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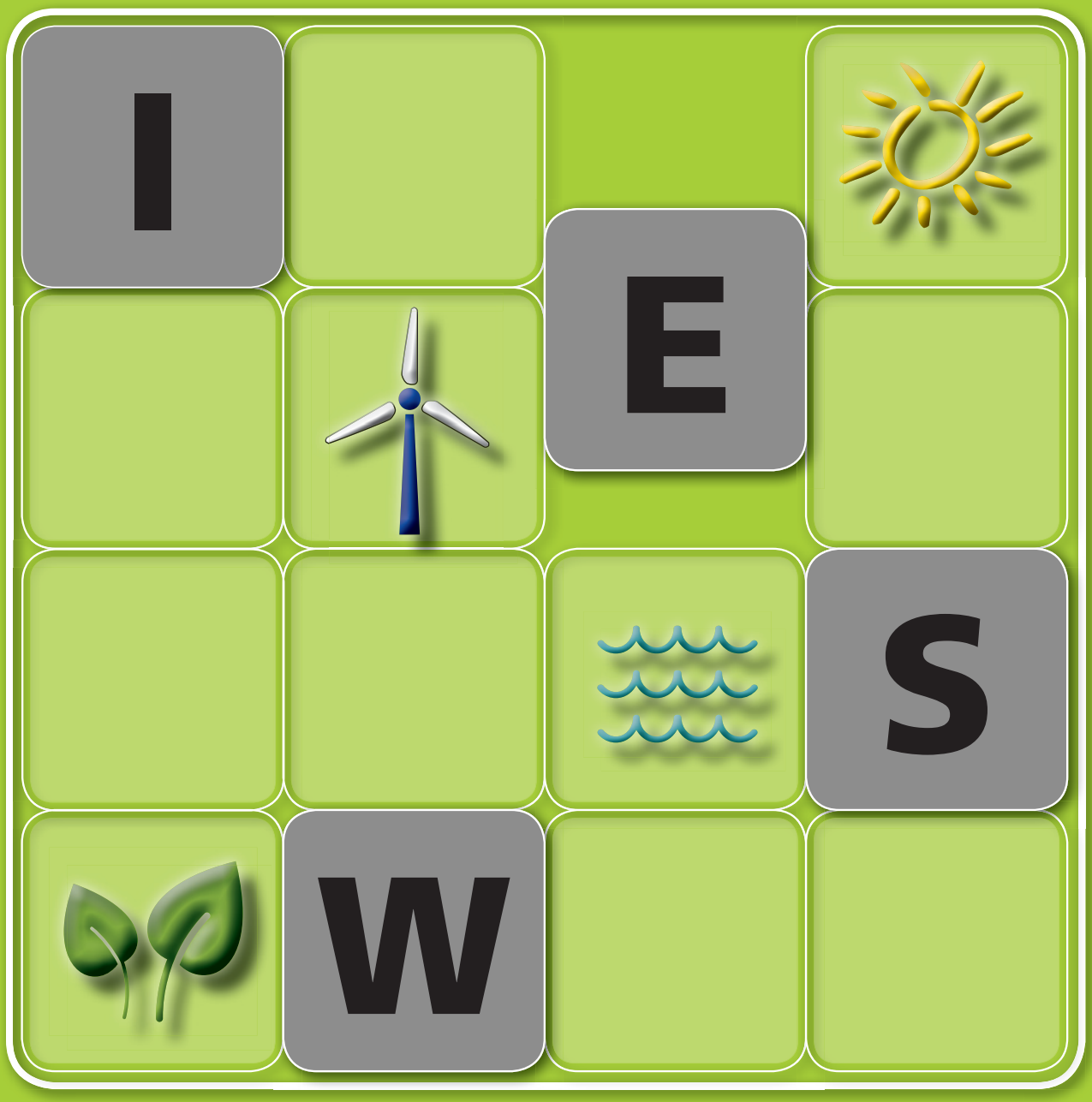
FRAUNHOFER INSTITUTE FOR WIND ENERGY AND ENERGY SYSTEM TECHNOLOGY IWES



ANNUAL REPORT 2011/2012

Fraunhofer Institute for Wind Energy and Energy System Technology

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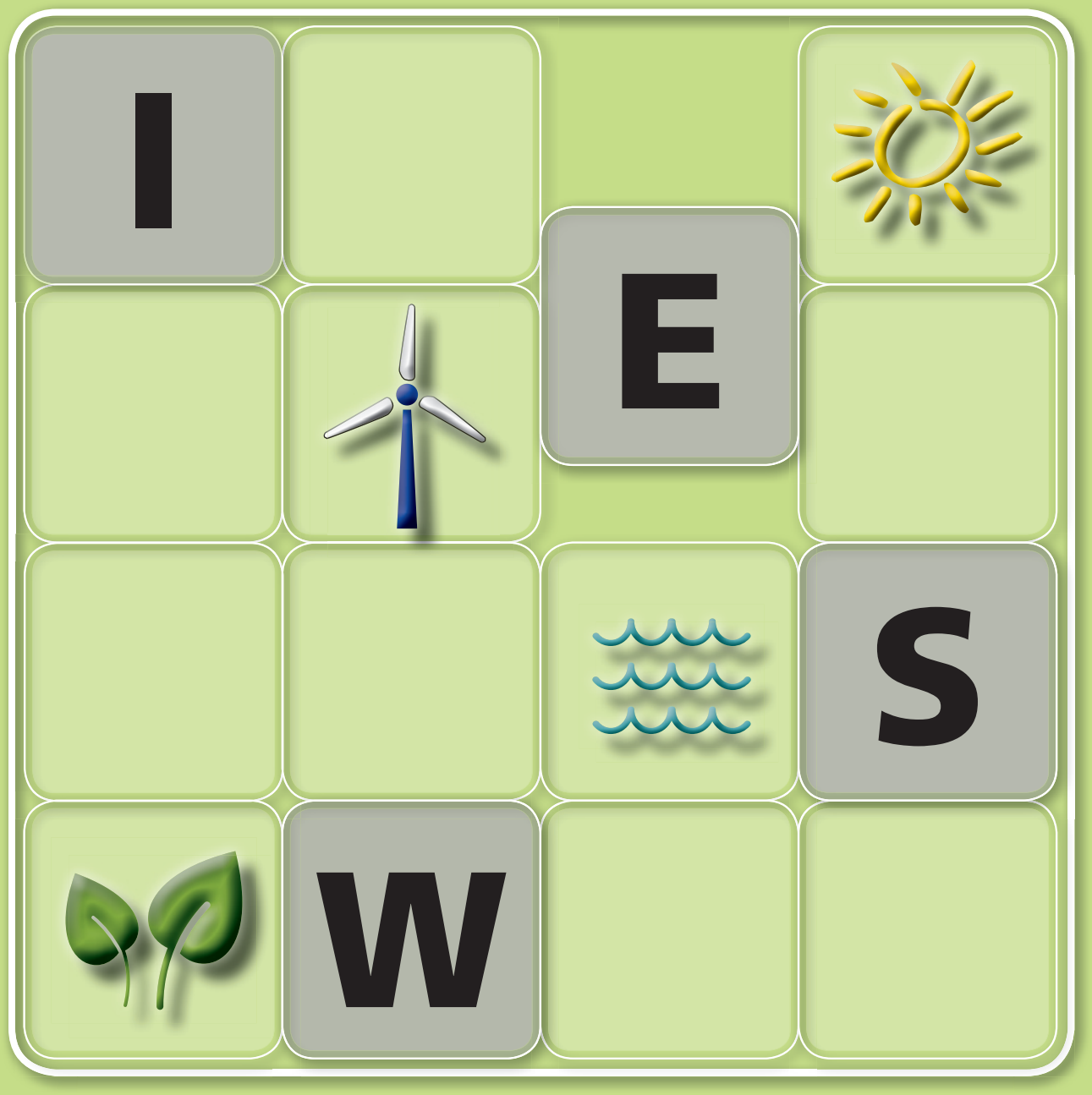

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PREFACE

Growing together – combining resources for a shared goal

In 2011, energy transformation became official policy – the age of renewable energy has begun. The path to transformation requires a clear programme, a well-planned, strategically oriented course of action, and decisive steps. The associated changes are wide-ranging and will define our quality of living and that of future generations. They will also determine the course of Germany's future as an industrial nation. This historic challenge offers a great opportunity: the current 2011 Report on the Environmental Economy, drawn up by the Federal Ministry for the Environment and the Federal Environment Agency, demonstrates that against the general trend, goods production in the environmental industry has increased. According to strategy consultants Roland Berger, worldwide growth rates in sales of photovoltaics, solar thermal energy systems, biogas systems and wind energy are expected to reach between 15 and 30 percent and more depending on the sector.

The future potential of the environmental industry is based on an above-average proportion of research: almost 80 percent of production sectors in the environmental industry are especially both research and knowledge-intensive, according to the report. This trend is also reflected in the indicators compiled by Fraunhofer IWES for the year 2011: the institute's previous growth has accelerated substantially, with its overall budget increasing to 31 million euros (2010: 22 million euros). All three funding pillars – business revenue, public revenue and EU revenue – have increased significantly. Both the operating and the investment budget have been raised – by approximately 5 million and approximately 4 million euros respectively. This growth is manifested in the opening of our new test centre for rotor blades of up to 90 metres in length, our test centre for smart grids and electromobility and our biogas production research centre, the only one of its kind in Germany. We were able to reach these milestones in 2011 thanks to support from the Federal Government and the federal states of Bremen, Hesse and Lower Saxony.

Expanding our infrastructure is the "hardware", but only motivated employees who contribute specialist expertize and experience and take pleasure in meeting challenges enable us to maintain our high level of performance. The number of specialist staff supporting the operation of our existing infrastructure and its further expansion has increased to a total of over 370 at the IWES sites in Bremerhaven, Oldenburg, Hanover, Kassel and Saarbrücken. Integrating them, giving their enthusiasm in the search for new solutions sufficient room, and systematically networking competencies across department, location and institute boundaries is the major challenge arising from this development.

On the wider level of innovation and environmental policy, the central challenge is also to strategically combine existing resources. A coordinated research programme is an indispensable requirement for the work of policy makers, industry representatives and researchers alike. Fraunhofer IWES has therefore joined forces with ForWind, the centre for wind energy research of the Universities of Oldenburg, Hanover and Bremen, to form the Forschungsverbund Windenergie, which coordinates the shared use of infrastructures both existing and currently under development, manages the institutions' cooperation in European committees and defines key research areas for the coming years.

Along with the advancement of usage technologies, the proliferation of the various forms of renewable energy means that a structured reshaping of our energy supply systems is becoming increasingly important. Fraunhofer IWES is contributing significant research in this area and further intensifying its already high levels of national and international networking, in particular its ties to other institutes within the Fraunhofer-Gesellschaft. At the same time, we hope to also continue expanding our institute, as the challenges posed by the energy transformation are significant and diverse.

Prof. Dr. Andreas Reuter
Director IWES North-West

Prof. Dr. Jürgen Schmid
Director IWES Kassel

BRIEF PORTRAIT OF FRAUNHOFER IWES

Objectives and main areas of work

The research activities of the Fraunhofer Institute for Wind Energy and Energy System Technology IWES cover all aspects of wind energy and the integration of renewable energies into energy supply structures.

The main areas of research are:

- Technology and operational management of wind turbines and wind farms
- Dynamics of wind turbines and components
- Component development for rotors, drive trains, and foundations
- Test and evaluation methods for wind turbines and components
- Environmental analyses of wind, sea, and seabed for utilization of wind energy and marine energy
- Control and system integration of decentralized energy converters and storage systems
- Energy management and grid operation
- Energy supply structures and system analysis

Development of Fraunhofer IWES

Fraunhofer IWES was founded at the start of 2009 through the merger of the former Fraunhofer Center for Wind Energy and Maritime Engineering CWMT in Bremerhaven and the Institut für Solare Energieversorgungstechnik ISET e.V. in Kassel.

By agreement with the Fraunhofer-Gesellschaft, the institute directors also hold professorships at the universities in Hanover and Kassel. Fraunhofer IWES in Bremerhaven is headed by Prof. Dr. Andreas Reuter who is Professor of Wind Energy Technology at the University of Hanover. Director of the Kassel site is Prof. Dr. Jürgen Schmid, who has been chairman of the ISET Executive Board since 1998. A new Director is expected to be appointed in the Autumn of 2012, at which time Professor Schmid will retire.

The growth of the institute was considerably accelerated in 2011 and revenues were increased to approx. 31 million euros in total. Of this sum, 9 million euros were invested in infrastructural expansion. Income from industry grew from 3.5 to 4.6 million euros. In order to meet its new challenges, Fraunhofer IWES was able to start 2012 with more than 370 employees as opposed to 300 in 2011.

Collaboration

Fraunhofer IWES works very closely with the ForWind alliance universities of Hanover, Oldenburg, and Bremen. Both partners form the new Nationalen Forschungsverbund Windenergie (National Wind Energy Research Alliance). Further intensive collaborative work is carried out with the Universities of Kassel and Stuttgart. Moreover, amongst other colleges, contact with the Bremerhaven Technical College has been further strengthened.

A additional collaboration began in Bad Hersfeld in August 2011 with the Hessian Biogas Research Center – HBFZ at the Landwirtschaftszentrum Eichhof which is run jointly with the Landesbetrieb Landwirtschaft Hessen.

Within the Fraunhofer-Gesellschaft, use is made of the expertize and experience of partner institutes especially through the Fraunhofer Energy Alliance, and in Fraunhofer networks in the area of Wind Energy and Smart Grids.

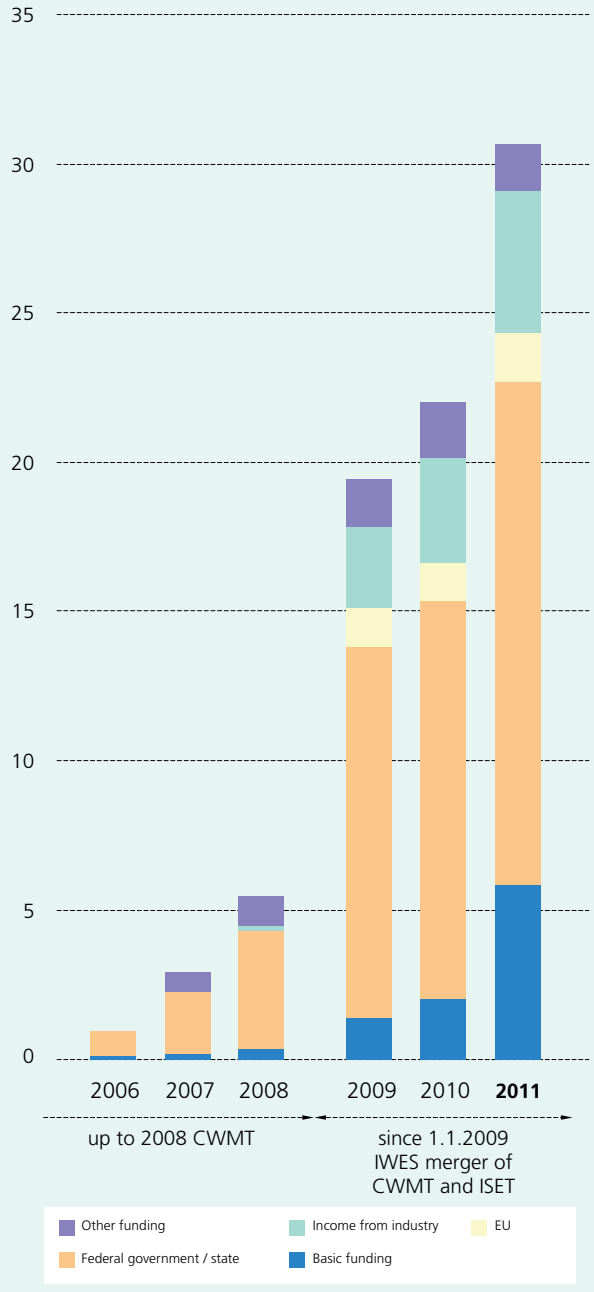
At a national and international level the institute successfully collaborates with many public and industrial research organizations. The application-oriented work of Fraunhofer IWES is highlighted by the large number of direct projects and contracts with industry.

Our research results are the basis for the participation of many IWES scientists in national and international bodies such as DKE, CENELEC, and IEC and the use of those results for standardization and norms. With its technical expertize, Fraunhofer IWES is thus able to shape political and commercial decision-making processes, for example the drawing up of the Renewable Energy Act, development of offshore wind energy utilization, development of future energy supply structures, and participation in the German Advisory Council for Global Environmental Change (WBGU).

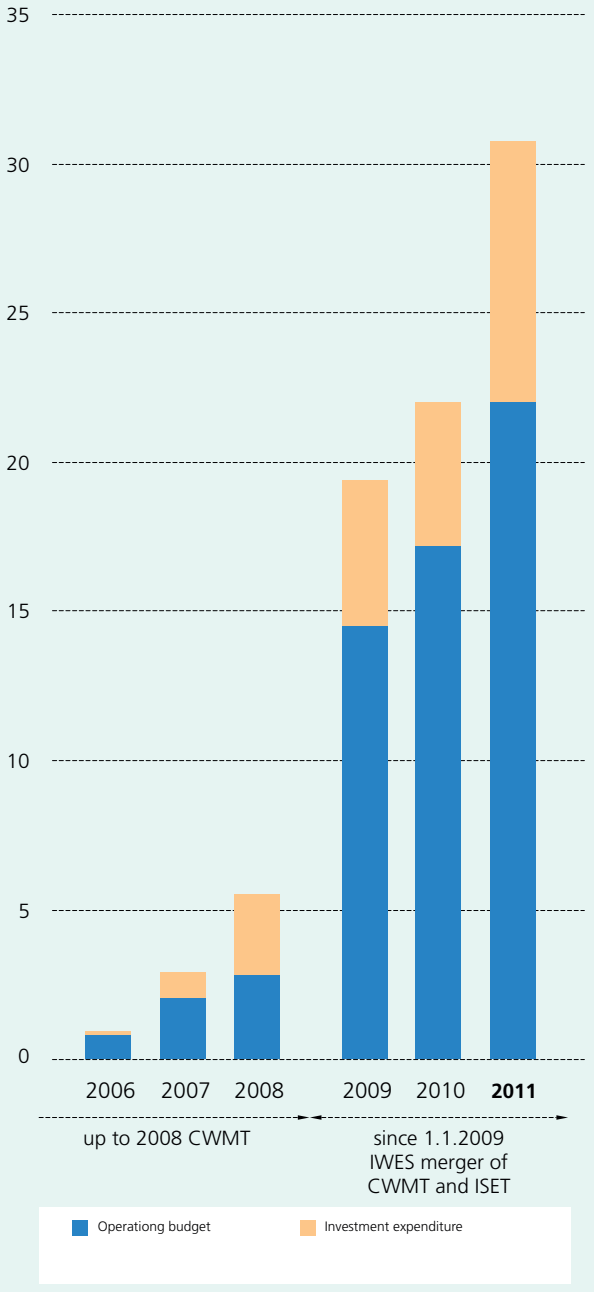
1 *Fraunhofer IWES in Kassel*
2 *New institute building in Bremerhaven*

FRAUNHOFER IWES IN FIGURES

Financing / Development of earnings
2011 in millions of euros



Development of operating and investment budget
2011 in millions of euros



Finance structure

IWES considerably accelerated its rate of growth in 2011 and significantly increased its total budget from 22 million euros to 31 million euros.

Compared to the previous year, the revenues from industry increased by more than one third to 4.8 million euros.

Public funding increased by 27 percent to reach a total of 16.9 million euros.

EU-Funding increased by 300k euros to 1.6 million euros and accounts for over 5 percent of the overall result.

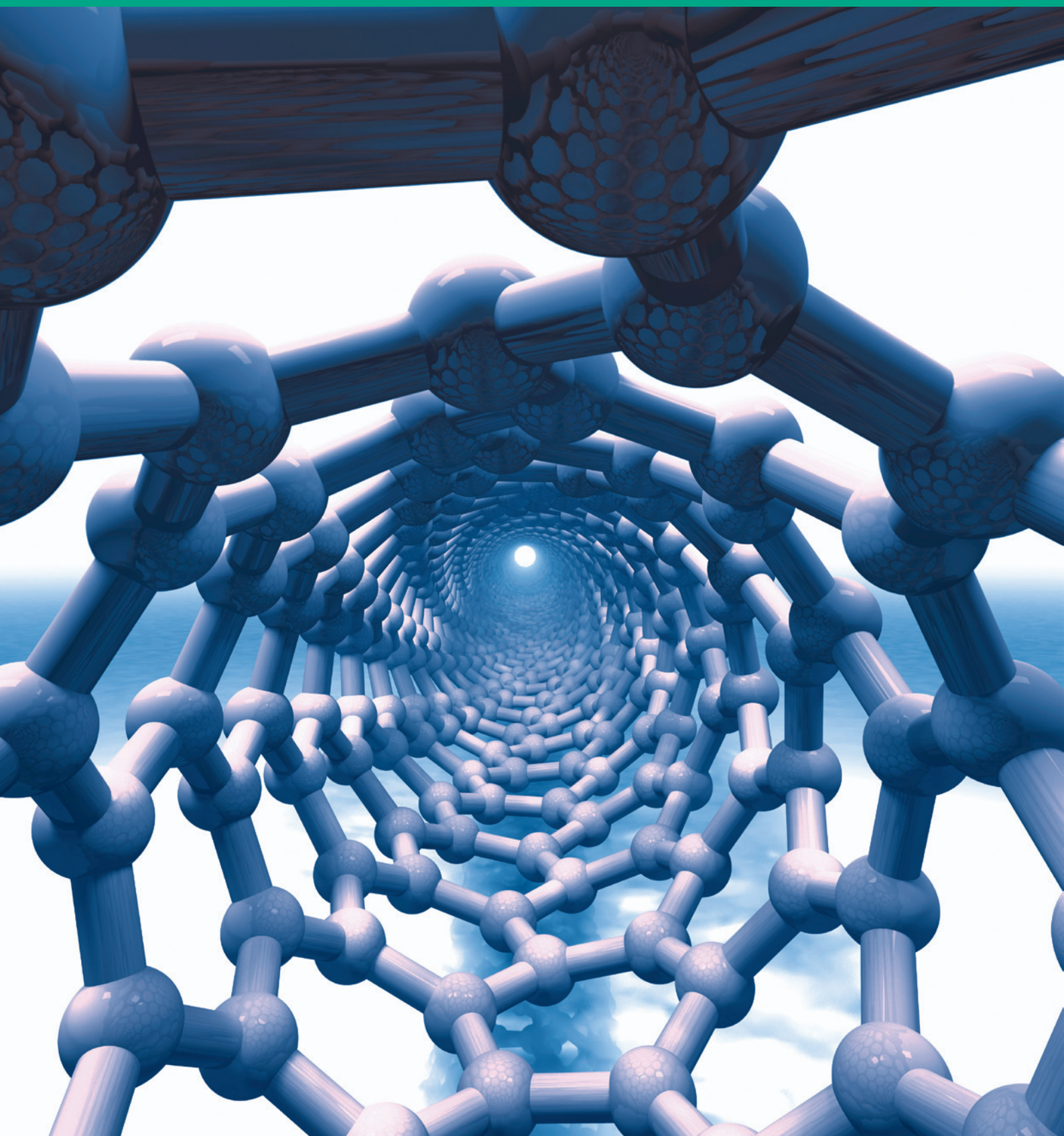
The continuing successful development of IWES as a whole was mainly due to an increase of 5 million euros in the operating budget and 4 million euros in investment funding. Investment funding reached the sum of 8.7 million euros and thus 28 percent of the total budget.

The main areas of investment were the further development of the rotor blade test center in Bremerhaven, while Kassel invested in the construction of test centers for smart grids and for bioenergy system technology.

Personnel

as at 31.12.	2009	2010	2011
scientists	110	138	192
technical staff	30	29	36
administration / internal services	25	31	48
assistants, trainees and students	29	27	100
total	**194**	**225**	**376**

THE FRAUNHOFER-GESELLSCHAFT



Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains more than 80 research units in Germany, including 60 Fraunhofer Institutes. The majority of the more than 20,000 staff are qualified scientists and engineers, who work with an annual research budget of 1.8 billion euros. Of this sum, more than 1.5 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

Affiliated international research centers and representative offices provide contact with the regions of greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

Carbon nanotubes are innovative materials of great promise. Nanotubes are being researched at Fraunhofer IWES for reinforcing rotor blades and improving the service life.
www.inno-cnt.de

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.

“OUR FOCUS IS RETURNING TO TECHNOLOGY DEVELOPMENT“

The goals have been set – but how do we advance the development of renewable energies while safeguarding value creation in Germany and ensuring its implementation by consensus with the population? Kerstin Deller, director of the Research and Development division in the Renewable Energies directorate of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), and Andreas Reuter, director of the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) North-West, answer this question.

Ms Deller, what long-term course do you hope to set? What part does Fraunhofer IWES play in your considerations?

Kerstin Deller: We have added a new key area "Regenerative energy supply systems – Integration of renewable energies" to our research funding programme, and are expanding it continuously. Optimizing our energy supply system is the central issue in developing regenerative energies. If we want to see a major proportion of renewable energies in our energy supply, we will have to find an answer to the question of how we can reliably provide energy when dealing with a large proportion of fluctuating energy sources. Networks, storage, regenerative combined cycle power plants – these are research topics that will ultimately benefit all forms of renewable energy. We are therefore placing increased emphasis on developing this area.

Our funding of alpha ventus and the RAVE research programme has meant that the focus in the field of wind energy has so far been very strongly on offshore research, including the accompanying ecological research. And we are continuing to see excellent research projects in this area. But currently our focus is returning to actual technology development, which benefits both onshore and offshore wind energy: for example in the form of advanced transmission systems and generators, process automation in rotor blade manufacturing, or systems to actively control rotor blades in operation.

Many small and a few large-scale contributions are shaping sustainable growth in an increasingly energy-conscious society

The BMU has supported and accompanied the creation and development of Fraunhofer IWES by providing project funding because we believe that there is an important role in Germany's research landscape for an institute that is able to cover almost all fields of wind research and the connection between wind and regenerative energy supply systems. Without saying that there should be THE institute for wind research, as is the case in other countries, a broadly positioned stakeholder that can also operate internationally is important. We believe that IWES bridges this gap well, and have the impression that it also collaborates well with the other institutes and organizations in wind energy research.

How can IWES ensure that it meets these expectations?

Andreas Reuter: I believe the concept of a "system approach" is extremely important: to not have one's eye on only one component or specialist discipline, but see the whole picture. At the very latest when you look at costs and effectiveness you find that it's all connected anyway. Therefore I think the size and scope of the institute is very important. Before IWES was founded, there was a wide range of wind-related activities in smaller organizations and institutes, but there was no overall approach. Size is necessary in order to provide the infrastructure that is indispensable if you want to promote research. Large-scale test facilities cannot be implemented without also covering the areas to the left and right of them. That is where I see our responsibility: we don't have to do it all, but we do have to have the necessary understanding of the system and be big enough to handle these large tasks – for example operating a nacelle testing facility.

What strengths and weaknesses do you see in Fraunhofer IWES?

Kerstin Deller: Fundamentally, there is a lot of expertize in the various disciplines at IWES, and the institute is well networked in the scene – these are strengths which must be developed further. The challenge I see is to ensure solid growth. Ultimately, research is conducted by people, so good research needs qualified personnel who have good ideas and are able to implement them. We support that implementation by providing funding.

Where do you see potential, and where do you see future challenges?

Andreas Reuter: I too consider recruiting well-trained expert personnel to be extremely important; the new "Wind Energy Engineering" Master's degree course at Leibniz Universität Hannover or the "Wind Energy Techniques" Master's degree course at the Bremerhaven University of Applied Sciences therefore form an important component. Being connected to a university, training young people for our own requirements and providing further training for specialist personnel are central building blocks for further growth. International networking is also important. The fact that other European countries are financially not so well off at the moment allows us to headhunt and employ good people. As a result, Fraunhofer IWES faces the challenge of embodying internationality, that means being able to communicate internationally, integrating new staff quickly, establishing a standard of quality. We are currently in the process of gaining our ISO certification in order to create a solid foundation for high-quality work.

The solar industry is struggling with competition from Chinese companies. Do you foresee similar developments in the wind industry?

Kerstin Deller: Competition is not a bad thing, in general it should be welcomed. A different matter would be if unfair methods were being used in that competition – that would require a response at trade policy level. But the issue is less about keeping others out, and more about being well positioned ourselves. Competition is generally becoming more severe in all areas of renewable energies. In terms of research policy we are therefore concentrating on funding application-related research and development, and promoting collaboration between industry and institutes in order to ensure that research results actually lead to competitive products.

How can research and development contribute to strengthening competition?

Andreas Reuter: I see a difference between the wind and the solar energy industry, as wind energy is far more complex. Photovoltaic cells are easier to copy and to transport. Wind turbine technology is more complex, especially in the offshore sector. Being able to cover the entire system offers a certain degree of protection. That is our advantage in the northwest cluster: networking across the entire value creation chain is extremely important for product optimization, but at the same time it protects us against copies of certain components being built in China or Korea. For research that means that we have to work on industrializing the process chain. Competition is necessary as long as it is fair. If we look at the process chain as a whole and develop it in a targeted fashion, that protects us from the situation where only a small amount of value creation remains in Germany.

People generally approve of renewable energy development, but when it becomes apparent in their immediate surroundings, they reject it. How can its acceptance be increased?

Kerstin Deller: The only way to create acceptance is to involve people early on, to provide good and timely information and create an understanding of the technologies and interrelationships. That is a task for politics. Research, particularly technology research, can contribute by finding a way to design the de-


Andreas Reuter


Kerstin Deller

velopment of infrastructure for utilizing renewable resources in such a way that it does not affect the people on the ground, or affects them as little as possible. Our research funding also supports social science components of technology-oriented projects that promote acceptance. Examples can be found for instance in geothermal energy, but noise abatement projects are also specific examples of how technology research can contribute to acceptance.

How can research contribute to balancing the interests of economy, ecology and society?

Andreas Reuter: We have to explain far more what we are specifically doing, and convey an enthusiasm for technology. Research is still seen as a separate entity, many people fail to realise how research work benefits them. People have an entirely different attitude after ascending a wind turbine for the first time than when they only see them as they drive by on the motorway. We have to create an enthusiasm for technology and the research behind it, and promote an openness to change. More and better PR work can be very valuable here. Targeted communication has to convey how much better the new solutions are compared to the status quo – we are currently still far too hesitant in that respect. We describe the downsides in great detail instead of focusing on the sustainability and controllability of an energy supply from renewable sources. If we someday find a better way to generate energy, we can dismantle the current wind energy systems completely and with no lasting damage. Many people don't realise that, but a better understanding would also increase acceptance.

Peering into the crystal ball: what will our energy mix look like in 2040? How do you explain current climate phenomena and the impending changes to your children?

Kerstin Deller: I hope that the energy mix will be compatible with the requirements arising from the need for climate protection – a massive reduction of greenhouse gas emissions by over 80 percent by 2050, so by at least 70 percent by 2040. That means that by 2040 almost half of our final energy consumption and 60 to 70 percent of our electricity supply would have to be based on renewable energies. We will also have to achieve a significant increase in energy efficiency. The scenarios underpinning the Energy Concept have shown that this could be done in an economically feasible way. We are doing everything we can to encourage development in this direction. I discuss climate and energy policy with my children when there is a specific occasion – e.g. if they ask why polar bears no longer have enough ice floes, or why we take the train or get on our bikes in the morning instead of conveniently getting into the car. I try to teach them that there is a connection between large-scale climate change and the little things we do in our everyday lives, and raise them not to use energy or other resources unnecessarily or thoughtlessly. I also encourage them to form their own opinions – but at 4 and 6 years of age they're still a little young for that.

Your children are teenagers and already have a clear opinion on energy matters. What is it?

Andreas Reuter: My children have a clear and uncompromising demand: they want my generation to act now so that the world we leave behind is still liveable. For them, renewable energy sources are an obvious choice because they've grown up with the subject. They see nuclear power stations as dinosaurs that are still roaming the Earth. They find it hard to accept that it's all taking so long. They see what lies in store for them and that it's far from harmless. The target of 2040 is generous – I believe change is possible more quickly.

ENERGY TRANSFORMATION: “YES, THERE ARE RISKS, BUT THE OPPORTUNITIES ARE GREATER!”

Following the nuclear disaster in Fukushima in March 2011, the German government has revised its Energy Concept and decided to phase out the use of nuclear power in Germany. The Federal Government wants to become one of the world's most energy-efficient economies and enter the age of renewable energies as quickly as possible. Prof. Jürgen Schmid discusses the challenges and risks of this great future project with Dr. Knut Kübler of the Federal Ministry of Economics and Technology.

Jürgen Schmid: Dr. Kübler, what does the Federal Government's decision on energy transformation mean for your work as head of department and coordinator of the energy research programme?

Knut Kübler: As one of the first steps towards implementing its Energy Concept, the Federal Government has revised its energy research policy. The 6th Energy Research Programme was adopted by the Cabinet on August 3, 2011, and gives industry and science a clear indication of future funding priorities. This programme is a joint effort of the Federal Ministry of Economics and Technology (BMWi), the Federal Ministry of the Environment (BMU), the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) and the Federal Ministry of Education and Research (BMBF). My job as the responsible head of department for energy research at the BMWi was to bring together the various interests of the individual portfolios and develop a programme that could contribute effectively to the intended transformation of Germany's energy supply. If I have succeeded in this, it is thanks largely to my dedicated and motivated colleagues. Working on the energy research programme has shown that nothing motivates people more than finding meaning in their work.

Renewable energy sources require changes to the network infrastructure, an expansion of energy storage and adjustments in consumer behaviour

Jürgen Schmid: How important do you believe expanding existing and creating intelligent networks is for transforming our energy systems?

Knut Kübler: The Federal Government wants to become one of the world's most energy-efficient economies and enter the age of renewable energies as quickly as possible. In order to integrate renewable energy sources into our energy system we need to make changes to our network infrastructure, to expand our energy storage, and lastly we also need changes in consumer behaviour, which thanks to the latest developments in the field of information and communication technologies are now possible without causing consumers any loss of comfort. All three options, "network expansion", "energy storage" and "demand-side management", are important if we are to successfully restructure our energy supply systems. To what extent each will be applied is difficult to say today. New energy networks are part of the solution, not the solution.

Jürgen Schmid: What key areas do you see for the further development of energy storage?

Knut Kübler: Among specialists there is today a consensus that the further development of energy storage is of central importance. This is particularly the case regarding the opportunities for photovoltaics to expand its share of a more competitive energy market. Further research and development will initially be needed here. In 2010 the Federal Government launched a cross-departmental funding initiative called "Energy Storage" and made 200 million euros available for it. The vast response to this funding initiative (over 400 funding applications) demonstrates the interest of industry

and science in this topic. The participating ministries – BMWi, BMU and BMBF – will be approving the first projects in the coming weeks.

Jürgen Schmid: The transformation will not succeed without significant increases in efficiency. Where do you see the greatest potential in this area, and what measures could allow us to tap this efficiency potential more quickly?

Knut Kübler: Energy efficiency and energy savings are the key to a sustainable energy future. The development of renewable energy sources also depends on our progress regarding energy efficiency, as "it is easier for a camel to go through the eye of a needle than an inefficient economy to enter the kingdom of renewable energies". We have to address all levels of the energy chain – energy generation, energy transport and energy consumption. Where is the greatest potential? This question can be answered by looking at the energy balance. Approximately 40 percent of our total energy consumption is used for buildings. That is one of the areas that will determine whether energy transformation in Germany succeeds or not. Research and development can contribute to tapping this potential, particularly in order to provide the necessary energy technologies that are able to compete on the market and will be accepted by consumers.

Jürgen Schmid: What could researchers do better, in your opinion, to ensure that the transformation succeeds?

Knut Kübler: That question is difficult to answer, and would require more space than is available for an interview such as this. To nonetheless give you an answer, I would like to quote Albert Einstein, who recommended to his colleagues that they should "spend at least half an hour a day thinking the opposite of what science considers certain«. Although we have an idea of how our energy system works, we should not underestimate how little we actually know.

Jürgen Schmid: What risks do you see for creating and operating an energy system that is based mainly on renewable energies?

Knut Kübler: Everything in life has its risks. Creating an energy system based on renewable energy sources also has its risks. Some say an energy supply is secure when you have more energy at your disposal than you need. Ensuring this criterion in the transition phase from today's to a future energy supply system is one of the greatest challenges. So, yes, there are risks, but the opportunities are greater!

Jürgen Schmid: Do you see energy research in Germany as well placed to meet the challenges resulting from energy transformation?

Knut Kübler: Germany has good basic research, a powerful scientific and technological infrastructure and outstanding industrial energy research. Many member states in Europe envy us this system. The energy research budget provided by the Federal Government is also ample. From 2011 to 2014, approximately 3.5 billion euros will be made available through the energy research programme to promote the research and development of sustainable energy technologies.

Jürgen Schmid: Is German energy research sufficiently networked at a European and global level or should it seek to become better connected?

Knut Kübler: One of the most important new aspects of the Federal Government's energy research policy is its greater international orientation. Germany's energy market is shrinking, while the energy markets in developing and emerging countries, but also in many other industrialised countries are expanding. Research and technology policy will also have to adjust to these trends. In a European context, the Strategic Energy Technology Plan (SET Plan) offers the appropriate framework. Germany will be placing particular emphasis on this area in the future in order to ensure the success of the SET Plan.

Knut Kübler

Jürgen Schmid

Jürgen Schmid: You privately operate both a thermal solar power system and a photovoltaics system. What has been your experience of these?

Knut Kübler: I have been operating a solar water heating system (3 m^3 evacuated tube collectors) and a photovoltaics system (1.02 kW, monocrystalline) on the roof of my house since 1993. My experience confirms the general opinion: it is possible to heat water and generate electricity with solar power in Germany, but under the current standard calculation methods neither technology is competitive without financial assistance. Nonetheless I advise people to invest in these technologies, and to do so without accessing state funding if possible. From my personal experience I know that it simply feels better to be doing something for the environment without putting one's hands in the pockets of one's tax-paying or energy-consuming neighbour.

Jürgen Schmid: Do you believe that the energy transformation will succeed?

Knut Kübler: I firmly believe that the energy transformation will succeed, but I would nonetheless advise all concerned parties to also be prepared for the possibility that things might develop differently – as always in life.

TEST CENTRES AND LABORATORIES

Fraunhofer IWES possesses extensive testing and experimental facilities, laboratories, and state-of-the-art equipment. Our expertize has allowed us to develop and introduce new testing facilities and test methods. These facilities, coupled with the know-how of our scientists and engineers, enable Fraunhofer IWES to offer its customers and partners world class research and development services and infrastructure. Our main facilities and services are described in brief here. More detailed information and the names of contact persons can be found at www.iwes.fraunhofer.de

Competence Center Rotor Blades

Static and fatigue tests on full-scale rotor blades verify that the design and manufacturing of the blade can withstand the loads that have been calculated for its 20 year life-span. The test stand can accommodate rotor blades up to 90 m in length and has a bending moment capacity of up to 115 MNm. Static test loads can be applied using up to 8 hydraulic cylinders, which enables precise control of the applied loading. Up to 250 strain gages along with load cells, cable sensors, angle sensors, acceleration, and temperature/humidity sensors provide a wealth of meaningful data. Utilizing the installed instrumentation, the eigenfrequencies can be determined through measurement and frequency analyses.

In addition to the testing of full-scale rotor blades, the laboratory infrastructure has facilities for coupon and component testing, providing characteristic values for the evaluation and development of rotor blade materials and structures. For sub-component and component structural testing, a 12 m x 3 m test bench with adaptable mounting and hold-down setups and versatile loading capabilities, i.e. hydraulic cylinders up 100 kN and an excenter with 20 kN at 2 Hz, is utilized. This adaptable test bench is useable for various sub-component and component tests such as the characterization of bonded joints by static and dynamic 3 point beam bending tests. The operational lifetime of a rotor blade is then determined from the results of the coupon and full-scale rotor blade tests.

↘ Dr.-Ing. Arno van Wingerde
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Offshore test locations

The cumulative loads at an offshore test site differ considerably from the loads on materials in laboratory tests. Materials are subjected to extreme conditions offshore: temperature fluctuations, increased UV radiation, exposure to seawater, biologically induced corrosion and mechanical loads. At four test locations – Wilhelmshaven, Sylt, Helgoland and at the mouth of the River Weser – materials and components are being tested under offshore conditions in order to acquire new knowledge about the long-term stability of sensor systems.

As the environmental conditions at the locations differ, so do the damage profiles. Accordingly, customized strategies for protection are being developed. Sensors are being increasingly used in offshore wind turbines for recording material fatigue data. They can detect very small changes in the material structure and report these to the system.

The results are used for validation and improvement of current laboratory test methods. Laboratory material tests designed to mimic and increase the real loads are able to give meaningful statements in a short space of time. In turn, these results are used for developing general standard tests for offshore materials and components. New methods for material testing are also developed for specific tasks.

↘ Dr. rer. nat. Hanno Schnars, hanno.schnars@iwes.fraunhofer.de

Performance test areas for small wind turbine prototypes up to 50 kW

Fraunhofer IWES has installed two performance test areas for small wind turbines: in Bremerhaven, directly next door to the engineering building and the rotor blade test halls, and on the SysTec grounds very close to Kassel. Successful small wind turbine projects require robust, cost-effective design and best possible production management. The aim therefore is to optimize prototypes and commercial turbines in long-term tests in preparation for later certification. The test infrastructure enables the operation of small wind energy turbines with a performance of up to 50 kW and with a maximum height of 60 metres.

↘ Dr.-Ing. Jan Wenske, jan.wenske@iwes.fraunhofer.de
↘ Paul Kühn, paul.kuehn@iwes.fraunhofer.de

Climate chamber for simultaneous simulation of mechanical and environmental influences

Fraunhofer IWES has developed a special offshore test chamber; which for the first time simultaneously simulates the mechanical and environmental loads that offshore wind turbines are subjected to. This allows realistic simulation of the actual loads under offshore conditions and gives feedback about the reliability of the systems under test and their service life. This test facility is a valuable addition to the offshore test locations as the information being acquired there about the mechanisms of material failure are used to design near-reality tests under laboratory conditions. Laboratory tests that give reliable statements about material behavior are beneficial for customers, due to the accelerated testing and the reproducibility of the results. This allows accurate conclusions to be drawn about service life and effective protection strategies to be developed.

↘ Dr. Holger Huhn, holger.huhn@iwes.fraunhofer.de

Wind measuring network and 200 meter measuring mast

Fraunhofer IWES has since 1990 operated a Germany-wide network of measuring masts. The network currently comprises 30 masts. All the measuring stations are close to wind farms and are fitted with MEASNET calibrated anemometers. Besides the standard 30 m masts (for wind measurement at heights of 10 m and 30 m), four 50 m masts have also been erected. These allow not only wind conditions but also other meteorological data to be recorded. The measurement data are recorded at a sampling rate of 1 Hz and are transferred hourly in 5 minute data sets to the data center in Kassel. In addition, Fraunhofer IWES operates three mobile LIDAR measuring units and these will be complemented this year by a 200 m measuring mast.

↘ Reinhard Mackensen,
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↘ Paul Kühn, paul.kuehn@iwes.fraunhofer.de

Laboratory for control systems for large wind turbines

A development platform for pitch control systems for rotor blades for large wind turbines is available in Kassel which enables load-reducing control systems to be developed. The test stand allows realistic testing of three interacting, controlled pitch drives for individual blade pitch control. Near-real counter-moments are produced via the real-time simulation of large wind turbines using synthesized inhomogeneous and turbulent wind fields. Additionally there is a test stand for antagonistically controlled pitch drives which permits very low-load blade pitch control.

↘ Martin Shan, martin.shan@iwes.fraunhofer.de

HBFZ: Hessian Biogas Research Center

The HBFZ came in to being in August 2011. In cooperation with the Hessian Department of Agriculture (LLH), the Hessian state laboratory (LHL) and the Eichhof Agricultural Training and Research Center, Fraunhofer IWES operates an experimental center for bioenergy system technology in Bad Hersfeld (Hesse). The whole process chain from biomass production through to grid integration is covered here. A biogas test plant with a raw gas capacity of up to 50 m^3/h is available for demonstration purposes and pilot plant trials. Up to 6 containers with test equipment can be provided. Experiments on biomass preparation, residue treatment, thermal biogas utilization, and gas upgrading and feeding are possible. Laboratories are also available for investigating specific biological, chemical, and physical parameters.

↘ Dr. sc. agr. Imme Deecke

DeMoTec: Design-Centre for Modular Supply Technology

The DeMoTec Center is jointly operated with the University of Kassel. Decentralized electricity generators, storage systems, loads, and novel energy management systems are developed and tested here. The network integration of converters and the design of hybrid systems and island grids have special roles. The control technology for decentralized grid services can be tested here on a real scale in combination with decentralized generators. In particular, systems for electrification in rural areas remote from the grid and on islands are optimized here and are used for training purposes. A reproducible hardware simulation of a 90 kVA grid connection and an adjustable direct current source allow accredited testing of grid converters and the evaluation of photovoltaic converters for example with regard to MPP tracking behavior.

↘ Markus Landau, markus.landau@iwes.fraunhofer.de

Accredited test laboratories for converters and electromagnetic compatability

Fraunhofer IWES, in its DIN EN ISO/IEC 17025 accredited laboratory, is investigating electromagnatic disturbance emissions and disturbance immunity as well as grid characteristics and efficiency factors of converters and decentralised power plants. The framework of accreditation covers, for instance BDEW tests, FGW-TR3 and DIN EN 50530, alongside the classic EMV testing norms. Development accompanying tests for the qualification of finished devices and components, especially converters, are also available.

↘ Jörg Kirchhof, joerg.kirchhof@iwes.fraunhofer.de

Development laboratories for converters

Fraunhofer IWES develops converters for wind turbines, battery systems and other decentralized electricity generators. Several laboratories are available for the development of electronic circuits. In the laboratory for microprocessor and device-oriented software technology, control circuits for converters can be developed using the hardware-in-the-loop and rapid-prototyping methods. The reliability of equipment can be tested in climate chambers and thermographically.

↘ Dr. Norbert Henze, norbert.henze@iwes.fraunhofer.de

Battery laboratories

The infrastructure for testing electrochemical systems comprises automated charging and discharging equipment, climate chambers, and the necessary measuring technology and safety technology. There is also a laboratory for testing fuel cell systems. These facilities are complemented by a development platform for virtual and multi-virtual electrochemical systems such as starter batteries and virtual lithium ion cells.

↘ Matthias Puchta, matthias.puchta@iwes.fraunhofer.de

IWES SysTec: Test Centre for Intelligent Networks and Electromobility

The new Fraunhofer test centre for intelligent networks and electromobility IWES SysTec was brought on line in 2011. The test centre comprises:

- PNI Grid Integration Research and Test Laboratory
- TPE Electromobility Test and Proving Centre
- Photovoltaic System Outdoor Test Areas

↘ Dr. rer. nat Thomas Degner, thomas.degner@iwes.fraunhofer.de

IWES PNI: Grid Integration Research and Test Laboratory

The new PNI is a reference laboratory, in which grid components and power supply operation equipment can be realistically developent and tested with regard to new system functions. The main focuses are grid storage interfaces, generators, combined heat and power plants, variable loads, electric vehicles, and adjustable transformers. The infrastructure enables investigation in low and medium voltage grids with a performance of up to 6 MVA. The laboratory can provide proof of behaviour of the devices and equipment under varying grid conditions especially in regard to the following aspects: static voltage support, voltage maintenance, dynamic votage support, feed and load management dynamische frequency support, co-ordinated control characteristics.

↘ Dr.-Ing. Gunter Arnold, gunter.arnold@iwes.fraunhofer.de

IWES TPE: Electromobility Test and Prove Centre

In the IWES TPE, IWES and partners from industry and the Kassel University research association for vehicle systems technology develop and test electric vehicles, batteries and charging systems as well as grid integration. On a dynamometer, vehicles and battery layouts in specific driving conditions can be tuned to compatibilty with the help of high-precision battery simulators (virtual batteries). Inductive loading is being further developed on electric vehicle charging stations and on a dedicated test circuit. Network simulators help develop the charging stations and the corresponding converter technology, and optimize them in response to new demands from so-called intelligent networks (smart grids).

↘ Markus Landau, markus.landau@iwes.fraunhofer.de

Outdoor testfields for photovoltaic systems

In outdoor test fields for photovoltaic systems, individual modules and complete systems are measured over a long period in accordance with European guidelines for different manufacturers. Kassel is a key reference site for standardized tests offered by DERlab e.V. Europe-wide.

↘ Peter Funtan, peter.funtan@iwes.fraunhofer.de

DERlab: European Distributed Energy Resources Laboratories

Under the direction of Fraunhofer IWES, the international non-profit association DERlab was founded at Fraunhofer IWES in Kassel. Over 20 leading research and test institutes are members of DERlab e.V., and carry out collaborative development of criteria for operation of decentralised energy generators on the grid. This development helps derive new test procedures and norms. The laboratory infrastructure is being built up in co-ordination with the partners whose work is therefore complementary. In the context of European research projects, DERlab offers the possibility of using its infrastructure for research purposes partly free of charge. The association's offer to carry out norm tests, such as grid integration tests, is also available to industry.

↘ www.der-lab.net

↘ Dr.-Ing. Philipp Strauß, philipp.strauss@iwes.fraunhofer.de

RESEARCH DEPARTMENTS

COMPETENCE CENTER ROTOR BLADE

In wind energy, the common approach for experimental validation of design assumptions and verification of structural characteristics is a four-level system: coupon testing, element and detail testing, sub-component testing, and full-scale rotor blade testing. The number of tests required at each level decreases from the coupon to the full-scale levels, and is adapted at the individual levels in response to the complexity of the designed structures. An increasing amount of development work in wind energy is being concentrated on detail and component testing in response to the efforts for lightweight construction.

Wind energy turbine rotor blades are complex and highly-loaded components. Due to the requirements for lightweight construction of rotor blades and their high fatigue loadings, they are built from fiber composite materials. To ensure and verify the reliability of such fiber composite structures, analytical and numerical calculations are combined with experimental investigations in the design and evaluation process. Innovative materials and material combinations can increase fatigue resistance, facilitate manufacturing ease and improve stiffness, and therefore the structural integrity. Costs play an important role in wind energy – a rotor blade costs about 10 to 12 euros per kilogram, while costs per kilogram in the aviation industry are between 100 and 1000 euros. This large difference is caused by different manufacturing and testing methods, and quality assurance requirements. Therefore, for wind energy, the development of efficient design methods is essential.

Verification of structural characteristics on four levels

The relative cost of coupon and element tests are relatively low; therefore, it is possible to test a relatively large number of specimens at these levels and to gain statistical significance in the testing results. Furthermore, it is possible at this level to do parametric studies on the varying performance and behavior of different construction details. At the highest level of testing, e.g. full-scale rotor blades, usually only a single blade is tested. The testing of a single specimen enables verification of the design, but is incapable of providing statistical evidence on material or manufacturing variations.

Material testing

Material tests are used to define the physical properties of the materials to be used in the structure. This testing establishes the static and cyclic parameters which describe the mechanical behavior of the fiber composite materials, core materials and adhesives. Alternative materials characteristics are often determined in order to be able to make a materials selection. Investigations at the materials level are conducted on relatively small specimens (e.g. 15 cm length plus mounting) and are well established and standardized for numerous types of tests. Investigations are normally conducted uniaxially, but for the development of material models, multi-axial tests are important. Torsion tests are commonly used for determining the shear strength characteristics of bonding pastes. The above tests can be enhanced further through climate chamber testing. Using these material models, the influence of several loads, usually two, can be investigated. Due to the high operational demands and long service life of rotor blades, the fatigue characteristics of the utilized materials are very important.

Element and component testing

The load and resulting stress distributions for 15 cm long coupons can differ greatly from the actual load and stress distributions in a rotor blade because of manufacturing, geometric effects, and the actual applied loads. Therefore, larger scale specimens (details and/or components) are increasingly being tested in order to close the gap between full-scale blade testing and coupon-level materials testing. Such details and components are tested in particular for critical rotor blade areas (e. g.

bond lines, transition regions, laminates and core materials). Up to now, these tests have only been partially standardized and establishing standardized tests to a level of competence, considering the variety of rotor blade designs, is improbable in the near future. Researchers at Fraunhofer IWES, in cooperation with industrial partners, have developed an element test for bond lines which enhances the understanding of material behavior and structural performance. Having a more thorough understanding of the structure and material performance from the element testing limits the risk with up-scaling from materials to full-scale rotor blades. These tests help to respond to the design and engineering challenges of ensuring a 20 year operational life of bond lines which have thicknesses around 10 mm and lengths up to 60 m.

Overall structure

Wind energy turbine rotor blades are still produced mostly by hand. Placing the dry fibers is completed manually, as well as the application of the bonding paste. As the components are subject to high stresses, it is very important for safe operation to ensure the quality of the whole blade. Additionally, rotor blades are continually being developed, which leads to changes in the materials, structure, manufacturing processes and, more importantly, the production team. For the certification of a new rotor blade, certifiers require structural testing of one of the first blades to be produced. The goal of the testing is to identify possible issues from the design and production by replicating the loading experienced by the structure during its complete operational life. The natural frequencies, stiffnesses, deflections, and deformations of the rotor blade are determined during testing to where they can be compared with and help improve numerical simulation results. After a natural frequency test, the rotor blade is loaded in four directions using hydraulic cylinders and loading ropes until extreme structural loads have attained the safety margins stipulated in certification requirements. Upon completion of the extreme load test, fatigue testing is conducted in the edge and flap directions of the rotor blade. At Fraunhofer IWES, the fatigue loading is applied by hydraulic cylinders which oscillate the rotor blade near its natural frequency. The fatigue testing is conducted over a period of several weeks in order to apply the necessary 1 million to 5 million cycles. Finally, a last extreme load test is conducted to simulate, for example, a high wind loading at the simulated end-of-life time.

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Steering committee

SUPPORT STRUCTURES AND MONITORING

The ever increasing power and size of wind turbines – in particular those offshore – is putting extreme demands on their foundations and support structures. The new dimensions of components and the higher load level require accompanying theoretical and experimental studies to be carried out on the support structures. Aggressive offshore conditions have an impact even on massive components. For an early damage detection of a turbine, a permanent condition monitoring process is required. A high overall profitability can only be secured by maximal availability.

Fraunhofer IWES is systematically expanding its expertise in support structures for wind turbines. The collaboration with the universities in the ForWind alliance and the planned large test laboratory make a case for the extension of this site. From 2014 onwards, structural and deformation behavior as well as load-bearing characteristics of support structures will be tested and evaluated under stress over a longer period. By applying exactly defined loads up to an extreme level, contingency reserves can be qualified and adjusted. Statements on the performance during 20 years of operational life time become possible after an accelerated test of 3-4 months. The results help to optimize and develop support structures for repowering measures onshore and offshore. Innovative concepts for support structures are the result of improved models and tools for simulation, supplemented by experimental investigations and measurements in the field and the laboratory. Further topics for development are new material combinations, corrosion protection systems and building process engineering.

Experimental tests under multi-axial loads

Lattice support structures for water depths of between 25 m and 70 m are exposed to multi-axial stress at sea due to wind, waves, and operating loads, in particular in the region of the structural nodes. In contrast to existing test facilities, the planned experimental rigs will allow Fraunhofer IWES to undertake innovative structural tests under multi-axial dynamic loads.

Seabed-support structure interactions

The dynamic properties of the support structure depend sig¬nificantly on the soil conditions. When developing the fatigue design it is essential to consider ground/seabed conditions that change during the course of the operating life of a wind turbine due to the dynamic loads. There is an enormous need for research to be able to more precisely predict the behavior of foundation elements under cyclic loads. A novel test concept for support structures with foundation elements under real offshore seabed conditions and on a large scale should validate and improve the design basis for the whole structure and for the foundation elements.

Optimization and innovation

Optimized, lighter support structures increase the economic viability of wind energy due to material and cost savings and also protect the environment. Tests on a large scale on com¬plete structures and tests on a 1:1 scale on critical components under near-realistic, multi-axial load scenarios provide a first class basis for this. Validation tests, accelerated service life tests for structures made of steel, steel composites, and fiber composite materials, tests on foundation elements under cyclic loads and mimicked offshore seabed conditions, testing of the dynamic behavior of the complete structure with near-realistic simulation of soil-support structure interactions, quick deriving of fatigue strength by high-frequency tests of material specimen und optimization and testing of construction technologies will be carried out at the support structure test center.

Early damage detection
Reliability and availability of turbines is of paramount importance for operators of offshore wind energy turbines since breakdown and unplanned maintenance mostly lead to high cost. A key factor for improved efficiency is the identification of improvement possibilities during the development of new generation wind turbines and potentials for later refurbishment of existing wind energy turbines.

Condition-oriented maintenance
The demand for reliable measuring and sensor technology for remote structure and turbine monitoring will grow in importance over the coming years since future offshore windfarms will be built very far from the coasts, making access very difficult. Offshore wind energy turbines are exposed to strong mechanical and weather-dependent loads. In these cases, existant critical area faults must be detected in time and repaired in the framework of condition-oriented maintenance measures. Condition-oriented maintenance requires permanent monitoring and the development of algorithms for early damage detection.

Technically reliable sensor design and application
Structural Health/Condition Monitoring Systems (SHM/ CMS) supply the necessary data for the determination of load collectives and turbine and component stresses. For this purpose, rotor blades, tower, foundation as well as drivetrain are fitted with sensors. The technically reliable design and application of sensor technology in the offshore area is a basic requisite. The simulation of offshore environmental conditions by means of an offshore climate chamber and load tests using HALT/HASS methods, enables, for the first time, benchmarking and qualification of sensor technology and electronic components as well as the determining of design guidelines for offshore-capable sensor and measuring technology with higher reliability.

Endurance test under offshore conditions
Corrosion protection systems and polymer materials for offshore use are being tested under real conditions at various field test sites along the German North Sea coast. During this testing process, biological load collectives are particularly investigated since their transfer into a laboratory would be extremely difficult and costly. Damage mechanisms are revealed and appropriate countermeasures and protection strategies developed.

Services
- Testing and evaluation of offshore corrosion protection systems, e.g. according to ISO 20340
- Material degradation field and laboratory testing
- Offshore environmental conditions simulation by means of offshore climate chamber
- Robustness test using HALT/HASS methods
- Technically reliable sensor design and application
- Measuring campaigns for turbine monitoring incling data evaluation
- Determining load collectives and demands
- Support structure concept development
- Innovative foundation system geotechnical consultancy

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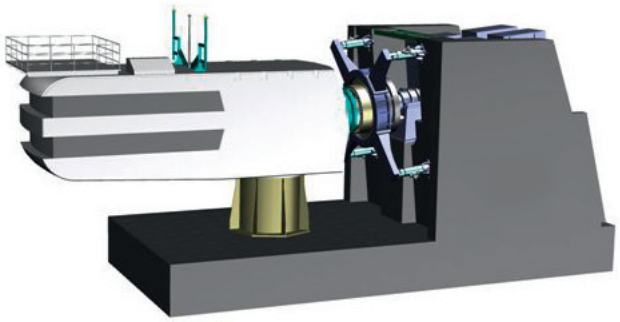

DRIVE TRAIN

The drive train of a wind power plant is the highly stressed link between flow-mechanical energy conversion through the rotor system and electromechanical energy conversion on the network side. Its system behavior has an immediate effect on these interfaces or it can be substantially affected by interference from plant control. Furthermore, there are direct interrelationships with the load-bearing nacelle structure in all degrees of freedom through the bedding, torque supports and dampening elements

Within the scope of its publicly promoted research project DyNaLab (Dynamic Nacelle Laboratory), Fraunhofer IWES is working on a large-engineering test stand for complete nacelle of wind power plants. For the first time in Germany, beginning at the end of 2013, the DyNaLab will be a realistic test environment that is available to all wind power system manufacturers in the megawatt range so that they can carry out meaningful laboratory tests for assessing and streamlining existing and future turbine designs. The technical requirements for this test and experimental platform were defined in close cooperation with the wind power industry and research & development partners. Within this department, technological developments and research in proximity to industry on the mechatronic drive train subsystem will be another focus in the future.

This pod test stand with a planned drive output of approximately 10 MW will have additional equipment for simulating various network states to replicate fault ride through scenarios and compatibility tests with various grid codes.

Direct or hybrid drive technology

The drive train department's research & development work is focused on direct or hybrid drive topologies, i.e., compact drive train designs with slow-moving direct drives or built-in low-transmission drive solutions and medium-fast generators. The special focus is on streamlining existing and developing new types of generators, mechanical integration, enhanced magnetic circuits and using new materials for electromechanical engineering. Triggering techniques aligned with the generator design for the medium-voltage range, detailed loss analyses and analyses of the thermal household round up this picture. Beyond this, new ideas for regulating active vibration dampening in direct and hybrid drive trains that can adapt themselves to changing external influences, variable system characteristics and target functions will be developed.

- Optimization of existing / development of new generator concepts
- Mechanical integration
- Improved magnetic circuit design
- Use of new construction materials for electrical systems engineering
- Definition and validation of standardized interfaces for components and sub-systems

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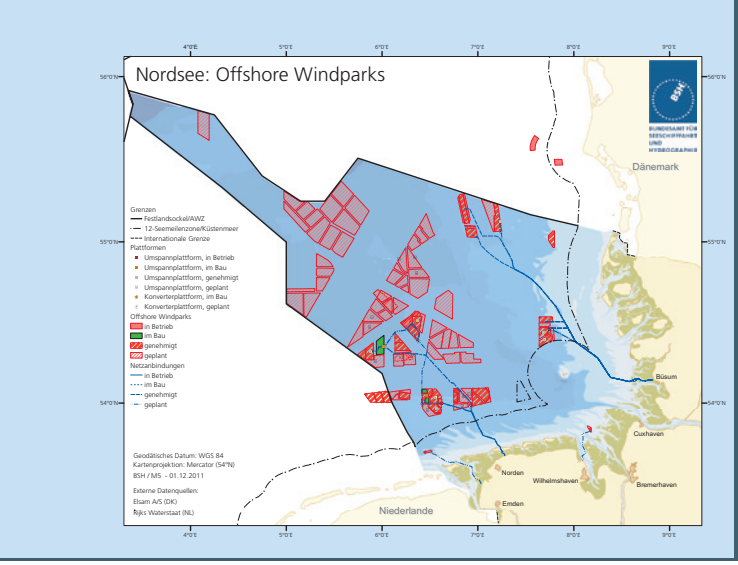

PROJECT AND RISK MANAGEMENT

The implementation of offshore wind energy projects is subject to significant risks. These range from planning to construction, operation and decommissioning. Currently used tools of risk, time and cost management are mostly specific to the various project stakeholders such as lenders, insurers, planners and operators, but also poorly comparable. Fraunhofer IWES develops methods and offers assistance to recognize and evaluate risks as well as to optimize the projects, independently with regard to individual interests. In addition to specific tools of risk, time and cost management, all Fraunhofer IWES existing competencies and skills of wind energy are included.

"Never trust statistics you didn't forge yourself." Shamed be he who thinks evil, if he refers this sentence to the risk, time and cost management of large wind farm projects, particularly as they are currently being implemented at sea. Basically, the task reads simply: Uncertainties and cost drivers must be recorded, assessed and minimized. In practice, however, serious problems quickly arise in its quantitative realization and comparability. Thus, the value of many risk, time and cost analyses falls quickly into insignificancy. The reasons are obvious: Firstly there are conflicting interests among the various project stakeholders being the project companies, sponsors, banks, public investors, regulatory bodies, approval agencies, suppliers, vendors, operators, energy suppliers and network operators. Secondly the various legal, economic, planning, engineering and scientific tasks cover a very broad spectrum of different technical disciplines. This diversity of interests and responsibilities together with the specialties of the offshore wind energy requires the development of a common language, coordinated ways of working and consistent methods to arrive at assessments of risks, scheduling and financial structures, in which all project participants can place their trust. Fraunhofer IWES is dealing with all technical disciplines around wind energy. In addition it is now developing methods and tools, with which it provides trans-disciplinary services and assistance to optimize risk, time and cost management. In addition, it supports the development of minimum standards to facilitate communication between different project stakeholders and disciplines and to increase the predictive value of cost, time and risk analyses.

Our offer:

- Cost, time and risk analysis for offshore wind farm projects and their sub-systems
- Optimization of financial structures, timelines and resources for planning, installation and operation

Considered variables:

- Wind turbines, support structures, substation and cabeling
- Wind and wave statistics
- Geographical conditions
- Technical downtime
- Logistic concepts
- Costs for acquisition, logistics and waiting times

Used working methods and means:

- Scenario and sensitivity analysis for optimizing cash flow, time- and resource-planning
- Monte-Carlo simulations, critical path, Gantt charts, tornado charts, histograms, etc.
- Statistical analysis particularly with @RISK (Pallisade), Microsoft Excel and Microsoft Project
- Specialty software for the planning / installation and operation phase

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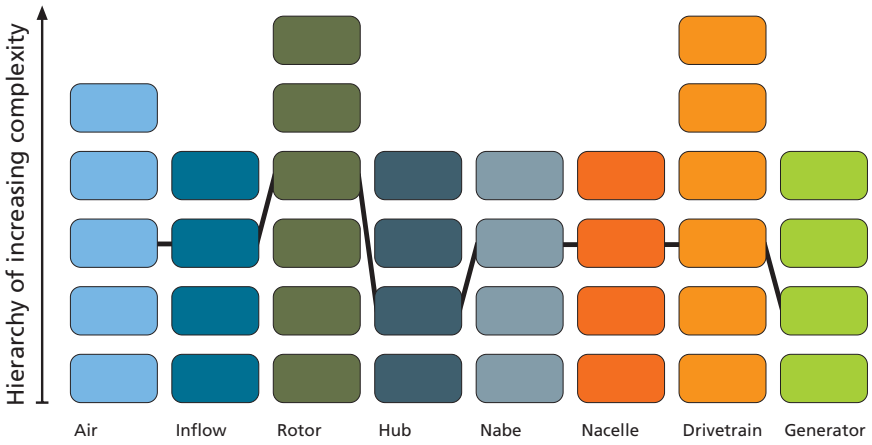

SIMULATION AND ASSESSMENT OF WIND TURBINES

Computational forecasting of the behaviour of wind turbines in early development phases enables the optimization of system components at minimum cost. As we are dealing here with a cross-sectional engineering task the co-workers are engineers from a variety of scientific fields, physicists, computer scientists and one naval architect.

Load calculation and turbine development

Because of dynamic interactions and significant non-linearities, the varying subsystems of (offshore) wind turbines such as rotor blades, drive train, support structure and controls are all combined in a numerical model in order to simulate their behaviour realistically. The so-called aero-servo-hydro elastic simulation of (offshore) wind turbines is used to calculate loads upon them and is the basis for the design of each component. The certification of the turbine is also not possible without such load calculation.

Continuous new demands

The constant advance of turbine technology and the professionalization of the development process within the ever expanding sector both create continuous demands on simulation. Welded joints of branched support structures, rotor blades with relevant bending-torsion coupling, anchoring systems for floating offshore wind turbines or ice loads on rotor blades and support structures must all be calculated correctly. For this purpose, advanced simulation systems are constantly being tested and validated. The trend towards larger turbine series and project budgets allows for a more elaborate development process through which optimization potentials can be achieved more comprehensibly.

Co-workers and tools

The development and further development of simulation tools, system simulation, assessment of the results and the adaption of the turbine design on this basis are multidisciplinary tasks which are dealt with by a team comprising of engineers from a variety of fields, computer scientists and physicists The main focus here is on the complete system know how, which allows the transfer to other systems and for example, to projects in the fields of high altitude wind energy and marine energy. Alongside the application of commercial simulation software, the development of our own software takes place on an extensive scale. Our software development is carried out by combining the technical physical system knowledge of the engineers with the wide experience of the computer scientists in the field of software development. For the first time, IWES´ OneWind software offers the possibility of automating the interfaces between load calculation and component design and thereby to reduce the probability of error in this interface and lower development process expenditure.

The ADCoS-Offshore software already in use at IWES allows the calculation of offshore wind turbines including matrix reduction methods in the models of support structures. First results confirm the necessity for these improved methods for turbines with tripod support structures.

Services

- Load calculation for offshore wind turbines and current turbines
- Consulting during the development and certification processes of offshore wind turbines
- Development of software components for simulation

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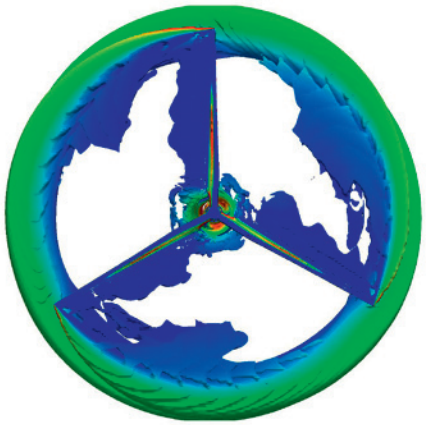

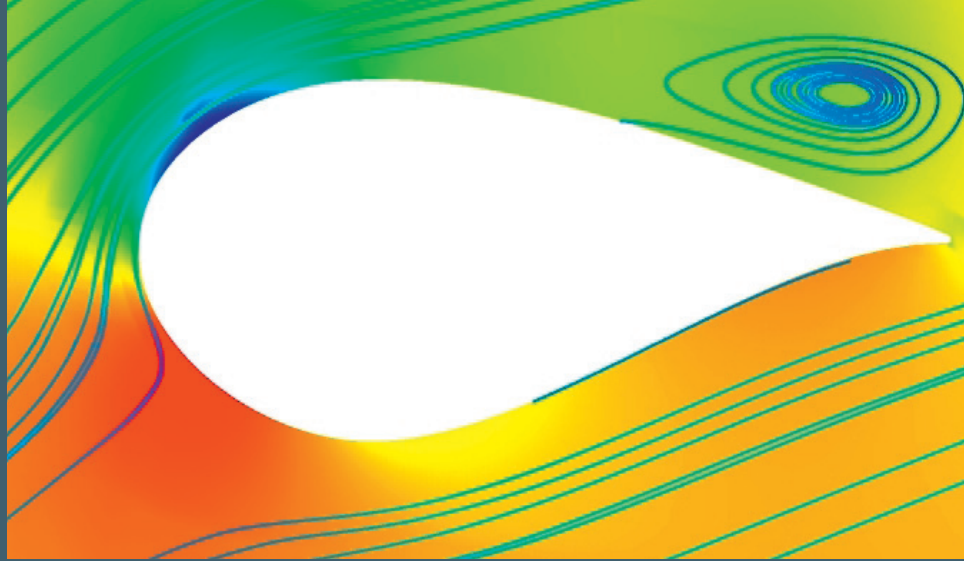

NUMERICAL FLUID AND SYSTEM DYNAMICS

Our competence is the physics of the wind and its impact on wind energy converters. Using mainly different numerical methods of Computational Fluid Dynamics (CFD) we investigate on the multiple problems of the interaction between the wind and wind turbines. Our field reaches from complex effects of aerodynamics, which we investigate on different scales of accuracy, to the analysis of wind potential in complex terrain for complete wind farms.

Wind energy converters are primarily aerodynamic machines. Even small improvements in aerodynamic design pays in form of the power output. Aerodynamic profiles and blades optimized for turbulent inflow conditions reduce unfavorable loads and thus the turbine failure rate. CFD methods allow an insight into the aerodynamic details at relatively low expense. Thus we are able to support the aerodynamic design process for wind turbine blades. A special interest is the impact of realistic turbulent conditions of the wind on the aerodynamics, yawed conditions and the aerodynamics of vertical axis wind turbines (VAWT).

Power output and reliability of wind turbines depend strongly on the ambient flow conditions. Especially in complex terrain, in forestal areas or for large wind farms CFD methods offer a great potential to calculate the turbulence and wind conditions. Our numerical capacities allow the use of unsteady methods which are essential for the analysis of the characteristics of turbulence in wind farms. Especially in offshore applications the interaction of different wind farms is of great interest for wind farm operating companies. Here unsteady calculations promise a detailed analysis which can hardly be achieved using steady methods.

The group of computational fluid and system dynamics works increasingly with its own developments within the opensource tool OpenFOAM®. The code offers the users to do complex simulations with a high degree in accuracy in a parallel computing environment without large license costs. However, the learning curve of the code is quite steep. It is our pleasure to support you.

The CFSD-group is embedded in a close cooperation with the research activities on wind physics at the university of Oldenburg. This leads further to an additional focus on stochastic analysis of turbulent flow as well as the dynamics of the turbine itself. Processes that seem to be hiding in a noisy signal, extreme events or dynamic statistical variations are detected and modeled by the group. New approaches allow more detailed information than the standard procedures used so far. Ask us – we are pleased to provide information.

Services

- Wind physics
- Aerodynamics
- Computational fluid dynamics
- Wind potential in complex terrain
- OpenFOAM® consultancy
- Stochastic analysis

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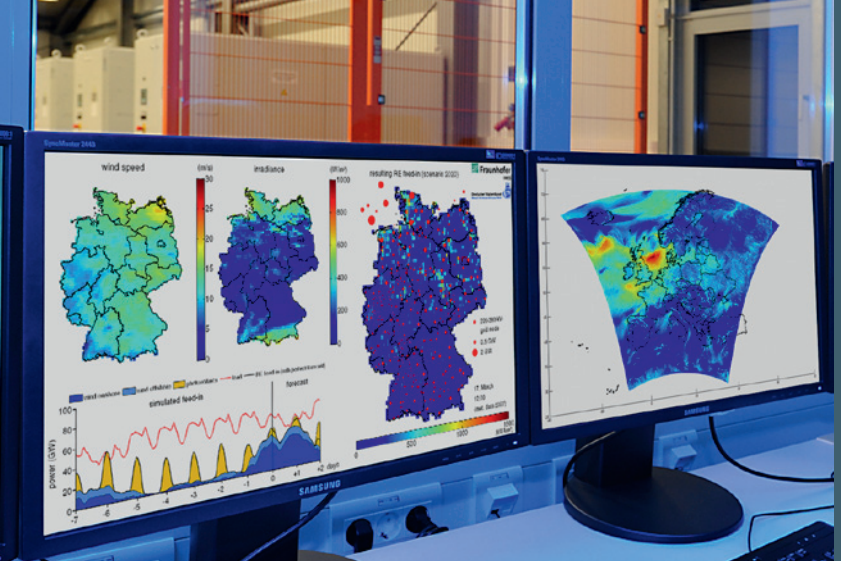

ENERGY ECONOMY AND GRID OPERATION

Worldwide supply energy stands before its greatest challenge to date: the transformation of today's structures to a decarbonised, purely renewable energy-based supply. Wind energy has been accorded the key role in this transformation, which however, can only be truly realised through an adequate link to grid control and systems management. Despite R&D progress in the areas of turbine technology, site analysis energy meteorology, control and operational management as well as grid connection, there still exists an enormous need for innovation. The particlar challenge lies in the observation of the whole system, for which the roles of system services, network expansion, production and load management, as well as storage systems must be analysed and evaluated.

Orientation
The R&D department handles technical and energy economy issues concerning the grid integration of renewable energy from today's situation through to future scenarios of total energy supply. The work covers analyses and studies, model design and simulation, software solution development for operational management and grid integration, training and further training measures as well as measurement and test tasks. Other activities include the monitoring of onshore and offshore wind energy utilization and the development of new maintenance strategies. With regard to grid integration, new methods are being developed for performance assurance, the optimal interplay between power generation and demand, as also an adapted power plant and grid structure, with special attention being placed on structures for large-area useage. The focus here is on integrated, systemic-oriented observation and improvement.

R&D topics and specialist departments and groups
The R&D topics are processed by several specialist groups and departments.

Energy meteorology and system integration
This department works cross-locationally with groups in Bremerhaven, Bremen and Kassel. The research activities in Kassel cover the development of measurement and analysis methods for characterising offshore windfarm environmental conditions, the simulation and characterisation of wind performance, methodology for reliability-oriented maintenance processes, coordination of the RAVE research initiative as also the monitoring of offshore technology development. (see p. 36)

Energy informatics and information systems
The focus of this department lies on the exploitation of modern information and communication technology potentials as well as the development of software tools for the integration of renewable energies, such as a wind power feed-in forecasting system. In addition to this, overlapping areas of interest such as administration of the central data bank, server maintenance and support of the IWES wind measurement network are covered.
(see p. 37)

Large area energy networks
Weather dependence of future energy supply structures demands new approaches to grid planning and operation. This is based on analyses of regenerative power plant feeder panels, and achieved by means of temporal and spatial high-resolution simulations on a high-performance computer cluster. A particular focus lies with the analysis of residual load temporal-spatial behaviour, the integration of innovative load-covering options as well as load-flow analysis. For network operation support, forecasting methods for solar energy feed-in are being developed; these are to be combined with wind performance forecasting to form an overall renewable energy forecast.

Transmission networks

The bestowal of power-plant-similar characteristics with regard to reliability and support of network and systems management on high-voltage and ultra-voltage levels is one of the greatest challenges for the expansion of renewable energies (RE). With a hierarchical operational management level for windfarm clusters, the group is developing new methods for the active integration of windfarms in network and systems management.

Regenerative energy power plants

Regenerative power plants are information technology connecting points of various regenerative feeders (RF), storage systems and consumers, with the goal of optimal integration in the energy system. The department deals with the optimal marketing and scheduling of RF. Further focal points are the transformation of energy systems, with funding instrument design issues, in order to integrate RF into the market: the adaptation of legal and organizational framework conditions to the changing energy system, with ever increasing RF integration, the contribution of system services (e.g. power regulation) through decentralised RF, and the future role of regenerative power plants in regional energy supply concepts. These and other questions are being handled, for example, in the E-Energy project Regenerative Model Region Harz, and in the Combi Power Plant II project.

Energy economy and systems analysis

The work of this group comprises the dynamic simulation of power supply, energy systems transformation scenario development, system solutions development for coupling gas and electricity supply networks and regenerative energy supply. Included in this is the creation of energy scenarios such as the BMU pilot study, the UBA Energy Target 2050, the FVEE Energy Concept and the WBGU decarbonisation scenarios. Among other excellent projects, energy system technology is being developed for the storage of regenerative electricity in the natural gas grid as renewable gas in industrial and public settings.

Training and further training

This focal point targets the further academic qualification of specialist and managerial staff to respond to the growing needs of the RE job market. Flexible programmes for a career-accompanying further qualification are conceived to meet customer needs and carried out in learning alliances with industry. In this process, both technology-oriented know-how from industry, as well as research and development experience flow into the curriculum. An online Masters Course in Wind Energy Systems is being prepared in cooperation with Kassel University.

Services and products

- Contract research: Carrying out contract research in all areas of work
- Energy economy studies: Studies and analyses for companies in the energy industry
- Regional energy concepts: Development and support of regional energy supply concepts with regenerative energies
- Analyses and assessment reports for system services: Issue and support of system services assessment reports for regenerative energy producers
- Consultancy, studies and further training: Competent consultancy, scientific assessment reports, studies and further training for specialist and management staff
- Licences: Issue of Fraunhofer IWES-owned property right non-exclusive licences
- Further products and services are to be found on p. 36 and p. 37

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ENERGY METEOROLOGY AND SYSTEM INTEGRATION

With power generation being increasingly dependent on the weather, there is a need for a fundamental rethink about the planning and operation of energy supply systems and the use of methods and tools of energy meteorology. Precise knowledge of site conditions and robust and accurate forecasting of the weather-dependent power generation is decisive for the design and reliable operation of wind turbines and wind farms as part of the power supply system.

Site assessment
The main focus of the research activities is the development of measurement and analysis methods for characterizing the environmental conditions. Onshore the focus is on the planning of wind farms with high hub heights in hilly or forested terrain. Innovative and adapted measurement and analysis methods for offshore are being developed for wind, waves, currents, and the seabed. For offshore seabed assessment a concept is being developed for the optimal combination of seismic surveys and geological and geotechnical exploration techniques.

Tools for system integration
The R&D activities in the area of grid operation focus on deterministic and probabilistic wind power forecasting methods using various numerical weather forecasts and online measurements. Based on this, new concepts for operational control and power management systems are being developed for improved integration of wind energy into electrical supply systems. In addition, wind power time series and forecasts are being simulated for future scenarios.

Development of offshore wind energy utilization
In the area of offshore wind energy utilization the department coordinates the RAVE research initiative at the alpha ventus test field and is conducting a monitoring program for technology development for offshore wind energy utilization.

Reliability
The main area of research concerns methods for reliability oriented maintenance based on statistical analysis of empirical data. Failure probabilities can be determined from the maintenance data and operating experience, and weak points in maintenance procedures and in design can then be identified. For small wind power plants also a test site is operated.

Services and products
- Measurement of the environmental conditions and site assessment for onshore and offshore wind farms
- Seismic seabed surveys for offshore wind farms and laboratory tests on seabed samples
- Development of algorithms for deterministic and probabilistic wind power forecasts
- Consultancy in the analysis of different wind power forecast methods and their uncertainties
- Simulation of time series of the wind power supply and its forecasting for system planning

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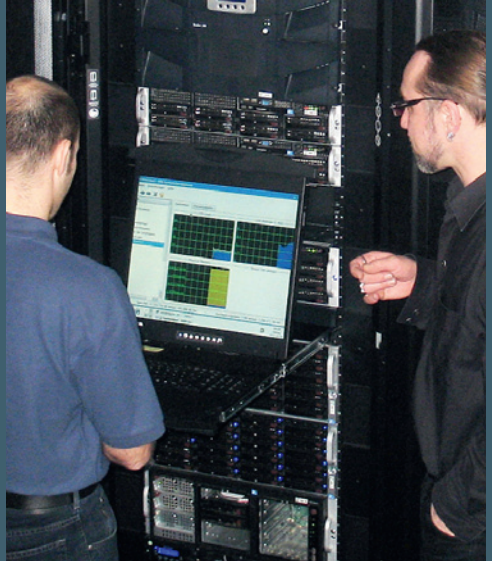

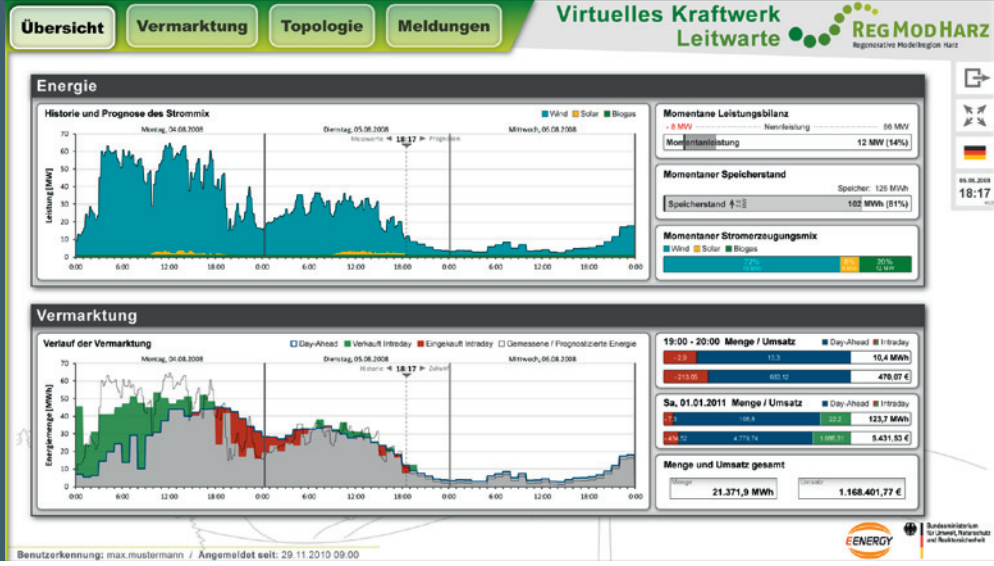

ENERGY INFORMATICS AND INFORMATION SYSTEMS

The integration of renewable energies into the energy supply systems of today requires a high degree of information and communication technology. Focal points of activity are the construction of supporting work tools and methods such as the forecasting system for wind power feed-in, the grid connection of power generators, storage systems and consumers to virtual power plants and the investigation as also the further development of modern concepts for data exchange and safety in regard to tomorrow's intelligent network structures (smart grids).

Architecture and implementation of virtual power plants

In the future, Germany's electricity supply will be supported by many small power production units. The combination of a large amount of individual plants demands appropriate architectures and communication components to assure safe operation. One focal point of R&D activities is the draft of such architectures and their implementation, taking into account or enhancing recognised norms such as IEC61850, IEC61970 and the Common Information Model (CIM).

Investigation into the role of electric vehicles

A further focal point is the investigation into the role of electromobility in power supply systems of the future. Alongside the consumer aspect of electromobility, the possibility of e-vehicles serving as short-term storage modules for the electric grid is also being investigated including how far renewable energy supplies may be optimized through these methods.

Actual value determination and forecasting systems for wind power feed-In

Without reliable determining of current feed-in as also reliable forecasting of future feed-in from wind energy turbines, neither would it be possible today to have reliable operation of electric networks nor could stored energy be intelligently integrated into the electricity market. New forecasting methods, as also the demands generated by consumer integration of modern IT systems, ensure that forecasting methods and software implementation remain state-of-the-art.

Services and products

- Forecasting software systems for wind power feed-in for different target areas (short-term and next-day forecasts)
- Algorithms and parameters for online wind energy feed-in calculations
- Recording and operational allocation of wind measurement data (wind speed and direction) from a German-wide network using measuring masts of heights from 30 m to 50 m.
- Consultancy services, demonstrators and virtual power plant function models
- Freely parametrical simulation of electric vehicles under a variety of marginal conditions

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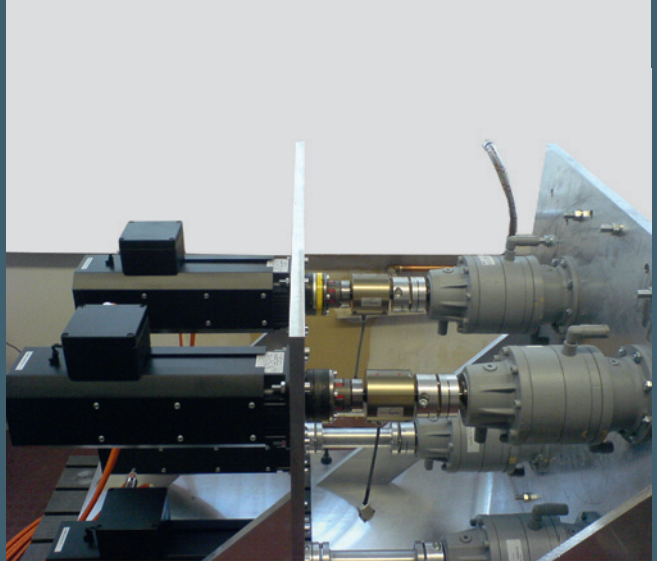

CONTROL ENGINEERING AND ENERGY STORAGE SYSTEMS

The activities of the department link the areas of energy conversion and control engineering using sophisticated methods of control and system technology. The most important application fields are wind energy technology, marine energy technology, and energy storage system technology. The work covers fundamental theoretical studies, mathematical modeling and simulation, experimental verification and practical trials in the laboratory and in the field, realization of functional prototypes, and integration into turbines and systems.

Main activities

Despite the enormous success of wind energy utilization and advanced turbine technology, there is still great scope for innovation and cost reduction in the wind energy sector. The aim is to develop reliable, low-maintenance wind turbines for offshore and onshore. In the coming years, special attention must be given to the control of large wind farms.

Technology for utilizing marine energy sources is still in its infancy. Marine current turbines appear to be of particular interest. Despite there being many parallels to wind energy technology, many technical problems still have to be overcome. The same applies for all other technology for utilizing marine energy.

Storage systems play a major role in the utilization of renewable energy. In the area of electromobility, storage technology truly plays the key role. Here, energy storage system technology can help to open up new technical opportunities, to improve efficiency and environmental acceptance, and to lower costs.

R&D topics

- New control methods for reducing mechanical stresses in large wind turbines and wind farms
- Condition diagnosis and fault prediction systems for wind turbines and wind farms
- Development of mathematical models and virtual systems for wind energy technology, marine energy, and storage system technology
- Control and system technology for marine energy utilization
- System technology for electrical energy storage systems and new energy converters

Services and products

- ISET-LAB and ISET-LIB: Software for simulating lead acid and lithium ion batteries for use in pre-industrial and industrial research under different simulation environments
- Virtual battery: Hardware simulation of the terminal behavior of lead acid or lithium ion batteries with the real-time variants of ISET-LAB and ISET-LIB
- Alternative power library: Universal model library for simulation of decentralized energy supply systems
- Virtual wind turbine: Software for HIL (hardware-in-the-loop) simulation of wind turbines in experimental and test facilities
- Wind turbine control designer: Software for developing control systems for large wind turbines
- Contract research: Research projects can be undertaken on a contract basis in all areas of our work

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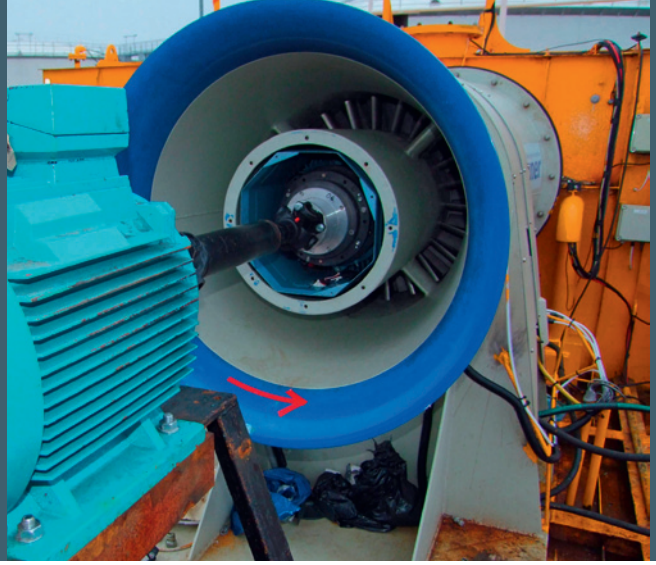

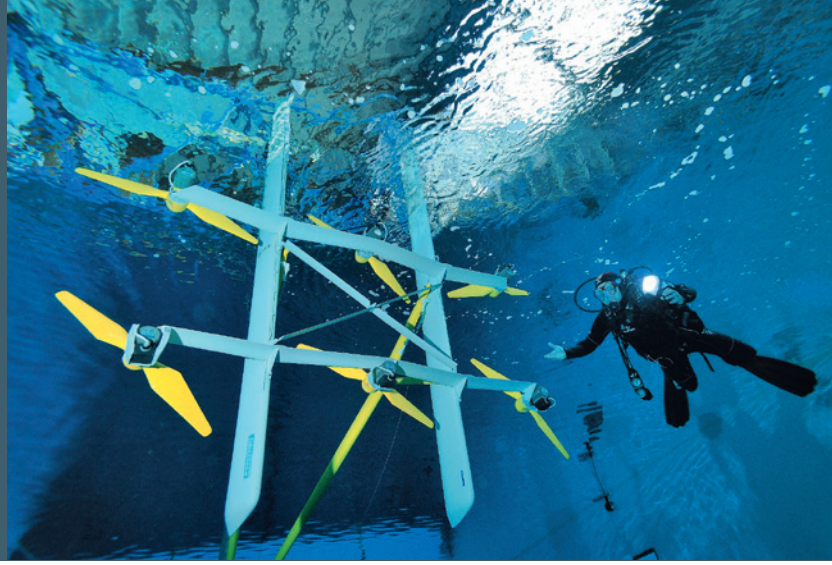

MARINE POWER USAGE

Marine energy, in the form of waves and tidal currents, has the potential to provide significant contributions to a sustainable power supply. Different technologies are being developed at present. This department supports industry in developing competitive technologies: from the concept phase, tests and trials at laboratory scale, through to demonstration and pilot projects in the megawatt scale. Resource and feasibility studies are carried out and market strategies are developed.

Focal points

The commercialisation of marine energy technology requires a profound knowledge of economically viable resources, the development of reliable and competitive technologies and the implementation of market strategies and instruments. The key challenges in the utilization of wave and tidal current energy are the understanding of available resources, their characterisation by means of measuring processes as well as the application of advanced simulation models. The device and component technology development proceeds incrementally from the concept phase, through model trials, up to small-scale field trials and finally demonstration projects in the megawatt scale. In this process, experience, concepts and models from the development and realization of other technologies, in particular hydro-power and offshore wind energy, are used and adapted to specific marine energy system requirements and developed further. Regarding norms and international harmonization, projects are carried out in cooperation with the IEA, IEC and other networks and organizations.

R&D themes

- Resource investigation for wave and tidal current energy and offshore wind energy
- Site and device measurement and characterization and development of new methods
- Control engineering development, modeling and simulation towards improvement of energy yield and dynamic load reduction
- Energy conversion systems technology development in tidal turbines and wave energy plants (Power Take Off – PTO)
- Concept investigation for combined tidal, wave and offshore wind energy devices and non-energetic applications
- Concept development for grid connection of marine energy systems
- Feasibility studies, pilot and demonstration of deep water offshore wind potential, project realization (floating wind energy turbines)

Services and products

- Resource, market and feasibility studies for marine energy systems and floating wind turbines
- Technology-specific solutions for control engineering and operational management and energy conversion (PTO) and grid integration.
- Synergy effects and technical solutions for combined offshore renewables applications
- Design, implementation and evaluation from small-scale model tests to commercial-scale demonstration projects
- Customer oriented research in all fields of the department

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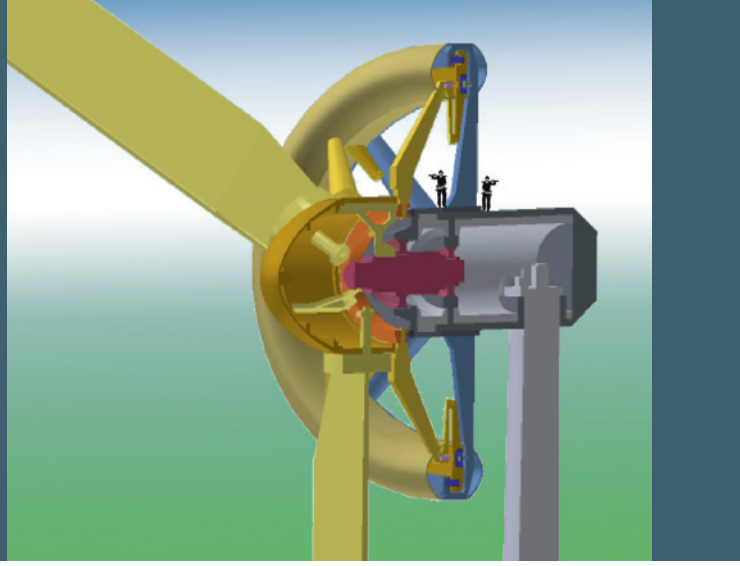

SYSTEM ENGINEERING AND DISTRIBUTION GRID

This division researches system technology for the utilization of renewable energies such as solar energy and wind energy as well as for other electricity generators, storage systems, and electrical vehicles. The converter technology is important because it connects electricity generators, storage systems, and consumers with the grid. Converters and other equipment are being developed which support the new requirements of smart grids. The laboratory equipment allows us to carry out standardized equipment tests and tests in sections of distribution networks using new information and communication systems.

Main activities

The division investigates fundamental technical issues regarding energy provision from renewable sources, draws up new approaches for system technologies, and carries out laboratory and field tests. Other main areas of research focus on the technology of photovoltaic systems, storage systems, and the electrical parts of wind energy converters. Besides developing equipment up to a laboratory prototype, complete system technology for the grid integration of decentralized electricity generators, storage systems, and loads are all designed. The setup and demonstration of smart electricity distribution networks and island grids is a key aspect of our work.

The network interface and the system behavior of wind turbines and photovoltaic systems are being further developed via the control of converters and electrical machines. Communication interfaces and the interaction with network resources and operational management at the distribution network level are looked into. Included here are components for control engineering, energy management, metering technology as well as safety and protection systems for grid operation.

The department operates a test center for the grid integration of decentralized electricity generators and coordinates DERlab, the leading European Network of Excellence in this field.

R&D topics

- Operational management, equipment, design and control technology for electricity distribution networks
- System technology and the testing of photovoltaic systems, wind turbines and e-mobility
- Grid integration of decentralized generators, storage systems, controllable loads, and electrical vehicles
- Electrical machines and converter technology for decentralized generators
- Electromagnetic compatibility of components and systems
- Inductive and conductive transmission systems for e-mobility
- Economic aspects of decentralized network services
- Decentralized energy and power management
- Island grids, hybrid systems, rural electrification
- Information and communication technology for electricity supply systems

Services and products

- Contract testing: Electrical system components, converters for photovoltaic systems and wind turbines, electricity storage systems, PV modules and systems
- Contract research: Research projects funded by industry and the public sector
- Laboratories and special equipment: 6 development laboratories, 3 outdoor test fields, accredited EMC laboratories, grid converters, solar cell sensors, test field for smart grids, laboratory for the grid integration of electric vehicles, fault ride through (FRT) test system for wind turbines up to 6 MW

Specialist departments and groups

Turbine and measuring technology department

The department's focus is on technical measurement investigations of conductors and photovoltaic modules and wind energy turbines (EMV, efficiency, grid integration).
(see p. 42)

Energy management

The department deals with private household, commercial and industrial energy production and load management in the context of the distribution network. The aim is the integration of decentralised energy and building management in the grid and energy markets.
(see p. 43)

Distribution network operation

The department develops processes for the planning and operation of distribution networks and also for the operational management of customer plants for the allocation of system services. Furthermore, operational management strategies for incentive mechanisms and aggregation mechanisms are being researched.
(see p. 44)

Grid technology and integration

The central themes are grid quality and grid dynamics, new processes for grid control, new network distribution means and network technology, grid connection rules and test processes for grid connection of decentralised energy production plants, as well as grid protection, communication and innovative information technology.
(see p. 45)

Generators and drives

The generator and electric drive group works on the calculation and optimization of various electric machines and the corresponding control technology necessary to fulfill grid integration rules. The performance range varies from small wind energy turbines through to the multi-megawatt level. A magnet ring generator concept has been developed for very large generators, which should lead to specifically lower nacell mass.

Electromobility

Electric vehicle grid integration, as also charging infrastructures and battery management, are the core themes of this specialist group. Network-emitted interference and e-vehicle susceptibility to interference, as well as electric charging stations for e-vehicle fleets are tested according to specified norms. The focus is on the development of energy management systems for temporal interconnection of renewable energy production sources and the charging of electric vehicles. A special test stand enables hardware-in-the-loop optimization of vehicles with different battery types, under reproduceable marginal conditions, as well as grid integration optimization.

Static converters

This specialist group designs control systems and hardware for converters as links between scattered energy plants and the energy supply grid. The development and optimization of control strategies for converters, which also influence the behavior of grid-integrated components, are among the principal elements of research. In particular, converters for wind energy turbines and storage systems, as well as electro-drives and charging stations, are optimized.

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ENGINEERING AND MEASURING TECHNOLOGY

The department of engineering and measuring technology works on the technical aspects of environmentally-friendly power supply plants. One focal point comprises photovoltaic systems and photovoltaic-supplied devices whereby especially building integration is also taken into account. Besides concepts and realization of customer-specific and standardized tests of PV modules and systems, special task-oriented measuring technology components are being developed. A further work area is the electromagnetic compatibility of devices and systems and inverter testing.

PV systems and measuring technology

This group designs, develops and tests environmentally-friendly power supply plants. Scientific investigations are carried out in different test laboratories to characterize system and device properties. Key aspects of activity are technical measurement investigations of PV systems and components. Appropriate measurement techology solutions are developed for this purpose. In an outdoor testing laboratory for photovoltaic systems, high-resolution characterstic measurement data can be collected in the context of long-term measurement. A further focal point is model design and simulation of photovoltaic systems and their components.

Photovoltaic building integration

The integration of photovoltaic elements in buildings offers, along with electricity generation, the possibilty of using other construction element properties. In this way, multifunctional PV modules can greatly increase building value. The specialist group is concerned with all technical aspects of building-integrated PV systems. Electric, mechanical and construction issues are addressed. Multifunctional properties can be characterised by means of measuring and simulation. In particular, roof-integrated and façade-integrated systems are investigated in field tests under real operating conditions.

Electromagnetic compatibility

Electromagnetic compatibility (EMC) is an important element in renewable energy electronic components due to device and personnel safety. The compliance with EMC guidelines guarantees failure-free operation of electronic systems, and that the environment will not be loaded with an inadmissible amount of electromagnetic fields. The specialist group carries out device testing and development of test appliances as well as simulation of electromagnetic fields and their interaction at the system and component level. Furthermore, Fraunhofer IWES is accredited according to DIN EN ISO/IEC 17025 for EMC tests carried out in its laboratories in Kassel.

Services

- Accredited as well as development-accompanying EMC testing
- PV inverter efficiency measurement according to DIN EN 50530
- Electroluminescence measuring
- PV module and system long-term measurements
- PV yield certification and plant appraisal
- Customer specific measuring technology development
- Calibration of sensors and ISET*mpp meter*®

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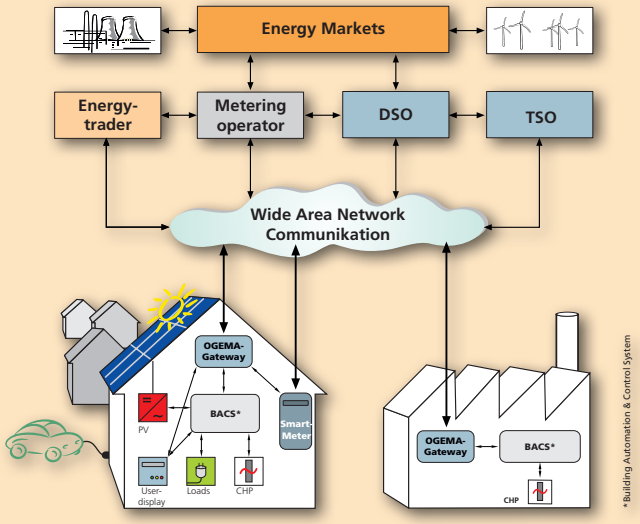

ENERGY MANAGEMENT

The energy management department deals with the management of generation, loads and storage. Further topics include efficient energy conversion for households, commerce and industry. Research themes vary from the development of necessary hardware and software for the implementation of energy management systems at customers' sites through to the interaction of energy management systems with trade and network management.

Here, the interfaces to the users' building automation systems as well as network operations are especially important. One research focus lies in the development of appropriate information and communication technology (ICT) for energy management in electricity supply systems. New ICT solutions enable switching times and operational modes of devices to be automatically optimized. In this way decentralized energy management can increase customer energy efficiency and reduce peak load. Power suppliers or network operators can also employ this technology for technical/cost optimization. The department also supports the corresponding standardization processes, actively participates in relevant committees and runs the "Open Gateway Energy Management Alliance" (OGEMA) together with industrial partners and other research institutes.

Energy management software

This group develops software for automatic energy management systems. One of its core activities is operational software for so-called energy management gateways between supply networks and local structures. The tasks of such gateways include measuring, controlling, optimizing and visualizing power flows and electrical energy quality. Data security also plays an important role. For this purpose, a modular environment is specified, serving as a platform for the implementation of gateways. Furthermore, applications concerning energy management and efficiency are adapted as software modules (apps) based on OGEMA requirements. These include the development of data models and user support through laboratory tests and practical trials.

Application development

Customer network energy management systems have a multitude of applications – both locally and in the active distribution network field. The main focus of this group is the conceptual design, implementation and integration of appropriate modules for multifunctional software and hardware infrastructures, including the analysis and description of use cases as well as the choice, development and implementation of sensor and actuator systems. Hardware/software interfaces are being developed with the aid of the OGEMA platform with the target of achieving modulization and standardization. A further focus is the simulation-based investigation of applications in customer networks. This group collaborates intensively with the "Distribution network operation" department regarding the effects on distribution networks.

Services and products

- Energy management potentials investigations
- Customer plant energy management solutions
- Demonstrations and practical trials, support, implementation and evaluation
- OGEMA application consulting, schooling and support
- OGEMA-based solution development, certification, test and quality controlling
- Energy management and variable electricity pricing tariff and business model development

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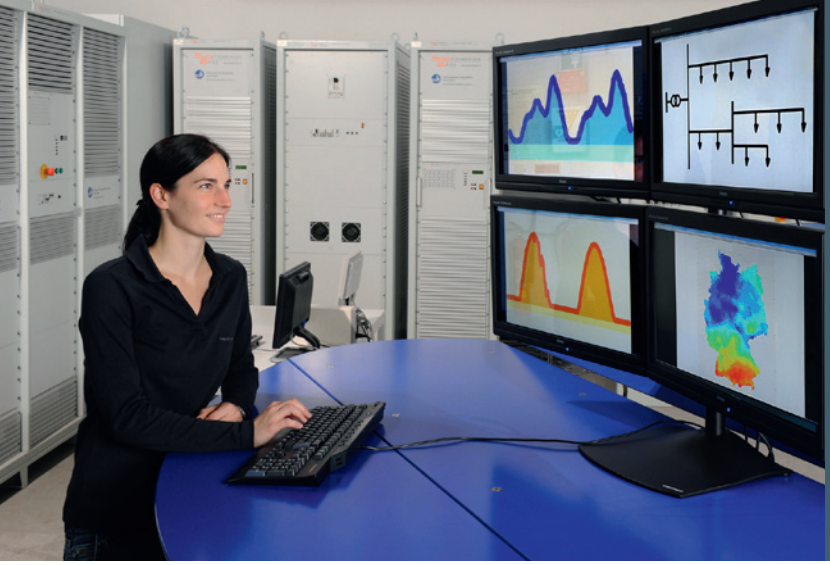

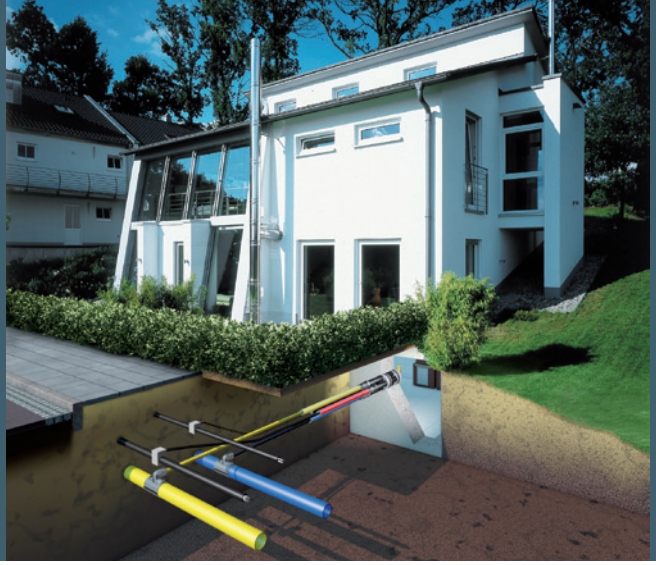

DISTRIBUTION SYSTEM OPERATION

Already today, there are over one million energy generation plants connected to distribution grids in Germany. In addition to decentralised energy production plants, more and more load and storage systems are being integrated. In this situation, the multi-utility approach (electricity, heat/cooling, gas, mobility) must be rigorously implemented in order to achieve a minimal cost structure for network infrastructure investment and operation across the entire power supply industry. The department is developing and investigating processes for the planning and operation of distribution grids, as well as processes for customer operational management for ancillary services availability. In addition, the interaction between varying operational management strategies, including incentive systems and aggregation mechanisms, is being investigated.

Multi-utility storage systems

Grid customers comprise regular energy generators (e.g. PV and CHP plants), storage systems (e.g. electric vehicles, batteries, heat storage systems) and consumers (e.g. heat pumps). The group's focus lies in the investigation of multi-utility ancillary services at grid connection points in consideration of local energy management. For this purpose, a grid-orientated multi-utility power management will be implemented, with network operator set point values, tariff incentives and local measurement information at grid connection points.

Operation and planning/hybrid grids

The transformation of energy supply systems and its respective decentralization lead to a novel situation in distribution grids. The group is developing processes for both centralized and decentralized distribution system operation strategies through the use of ancillary services. To succeed in this, it is necessary to employ a high temporal resolution as well as multi utility observation. In addition, it is important to keep combined optimization of network planning and operation in mind also during grid multi-utility observation. In this way, recommendations for strategic further development of distribution grids to smart grids may be given.

Aggregated system operation

Power supply systems are becoming more complex through local/regional energy management as well as integration and aggregation strategies. The focus of the group is on the development of a distribution system simulation platform which reproduces the interdependancies of different operational systems at grid customers, aggregators and the transmission systems to distribution systems. New operational management concepts, e.g. for the supply of incentive-based and aggregated ancillary services in distribution grids, will be developed on the basis of this complete systems reproduction model.

Services

- Network calculations
- Power flow and network simulations
- Process network operation and network planning
- Operation of storage systems
- Software-based real time simulation and laboratory testing
- Business model, regulatory framework conditions and incentive systems analysis

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NETWORK TECHNOLOGY AND INTEGRATION

This department works on the technical aspects of distribution networks and new technologies with main activities on distributed generators and storage systems, controllable loads and electric vehicles. Grid quality and dynamics in distribution networks, the development, testing and implementation of new grid control processes, the development of new network operational means and technologies, grid integration requisites and test processes for grid connection of distributed energy production plants, as well as grid protection, communication and innovative information technology are other main areas of work.

Power quality and grid connection

Through distributed feed-in, power flows, grid dynamics and grid quality in the distribution networks are changing. These changes are recorded and analysed in the distribution network using geographically distributed and temporally synchronised measurements. Other focuses of the specialist group are the development of grid connection guidelines for power production plants, the development of test processes and setups and the development of unit and plant models for distributed generators.

Power system control and dynamics

This specialist group concentrates on the development of new control processes and operational systems for networks containing a high percentage of distributed production. Due to the prospective progressively diminishing share of conventional power plants in the networks, new processes should guarantee stable grid operation. Newly developed control components can be tested and validated by means of hardware-in-the-loop systems. Grid control and operational management tools are being developed and implemented for smart controllable MV/LV substations.

Protection and controls for power distribution

This specialised group analyses network operation under the aspect of grid protection and develops new processes and technologies for grid protection in networks with distributed power generation. Network communication and information technology, especially for networks with a high proportion of small power production plants are further topics.

Rural electrification and hybrid systems

Hybrid electricity supply systems unite various sources and storages. Typically, photovoltaic wind energy and diesel technologies are combined with stationary storage systems. The group deals with the development of new concepts and operational management processes, optimized planning and systems design, as well as field testing.

Services

- Testing of generation units and certification of generation plants according to grid connection guidelines
- Metrological examination of performance (tripping characteristic) of protection devices for distribution grid components
- Measurements of grid quality and analyses of performance
- Investigation of new network management systems
- Investigation of network control characteristics of photovoltaic systems, grid-integrated storage systems, biogas plants, CHP plants etc.
- Generation of defined network conditions in low voltage electricity networks
- Testing of devices and components in a system context (in combination with power hardware-in-the-loop systems)
- Modeling and simulation of grid characteristics of generation units and generation plants

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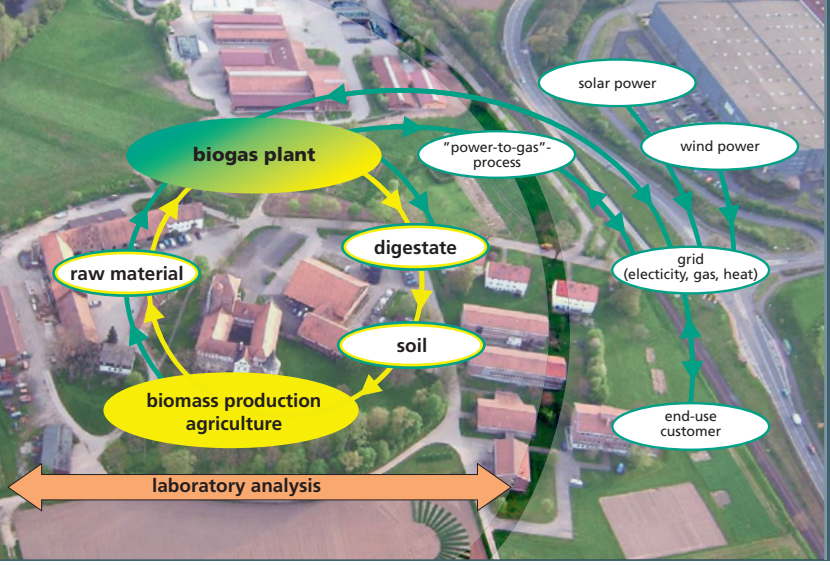

BIOENERGY SYSTEM TECHNOLOGY

This department carries out research on the integration of bioenergy plants into energy supply structures. The objective is to utilize opportunities for these technologies in providing sustainable energy supplies which have a high share of renewable energy, and to open up new potential. The focus of the R&D work on energetic biomass utilization is system technology for biogas plants and biogas upgrading. These offer high potential for offsetting supply-demand fluctuations in future energy supply structures.

Focus

In some areas, energetic biomass utilization technology has already reached an advanced stage. With this as the starting point, the research activities of Fraunhofer IWES aim at integrating biomass plants efficiently in regenerative power plant parks. This is the only way that biomass can fulfill its essential future role as balance energy. Bearing this in mind, more possible uses and wider commercialization aspects of not only whole plants but also individual components are closely examined. To achieve this there is a need for new total concepts which show improved energy balances and life cycle assessments, which utilize biomass more efficiently and sustainably, and which simultaneously lower energy production costs. Future power supplies which are able to meet consumer demand through the use of biogas plants will only be feasible with a suitable, highly efficient heat utilization concept and, as the case may be, only in combination with a gas network.

Besides decentralized use in large combined networks, biomass power plants are also ideal for complementing autonomous hybrid systems.

R&D topics

- Total system technology-based consideration and investigation of the whole process chain for electricity, heat, and energy source production from biomass
- Biomass usage for new energy conversion technology such as micro gas turbines, fuel cells, Stirling engines
- Biogas-based systems for small and medium power ranges for decentralized use and also the integration of larger systems into network systems
- Optimization of the interaction between bioenergy systems and other renewable energy forms
- Analysis of existing opportunities and development of new integration and commercialization opportunities for bioenergy systems
- Monitoring and integration of biogas upgrading technology
- Methanation of surplus electricity from other renewable energy sources

Services and products

- Contract research: In all work areas of the department; research projects can be undertaken on a contract basis
- Contract measurements: Wide range of tests and monitoring of bioenergy systems
- Studies and consulting: Supervised research and studies on the integration of biogas plants, technology evaluation, consultancy, training and follow-up training
- Technology assessments
- Pilot plants and demonstration plants

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RESEARCH IN FOCUS: HIGHLIGHTS AND INTERVIEWS

COMPLETE ROTOR BLADE TESTING UP TO 90 M IN LENGTH

THE COMPETENCE CENTER ROTOR BLADE COMPREHENSIVELY ADDRESSES THE NEEDS OF THE ROTOR BLADE INDUSTRY THROUGH CLOSE COLLABORATION AND THROUGH ITS CORE COMPETENCIES. THE AREAS OF SPECIALIZATION ARE IN: OPTIMIZATION OF FIBER COMPOSITE MATERIAL MANUFACTURING PROCESSES, MATERIALS TESTING, ADVANCED DEVELOPMENT OF COMPONENT TESTING METHODS, AND CERTIFICATION TESTING OF ROTOR BLADES UP TO 90 M IN LENGTH.

Before a new rotor blade design goes into serial production and is installed on a wind turbine, a prototype blade must be certified by a recognized authority. The testing halls of Fraunhofer IWES have the capacity to accommodate rotor blades of up to 90 m in length and test them with defined static and dynamic. For static testing the rotor blades are mounted to a steel-reinforced concrete test stand and loaded vertically downwards by ropes which are connected to hydraulic cylinders on the one side, and precisely manufactured load frames attached to the rotor blade on the other side. The Competence Center Rotor Blade at IWES has a maximum static bending moment capacity up to 115,000 kNm. Throughout testing the blade is closely monitored using strain gages, force transducers, optical displacement measurement systems, draw-wire sensors, acceleration sensors and temperature sensors.

Fatigue testing for the flap and edge directions are conducted vertically and horizontally, respectively. The rotor blade is excited to oscillate at or near its natural frequency using an externally mounted hydraulic cylinder. Testing at the natural frequency allows application of the required bending moment distribution up to ±30,000 kNm using minimal energy and force input. Successful completion of a certification testing program not only leads to certification of a rotor blade, but provides valuable input and feedback on the design and manufacturing methods.

Manufacturing processes for fiber-composite materials

The source of up to 40 percent of all failures in rotor blades is in the manufacturing process. The huge dimensions and complex geometry of a rotor blade pose significant challenges to the designers and manufacturers, and the materials they employ. New materials are tested for their adequacy in rotor blade manufacturing in the manufacturing and materials testing laboratories at the Competence Center Rotor Blade. The use of appropriate resin systems and adhesives are especially critical criteria for the manufacturing process and resulting rotor blade materials. Resins with additives, such as carbon nano-tubes, show possible improvement of the final composite's structural characteristics. However, the vacuum infusion process of laminates up to 15 cm thickness can be further enhanced to optimization. Representative parts or a scaled rotor blade can be manufactured to demonstrate the adequacy of the material to the specific demands of the rotor blade manufacturing process.

Non-destructive testing

Reliable identification of defects in rotor blades can be identified with non-destructive testing techniques. In cooperation with our partners, various methods have been applied and evaluated. Thermography, acoustic emission analysis, ultrasonic tests have all shown good results individually, but they are especially promising in combination.

Numerical investigation of fiber-composite structures

Numerical investigation supports experimental testing methods and delivers detailed knowledge of stress distribution and so called hot spots in components. Using the simulation programs ANSYS, FOCUS and ABAQUS, it is possible to define the optimum load introduction points of complex components or to analyze complicated non-linear problems in the area of fiber composites.

Transporting a rotor blade prototype to the 90-m-test hall

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PROGRESS IN PRECISE LOAD ASSUMPTION FOR OFFSHORE WIND ENERGY TURBINES

WIND TURBINES ARE DEVELOPED WITH THE AID OF COMPLEX SIMULATION TOOLS. THE VERIFICATION OF SUCH TOOLS IS CARRIED OUT WITHIN THE CONTEXT OF AN "IEA TASK" TOGETHER WITH NUMEROUS INTERNATIONAL PARTNERS. ALL THE SIMULATION RESULTS FOR A 5 MW OFFSHORE WIND TURBINE WITH JACKET SUPPORT STRUCTURE ARE COMBINED, CENTRALLY EVALUATED AND INTERPRETED BY THE PROJECT GROUP. THE CONCLUSIONS ARE THEN USED FOR SOFTWARE DEVELOPMENT AT IWES.

On account of dynamic interaction and significant non-linearities the subsystems of (offshore) wind turbines (OWT) and external loads are compiled numerically for realistic simulation. A so-called aero-hydro-servo-elastic simulation is used to calculate stress factors on the turbines which are in turn the basis for the design of each turbine component. Further development of turbine technology is only partially possible without the aid of appropriate numerical tools. For this reason, numerical codes and simulation results are of immense importance.

Constant checking of numerical tools

Simulation tools are constantly being developed further and adapted to changed demands driven, for example, by new support structure concepts. On account of system complexity and the importance of calculated results, these must be constantly verified and validated. Verification through code-to-code collating enables a gradual increase in the complexity of models and load cases handled; this level of validation is not achieveable using standard measured data. The danger of generating unrealistic convergent simulation results is minimised in the following manner: firstly, a multiplicity of calculation models is used and furthermore certain codes have already been validated upfront for other boundary conditions.

IEA Project lead by IWES

In the context of the Wind Implementing Agreement of the International Energy Agency (IEA), the Offshore Code Comparison Collaboration (OC3) project was run from 2005 to 2009 during which a generic 5 MW OWT was simulated in combination with four different support structures. Upon completion of the OC3 project a further need for research was recognised and therefore a second project was started in 2010 under the name of IEA Wind Task 30 Offshore Code Comparison Collaboration Continuation (OC4). This project is run by the National Renewable Energy Laboratory (NREL, USA) and Fraunhofer IWES. To this date 24 organizations from 9 countries are active partners in OC4. Along with NREL and IWES resarch institutes such as RISØ DTU (Denemark), CENER (Spain), ECN (Holland), and companies such as German Lloyd or Repower and universities such as Stuttgart University or the NTNU (Norway) are to be found. The majority of internationally relevant simulation tools are being benchmarked in the OC4 project in order, among other things, to achieve the following targets: compilation of exactitude and reliablitiy of codes and results, determination of limits to implemented theories, improvement of analysis methods and indentification of needs for further research. The project is structured in two phases, with an additional expert forum. Firstly, a jacket structure turbine is inspected, after which a floating support structure (semi-submersible) is inspected in turn.

Results are integrated into further development

Now that the reference model and a number of load cases have been established the majority of phase I (jacket) simulations have been carried out. All partner results are compiled and evaluated at IWES. Results gained concerning OWT modelling and simulation in general and jacket structures in particular will lead to more precise load assumptions and therefore finally to more reliable and cost effective OWTs. These results are already being integrated into the further development of simulation software at IWES today.

Precise load assumptions for simulation lead to more reliable and cost effective OWTs.

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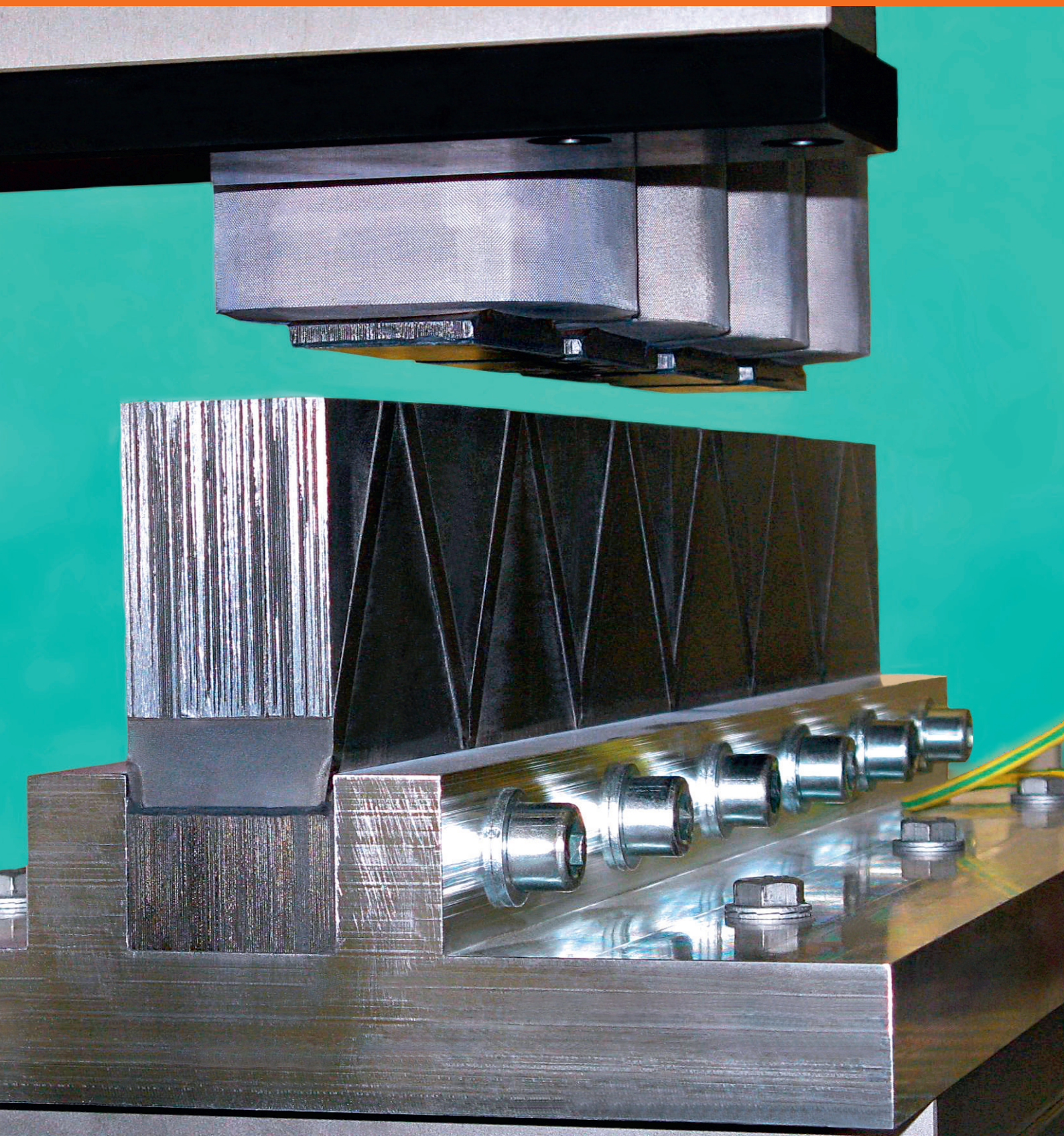
MAGNET RING: A NEW GENERATOR CONCEPT FOR WIND TURBINES



THE LARGEST WIND TURBINE IN THE WORLD TODAY WEIGHS 7,000 TONS. THE GENERATOR WEIGHS 220 TONS AND DELIVERS A MAXIMUM OF 7,500 KILOWATTS OF ENERGY AND WHILST BEING VERY POWERFUL IT HAS, HOWEVER, A GREAT SPECIFIC MASS. USING A PERMANENT MAGNET-EXCITED GENERATOR IT IS POSSIBLE TO REDUCE THE WEIGHT OF WIND TURBINES OF THIS PERFORMANCE CLASS AND THEREFORE SAVE CONSTRUCTION TIME AND EXPENDITURE.

Fraunhofer IWES is researching innovative generator concepts as part of the Magnet Ring project. Lighter, more reliable and cost effective wind turbines are being developed using new technology and for this reason the electromagnetic and mechanical characteristics of new generator types are being examined. The design of the generator relies on the combination of analytical models as well as numerical computer simulations. The characteristics of individual generator segments are then examined using several experimental test setups.

New generator concept

The generator rotor is activated by permanent magnets collectively arranged in a V-shape. The stator poles are comprised of single-toothed windings arranged in a multiphase manner. Four stator poles are combined in one segment. In this way, more than 500 poles are positioned on a circular ring next to each other to form a generator with a diameter of almost 20 m. In this system, the rotor and stator poles form two large rings placed opposite each other at a distance of 10 mm. Contrary to conventional high-speed machines which have less poles, this generator is gearless and works at a low speed. A contact-free and self-adjusting magnetic bearing is utilized to adjust the air gap of the generator, i.e., the space between rotor and stator, with an accuracy of one millimeter. These measures ensure a higher power density thus enabling weight reduction with the new generator concept compared to conventional generators. Theoretically, an active mass of only approximately 7 tons is necessary for such a 10 MW generator.

Experimental setup to measure the magnetic forces of generator segments

Experimental setup to determine the magnetic forces of generator segments

The V-shaped arrangement of the permanent magnets in the rotor strengthens the flux density of the magnetic field and simultaneously increases the force density of the electromagnetic coupling between rotor and stator. The greater the diameter of the generator, the smaller the length of the active laminated core (thickness of the generator), which is necessary to produce a specific electric power. The generator weight is essentially determined by the length of laminated core. It is possible to deduce values for generator laminated core length and generator diameter in order to minimize the mass of the generator. Therefore, the new generator concept under examination will increase the electric power whilst minimizing the mass. Due to the low rotation velocity and its contact-free generator bearing, wear and tear on the bearing is reduced and the lifecycle is enlarged. In spite of the low rate of rotation, the large diameter enables high angular velocities and therewith high power densities.

Concept verification using force measuring setups

To precisely determine the maximal increase of the force density and the corresponding maximal electric current in the coils, measuring setups have been developed in collaboration with the company Krämer Energietechnik GmbH, Zierenberg and the Institute for Electric Energy Technology (IEE), University of Kassel, to verify the tangential and normal force components acting inside the generator. These measurements verified the distinct increase of the force density as well as power density in the generator segments. In addition, a measuring setup has been developed to determine the restoring forces inside the magnetic bearing. A well-designed magnet bearing generates sufficient force to stabilize the position of the rotor ring.

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WIND TURBINE AND WINDFARM CONTROL

INNOVATIVE CONTROL SYSTEMS FOR WIND TURBINES LEAD TO LOAD REDUCTION AND INCREASE IN OPERATIONAL RELIABILITY. WINDFARM CONTROL SYSTEMS ENSURE STABILITY AND FACILITATE GRID INTEGRATION.

Modern wind turbines are built to a height of up to 200 m. The height and rotor diameter of such turbines exert an enormously increased structural load. Modern control systems limit and reduce both extreme loads and operating loads. Large windfarm grid integration demands highly devoloped control systems.

Load reduction control systems

Active load reduction through individual pitch control encompasses two different targets: the reduction of periodic excitations caused by dissymmetric air flow and the attenuation of natural oscilation through controlled generation of aerodynamic counterforces. The first target comprises pitch and yaw moment compensation at which these moments are measured and then compensated through individual pitch control. To do this a small individual offset to the collective pitch angle is predetermined for each rotor blade and varies cyclically with the rotor revolutions. The second target comprises active tower vibration damping whereby through individual pitch control periodic aerodynamic force components are generated in antiphase to the displacement speed at the head of the tower.

In numerous research and development projects Fraunhofer IWES has developed a range of active load reduction control systems which are being tested at the moment in collaboration with industrial partners on multi-megawatt wind turbines.

Large windfarm grid integration control systems

An important aspect of large windfarm grid integration is network compatibility. Windfarms must increasingly participate in grid stabilising and controlling, just as traditional power stations do, in order to increase their share of electric energy supply without endangering electrical network stability. Windfarm control systems coordinate the dynamic interplay of individual wind turbines taking into account the interactions caused by wake effects and observing numerous other criteria. This demands the use of highly developed optimization processes capable of handling multi-criteria target functions.

Designing such control systems is hardly achieveable with presently available development tools. On this account specialised tools destined to greatly alleviate the task of designing windfarm control systems are being developed as part of currently running projects. A real time windfarm simulator will enable newly developed control system algorithms to be tested easily in a hardware-in-the-loop application. To date, control system algorithms for regulating voltage output and reactive power have been developed for different industrial partners.

Blade pitch system for a multi-megawatt turbine.

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GEOPHYSICAL SURVEYING

CONSTRUCTION SITE CONDITIONS MUST BE PRECISELY DETERMINED BEFORE THE INSTALLATION OF OFFSHORE WIND TURBINES. AMONG OTHER THINGS, PRIOR GEOPHYSICAL SEABED MEASUREMENTS MUST BE TAKEN. IWES HAS DEVELOPED A NEW SEISMIC MEASURING SYSTEM ESPECIALLY FOR THIS PURPOSE. THIS SYSTEM WAS EMPLOYED IN THE GERMAN NORTH SEA AREA FOR THE FIRST TIME IN SPRING 2011 AND SUCCESSFULLY DEMONSTRATED ITS PERFORMANCE CAPABILITIES.

It is compulsory to carry out geophysical measuring at the start of any offshore windfarm geological survey. The aim is to quickly and extensively determine the geological conditions of an area without having to carry out numerous time consuming sampling operations (geological drilling, cone penetration tests). Potentially critical structures in particular should be able to be rapidly identified. This information is of utmost importance for the stability and serviceability of offshore wind energy turbines and the selection and dimensioning of foundations.

The measuring technology mostly used nowadays (Boomer single-channel seismics) can only inadequately meet demands. Notably, signal penetration depth is often no more than approx. 20 to 30 m and, in most cases, does not reach the foundation depth required. Therefore, any statement concerning the construction area is inevitably marred by uncertainties. Instead of using this method, IWES works with digital multi-channel seismics. This measuring system essentially consists of seismic source, highly sensitive signal receiver (streamer) and data registering unit, reaching a new level of efficiency; penetration depths of over two hundred metres have already been attained.

North Sea premiere

The new Fraunhofer measuring system was used for the first time in the North Sea in May of this year. During a three week expedition, measurements were taken in the whole of the German North Sea area. More than half of all the planned offshore windfarm areas in the German North Sea were transversed. The first measurements produced very promising results. The system proved to be especially suitable for the detection of sediments with high gas content. In addition, seabed peat deposits were identified in numerous locations – relics of sunken ice-age moorlands. The course of the Elbe glacial valley, buried today under several metres of heavy layers of sediment, could also be followed very clearly far into the North Sea.

One of the most important tasks for the Fraunhofer IWES measuring system is the localization of sediment structures relevant to the construction of offshore wind energy turbines. The sub-glacial trench systems which were created at the base of massive glaciers during the last ice ages are very wide-spread but remain largely unexplored. An increase in the occurrence of problematic soft sediments can be expected in these areas. One of the great strengths of the IWES multi-channel seismic measuring system is apparent here when compared with conventional measuring methods. Whereas ice-age trench structures have often remained unrecognised up till now, the IWES system is capable of delineating them clearly. A large number of such trenches were able to be identified during this year's expedition. Some of them, even though partly inside intensely surveyed windfarm areas, had, until then, been completely unknown.

Successful test phase completion

The newly-developed and globally unique Fraunhofer IWES shallow-water measuring system is the missing link between established high-frequency single-channel seismics and low-frequency multi-channel seismics used in the field of hydro-carbon exploration. Its first use in the North Sea has shown that it is especially suitable for surveying construction site conditions in offshore shallow-water areas and that it is capable of increasing the quality of geophysical measurement data significantly.

Seismic measuring reveals the structure of the seabed in depth.

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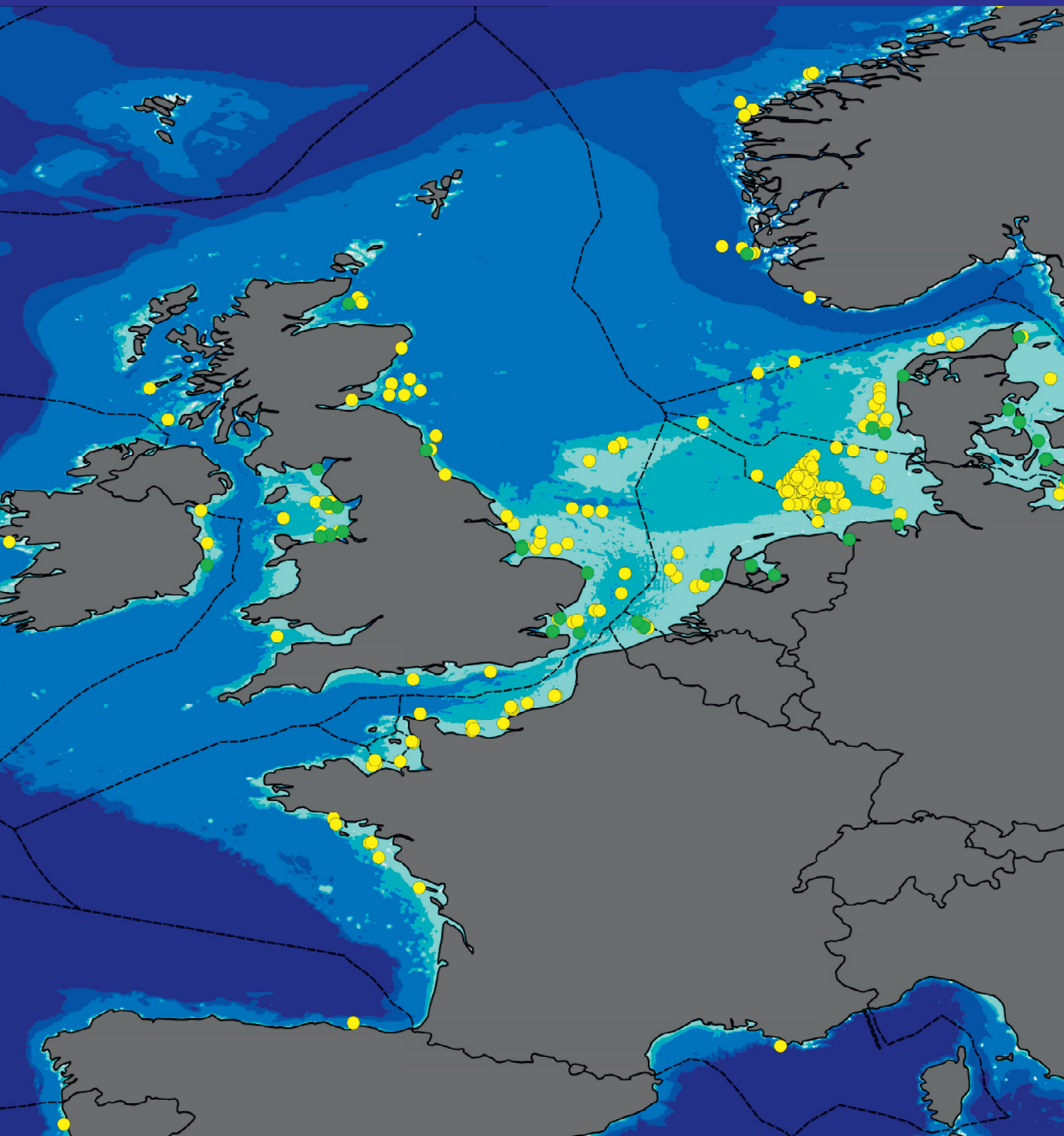
ORECCA: OFFSHORE RENEWABLE ENERGY CONVERSION PLATFORMS – COORDINATION ACTION



THE GOALS OF THE ORECCA PROJECT ARE TO CREATE A PAN EUROPEAN FRAMEWORK FOR KNOWLEDGE SHARING AND TO DEVELOP A ROADMAP FOR RESEARCH ACTIVITIES IN THE CONTEXT OF THE UTILIZATION OF OFFSHORE WIND- AS WELL AS CURRENT AND WAVE ENERGY. THROUGH THE CENTRAL PROVISION AND THE EXCHANGE OF KNOW-HOW BETWEEN ACTORS FROM POLITICS, INDUSTRY AND RESEARCH, THE PROJECT AIMS TO FACILITATE THE EUROPE-WIDE DEVELOPMENT OF RENEWABLE OFFSHORE ENERGIES.

ORECCA (Offshore Renewable Energy Conversion platforms – Coordination Action) is an EU-project funded under the Seventh Framework Programme (FP7). Besides Fraunhofer IWES as project coordinator, 29 other research institutes, universities and companies from all across Europe and also the USA and Canada, participated in the project. The project's principal aim was to avoid and overcome the fragmentation of know how in the areas of offshore wind energy, current energy and wave energy by improving scientific collaboration on a European level and transferring knowledge amongst research organizations, industry stakeholders and policy makers, stimulating these communities to take the necessary steps to foster the development of the offshore renewable energy sector in an environmentally sustainable way.

Knowledge transfer portal

Concrete actions taken by ORECCA to reach these goals are one the one hand the development of a knowledge transfer portal: Through the internet and browser based ORECCA-portal (www.orecca.eu) not only project partners but international organizations and also single persons have access to documents which were created in the course of the project, covering the fields of resources, technology and scenarios. Amongst these documents there are reports with the focus on resources, site selection, national policies and investment opportunities, environmental impacts, regulation and legislation, state of the art platform technology, guidelines, tools and standards, offshore infrastructure (ports and vessels) and synergies, hybrids and multipurpose platforms. Additionally a database with specification sheets of now and in future available offshore installation and maintenance vessels is provided.

Web GIS application

Furthermore there is a web-GIS (Geographical Information System) application available, allowing the user to visualize and utilize results from the documents on a European map (see illustration): For example it is possible to generate a map of functional and scheduled offshore wind farms in different contexts, such as water depth, distance to shore, mean wind speed or specific wave energy.

EU roadmap

The second action taken by the project is the development of a roadmap with recommendations for technology facilitation with focus on synergies between the different energy conversion technologies as well as their development potentials and possible existing barriers. This roadmap covers strategic investments, research priorities and regulations, as well as socio-economic aspects which are to be addressed in the medium to long term to achieve and secure a pan European development in the sector of offshore renewables.

Existing (green) and currently scheduled (yellow) offshore wind farms in Europe in different water depths and national economic zones

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TRANSFORMATION OF THE ENERGY SUPPLY SYSTEM

CLIMATE PROTECTION GOALS CAN ONLY BE ACHIEVED IF POWER SUPPLY SYSTEMS ARE TRANSFORMED. THIS NECESITATES CHANGES FOR POWER SUPPLIES, HEATING AND TRANSPORT.

Transformation of the energy supply system to decarbonize electricity generation and the implementation of all corresponding measures is the challenge of the 21st Century. This remodelling concerns energy-dependent sectors, electricity, heat, transport and all ancillary areas such as producers, networks, storage, consumers and markets. This raises a wide variety of research questions, and finding answers to these is a central task of Fraunhofer IWES. Numerous strategic project research models are therefore further developed and any sub-issues addressed resulting in a synergetic advance in overall development.

Fraunhofer IWES has built a very high-perfomance simulation environment for the analysis of future energy supply concepts which enables the generation of scenarios with detailed spatial imaging linked with high temporal resolution. To achieve this, a simulation model has been developed based on detailed geographical information and high-resolution weather-model data as well as network, power plant and storage models and run on high-performance computer hardware. With the aid of this simulation environment IWES has conducted or supported numerous studies for the political sector, associations and industrial partners.

Apart from precise predictability, fluctuating power production requires a higher proportion of controllable flexible elements in wind energy generation. The Windfarm-Cluster-Management-System (WCMS) developed at Fraunhofer IWES combines individual windfarms into clusters and coordinates them in such way that feed-in characteristics comparable with those of conventional power plants can be determined. This higher-level control system permits windfarms to handle future functions such as frequency and voltage control and allows participation in the control power market.

The electricity grid and the wide geographical distribution of electricity producers and consumers are decisive factors in the analysis of grid stability and security of supply. A well-operating and stable electricity supply requires not only sufficient capacity to cover demand but also the providing of ancillary services (frequency and voltage regulation). That renewable energies can provide necessary ancillary services themselves is being demonstrated in the joint project named "Regeneratives Kombikraftwerk". Within the framework of this project, and in cooperation with known turbine and component manufacturers, IWES is developing a large-sized virtual power plant. Such a facility poses high demands on technical operation management as well as on information and communication technology. The optimal economic operation of such a power plant is also of interest for regional electricity supply and is the main focus of the Regenerative Model Region Harz project. In this project, regenerative feeders are coordinated with both traditional and new storage technology and flexible consumers in such a manner that regional regenerative electricity supply is made realistic.

European electricity network

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RE-EVALUATION OF INLAND WIND ENERGY

INLAND WIND ENERGY USE HAS EXPERIENCED A CLEAR UPSWING IN GERMANY. FRAUNHOFER IWES SUPPORTS THIS DEVELOPMENT BY RESEARCHING WIND POTENTIALS AND CHARACTERISTICS, ESPECIALLY AT INLAND SITES.

The use of wind energy on land will play an important role as a pillar of future energy supply systems. In recent years expansion has only been slow, with 1-2 GW per year; at the end of 2010 there were approx. 27 GW wind turbines installed on land. The technological development of wind energy turbines and the increased acceptance of wind energy projects following the nuclear disaster in Fukushima, have lead to a re-evaluation of inland wind energy use. Many German federal states are formulating new, and clearly more ambitious wind energy expansion targets reaching a total of around 60 GW by 2020.

Wind energy use potential on land

The technological development of wind turbines in recent years has lead to the availability today of especially high towers and large rotors. This has caused the potential of on-land wind energy use to increase significantly. This was confirmed in a Fraunhofer IWES study carried out on behalf of the Federal Association for Wind Energy (BWE). On the basis of geo-information systems (GIS) data, land potentials were categorized into different types of area and land use. It was able to be shown that the proposed BWE target, 2 % of German land to be developed for wind energy power production, is technically possible. This would be sufficient, using large, modern wind energy turbines with hub heights of up to 150 m, to meet approximately 60 % of present German electricity needs. It was also revealed that there is great potential to be found in woodland areas. Woodland areas especially are hardly used for wind energy and there is considerable need for research into prevailing wind conditions in these areas.

Wind characteristics in wooded central mountain range sites

Exact knowledge of hilly or wooded inland region wind characteristics is indispensable for successful windfarm projects and appropriate wind energy turbine optimization, especially at such sites. Therefore, planners, operators and manufacturers of turbines and components need precise, high-resolution measurements and models of prevailing wind conditions. Above all, research questions as to how wind resources at a site may be sufficiently precisely determined, and which location-adapted load assumptions for turbine design should be used, still require developing. Within the framework of the "Wind energy inland" research project, a 200 m high meteo-mast is presently in operation near Kassel in order to find answers to these questions. The target is the development of more accurate methods for determining resources for turbines situated at great heights on wooded and hilly land. In addition, wind profile and turbulence should be characterized in order to be able to make better assumptions regarding design-determining wind energy turbine loads. Moreover, Fraunhofer IWES researchers are using LIDAR (laser-supported wind speed measuring) systems to measure wind speeds at heights of up to 200 m. This new ground-based remote measuring technology should be capable, in the long term, of replacing wind measuring masts. In this context, Fraunhofer IWES is developing methods for the deployment of LIDAR measuring devices in complex terrain.

Use of LIDAR measuring devices for wind-profile characterization

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ELECTRIC VEHICLE CHASSIS DYNAMOMETER WITH VIRTUAL TRACTION BATTERIES

SPECIAL REPRODUCEABLE HARDWARE-IN-THE-LOOP (HIL) DRIVE TESTS ARE MADE POSSIBLE BY COMBINING A CHASSIS DYNAMOMETER WITH VIRTUAL BATTERIES. TIME CONSUMING COMPATIBILITY OPTIMIZATION PROCESSES BETWEEN VEHICLE AND DIFFERENT TYPES AND CONDITIONS OF BATTERIES CAN THUS BE SHORTENED.

Electric vehicles are capable of not only reducing carbon dioxide emissions in the overall traffic sector but also of reducing urban exhaust pollution if they use regenerative energy. A critical subject for the widespread introduction of electrotraction is however, the technical design of electro-chemical storage. Fraunhofer IWES has therefore developed a special hardware-in-the-loop chassis dynamometer to support electric vehicle battery design. This roller test bench enables the testing of vehicles with defined driving profiles and, in so doing the varying of battery characteristics through the use of virtual traction batteries. Speeding up development and assuring measurement reproducibility are important advantages of this concept.

HIL-chassis dynamometer

Apart from vehicle response when connected to the electric grid, many of the programmed tasks concern vehicle response in driving conditions. Here, for example, an important role is played by the interaction between battery, motor and connecting power electronics. For this reason, it is extremely advantageous for reasons of research and development to be able to precisely reproduce driving conditions in the laboratory. A chassis dynamometer enables testing and optimizing of both two-wheel and four-wheel drive vehicles using either standardized driving or field-test driving profiles. Optimization criteria are, for example, drive train performance capability and regeneration efficiency. The configureable hardware-in-the-loop (HIL) electric vehicle test facility has the advantage that specific stress situation effects relevant to vehicle power management can be studied and resulting data reproduced exactly. On the basis of these studies, standardized test parameters can be developed for variance comparison of different vehicle models under defined operating conditions.

Network simulator

The use of a parameterizable grid connection coupled to a real time network simulator allows detailed study of electric vehicle power grid integration. Battery design and power management can be optimized through vehicle and power grid integral monitoring. In particular, it is possible to study and evaluate in detail dependency between long-range operating span, long service life and maximal grid support for target achievement.

Virtual batteries

Lithium-ion batteries will play a key role in electromobility. The dynamic characteristics and ageing behaviour of these batteries both play an important role in the development of future hybrid and electric vehicles and in the design of intelligent systems for bi-directional grid connection. Therefore, good lithium-ion battery simulation models are of great importantance for research and development in the field of electromobility. ISET-Lab has been the standard simulation software for lead acid battery dynamic behaviour in the automotive and supply industry for many years; all relevant physical and electrochemical cell processes have been modelled so that the software can be parameterized applying simple manufacturer data. The ISET-Lib software package for Lithium-ion battery simulation has been developed on the same basis. ISET-Lib real-time variants are used to construct virtual batteries which physically simulate real battery terminal behaviour.

Chassis dynamometer for electromobility at IWES SysTec

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POWER-TO-GAS – IN SITU METHANIZATION WITH BIOGAS

AS WELL AS ENABLING THE STORAGE OF SURPLUS RENEWABLE ENERGY, THE POWER-TO-GAS METHOD OPENS UP NEW METHODS OF GENERATING, IN LINE WITH DEMAND, POWER FROM BIOMASS PLANTS. AS PART OF A JOINT RESEARCH PROJECT WITH ITS PARTNERS ZSW AND SOLARFUEL, FRAUNHOFER IWES WILL TEST THE POWER-TO-GAS METHOD IN COMBINATION WITH A BIOGAS PLANT AT THE HESSIAN BIOGAS RESEARCH CENTER IN BAD HERSFELD.

Needs-based electricity storage – needs-based electricity production

The Power-to-Gas process – conversion of surplus electricity gained from wind and sun into storable methane through electrolysis and methanization processing stages – is a future-orientated, and already award-winning concept. This process was developed by Fraunhofer IWES in cooperation with the Centre for Solar Energy and Hydrogen Research in Baden-Württemberg (ZSW) and the SolarFuel company. These partners are now taking the next logical step. The carbon-dioxide contained in biogas is used directly, without prior separation, as a carbon-dioxide source for (in situ methanization). In this way, the gas end-product is of 100% renewable origin.

Power-to-Gas with biogas: High-performance system services

The research project target for ZSW, SolarFuel and IWES, is in situ methanization with biogas from an agricultural biogas plant. SolarFuel's 25 KW alpha plant has, for this purpose, been integrated into the already existent infrastructure set up on the grounds of the Hessian Biogas Research Centre (HBFZ) in Bad Hersfeld. At the end of the project, and despite ever changing farm-operation conditions (e.g., fluctuations in gas quality), the process should be permanently operational. The compensatory function of biogas plants is indispensable for a safe, renewable electricity supply in electric supply networks of the future and can be greatly improved since this process enables not ony needs-based electricity production but also needs-based electricity storage. The role of a biogas plant as system service provider can be strengthened and expanded due to transregional support given by the Thuringian Ministry for Agriculture, Forestry, Environment and Nature Protection (TMLFUN) and the Hessian Ministry for the Environment, Energy, Agriculture and Consumer Protection (HMUELV).

Power-to-gas with biogas: Alternative biogas treatment processes

If in situ methanization in agricultural biogas plants is successful, the Power-to-Gas process can be an alternative to conventional biogas treatment processes. In classic regeneration plants carbon-dioxide is separated from the biogas in order to increase biogas-methane content, but, with in situ methanization, carbon-dioxide can be converted directly to methane thereby increasing the biogas-methane content to produce a feedable natural gas equivalent. Through feeding biomethane into the natural gas network the use of gas is no longer dependent on time and place of production. This is valid for both biogas and electricity stored in the form of methane.

Biogas plants play an important role in needs-based power production.

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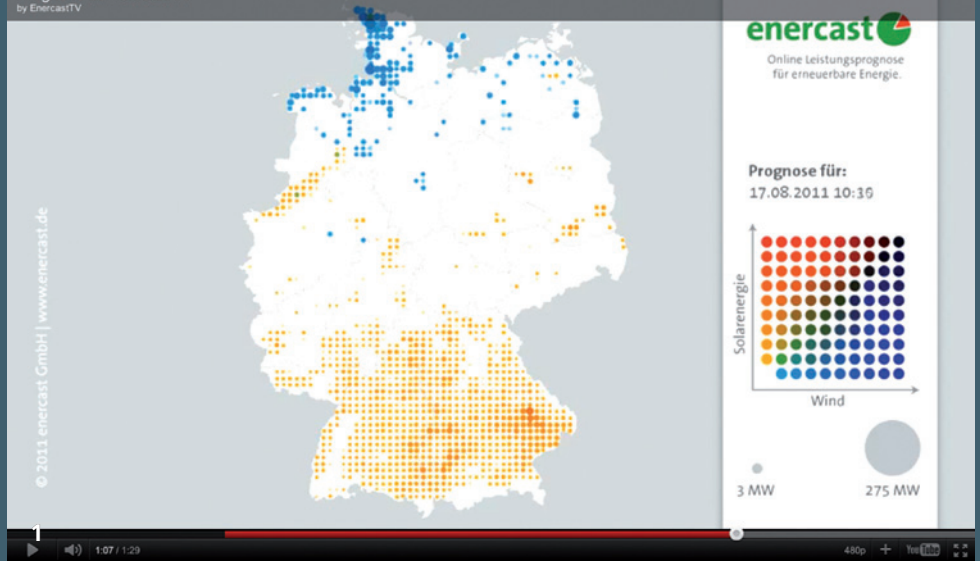


PRECISE WIND AND PV FORECASTING VIA THE INTERNET

Since the change in energy policy, hardly any economic sector has been more affected by the weather than the energy industry. The energy industry needs weather forecasts tailored to its speciifc requirements in order to be able to estimate how much energy the volatile solar and wind electricity generators are going to produce. For the past two years, in a cooperation project with enercast GmbH, Fraunhofer IWES has developed reliable and accurate power forecasts and as well as now-casts for wind and photovoltaic feed-in which can be accessed on the enercast.de. web portal. Calculations are based on artificial intelligence – by the use of neural networks.

enercast compiles energy prognoses. How should we picture this? How does your forecasting system work?

Kurt Rohrig: The basis of enercast.de is the Fraunhofer IWES Wind Power Management System which is built up around meteorological forecasting data from weather offices and recorded power data from windfarms. In addition, satellite data concerning solar radiation and data from the SMA Solar Technology AG solar energy measuring network are used. Wind power forecasts are carried out by artificial neural networks (ANN).

Thomas Landgraf: All data is processed through these algorithms. The artifical neural networks model the complex interrelation between weather data and wind power production by means of past experience and data, drawing conclusions for expected power feed-in. The enercast.de. web portal user is then able to receive power forecasts for the respective wind and solar energy facilities.

What are the tasks of the Wind Power Management System (WPMS)?

Kurt Rohrig: The WPMS is a system for short and long range forecasting for wind-power feed-in. Frequency and voltage are kept stable in the electric grid through the controllability of active and reactive power. Today, conventional power stations provide these functions. In the future when renewable energies, from time to time, cover the total demand, conventional power stations will have to be throttled or shut down. In order to maintain stability on the grid, windfarms and other renewable energy sources must provide the necessary system services.

Thomas Landgraf: The implementation of WPMS functionalities on the enercast.de platform enables the realization of these requirements in a simple, safe and cost-effective manner.

For which sectors are forecasts for volatile renewable energy already of importance?

Kurt Rohrig: Wind power forecasting models have already been used by German transmission system operators for more than 10 years. Prediction models for PV feed-in have gained in significance since 2010. The system supports grid operators, in the procurement of reserve power and balancing power, and grid management. Windfarm operators and green-power providers can now obtain the forecasts from the enercast.de web portal.

Thomas Landgraf: A further area is the direct marketing of electricity on the stock exchange which has become more interesting since the introduction of the Renewable Energy Law in 2012. If one wishes to obtain an optimal price for electricity


Thomas Landgraf


Kurt Rohrig

from windfarms or photovoltaic installations on the electricity markets, one needs especially precise forecasts. The better operators and dealers can predict quantities of electricity, the less reserves need to be provided. Costly additional acquisition of reserve energy is also reduced.

In which other areas will enercast also play a role in future?

Kurt Rohrig: Forecasts in framework of direct marketing of renewable energies for stand-alone facility operators and electricity dealers, as well as marketing and control of virtual power plants and storage systems, will be of great importance in the future. Probalistic forecasts, especially, will be essential for these application areas and the risk management associated with them.

Thomas Landgraf: Electromobility will be an issue. With the aid of forecasting, electric vehicles could be recharged during the periods in which there is a surplus of electricity gained from wind turbines and photvolaic installations. On the other hand, there is the possibility of using stored energy to bridge short term spans of electricity shortages in the grid. Exact forecasting of utilizable energy amounts is also necessary for this purpose.

Together with enercast, Fraunhofer IWES has implemented a forecasting service. What is special about this cooperation?

Kurt Rohrig: The cooperation with enercast is a typical Fraunhofer model: science and industry work in close collaboration, complementing each other. The scientific competences of Fraunhofer IWES in the field of wind and PV forecasting is complemented by the in-depth expertize of enercast in the operational sector and merge to create a very high-performance system.

Thomas Landgraf: Fraunhofer IWES ensures that the forecasting systems are based on the latest research and development results, and enercast ensures that these research results are quickly and reliably integrated into the operational system.

Thomas Landgraf
is managing director of the specialists for energy meteorology enercast GmbH, a spin-off from Micromata GmbH where Landgraf, managing director since its foundation in 1996, was responsible for all the projects in the energy and raw-materials sectors. As engineer for theoretical technology, he was then also chief project leader for the online portal enercast.de.
www.enercast.de

MASTERING CHALLENGES THROUGH JOINT RESEARCH PROJECTS

Photovoltaic systems presently installed in Germany have a capacity of approx. 20 gigawatts. Around 85 percent of the systems feed their electricity into the low voltage grid. On sunny days in some regions power grids reach their capacity limits. However, the grid extension necessary for the integration of renewable energies is still awaited. We asked Professor Bernd Engel, representative of the board of management of SMA Solar Technology AG, about challenges and solution approaches.

Philipp Strauß: Professor Engel, which challenges do our power networks have to master?

Bernd Engel: At present, our power grids are confronted with two great challenges. One of them is the integration of wind energy. On windy days the large offshore and onshore windfarms in North Germany regularly generate more power than the actual grid infrastructure can cope with. We must extend the high-voltage transmission lines to enable wind power to be transported inland. The second great challenge is the decentralized feed-in of solar power into the distribution network. The power grid, as it stands today, was designed so as to produce electricity from a central site in large, conventional coal or nuclear power stations, and to get it to consumers. The growing number of decentralized, fluctuating power-feeding photovoltaic systems however, now demands a re-think. We must enhance existing distribution networks so they may handle more PV power. At the same time, we must structure this expansion as economically as possible.

Philipp Strauß: SMA is working with Fraunhofer IWES on several projects concerning grid integration of decentralized energy producers. What is at issue exactly?

Bernd Engel: Currently, we are working on four projects with running times of three to four years which are funded by the German Ministry for the Environment. The projects are "PV Energy Management Station", in short PV-EMS, "Active Intelligent Low Voltage Grid", "PV Integrated" and "Combi-Power Stations 2". The PV-EMS project is the furthest advanced. This project concerns, among other things, how many decentralized solar inverters can deliver the same network services as a few central, large inverters.

Philipp Strauß: What results have you achieved so far?

Bernd Engel: Overloads in the low-voltage grid can occur due to increased PV systems' power feed-in. The aim of the project was to find cost-effective possibilities for connecting increased photovoltaic capacity to existing distribution networks without having to add extra copper cables or transformers. Our project showed that simply through inverter network-services the grid capacity may be increased by more than double. If, at critical voltage values, the inverter removes reactive power from the grid or provides it, this will have a stablising effect on voltage. As a result, grid expansion costs are significantly reduced.

Furthermore, we looked into the so-called 50.2 Hertz problem: originally, at the request of the distribution network operators, inverters had to be separated from the network if the grid frequency exceeded 50.2 Hertz. In the case of PV multi-gigawatt power perfomance, as we now have in Germany, this can lead to considerable power loss and, under certain circumstances to blackouts. For this reason it makes sense if inverters continue to feed the grid even when frequency is increasing, but simultaneously incrementally reduce their output. Our findings have significantly advanced work on the standardization and certification of solar inverters. New grid-connection guide-

lines have taken our results into consideration and regulate network-services inverters can produce.

Philipp Strauß: What targets do you wish to achieve with the other projects?

Bernd Engel: We are investigating the capacity of distribution networks in the context of the "Active Intelligent Low-Voltage Grid" project. The aim is to develop a variable, intelligent and active substation which can control grid voltage. We are also investigating which potentials are achieveable in the interaction between controllable inverters and other components.

On the other hand, in the "PV-Integrated" project, in cooperation with Fraunhofer IWES and other partners, we are searching for rules concerning how future distribution networks with more photvoltaic content can be cost effectively designed and operated. Doing this, we also include future power storage technology in order to involve photovoltaic systems in the operational management of medium and low-voltage grids. Within the framework of the "Combi-Power Plant 2" project, we are investigating, by means of models and field tests, the interaction between solar energy, wind energy and biogas plants. These three projects began at the end of 2010 and will run until 2013.

Philipp Strauß: How are the tasks divided amongst the project partners?

Bernd Engel: As a rule, Fraunhofer IWES, by means of network simulations, develops the requirement profiles for the desired grid behaviour of decentralized power production facilities. We then investigate how we can be implement these requirements in solar-inverters. The proposed solutions are then conjointly tested in the IWES DeMoTec test facility or at the grid operator plant. Fraunhofer IWES develops the appropriate test procedures. In the case of the "PV-EMS" project, inverters underwent certification tests which, meanwhile, have become the standard for the BDEW medium-voltage guidelines. Under the auspices of Dr. Gunter Arnold, Fraunhofer IWES played no small part here either.

We have been cooperating with Fraunhofer IWES for 20 years now. This collaboration is very harmonious and we complement each other extremely well.

Professor Dr. Bernd Engel
was head of development for solar inverters at SMA Solar Technology AG from 2003 to 2008. He has been a professor at Brunswick Technical University, specializing in sustainable energy system components since 1.10.2011. Apart from this, he is still active as board representative for grid integration at SMA and is also active on various committees. For example, he is an elected member of the Forum for Network Technology and Network Operation (FNN) in the German Association for Electrical, Electronic & Information Technologies (VDE), and speaker of the professional study group for network issues at the Federal Association for Solar Economy (BSW).

INDUSTRIAL RESEARCH AT THE HBFZ – HESSIAN BIOGAS RESEARCH CENTRE

In cooperation with its partners, the Hessian Department of Agriculture (LLH) and the Hessian state laboratory (LHL), Fraunhofer IWES has founded the Hessian Biogas Research Centre (HBFZ). At this centre it is possible to observe all conversion pathways from primary production to substrate preparation, the production and distribution of energy, right up to fermentation residue application to fields. The depth of expert knowledge and the technical facilities of the partners involved allow project planning from laboratory to practical experience. Dr. Bernd Krautkremer and industrial partners of Fraunhofer IWES describe the added value of the HBFZ.

Who are the services of the HBFZ intended for?

Bernd Krautkremer: The HBFZ is available as a research platform for both industry and science. The aim is to facilitate interdisciplinary research for needs-related biogas production. The HBFZ offers the complete range, from contract research right up to supporting industrial in-house research. Strategic cooperation between state authorities and Fraunhofer IWES permits the development of integral energy supply concepts representing the entire process chain from agriculture to methods and process automization and the energy industry. On account of the HBFZ being linked to gas and heat networks, the Eichhof offers services for both enterprizes and research institutes in all areas relevant to energy systems technology.

How was the HBFZ created?

Bernd Krautkremer: The idea of setting up a mutual research facility in the Eichhof was developed during the more than ten year collaboration between the LLH, LHL and IWES. The basis was then able to be created through funding from the Federal Economic Stimulus Package II and financial support from the Hessian Ministry of Science and the Arts, as well as from the Hessian Ministry for the Environment, Energy, Agriculture and Consumer Protection, but also from the own resources of the partners. The further development of the HBFZ is being built on this. Numerous enquiries from industry and initial projects have confirmed to us that our concept has met a definite need.

How are these test facilities equipped?

Bernd Krautkremer: The HBFZ biogas plant comprises a 650 m³ mother fermenter and a 400 m³ research fermenter. At LHL there are test reactors available for both continuous and discontinuous operation (6* 200 l, 160* 20 l) and also state-of-the-art analysis instruments. In the container area referred to, various fermenters, gas-processing plants and block heating and power stations (BHKW) can be operated and optimized. Converter units are available in the form of BHKWs, microturbines and a hybrid burner.

In addition, Fraunhofer IWES operates two pilot facilities. The renewable raw materials pilot facilitiy is available for agronomic testing. The biogas pilot facility is equipped for testing on laboratory and semi-industrial scales. The range of available research facilities underlines the attractiveness of the HBFZ.

How do industrial partners describe the cooperation with Fraunhofer IWES?

Achim Nottinger, one of the two managing partners at ÖKOBIT GmbH, builders of the HBFZ biogas research facility: The decision in favour of ÖKOBIT substantiates our power of

innovation and is a proof of the good networking which exists in research.

Christoph Spurk, co-founder and managing director of ÖKOBIT GmbH: Our commitment concerns the intelligent integration of biogas electricity into the power market and needs-orientated power production, a subject we have been pursuing with Fraunhofer IWES for a long time now.

Andreas Ganz, CoE Bio-mass, ABB automation: The increasing professionalization of biogas technology makes this branch of energy technology interesting for our company too. In IWES, we have a research partner with whom we can seize new impulses early on, and so offer our clients future-proof solutions.

How will biogas technology be developed at the HBFZ in the future?

Bernd Krautkremer: The future task of biogas plants will be needs-orientated energy production. In order to achieve this, innovative concepts in the fields of facility technology and process automization are required. This was already taken into account when constructing the biogas research facility. Fraunhofer IWES has been able to bring two competent industrial partners together, namely ABB and ÖKOBIT, who, alongside IWES, both wish to develop tomorrow's biogas technology.

Achim Nottinger, Christoph Spurk
Managing Partners of ÖKOBIT GmbH
www.oekobit-biogas.com

Andreas Ganz
CoE Biomass, ABB Automation

“GEAR UNITS WILL BE BUILT FOR DECADES TO COME”

High efficiency, reliability, a slim design and operational safety are crucial for the efficiency of offshore turbine systems. The best possible compromise between these competing demands must be sounded out. The potential to reduce electricity generation costs can only be exploited if turbine operation is observed throughout its service life. Prof. Friedrich Klinger and Dr. Jan Wenske discuss drive-train concepts and standardization potentials.

Jan Wenske: We forecast, in the medium term, a further increase in the diversification of drive-train concepts. Do you consider there is a clear trend for future developments?

Friedrich Klinger: I believe there is a very clear trend towards direct drive. Many companies are now changing over. Either they already have products on the market or they are in the process of discussing new developments, or building or testing them.

The Siemens company has sent out a clear signal. After taking over Bonus, Siemens has done good business with their reliable gear unit and expanded production, only to say, two years ago: We are changing to gearless turbines, the last gear unit will be sold in 2012. That is a strong argument in this market and from this important manufacturer.

Jan Wenske: Could the short track record for these gearless turbines with PM generators, especially in the offshore area, not become a problem?

Friedrich Klinger: Siemens advertising clearly states: We have a direct drive concept with only half as many parts. And this is particularly suitable for offshore because it simply causes less maintenance costs. This is not qualified anywhere at Siemens with the added note that new machines are now needed. The fact is they do not yet have them. The new machines are in trials or being prepared for series production.

Jan Wenske: In the sum of characteristics such as manufacturing costs, weight and repair susceptibility – which concept do you mark the best?

Friedrich Klinger: Quite clearly, the direct drive concept. At first it was said that gearless drives were twice as heavy. That was correct in the 90’s. Nowadays, they have already reached the lower limits of the spectrum. Things are changing round: in the meantime, quite a lot of development and investment is going on to make gearless lighter and more cost effective. In people’s minds the opposite, of course, prevails: gearless equals heavy and expensive. Whether the gear units, especially for onshore, can be produced more cost effectively is always measured against the large Enercon machines which are more expensive to manufacture. However, if gearless drives really do continue to be so rigorously developed, as Siemens are doing at the moment, then they will probably be cheaper than gear units. To say nothing of maintenance and consequent trouble.

Jan Wenske: Is the combination of two-stage gears and an electrically excited synchronous generator an alternative to classic gear systems or the PM direct drive? Finally, the weight disadvantage of the electrically-excited variant compared with the PM drive is of lesser significance since its specific disadvantages can be avoided: for example, the use of rare earths or efficiency losses while operating outside the nominal point.


Friedrich Klinger


Jan Wenske

Friedrich Klinger: There are disadvantages in both concepts of the so called Hybrid Concept: you have a larger generator and the gear, especially the high-stress stage, however it has to be said that the fast moving parts are the problem. This is possibly due to the fact that for years a very large independent development office highlighted this concept as being the great step forward, as it allegedly produces the lightest machines. But, they have never successfully brought a gearless system into production. Then they simply say, "Now we make Hybrids". That is a trend which goes down well. Throughout China it is known as the model of the future. But I do not see this as being the case in Germany. One has the disadvantages of both worlds. The machines are lighter but in the occurrence of damage one must take the whole thing home. This is a particular problem for offshore.

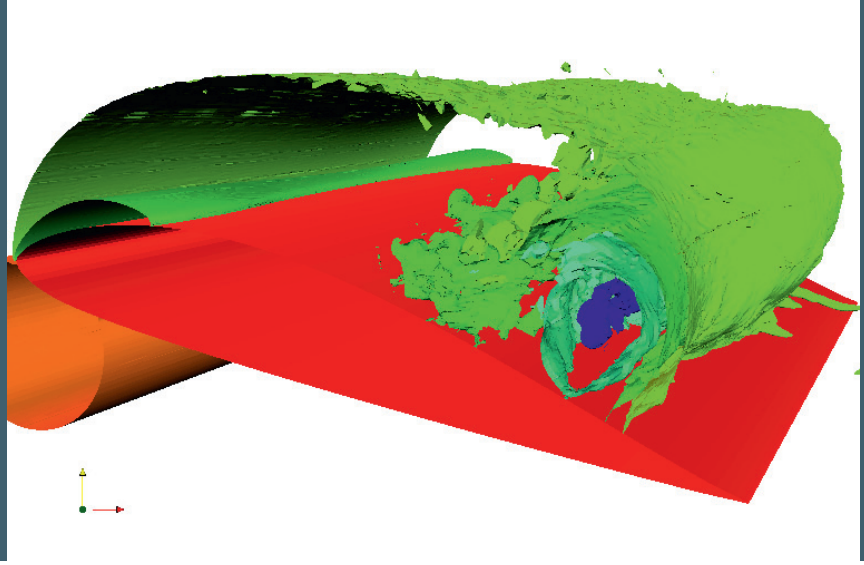
Jan Wenske: Have gear units outlived their usefulness?

Friedrich Klinger: Gears will continue to be made and developed for decades to come. The way people are talking about electric vehicles today, they believe that the change will be here in two years. However, Otto and Diesel engines will be running for a very long time still. The same applies for wind turbines. It could take a long time before everyone has changed over. And spare gears must also be available. For this reason, gears and gear systems will not disappear from the market in the foreseeable future. Nevertheless, we can look in a new direction and say: in the long term, direct drive is the future.

Jan Wenske: Would not construction kit turbine concepts, with standardized interfaces, possibly bringing price advantages in series production and allowing replacement of components from different suppliers, be practical?

Friedrich Klinger: On first hearing it sounds sensible to get advantages from larger production numbers and modular-assembly wind energy turbines. The same applies for other products. For example, in the case of vehicles, no-one has the idea of developing their own tyres, they buy them from the tyre manufacturer. However, in gearless drives the centrepiece is the generator, on which almost everything depends. Anyone who has brought a low-cost generator concept to the market does not intend selling on to others. This, at the utmost, is conceiveable if, for example, an institute such as IWES were to say: "We will build the generator and test it for interested manufacturers". That though, is rather unlikely.

Prof. Friedrich Klinger
is known as pioneer in the field of direct drive wind turbines and obstetrician of Vensys Energy AG´s turbine technology. He took over as leader of the IWES Gearless Systems Design project group in Saarbrücken in October 2011. Furthermore, he is participator in the Innowind Forschungsgesellschaft mbH. Before this he directed the research group "wind energy" at the University of applied sciences HTW, Saarland.



“COMBINING CONTROL ISSUES WITH AERO AND STRUCTURAL DYNAMICS”

Numerical modeling of currents, mostly summarized under Computational Fluid Dynamics (CFD), widens the possibilities of identifying wind turbine physical processes more precisely. The way in which aerodynamics can contribute to the further development of turbine technology, minimize loads and optimize performance is outlined here by Prof. Gijs van Kuik and Prof. Joachim Peinke in their conversation.

Joachim Peinke: Which contributions do you expect from aerodynamics to further developments for wind turbines?

Gijs van Kuik: The aerodynamic research for wind turbines moved, in the past, from optimization of efficiency to accurate assessment of the loads. In both fields improvements are still possible, specifically in off-design conditions. A next step is in the integration of aerodynamics, structures and control in a Fluid-Structure-Control-Interaction approach FSCI. Currently the only stochastic parameter is the atmospheric turbulence. This FSCI should incorporate more stochastic parameters like the uncertainty in the blade geometry and in the material properties.

Joachim Peinke: Which are the main challenges within aerodynamics?

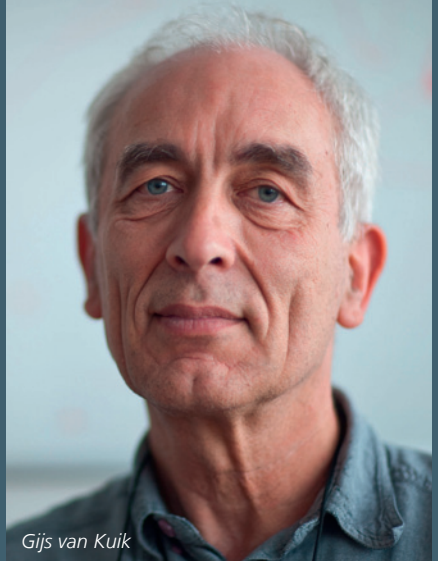
Gijs van Kuik: The state-of-the-art design tool is BEM, which works fine since it is tuned with many engineering add-ons that cover the topics that we do not know or that BEM is unable to represent. For severe off-design conditions (large yaw angles, wake interactions) of innovative rotor designs (high lambda, swept blades) this is insufficient. The knowledge base of the details of the flow needs to be extended, by experiments, vortex modeling and CFD. CFD has become a powerful tool for analysis and details of the design. Integration of meteorological models with rotor-CFD models is a big challenge lying ahead.

Joachim Peinke: Which role will numerical simulations (CFD) play for R&D in future?

Gijs van Kuik: CFD is and will be very important, for power optimization and load minimization in complex situations as wind farms. When CFD has become FSCI detailed optimization is possible. The drawback of CFD is the calculation time, and the difficulty to ‘play around’ to analyse the effect of input parameters or physical phenomena. The gap between BEM and CFD is filled by vortex models, which are much better for this job.

Joachim Peinke: Are there special needs from the side of industry to the research of aerodynamics?

Gijs van Kuik: Industry is very well able to define R&D tasks and cooperate with R&D institutions on topics as mentioned above. With respect to design codes, BEM is the work horse, but extensions to vortex codes or CFD for details of the flow will become practice more and more.



Gijs van Kuik

Joachim Peinke

Prof. Gijs van Kuik
Within the framework of a research visit in Oldenburg, Prof. van Kuik will be supporting the IWES aerodynamics work group in 2012. The wind energy research pioneer has been working in the field of renewable energies since 1977. In 2000 he established DUWIND, the inter-faculty wind energy institute of TU Delft, and is setting up its schedule in his function as scientific director. In 2011 he was awarded the European Academy of Wind Energy (EAWE) Science Award.

LEASHING THE WIND

Sooner or later many surfers pep up their beloved board by crossing their sail with a kite. When the wind siezes the colourful kite it carries the surfer aloft in sporting flight. However, modern steerable kite systems are not only sports equipment but are also producers of energy. The flight movement of a kite system can be used to drive a generator. Michael Strobel spoke with Stephan Brabeck from SkySails about offshore energy production using kite systems.

Michael Strobel: With the SkySails Power division, you are entering into the energy production business segment using kite systems. How much energy can be generated with kites and which offshore locations are suitable for this purpose?

Stephan Brabeck: At the same cost of manufacturing, our system generates around 30 % more energy than conventional systems. One special advantage of our system is that it has only about 1/3 of the mass of a conventional wind energy turbine, and the generator unit is close to ground level. As a result, installation at offshore sites in particular is considerably simplified and the system can even be installed on floating platforms with comparatively little effort and cost. On this account deep water and far-offshore sites are also accessible. The seas off Norway, Scotland and Ireland for example, offer good possibilities in this respect. The nominal performance of the systems should initially be 200 kW – 3.5 MW. Later models should have higher nominal output performance.

To realise consistent yields, four systems per site are operated as a cluster so that, through switching, continuous output-current can be achieved. The generated power is transmitted via a converter as direct current to the internal grid. The clusters are combined to form a windfarm. The flight movements are coordinated and the heights staggered in order to avoid mutual shadowing. SkySails is planning its first wind power cluster with an output of several megawatts for 2016.

Michael Strobel: What service life are the kite system components designed for?

Stephan Brabeck: The kite is a comparatively cost-effective expendable unit and has a life expectancy of one year; at present control pods and towing ropes are replaced every two years. There is still room for optimization within this calculation – through further development a forty-fold durability increase has been achieved for ropes in comparison with initial designs. The design and sail pattern of the kites come from SkySails, the sewing and glueing of the sails takes place in New Zealand and the components are manufactured at SkySails' own production plant in Wismar. Building and development of control-software is done at the Hamburg headquarters. The telescopic mast for automatic kite take-off and landing is supplied by a collaborating crane manufacturer.

Michael Strobel: How do the systems take off and land offshore?

Stephan Brabeck: As they already do on cargo ships with SkySails wind propulsion: the telescopic mast slides out of a shaft, thereby lifting the still reefed towing kite from its stowage up to a height of around 25 metres. Once there, the kite unfurls in a controlled de-reefing process. When fully unfurled it is launched. The kite is leeward of the mast and adjusts itself. Two operators on the foredeck steer the operation. When the kite undocks from the mast the autopilot takes over and lifts the kite to its working height – for wind propulsion this is 300 to 400 metres, for energy production systems it will be around 800 metres. The crew on the bridge is kept informed of the


Michael Strobel Stephan Brabeck

condition of the system by means of a user interface and can intervene at the touch of a switch. A similar process will occur in the control station of a windfarm.

Michael Strobel: Is airspace control an obstacle to the spread of this technology?

Stephan Brabeck: Traffic density over the North Sea is very high. On German territory there are no limits up to kite visual flying altitudes of 800 metres. In cooperation with the Dutch authorities, however, a system is being developed whereby transponders are used to transmit data to air traffic control.

Michael Strobel: Which stages mark the way forward for your company?

Stephan Brabeck: At the moment, SkySails is setting up a test station so that we can test energy-generating kite systems with a span of 400 m², and at altitudes of up to 800 metres. A demonstrator with automatic kite controls is expected to be installed in the Baltic Sea in 2013.

Michael Strobel: Flying kites as a full-time profession and thereby making a contribution to environmentally friendly energy supply sounds like a childhood dream. What motivates you in your position?

Stephan Brabeck: My professional basis is in aerospace technology. I have also been employed at a ship-engine manufacturer's where I gained a comprehensive knowledge of drives. In my free time I like to be out and about in sailing boats. At SkySails I can bring all these passions and experiences into the company and make an innovative contribution to offshore wind energy production. Our team of 80 staff members accompanies me on the path from original idea to finished product with great enthusiasm. This dynamic carries the search for new and sophisticated technical solutions and creates space for new approaches and developments. And this is how, in the framework of our basic product – towing kite wind propulsion for cargo ships - the idea of using our technology for energy generation from especially strong wind at high altitude came into being.

Stephan Brabeck
is responsible, as technical director of SkySails GmbH, for the areas of research & development, production and service. Previously, he was an expert for ship propulsion employed for 14 years at the ship propulsion systems manufacturer Schottel as, among other things, chief of development, head of the technical department and also as temporary managing director.

The "OnKites" project began on 1st November 2011. In this project Fraunhofer IWES, commissioned by the Federal Ministry for the Environment, is studying the potential of controllable kite systems for the generation of energy. The SkySails company has provided a prototype of their kite system for the study.

“WE NEED ACCOMPANYING RESEARCH AND COMPETENT DISCUSSION”

There are lively discussions as to whether jacket, tripod or tripile are satisfactory for offshore logistics, installation, systems operation and in manufacturing. Heavyweights which can be used at depth are a further alternative: gravity foundations promise up to 70 percent less offshore risk through optimal pre-assembly of the wind energy turbine on land. Dr. Klaus Weber, Strabag Offshore Wind, and Dr. Holger Huhn ask the crucial offshore question: steel or concrete?

Holger Huhn: Will Strabag be relying on gravity foundations in future?

Klaus Weber: Construction engineers will always determine to specific site conditions and according to economic criteria whether a gravity foundation or a pile foundation is the practical solution. If the seabed has the required load bearing capacity, gravity foundations are used, as this is the more cost effective solution. If the seabed is not so intensely compacted, pile foundations – in my view mainly jackets – are used. An overall project-specific solution is offered – the customer then decides. We want to realise cost-effective offshore foundations. Price, schedule and guarantee are decisive for customers.

Holger Huhn: Will the logistic process be made easier by the choice of gravity foundations?

Klaus Weber: The complete turbine can be pre-assembled on land, reducing offshore risk by 69-70 %. On land, a stationary and very robust crane is used for this prupose. One complete turbine weighing 7.000 tons is transported per trip. The gravity foundations are taken with the wind energy turbine to the location by a semi-submersible ship. Ship movements at sea are minimized, one is less dependent on wave height. The complete operation, depending on the distance from the coast to the windfarm, takes 2 to 3 days. Inside the 60-80 sea-mile zone the operation is quicker.

Installation costs of gravity foundations, using available floating cranes, are relatively high. Gravity foundations produced in large series with a special logistics solution – here, I am talking about several hundred foundations – are gravity foundations of first choice. The Strabag gravity foundation has a slim design which keeps wave loads minimal. When producing large series of gravity foundations the Strabag installation ship’s costs are amortised rapidly. Furthermore, the Strabag gravity foundation facilitates dismantling.

Holger Huhn: How do gravity foundations score when considering environmental compatibility?

Klaus Weber: The principal advantage of gravity foundations when considering environmental compatibility is the avoidance of ram-noise emissions. When laying pile-foundations in the extremely compacted density of the sandy bed of the North Sea, the piles must be rammed 50 to 70 meters into the seabed. Effective noise protection technology for environmental protection is still to be developed - we are also working on solutions for this. In addition, gravity foundations are completely dismantable. The materials are recycled and are used in road construction. On the other hand, gravity foundations require a sufficiently hard sand layer on site which as a rule is at a depth of 3 to 5 meters. Suspended particles are released during excavation which leads to water turbidity and possible environmental impact. Area useage of gravity foundation installations and pile-foundations is on a relatively comparable scale because scour effects are the decisive factor.


Klaus Weber


Holger Huhn

Here, accompanying research has to show which mid-term and long-term effects will occur. Strabag is cooperating with all authorities involved such as, among others, BSH, BAW, BAM and The Federal Ministry for the Environment.

Basically, wind energy turbines will always have environmental impacts which need to be evaluated. The different technical systems in use must be weighed against each other. Sometimes, public discussion is unfortunately black-and-white and conducted partly in an over emotional manner. Both accompanying research and objective discussion are needed. The federal authorites focus on technology effect assessment and compare conceivable scenarios. I am a keen advocate of this careful approach regarding permission for wind farms in Germany.

Holger Huhn: In the context of the Albatros 1 project, 10 turbines are to be installed 100 sea miles off Cuxhaven. What knowledge do you hope to gain from this project?

Klaus Weber: Albatros 1 is the first project from the Strabag project pipeline and comprises around 850 offshore wind energy turbines. With Albatros 1 we are entering the market with a gravity foundation type we have developed in-house. Our gravity foundation has already been comprehensively checked and analysed at our production plant in Cuxhaven in full-scale tests funded by the Federal Ministry for the Environment. During these trials, North Sea storms were realistically simulated over a nine month period with special emphasis on the study and research of their effects on the seabed and the load-bearing behaviour of the foundation - this is unique in Europe. The next step is to verify the thoroughly positive results of the Albatros 1 demonstration project. In the context of accompanying ecological and technical research, Albatros 1 will be tested for its environmental compatibility.

A later step will see Strabag present on the international market featuring its foundation technology and planned manufacturing plants.

A test facility for support structures on a scale of 1:10 can be a valuable enhancement to original tests so as to compare test results and to scale. This can accelerate developments, rendering offshore wind energy more efficient.

Dr. Klaus Weber
has been working in the area of offshore wind for 10 years and during the start-up phase of this branch helped to establish the offshore wind business area at Ed. Züblin AG and then later at Strabag S.E. He has been managing director and head of operations at Strabag Offshore Wind GmbH in Cuxhaven since 2010.

“A STANDARDIZED PROCESS FOR OFFSHORE RISK MANAGEMENT IS LACKING”

The innovation quota of offshore wind management is significantly above that of the German benchmark. New technical solutions for complex issues are being developed making risk prediction extremely difficult. Establishing trust depends on track record and valid data. Thomas Haukje of Nordwest Assekuranzmakler and Dr. Hans-Gerd Busmann tackle the question of how one can quantify and compare a calculation containing many unknown factors.

Hans-Gerd Busmann: From an insurers viewpoint, what are the greatest risks in the implementation of wind energy projects?

Thomas Haukje: Generally speaking, the greatest risks lie in the area of technology. Has the technology already been tested and matured? Is it really deployable? Basically, what is disconcerting for insurers, because it is difficult to assess, are, on the one hand, the interfaces between the individual parties involved in an offshore windfarm. On the other hand, insurers view the subject of grid connection critically – is it truly assured and reasonably redundant? In particular, if one knows little about the grid operator’s facilities in the offshore area, the technological risk in the background is very difficult to estimate.

Hans-Gerd Busmann: What form does interaction between project companies and the insurer and the banks take? Is there a need for a closer link between project and risk management?

Thomas Haukje: What is lacking, at least for us, is a standardized process for offshore risk management capable of bringing security. At present, every institute is going its own way. We see the first signs of an approach towards harmonization. When one has completed a specific process and come to a specific conclusion all should know whether the project is to be evaluated as “low risk”, “moderate risk” or “high risk”. There is definitely still a need. I know many advisors who are involved in these processes and, as an additional task, take on risk evaluation.

Hans-Gerd Busmann: If one reconsiders the idea of standardization or harmonization – would there be a possibilty of bringing the parties involved to a round table?

Thomas Haukje: That would be useful, in any event, to get to know all the different spheres and areas of influence within companies. Banks focus on other areas of risk management than do manufactures. A round table would certainly be useful to determine a uniform procedure. From personal experience I can add: round table, yes, but never too big, so as not to slow down the producing of results. Each party could send one to two representatives.

Hans-Gerd Busmann: What do insurers do to accrue know-how on the subject of offshore wind energy?

Thomas Haukje: Usually, staff members previously active in the onshore business, receive further qualification. I also believe that it is difficult, at least at present, for insurers to get experienced offshore people – the insurance business is not exactly the most exciting thing in the world for the offshore man and the offshore woman. These people want to be out there and build windfarms or negotiate large supply and service contracts.


Thomas Haukje


Hans-Gerd Busmann

Hans-Gerd Busmann: Is there a benchmark figure as to how many offshore projects insurers take on in their portfolios in order to achieve optimal risk diversification?

Thomas Haukje: In this case, each insurer has its own philosophy. There are some, mainly in large corporations, who want to be involved everywhere, others, from their perspective, go cherry picking and determine that they would like to be around when turbine A or B or C is being erected. Those are the different corporate philosophies. So far, no clear trend has emerged.

Hans-Gerd Busmann: Keyword transparency: how accessible are the relevant figures, upon which the risk of a project is evalued?

Thomas Haukje: It is very intensive detailed work. The problem is that important data used for the evaluation of risk, for example, the executive companies data, first become clear in the process. Therefore, one has to work in a simultaneous and successive manner. If, for example, we retrace the path of an insurance programme for an offshore windfarm, from the first telephone call, to the first meeting for analysis and detailed work, up to the closing of the insurance contract, three years go by easily. That means, we are talking here of a very long process steered reciprocally. One mostly knows the customers offices better than one's own, it's as simple as that. When I talk of financeability as a target, I do not only mean the provision of funds through banks but also the indirect provision of funds: the board of an energy supplier would never release monies for a project without adequate insurance protection and sound risk management. To this degree, it is an extremely important factor in the successful setting-up of projects.

Hans-Gerd Busmann: At the moment, large energy suppliers are financing or supporting German offshore projects. Will the field of investors be more colourfully mixed in future?

Thomas Haukje: One can definitely see new interested parties surfacing on the market. Pension funds have extremely long-term investment strategies and are willing to take low returns on investment into account. And for this, want one thing above all: security, security, security. Here, we come again to the issue of risk management – it makes the issues of rateable and security accountable. These investors prefer an offshore fixed-intersest investment.

Fraunhofer IWES is developing comprehensive work methods and tools in order to further increase the prediction value of cost, time and risk analyses.

Thomas Haukje
is a specialised insurance agent and worked for a German industrial insurance for almost 10 years. He worked for international industrial insurance brokers for 7 years where he had a leading role in building up the wind energy insurance business. He structured and positioned the insurance and security concepts of well known operators, suppliers and manufacturers. He has been managing partner of Nordwest Assekuranzmakler GmbH & Co. KG (NWA) since 01.01.2008.

"COST REDUCTION OF 50 PERCENT IN 10 YEARS IS POSSIBLE"

Ambitious targets for offshore wind energy lead to gleaming eyes in some people and frowns in others. Is the huge expansion planned at sea realizable, and what can concentrated research in Europe contribute to this? Jos Beurskens, ECN Wind Energy, John Olav Tande, SINTEF, and Bernhard Lange, Fraunhofer IWES, discuss how realistic the plans are and what impulses offshore expansion needs.

Bernhard Lange: In recent years, politicians and wind energy associations seem to compete in ever more ambitious targets for the offshore development. Do you think these plans can be met by the industry?

Jos Beurskens: Adding all present targets of the North Sea countries, results in more than 72 GW by the year 2030. In the past the wind industry has shown that it can build the same capacity of wind energy systems on land. So from the point of view of manufacturing capacity, I see no major insurmountable barriers to realize these targets. The potential showstoppers however lie in the necessary conditions which have to be fulfilled within the short term, but require a long lead time. These include education of sufficient expert personnel, electrical infra structure at sea, European or multinational offshore spatial plan and legislation and stable long term financial incentives.

John Olav Tande: I agree that it is not only a question of the industry capabilities, but also about governments and research. Research is important to bring forward improvements and innovative ideas, whereas governments must provide enough support to ensure market volume.

Bernhard Lange: Which topics have the largest potential for improvement by research?

Jos Beurskens: Integration of transport, installation and support structures in a common concept has the potential to bring down cost, as well as a further optimization of foundations for various depths, sea bottom conditions and automated production. O&M strategies with special emphasis on accessibility of wind turbines and preventive maintenance are another key element. On the long term I would see a potential for dedicated radical new designs of offshore wind turbines, including turbines for deep water.

John Olav Tande: I take the perspective that the main challenge for offshore wind is to bring down the cost. I suggest research can bring very significant cost reductions on O&M, grid connection, sub-structures and installation.

Bernhard Lange: The development of offshore wind farms is not dependent on the wind turbine technology alone. What else do you see as main challenges?

Jos Beurskens: The greatest challenges are: realizing electrical infra structure offshore and integration in transport grids on land, education of expert personnel and assessing cumulative effects of wind farms on the marine ecosystem and finding mitigating measures if necessary.

John Olav Tande: Taking a more general perspective on challenges for development of offshore wind farms, I think the market issues are maybe the biggest challenge. This goes for realizing an offshore transmission grid and for maintaining economic support to developers through feed-in tariffs and others. The economic crisis makes it harder to finance new projects. Risk reduction and good models for risk sharing are important topics.


Jos Beurskens


John Olav Tande


Bernhard Lange

Bernhard Lange: As offshore wind power is still a very young technology, the cost of electricity is currently still high. How can research and development best facilitate the cost reduction process?

Jos Beurskens: 50 percent cost reduction in a period of less than 10 years seems feasible if on the short term the R&D community in industry, universities and research establishments concentrate on capacity factor issues, cost reduction of installation and support structures and on dedicated radical offshore wind turbine concepts on the long term. Up scaling does not lead to cost reduction per se, but it will lead to cost reductions at other elements in the offshore power system (e.g. installation, O&M).

John Olav Tande: I think there are more paths that shall be followed. One is to work closely with the industry to assist in the continuous development in improving design and reducing risks. Providing qualified staff through education is another. A third issue is the more long term research. I see this as critical for ensuring innovations.

Bernhard Lange: Will electricity generated offshore ever be price competitive to onshore generation?

Jos Beurskens: The answer depends on wind speed, distance to coast, etc. On the short term: No. On the medium term: Perhaps. On the long term: Yes. But I agree that cost is not the reason for going offshore. You go offshore because of resource limitations on land. The full wind resource can only be exploited when offshore sites are included!

John Olav Tande: Yes, in the long term, I think so. Not necessarily so that offshore will be cheaper than the cheapest onshore wind farm, but limited land resources and other issues will mean that onshore wind farms in the future in many cases will be difficult to develop.

Dr. Jos Beurskens
is the director of the Dutch offshore programme WE@SEA and senior researcher at The Netherlands Energy Research Centre (ECN). He is co-founder of the European Academy of Wind Energy (EAWE) and is advisor to the European Commission. He was awarded the "Poul la Cour" prize in 2008. In 2009 he was awarded an honourary doctorate at Oldenburg University.

Olav Tande
holds the position of Senior Research Scientist at SINTEF Energy Research in Norway, and in his capacity as managing director is responsible for the NOWITECH research facility. Within the framework of the European Research Alliance he is leader of the Offshore Wind energy unit. He is also head of the Offshore Wind work group for the European Technology Platform.

EVENTS AND DISTINCTIONS

Before the arrival of the guests, Prof. Andreas Reuter, Fraunhofer IWES, The Bremen Senator Martin Günthner and Bremerhaven's Lord Mayor Melf Grantz enjoy the view in the vast testing hall.

Over 200 invited guests from business, politics and research attended the inaugural festivities.

Dr. Helmut Schmidt, Fraunhofer-Gesellschaft, Dr. Rita Kellner-Stoll, Bremen Senate for the Environment, Building, Traffic and Europe, Prof. Dr. Andreas Reuter, Fraunhofer IWES, Kerstin Deller, BMU, Melf Grantz, Bremerhaven's Lord Mayor and Dr. Arno van Wingerde, Fraunhofer IWES, held the inaugural speeches.

Inauguration of the IWES rotor blade test facility

After a construction period of one and a half years, Fraunhofer IWES opened its 90 m rotor blade testing facility with an inaugural ceremony on 9th June 2011. The 20,000 square metre facility doubles the existing rotor blade testing capacity at the institute. At a cost of 11 million euros, the new building provides a valuable contribution towards quality assurance of rotor blade prototypes.

Fraunhofer IWES, at its Bremerhaven site, has created a wholly unique test facility in which loads on rotor blade prototypes can be especially realistically applied. The facility was financed by the Federal Ministry for the Environment, Nature Conservation and Reactor Safety (BMU), the Fraunhofer-Gesellschaft, the State of Bremen and also the European Fund for Regional Development (EFRE). Within only a few months, and pursuant to IEC guidelines, the rotor blade testing provides sound statements as to whether a rotor blade may remain undamaged over 20-years of service life. Industry requirements were incorporated in the test stand conception: the project was accompanied by a control body of industrial representatives from the preparatory planning stage up to the operating stage.

In comparison with the 70 metre test hall which is working at full capacity and has been in operation since 2009, the new test facility offers not only room for very long rotor blades but also a tiltable mounting block. This steel giant is capable of inclining, to up to 20 degrees maximum, making it possible, even with very long rotor blades, to bend blade tips over a span of 30 metres and to shorten assembly times. With a rotor blade testing capacity able to handle blade types planned for future 10 MW turbines, the IWES is well placed for the future. The first testing took place only a few days after the inauguration festivities.

Inauguration of the SysTec Test Centre for Intelligent Networks and Electromobility

The new Fraunhofer Test Centre for Intelligent Networks and Electromobility, supported by the State of Hessen with around 1,5 million euros from the Federal Stimulus Package II, was inaugurated on 16th September 2011 in Fuldatal-Rothwesten near Kassel. Over 250 guests attended. Alongside the building costs, the Federal Ministry for Economy (BWMi) contributed a total of 3.2 million euros to the modern test facilities within the framework of the FuE Projects "Testing New Networks" and "Power Parking Spaces for Electric Vehicles". The Federal Ministry for the Environment (BMU) has funded the development and expansion of SysTec testing facilities within the framework of the "Optinos", "PV Multi-element", "PV Integrated", "Active Intelligent Low Voltage Network" and "PV & Network" research and development projects, to the total amount of 4.5 million euros.

The total investment sum for the main expansion stage was around 9.5 million euros. Prof. Dr. Jürgen Schmid, Director of Fraunhofer IWES in Kassel, and member of the German government's Scientific Advisory Council for Global Environmental Change (WBGU), thanked the State of Hesse and the Federal Ministry for the Environment for their support of this strategically important investment: "With this facility, IWES in Kassel has extended its unique position Europe-wide, as a research and development centre for the integration of renewable energies in supply networks."

At SysTec, Fraunhofer IWES develops and tests new manufacturing equipment and processes for intelligent low and medium voltage networks. Furthermore, the grid integration and network connection of electric vehicles and their supply with power from renewable energy sources such as photovoltaic systems, wind energy turbines, and storage and hybrid systems, are tested under real conditions.

Hessen's Minister of Science Eva-Kühne Hörmann stressed the importance of research investments.

Applause for a successful building project: Minister Eva-Kühne Hörmann, Head of Division Dr. Knut Kübler (BMWi), Head of Division Kerstin Deller (BMU), Fraunhofer Board Member Prof. Ulrich Buller, Mayoress Annegret Werderich, Helmut Barth (HMWK)

IWES-SysTec Test Centre Smart Grid and E-mobiliy

EVENTS AND DISTINCTIONS

Consensus to concentrate Hessian Biogas Research: Director of LLH Andreas Sandhäger, IWES Director Professor Jürgen Schmid, Science Minister Eva Kühne-Hörmann, Environment Minister Lucia Puttrich, Klaus Reinhard, (LLH), Dr. Bernd Krautkremer (IWES).

New biogas research plant at HBFZ for power supply in line with demand

Peter Funtan (IWES, right) is presented with a check for €30,000 from Harald Kownatzky (center) and Martin Grote (Members of the Executive Board NH/HH-Recyclingsverein).

Inauguration of the Hessian Biogas Research Centre HBFZ

Hesse's Science and Environment ministries together supported the founding of the HBFZ. On 19th August 2011 they inaugurated the Research Centre for Biogas Production, unique in Germany, and created cooperatively by Fraunhofer IWES, the Hessian Agricultural Centre (LLH) and the Hessian State Laboratory (LHL). Now, the HBFZ can access the existing biogas research facility, the agricultural pilot plant, the village-like structure of the Eichhof, as well as the existing LLH laboratory equipment. Around 3.3 million euros were invested in infrastructure upgrading. The performance of the existing biogas facility has been supplemented by the addition of a technical-scale pilot fermenter and converted into a modern, practical biogas research facility for needs-orientated production of electricity. A new building complex has been constructed to house a technical department for renewable raw materials, and an existing building has been converted for IWES to carry out special laboratory tests in the field of biogas technology. The Hessian Ministry of Science and Art made funds of around 2 million euros available for these measures. Final financing was contributed by the Hessian Ministry for the Environment, Energy, Agriculture and Consumer Protection, the LLH and the IWES.

Peter Funtan's research work wins an award

Within the scope of the Hannover Trade Fair 2011, the NH/HH Recycling Association honoured activities in the field of melting fuses and their components. Ten leading German universities, technical colleges, and Fraunhofer IWES received donation cheques to the value of 20,000 to 35,000 euros. The long years of research work by Peter Funtan into the use of fuses in photovoltaic systems was honoured with a cheque for 30,000 euros. In return, a didactic teaching CD for professional training use, should be developed in collaboration with Kassel University.

VDI specialist conference for wind energy turbine rotors and rotor blades

The speed at the tip of a rotor blade is comparable with that of a Formula 1 racing car: the blades cut through the wind at speeds of up to 320 kilometre per hour. To achieve this high performance, material and design must work perfectly together. The VDI, in collaboration with Fraunhofer IWES, organized a conference in Hamburg on 12th and 13th April 2011. In this context test values for new materials and approaches for optimization of manufacturing processes were presented by experienced practitioners. The question was how rotor blade service life can be be simulated and increased. Around 150 participants also discussed approaches for load reduction and aerodynamics.

Conference location on the pontoon: around 150 participants also discussed approaches for load reduction and aerodynamics.

IWES chairs the largest German photovoltaic symposium

1,000 participants met in Bad Staffelstein from 2nd to 4th March 2011 at the largest ever German symposium for photovoltaic solar energy. The technical management of the symposium was taken on by Dr. Philipp Strauß of IWES with this year's focal point being the grid integration of solar electricity plants. Contributions by IWES dealt with the certification of PV power generation units and plants, possibilities of active voltage regulation in low voltage networks, operating noises of PV inverters, DC-sided network simulations for EMV measurements, modeling PV modules' temperature behaviour, and efficiency and performance measurements of PV inverters.

The largest ever German photovoltaic symposium was chaired in 2011 by Dr. Philipp Strauss of IWES.

EWEA Brussels

Fraunhofer IWES presented itself to the 9,000 visitors at the EWEA Trade Fair from 14th to 17th March 2011, with rotor blade testing, grid integration and turbine simulation as the principal themes. Specialist forums concerning the international joint research projects HiPRWind and OC4 took place under the EWEA roof, offering a view of the projects' current status. Visitors were informed of latest developments at the IWES stand.

The rotor blade points the way: concentrated wind energy expertize at the EWEA in Brussels.

EVENTS AND DISTINCTIONS

Fraunhofer IWES and the Fraunhofer Windenergy Network shared a joint stand at the Hannover Messe 2011.

With great pleasure Dr. Dietrich Schmidt (IBP, right) and Patrick Selzam (IWES, left) explain their model of the "Urban Energy System" to the Fraunhofer board members, Prof. Ulrich Buller and Prof. Alfred Gossner as well IWES Director Prof. Jürgen Schmid (from left).

Status and perspectives of biogas plants were discussed at the OTTI User-Forum in Regensburg.

Hannover Trade Fair 2011: joint stand on wind

Vom 4th to 8th April 2011 Fraunhofer IWES and the Fraunhofer Wind Energy Network presented the theme "Smart Grids" in Hall 27. Many visitors were attracted to the stand by the question as to what virtual power plants can contribute to stable decentralized energy supply from renewable energy sources. A new IWES software demonstrated how wind energy and biogas power plants and solar energy electricity systems in models and field trials can be combined into a virtual unit through modern information and communication technology. Furthermore, the issue of quality was the centre of debate: plastic exhibits showed how rotor blades can be tested, and damage indentified by means of infra-red thermography, before initiating series production.

Hannover Trade Fair 2011: joint stand Energy Alliance

The transition to a sustainable energy supply is one of the central future tasks of the 21st century. The Fraunhofer Energy Alliance, formed of 16 institutes with 1,500 members, develops future-oriented and competetive products for your clients. At the Hannover Trade Fair, the researchers presented chosen highlights in categories covering regenerative, efficient, intelligent and compact solutions. Together with IBP, IWES presented the "Urban Energy System" cooperative project.

Hannover Trade Fair 2011: joint stand E-Energy Projects

E-Energy – Smart Grids Made in Germany, that is the slogan for a funding programme run by the Federal Ministry of Economics and Technology in an interdepartmental partnership with the Federal Ministry of the Environment. Technology partnerships in 6 model regions are developing and testing key technologies and business models for an "Energy Internet". The interim results were presented at the Hannover Trade Fair at a large joint stand. A special highlight was a remote control unit developed by IWES and its partners for the Harz model region.

Fraunhofer press conference at the Hannover Trade Fair

"The additional transport of electricity is an enormous load on the networks because they have not been designed for thousands of wind energy turbines in the north of Germany as well as millions of solar modules which feed their power into the transmission and distribution grids. In order to keep the power grid functioning, it must be re-equipped for the new age of green power. And for network operators, there are new control instruments such as, for example, wind and performance prognoses for power plant operational planning which must be made available." outlines Prof. Dr. Jürgen Schmid in regard to future tasks during the press conference at the Hannover Trade fair 2011.

Fraunhofer press conference at the Hannover Trade Fair 2011 (from left): Dr. Jens Tübke (ICT), Prof. Dr. Matthias Busse (IFAM), Prof. Dr. Hans-Jörg Bullinger (President of the Fraunhofer-Gesellschaft), Prof. Dr. Jürgen Schmid (IWES).

Girls' Day at Fraunhofer IWES in Bremerhaven

Economic growth in the Northwest region has a distinctive technological character. The wind energy branch offers very promising perspectives for well-qualified technical staff. 25 girls gained knowledge of the every day work of an electrician as also measuring technology and material development for offshore windfarms, during a "Wind Tour" on the 14th April 2011 in the context of Girls Day, Maritime Technologies, and produce "North Sea Climate" at the push of a button themselves. This way they got an impression of the multitude of possibilites which exist in research and industry today.

Working with large, precisely manufactured components – interested girls between the ages of 14 and 17 find out about professional opportunities at Fraunhofer IWES.

Girls' Day at Fraunhofer IWES in Kassel

On Girls' Day 2011, the girls brought many questions with them to the IWES on the 14th April 2011. "What does it really mean, to have electricity and how does electricity come for the wind turbine or solar cell to the hair dryer or the wall socket?" The answers were given by scientists of Fraunhofer IWES. Then the 14 schoolgirls went to work themselves and soldered a solar system together which drove a self-made wind wheel. After a tour through the laboratories, there followed an outing in electrically-driven vehicles belonging to the institute.

Maria Roos from Fraunhofer IWES explains to the interested girls on Girls' Day how a photovoltaic plant works.

EVENTS AND DISTINCTIONS

Prof. Erich Barke, President of the Leibniz University Hannover (l.), Dr. Wolfram von Fritsch, Chairman of the Board, Deutsche Messe AG (centre), and Prof. Andreas Reuter initiated the Leibniz Dialogue for the Future.

Tour talks about electromobile experience with Pedelecs: Science Minister Eva Kühne-Hörmann; Prof. Jürgen Schmid; Board Member of the Municipal Utilities Plant, Dr. Thorsten Ebert; Dr. Kurt Rohrig; Dr. Bernd Leßmann (HMWK); Dr. Ulrich Adolphs (HMWK)

How can you increase the availability of a wind energy turbine? Concepts were debated in Bremen.

Leibniz "Future Dialogues" – Science meets Economy

Offshore wind energy was the focus of the opening event of the new series organized by Hannover University and the Deutschen Messe AG on the 17th May 2011. Proven experts lectured on scientific technological and economic aspects of the subject and described the political framework conditions. Andreas Reuter, director of the IWES in Bremerhaven and professor for wind energy technology at Leibnitz university, chaired the scientific coordination of the Leibnitz Dialogue. The event gather around 120 board members, managers and development directors from northern German states.

Summer Electromobility Tour by Hessen's Minister of Science and Art Eva Kühne-Hörmann

"Electromobility Experience – from laboratory to street" that was the title given to the summer tour on 2nd July 2011 by Eva Kühne-Hörmann, Hessen's Minister of Science and Art. During the tour she gathered information about electromobility activities in North Hessen at the municipal utilities plant in Kassel, at the Fräger company in Immenhausen, Volkswagen in Baunatal, the university and Fraunhofer IWES in Kassel. The transfers offered "practical experience" since they were done with E-cars as well as Pedelecs. The IWES gave presentations to the minister and the accompanying reporters on the virtual battery, recharging infrastructure standardization approaches, a new contact-free charging station and the integration of electromobility into power supply structures.

VDI Specialist Conference on Wind Energy Turbine Maintenance

One of the key success factors in ensuring high availability of and low damage to wind energy turbines is an implementable concept for pre-emptive service, maintenance and logistics. In the wind energy branch, maintenance services are considered to be one of the markets of the future. For this reason, and in cooperation with Fraunhofer IWES, the VDI Knowledge Forum organized its own conference in Bremen, which took place on 23rd and 24th August 2011, to discuss this important theme. In an in-depth seminar, legal aspects of repair and maintenance were also addressed.

International Solar World Congress 2011

The SWC took place in Kassel from 28th August to 2nd September 2011. The organizers were Kassel University and the International Solar Energy Society (ISES). The largest congress in the field of solar energy and architecture worldwide, at which themes such as wind energy were discussed, brought around 800 participants from over 60 nations together in the Kassel Congress Palais. Fraunhofer IWES and Fraunhofer IBP supported this important world congress with a joint stand on the transformation of energy systems and visions for urban energy systems, and also offered excursions to the institutes' laboratories.

Joint IWES/IBP stand at the International Solar World Congress

Parliamentary evening on electromobility in Hessen

One of the main tasks for Hesse as a transit state and logistics location is to bring more traffic in line with the challenges of environmental protection. In Berlin, on 8th and 9th September 2011, under the motto "Electricity Moves", the Hessian State Government promoted its application to be a shop-window region for electromobility. The various Hessian participants presented their latest developments and projects in an accompanying exhibition. Fraunhofer LBF introduced a new wheel-hub motor and IWES its virtual battery.

Visitors at the IWES Virtual Battery stand (from right) Prof. Dr. Holger Hanselka (LBF), Minister of the Environment Lucia Puttrich, Minister Axel Wintermeyer, Matthias Puchta (IWES), Uwe Krengel (IWES)

VDI Specialist Conference on Wind Energy Grid Connection and Integration

In Bremen, from 13th to 14th September 2011 and under the scientific leadership of Prof. Jürgen Schmid, this conference showed which requirements wind energy turbines must fulfill in order to be able to feed the power they have generated into existing power grids. It illustrated which interactions between machine technology and grid connection systems are to be considered, and the effects of the system service regulation SDLWindV. Furthermore, aspects of grid expansion and the ensuing requirements for generating units were discussed.

Sustainable grid expansion (Photo: Jetti Kuhlmann, pixelio.de)

EVENTS AND DISTINCTIONS

Biogas plants play a vital role in demand-oriented electricity generation (Photo: fotalia.com).

At the IAA 2011 in Kassel, Matthias Puchta (r.) described the advantages of the Fraunhofer IWES Virtual Battery. (Photo: Andreas Fischer)

The event location inspired the offshore discussion: experiences were exchanged in the Sail City Hotel in Bremerhaven.

VDI Specialist Conference: Stationary Storage Systems for Renewable Energies

The demands and different power storage technologies for buffering the fluctuating availability of renewable energies was the focus of a special conference on 15th September 2011 in Bremen. Themes included future storage characteristics, balancing energy and performance, controllable bioenergy production, load management with heat pumps and electric vehicles. Prof. Jürgen Schmid and Prof. Michael Sterner had technical directorship of the conference.

International Auto Exhibition IAA

IWES presented the latest development tools for the automobile industry at their joint "Electromobility in the State of Hesse" stand at the 64th International Auto Exhibition IAA in Frankfurt am Main from 13th to 25th September 2011. Fraunhofer IWES virtual batteries are helping industry and research to save time and money in the development of electric vehicles.

2nd VDI Specialist Conference on Offshore Wind Energy Turbines

The German government funds ambitious plans for future expansion – among other things, with credits to the value of five million Euros for the first ten windfarms on the high seas. The trend, especially for offshore, is for larger rotor diameters with which more full load hours can be produced. The central challenge here is aerodynamic efficiency without creating noticeable weight increases and extra costs. The VDI conference from 27th to 28th September 2011 in Bremerhaven, provided an ideal opportunity for planning authorities, insurers, producers and developers to exchange experiences. The co-organizers, Fraunhofer IWES, contributed by presenting future perspectives for applied research.

Third Congress on 100% Renewable Energy Regions
The congress on 27th of September 2011 at the Kassel Congress Palais was a suitable platform for the exchange of experiences and the presentation of proven strategies on the road to a sustainable regional power supply. At a joint Fraunhofer stand, IBP and IWES presented their complementary competences concerning energetic sustainable urban and regional development.

Start of the Wind Energy Technology Study Course
The new Master's Course "Wind Energy and Engineering" began in the winter semester 2011/2012 at the Leibniz University, Hannover. 25 places are available to graduates in the fields of civil and environmental engineering, civil engineering, mechanical engineering, electro-technology and computer-supported engineering sciences. The four-semester study course allows entry into classic civil engineering professions but can also lead to employment with energy suppliers, wind energy turbine manufacturers or banks or insurance companies. Prof. Andreas Reuter, Director of IWES in Bremerhaven and Director of an institute at the Leibniz University, Hanover, is co-developer of the study course concept and supports lecturing.

Joint Online Wind Energy Systems Study Course
Kassel University and Fraunhofer IWES are developing Europe's first online Master's Degree Course for Wind Energy Systems. Target groups for the course are natural scientists or engineers seeking professional further qualification to become a Master of Science in wind energy systems. Prof. Dr. Detlef Kuhl from Kassel University as well as Prof. Dr. Jürgen Schmid and Dr. Kurt Rohrig from IWES will be taking on the academic supervision. This time and location-independent study course should kick off in the winter semester of 2013.

The "Intelligent Town" model was the centrepiece of the joint Fraunhofer IBP and IWES trade fair stand.


Welcome to post-graduate studies! Excellent job perspectives in wind energy ensured a strong demand for the 25 study places.


In future, students can study at the computer for their wind energy systems degree Europe-wide.

EVENTS AND DISTINCTIONS

The IWES project team used a helicopter to assemble the last mast elements (from left): Doron Callies, Klaus Otto, Kurt Rohrig, Richard Döpfer, Tobias Klaas.

Construction of a 200 m Wind Measuring Mast

By order of and funded by the Federal Ministry for the Environment, Fraunhofer IWES is researching wind characteristics in wooded areas of the central mountains of Germany and the application of modern laser-based telemetry systems (LiDAR) for use in wind energy. For this purpose, Fraunhofer IWES has erected a 200 m measuring mast on the Rödeser Berg in Wolfhagen-Nothfelden near Kassel. This North Hessian site is very suitable for research because of the structure of the terrain and the woods which lie upstream from the prevailing wind. The aim of the project is, using this infrastructure which is unique in Germany, to gain basic knowledge about higher-situated wind energy turbines near or in woodland.

DERlab Conference in Kassel (Photo: DERlab e.V., Frank Hellwig).

DERlab Conference

The European Excellence Network Distributed Energy Resources Laboratories, DERlab, established at the initiative of IWES, discussed, in Kassel on 6th October 2011, the challenges occurring due to the rapid growth of decentralized electricity producers' integration in the networks. As a result, IWES wants to establish a new industrial work group for grid integration, in order to allow research knowledge to flow faster into products and, conversely, to integrate industrial experience into the agenda of researchers.

16th Kassel symposium on energy system technology

16th Kassel Symposium on Energy Systems Technology

Grid integration of renewable energies was the theme of the 16th Kassel Symposium on Energy Systems Technology from 6th to 7th October 2011. Conference leader Dr. Philipp Strauß was able to welcome around 250 experts. The diverse challenges of implementing decentralised and grid-integrated power supplies were the focal points of the conference. The grid integration of wind energy and the question of how electricity networks react to high-level feed-in from photovoltaic systems, were of special importance to the scientists.

5th Biomass Forum

Amendments to laws and regulations, EEG (Federal Renewable Energy Law), Bio-AbfV and KrWG and their associated effects on the recycling of biowaste, were the central themes of the 5th Biomass Forum in the Bad Hersfeld Stadthalle from 16th to 17th November 2011. The forum was organized by the Witzenhausen Institute in cooperation with the Hessian Biogas Research Centre (LLH, IWES).

5th Biomass Forum in Bad Hersfeld.

EEG Biogas Workshop: Flexibilisation of Power Input

The EEG Biogas Workshop which took place after the Biomass Forum from 17th to 18th November 2011, dealt with questions concerning intelligent biogas energy generation and new EEG instruments for optional market premiums and flexibility premiums. The workshop was organized by the Hessian Biogas Research Centre (HBFZ) at Schloss Eichhof.

EEG biogas workshop: Frank Schünemeyer (IWES) reports about constraints on the transition to flexible power production

5th OTTI User Forum on Inland Wind Energy

Political frameworks, location finding and permit procedures, financing, cost effectiveness and wind power turbine insurance, innovative turbine and storage technology; examples of success and experience reports were on the agenda of the 5th OTTI User Forum from 17th to 18th November 2011 in Neumarkt. The event was co-organized by IWES.

OTTI "Wind energy Inland" User Forum in Neumarkt

EVENTS AND DISTINCTIONS

The Power-to-Gas Workshop organized by the Federal Network Agency and IWES in Berlin aroused a great deal of interest

Campaigning for wind energy in the northwest: Dr. Stephan Barth, Prof. Dr. Babette Simon, Prof. Dr. Andreas Reuter, Minister Prof. Dr. Johanna Wanka, Senator Dr. Joachim Lohse, Ronny Meyer, State Councilor Dr. Heiner Heseler (from left).

The status and perspectives of Biogas plants came under discussion at the OTTI-Userforum in Regensburg (photo: fotalia)

Power-to-Gas Workshop with the Federal Network Agency in Berlin

A very promising approach to the storage of renewable energies was discussed on 22nd November 2011 in Berlin by around 300 experts from energy, industry, and associations, from science, politics and administration. The Federal Network Agency and Fraunhofer IWES had invited guests to the workshop on the theme "Power-to-Gas".

Parlamentary Evening: Wind Power Cluster

The northwest region's Wind Power Cluster made it to the finals of the Federal Ministry of Education and Research's leading edge cluster competition. The three co-ordinators of the competition, the branch network WAB, ForWind and Fraunhofer IWES, issued an invitation to a parliamentary evening in Berlin on 22nd November 2011 under the motto "Offshore Wind – Energy of The Future". The planned activities of all 300 cluster partners were presented in the rooms of the Fraunhofer Forum. Around 150 participants took up the invitation to the German capital to be informed of the potentials of the Northwest Region.

OTTI User Forum on Biogas Plants

Under the technical direction of Dr. Bernd Krautkremer of IWES, noteable speakers from industry and research presented up-to-date information on framework conditions, financing, technology, logistics and innovative concepts for biogas plants on 23rd November 2011 in Regensburg.

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Launching of OneWind Student Simulation Software

Which support structures are most suitable for the demands of a specific offshore site? How are the installations of an offshore windfarm to be best organized in order not to negatively effect each other. The answer can be delivered by a detailed simulation programme – OneWind – that has been developed by Fraunhofer IWES. On 25th November 2011 Prof. Andreas Reuter launched the student version, for the first time, at the Leibnitz University, Hannover in his paper entitled "Wind Energy Technology". The software programme is now available to be used for learning purposes. This software called "OneWind Student", in its first version, is a design tool for rotor blades and for blade adjustment regulation, and is based on theories from technical works which have since been implemented.

EWEA Offshore 2011

"Course Offshore" is the motto written on the flags of the leading IWEA International Trade Fair. 480 exhibitors offered visitors their components and solutions for this motto from 29th November to 1st December 2011. Fraunhofer IWES was represented on the joint stand of the branch network WAB and gave the congress support with technical lectures.

EOW 2011 Side Event RAVE

In extra sessions, the film "RAVE – Research at alpha ventus" documented the progress made by the group research project. The 2nd OMO Workshop, "Operation and Maintenance of Offshore Windfarms", reported on current maintenance concepts.

Early practice makes perfect: students at the Leibniz University, Hannover calculating the loads on wind energy turbines with Fraunhofer IWES freeware.

At the WAB joint stand, Fraunhofer IWES presented the RAVE research project.

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7 | 1 Prof. Dr. Andreas Reuter, Director Bremerhaven (photo: Dawin Meckel), 2 Prof. Dr. Jürgen Schmid, Director Kassel (photo: Dieter Schwerdtle)

17 | 1 Prof. Dr. Andreas Reuter; 17 | 2 Kerstin Deller (photos: Dawin Meckel)

18 | Thomas Becker (fotalia.com)

21 | 1 Dr. Knut Kübler, BMWI (photo: 2011 Energie- und Umwelt-Managementberatung Pöschk)

21 | 2 Prof. Dr. Jürgen Schmid, Director IWES, Kassel (photo: Pia Malmus)

23 | 1 Accelerated material aging during tests on complete rotor blades let weak points become obvious within a short time (photo: Jan Meier)

23 | 2 200 meter measuring mast (photo: Richard Döpfer)

24 | 1 Biogas plant at the Hessian Biogas Research Center (photo: Volker Beushausen)

24 | 2 Design-Centre for Modular Supply Technology (photo: Renate Rothkegel)

25 | 1 Grid Integration Research and Test Laboratory (photo: Volker Beushausen)

25 | 2 Test Centre for Intelligent Networks and Electromobility (photo: Frank Hellwig)

27 | 1 Shipment of a rotor blade (photo: Jan Meier)

27 | 2 Approval processes for certification of a rotor blade prototype are carried out at Competence Center Rotor Blade (photo: Jan Meier)

28 | 1 Unloading of a tripod structure at an offshore site (photo: DOTI alpha ventus 2009)

28 | 2 Preparation of the piling section of a tripod structure (photo: DOTI alpha ventus 2009)

29 | 1 Welding of a jig for steel specimens for tests under offshore conditions at the North Sea

29 | 2 Maintenance work becomes predictable thanks to continuous condition monitoring (photo: Jens Meier)

30 | 1 Final assembly of wind energy turbine nacelle (photo: Enercon); 2 Enercon E 70 (photo: Enercon)

31 | 1 Plan for future wind parks in the North Sea (photo: BSH/M5, 1.12.2011)

31 | 2 Towboat on its way to an offshore construction site (photo: DOTI alpha ventus 2009)

32 | 1 Joint as shell element; 32 | 2 OneWind Turbine Library

33 | 1 RANS simulation of the tip vortex generated by a rotor; 33 | 2 Streamlines around a thick airfoil of a WT rotor inboard area

34 | 1 Control room (photo: Volker Beushausen); 34 | 2 Control room (photo: RED Eletrica)

35 | 1 Alpha-Ventus (photo: doti); 35 | 2 200 meter measuring mast (photo: Klaus Otto)

36 | 1 Use of LIDAR units for characterizing wind conditions (photo: Renate Rothkegel)

36 | 2 Current measurement device including a retrieval system (photo: Jan Meier)

37 | 1 Computer cluster for calculating detailed simulations; 37 | 2 User interface of a virtual power plant

38 | 1 Virtual battery in the power supply system of a car with combustion engine (photo: Volker Beushausen)

38 | 2 Test stand for pitch control systems for rotor blades

39 | 1 Commissioning the CORES project test plant in Ireland; 39 | 2 Testing the current using Ifremer's channel for the Marinet project (www.maritimejournal.com)

40 | 1 Test Centre for Intelligent Networks and Electromobility (photo: Tom Prall); 40 | 2 Experimental setup to measure the magnetic forces of generator segments

41 | 1 Medium voltage plant at IWES SysTec (photo: Frank Hellwig); 41 | 2 Test site grid integration at IWES SysTec (photo: Volker Beushausen)

42 | 1 Test site for photovoltaic modules (photo: Frank Hellwig); 42 | 2 Commissioning a PV inverter in an GTEM measuring cell

43 | 1 Test site energy management (photo: Renate Rothkegel); 43 | 2 OGEMA Gateways in the smart grid

44 | 1 Plant management in distribution grids (photo: Volker Beushausen); 44 | 2 Multi Sector Storage Systems (photo: www.doyma.de)

45 | 1 Control center in the test laboratory (photo: Volker Beushausen); 45 | 2 1 MVA AC grid simulator (photo: Volker Beushausen)

46 | 1 Holistic research approach at the Hessian Biogas Research Center (HBFZ) (Aerial photograph: Jean Corell); 46 | 2 Biogas plant (photo: Michael Beil)

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48 | Transport of a rotor blade prototype to the 90 meters test rig (photo: Jan Meier)

50 | Exact load estimates for simulations enable more reliability and cost reductions for offshore wind energy power plants (photo: DOTI alpha ventus 2009)

52 | Experimental setup to measure the magnetic forces of generator segments

54 | Rotor blade pitch control system for a multi-megawatt wind turbine (photo: Multibrid)

56 | Seismic measuring reveals the structure of the seabed in depth

60 | European electricity network (photo: DLR)

62 | Use of LIDAR units for characterizing wind conditions (photo: Renate Rothkegel)

64 | Chassis dynamometer for electric vehicle batteries, IWES SysTec (photo: Volker Beushausen)

66 | Bioagas plants play an important role in needs-based electricity generation (photo: fotalia)

68 | 1 Online power forecasts for renewable energy

69 | 1 Thomas Landgraf, enercast; 69 | 2 Dr. Kurt Rohrig, Fraunhofer IWES

70 | 1 25 GW PV outdoor test site and IWES SysTec (left) in Fuldatal near Kassel (photo: Tom Prall)

71 | 1 Dr. Philipp Strauss, Fraunhofer IWES, in conversation with Prof. Dr. Bernd Engel (photo: Andreas Berthel)

72 | 1 Biogas research plant at the Hessian Biogas Research Center, Eichhof (photo: Volker Beushausen)

74 | Scheme of a nacelle test rig (photo: RENK Test Systems GmbH)

75 | 1 Prof. Dr. Friedrich Klinger; 75 | 2 Dr. Jan Wenske, Fraunhofer IWES

76 | Numerical computation of the airflow around a section of a rotor blade

77 | 1 Prof. Gijs van Kuik, TU Delft; 77 | 2 Prof. Joachim Peinke

78 | Coupled kite systems for energy generation (photo: SkySails GmbH)

79 | Stephan Brabeck (re.), SkySails, Michael Strobel (li.), Fraunhofer IWES

80 | Test rig for heavy duty support structures at Cuxhaven (photo: Britta Rollert)

81 | 1 Dr. Klaus Weber, STRABAG Offshore Wind GmbH; 81 | 2 Dr. Holger Huhn, IWES

82 | Numerical models ease the planning of a wind turbine from planning phase to operation and reduce uncertainties

83 | 1 Thomas Haukje, Nordwest Assekuranzmakler GmbH & Co KG; 83 | 2 Dr. Hans-Gerd Busmann, Fraunhofer IWES

84 | 1 Offshore Windparc (photo: Vestas S/A)

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