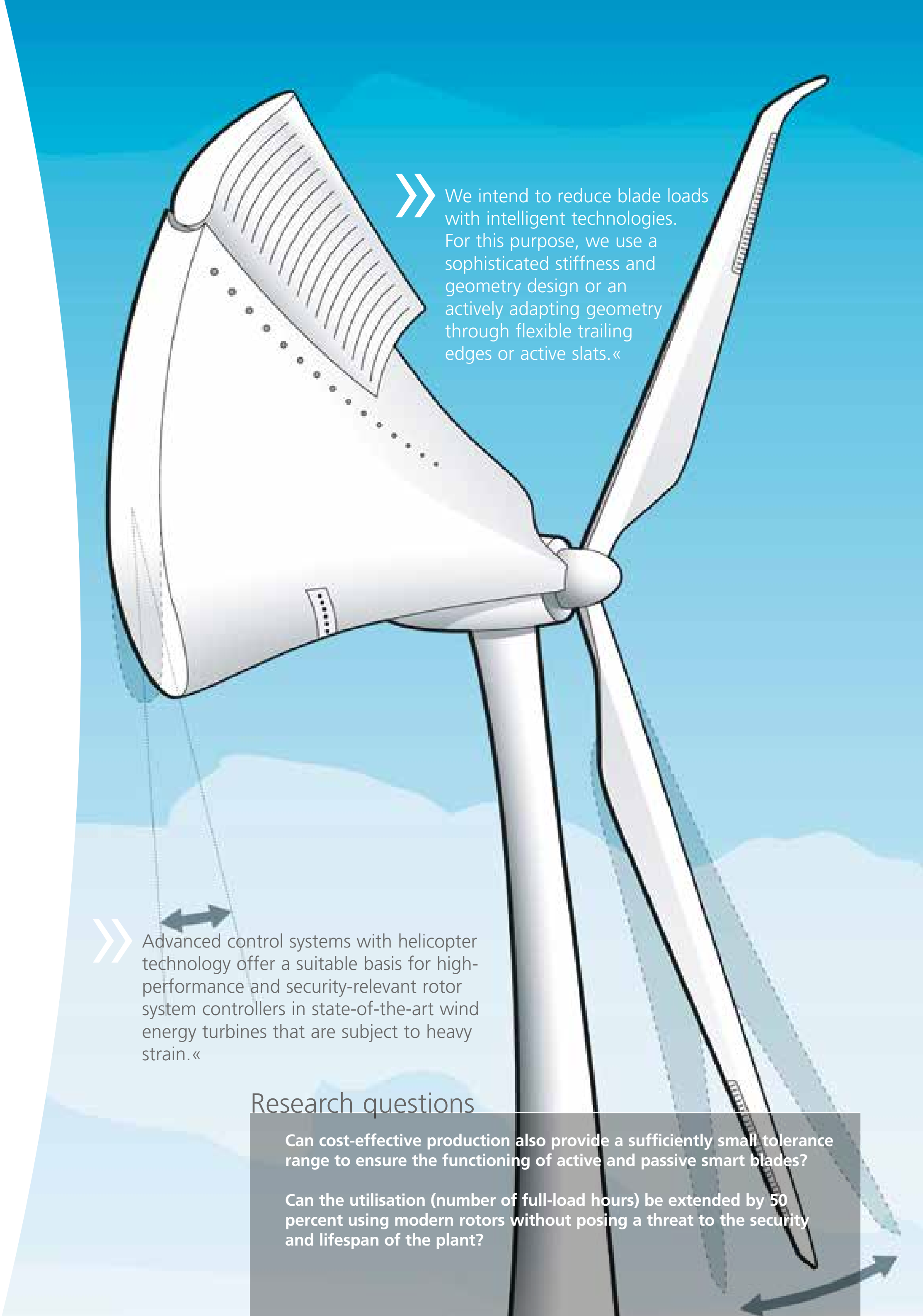


»We intend to reduce blade loads with intelligent technologies. For this purpose, we use a sophisticated stiffness and geometry design or an actively adapting geometry through flexible trailing edges or active slats.«

»Advanced control systems with helicopter technology offer a suitable basis for high-performance and security-relevant rotor system controllers in state-of-the-art wind energy turbines that are subject to heavy strain.«

Research questions

Can cost-effective production also provide a sufficiently small tolerance range to ensure the functioning of active and passive smart blades?

Can the utilisation (number of full-load hours) be extended by 50 percent using modern rotors without posing a threat to the security and lifespan of the plant?

SimBA – Simulation tool for highly accurate and efficient aerodynamic design and analysis of wind energy plants

With THETA, German research software is being developed for numerical simulation of flows around wind energy plants in the SimBA project. With efficient and precise simulation it will contribute to the design and optimisation of the aerodynamic, aeroacoustic and structural aspects of wind energy plants.

Employing some components of the DLR TAU software, the highly efficient flow solver THETA allows the simulation of entire wind turbines with high temporal resolution. The CHIMERA technology is applied to integrate moving meshes – a prerequisite for the turning of the rotor and the blade adjustment. Simulations include separation effects on the rotor blades and the propagation of the blade tip vortices. Interfaces are provided to simplify the integration of THETA into the multidisciplinary simulation of complete wind energy plants.

Dieter Schwamborn
Institute of Aerodynamics and Flow Technology
Dieter.Schwamborn@dlr.de

ELBA – Control systems for extreme load limitation in large wind energy plants

The ELBA project aims to develop a novel control system for active limitation of extreme loads that are relevant for the design of wind energy power plants. These extreme loads – caused by wind gusts, for example – occur within fractions of a second and therefore need dynamic control. For this purpose, the corresponding loads are measured so that appropriate actuators can actively mitigate them. These may be aerodynamic forces, as they are usually the root cause for changes. This is why the focus is placed on developing and validating models for transient aerodynamics with fast aerodynamic force actuators and, in particular, on the design of the necessary controllers. Additionally, this project will provide a deeper understanding of the interplay between fast aerodynamic force actuators and aeroelasticity in wind energy plants. At the same time, the project is expected to reduce costs for mechanical components; these represent an important share of the overall investment.

Holger Hennings
Institute of Aeroelasticity
Holger.Hennings@dlr.de

» Using THETA, we can compute complex flow simulations on wind turbines very quickly and accurately, building on decades of previous developments in aeronautics.«

» Extreme loads are decisive factors for the dimensioning of rotor blades and towers. A reduction of such loads through air-driven actuators offers a promising possibility for cost reductions and improvement of turbine technologies.«

Research questions

How can vibrations and eigenfrequencies caused by the aeroelastic load excitement of larger and more flexible blades be controlled safely?

Is it feasible to put good ideas into practice reproducibly without entailing high costs?

Aeroacoustics and noise – source, propagation, effects

Plant operators are increasingly faced with challenges in convincing local residents of the further expansion of onshore wind energy. Reliable forecasts about noise pollution depending on the weather and topography of the region are indispensable for the layout and design of wind farms. On the other hand, the source-related physical modelling of noise produced by the airflow of the rotor provides the basis for improved control strategies and the design of new low-noise rotor blades and retrofitting of existing ones. In general, the time resolution of turbulent noise sources requires computationally intensive methods, like direct numerical simulation (DNS) or large eddy simulation (LES).

Therefore, during the design process, DLR researchers use a stochastic model approach to preserve resources. This is a way to reconstruct the unsteady noise sources based on a numerical solution of the Reynolds-averaged Navier-Stokes (RANS) equations. The sound field is calculated with a variety of numerical methods in computational aeroacoustics (CAA), such as the integration method of Ffowcs Williams and Hawkings or methods based on the linearised Euler equations (LEE) or the acoustic perturbation equations (APE).

Innovative design options are acoustically evaluated with stochastic source models taking into account three-dimensional flow effects. Measured noise reduction effects of selected low-noise technologies have been simulated. Our comprehensive measurement database for trailing edge noise also serves to develop extremely rapid semi-empirical noise forecast methods.

Research infrastructure

(Aeroacoustic) Low-Speed Wind Tunnel Braunschweig (DNW-NWB)
Andreas Bergmann, Andreas.Bergmann@dnw.aero

Localisation of Stationary and Moving Sources of Sound using Microphone Arrays
Henri Siller, Henri.Siller@dlr.de

Acoustic Wind Tunnel Braunschweig (AWB), Far-Field Ground Microphone System for Directivity Measurements in Field Tests
Michael Pott-Pollenske, Michael.Pott-pollenske@dlr.de

Good to know

Noise is an interdisciplinary topic. DLR works on the entire chain – from the source, through propagation and up to its effects – analysing scenarios and potentials for reduction.

BELARWEA – Blade tips for efficient and low-noise wind turbine rotors

BELARWEA aims to design efficient and low-noise wind turbine rotors with a specific three-dimensional layout of the outboard blade region. Here, simulation methods from aeronautics, like CFD (computational fluid dynamics) and CAA (computational aeroacoustics) are applied and expanded to wind power systems. Additionally, positively pre-tested passive noise reduction technologies (porous edge modifications, like brush extensions, trailing edge slots and corresponding derivatives) are applied on the 3D outboard blade area of wind turbine rotors. The experimental proof stems from static wind tunnel tests on selected three-dimensional blade tip samples. These experiments are conducted in the Acoustic Wind Tunnel Braunschweig (AWB) and in the Low-Speed Wind Tunnel Braunschweig (DNW-NWB). Altogether, we intend to lower noise by at least three decibels at a given rotor performance.

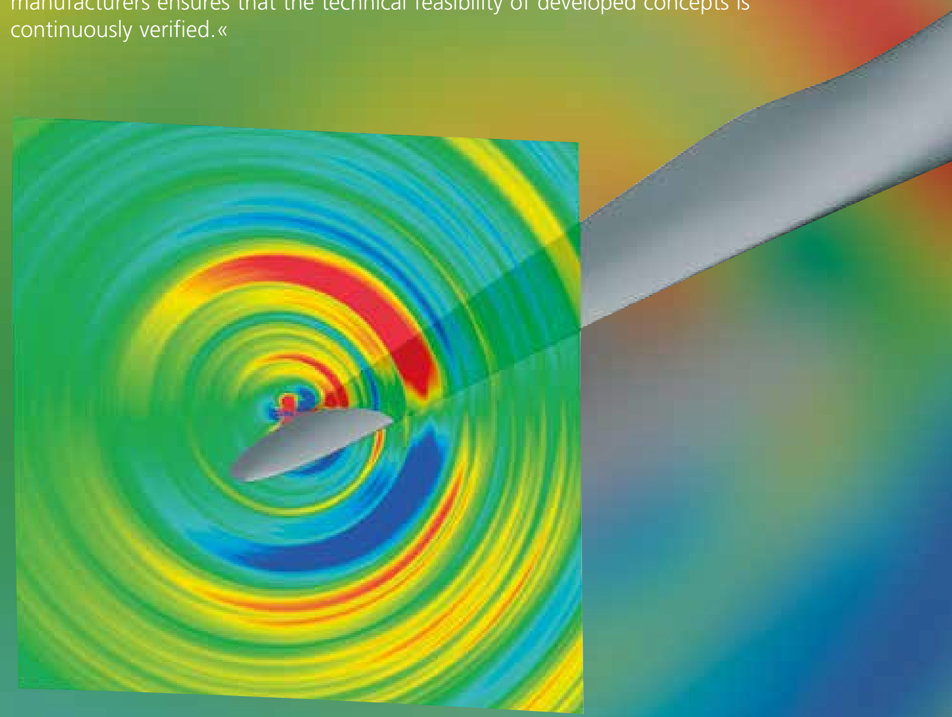
Michaela Herr
Institute of Aerodynamics and Flow Technology
Michaela.Herr@dlr.de

Lips – Weather-dependent characterisation of noise pollution around wind energy plants in a structured topography

The Lips project involves the quantification of noise pollution around wind power plants depending on the current operation, meteorological conditions and topography. The project takes into account the airflow measured in front and behind the wind turbine and calculates the impact of emission reduction of audible sound and infrasound in the environment with numerical noise propagation models. This combined model system for flow and noise may be used to determine sound propagation classes, to derive parameterisations for simplified noise forecast procedures and to assess simulations and measurements.

Arthur Schady
Institute of Atmospheric Physics
Arthur.Schady@dlr.de

»We strive to achieve significant noise reductions with aeroacoustically optimised rotor blade geometries. An associated advisory board representing the leading plant manufacturers ensures that the technical feasibility of developed concepts is continuously verified.«



»We use state-of-the-art measurement and simulation methods to elaborate easy-to-use noise assessment methods and classifications for turbine operators and municipalities.«

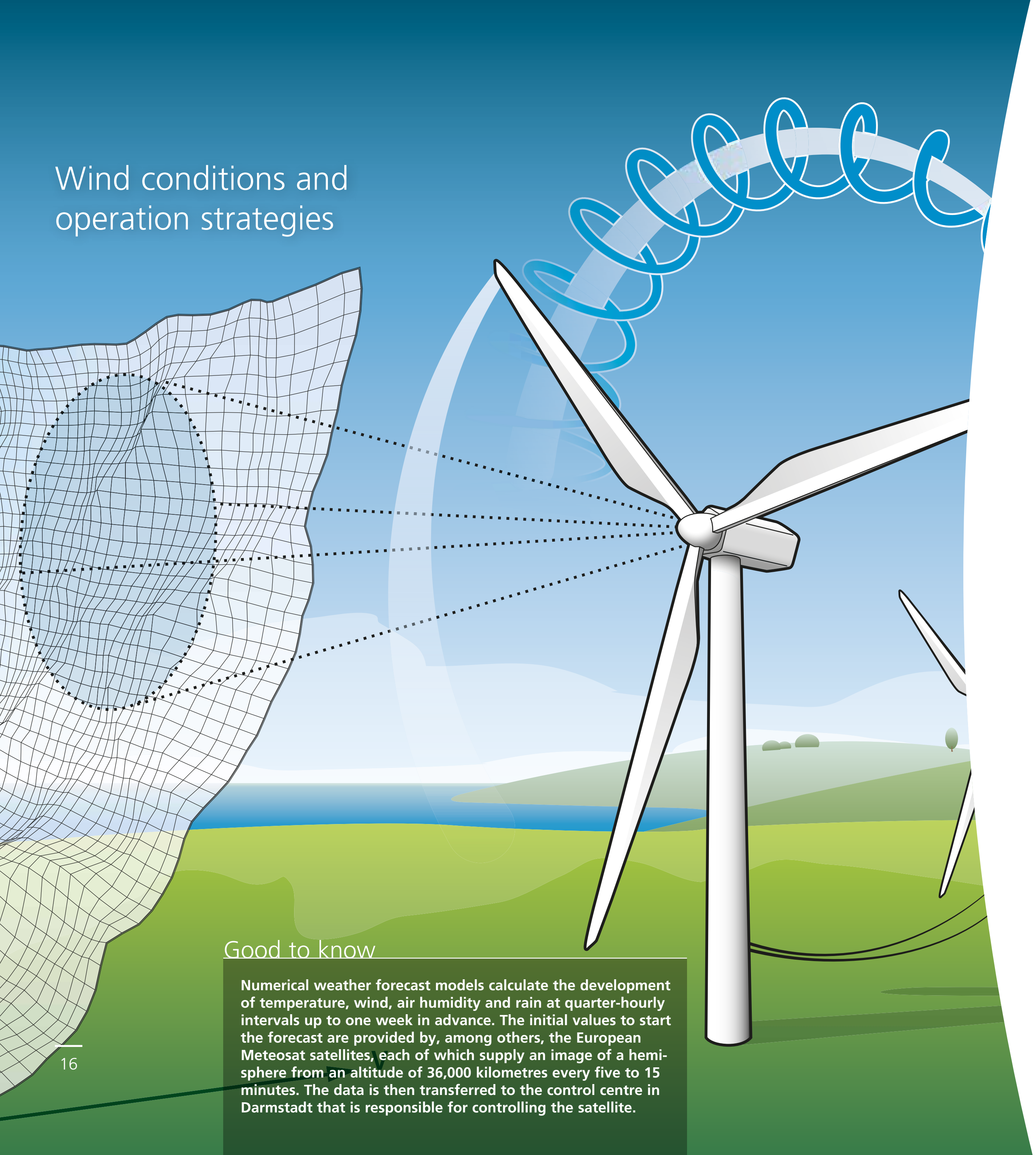
Research questions

How can wind energy power plant operation be optimised so that local residents have a good night's sleep – even at night with strong low-level jets?

Are there optimal custom-fit blade tips for ideal noise/performance ratios?

Can aircraft noise mitigation measures be translated to wind power plants?

Wind conditions and operation strategies



Good to know

Numerical weather forecast models calculate the development of temperature, wind, air humidity and rain at quarter-hourly intervals up to one week in advance. The initial values to start the forecast are provided by, among others, the European Meteosat satellites, each of which supply an image of a hemisphere from an altitude of 36,000 kilometres every five to 15 minutes. The data is then transferred to the control centre in Darmstadt that is responsible for controlling the satellite.

DLR has various technologies and skills at hand to determine and characterise wind resources and environmental conditions. Wind lidar (light detection and ranging) can be used for individual wind turbines as well as for entire wind farms to obtain accurate and high-resolution measurements of the turbulent flows on scales between 100 metres and several kilometres. The offshore expansion and increased use of complex terrain for wind power requires more detailed information about wind characteristics, in particular over rough surfaces like mountains or forests.

A further technology used is radar, functioning continuously – regardless of cloud cover or daylight – to acquire images of the ocean surface at particularly high resolution. SAR (Synthetic Aperture Radar) oceanography helps to calculate large-scale wind fields and wave heights using data from the satellites ERS and Envisat, as well as the German satellite TerraSAR-X.

In combination with highly advanced in-situ measuring technology for evidence of turbulence on the centimetre and metre scale, enhanced forecasts can be provided for the effect of wind on turbines, wind parks and load situations. Better load control leads to more efficient grid integration and thus contributes to cost reductions. Numerical procedures describe the interaction between the global wind field, terrain and several turbines, and deliver input for local calculations on an individual turbine. This allows for optimal operation and accurate performance forecasts.

Research infrastructure

LIDAR
Oliver Reitebuch, Oliver.Reitebuch@dlr.de

Satellite TerraSAR-X with Radar Sensor for SAR Data in the X-Band Frequency Range
Susanne Lehner, Susanne.Lehner@dlr.de

Lips – Simulation and measurement of flows around wind power plants in a structured topography

In a second work package in addition to acoustics, the Lips project serves to calculate the three-dimensional transient flow in front of and behind the turbine with LES (Large Eddy Simulation) under varying meteorological, topographic and orographic conditions and at different times of day. These calculations provide the meteorological entry data and framework conditions for further noise propagation forecasts. Pulsed wind lidar technology is deployed for experimental measurements and the validation of simulation calculations. It is used to survey the three-dimensional wind field several kilometres in front of and behind turbines.

Thomas Gerz
Institute of Atmospheric Physics
Thomas.Gerz@dlr.de

SAR – Synthetic **A**perture **R**adar – Wind field analysis

The DLR satellites TerraSAR-X and TanDEM-X offer new possibilities for area coverage in ocean surface studies. The SAR systems on board the twin satellites acquire data with an extremely high spatial resolution down to one metre and are – unlike optical methods – almost independent of the weather, cloud cover and daylight.

Via the radar backscatter from the roughened ocean surface, the sensors provide information on the oceanographic and meteorological processes, such as wave heights and wind fields. DLR is developing the algorithms for the derivation of these parameters. For the first time ever, very small-scale atmospheric phenomena can be resolved and examined with these satellite measured meteorological fields – for example, in the area of wind turbines.

Susanne Lehner
Remote Sensing Technology Institute
Susanne.Lehner@dlr.de

» Today, lidar technology enables us to acquire highly accurate and detailed data of the wind conditions in the entire area influenced by wind power plants, and thus validate simulation methods.«

» We use SAR to discover vortex trails behind Alpha Ventus turbines at distances of up to 20 kilometres from the wind farm.«

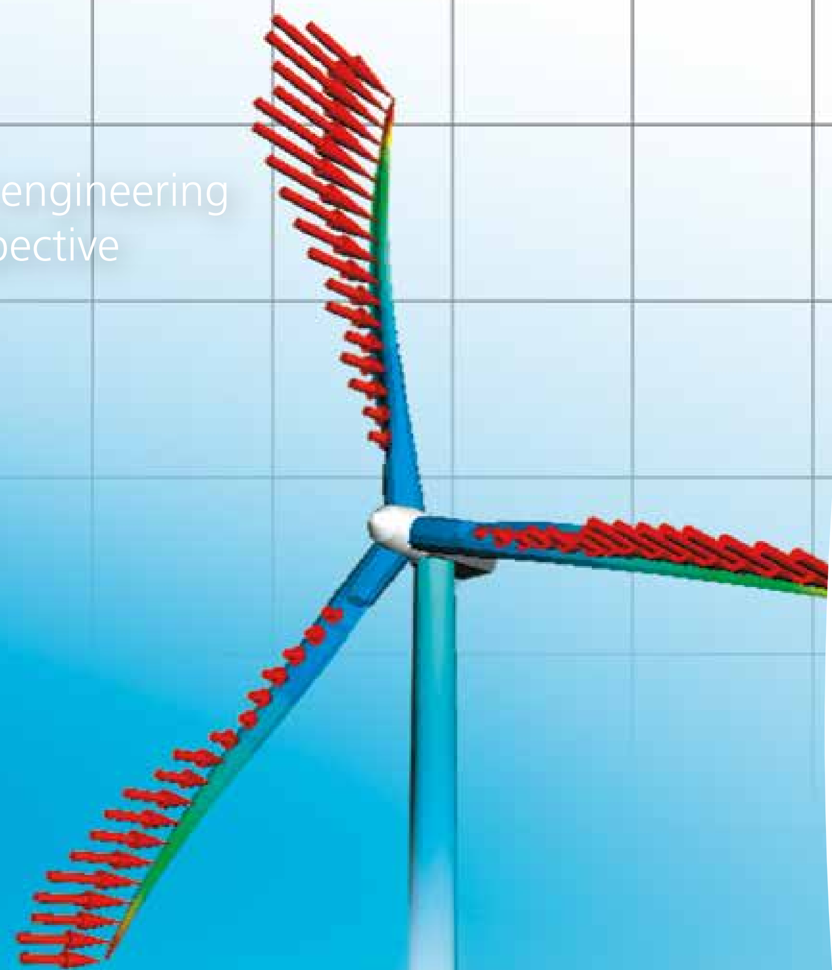
Research questions

How can on-site instruments be improved with satellites and other technologies?

What is an efficient way to couple global and local simulation and analysis processes for accurate real-time analyses and forecasts?

How can data collected by the TerraSAR-X satellite help to avoid damage to off-shore installations caused by extreme waves?

Computer-aided engineering and system perspective



FreeGreenius
freegreenius.DLR.de

Global Atlas IRENA
www.irena.org/
GlobalAtlas

Good to know

State-of-the-art calculation methods and advanced computer technology pave the way for extremely challenging simulations. The largest high-performance computer for aeronautics research – the C²A²S²E² system – is available for this purpose at DLR. Measuring three by eight metres, it offers 1120 processors with 13,440 floating-point processors and a performance of 262 teraflops per second.

The first global portal for renewable energy resource mapping was published based on DLR's knowledge of energy system modelling, remote sensing and geodata processing (www.irena.org/GlobalAtlas).

Our researchers offer a freeware simulation program called FreeGreenius to provide a tool for power plant project forecasts. The program calculates the revenue of a renewable energy power plant at a certain location. It also determines how a power plant system must be designed and laid out to feed the desired amount of power to the grid. (http://freegreenius.DLR.de).

Wind turbines and wind farms are subject to high levels of interaction between the aerodynamic efficiency of the rotor blades, the structural design and oscillation types of the turbine, its control and the wind conditions on site. Depicting a real turbine accurately on the computer requires comprehensive simulation. Once the interaction is included exactly, turbine layout can be optimised. At DLR, different model accuracies are applied for the entire turbine simulation. This enables high-precision capture of some phenomena, while other simulations may work with approximate data in real time. Only holistic modelling of aerodynamics and structure gives a clear insight into rotor structure dynamics. These are used to simulate wind turbines and wind farms and allow for conclusions to be drawn about optimisations and model-based control methods. These tools also serve to set up feasibility studies for novel wind turbines designs and concepts. Additionally, DLR works on developing industrial standards to strengthen exchange of turbine and model data.

Research infrastructure

C²A²S²E²-High Performance Computer
Dieter Schwamborn, Dieter.Schwamborn@dlr.de
Norbert Kroll, Norbert.Kroll@dlr.de

The DLR Institute of Engineering Thermodynamics develops and uses methods and tools tailored to the specific issues of systems analysis and technical evaluation in the field of energy supply. Here, top-down analyses of the entire energy system are carried out at regional, national and European levels and combined with technology-focused bottom-up studies in relevant areas – for example, analyses of potential and feasibility. The methods applied range from the assessment of the potential of renewable energy through Earth observation and modelling of energy systems with high shares of renewable energies in high spatial and temporal resolution up to scenario studies for the analysis and development of implementation strategies for the energy transition.

Institute of Engineering Thermodynamics
Carsten Hoyer-Klick, Carsten.Hoyer-klick@dlr.de

MERWind – Multi-disciplinary d**E**sign fundaments for **R**otors in **Wind** power plants

The MERWind project is striving to build a multi-disciplinary simulation environment with high fidelity cutting edge methods for for wind turbines. As a consequence, sensitivities can be calculated using response surface models, and guidelines for the integrated design of wind power plants can be elaborated. Within the project, various disciplines – namely aerodynamics, structures, aeroelastics, acoustics, as well as manufacturing aspects – are considered simultaneously. Computational Fluid Dynamics (CFD) methods for the aerodynamic calculations, Finite Element Method (FEM) for structure calculations, multi-body simulation for an aeroelastic analysis with fluid/structure coupling, acoustic evaluations based on Computational Aeroacoustics (CAA) calculations and a parametric blade model generator are integrated in a common framework. The variation of geometrical and structural features on a reference blade allows the determination of the impact of these parameters on the performance of the wind turbine, which is decisive for its design. At the same time, manufacturing aspects and costs are taken into consideration. In the medium term, the incompressible THETA code (Turbulent Heat Release Extension of the TAU Code), specifically developed for wind turbines (see SimBA project), will replace the TAU code, an unstructured Reynolds-averaged Navier-Stokes (RANS) solver currently used for aerodynamic simulations.

Manfred Imiela
Institute of Aerodynamics and Flow Technology
Manfred.Imiela@dlr.de

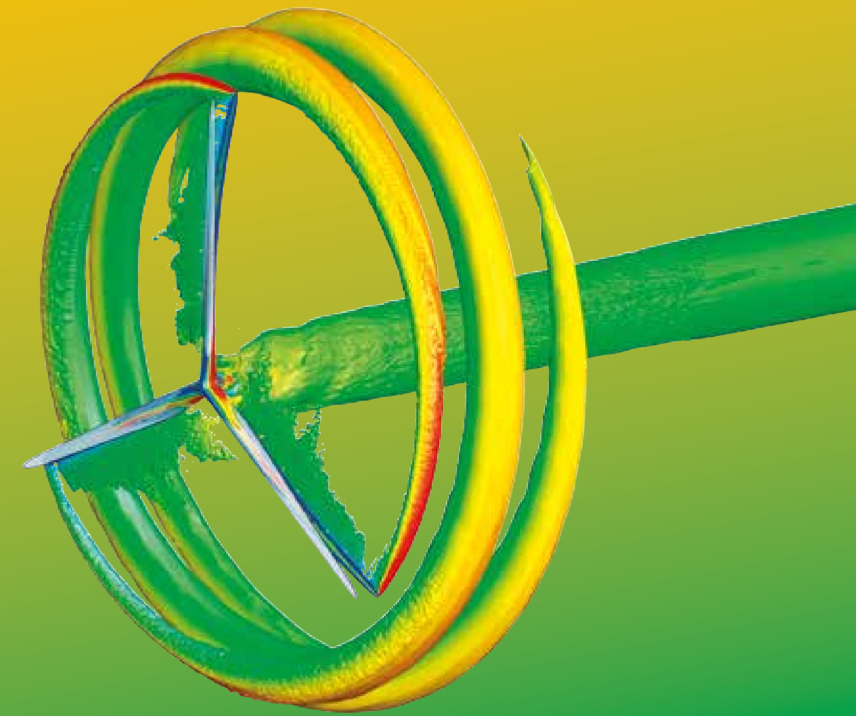
WindMUSE – Wind Turbine in a **MU**ltidisciplinary **S**imulation **E**nvironment

In aeronautics, simulation on the ground prior to real flight has been proven as an efficient approach for decades. This ensures that the test processes – in particular the methods and concepts – are optimised and risks are reduced prior to flights. DLR's well-established aeronautics simulation models and tools are now to be adopted for wind energy. This will allow for holistic simulation in a multi-disciplinary simulation environment at DLR.

In this endeavour, both models for extremely fast computation and those for precise, highly accurate processes are applied. The simulation environment WindMUSE will be used for a number of research topics, including the forecasting of loads, for the preparation and the integration of real tests prior to hardware-in-the-loop tests. With respect to this application, WindMUSE must work in real time. For the first time, this project aims at combining the DLR simulation tools with OneWind®, developed by the Fraunhofer Institute IWES, via tool-to-tool coupling to combine the experience and potential of the two partners.

Holger Schumann
Institute of Flight Systems
Holger.Schumann@dlr.de

» We connect novel processes from science and research to create a multidisciplinary simulation environment to enhance the design of rotors in wind turbines and support our industry partners.«



» Multidisciplinary simulation is necessary for a holistic approach and understanding of complex systems.«

Research questions

What role do operational simulations play under extreme weather conditions?

What would be a way of leveraging our comprehensive system analysis?

How can holistic modelling be used to estimate the impact of new technologies?

Synergy topics within DLR energy research

Power-to-gas – Electromobility and energy storage

The Institute of Engineering Thermodynamics develops efficient electro-chemical energy storage and conversion technologies – mainly fuel cells, electrolysers and advanced-technology batteries. We explore system-level integration issues for stationary energy applications as well as for automotive applications in electromobility. We also evaluate the impact of such systems on achieving the environmental goals. A concept with high potential is the conversion of surplus electricity from wind farms to hydrogen, which can be used flexibly for transport, chemical industries, heating or for generating power. We investigate the ability to integrate energy from variable-speed wind turbines directly with the hydrogen-producing stacks of commercially available electrolysers. Cost-effective components for particularly flexible and efficient polymer membrane electrolysis are developed and their system integration analysed. E.ON Hanse AG in Hamburg runs a power-to-hydrogen plant using this technology to feed large-scale volumes of hydrogen into a natural gas grid. The Institute of Composite Structures and Adaptive Systems develops hydrogen tanks for mobile storage at reasonable costs.

Institute of Engineering Thermodynamics
K. Andreas Friedrich, andreas.friedrich@dlr.de

Helicopter-assisted offshore operation

When it comes to operating offshore systems, the industry faces major challenges. In future, the ever-increasing distance to offshore plants and the resulting difficulties with transporting injured workers could cause problems. For the latter aspect, human lives depend on smoothly functioning and fast rescue methods, alongside a continuous rescue chain. With the Air Vehicle Simulator (AVES) and the Flying Helicopter Simulator (ACT/FHS), the Institute of Flight Systems provides unique facilities to establish new operational processes that can be tested and optimised within the simulator to find new approaches for the support and rescue of aircraft crews.

Institute of Flight Systems
Christoph Keßler, Christoph.Kessler@dlr.de

Research collaborations

»We still have some fundamental aerodynamic issues to really understand in wind power, although I believe that ours are actually rather more complicated than theirs – we have highly turbulent flows, rapidly varying angles of attack and large radial pressure gradients. Nevertheless they have been at it longer, have received huge sums of money and there should be a lot to learn from their methodology.«

Andrew Garrad,
Member of the Supervisory Board DNV GL Energy

EERA European Energy Research Alliance

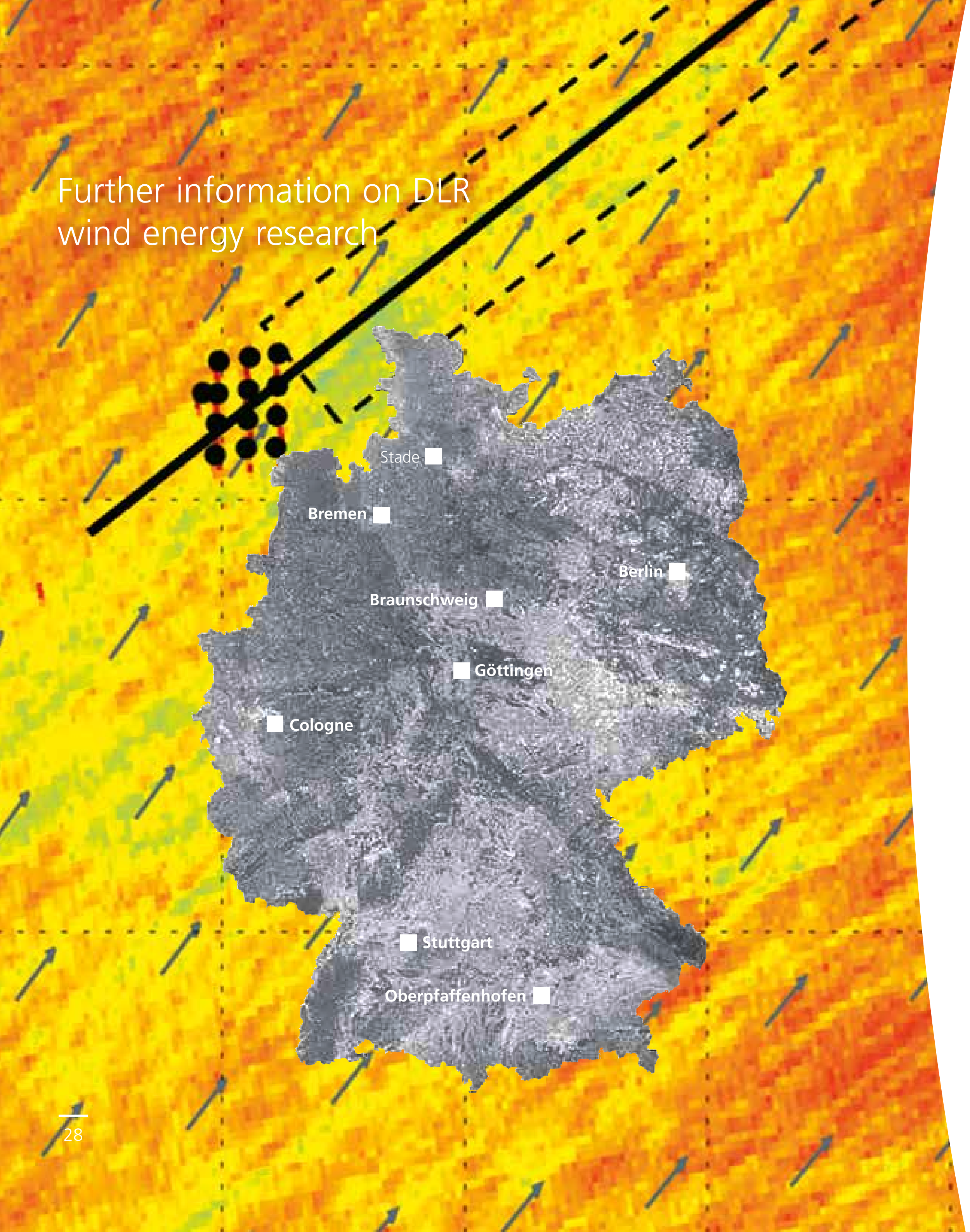
iea International Energy Agency

FVEE ForschungsVerbund Erneuerbare Energien Renewable Energy Research Association

DLR collaborates with numerous industrial enterprises to work jointly on crucial aspects for the further development of wind energy. In addition, we intensely agree on and match research activities with national and international institutions. The **Renewable Energy Research Association** (FVEE) is a collaboration of research institutes throughout Germany and the largest research network for renewables in Europe. The **European Energy Research Alliance** (EERA) is an independent network comprising more than 250 European research centres and universities. The long-term research activities are organised in joint programmes allocated to the corresponding technology. The **International Energy Agency** (IEA) is a free association of OECD nations bundling the member countries' activities in research, development and use of renewable energies in the Renewable Energy Working Party (REWP). National experts and players from industry cooperate in the **'Implementing Agreements'** (IEA) in research projects and specialised technology clusters. In addition, DLR is also connected with the **Helmholtz Association of German Research Centres** – for example to transfer knowledge in the field of aeronautics research.

The **Wind Energy Research Association** (FVWE), established in 2013, combines the expertise of approximately 600 scientists to give major impetus to energy production in the future. The three partner associations, ForWind – the joint Centre for Wind Energy Research of the universities of Oldenburg, Hannover and Bremen – the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) Northwest and DLR are well staffed and interlinked with industry, government and research, enabling them to work successfully on large-scale and strategic long-term projects. These competencies and skills provide a broad basis for optimised and socially accepted wind turbines, supporting the German wind energy industry in the technology lead with regard to international competitors. Speaking with one voice through the Research Alliance is an international statement paving the way to synergies for large wind power projects.

Further information on DLR wind energy research



messtec.DLR.de

DLR MessTec –
The DLR measurement technology and facilities database

The 'MessTec' database provides a detailed overview of the expertise in measurement technology and the DLR test facilities. Currently, it comprises data from 220 measurement technologies available at DLR and the 250 test rigs, which are also accessible to interested users in industry. Among other things, the database shows a description of the measurement technology or facility, as well as a definition of the value of the measured parameters and the application area.

elib.DLR.de

DLR eLIB:
Electronic library for DLR publications

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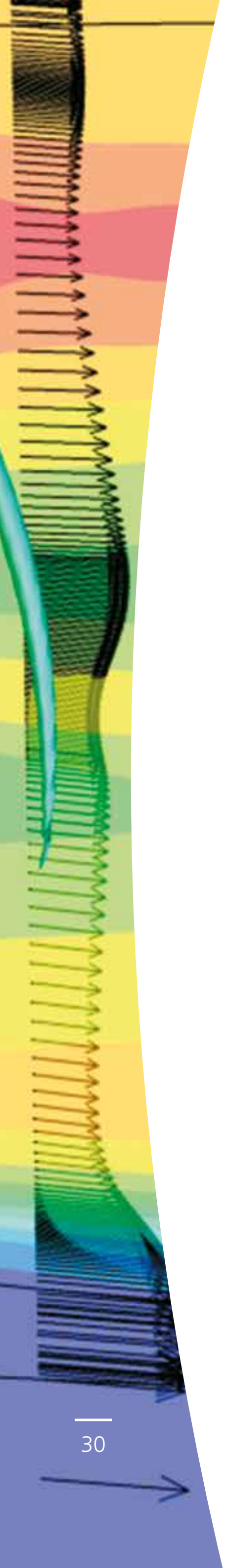

Your contact at DLR

Institute of Aerodynamics and Flow Technology
Simulation methods (CFD, CAA, FSC), profile design, rotor blade aeroacoustics

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DLR.de/as/en

DLR Braunschweig
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Institute of Aeroelasticity
Structural dynamics, aeroelastic stability, flutter, aeroelastic tailoring, loads

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DLR.de/ae/en

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Institute of Propulsion Technology
Acoustic measurements under free field conditions, microphone array technology for stationary and mobile sources of noise simulation methods, rotor blade design and automatised optimisation

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Institute of Composite Structures and Adaptive Systems
Rotor blade design, fatigue analysis, production processes, automation of manufacturing processes, quality assurance in production, sensor systems for structural health monitoring, smart materials, and active structures

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Institute of Flight Systems
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Remote Sensing Technology Institute
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Institute of Atmospheric Physics
Wind field measurements (LIDAR) and simulation (LES), noise propagation and immission, site assessment

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Institute of Engineering Thermodynamics
Energy systems analysis, energy storage, fuel cells and electrolysis

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