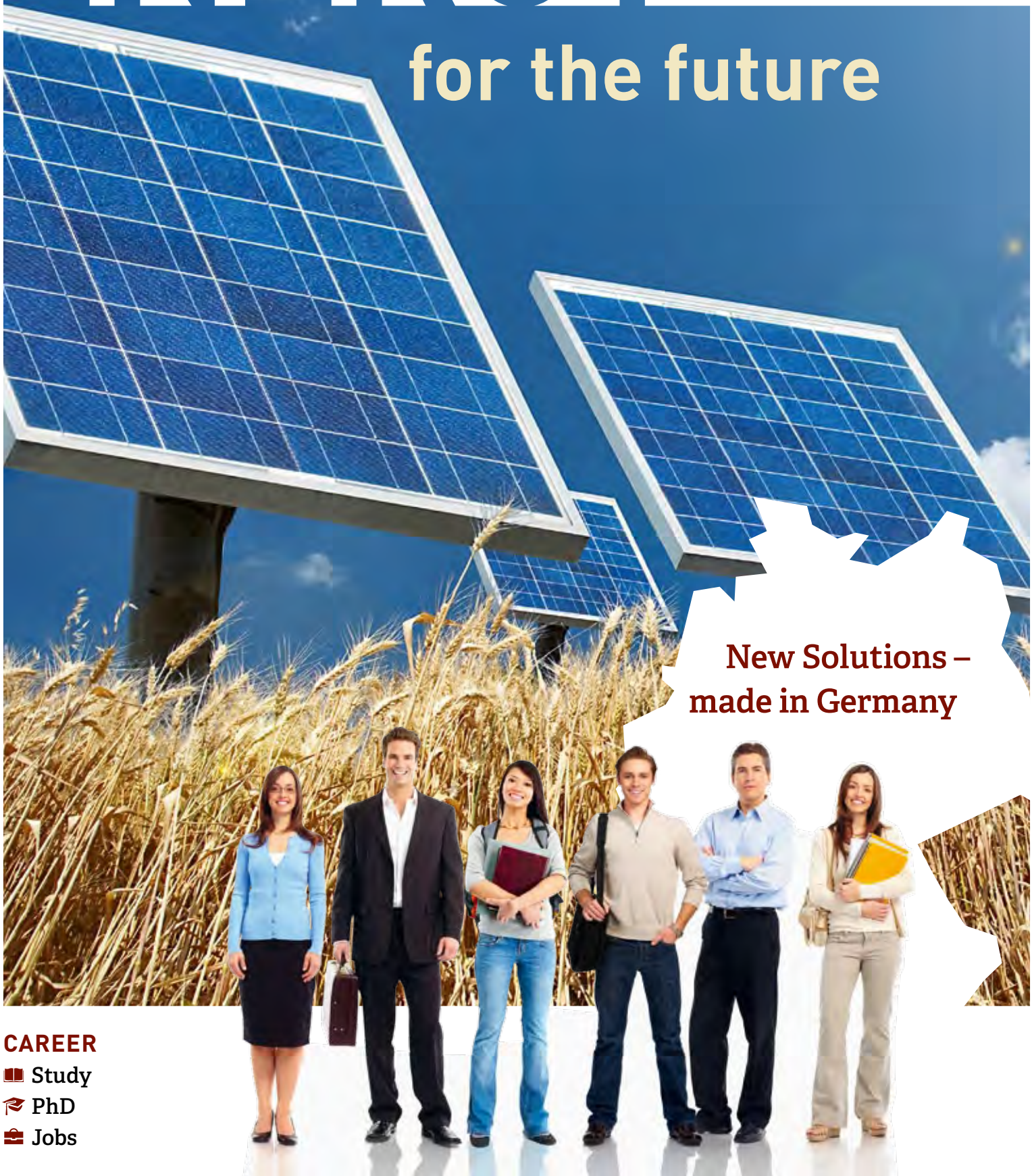
Study in Germany
Land of Ideas

ENERGY

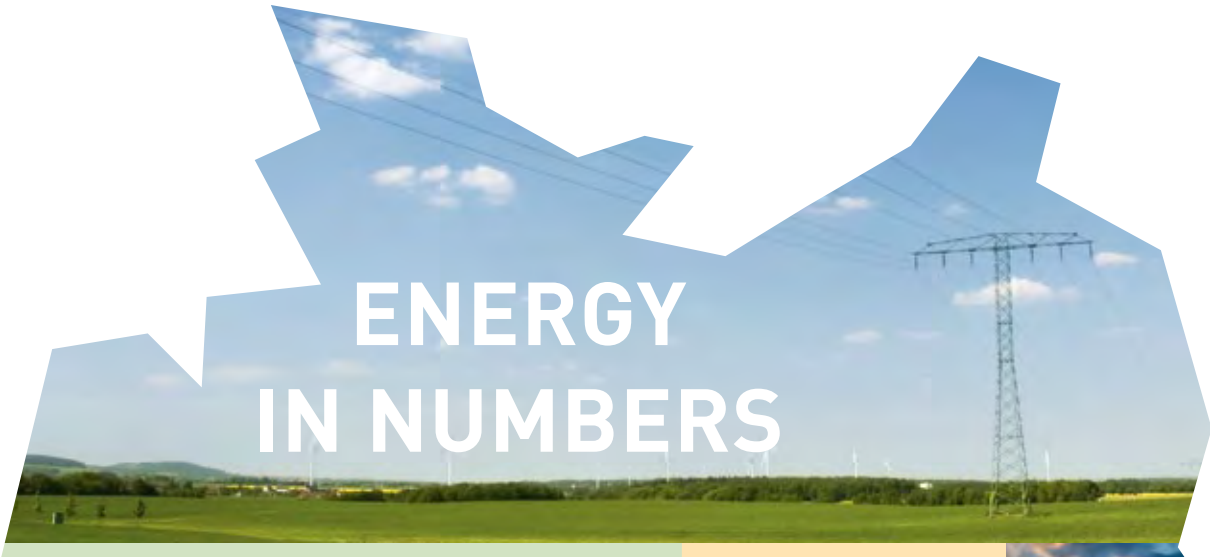
for the future



New Solutions – made in Germany

CAREER

- Study
- PhD
- Jobs



ENERGY IN NUMBERS

1000 GW The amount of electricity that could be generated globally by wave and tidal energy – an amount, according to a World Energy Council estimate, capable of meeting 15 % of the world's energy needs.

1 m^2 The area of the sun's surface required to produce 62,000 KW. That's equivalent to about 60,000 electric heaters or a million light bulbs.

10.3 % The proportion of Germany's total energy consumption that is met by renewable sources of energy – more than twice the amount recorded in 2000. World-wide the figure stands at 16%.

20 W The amount of energy our brains consume when we are reading or thinking about something – about the same amount it takes to power a small light bulb.

21,164
Number of operational wind farms in Germany at the end of 2009. Together they generate 25.777 MW, accounting for about one third of the electricity demand at peak times on cold winter days.

1,800,000 km The total distance covered by the German electricity grid. If the grid were made up of a single cable, it would circle the Earth 45 times.

17.9 Percentage of the world's electricity generated by renewable sources of energy in 2007. Hydropower made up the lion's share with a contribution of 15.6%.

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Study, PhD, Jobs

WELL SAID

» Today we are once again in the middle of a new industrial and energy technology revolution. Times like these have always been characterized by big changes. There is nothing negative about climate change for industry – in fact, it's actually a fascinating challenge. From a technology point of view, it is even a huge positive, as it opens up new markets for new and more energy and natural resource efficient solutions. «

Professor Klaus Töpfer, Executive Director of the Potsdam-based Institute for Advanced Sustainability Studies (IASS)

An interview with Hermann Scheer

From Grassroots Movement to Political Power

→ Hermann Scheer was awarded the Alternative Nobel Prize in 1999 in recognition of his commitment to solar energy. As an activist for a fundamental energy transition he is lauded as a "Hero for the Green Century". In 2002 the American magazine "Time" bestowed the title on five of the most important people worldwide who are helping to preserve our planet and make the 21st century a "green century". Hermann Scheer passed away shortly before the publication of this issue.

When did the energy debate start in Germany?

People started to mobilize around the issue of environmental sustainability in the 1970s. There were lots of citizens' initiatives campaigning against issues such as deforestation, or the construction of a nuclear power plants in their community. It became clear that left unchecked, market forces posed a terrible threat to nature. People's fears and protests intensified in the wake of the Chernobyl disaster in 1986. In lots of countries more and more people from all social ranks demonstrated against nuclear power and the storage of nuclear waste. In Germany – and in Germany only – the protests and the new concepts they spawned became a real political force.

How was it possible for these ideas to gain political currency?

The first step was the founding of the Green Party. But the Greens alone wouldn't have been able to push through wide-ranging political change. It was only when ideas about an alternative energy supply and a new definition of environmental protection were accepted by the Social Democratic Party of Germany (SPD) that new political majorities became possible. During the coalition between the SPD and the Greens (1998-2005) laws such as the Renewable Energy Sources Act were passed that had practical consequences. That really got the energy debate moving and that is key, among other things, to making long-term change possible. If ideas don't gain political momentum then citizens' initiatives and similar groups run out of steam after a while. A change in politics gives rise to new practical experiences, which have wide-ranging implications and reach right back into politics – a mutually reinforcing spiral of change.

How does Germany compare to other countries?

In Germany we can talk about a social movement on energy issues that is beyond the organising phase. That makes Germany unique. Many different parties – tradespeople, towns, communal energy suppliers, companies from the renewable energy sector and consumers – all see a tangible future in energy transition. 90 per cent of Germans support a massive development of renewable energy sources; only 10 per cent are in favour of coal-fired power stations. In addition, they are increasingly aware of the risks inherent to our current energy supply and potential environmental disasters. Renewable sources of energy are also regarded with economic optimism: the sector creates a lot of new jobs.

What still needs to be achieved?

Society's attitude to energy transition is essentially positive and deep-seated. What we need to focus on now is making sure that the relevant changes are made at all political levels. We have to be aware of just how high our standard of life is and of the myriad opportunities offered to us through renewable sources of energy. Energy transition also stands for a globally equitable energy supply.

Interview conducted by Isabell Lisberg-Haag

BIOGRAPHY

→ Economist, politician, and author Hermann Scheer was an international activist for renewable energy. He was the founder and president of the European Association for Renewable Energy EUROSOLAR. Scheer was a key player in passing the German Renewable Energy Sources Act in 2000, which serves as a prototype for initiatives in 40 countries worldwide. He also chaired the World Council for Renewable Energy (WCRE) and the International Parliamentary Forum on Renewable Energies.

An interview with DAAD President Prof. Dr.-Ing. Dr. Sabine Kunst

Constructive Experimentation

→ Professor Sabine Kunst assumed office as President of the German Academic Exchange Service (DAAD) on 1 July 2010. She aims to make even more use of the wealth of experience that the DAAD and its grantees have gathered to address global issues – such as a sustainable energy supply. It is her firm belief that in a globalized world, international experience is absolutely crucial.

In your first press conference as President of the DAAD you announced that the DAAD will be making an even greater effort toward solving global problems. What does that mean exactly?

We should make use of specific, existing opportunities which the DAAD offers in as many ways as we can. That starts with reaching out to talented young people who have, for example, expressed an interest in a university degree in renewable energies, or who want to pursue further studies. Our regional offices, lectors and alumni are ideally suited to do just that. We can offer incentives for programmes focusing on the developing world, as energy research is a very important issue in these countries. We can also pay special attention to whether or not issues such as energy, water, climate and megacities are covered in the DAAD programme "German university courses offered abroad" – the main thing here is that we pass on positive examples.

Does that mean that there is a shift in emphasis from supporting inter-disciplinary excellence to supporting specific subjects?

No, what we are doing now is constructive experimentation. In the long run I imagine a matrix in which the type of support we have given up to now is interwoven with a focused thematic direction. The DAAD is very well placed to make that possible. If we don't have a solid foundation of excellent scholars then attempts to reach the highest peaks, namely thematic networks, won't even be conceivable. So what we are talking about is extending our field of vision, so that we consider focal themes in addition to specialist quality.

Which issues will receive the most funding?

I have selected four main areas of focus: energy, climate, water and megacities. How that breaks down exactly depends on the respective regions. As a water and sewage biologist, I am well aware how important clean water is for public health – but that is just one of many important issues which, in a globalized world, affect everyone. On the issue of energy research in particular, Germany has excellent know-how, and it should be built upon to meet the demands that exist in many countries throughout the world.

How might more DAAD alumni be mobilized around these issues?

Our alumni are highly qualified men and women from all over the world – we have had some 545,000 foreign grantees since 1990. The DAAD network has long been sustained through personal contacts. Another idea is to organize future alumni meetings around specific issues. Why not use our numerous meetings as catalysts for technical networks in which alumni can bring together their expertise across disciplines and geographical borders?

Interview conducted by Isabell Lisberg-Haag

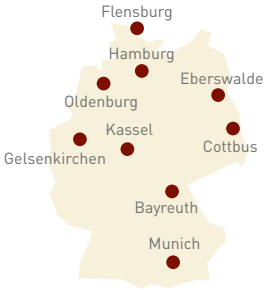
BIOGRAPHY

→ Sabine Kunst studied biology and completed her doctorate at the Leibniz Universität Hannover (University of Hanover) in 1982, qualifying as a Dr.-Eng. in environmental biotechnology in the field of civil engineering and surveying. At the same time Sabine Kunst was also studying political science and completed her doctoral thesis in 1990 on the conflict between technology assessment and interdisciplinarity. She completed her Habilitation at the University of Hanover the same year, qualifying as a university lecturer. After two years in office as vice-president of the University of Hanover for Teaching, Studies, Further Education and International Affairs, she was elected president of the University of Potsdam in January 2007. She already has close ties with the DAAD, having been a Board Member since January 2008.

German universities offer a wide variety of courses in renewable energy

Degrees for a Green Future

→ At first glance, Venezuela could be considered a showcase for climate neutral energy production: around 70 per cent of the country's electricity is generated at large-scale hydro-electric power plants. "But look again, and you will find that the rapid growth in energy demand is, for the most part, being met by power stations run on crude oil and natural gas," points out Santiago Bautista. Although there are many excellent sites for harnessing wind energy in the South American country, renewable energy is not really considered an option, bemoans the 31-year-old engineer, who spent several years working for a state-run energy company. "It isn't possible to explore these subjects in depth at any university in Venezuela." For Bautista, that makes the opportunity to delve into issues in sustainable energy production in Germany all the more valuable.



"Germany is an absolute leader in the renewable energy field, offering first-hand experience of how the various technologies are being implemented," says Bautista. In early 2009 he began his studies in "Sustainable Energy Systems and Management in Developing Countries" at the University of Flensburg after winning a DAAD scholarship. The Masters programme is interdisciplinary, covering the technical and economic aspects of renewable energy with particular attention given to the situation in developing countries.

Experts with a solid training are sought after in these countries in particular, but also elsewhere. The technology is often already in place, but in most countries there is still a huge deficit in trained personnel able to install and maintain the facilities, as well as those qualified to handle the management and financing of such power stations and garner the necessary political support. The DAAD is tackling these problems head on. It is supporting three courses of study in renewable energy with international focus offered at German universities through individual scholarships, teaching and subject material as well as supplementary events. In addition to the course offered in Flensburg, the DAAD also funds the "Postgraduate Programme Renewable Energy" at the University of Oldenburg with a focus on technical issues. It also contributes to the German-Arab Masters course "Renewable Energy and Energy Efficiency for the MENA Region", which is run jointly by the University of Kassel and Cairo University and is intended to further cooperation between German and Arab countries in the development of renewable energy sources.

Energy on offer at numerous universities

German businesses are world leaders in the renewable energy sector and Germany also enjoys an excellent international reputation for the courses it offers on the subject. Universities throughout the country offer Bachelor and Masters programmes devoted entirely to renewable energy. The spectrum ranges from a

Transdisciplinary research for the future: Environmental sciences receive priority treatment at Brandenburg University of Technology Cottbus.

» Germany is one of the leading countries for research and innovation on environmental and energy-related topics. «

Cinthya Guerrero (28), industrial engineer from Mexico. She is currently conducting doctoral research as part of the PhD programme "Environmental and Resource Management" at the Brandenburg University of Technology Cottbus. Her research is geared toward the development of biofuels in Latin America.

programme on "Energy Systems Technology" run by Gelsenkirchen University of Applied Sciences in cooperation with the company Siemens Power Generation, to "Renewable Raw Materials and Renewable Energy" at the Brandenburg University of Technology Cottbus and automotive engineering with a special focus on electromobility at the Technische Universität München (TUM). The University of Applied Sciences in Eberswalde located just outside Berlin has made a strong commitment to sustainability by renaming itself the University for Sustainable Development. Its research and teaching motto is "helping people by working with nature".

Students also benefit from the strong links between German science and industry, which make it possible for new discoveries to be put into practice quickly. For example, students can make on-site visits to wind farms and solar parks, or organize internships and study projects with a strong industry focus. These strong ties have also impressed the technology company Masdar based in Abu Dhabi, which chose to set up a plant for producing thin-layer solar cells in the state of Thuringia. The excellent links to universities and research institutes were a major factor in their decision to locate in Germany.

An alternative route to earning a doctorate

These well-established networks are also a plus for PhD students. In Germany, close collaboration between industry, academia and research extends beyond the energy sector. This synergy creates lots of exciting issues for early stage researchers to work on.

There are two ways to get a PhD. The traditional route is for a PhD student to be mentored by a thesis adviser. It is completely up to the individual to decide on a thesis topic, select a supervisor and devise a work plan. Alternatively, doctoral degrees can also be obtained through structured PhD programmes offered at graduate institutions. World-famous research organisations such as the Max Planck Society and the Helmholtz Association emphasize a mixture of subjects and welcome PhD students from both home and abroad. The advantage is that there is constant exchange between advisors and other PhD students as well as additional seminars and lively interdisciplinary debate. "Young people today need to be educated in a way that allows them to move easily between traditional disciplines," maintains Professor Jürgen Köhler. He is the spokesperson for the graduate college "Photophysics of Synthetic and Biological Multichromophoric Systems" at the University of Bayreuth, which is funded by the German Research Foundation (DFG). The college offers young researchers diversity across the board: excellent teaching by scientists from a variety of disciplines and countries, the organisation of international conferences as a well as an issue that is of vital importance for the energy supply of the future. The 58 International Max Planck Research Schools (IMPRS) are particularly geared towards international PhD students. At the "IMPRS on Earth System Modelling" in Hamburg, PhD students from 33 countries are researching various aspects of Earth systems. They also work at recognized Global Change Research Institutes in Germany.

Links

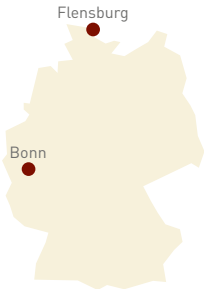
www.iim.uni-flensburg.de
www.ppre.uni-oldenburg.de
www.uni-kassel.de/remena
www.fh-gelsenkirchen.de
www.tu-cottbus.de/fakultaet4
www.fahrzeugtechnik-muenchen.de
www.earthsystemschool.de
www.ep4.phy.uni-bayreuth.de
www.hnee.de

Spotlight on renewable energies: Postgraduate training at the University of Oldenburg.

Diverse career opportunities in the renewable energy sector

Climbing the Green Career Ladder

→ The green sector is booming. During the first quarter of 2009 alone, companies which produce photovoltaic, wind and bioenergy technologies in Germany advertised around 1,600 jobs. The future lies in sun, wind and bioenergy. There is a growing need for training, research and development in the alternative energy sector. Production engineers are in demand for biofuels, mechatronics for wind energy installations and development engineers for solar technology, and the list goes on. More and more new types of jobs are being created.



"Over the last decade or so the sector has seen job opportunities increase at an annual rate of around ten percent," says Theo Bühler from the Bonn Science Shop. "30 to 50 per cent of the newly created positions are filled by technicians and engineers." A trend which is reflected in the programmes offered at German universities. According to a study by the Bonn Science Shop, the number of programmes in renewable energy has risen from 144 to 251 over the last two years. That makes Germany an international front-runner. "I don't know of any other country that offers so many different opportunities to get a foothold in the green sector," says Bühler.

Of the programmes on offer, one quarter are dedicated entirely to renewable energy, while 187 give students the option of selecting certain areas for in-depth study. "Being able to choose which areas to specialize in is great for students who want their degree to cover a wide range of topics," explains Bühler. Those with a more cautious bent will go for a traditional engineering course and explore the field through work experience or an additional Masters programme. All forms of alternative energy are now covered at the Masters level. Employers also offer their new recruits on-the-job training. "Still, students who are set on working in this field should make it a clear focus of their studies from the get-go," advises Bühler.

Students who graduate from these programmes have to be aware that their 'green' job is not necessarily waiting for them on the doorstep. "The renewable energy sector operates globally," points out Bühler. "Because of the variety of programmes on offer in

Germany, specialists who qualify here are in demand all over the world."

Safe jobs in hard times

Many German companies have long since discovered the international market for themselves. The Bremen-based wpd group, which specialises in on- and offshore wind farms, is just one example. It has more than 500 employees and has set up shop in 15 countries, including Argentina, Vietnam, Sweden, Spain and France. 26 year-old Ben Bisenius covers the French market. The Luxemburg native works as a business project manager for wpd, specialising in the financing and efficiency of wind farms. His degree in energy and environmental management from the University of Flensburg has stood him in good stead. "As I see it, wind power is the most likely contender to provide Europe with affordable clean energy in the near future, as it is the most technologically mature," says Bisenius. The decisive factor in his choice of career, apart from his commitment to the environment, was the fact that the sector is immune to crises. That's what makes the green sector so appealing to many people. "Most jobs are permanent, which is rarely the case in other industries," says Theo Bühler.

Career changers in demand

The young sector needs many skilled workers. "Right now there are more engineers retiring than there are graduating," Bühler explains. As a result, career changers from a traditional engineering or mechanical engineering background are also finding themselves in the fast lane to a green career. There has also been a big expansion in opportunities for further training within the alternative energy sector in Germany. Women in particular, who are underrepresented in traditional engineering, are increasingly interested in the jobs on offer. "It certainly helps that young people strongly identify with this work and can help shape the sector," says Bühler.

While more and more graduates are flooding the market, there is often a lack of qualified candidates with work experience. As Agnieszka Marszalek, a recruiter for the Bonn-based company Solarworld, can confirm. The photovoltaic company has around 2,200 employees world-wide and is looking for new hires.

Wanted: Qualified professionals. The Bonn-based company Solarworld offers jobs in the solar energy industry.

"As a result of the economic downturn people are less willing to change employers," Marszalek observes. And although programmes in renewable energy are now well established, they can differ widely in structure, content and quality, which in turn impacts both transparency and assessment.

Although German companies are international market leaders in wind energy and solar power, they have so far only played a minor role in geothermal energy. There are only around 500 companies, accounting for some 4,200 employees, producing geothermal power. In comparison, the solar energy sector tallies around 10,000 companies and 40,000 employees. Wind power is considered to have the most potential as the energy source of the future. Theo Bühler also sees a bright future for bioenergy, thanks to its great diversity. One thing is certain: the green sector will continue to offer interesting jobs for pioneers.

Sabine Wygas

Links

www.research-in-germany.de
www.euraxess.de
www.jobmotor-erneuerbare.de
www.renewables-made-in-germany.com
www.greenjobs.de
http://ec.europa.eu

» I am particularly interested in wind power and solar energy. I like the fact that there are so many job opportunities, not just in Germany but elsewhere, too – in China, for example, or in Arab countries – where solar panels and air conditioning technology are particularly important. «

Christian Denzel (25) studies environmental technology and resource management at the Ruhr University Bochum, specialising in sustainable process- and environmental technology with a special focus on energy technology.

SUN

Light, warmth, energy – Not only does the sun lift our spirits, it produces energy with an intensity that is beyond our grasp. Our future will be bright if researchers can learn how to harness just a fraction of its power. German scientists are working on it.

German researchers successfully focus on the sun's energy

Natural Power Plants: Energy You Can Count On

→ It sends the Earth more energy in 30 minutes than humankind uses up in one year: the sun. This huge ball of hot gases has been heating up our planet for more than 4.6 billion years, enabling life to flourish through its continual supply of 120,000 billion kilowatts. Internationally, solar researchers are also working at full capacity – be it in photovoltaics, generating electricity from solar energy, or in solar thermal energy, harnessing the sun's rays for easily accessible heating.

Germany was quick to understand that harnessing the sun's energy would be one of the global challenges of the 21st century and responded accordingly. "The Renewable Energy Sources Act was passed in 2000 and showed real political initiative. It gave the entire German solar energy sector a massive boost and has been the source of much international admiration," says Professor Eicke R. Weber, Director of the Fraunhofer Institute for Solar Energy Systems (ISE) located in Freiburg. The last few years have been busy for the largest European research institute for solar energy. It has generated the most highly cited scientific papers on photovoltaics and spawned discoveries which have been crucial for the development of the solar industry. Scientists at the institute have even set a world record by developing a multiple photovoltaic cell with an efficiency factor of 41.1 per cent – substantially higher than what had previously been possible.

A classic: the silicon solar cell

The list of top German research institutes also includes the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW), based in Stuttgart, the Fraunhofer Center for Silicon Photovoltaics (CSP) in the city of Halle an der Saale, the Helmholtz-Zentrum Berlin für Materialien und Energie (HZB) and the Institut für Solarenergieforschung Hameln (ISFH). Eicke R. Weber is convinced that future energy needs will only be met with help from renewable sources of energy. In the long-run, the physicist regards photovoltaic energy as having the most potential to generate a substantial amount of sustainable electricity with negligible operating costs. Solar cells have a key role to play in making this possible.

Solar cells based on silicon are currently the most widely-used, accounting for around 90 per cent of the global market. Silicon is made from sand and is therefore in almost unlimited supply. At the same time, it is expensive to produce. With an efficiency factor of 19 per cent, so-called crystalline silicon solar cells are the most effective at converting sunlight into energy. A cheaper to produce but less efficient option is thin-layer solar cells.

Exciting potential: organic solar cells

One of the most exciting alternatives is organic solar cells. These are based not on silicon but on organic semi-conductors, types of molecules similar to those found in plastic bags or colorants. Organic solar cells are 500 times thinner than a human hair which allows for extreme flexibility in usage and makes it easy to attach them to almost all types of material. The first set of products, including a bag with an integrated organic solar module, is already on the market. For those times when there isn't an electrical outlet handy, the "solar bag"

Portable energy: Outfitted with an organic solar cell module, this shoulder bag can recharge a mobile phone.

» Germany is an international front-runner in its use of solar electricity thanks to its law on renewable energy. In the space of a few years it has built up a research structure which is second-to-none. «

Professor Eicke R. Weber, Director of the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg

makes it possible to recharge a mobile phone or razor. "For now, these variations of photovoltaics are mostly being used for small electronic devices," explains Dr. Elizabeth von Hauff, who researches organic solar cells at the University of Oldenburg. The idea is for this type of solar cell to be used at stationary photovoltaic plants and to supplement silicon photovoltaics.

With an efficiency factor of 8 per cent, organic solar cells aren't yet able to keep up with silicon cells. There is also room for improvement in regard to endurance and stability. "However, the question is whether we have to meet the same levels as silicon at all," says von Hauff. She describes photovoltaics as being like a triangle composed of endurance, price and efficiency. Because it so cheap to produce organic solar cells, endurance and efficiency issues can be accorded some flexibility.

Elizabeth von Hauff and Eicke R. Weber concur: if chemists discover the right molecules, then the range of applications for organic solar cells can hardly be overlooked. From sails on ships, to large windows or curtains and solar panels on the roof – everything is possible. "At any rate, the potential they have is truly exciting," says Weber.

German research is also leading the charge in organic photovoltaics. The programme "Elementary Processes of Organic Photovoltaics" run by the German Research Foundation (DFG), is helping to speed up the process of turning ideas into reality while strengthening Germany's pole position. An interdisciplinary network of 40 institutes has been working closely together since 2007.

An export hit: solar thermal power plants

Germany's expertise is also in demand in issues related to solar thermal power plants. The principle consists of using sunlight, which is concentrated with the help of parabolic reflectors, to heat water. The resulting steam drives turbines which produce electricity. The generated heat can be stored in huge salt tanks, so that the turbines can also produce electricity at night.

Solar thermal power plants are a German export hit. There isn't a domestic market for them, as they can only be used in places which receive a lot of sunshine. Spain is a good candidate, for example, home to the 150 megawatt project Andasol, located near Granada. The project was developed by the Erlangen-based company Solar Millenium. The first of three power plants is already operational. Mirrors covering an area as big as 70 football pitches are busy harnessing the Southern Spanish sun.

The Desertec project, which is still on the drawing table, would take things one step further. Plans are afoot for a series of huge solar power plants to be set up in the North African desert. They would provide an almost unlimited supply of energy – carbon neutral and affordable energy at that. Solar electricity from the African desert could help make Europe less dependent on fossil fuels. Credit for thinking up the largest green electricity project in the world goes to Gerhard Knies. The German physicist pursued his idea for years, bringing more and more countries and industry partners on board. There are still a lot of hurdles to be overcome before Europe runs on desert electricity, but scientists such as Eicke R. Weber and

Modern architecture and high energy efficiency: The planned 'green' urban development Masdar City near Abu Dhabi.

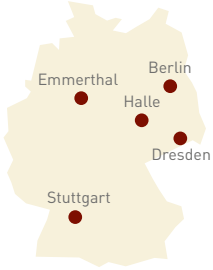
institutions such as the German Aerospace Center (DLR) think the project is realistic.

Masdar City is a similarly ambitious project. Located some 30 kilometres from Abu Dhabi, the capital city of the United Arab Emirates, is a six square kilometre building site which is set to become a green city, and home to around 50,000 inhabitants. The goal is for Masdar City to be carbon neutral. Cars with combustion engines will be banned, waste will be recycled, houses will be built with energy-saving in mind, and electricity will be generated from solar and wind power plants. The sunny future is sending its rays all the way to Ichtershausen in the German state of Thuringia: the Erfurt-based company Masdar PV is producing thin-layer solar cells for Masdar City.

Katja Lüers

Links

www.zsw-bw.de
www.csp.fraunhofer.de
www.helmholtz-berlin.de
www.isfh.de
www.iapp.de



Beneath the Spanish sun: Solar thermal power plant with heliostat field and parabolic trough concentrator at the Plataforma Solar de Almería.

IN THE KNOW

→ Professor Eicke R. Weber, Director of the Fraunhofer Institute for Solar Energy Systems (ISE) located in Freiburg

In what ways is harnessing the sun's energy one of the most important global challenges of the 21st century?

There is no alternative to renewable sources of energy. Solar energy will supply the lion's share, around 50 per cent.

Renewable sources of energy accounted for less than 20 per cent of global energy consumption in 2008. How will things be different in 2050?

Hopefully by 100 per cent. Europe could meet that goal by 2030, but for that to happen there would have to be strong political consensus.

Right now thin-layer technology is all the rage in photovoltaics. The modules are cheap to produce. Does that mean producers of crystalline silicon modules are on the way out?

No. I am sure that they will survive and will even gain the upper-hand in the long-term. After all, they have a 15 to 17 per cent efficiency rate, which is significantly higher than the efficiency rate of thin-layer technology, which stands at around 10 or 11 per cent.

TO THE POINT

→ Fraunhofer ISE: The Fraunhofer Institute for Solar Energy Systems (ISE) conducts research on the technology needed to supply energy efficiently and on an environmentally sound basis throughout the world. To this end, the institute develops materials, components, systems and processes in target areas. The Fraunhofer Institute sees itself as an intermediary between academia and industry. The ISE cooperates with numerous German universities, both in the lecture hall and beyond. Undergraduates and PhD students are given the opportunity to participate in research projects in the field.

→ www.ise.fraunhofer.de

WIND

Wind energy is a success story. Wind farms, both on land and offshore, are sprouting up in ever-increasing numbers. In terms of its potential, however, wind energy remains virtually untapped. Researchers, engineers and builders face sizeable challenges.

Dynamic development of wind energy in Germany

Concentrated Energy from the Ocean

→ One press of the green button and twelve huge wind turbines in the North Sea are set in motion: April 2010 saw the launch of alpha ventus, the first oceanic wind park in German waters, to the applause of the German Federal Environment Minister and CEOs of the large energy companies EWE, Vattenfall and E.ON. The site, which is located 45 kilometres off the island of Borkum, supplies electricity for 50,000 homes on shore.

alpha ventus is just a first step. Increasingly large wind parks are going up in the North Sea, off the coast of Denmark for example, or in the Thames Estuary. German energy companies are frequently members of the consortia, and German technologies are also on board. This is hardly surprising given that the German wind energy sector comprises some 2500 companies and 100,000 employees, supplies almost 30 per cent of the world market, and easily generates € 8 billion a year.

Germany ranks third in the development of wind energy, behind China and the USA. "The future potential is still huge," says Hermann Albers, President of the German Wind Energy Association (BWE). The market is set to grow from a current annual turnover of around € 30 billion to € 200 billion in 2030. Thanks to wind energy, Germany is well-placed to meet the European Union's goal of generating at least 20 per cent of electricity through renewable energy sources by 2020.

The wind energy success story is also a challenge to its future development. Wind turbines are constantly growing in size, but their external appearance remains pretty much the same. For the uninitiated, it looks as though everything has already been developed. "We have to help the public and politicians understand that there is still massive potential for research and development," stresses Martin Kühn, Professor of Wind Energy Systems at the University of Oldenburg. In a bid to give their discipline more clout, the universities of Oldenburg, Hanover and Bremen are coordinating their research in a centre for wind energy research called ForWind. Additional institutes have also been set up elsewhere, especially in wind-rich Northern Germany, around the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) in Bremerhaven and Kassel, for example.

Confirmation of the discipline's infancy is also provided by the European Technology Platform for Wind Energy (TPWind), which has defined an EU research strategy and coordinates a network with representatives from science, energy companies and politics. Five issues have been singled out:

→ Wind as a resource: Wind-generated electricity should be made easier to plan through better research into the interactions between weather, location and rotor blades. Computer simulations and radar technology have a part to play in this. Radar technology in particular will soon make it possible to calculate wind speed a few seconds in advance and to then adjust the rotor blades in such a way as to produce energy as smoothly as possible.

→ Wind turbines: It isn't possible for engineers to push the technology's limits as many of the processes which happen at the level of the rotor blades or the power train have yet to be comprehensively researched. However, if output is to continue to rise, up to ten megawatts or more per wind turbine at offshore-parks, then new technologies such as carbon fibres or superconductors will come into play, opening up new frontiers for the sector.

Invisible from shore: alpha ventus is Germany's first offshore wind farm.

More electricity from wind means more lines: Wind farm operators have guaranteed access to the grid.

- Offshore: The potential for developing wind energy on shore is huge, but politically contentious, as many people reject proposals for new wind turbines. That is why the future of wind energy is in the ocean. This raises a whole new set of questions with regards to reliability, maintenance and integration into the grid.
- Feed-in: Wind is extremely variable, as is the demand for electricity. Balancing them out is the biggest challenge of grid integration. The aim is to make wind farms as reliable and quick to regulate as gas turbines.
- Economics and politics: The energy sector plays an important role in job creation, but there are also issues to be clarified relating to safety and development policy.

The last two points in particular could lead to a bottleneck in the further development of wind energy. According to the law on renewable energy which was passed in 2001 and has since been amended twice, electricity generated through renewable energy sources is given priority status. This includes giving companies which run wind farms guaranteed access to the grid and, in the long-term, a higher feed-in tariff. That being said, at some sites in the Baltic Sea, wind turbines have to be slowed down from time to time because the grid isn't able to manage the high energy feed-in. In addition, consumers are more likely to be found in Southern Germany or the Ruhr. For wind energy to reach consumers new supply lines are necessary. ENTSO-E, a consortium of grid operators from 34 European countries calculates that € 28 billion needs to be invested over the next five years. The grid is set to increase in size by 35,000 kilometres by 2020.

While all eyes are on the big wind farms and the massive investments in grid expansion, a market for small wind turbines has been developing almost on the sly. The term refers to wind turbines with a maximum capacity of 70 kilowatts and a maximum height of 20 metres. Kilowatt for kilowatt they are more expensive than large turbines. However, in isolated areas which are not connected to the grid they guarantee a basic energy supply.

Bernd Müller

IN THE KNOW

The town of Dardesheim in the federal state of Saxony-Anhalt meets all of its electricity needs by itself. Dardesheim mayor, Rolf-Dieter Künne, talks about the aims of the 1000-strong community.

Why does Dardesheim describe itself as "a renewable energy town"?

We have lots of big roofs covered with solar panels, cars which run on biofuels and electricity, and we have had a green petrol station since 2008. And then there's the wind farm, which was set up in 1994 and has been extended to a current level of 66.6 megawatts. It enables Dardesheim to produce 40 times more energy than it uses. We are now at the point where energy tourists from all over the world come to visit us and find out more about what we are doing here.

How did it all get started?

In 1994 we were approached by a private company which manages wind turbines. The operating company made us an attractive offer of one percent of the feed-in tariff. We are actually using this money to invest in additional sources of renewable energy. We don't want to find ourselves in a situation where other countries can cut off our oil or gas supply, or where our children are saddled with atomic waste. We have set a precedent: our whole county aims to be energy independent by 2015.

Is the whole town on board?

Yes. Our residents have attended every meeting, and their support has been unwavering. We have always kept everyone informed about what is happening at the wind farm at the Druiberg site.

Links

www.wind-energie.de
www.forwind.de
www.iwes.fraunhofer.de
www.windplatform.eu

» The courses on energy offered at German universities are in high demand from international students. Over the last 23 years the "Postgraduate Programme Renewable Energy" in Oldenburg has attracted students from more than 80 countries. There is also a great deal of international interest in the "European Master in Renewable Energy", which is offered jointly together with seven additional European universities. Part of the attraction is the opportunity for students to spend time studying in at least two, often even three different countries over the course of their degree. «

Martin Kühn, Professor of Wind Energy Systems at the University of Oldenburg

Martin Kühn, Professor of Wind Energy Systems at the University of Oldenburg talks about what makes his subject so attractive

"Wind Energy is Extremely Multi-Disciplinary"

Germany is considered a world leader in the development of wind energy. Can the same be said for its research and teaching?

We are doing very well in those areas too, although it should be said that we are still at an early stage in development. It's not like solar energy, where an established research landscape has already been in place for many years. Wind energy is extremely multi-disciplinary. Developing and building a wind turbine requires input from the natural sciences, mechanical and electrical engineering, as well as know-how provided by civil engineers and lawyers. The advantage is that there are lots of ways to approach wind energy from a research or teaching point of view. At the same time, the subject suffers from primarily being defined in terms of different approaches.

What steps need to be taken in order for wind energy to become established as an independent subject?

A lot of progress has already been made. Before I came to Oldenburg I was at the University of Stuttgart, where the first chair in wind energy in Germany was introduced, albeit as an endowed chair financed by industry. Now the number of regular chairs in wind energy is constantly increasing. They serve as a nucleus for further teaching activities which, in turn, cover the length and breadth of the subject. Universities are also offering students more options. Renewable energy has been acknowledged as an issue with a very wide impact, which should be covered in other university courses, too. What we still need are adequate opportunities for specialisation in Masters programmes. The opportunities for PhDs are already very good.

How much demand is there for the new university courses?

A huge amount. In 2009 Stuttgart received over 700 applications for the Bachelors programme in renewable energy. We ended up only offering places to people who had the best exit exam grades possible, with very few exceptions. Wind energy in particular is extremely popular. That helps us to attract students from disadvantaged backgrounds. We also have a higher proportion of women than other comparable engineering programmes. It is important to point out that students still receive a broad education and are also equally qualified to work in other fields.

Interview conducted by Bernd Müller

TO THE POINT

→ Wind energy research has a long tradition at the University of Oldenburg – predominantly as a branch of physics. The endowed chair in wind energy systems financed by the federal state of Lower Saxony and the energy company EWE is intended to strengthen the engineering science component of wind energy research and to promote cooperation with other faculties, such as computer sciences. An additional push is provided by the "Postgraduate Programme Renewable Energy", which gives international students the opportunity to earn a Master of Science after three semesters. The degree programme cooperates with numerous foreign universities and makes a big effort to maintain strong ties to alumni who have gone on to work in research, industry, politics and consulting. Students in the programme "European Master in Renewable Energy" often spend time studying at two or three of the seven European partner universities.

→ www.uni-oldenburg.de

WATER

Raging rivers, waterfalls, the tides. Water is motion, life, energy. A look into German research reveals just how diverse and profitable many of the new technologies are, both land-based and offshore.

German water experts are in demand all over the world

Powerful Waves and Extraordinary Treasures

→ Water carries formidable sources of power which can be tapped as energy. The oceans also harbour huge stores of combustible methane, which are locked into ice-like gas hydrates. German researchers are successfully working on efficient and environmentally-friendly technologies to salvage these treasures.

Solar energy, wind energy, biofuels – take your pick, they are the stars of a sustainable energy supply. Hydropower, on the other hand, is often left out of the limelight. And yet conventional hydropower plants make up the lion's share of electricity generated from renewable energy sources – and there is still a huge amount of potential.

"Hydropower has an image problem," says Professor Peter Rutschmann, who chairs the Department of Hydraulic Engineering and Water Management at the TU München (TUM). He explains how conflicts between energy providers and conservationists have tarnished its reputation. And yet it is perfectly possible to manage large-scale projects in an environmentally-friendly way. Together with the University of Stuttgart, the TU Dresden and the Universität Leipzig, the TUM is one of the leading centres for German hydropower research. "The environmental impact of hydropower projects is an important research focus right now," says Rutschmann.

The optimal management of such large volumes of water is also an important issue. How can flow rates and storage capacity help prevent the storage basin from silting up, avert flooding and reach a compromise between efficient power production and the environment? Modeling and computer simulation are increasingly useful tools in answering these types of questions. 3-D simulations also help make turbine designs more effective. All in all, however, turbines, generators and hydraulic engineering structures are considered to be fully developed. For the most part, developers spend their time working on fish-friendly and lubricant-free turbines that do not negatively impact the water quality.

World-wide, hydropower plants work at a capacity of around 800 gigawatts – that is more than six-fold the total capacity of all of Germany's power plants. According to an estimate from the International Hydropower Association, that figure only represents 30 per cent of the water energy which could be harnessed by industry. Hydropower is increasing massively, particularly in Asia, Latin America and Africa.

German manufacturers and engineering companies, which boast the most internationally sought after specialists, have order books that are bursting at the seams. The German Engineering Federation (VDMA) estimates that at least 50 per cent of all hydropower plants worldwide are based on German know-how. German manufacturers have an export ratio well in excess of 80 per cent. And the boom is going to last. According to an evaluation by Professor Hans-B. Horlacher, a hydropower expert at the TU Dresden, built-in capacity will double by 2050.

Conventional hydropower plants (left) still produce the lion's share of electricity.

Marine current turbines are a new technological concept.

WATER

A technological and environmental challenge: Three Gorges Dam in China.

IN THE KNOW

- Dr. Julia Ulrich, a research assistant for the Yangtze Project at the Forschungszentrum Jülich
- The Three Gorges Dam is a construction project which invites superlatives. The German-Chinese Yangtze Project studies its environmental implications.

In theory, the 26 turbine-strong dam could replace 15 coal-fired power plants. Doesn't that make questions about its environmental impact redundant?

Of course the hydropower plant produces green electricity. At the same time, the dam's environmental impact is huge. Understanding the ecological risks is key in formulating an adequate response.

What are some of the potential hazards?

The Yangtze River contains a lot of toxic substances. Damming up the river causes a build-up in these substances which then impact the ecosystem. In addition, since the dam was built, flooding is occurring in areas which have never been flooded before. If the plants in these areas are not adapted to these new conditions then they will not be able to stand their ground. That could result in landslides and large-scale soil erosion, and also pose a threat to biodiversity and agriculture.

Isn't it too late to be researching all of these side-effects?

We are not advocating that the dam was a bad idea. Our aim is simply to monitor the dam's impact. The results of our research will help establish guidelines for how to deal with possible scenarios.

TO THE POINT

- With a staff of about 4400, the Forschungszentrum Jülich is one of the largest research centres in Europe. Researchers at Jülich have numerous large-scale devices at their disposal. These include a research reactor, a particle accelerator and several supercomputers, which can, amongst other things, help simulate climate models. Forschungszentrum Jülich pursues cutting-edge interdisciplinary research on solving the huge challenges facing society in the fields of health, energy and the environment, and also information technologies. Work at Jülich focuses on both long-term, fundamental and multidisciplinary contributions to science and technology as well as on specific technological applications.
- www.fz-juelich.de

A variety of technological approaches

By that time it is likely that another source of energy will have gained considerable momentum – ocean energy. There are a variety of technological concepts involved: turbines anchored to the sea bed – essentially underwater wind turbines – which generate electric energy from ocean currents; platforms washed over by ocean waves that use the run-off water to drive water turbines; water columns built into hollow concrete structures on shore that oscillate and drive wind turbines from the subsequent suction and compression dynamic. "However, even the most highly developed turbines are still in the pilot phase," says Professor Jochen Bard, Head of Ocean Energy Systems at the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) in Kassel.

Operating on the high seas presents a whole new set of challenges. Ocean waters can be aggressive, with waves and currents placing enormous pressure on plant machinery. The reliability of the material used for the rotor blades must be ensured, as well as the safe running of underwater generators. That is why so many of the concepts include plans for hydraulically directing ocean energy back to the shore before converting it into electricity on land.

While German researchers are working hard to solve these types of problems, the natural potential for harnessing ocean energy off the coast of Germany is small. The North and Baltic Seas offer neither large waves nor a sufficient tidal range or current. "That being said, if we go a long way offshore, then a combination of offshore hydropower and wave energy on one platform could make sense for the German economic zone as well," says Bard. "Combined platforms will make it possible to retrieve more energy out of one ton of steel in the future, which will increase the cost-effectiveness of offshore projects."

Researchers also still see more development potential for hydropower in Germany. Upgrading older power plants could boost capacity by 20 to 30 per cent. With the arrival of new technologies for small and medium-sized facilities, sites which are less than optimal can be shut down. Low drop heights and variable fluid-flow measurements in small power plants create a need for new types of turbines and intelligent control technology to operate efficiently. "At the same time, it is also important that construction and maintenance costs are reduced so that small power stations are cost-effective," says Peter Rutschmann. Overall, there is still considerable room for growth in the proportion of electricity generated by hydropower. In the state of Bavaria, for example, it could grow from around 15 per cent to something more like 25 per cent.

Dietrich von Richthofen

Links

www.tu-dresden.de
www.uni-leipzig.de
www.iwu.bv.tum.de
www.uni-stuttgart.de
www.iwes.fraunhofer.de

Environmentally-friendly extraction of gas hydrates

A Positive Exchange

→ German researchers are developing an exciting new technique for extracting gas hydrates: replacing methane molecules embedded in ice with the greenhouse gas CO_2.

Burning ice: Powerful methane gas is locked in the world's ocean floors.

Researchers from IFM-GEOMAR explore gas stores at the bottom of the ocean with the submersible JAGO.

It is a fuel that makes your fingers freeze: Gas hydrates are composed of methane molecules which adopt a solid, ice-like state when combined with water. The fossil fuel is stored up to 400 meters beneath the surface of the oceans. World-wide stocks are huge: according to current estimates around 3,000 gigatons of carbon is tied up in gas hydrates. That's about thirty times more than the amount of conventional natural gas deposits.

Environmentally-friendly extraction of gas hydrates

Gas hydrates have yet to be commercially exploited. But when they are, it could be largely thanks to German technology. German researchers and companies have been working together on an environmentally friendly process for extracting the gas since 2008. The project is called SUGAR (Submarine Gas Hydrate Reservoirs) and aims to replace methane that is embedded in ice with sequestered CO_2 from power plants. "By simultaneously taking advantage of the opportunity for carbon storage, natural gas companies can make a contribution to climate protection and generate additional revenue," says acting project leader Dr. Matthias Haeckel from the Kiel-based Leibniz Institute of Marine Sciences (IFM-GEOMAR).

Germany does not have access to any reserves of its own as the North and Baltic Seas are relatively shallow. Gas hydrates are only formed in areas where temperatures are low enough and the pressure is sufficiently high. "What Germany does have, however, is excellent skills in many of the areas that are important for exploiting gas hydrates such as exploration technology, chemical processing technology and drilling technology," says the geochemist. The SUGAR project aims to develop existing technologies and gear them towards gas hydrate extraction.

Exploiting the vast reserves of gas hydrates is far from being a cost-effective and risk-free endeavour. The top of the hydrate layer is home to sensitive marine ecosystems. In many cases the ice sheets stabilize continental slopes; removing them could cause formidable landslides. "But even if we could only extract ten per cent of what is out there, it would still be an inconceivable amount," says Haeckel. In terms of energy content, it would be the equivalent of all the commercially viable oil and natural gas reserves in the world.

Dietrich von Richthofen

Link

www.ifm-geomar.de

EARTH

The Earth is rich in energy sources, both above and below its surface. Renewable resources and geothermal energy make for climate-friendly power. Germany is the home to creative projects and promising prototypes.

Germany leads the field in biofuels

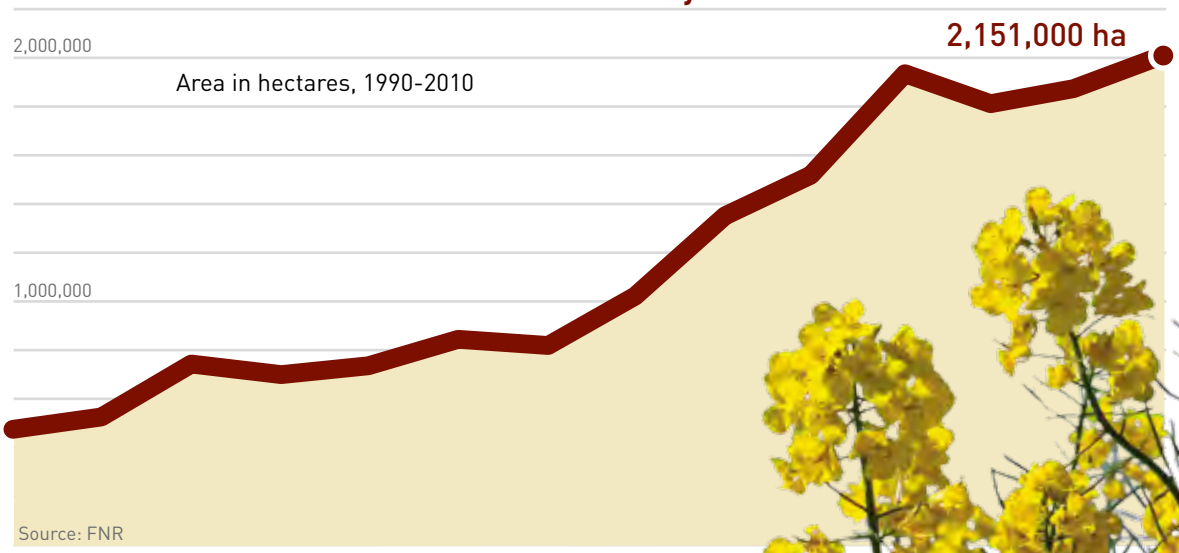
Designer Diesel and Deep Heat

→ There are more than 50 million cars registered in Germany, and most of them run on petroleum-based fuel. But stocks of this fossil fuel which does so much damage to our environment won't last forever. The Member States of the European Union have set a target for ten per cent of liquid transport fuels to come from renewable sources of energy by 2020. The automobile industry is powering ahead with the development of electric cars, but existing technologies won't disappear from the market overnight.

"For the time being, spark ignition and diesel engines will continue to be the major drive forms," says Dietmar Kemnitz of the FNR (Agency for Renewable Resources), putting a damper on inflated expectations. The FNR – an initiative of the German federal government – coordinates related research projects. According to Kemnitz, developing alternative fuels is a matter of urgency – and Germany is still leading the charge internationally. "We have been market-leaders in biofuel production and usage for many years now."

German research institutions are driving the technology forward. They are cultivating new species of grain, for example, and making improvements to the production of existing biofuels such as biodiesel and bioethanol. However, the future might lie in synthetic fuels. These so-called Biomass to Liquid (BtL) fuels are made from straw or scrap wood through a thermo chemical route. Their advantage: they can be used in new engines and generate few pollutants. Energy-producing plants are also a promising field, opening up a wide range of raw materials for BtL fuels. In contrast to existing biofuels the process makes use of the whole plant, not just the seeds. Kemnitz claims that 25 per cent of the country's fuel needs could be met by BtL fuels, if and when they are industrially produced.

Cultivation of renewable resources in Germany



At the biomass power plant electricity is generated by burning biomass fuels. Wood pellets are an ideal source of such fuel.

Direct application

The cluster of excellence "Tailor-Made Fuels from Biomass" at the RWTH Aachen University is putting these fuels under the spotlight. "We are combing various disciplines such as biology, chemistry, process engineering, combustion research and motor technology to find the best solutions in all areas," says coordinator Professor Stefan Pischinger. Additional partners include the Aachen-based Fraunhofer Institute for Molecular Biology and Applied Ecology (IME) as well as the Max Planck Institute for Coal Research located in Mühlheim an der Ruhr. An advisory board composed of internationally renowned researchers, including scientists from Princeton University, Yale University and MIT, as well as industry representatives from Bayer, Shell, Daimler and Volkswagen, makes regular progress reviews. The aim is for research results to flow directly into industrial applications.

Biomass isn't just a source of fuel. Dr. Jan Mumme, a researcher at the Leibniz Institute for Agricultural Engineering Potsdam-Bornim (ATB), works on a process that is set to produce both biogas and biochar. Mumme took one of the four top spots in the ideas competition "Bioenergy 2021 – Breaking New Ground" held by the German government. His premise: Producing biogas through conventional processes creates organic waste material that doesn't decompose easily. Mumme developed a type of biogas-biochar-hybrid process with the aim of refining this organic waste material through a thermal route, similar to charcoal production.

What makes his idea so unique is the fact that he plans to use only waste products such as straw, grass cuttings and animal waste. While energy can be produced from biogas, the byproduct biochar, with its high storage capacity for water and nutrients, can serve as a natural humus. At the same time, biochar provides long-term storage in the earth for the carbon dioxide it contains.

Electricity at 150 degrees Celsius

Another source of energy lies dormant deep under the Earth's surface: hot rocks. Germany has access to enormous sources of geothermal power, which are hardly exploited. At the GFZ German Research Centre for Geosciences in Potsdam, scientists are developing geothermal processes that make better use of this energy source. The current technology is still too pricey. The GFZ is using a research borehole at its geothermal laboratory in Groß Schönebeck to access water at temperatures of around 150 degrees Celsius – the minimum temperature at which the Earth's heat can be

Home-made electricity and heat? A 'home power plant' will make it possible.

converted into electricity. Water channels through hot rock, absorbs heat, and is then conveyed to the borehole. Researchers capture the water via an initial drill hole. Once the water's thermal energy has been tapped at the power plant, it is sent back to the underground reservoir via a second drill hole – a cycle that provides a long-term energy supply.

A very different approach to energy generation is offered by the green energy company LichtBlick in the shape of the "home power plant". Working in cooperation with Volkswagen (VW), LichtBlick has plans to install small co-generation power units in homes and businesses. The units provide heat as well as electricity, which is fed into the public grid. They run off natural gas-powered car motors, which are produced at low cost by VW. Prototypes are already being built at VW's research unit located in Salzgitter. The company showers have already been fitted with a prototype for producing warm water.

Boris Hänßler

Links

www.nachwachsende-rohstoffe.de
www.fuelcenter.rwth-aachen.de
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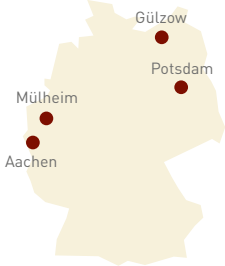


IN THE KNOW

➔ The energy company LichtBlick is a market leader in green electricity. Company spokesman Ralph Kampwirth talks about the benefits of doing business in Germany, and his ideas for the future.

What role will natural gas play in the future?

In the medium-term, natural gas will increasingly be used for heating and electricity. Technology is improving all the time, which will bring down demand for energy and gas in the long-run. In the electricity sector so-called COGAS – combined gas and steam turbines – are an attractive option because they use renewable sources of energy to balance out fluctuations in energy input. The same is true of smaller power-heat-coupling-plants which produce electricity and heat at the same time. Unlike coal and nuclear power, natural gas is a real bridge fuel for the transition to a renewable era. What is more, natural gas can gradually be replaced with biogas. That is the idea behind the gas-powered LichtBlick home power plants. Because they are so efficient they already supply green electricity through natural gas operations. Biogas would enable the home power plants of the future to operate on a renewable and therefore climate-neutral basis.

What are the benefits of operating in Germany for a company like LichtBlick?

Germany formally opened up its electricity and gas markets in 1998, creating the conditions for an independent energy provider like LichtBlick to be successful. Our business units are closely aligned with the German energy market. At the same time, ever since the company was founded we have made a big effort to translate the statutory requirement for competition into practice. Up until now, the market has been dominated by a few large companies, making it difficult for alternative providers to get established. There is still a long way to go before there is pure competition.

What are your expectations for co-generation power units?

LichtBlick has developed an intelligent co-generation power unit concept. We call it "swarm power'. LichtBlick links up 100,000 "home power plants" to a computer-controlled decentralised large-scale power plant. The power plant supplies electricity at times when renewable sources of energy, which fluctuate depending on the weather, are unable to meet demand. In addition, the generated heat is stored locally and is available to homes and businesses as heating energy. In keeping with our concept, co-generation power units make an important contribution to achieving an ecological energy transition as wind and solar energy are ideally suited to balance out fluctuations in energy input.

Energy economist Claudia Kemfert: Climate protection as an opportunity for change

Sending the Right Signals

→ The average German produces around ten tonnes of carbon dioxide every year. Individuals could actually offset their CO_2 emissions by paying 70 cents a day. Professor Dr. Claudia Kemfert, energy economist at the Hertie School of Governance and departmental chair at the German Institute for Economic Research (DIW), advises politicians at both the state and EU levels. She sees the promotion of renewable energies bringing strong, positive economic impacts.

Claudia Kemfert has a soft spot for number crunching – and she's also one to get her point across clearly. As Chair of the Department for Energy, Transportation and Environment at the German Institute for Economic Research (DIW) and Professor of Energy Economics and Sustainability at the Hertie School of Governance in Berlin, she addresses political decision makers in a bid to alert them to the opportunities offered by climate change. "Extreme climate events create costs. By 2050 the bill could run to € 800 billion in Germany alone."

A lot of companies are investing heavily in renewable energy sources and sustainable transportation right now. "We knew that our oil supplies were dwindling thirty years ago, and yet the global economy is still almost completely reliant on oil." It takes a catastrophe like that in the Gulf of Mexico to start a public discussion about a sustainable energy supply, and even then it is not taken seriously enough. The roots of the problem are not addressed at all. "An amazing amount of energy is wasted by industrial nations. The price of oil-based transportation is kept artificially low, and there are no market alternatives to crude oil. That's the real catastrophe," criticizes Kemfert.

Renewable sources of energy played a crucial part in starting the process of forgoing fossil fuels. Germany was quick to provide funding for these alternatives, "But an affordable energy supply and sustainable transportation are only possible with industry support," says the energy economist. Consumers can also influence the market through their buying decisions, by choosing to buy cars which run on biofuels, for example. "It's important to support global climate protection. To turn the argument on its head and come to the conclusion that it is irrational for local authorities or countries to initiate the energy turnaround is counterproductive and absurd."

The German government sent the right signals, says Kemfert. "You can't change an energy system overnight. Putting an infrastructure in place, introducing new vehicles or building new power plants takes decades. That's why it makes sense to start small and celebrate the small victories."

Sabine Wygas

TO THE POINT

→ The German Institute for Economic Research
The German Institute for Economic Research (Deutsches Institut für Wirtschaftsforschung – DIW Berlin) is the largest economic research institute in Germany. Its core mandates include applied economic research and economic policy consulting, inter alia on environmental issues. DIW Berlin cooperates with over 20 German and over 50 international universities and institutes. The affiliated Graduate Centre gives PhD students from all over the world the opportunity to do research and complete their degrees at various universities in Berlin. At the same time, the Centre brings the early stage researchers into direct contact with political decision makers and with the social and economic problems that they have to deal with.
→ www.diw.de

→ Hertie School of Governance
The Hertie School of Governance is a foundation-run school in Berlin that prepares highly qualified students for leadership positions in the public sphere. Lectures, panels, symposia, and other events are open to interested members of the public. The Hertie School of Governance is a project of the non-profit Hertie Foundation.
→ www.hertie-school.org

Environmental psychologist Ellen Matthies

Car Today, Bike Tomorrow

→ What impact does climate change have on our behaviour? Under what conditions are we prepared to make lifestyle changes? These questions are being addressed by Ellen Matthies, an environmental psychologist at the Ruhr Universität Bochum (RUB).

People often behave irrationally, so there are no easy answers. "Faced with rising energy prices, you might think that a lot of German households would invest in cost-saving solar thermal panels, but that isn't the case," says the 49-year-old. "People don't set out to harm the environment. Their behaviour can more accurately be described as a product of actions resulting from a variety of motivations." Financial incentives are one aspect. Factors such as convenience, social acceptability and personal preferences also have roles to play. "Sometimes the reasons why people don't deck-out their roofs with solar panels are really quite banal. They don't like the look it creates or their plumber thinks it is taking it all too far." There aren't many people who are well-informed enough to make environmentally relevant decisions.

That's why raising public awareness is such an important driver for change. No easy feat. On the one hand the information that people are given is not always clear enough. "Lots of the subsidies on offer are so complex that they are incomprehensible to the uninitiated." At the same time, a lot of information never reaches its target audience because, for example, it is not sufficiently clear that a certain style of driving saves on petrol. "The system has too many barriers built into it". Dismantling these barriers is a political responsibility. People will only become more environmentally aware if they are well-informed. That is also the basis for political decisions being well received. "It also makes restrictions and limitations easier to enforce."

Schools and educational programmes could provide people with the information they need to make environmentally conscientious decisions. "Feedback systems which immediately show consumers that they can save energy by changing their behaviour are very important," says Matthies. One example is an individual's carbon footprint, which can be calculated over the Internet. The online tool also gives a break-down of personal energy use, and at the same time, it gives tips on how to reduce their emissions.

"It's not always possible to make changes because people tend to stick to the status quo, especially when it comes to things that seem routine, like driving a car or taking long showers," explains the psychologist. Conversely, behavioural patterns which come less automatically are easier to change. The result might even take the shape of a new energy-efficient washing machine. "These successes can act as a catalyst for bigger changes."

However, not everyone can understand the significance of climate change by drawing on direct experiences, despite the fact that extremes in weather, such as wild fires in Russia and flooding in Pakistan are becoming more common and are well documented by the media. In the first instance, climate protection needs to take place at the level of international treaties. "Unfortunately, meetings like the climate summit in Copenhagen are tarred by the complex political necessities of participating countries," says Matthies. "And that's why a climate summit can fail, even though our problems are increasing dramatically." Psychological studies have shown that in situations like these, it is beneficial if individuals take a stand and practice climate protection in an exemplary way. "That has positive long-term effects on other people's behaviour."

Sabine Wygas

Hybrid technology paves the way for "clean" buses and trains

The Secret Lies under the Bonnet

→ On the surface, it looks like a perfectly normal public transit bus – spacious and somewhat bland. Until it pulls away, without making a sound. The only thing which lets on that the engine is running is a quiet whine; the typical diesel noise doesn't kick in until after a few hundred metres. The secret lies under the bonnet in the shape of two engines: an electric engine which drives the wheels and a diesel engine which powers a generator and only kicks in when the stored energy, created when braking and stored in a battery pack of ultra condensers, is not sufficient.

The ELFA-system was developed by Siemens and is set to be incorporated into MAN and Evobus models as well as into buses from other international manufacturers, among them Tata in India. The hybrid concept which is currently doing the rounds in the car industry has crossed over to the utility vehicle sector. According to Siemens the ELFA-drive is suitable both for delivery and refuse disposal vehicles as well as mobile harbour cranes. Depending on usage, the system can cut fuel consumption by up to 40 per cent.

The MITRAC Energy Saver is a system for trams developed by the company Bombardier with the support of the German Federal Ministry of Education and Research (BMBF). It is not a hybrid, but the concept is similar. A battery consisting of double layer condensers on the roof of the tram stores energy which is released when braking, energy that is wasted in conventional trams. In this case, however, the battery feeds the energy back into the electric motors when pulling off, thus reducing the current drawn from the overhead power line. "It will help us save around 93,000 kilowatt hours per vehicle each year," says Martin in der Beek, managing director of the Rhein-Neckar Transport Association (RNV). RNV is set to launch a total of 19 Bombardier Energy Saver variotrams on routes in Heidelberg and Mannheim by the end of 2010.

The energy-independent tram

The exceptional thing about Energy Saver is the fact that trams are even able to go short distances without using an overhead power line at all. That makes it particularly useful in areas where an operating company would prefer not to install overhead power lines, out of concern that they could spoil the townscape if erected in front of listed buildings, for example. The tram simply continues independently for a few hundred metres until it reaches the next overhead power line. In Heidelberg cutting out overhead power lines also serves a further purpose: two sections of track without overhead power lines are planned for the Neuenheimer Feld area in order to prevent electrical fields produced by power lines from affecting the sensitive measuring instruments of the university's physics institute and the German Center for

No overhead power line: Trams of the future will do without.

Half bus, half tram: New energy storage components are currently being tested for the AutoTram.

Cancer Research (DKFZ), which are both situated very close to the tram line.

In fact, it is now even possible to do without overhead power lines altogether. With its PRIMOVE system Bombardier has introduced a contact-free charging concept for the MITRAC Energy Saver. Power transfer is achieved via induction loops which are located out of sight under the tracks. The few seconds it takes for a tram to make a stop are enough to replenish the battery with sufficient power to reach the next tram station.

The AutoTram, an interesting cross between a tram and a bus, is a new concept developed through a collaboration of 33 Fraunhofer Institutes. The vehicle is fitted with rubber tires but is as long and flexible as a tram. The AutoTram isn't ready to go into production just yet. For the time being it serves as a development platform for new transmission components, in particular power packs which combine several technologies such as double layer condensers and lithium-ion batteries or fuel cells. The Fraunhofer Institutes are developing appropriate charging concepts for the power packs which replenish the battery at tram stops within 30 to 60 seconds with a current of 1000 amps at 700 volts.

The reason why hybrid systems are so energy efficient is that they win back energy that is released when braking. This energy does not necessarily have to be stored; it can also be used immediately. This has been put into practice recently in locomotives. Siemens has built the first electric locomotive with energy recovery, albeit without batteries. Energy that is created during braking feeds into the overhead power line to be used by other locomotives which might need it at that particular moment in time. The Siemens locomotive pulls large freight trains full of coal in Australia. On the journey from the country's interior down to the coast the fully laden trains generate a huge amount of braking energy, which is immediately used by empty trains travelling up hill in the opposite direction.

The right energy balance

However, the ability to save energy while operating is only one aspect of a locomotive or tram's energy balance. Producing and recycling these vehicles also uses energy and generates greenhouse gases. These considerations impact on production processes and often raise conflicts with regard to outcomes. For example, a locomotive with an aluminium roof is lighter and therefore needs less energy. However, producing aluminium uses up more energy. Today's train manufacturers therefore have to present their customers with detailed life cycle costs and material balance analyses, which take total energy and material inputs into account.

To this end, engineers at the Siemens locomotive factory in Allach near Munich manage a database which runs to many thousands of part numbers. In addition to details about material composition, each entry also lists information about emissions, and is even sorted by country of origin. This is important because aluminium produced from green-energy in Iceland, for example, has a much smaller carbon footprint than aluminium from China, where the electricity used to produce it comes mainly from coal-fired power stations. There are similar differences when it comes to operating costs. A subway train like the one which Siemens has supplied to Oslo produces only 827 tons of CO_2 in the course of its 30-year service, making it the most energy-efficient metro train in the world. If it were to operate in Prague, it would produce 47,900 tons of CO_2, as most of the Czech Republic's electricity is also generated from coal. On the other hand, the Prague subway runs underground which makes it warmer so the heating does not have to work so hard and there is no need for an extra thick insulation layer, as there is in Oslo.

Nowadays customers take these subtleties into account, and don't just look at the sticker price. After all, a ten per cent higher purchase price for a locomotive which is made of lightweight materials or has been fitted-out with more efficient engines is easily offset by energy savings of just one or two percentage points. Bernd Müller

Links

www.bmbf.de
www.ivi.fraunhofer.de

Researchers put their foot on the accelerator for electromobility

Pioneering the "Silent" Car

→ Most cars today run on petrol or diesel. That is set to change as stocks of crude oil continue to fall and prices keep on rising. Concerns about car exhausts contributing to global warming by churning out carbon dioxide are another motivator. Plenty of reasons for a change in technology.

Electric cars could be one solution. They have yet to hit the streets in large numbers - in Germany there are at most a few thousand humming away on the roads. The German federal government wants to change that by setting a target of one million electric cars by 2020. Teams of scientists are rising to the challenge and gearing up electromobility research.

In the ideal scenario, most of our future energy needs will be met by renewable sources of energy such as wind, solar and geothermal energy. Energy will be converted into electricity and stored in electric car batteries. Cars will run off electric motors. A promising alternative is offered in the shape of hybrid cars. Built-in small petrol motors can be turned on if necessary for covering longer distances, reducing the size of the electric battery accordingly. There are numerous projects dedicated to the development of hybrid and electric cars throughout Germany.

Affordable electric cars aren't just a pipe dream

One of the most exciting projects was launched at the end of 2009. The project, run by a group of researchers at the Technische Universität München (TUM), is called MUTE, and its aim is to develop a concept car that ticks all of the right boxes. The researchers want to prove that it will soon be possible to build affordable electric cars for the mass market. The model car is due to celebrate its premiere at the 2011 International Motor Fair (IAA) in Frankfurt. Researchers are also hoping to catch the attention of a company to commercially produce the car. The concept car is intended to push 120 kilometres an hour with the help of two types of batteries: a rechargeable lithium-ion battery for town traffic and for longer distances, an additional zinc air battery, which has to be replaced at the end of the trip.

More than 20 professors, around 30 research assistants and at least 200 students are collaborating on the Munich-based MUTE project. "We are pooling our resources," says Professor Markus Lienkamp (see short interview). That way, the team can be sure that the components fit together properly. There are sometimes surprises along the way. When the car's heating was on the drawing table the first drafts were for an electric heating system. However, given that the car shouldn't weigh in at more than 400 kilogrammes, it would have been too heavy. Instead, researchers opted for a bioethanol burner. In order to keep the car as light as possible many of the parts are made out of aluminium and synthetic materials reinforced with carbon fibres. To ensure that the car's safety isn't compromised by the lack of bulk, long crumple zones are being built-in at the front and rear, explains Lienkamp.

Over the next five years, the Munich-based researchers will be cooperating with colleagues in Singapore. Work at the "Campus for Research Excellence and Technological Enterprise" (CREATE) will focus on the development of a joint-concept for electromobility in the tropics. "We will have to spend a lot of time thinking about the car's cooling system," says Lienkamp. The Asian scientists will also spend time researching in Munich.

Science is a global affair, and competition in car manufacturing is no less international. Germany ranks third in the production of passenger vehicles after Japan and the USA. It owes its success to companies like Daimler, Volkswagen and BMW. The arrival of the electric car has led to a reshuffling of the pack. A global jostling for the best starting position in the future market has begun. Germany is well placed to lead this new field, too.

Forward-looking production: Suppliers and car manufacturers are gearing up for hybrid and electric cars.

Currently under development: The lithium-ion battery is the planned energy source for electric cars.

The battery of the future

The German Federal Government has so far provided more than 500 million for electromobility research and development. The range of topics covered goes beyond electric motors, power electronics and materials research. German research also extends to energy storage. The expert opinion is that lithium-ion batteries are the best option for providing electricity to hybrid and electric cars. These batteries have a high energy density and, so far, have mostly been used in small electronic devices such as cell phones and cameras.

There are still several obstacles to be overcome before lithium-ion batteries are ready to be deployed in cars, explains Professor Martin Wietschel, director of the business unit in energy economy at the Fraunhofer Institute for Systems and Innovation Research ISI in Karlsruhe. Working in collaboration with other colleagues from the institute, Weitschel has drawn up a technology roadmap for battery research. "We need to reduce the cost of these batteries by two thirds, increase their life span from six to ten years, and really get a handle on safety issues." It is true that there is room for improvement in electric motors and in power electronics. For example, there are very few factories which produce electric motors in the 50 to 80 kilowatt performance category. But compared to battery research, these issues are secondary.

Together with a consortium of German businesses, the German government provides funding for the Innovation Alliance Lithium Ion Battery 2015 (LIB 2015). This national research association with representative from science and industry aims to develop batteries and set in place an accompanying infrastructure. The project was launched in 2009 and is scheduled to run for four years. Germany's strong political commitment to electromobility is also evidenced in a number of other support initiatives. The government funds the ProLiEMO project, in which battery and car manufactures are developing techniques that will make it possible to produce large-sized batteries for passenger vehicles. In addition, funding has been awarded to the Innovation Alliance for Automotive Electronics E/ENOVA, in which producers and suppliers are committed to improving the energy management of cars. The project "Electric Grids of the Future" is co-financed by the Federal Ministry of Finance. The aim of this project is to explore how electricity from electric cars can be fed back into the grid to balance out fluctuations in energy input.

Germany offers a wealth of opportunities for anyone who wants to make a concrete contribution to the project of the future that is electromobility. Programmes in electrotechnology, mechanical engineering, electrochemistry and transportation are offered at numerous universities and technical colleges. Not every course out there automatically has a direct bearing on electric cars. Some universities stand out in the programmes they

IN THE KNOW

→ Prof. Dr.-Ing. Markus Lienkamp, TUM Science Center for Electromobility, MUTE project leader

The MUTE project is dedicated to building an electric concept car. How did the project come about?

At the end of 2009 I took up my professorship at the TUM and approached some colleagues at the Science Center for Electromobility with my idea. They liked it and we set up the MUTE project together. A lot of research used to be done in isolation, that's not the case now.

How noisy will the electric concept car be?

You won't be able to hear a thing – at the very most you might hear the gearbox click. That's why we called the project MUTE. We might actually have to build-in some artificial noise so that pedestrians know the car is coming.

How will you prevent the car from stopping in its tracks because the batteries have died?

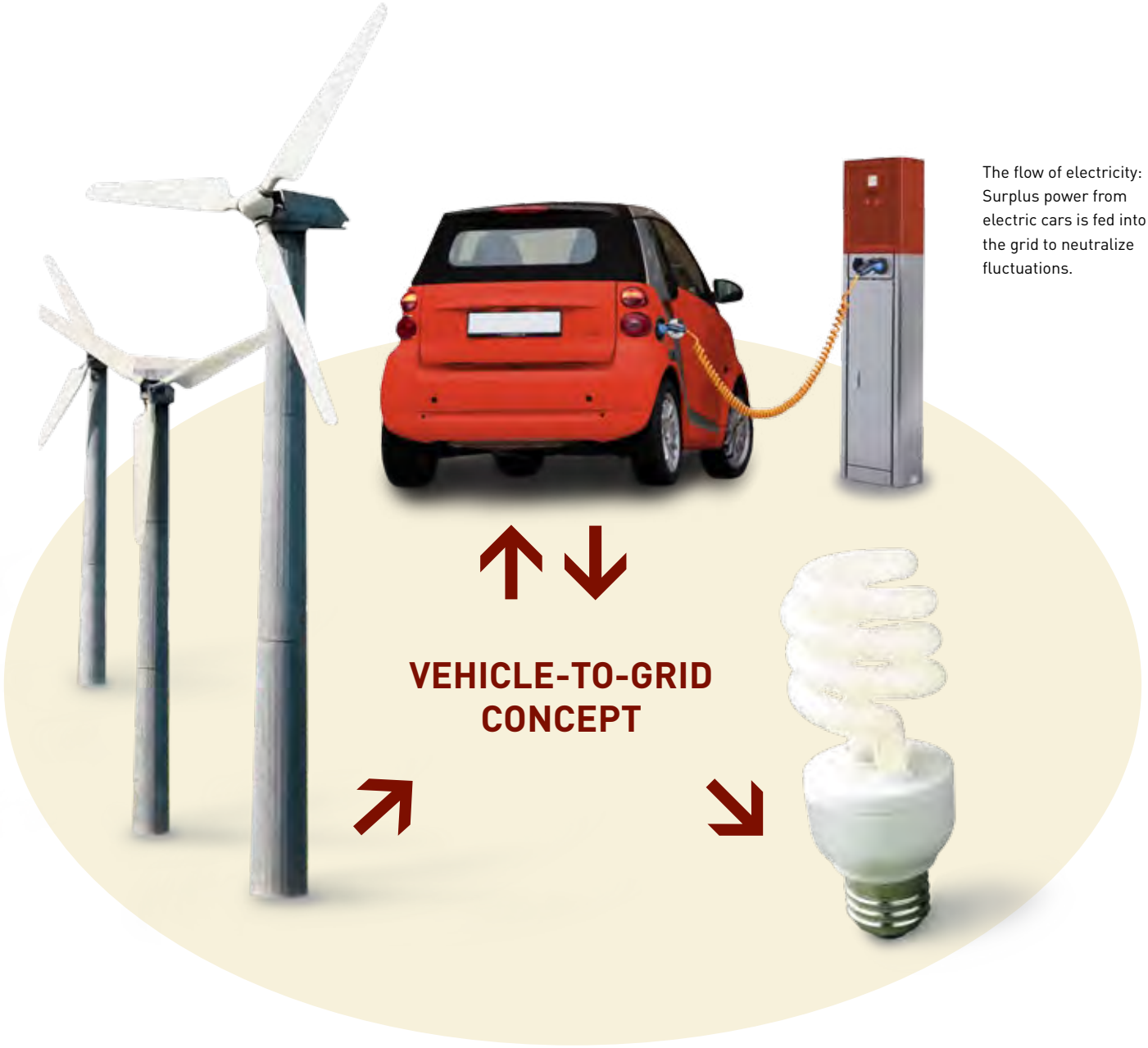
If the driver types in the destination of a given trip into a GPS before setting off, then the car computer will adapt the routing and the batteries' discharge strategy to keep that from happening.

offer, explains Professor Jürgen Janek from the Institute of Physical Chemistry at Giessen University, whose research group is working on various battery processes. For students who want to approach the subject from a chemistry angle, Janek recommends the programmes on offer at the universities of Bochum, Giessen, Münster and Ulm as well as at the Karlsruhe Institute of Technology (KIT). The TUM offers programmes which have more of a physics slant. The International Graduate School of Science and Engineering at the TUM offers students a structured PhD programme. Whether they opt for a structured programme or a more traditional route with a thesis advisor, the German university and research landscape offers students numerous options for PhDs in the field of electromobility.

A lot more effort will need to be put into research and development before electric car technology makes it onto the global market. But who knows, maybe the next generation of students in Germany will already drive to lectures in quietly humming electric cars. Sven Titz

Links

www.mute-automobile.de
www.isi.fraunhofer.de
www.lib2015.de
www.eenova.de
www.fkfs.de
www.bmbf.de



The flow of electricity: Surplus power from electric cars is fed into the grid to neutralize fluctuations.

Students at RWTH Aachen University design an energy project for the classroom

The School of the Future

→ What is the best energy management strategy for a school? It sounds like a job for an energy economists or the local electricity provider. Fabian Potratz and Bartholomäus Wasowicz, students at the industrial engineering department of the RWTH Aachen, disagree. They have designed a management game called "Plug Into Future – Schools and the Energy Revolution" in which pupils compete to come up with the best energy management strategy for their school. A high school in Aachen will be giving the project a test-run in the fall of 2010.

First up are the pupils in the school's lower grades. They collect important energy data about the school. How many windows does the school building have? How thick is the insulation layer? Hand-held electricity meters provided by Aachen's municipal utilities company are intended to help the school kids calculate how much energy their everyday equipment uses. "The aim is to increase the awareness of energy issues among the younger pupils," explains Bartholomäus Wasowicz. The 12th graders then use the data to come up with the best energy concept for their school. The competition covers four important areas: investment, communication, direction and information. For the pupils, that means delving into new areas – from meteorological data analysis to the functionality of a solar cell. The project's lynchpin is a web platform where pupils gather and exchange data. The platform's most impressive feature is an online simulation tool that enables students to see the consequences of their decisions straight away.

The Aachen student project takes its inspiration from a management game based on the stock exchange. In that game, players trade under the same market conditions as real traders with 'monopoly shares'. "As in the stock exchange management game, our aim is that the simulation is as close to the real thing as possible, and that it's repeatable for every generation of pupils," says Fabian Potratz. In the long-term, Potratz and Wasowicz can imagine schools from all over Germany or even Europe using their game to compete for the best energy concept.

The project team (from left): Stephan Raths, Andreas Roehder, Bartholomäus Wasowicz and Fabian Potratz

No easy task

"Above all, we want to show the complex factors involved in finding the right energy mix," says Wasowicz. Pupils are not the only target audience: the Aachen project team also wants to involve teachers and parents in the energy debate. To this end they have put together information booklets which are intended to help teachers prepare and de-brief students on energy issues.

How did the 25-year-old students access all the relevant information from such a variety of disciplines? "One thing we did was enlist the help of educators and computer scientists. Five of the people who came on board are now part of the core team." The prize for the group of pupils with the best energy concept will be awarded in December.

Julia Walter

TO THE POINT

→ "Plug Into Future" is one of 13 projects which were announced as winners of the "Energy for Ideas" competition. As part of the "2010 Year of Science" initiative, the German Federal Ministry of Education and Research (BMBF) called for students to develop creative concepts geared in particular to motivating younger members of the population on energy issues. Winners are awareded € 10,000 to help implement their ideas.

→ Information on all the winning projects is available in German at: www.energie-fuer-ideen.info

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SUGGESTED LINKS

→ Germany provides ample and exciting opportunities for those interested in the field of energy – from undergraduate studies and PhDs to interesting careers. For "power-packed" sources of information and tips click into the links listed below.

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