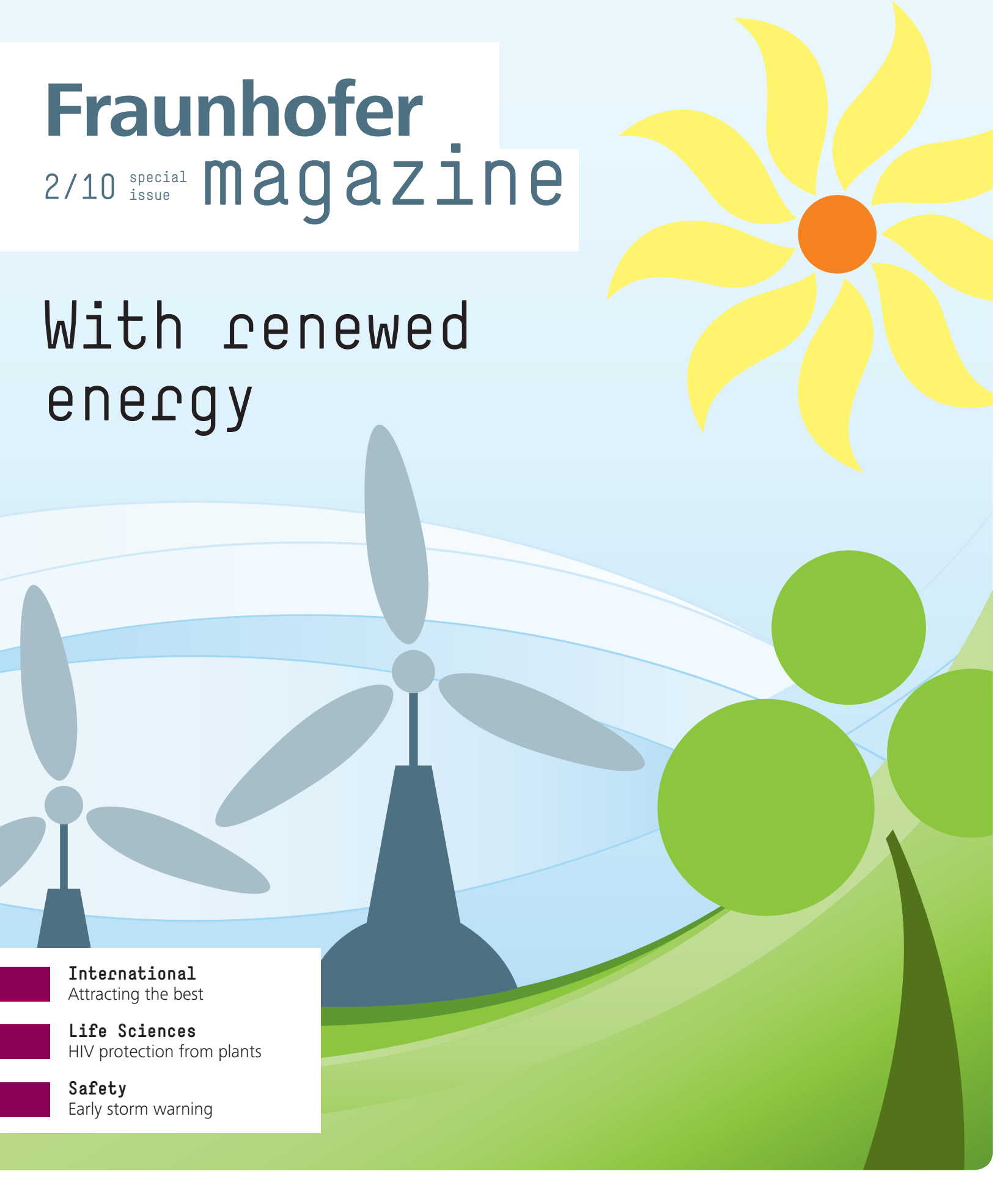
Fraunhofer magazine

2/10 special issue

With renewed energy



International
Attracting the best

Life Sciences
HIV protection from plants

Safety
Early storm warning

Emerging greener from the crisis

Prof. Dr. Hans-Jörg Bullinger. © *Bernhard Huber*

Increasing numbers of people, organizations, commercial enterprises and politicians are currently seeking to raise their ecological credentials. GREEN is no longer simply a word that embodies the idea of a sustainable future; GREEN has developed into a mega-market all its own. Economic analysts are predicting high growth rates for renewable energies and environmental technologies. Climate change, environmental pollution, rising energy costs and scarcity of raw materials are all driving this revolution in attitude, and the process is being further accelerated by the economic downturn, which is forcing companies to be even quicker in adapting their products to the changed needs of the consumer market. The result will be that the economy emerges greener from the crisis.

Over the coming decades, our central challenge will be to develop a sustainable, safe, cost-effective and environmentally friendly energy supply. This is one of the reasons why the German federal ministry of education and research has subtitled the Year of Science 2010 'The Future of Energy'. Renewable energies, advanced energy storage systems and ways to increase energy efficiency are all important areas of research for the Fraunhofer-Gesellschaft. Fraunhofer already boasts the largest capacities in Europe when it comes to researching renewable energies and is also an active strategic partner of the Massachusetts Institute of Technology and the ambitious Masdar City eco-town project in Abu Dhabi.

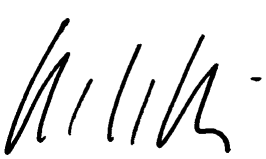
One thing is certain: The next decade will bring a sea change in energy consumption, conversion, storage and distribution. Initial studies and findings indicate a potential for great savings – not only in respect of energy consumption, but also as regards our use of raw materials. Buildings, in particular, are prime candidates for big developments. Roughly one third of all the energy Germany uses is channeled into heating and cooling homes and offices. Intelligent building technology could reduce energy consumption by up to 40 percent.

In the medium term, it should also be possible to make energy savings of up to 30 percent in industry too. The German federal government intends to promote the 'Efficiency – Made in Germany' brand worldwide. A global market is currently emerging for systems, products and services that enhance energy efficiency. The careful use of energy resources is an initial step towards achieving a sustainable energy supply. But in the long term, we will have to make the switch to renewable energy sources such as the sun, the wind, and biomass. Our main feature article explains how this can be achieved. Fraunhofer Institutes are not only sharing their expertise within numerous research projects looking into sustainability, they are also physically demonstrating it in several pilot projects.

With Renewed Energy

The automobile industry is of crucial importance to the German economy. If it is to remain competitive in future, it will need to develop 'intelligent', fuel-saving and environmentally friendly vehicles – for example, electric automobiles. From now on, the aim is to ensure not only that cars consume less fuel when driven, but also that their production process becomes less energy and raw material-intensive.

Climate protection, conservation of the environment and economical use of raw materials and energy are top of today's agenda – for Fraunhofer and a growing number of commercial enterprises as well. We take a holistic approach to these matters, never forgetting the all-important factor of the future well-being of mankind. Now that truly would be sustainability in the broadest sense of the word – succeeding in arranging the technical aspects of our world in such a way as to guarantee the ongoing health of both the human race and the natural environment. Moving into a future well worth living – and with renewed energy!



Content

Looking into the heart

To the naked eye, blood appears opaque; in the infrared spectral range, however, it is transparent, a characteristic that researchers are exploiting in a patented optical system developed by the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg and the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg. With an infrared-sensitive camera and customized lighting, blood becomes see-through. The IAF has developed the semiconductor laser module for this system, which now allows surgeons to find their way around inside a beating, blood-filled heart within a radius of a few millimeters. Angiocam Infrared Vision Systems GmbH is developing this process further.

Rubber from dandelions

Car tires, screw caps and latex gloves – examples of the 30 000 or so everyday products containing rubber. Most natural rubber comes from rubber trees in Southeast Asia, but this source is now under threat from a fungus. An alternative source of rubber is needed to meet the continuously increasing demand for this valuable material. Researchers from the Fraunhofer Institute for Molecular Biology and Applied Ecology IME have now optimized the Russian dandelion to make it suitable for large-scale rubber production.

The sought-after material takes the form of a white fluid which seeps out from the stems when the plant is harvested. It is difficult to use, however, as it polymerizes immediately. Scientists have now found the enzyme responsible for the rapid polymerization, and have switched it off; if the plant is damaged, the latex flows out instead of polymerizing. If the plants were to be cultivated on a large scale, every hectare would produce 500 to 1000 kilograms of latex per growing season. Researchers are now working on cultivating the optimized plants using conventional breeding techniques. In around five years they may well have achieved their goal. The dandelion is not just suited to rubber production: the plant also produces substantial quantities of inulin, a natural sweetener.

Dandelions in a greenhouse. © *Fraunhofer IME*

Protection against graffiti

Historical monuments mostly consist of porous materials such as natural stone and brick. Graffiti paint penetrates deep into the pores and is very difficult to remove. Unfortunately, the conventional protective films currently used to coat valuable buildings have not provided adequate protection: They do not last long enough, can prevent the building from breathing and have proven hard – even impossible – to remove.

A new type of polymer coating should help in the future. It has been developed as part of an EU project by scientists from the Fraunhofer Institute for Applied Polymer Research IAP in Golm together with the Center of Polymer and Carbon Materials of the Polish Academy of Sciences. The new long-lasting polymer film seals the pores, so that graffiti paint doesn't penetrate, but at the same time automatically creates a hydrophobic barrier on the surface with mini-holes that allow water vapor through. The building can therefore breathe again, while rainwater drips off. Most importantly, the invisible coating can be removed from the building if required, without damaging its surface.

A new type of polymer coating aims to protect historical buildings from graffiti. As the coating is permeable to water vapor, the building can breathe despite the coating. © *Fraunhofer IAP*

Protecting paintings during transportation

Original works of art frequently travel from one place to another on loan. To keep them safe, the paintings are placed in special frames in which they remain during transit and for the duration of the exhibition itself. These travel frames protect the painting from mechanical damage and keep out most of the contaminants from the surrounding environment. However, chemical substances such as acetic acid emitted in gaseous form by the painting or packaging can potentially build up within this microclimate. Under certain circumstances these substances may then react with the paint or canvas and damage the artwork. In the future, environmental sensors will be used in the travel frame, display case or warehouse to detect which gases are accumulating.

The dosimeters were developed by researchers at the Fraunhofer Institute for Silicate Research ISC in Würzburg in collaboration with European project partners. This team of specialists is working on improving transport and storage conditions for valuable paintings. Warranty issues also play an important role in this context – if a painting suffers damage, the dosimeter can provide the key to determining how the damage was caused.

Tomato juice enjoys sky-high popularity

Tomato juice is one of the most popular drinks served on airplanes – but why? A series of tests conducted by the Fraunhofer Institute for Building Physics IBP on behalf of Lufthansa has finally come up with the answer. It turns out that passengers perceive the taste of tomato juice completely differently depending on whether they are on the ground or in the air. "At normal pressure, people give tomato juice a much lower rating, typically describing it as musty," explains Andrea Burdack-Freitag from the IBP. But during flight the cabin pressure is lower – and that changes the taste. The tomato juice smells pleasantly fruity and tastes sweet. A number of test subjects took part in an elaborate taste test held in the original fuselage of an Airbus A310. Situated in a large low-pressure chamber, the aircraft enables simulation of the low cabin pressure typically experienced in flight. Many of the test subjects rated the food that was served as insipid. This is because taste and smell detection thresholds are higher at low pressures. People perceive the smells of food and drink "as if they had a cold". Salt, sugar and spices all have less of an impact, though the taste threshold for acids remains unchanged. The researcher adds that Lufthansa is now planning to make changes to the meals it serves on board its aircraft.

Tomato juice enjoys widespread popularity among air travelers. © *ddp*

Dynamic measurements

Will the large goods vehicle fit under the bridge? To answer that question, a car fitted with measuring equipment scouts out the route that the heavy load will be taking. A laser scanner mounted on the vehicle gathers data on bridges, houses, signs and trees by emitting short laser pulses which are reflected by the obstacles they encounter. The distance of each obstacle is determined by measuring how long it takes for the light to travel back to the sensor. Researchers at the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg have succeeded in significantly increase the speed of this distance measurement method. The enhanced scanners can either take readings ten times faster or, alternatively, retain the same measuring rate while analyzing ten times more points – an approach particularly suited to aircraft applications. To achieve this, the researchers developed new electronic circuits and special data processing software and optimized the scan rate of the laser beam. The new pulsed laser radar device is already available for laboratory use.

At 0.5 microseconds intervals the laser scanner determines the distance. © *Fraunhofer IPM*

Our future may well depend on energy from the sun, the wind and biomass.
© Vierthaler & Braun

With renewed energy

Text: Birgit Niesing

Sun, wind, water, biomass. These days, more and more energy is being derived from renewable sources. In Germany, over 16 percent of electricity is already generated by renewable energies, and that figure will continue to rise as current staples - oil, gas and coal - become increasingly scarce. Greater energy efficiency and a sustainable energy mix will allow us to reduce both our dependence on importswww and emissions of the greenhouse gas CO_2.

Whether the evidence takes the form of vast wind farms or gleaming solar panels on buildings, factories and farms, it's clear to see that Germany is becoming increasingly reliant on energy generated by the wind, the sun, and other alternative sources. Figures released by the German Energy and Water Association (BDEW) reveal there are already around 470,000 distributed power generation units feeding green electricity into the national power grid. Last year, renewable energies covered 16 percent of Germany's total electricity consumption. Germans are increasingly turning to these new resources, even for heating – this sector alone recorded a market share of 9.6 percent in 2009, up from 7.9 in 2008 – and overall, renewable energies currently cover approximately 10.6 percent of the country's total energy requirement.

There are two main drivers behind this increasing demand for renewable energies. Firstly, the rising costs of crude oil, natural gas and coal, which are climbing steadily as the world's reserves dwindle. And secondly, the findings of UN studies, which show that emissions of the greenhouse gas CO_2 must be cut dramatically if we are to limit global warming to no more than 2 degrees Celsius. According to the 'BP Statistical Review of World Energy 2009', based on extraction levels in 2008, the world's oil reserves will only last for another 42 years or so, gas another 60, and coal another 122. Even our reserves of raw uranium are finite and could be exhausted in around 70 years. At the same time, the energy needs of developing and emerging countries are steadily increasing, and in 2008, these nations consumed more primary energy than OECD countries for the very first time – a development that sent prices rocketing. That year, the cost of a barrel of crude oil peaked at a record 146 dollars, although prices subsequently dropped significantly again, not least because of the economic crisis. This year, experts are predicting average prices of 90 dollars a barrel (for the purpose of comparison, in 2003, the average price of a barrel of oil was 28 dollars). Naturally, Germany suffers as a result of these inflated prices, because the country has to import not only large quantities of fossil fuels such as crude oil, natural gas and coal, but also uranium for nuclear power.

Escalating energy consumption also means escalating environmental pollution. Burning carbonaceous energy sources produces CO_2, a greenhouse gas known to be one of the causes of climate change. But since the publication of UN Climate Report 2007, it has been clear that emissions of carbon dioxide must be cut by 50 to 85 percent (compared to the year 2000) by the middle of the century. Only then will it be possible to keep global warming within the manageable limits of around 2 degrees Celsius.

"Making the transition to a sustainable energy supply is one of the biggest challenges of the 21st century," states Professor Eicke Weber, managing director of the Fraunhofer Energy Alliance (see inset). He explains the urgency of the situation: "If the costs of electricity, heating and mobility are to remain affordable in the future, we need to use energy more efficiently and make greater use of renewable energies. That's the only way we'll be able to reduce our reliance on imported energy and cut carbon dioxide emissions, which are threatening our climate." To this end, the European Union has agreed a climate change package which stipulates that greenhouse gas emissions in the EU must fall by at least 20 percent by 2020 while the share of renewable energies and energy efficiency must rise by 20 percent.

For a long time, green electricity was considered too expensive. But with the rising costs of crude oil, natural gas etc., power obtained from renewable energy sources has gradually begun to look more attractive. Wind energy is currently one of the cheapest regenerative energy sources, with the construction of land-based wind farms costing roughly one euro per watt. In Germany, wind energy is the most popular means of producing electricity from renewable resources – last year it claimed a share of 6.4 percent. According to the German Wind Energy Institute, at the end of 2009, the country boasted more than 21,100 operational wind turbines generating a total output of 25,777 megawatts (MW). Worldwide, wind farms produce in excess of 120 gigawatts (GW) of electrical power.

Last year, despite the economic crisis, the market for wind turbines continued to expand. China is the biggest customer in the world, accounting for around 10,000 to 12,000 MW of newly installed power – the country practically re-doubled its capacities again in 2009. The USA, too, is increasingly turning to wind power, and the U.S. government is using economic stimulus packages to promote the construction of wind power systems. Having already largely exhausted its options as regards harnessing wind energy on land, Germany is now turning its attention to massive sea-based wind farms. The very first German offshore facility came online just a few months ago. The pressure to innovate is particularly great when it comes to offshore generation, as the turbines have to be planned and constructed in such a way as to successfully withstand years – even decades – of wind, waves and inclement weather. So what materials should be used? And how can these wind farms on the high seas be maintained? Researchers involved in the Fraunhofer Network Wind Energy are now seeking answers to these and many other questions as they work on technologies for the future offshore market.

Biomass and hydropower are two other important components that will make up any future energy mix. At present, they account for 4.4 and 3.3 percent respectively of power generation output in Germany. Fraunhofer researchers are currently investigating how to obtain biogas from fermented organic waste, agricultural waste, sewage sludge and substances contained in wastewater, while yet another focus of their work is the production of fuel gas from biomass for use in fuel cell systems.

The significance of solar energy is also gradually increasing. Last year, photovoltaics accounted for 1 percent of all the electricity produced in Germany and, for the first time ever, solar energy generated more electricity than waste incineration plants. Professor Weber, who is also the drector of the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, points out its advantages: "In the long run, solar energy can help secure energy supplies. The sun is a gigantic and inexhaustible power generator that continuously produces 120,000 TW of energy. For the sake of comparison, mankind's total energy requirement currently corresponds to an average output of 15 TW, a figure that is estimated will rise to around 20 TW by 2020. All in all, this means that relatively efficient use of just over one ten-thousandth of the sun's energy would cover the entire world's energy needs."

Electricity and heat from the sun

Solar energy has been a boom industry in Germany for many years. The Renewable Energies Act (EEG) made it profitable to feed electricity derived from solar energy into the national grid, and as a result, the country has driven this technology forward in leaps and bounds. But global demand for photovoltaic systems is also rising rapidly, with an average growth rate of 51 percent recorded every year from 2000 to 2008. The market has experienced particularly strong growth in the USA, where the installed photovoltaic capacity increased from 4 MW to 290 MW over the same period. As reported by Greentech Media Research in its study 'The United States PV Market Through 2013', this equates to an average annual increase of 71 percent. The experts at Greentech Media Research anticipate that the photovoltaics market will expand more quickly than any other energy market in the USA over the next few years, and expect investments to triple by 2012 – to over six billion dollars.

"For a long time, PV-generated energy was particularly expensive. But that's changed in recent years because of the rapid growth rates," notes Eicke Weber. "The costs have dropped below an overall system price of 3 euros per watt, which means that, in certain areas, photovoltaics can now compete with many other energy technologies." However, for solar energy to become significantly more commonplace, the costs still need to fall much further. Top cluster 'Solar Valley Central Germany' has announced the ambitious goal of producing electricity more cheaply from solar energy than from traditional power stations by 2015 at the latest. The partners from science and industry hope to achieve this by optimizing both processes and products. To this end, not only must costs be reduced along the entire value chain, but the effectiveness and service life of the products must also be improved. The Fraunhofer Center for Silicon Photovoltaics CSP in Halle is responsible for scientific coordination of the project.

These days, PV technology generally tends to be based on the use of crystalline silicon solar cells, which hold a market share of roughly 80 percent.

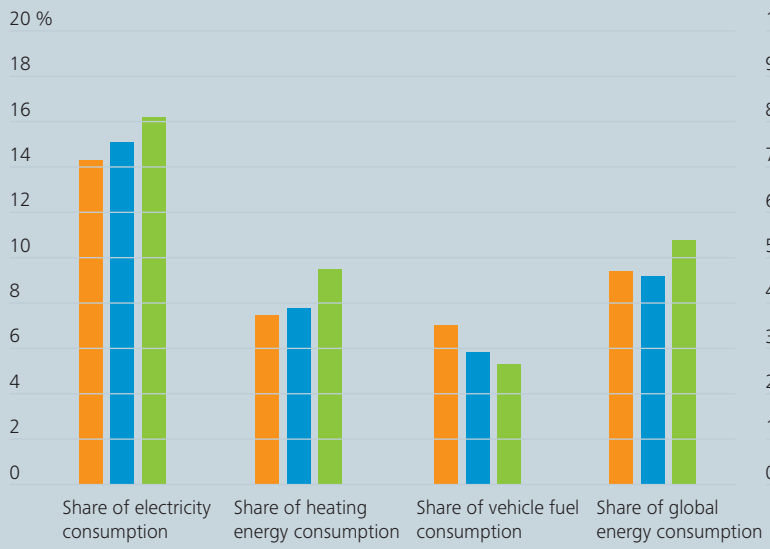
The Fraunhofer Energy Alliance

The Fraunhofer-Gesellschaft amalgamates its expertise in respect of renewable energy, energy technology and energy management within the Fraunhofer Energy Alliance. Working alongside industry, the Alliance seeks to further extend Germany's technological lead when it comes to the efficient use of energy and exploiting regenerative energy sources. Its work focuses mainly on the following areas: renewable energies (solar energy, biomass, wind power); efficiency technologies (e.g. CHP technologies, gas supply, storage and energy conversion technologies, fuel cells); buildings and components (low-energy homes, building energy technology etc.); intelligent energy networks (such as systems engineering and grid integration of distributed electricity producers); energy storage and micro-energy technology (lithium technology for batteries, fuel cell systems).

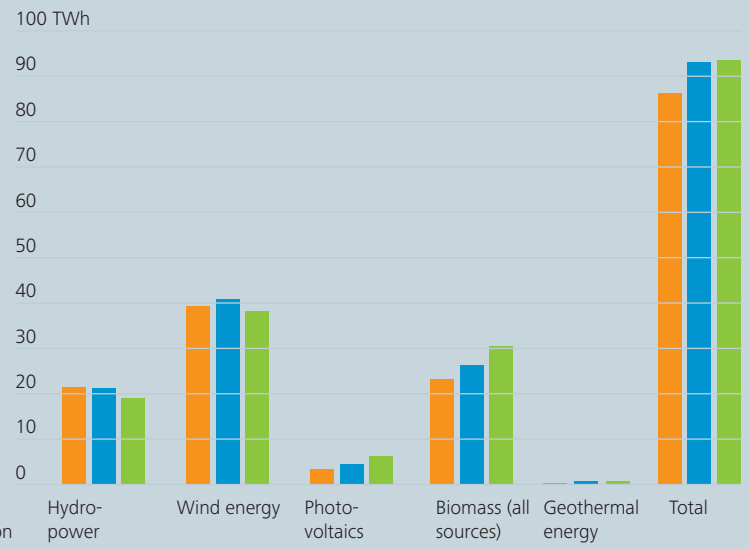
www.energie.fraunhofer.de

The Alliance comprises the Fraunhofer Institutes for:
- Building Physics IBP
- Chemical Technology ICT
- Factory Operation and Automation IFF
- Interfacial Engineering and Biotechnology IGB
- Integrated Circuits IIS
- Integrated Systems and Device Technology IISB
- Optronics, System Technologies and Image Exploitation, Application Center System Technology Ilmenau IOSB/AST
- Ceramic Technologies and Systems IKTS
- Silicatforschung ISC
- Solar Energy Systems ISE
- Fraunhofer Institute for Manufacturing Engineering and Automatisation IPA
- Systems and Innovation Research ISI
- Siliziumtechnologie ISIT
- Environmental, Safety and Energy Technology UMSICHT
- Wind Energy and Energy System Technology IWES
- Fraunhofer Center for Sustainable Energy Systems CSE

Market shares in percent
Energy supplied from renewable energy sources in 2009: 252 TWh



Electricity generation in TWh
Share of electricity consumption in 2009: 16.1%



Fraunhofer researchers are currently working to make these cells more efficient and scientists from the ISE have developed new methods and cell concepts for the manufacture of solar cells based on n-type silicon. As a result, it is now possible to achieve higher efficiencies and energy yields from commercially manufactured solar cells – the prototype exceeded an efficiency of 23%. "Our aim is to increase efficiency without raising production costs," says Weber.

ISE researchers have also been achieving significantly higher levels of efficiency with multi-junction solar cells made of GaInP/GaInAs/Ge III-V semiconductor compounds (gallium indium phosphide, gallium indium arsenide on a germanium substrate). In these systems, sunlight is concentrated by a factor of 454 and focused onto a small 5 mm^2 multi-junction solar cell; in laboratory trials, a record level of efficiency of 41.1% was achieved. Although still very new, this technology has already broken into the market, and the firm Concentrix Solar, which began as a spin-off from the ISE and is now part of the Soitec Group, offers photovoltaic concentrator systems for sale. However, these highly-efficient multi-junction solar cells are only suitable for use in solar power stations in countries which enjoy high levels of direct sunlight, such as Spain.

One problem initially encountered by the photovoltaics industry was the fact that it was difficult to procure sufficient quantities of high-purity silicon due to the high market demand. But that situation – now happily resolved – only served to speed the development of thin-film technologies. One identified solution produced thin-film solar cells made of amorphous silicon, copper-indium-gallium-selenide (CIGS) or even cadmium-telluride (CdTe), which need little or no silicon. However, the disadvantage of such cells is that their energy yield is significantly lower, with a conversion efficiency of only 8 to 12 percent.

An alternative solution is to use metallurgical silicon. Professor Weber explains the research strategy: "Instead of using expensive, high-purity silicon, we intend to use less-pure metallurgical silicon – also known as 'dirty' silicon." In a project funded by the Fraunhofer Foundation, ISE researchers are currently developing solar cell technologies based on relatively impure metallurgical silicon. This will cut the cost of solar cell production considerably in future, without compromising efficiency levels in any way.

Using concentrated solar thermal (CST) power stations (also known as concentrated solar power or CSP power stations) to produce electricity opens up a wealth of new possibilities. These systems incorporate a solar-tracking mirror (heliostat) which concentrates the sunlight on a receiver, allowing steam, for example, to be heated up in a linear pipe or tower, and thus electricity to be generated in a turbine. This technology is particular well-suited to sunny regions with 2,000 to 2,500 kWh/(m^2*a) of solar radiation a year.

Lower CO_2 emissions thanks to new energies

The DESERTEC initiative also envisages the use of solar thermal power stations. But what's it all about? Essentially, the idea is for solar electricity generated in Africa to be transferred to Europe, and for around 15 percent of Europe's electricity needs to be met in this way by the year 2050. Weber again: "The vision is to produce electricity in sunny regions, then export it to wherever it's needed – and to do this without the need for further government subsidies."

But now that we're obtaining energy from the sun, the wind and biomass, what effect is that having on the environment? To what extent have CO_2 emissions fallen? According to the German Renewable Energy Association (BEE), last year renewable energies helped to prevent the output of approximately 111 million metric tons of CO_2 equivalent. They also saved 6.4 billion euros that would otherwise have been spent on fossil fuels. In future, our energy will come from a growing number of sources – from

The amount of energy supplied from renewable resources has risen steadily over recent years. Source: German Renewable Energies Association (BEE)

2007
2008
2009

the wind and the sun, from biomass, and from conventional power stations. This will pose new challenges for energy suppliers. For example, both wind and solar energy plants have the disadvantage of producing 'unregulated' electricity supplies. If we are to be able to cope successfully with times of peak consumption and maintain electricity supplies even when the wind drops or clouds cover the sun, we therefore need to develop 'intelligent' energy management systems. New information and communications technologies offer a variety of ways of doing this. The Fraunhofer Network Smart Grids, which forms part of the Fraunhofer Energy Alliance, is currently studying grid concepts for virtual power stations that would use interactive networking to coordinate the yield and load forecasts of a number of decentralized producers and thus act as central power stations for the network as a whole.

In years to come, modern information and communications systems such as smart meters will allow consumers to play a part in the network balancing process thanks to the implementation of flexible energy prices. The basic idea is that large quantities of electricity will be expensive, but if less power is used, or if a lot of it is generated from solar and wind energy, the price will drop.

High-performance electricity storage systems can also help to balance out fluctuations in the energy supply. Consequently, grid-integrated energy storage systems are one of the twelve frontline topics that Fraunhofer researchers will be researching intensively over the next few years. Their work will focus primarily on two technologies that have not yet been used for large outputs: redox flow and lithium batteries. Redox flow batteries have a similar energy density to conventional lead-acid batteries, but their service life is ten times longer. And lithium batteries could prove useful for small-scale, off-grid suppliers. These kinds of small storage device are also likely to be used in electric vehicles. One idea put forward by the researchers is for such vehicles to function as mobile energy storage devices for electricity generated from wind and solar energy. The batteries in an electric vehicle would charge up whenever the sun shines, and while the vehicle is parked network operators would be able to tap into the energy stored in them. Certainly one way in which electric vehicles could help stabilize the electricity network.

Hydrogen is another useful way of storing energy. Fuel cells can be used to convert its chemical energy into electricity and heat with a high degree of efficiency – the electrical yield can be as much as 50 percent. And if the fuel cells are installed directly on the user's premises, the heat that is generated in the process can also be harnessed, thereby increasing the overall efficiency to anything up to 80 percent.

By far the best way of cutting energy costs is to adopt a resource-saving approach and make sure we use energy carefully. Being able to extract more light, more heat, more power from a single liter of oil or kilowatt-hour of electricity is not just a lucrative proposition for each individual household or business – the national economy will also benefit. One way of using energy more efficiently involves its conversion into several energy sources at once, or the simultaneous production of electricity and heat – also known as co-generation. In future, the supply and use of electricity, heating and cooling systems will be increasingly interconnected. Organic Rankine Cycle (ORC) plants, for example, can make use of the waste heat produced by biogas engines. And Fraunhofer researchers are currently developing small incineration plants with integrated combined heat and power (CHP) couplings to exploit waste with a high calorific value.

Reducing domestic energy requirements

Buildings, in particular, offer great potential for massive energy savings. Roughly one third of all energy consumed in Germany is employed to heat and cool homes and offices. Homes built before 1983 are especially wasteful of energy, often requiring over 20 liters of heating oil per square meter per year. By comparison, new build homes require just a third of that. Intelligent building systems can significantly reduce the energy consumption of older buildings (see page 26), while heat-insulating shells, efficient solar and ventilation systems and long-term storage solutions will all ensure that the energy consumption of new builds continues to fall in years to come. In future, new houses will no longer draw energy from the grid (zero-energy homes). Indeed, they may even produce energy (plus-energy homes).

One thing is certain: Given an ever-growing demand for energy, rapidly depleting resources and constantly mounting environmental pressures, policy-makers, industry and consumers are all facing enormous challenges. But there are also new market opportunities to be had. In recent years, the renewable energies sector has developed into an important growth area and sizeable employer – nowadays the sector provides jobs for over 278,000 people. In 2008, around 13.1 billion euros were invested in new facilities. Combining that figure with the profit gained from the operation of renewable energy plants produces impressive total revenues of approximately 30 billion euros for that year. When it comes to renewable energies, Germany still leads the field worldwide. In 2007, the country exported equipment and technology to the tune of 9 billion euros. ■

The automatic caretaker

How can energy waste in buildings be avoided? Management software is leading the way.

Text: Bernd Müller

To quote an old financial controlling maxim, you can only optimize what you can measure. Put differently– if you can measure it, you can optimize it. Unfortunately, this rule does not seem to apply to buildings. Modern building systems do indeed record temperature, humidity, weather conditions, energy and water consumption, and much more besides; yet they don't use this data to detect and plug efficiency leaks, leading to unnecessarily high energy costs. The property services firm Jones Lang LaSalle has calculated that the monthly costs for heating, electricity and water are one euro per square meter. In large office and industrial buildings that can easily mean total costs of several hundred thousand euros. Projects run by the Fraunhofer Institute for Solar Energy Systems ISE have shown that, depending on its condition, between ten and thirty percent of a building's energy consumption could be saved - and at little or no cost. All that's needed is a system that can locate energy leaks from existing data and introduce economy measures. This was the aim of the EU's "Building EQ" project, set up in 2007. The project brought together six European partners, led by the ISE. By the time it was completed at the end of 2009, the project had produced a process for intelligent energy management in non-residential buildings.

"Time and again it's the classic mistakes that result in unnecessarily high energy consumption," explains ISE project manager Christian Neumann. Heating pumps run nonstop, for example, although there is no-one in the building at night or at weekends. This was the case in the Kreuzgebäude in Essen, a Thyssen Krupp Real Estate property with 20 000 square meters of office space. ISE has been taking measurements there since March 2008, with the result that energy consumption has been reduced by ten percent, the equivalent of 15 000 euros per year. Similarly, the ISE team found two typical causes of energy waste in the North Rhine

The NRW Ministry for Economy, Small and Medium Sized Businesses and Energy in Düsseldorf serves as one of the project's demonstration buildings. *© Peter Albaum/JOKER*

Westphalian Ministry for the Economy and Small and Medium Sized Businesses in Düsseldorf. The district heating installation in the 30 000 square meter building is oversized, so that the maximum output available is double what the property actually needs. Adjusting the utilities contract accordingly would save 30 000 euros a year. Another mistake typical for office and industrial buildings was also identified: heating and cooling systems were at times operating simultaneously.

Saving energy and money

Property owners are usually unaware of this waste. In many of the buildings studied in the project the control technology is not set up for data analysis. The data is either not stored or not even recorded. Systems from different manufacturers are often installed concurrently in the same building, with little or no interfacing. This can be remedied by adding equipment to record the most important data – at less than 20 percent of annual energy costs. The ideal solution would be to evaluate this data and then use the results to automatically optimize energy efficiency through the property's control system.

One step in that direction has already been achieved with the implementation of automatic data evaluation. Software developed by ISE researchers, as part of the Building EQ project, collects information every hour on energy volumes, consumption and climate measurements. This data is called up once a day via the internet and is presented graphically, making it easy for the ISE building optimization team of five to detect energy waste. The second step, automatically optimized remote energy control, is to be tackled in a follow-up project. Christian Neumann cautions against high expectations, however, "It will be another five to ten years before it becomes marketable."

Technical hurdles are not the reason for this slow progress, as there are already commercial systems available for the remote maintenance of buildings. Unlike industrial processes in the chemical industry, aviation or power plant engineering, however, building operations are usually not systematically monitored. Low energy prices, combined with the comparatively low risks of running a building, have until now presented an obstacle to monitoring. But rising energy costs, the increasing complexity of buildings and the growing requirements of users, have worked to arouse much more interest in the topic.

www.buildingeq-online.net

Inconsistent guidelines amongst EU nations have also played a role here. Uniform standards were laid down in the EU building directive, EPBD (Energy Performance of Buildings Directive) a few years ago. The directive stipulates that every property, newly built or extensively renovated since January 2006, must have an energy performance certificate. The Building EQ project partners wanted to examine whether EPBD certification could be linked to operating surveillance, as the EU directive does not stipulate monitoring, a prerequisite for quality assurance of operations. An automatic analysis of available data, recorded for the purpose of acquiring the energy certificate, had to be abandoned: each country has adopted its own regulations within the very broad framework of EU law. "There are more variants regarding how the law on energy certificates is implemented, than there are member states in the EU," says Neumann. Belgium, for example, has adopted three different regulations for three regions of the country.

The EU has recognized that this situation is not tenable: a new law is expected to harmonize the various national regulations. Standardization makes sense, because the errors resulting in energy waste in buildings are the same in each country, as the measurements conducted by the Building EQ project's partners from Finland, Sweden and Italy confirmed. Automated building optimization is still at different stages. While the market in Finland is determined by a few players and sets high standards for quality assurance, the situation in other member states is more complex. Problems with data recording and communication have proven to be a big obstacle in demonstration buildings in Germany and Sweden. The Italian partner Politecnico di Milano has also had difficulties. In Italy utility supply contracts are based on the number of cubic meters of enclosed space . As Neumann remarks, "The actual energy consumption of buildings there was a completely unknown factor before the Building EQ project." ■

Power stations on the high sea

The wind is always more constant at sea than on land - and much stronger. That's why the wind energy industry is increasingly looking to offshore facilities. The first German wind farm in the North Sea - the 'alpha ventus' test and demonstration site - went online just a few months ago. Researchers are monitoring its progress.

Text: Birgit Niesing

45 kilometers north of Borkum, the climate is harsh. The wind speed averages 36 kilometers an hour (force 5), the waves are several meters high, and the air is salty and damp. The area is now home to the first German offshore wind park, dubbed alpha ventus (see inset), which was completed a few months ago.

Erecting offshore wind farms in the North Sea off the German coast presents planners, constructors and operators with enormous challenges, for not far from the coastline lies the protected Wadden Sea National Park, a UNESCO World Heritage Site. The farms cannot be built close inshore; instead, they have to be sited out to sea beyond the Friesian Islands, which stretch from Sylt to Borkum. This gives rise to certain disadvantages. Firstly, the generating turbines have to be built in water that is 20 to 40 meters deep – a technically ground-breaking accomplishment. Secondly, anchoring them to the sea bed and connecting them to the power grid on the mainland is a time-consuming, laborious and expensive process.

The alpha ventus offshore wind park has to withstand extreme conditions. Its twelve wind turbines were erected in water around 30 meters deep and are connected to the mainland by a 60-kilometer long undersea cable. A joint pilot project involving EWE, E.ON Climate & Renewables and Vattenfall, the park is a pioneering technological and logistical achievement. The dozen wind turbines that make up the test field are all of the 5 megawatt class: six are of the Areva Multibrid M5000 type, while the remaining six are of the REpower 5M type. The turbines are constructed on two different kinds of steel foundation. While the Areva Multibrid systems stand on tripods, so-called jacket foundations (comprised of a steel tube support structure and special cast transition pieces) were chosen for the REpower systems.

"The alpha ventus pilot project allows us to gather basic information about the construction and operation of an offshore wind farm in deep water for the very first time," says Dr. Bernhard Lange, a wind energy expert at the Fraunhofer Institute for Wind Energy and Energy System Technology IWES. He coordinates the 'Research at alpha ventus' (RAVE) project, which is funded by the German federal ministry for the environment to the tune of 50 million euros. The aim of the project is to acquire a broad knowledge base that will smooth the way for the construction and operation of offshore facilities in the future. The researchers are trying to determine how such facilities and offshore parks can be better designed, constructed and integrated into the power grid in years to come – and above all, how the associated costs can be reduced. Their work is focused primarily on foundation and support structures, measuring technology, systems engineering and monitoring, as well as integration into the grid, but additionally takes into consideration the ecological, acceptance and safety aspects of the operation.

Research at Alpha ventus
www.rave-offshore.de

IWES researchers are not only coordinating the research initiative, they are also taking the lead in two key areas of work. Firstly, within the 'Offshore WMEP' project, they are seeking answers to the following questions: How are operations affected by the particular meteorological conditions that prevail on the high seas? What effect do extreme values have on turbine availability? What are the actual electricity generation costs? And will it be possible to cut these costs in the future? Secondly, the scientists have been charged with investigating how offshore wind

alpha ventus

The 'alpha ventus' offshore test field in the North Sea, roughly 60 km off the German coast, was constructed by a consortium of German energy companies: EWE, E.ON and Vattenfall. This first German offshore wind farm is also a demonstration and research site. Last year, twelve wind turbines manufactured by Multibrid and REpower were erected in water 30 meters deep, each with an output of five megawatts. Ultimately, the site is expected to generate sufficient electricity to supply 50,000 homes. The various companies have invested 250 million euros in the project. The first six turbines are already up and running on a trial basis and generating power.

www.alpha-ventus.de

farms can be integrated into the power grid. For this, they need to find a way to produce reliable wind power forecasts. And they also need to determine how to manage fluctuations in output from such farms.

Findings from the RAVE initiative are eagerly awaited. The German federal government is aiming to meet around 30 percent of the country's energy needs using renewable resources by 2020, and if this ambitious goal is to be achieved, further offshore facilities will have to be built. "Offshore wind parks produce significantly more energy than land-based farms," says Lange. The plan is therefore to erect wind turbines in the North and Baltic Seas with a total generation output of 20-25 gigawatts over the next 20 years – they alone would cover more than 15 percent of Germany's electricity needs.

Although Germany is only now taking its first tentative steps towards harnessing offshore wind energy, many of its European neighbors have been reliant on sea-based power generation for a number of years already. Denmark was the first to begin operating an offshore wind farm back in 1991, and other countries have since followed suit. At the end of 2009, there were 33 farms connected to power grids around the world. Europe, in particular, is looking to expand in this area, and last year brought eight new offshore wind parks online, comprising 199 turbines and generating a total output of 577 megawatts. The European Wind Energy Association EWEA estimates that ten more offshore wind farms with a total output of 1,000 megawatts will be completed in 2010, which corresponds to an increase of 75 percent. ■

The Fraunhofer Network Wind Energy

Developing reliable and efficient wind turbines and then integrating them into the power grid is a complex undertaking. The Fraunhofer Network Wind Energy brings together nine different institutes specializing in materials research, operating safety, simulation, power electronics and energy systems technology, and tackles topics ranging from wind energy prediction models, load management methods and network design through algorithms for control technology and simulation tools to non-destructive testing of turbine components.
The following institutes are involved:
– Fraunhofer Institute for Wind Energy and Energy System Technology IWES
– Fraunhofer Institute for Factory Operation and Automation IFF
– Fraunhofer Institute for Integrated Circuits IIS/EAS
– Fraunhofer Applications Center for System Technology IOSB/AST
– Fraunhofer Institute for Solar Energy Systems ISE
– Fraunhofer Institute for Systems and Innovation Research ISI
– Fraunhofer Institute for Industrial Mathematics ITWM
– Fraunhofer Institute for Non-Destructive Testing IZFP
– Fraunhofer Institute for Wood Research WKI
– Fraunhofer Institute for Structural Durability and System Reliability LBF
– Fraunhofer Institute for Manufacturing Engineering and Applied Materials Research IFAM

More power to renewable energy

Can we harness renewable energy sources to safeguard electricity supplies in the future? And if so, what technologies will we need? These are two of the questions being tackled by researchers in the EU's FENIX project.
© *ddp/Henning Kaiser*

Partners in the EU's FENIX project

Project management: José Corera Iberdrola S.A., Spain ||| Iberdrola, Spain, distribution company | EDF, France, energy supplier | EDF Energy Networks, UK, distribution company | Red Eléctrica de España, Spain, transmission company | National Grid Transco, UK, transmission company | Siemens, Austria, component manufacturer (DEMS, DMS) | Areva T&D, France, component manufacturer (DEMS) | Gamesa, Spain, wind turbine manufacturer | ZIV, Spain, component manufacturer (FENIX box) | Korona, Slovenia, project planning and consultancy | ScalAgent, France, project planning and consultancy | ECRO, Romania, project planning and consultancy | Poyry Energy Consulting, UK, consultancy | Fundación Labein, Spain, research and development | IDEA, France, research and development | Fraunhofer IWES, Germany, research and development | ECN, the Netherlands, research and development | University of Manchester, UK, research and development | Vrije Universiteit Amsterdam, the Netherlands, research and development | Imperial College, London, UK, research and development

Could Germany meet all its energy needs with alternative energy sources? An electricity supply system that does not involve oil, coal or nuclear power plants is widely held to be a bold but unrealistic vision. However, new research has shown that renewable energy sources can, in fact, completely replace fossil fuels - provided that they are used efficiently and integrated in a supraregional grid.

Text: Monika Weiner

Europe is going green. According to plans drawn up by the European Commission, at least 20 percent of Europe's total energy requirements will be met by renewable sources in 2020. To achieve this goal, increasing numbers of solar plants, wind turbines and combined heat and power plants will be needed to take the place of oil, coal and nuclear power plants. That sounds fine in theory – but is it a realistic proposition? Can alternative energy suppliers really deliver enough electricity to cope with the surge in demand when everyone switches on their machines and computers at eight o'clock on a Monday morning? Do solar cells and wind farms generate enough power to provide a continuous supply of electricity to even the most isolated outlying communities?

Researchers have been getting to grips with these questions in the EU'S FENIX project, which stands for Flexible Electricity Networks to Integrate the Expected Energy Evolution. "Making the transition from our current centralized system – in which electricity is generated by nuclear, oil or coal-fired power plants – towards a distributed electricity supply system is certainly challenging, but it is nevertheless feasible," sums up Dr. Martin Braun, who coordinates FENIX research at the Fraunhofer Institute for Wind Energy and Energy System Technology IWES in Kassel. "The situation used to be a lot more manageable: you had a certain number of large power plants – say a few hundred scattered across Europe – which were capable of adjusting their output at any time to reflect changing demand. But the future looks a lot more complicated, because you are going to see hundreds of thousands of small, distributed energy generators, many of which will only be supplying electricity while the sun is shining or the wind blowing. That is what grid operators and energy providers will have to learn to deal with."

Working with 20 partners from nine European countries, the Fraunhofer researchers have come up with solutions that make distributed energy resource systems not only technically feasible, but also more economical. These solutions comprise "virtual power plants" – small configurations of alternative energy suppliers that are all linked together. This kind of network integration benefits everyone involved, as IWES researcher Braun explains: "Small operators are currently unable to get a foothold in the electricity markets where prices are negotiated for the following day, because they cannot afford the relatively high cost of entering these markets. But by creating a network, not only can these small suppliers make an important contribution to the electricity supply system, they can also make joint supply bids in the electricity market."

www.fenix-project.org

But linking up small energy suppliers is far from easy: all the power plants need to be connected to a central, intelligent control system, which is sufficiently familiar with the technical capabilities of all the participating suppliers to make optimum use of their respective capacities. For example, a solar cell should always be able to feed electricity into the grid when the sun is shining, while wind turbine capacity needs to be exploited the moment the wind starts blowing. Meanwhile, combined heat and power plants fueled with biogas can serve as a buffer to balance things out, since they can be connected at any time of the day, whatever the weather. Researchers working on the FENIX project have examined what information would have to be passed between the various suppliers, how the data transfer process could work and what regulatory procedures would need to be in place. "We were able to show that small suppliers that are integrated within a network can reliably perform the same grid services as the traditional large-scale energy producers," Braun reports. "They support grid operations in the same way, making the same contributions towards maintaining frequency and voltage and supplying electricity." The researchers then moved on to the task of developing the components of a virtual power plant, such as a communication system that comprises a central control entity known as the decentralized energy management system (DEMS). This is connected to the generators, which are controlled by FENIX boxes.

Proof that all this really works has come from a field trial carried out in Spain. Using a central control system, the organizers of the trial established a decentralized grid with co-generation plants – in which the generators produce heat and electricity – biogas plants and wind turbines. This network arrangement worked well, with the voltage staying within the prescribed limits at every point within the grid. The Fraunhofer Institute in Kassel has since built a miniature version of a virtual power plant, including the control system, communication network and controllable generators – a laboratory-scale model that allows grid and plant operators to try out new technologies. "The FENIX project that has now reached its conclusion represents a first but decisive step towards integrating renewable energy sources in the existing electricity supply system," concludes Braun. "We have developed and tested tools and strategies and shown that these can genuinely help to meet the European Commission's target of achieving 20 percent renewable energy by 2020."

So where do we go from here? The next step is to increase the size of the virtual power plants. "Our goal is to keep developing the technology to enable us to integrate the maximum possible number of renewable energy suppliers," Braun continues. If everything goes as planned, it will be possible to expand this decentralized electricity supply system further. According to the Fraunhofer experts' calculations, it has the capacity to provide not only regional electricity supplies but also supply power on a national level. "Theoretically," adds the director of the Fraunhofer IWES, Professor Jürgen Schmid, "you could meet all Europe's energy needs with electricity from distributed energy sources." ■

A glimpse into the future

Ever wondered what effect our efforts to limit global warming to 2 degrees will have on the European economy and labor market by 2050? A new study provides some answers.

Text: Klaus Jacob

Action against CO_2: A demonstration in favor of slashing carbon dioxide emissions was held during the United Nations Climate Conference in Copenhagen. © *ecopix/Friedel*

As demonstrated most recently by events in Copenhagen, international climate conferences are generally pretty tough affairs. But while politicians wrestle over reduction targets and percentage points, we tend to lose sight of the fact that a great deal of hard scientific research has gone into these figures. A veritable army of experts do the preliminary work for the negotiators, so that any potential agreements are not just words uttered in a vacuum. The Fraunhofer Institute for Systems and Innovation Research ISI in Karlsruhe recently took the lead in producing a particularly intricate report on global change on behalf of the European Commission. In the report, entitled "ADAM 2-degree scenario for Europe – policies and impacts", ISI researchers worked together with experts from a number of other institutes and countries to gaze far into the future – to the year 2050 – and find answers to questions such as 'What will Europe have to do in the interim to limit global warming to 2 degrees?' and 'What effects will our efforts to do this have on individual countries' economies and labor markets?'

Scientists and politicians are now agreed that the Earth's temperature must not be allowed to rise more than 2 degrees above pre-industrial levels if the effects on mankind are to be kept within tolerable limits. There is also a general consensus that, as the primary sources of greenhouse gases, the industrial nations must cut their emissions by a far greater amount than developing and emerging countries. For them, there is talk of a reduction target of 80 percent by 2050 compared with the base year of 1990, and the study produced by the ISI has proved that Europe is perfectly capable of achieving this without any detrimental effect on its economy.

80 percent reduction in greenhouse gases by 2050

It was a long, hard slog before the 400-page report was ready – trying to forecast so far into the future is like trying to solve a complex equation with numerous unknowns. It was particularly difficult to amalgamate all the different models on which the study is based, because, as project manager Wolfgang Schade of the ISI ex-

plains: "We had to find an integrated modeling system for all 27 countries." Pre-existing models dealt with individual sectors such as transport, energy supply or private households, but now, because they were seeking a more comprehensive outlook, all the various interdependencies had to be worked in. To give an example, converting from coal-based power to wind and solar power has the knock-on effect that less coal is transported, which in turn means less energy is required for transport.

The overall conclusion of the study is this: The 80 percent reduction target is achievable. But massive efforts will be required, not only to expand the use of renewable energies, but also to save energy overall – a great deal is still being wasted. Schade says: "We can make savings in all sorts of ways, for example by ensuring buildings are better insulated, by improving material efficiencies, or by using electrical equipment that draws less power." The study also makes it clear that polluters must pay for the harm they inflict on environment – a suitable price must be attached to carbon dioxide in order to increase the pressure to make changes. Incentives such as labels, norms and standards must be created for products with low CO2 emissions, to accelerate their launch onto the market. And last but not least, politicians must invest significant sums of money in research, so that new, climate-friendly technologies can be developed and commercialized.

As things stand at present, the biggest CO_2 emitter is the energy sector, which is to blame for roughly half of all greenhouse gases. But this is also where the greatest potential for savings can be found – a colossal 90 percent, in fact. In the study's 2-degree scenario, coal would have to forfeit its central role among energy sources, while the renewable energies sector could expand to provide as much as 75 percent of Europe's electricity within the next 40 years. Experts predict that wind power, in particular, will continue to experience substantial growth. If energy-saving measures also begin to take effect, Europe could not only stop expanding its highly-controversial nuclear power industry, but also do away with its current carbon capture and storage policy – and still achieve its climate targets.

Transportation also poses major problems. In future, this sector will take over as the highest emitter of carbon dioxide – its share of greenhouse gas emissions in Europe is expected to increase from a quarter to approximately half. Yet even here, there are huge savings to be made. In absolute terms, current carbon dioxide emissions could be reduced by 62 percent if more alternative drive concepts were adopted. But of course that presupposes researchers working on battery technology achieve a breakthrough soon. In forty years' time, almost a quarter of automobiles could be electrically powered. The study also finds that concerted efforts to protect the environment will have little detrimental effect on national economies. The expenditure needed to progress climate-friendly change will barely slow the growth of gross domestic product (GDP) – the net effect will be somewhere between 1.7 and 2.7 percent over the next forty years. In other words, during that timeframe, GDP will increase by approximately 83 instead of 85 percent. To put these figures into perspective, the financial crisis pushed GDP down by 4 to 6 percent in under two years. This slight economic braking effect is also easier to accept when we consider how much more it would cost our national economies to do nothing. "If that were the case, the consequences of climate change could slash GDP by as much as 20 percent," says Schade, referring to studies conducted in 2007 by Sir Nicholas Stern, a professor at the London School of Economics. And certain countries even look set to benefit from the change – specifically Eastern European countries which have significant biomass potential, and also Denmark, Finland, Norway and Sweden.

Climate protection initiatives will not impact greatly on the labor market either. Depending on the exact scenario, changes in overall employment levels will fluctuate between a reduction of approximately 0.3 percent and an increase of around 0.2 percent. There may well be a reorganization of the market - energy suppliers are likely to reduce employee numbers, while agriculture will undoubtedly benefit as biomass becomes an increasingly important energy source. Even industry is likely to gain, because technological change generally requires considerable amounts of new machinery and equipment.

Of course, the Fraunhofer study is based on a number of assumptions, not all of which will prove well-founded, since the future is always full of surprises. The financial crisis certainly showed us that. Even in the technological sphere, we may see breakthroughs over the next forty years that no-one can imagine right now. But one thing is certain: By embarking upon the necessary political path and retaining the flexibility to change course as required, Europe's contribution to the global effort will undoubtedly help halt climate change. ■

Storing heat with wax

Modern office buildings heat up quickly in summer. New building materials – tiny spheres filled with wax – can prevent this. In recognition of their work on this development, Dr. Ekkehard Jahns from BASF and the Fraunhofer research scientists Prof. Dr. Volker Wittwer and Dr.-Ing. Peter Schossig were nominated for the German Future Prize awarded by the Federal President.

Text: Birgit Niesing

Modern office complexes are stylish, quickly built and flexible. But buildings constructed using lightweight materials have one big disadvantage – because of their low mass the walls store hardly any heat. As a result, the rooms inside heat up very quickly during summer. Research scientists at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, working in collaboration with colleagues at BASF, have developed building materials that can soak up heat. The microencapsulated phase change materials prevent rooms from exceeding a pleasant temperature of 26 °C during high summer. This passive cooling also saves electricity. The development was nominated for the German Future Prize 2009.

Every year several teams of scientists are nominated for the Prize awarded by the President of the Federal Republic of Germany (see box). Nominated along with the team of Fraunhofer and BASF research scientists this year were scientists from Bayer Schering Pharma, who have developed a drug that prevents thrombosis. The blood vessel disorder is one of the most frequent causes of death in western industrial countries. The third nominated development, entitled "Messages from the heart – pacemaker sends doctor an e-mail", came from BIOTRONIK. The new technology makes automatic communication possible between a heart pacemaker or an implanted defibrillator and a data center. This year the Prize was awarded to the Bayer-BASF team of Dr. med. Frank Misselwitz, Dr. med. Dagmar Kubitza and Dr. rer. nat. Elisabeth Perzborn.

There is an urgent need for intelligent, energy-saving alternatives to air conditioning systems.

Dr. rer. nat. Ekkehard Jahns, Prof. Dr. rer. nat. Volker Wittwer, Dr.-Ing. Peter Schossig (from left to right).
All photos: © Ansgar Pudenz/Deutscher Zukunftspreis

German Future Prize

By awarding his prize for technology and innovation, Federal President Horst Köhler honors research scientists and development engineers who successfully create new products for the market as a result of excellent research. Endowed with 250,000 euros, the German Future Prize has been awarded since 1997, and on three occasions has been presented to Fraunhofer. In 2000 the 'Innovation Oscar' was awarded to the developers of MP3 audio compression at the Fraunhofer Institute for Integrated Circuits IIS. In 2004 the Federal President presented the Prize to a team headed by Dr. Rainer Hintsche at the Fraunhofer Institute for Silicon Technology ISIT in recognition of their work to produce the "laboratory on a chip". The German Future Prize 2007 went to research scientists at the Institute for Applied Optics and Precision Engineering IOF and the industrial partner Osram 2007 for the development of high-intensity light-emitting diodes.

www.deutscher-zukunftspreis.de

For years, more and more energy has been used to cool offices, commercial premises and residential buildings. "In Germany about 15 per cent of the electricity is used to generate energy for cooling," reports Prof. Dr. Volker Wittwer, former Deputy Director of the ISE. And the trend continues upwards. Whereas in 2000 the amount of energy required for cooling in Europe stood at approximately 50 terawatthours per year, power consumption for this purpose is expected to more than double, reaching over 110 TWh p.a. by 2020.

The research scientists made use of phase change materials (PCM), such as paraffin, to provide a passive cooling alternative. In the transition from the solid to liquid state they absorb large quantities of energy, and this characteristic can be exploited to stop rooms from getting too hot. "It functions in a similar way to an ice cube. While the ice cube is melting the temperature remains at 0 °C and doesn't rise above 0 °C until the ice has completely melted," Wittwer explains. Paraffins melt in the comfortable room temperature range between 20 °C and 26 °C, and as they melt they absorb lots of heat from their environment and prevent a rise in temperature. At night when the ambient temperature falls, the wax solidifies and the capsules release the absorbed heat, making them ready again to repeat the process the next day.

The principle has been known for a long time. The idea of using phase change materials to control the temperature in buildings first emerged 60 years ago. But for a long time the attempts to incorporate them in construction materials failed. No breakthrough was achieved until Professor Wittwer came up with his idea of

New microencapsulated storage materials enable buildings to be cooled using cold from the environment.

encapsulating wax in tiny spheres and integrating them in conventional building materials such as plaster, putty and lightweight panels. Research workers at BASF took on the task of developing the right encapsulation. "We looked for ways of enclosing the phase change materials in microscopic containers or microcapsules," explains Dr. rer. nat. Ekkehard Jahns from BASF. Microencapsulation offers several advantages. As the solid-to-liquid phase transition takes place in tiny spheres, no wax can leak out. What's more, owing to the large surfaces and small volumes, heat is quickly absorbed into the material and cold rapidly released.

The microcapsules have a diameter of about 5 micrometers – which is less than half the thickness of a human hair. "The tiny spheres are therefore easy to incorporate in building materials such as gypsum plaster, which can be applied to the wall in whatever form required. The plaster does not look any different from conventional materials," Jahns continues. "And there are plenty of other construction materials that are suitable for the integration of microcapsules, such as aerated concrete blocks, plasterboard and wood products."

The new building materials are particularly interesting for lightweight structures. A layer of PCM plaster about 1.5 centimeters thick has the same heat capacity as a concrete or brick wall. "This means that we can reap the benefits of lightweight construction and still store the heat," affirms Dr.-Ing. Peter Schossig from the ISE. "Modern phase change materials take us a long way towards solving the problem of rooms overheating, not only in offices, but also in portable prefabricated buildings and older-style loft apartments. Newly developed construction materials containing microencapsulated reservoirs of latent heat can play a significant role in raising the level of thermal comfort," Schossig emphasizes.

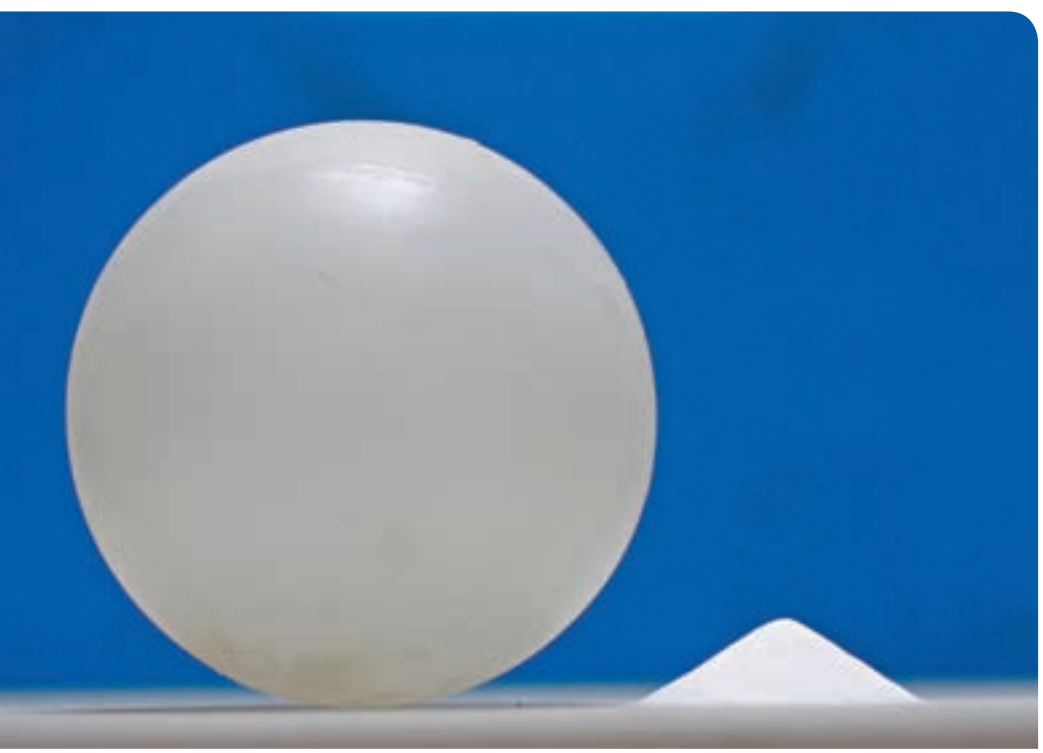
Major benefits from tiny spheres

Construction materials containing microencapsulated latent heat storage capsules have already proved successful in practice. They have been incorporated in numerous buildings, including the Badenova building in Offenburg and the Haus der Gegenwart (Contemporary House) in Munich. The raw materials are marketed under the name Micronal PCM®, but they are not yet available to buy in home improvement centers. "At present they still require too much explanation. The key is to integrate the new materials in the energy concept for the building during the planning phase," Schossig stresses.

But how long will these new building materials last? "They have a lifespan of 30 to 50 years," Schossig states. They also offer the further advantages that they do not require any maintenance and cannot be damaged by drilling holes or hammering in nails.

"These materials hold enormous economic potential. By 2050 the aim is to reduce energy consumption by 50 per cent, and a large part of this energy saving will have to come form buildings," emphasizes Professor Wittwer. "To do this efficiently, we need new technologies and our materials will make a major contribution." ■

Microencapsulated paraffins in construction materials function as cold storage reservoirs. They provide an intelligent way of cooling buildings without any input of energy.



Systematic endurance testing

The automotive industry is undergoing a major transition: Researchers are developing components and designs for the new series of electric cars, and a new test rig is now available to put axles and vehicle bodies through their paces.

Text: Marion Horn

The new whole-vehicle test rig also caters to the requirements of electric vehicles. © *Fraunhofer LBF*

There is just no stopping this brand new sedan: Tackling bumpy roads and tight turns, it covers 300,000 kilometers in three weeks – with no driver and without actually moving an inch! The new vehicle test rig at the Fraunhofer Institute for Structural Durability and System Reliability LBF in Darmstadt puts the entire car through an exhaustive and intensive series of endurance tests, with the 2.5 ton car subjected to forces in all directions. Will it manage to withstand such extreme handling? In a process that is similar to the TÜV (the German vehicle inspection and roadworthiness test) but considerably more comprehensive, the LBF's researchers check out the vehicle's safety and reliability.

The test rig features 26 electronically controlled hydraulic cylinders, enabling it to simulate all the forces that act on the wheels, chassis and vehicle body. Measuring wheels are installed where you would normally expect to find those used on the road. These special wheels manufactured by Kistler are equipped with sensors that record everything that happens during the test – from the effects of the car accelerating to the impact of materials stretching and components getting hotter.

New test systems for electric cars

The engineers analyze the results on a computer, enabling them to detect any potential damage to the vehicle and estimate the service life of specific assemblies.

"When companies make the switch to electric vehicles, we will see a radical change in how cars are designed. These new designs will impose different loads on the chassis, which will spur on demand for new methods of testing and appraisal. We are perfectly equipped to deal with that. Our innovative test rig was funded by 3.5 million euros from the German government's economic stimulus package," enthuses Professor Holger Hanselka, director of the LBF and coordinator of the Fraunhofer e-mobility systems research project. "We have the capacity to test everything from small cars to electrically powered transporters and buses up to 6 metric tons in weight, which we will increasingly be seeing in the city centers of the future. We give manufacturers and suppliers of electric and hybrid vehicles the opportunity to test out innovative products such as their new components for electric motors," explains project manager Erich Lücker. The switch to electric power requires a rethink of the entire vehicle concept. The batteries are heavy, which means that the car has to be designed to carry more weight. He adds: "We also use the data we collect as a basis for developing new test standards."

How did the vehicle cope with this? Which components and design features can be improved? The researchers process the data on their computer systems and provide the manufacturer with recommendations on how to make the sedan as reliable as they possibly can. ■

Relationship mining

Dr. Kristian Kersting is one of 26 scientists currently being funded by the Fraunhofer-Gesellschaft under the Attract program. He tells 'fraunhofer magazine' how he came to join Fraunhofer.

The interview was conducted by Birgit Niesing.

Dr. Kristian Kersting.
© Volker Steger

You were working at the Massachusetts Institute of Technology MIT as a postdoc. How did you find out about the Fraunhofer Attract program in the USA?

I met Stefan Wrobel, Director of the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS in Sankt Augustin, at a conference. He told me about the Fraunhofer Attract program, in which young scientists can set up their own working groups which are financed for five years. This is a great opportunity. The Institute conducts recognized research, is very well equipped and has good links with the University of Bonn. I found this all very attractive. At the MIT the researchers do not just want to solve problems, they are also keenly interested in the benefit the solutions will yield. This is a highly pragmatic approach. Fraunhofer does things in a similar way. The proximity to practical and industrial applications is really exciting. I like being motivated by real-world problems. In the Attract program young scientists have the opportunity to become acquainted with the Fraunhofer approach – without any pressure to finance their work straight away through revenue from industry.

The name of your working group is STREAM, which stands for Statistical Relational Activity Mining. What does this mean?

Everyone uses relations and cross-references to represent knowledge compactly and to draw conclusions. An example: before you arranged this interview you probably did not know very much about me. But you know Fraunhofer and therefore can assume that I am a scientist. And since I work at the IAIS, I am probably a computer scientist. It is not a good idea to generalize too much, however, because not everyone working at the IAIS is a computer scientist. STREAM's mission is to create a computerized model of this general reasoning approach. Using general rules, the computer could for example analyze articles about Fraunhofer and detect that indeed researchers work there. The computer will automatically figure out that we mainly focuses on IT technologies at the IAIS. These relations denote the term "relational". However, not only everybody working at the IAIS is a researcher. The Institute also employs secretaries for instance. To reflect this as well as missing pieces of knowledge, a statistical element also has to be taken into account. This explains the "statistical" term. The process of automatically searching through this information and analyzing it is called "mining". To summarize, we develop algorithms which enable us to quickly find general but noisy rules in massive data. Based on the rules discovered we draw conclusions efficiently.

You are involved in a project with the Phantasialand theme park. Why is a theme park interested in these techniques?

I am not allowed to say too much at this point, only that the goal is to make visiting the theme park an even better experience. For me this is an excellent opportunity to transfer my research work from the laboratory into real life. After all, it is in the real world that complex and noisy knowledge has to be analyzed.

What are these techniques used for?

Within the "Attract" program we are developing the basic principles. We envisage that the techniques could be applied for example in bioinformatics, to find out where molecules have common characteristics. The methods are also interesting for communication technologies, social network analysis, and robotics, among other application areas.

How can the techniques be used in robotics?

The behavior of a robot which, for example, is deployed in a warehouse, can be described by means of general rules or instructions, such as "fetch stock from top shelf". While this task is similar in any warehouse, every building is different. It would be a very expensive, however, if the robot manufacturer had to send staff to the customer for a number of weeks only to teach the robot how to handle the specific environment there. In domenstic environments, this would actually be completely out of scope. In an EU project we are collaborating with the company KUKA and several renowned researchers on the idea of programming a "out-off-the-box" robot using probabilistic programming languages. Using statistical relational mining methods, the goal is to enable robots to automatically adapt the program to the particular situation and in turn to learn how to act. The project has just started in spring 2010.

How many people do you have in your working group?

I started to set up my working group in 2008. Currently, it consists of one postdoc, 4 PhD students, one DAAD (German academic exchange service) PhD student and three research student. It is planned to add one or two PhD students.

Your working group will be funded until 2013. What do you want to achieve by then?

Scientifically, I would like to show that Statistical Relational Activity Mining has the potential to lay the foundation of the next generation of Artificial Intelligence. We made already some progress and co-organize a workshop on the topic at the Twenty-Fourth AAAI Conference on Artificial Intelligence together with colleagues from the MIT, Berkeley, Google, UW-Madison, and UMD. However, I would also be very pleased if our methods actually get applied for instance to analyze massive data. As an example applications, we downloaded 4 million images from Google and analyzed them using one of our techniques, convex-hull non-negative matrix factorization. Within only hours, a few basis images were found that well described the whole dataset. Interestingly, the basis vectors found look like the well-known Walsh basis. As another example, we analyzed 150 million activity observations of players of a massively multiplayer online game. We automatically generated activity profiles of whole guilds, i.e., groups of players that summarize the data well. It took only just two hours on a standard desktop computer to compute these profiles. I would be really excited though if by means of the Phantasialand project we could show that machine learning can help to make theme parks even more attractive. ■

Fraunhofer Attract

Attract program is an important way of encouraging creative people to join Fraunhofer-Gesellschaft. 100 million euros is available for selected projects to be conducted by young scientists. Researchers are given the opportunity to translate their ideas into innovations. For five years they receive annual funding of up to 500,000 euros, so that they can create a working group of up to five members. The intention is that after five years the research work will have progressed so far that the working group can finance itself from business and project revenue.

www.fraunhofer.de/attract

Internet access for five billion people

Providing Internet access for the inhabitants of remote villages in Africa, rural settlements on Greek islands or the sparsely-populated Argentine Pampa is by no means an easy task. As part of the NET4DC project, Fraunhofer researchers are now designing technologies specifically adapted to the requirements of individual developing countries. Recently, they set up a better Internet connection for the Ubuntu Campus, an isolated settlement near the village of Macha in Zambia.

Text: Britta Danger

When you think about Africa, the last thing that tends to spring to mind is rain. But on this particular day in November, it's pouring down, shrouding the hills in a watery curtain and turning the soil to thick, red mud – it's the rainy season in Zambia. Karl Jonas and Mathias Kretschmer of the Fraunhofer Institute for Open Communication Systems FOKUS in Berlin are waiting patiently in the small village of Macha for the sky to brighten. As soon as it does, they jump in their Jeep and start coaxing it along the muddy track to Ubuntu. They're on the lookout for the next water tower, transmission mast or similar high point, where they intend to install the high-performance radio router that will provide the two villages and the area in between with wireless Internet access. Recalling that day, Karl Jonas admits: "I really never expected to see such rain." But the weather was just one of the many surprises that Africa had in store for the researcher, who holdes a PHD in computer science, and his colleagues. And after all, that was why they were there: to get to know the country and its people better, and to gain a better understanding of their requirements. Jonas says: "There are four to five billion people in the world who have no Internet access, particularly in developing and emerging countries." It is for these people that the FOKUS researchers are currently working to develop tailor-made communication networks. Their countries often have no electricity grid or infrastructure to speak of, and they certainly boast no specialists capable of repairing the damage that will doubtless be inflicted very quickly by the harsh climatic conditions. The situation calls for radically different

Fraunhofer researchers are seeking to provide communication networks for rural regions like the village of Macha in southwest Zambia. *All photos © Fraunhofer FOKUS*

A power supply is critical: These computers are still operating off electricity produced by a generator. In future, the radio networks will be powered by solar energy.

solutions, yet at the same time, the technology must be affordable for the people in question. To this end, in January of this year, Fraunhofer FOKUS officially launched the information and communication technology center 'NET4DC – Connecting the Unconnected'. The DC stands for developing countries and the aim of the center, which was set up by the director of FOKUS, Professor Radu Popescu-Zeletin, is to provide access to global communications infrastructures and services for those living in rural areas in developing and emerging countries.

Back to Macha, where the people prove only too happy to help Jonas. They lend him their tools and suggest suitable locations for the router. He is impressed by their attitude, and comments: "The people here have an incredible thirst for the Internet." Not only does the Net provide them with an insight into the wider world, it can also significantly improve the quality of life where they are. The health centers responsible for providing medical care to the local population frequently don't even have a telephone. If a patient requires a particular medicine, they have to journey to the nearest hospital, perhaps half a day away. And often they'll arrive there only to find it doesn't have what they need either. The Internet would give each individual the chance to take responsibility for their own life planning. Jonas quotes a case in point: "Here in Macha, which is a long way from the nearest town, there's a young man who is using the Internet to study at a South African university."

However, it is perhaps the highly inventive ways in which the local people are making use of the new media that has impressed him the most. Take the bread ordering service by SMS, for example. Jonas explains the basic principle: "Beforehand, the baker used to do long rounds of his customers, without ever knowing if they actually needed bread or not. Nowadays, he waits for their text messages to arrive, and saves himself the time and effort." It's applications like that that simply don't occur to us in Europe. The malaria hospital in Macha has a pre-existing satellite link that Jonas and his colleagues are seeking to tap into. Thanks to a WLAN connection, houses near the hospital have been enjoying wireless Internet access for some time, but the Fraunhofer specialists have now succeeded in extending the connection to the village of Ubuntu three kilometers away – where a new school is being built – using high-powered radio routers. Satellite links are by no means rare in Africa; they are often used by development aid projects. "These connections cost three to five thousand euros per megabit per month," says Jonas. The bills mount up rapidly, even for a minimal 64 kilobit service. "The hospital in Macha alone pays tens of thousands of dollars a year for its satellite link," he reports. And that despite the fact that the link is poor, the data transmission speeds low. He goes on: "A terrestrial connection would cost half the money and make the rest available for practical health care." While Jonas' team installs an additional router on an old water tower, his gaze travels over the area already covered by WLAN. The plan is for a network covering 25 square kilometers to be

Improvisation is still the name of the game: An unconventional cabling system connects the generator to the computers in the training center.

Already connected: This lab assistant in the research laboratory at Macha Hospital is looking up current findings from international research into malaria.

Up we go! You don't want to suffer from vertigo if you're installing the antennas.

up and running smoothly by 2012. A network so good it can be deployed in any part of the world – and extended at will. A network so intelligent it will find alternative routes for a signal if one router fails, and can be powered by solar cells. Jonas says: "Ensuring a power supply has always been a key problem area, but in Africa, you have the perfect conditions for solar energy all year round." However, that solution requires routers that are more energy-efficient. One bit at a time, the FOKUS communications specialists are now working to identify where unnecessary activities can be eliminated. The routers should only transmit when data is actually being transferred. They shouldn't query, for example, whether an IP address is still valid every 100 milliseconds, as is standard practice in Germany. And in future, the solar cells should be firmly integrated within the routers so they cannot be misappropriated for private use. Jonas is quite clear on this: "It would be best if the cells were made to auto-destruct if anyone tried to steal them." NET4DC is working together with partners in South Africa and the Netherlands, and the center can also rely on the wide range of expertise available within the Fraunhofer-Gesellschaft as a whole. The Fraunhofer Institute for Solar Energy Systems ISE in Freiburg and the Fraunhofer Institute for Manufacturing Engineering and Applied Materials Research IFAM in Bremen are just two of the other organizations involved in the project. The ISE will produce particularly powerful solar cells, while the IFAM will integrate the cells into the routers. Jonas does not regard the fact that the Internet will initially only be available during daylight hours as a major problem, and comments: "If we're able to guarantee a reliable connection twelve hours a day, that's already a huge step forward." In most other areas of the world, the problem would never arise. In Europe, for example, almost everywhere is covered by an electricity network. Yet even in the Western world, there is also a requirement for inexpensive and robust radio networks – for example if the population density is low.

Above all else, the NET4DC communications specialists are continuing their efforts to improve the energy efficiency of the routers. Jonas says: "If we can reduce the solar cell area by twelve percent, that will shave five percent off the total costs. We're gradually drawing closer to our goal." That goal being 50 percent lower costs for the Internet, in order to free up the other 50 percent for the hospital. ■

NET4DC

For around five million people living in developing and structurally weak regions around the world, opportunities are limited when it comes to medical care, education, and involvement in economic or political life. One obstacle standing in their way is a lack of access to the Internet and to regional communications infrastructures. It was precisely in order to connect these regions to the Internet that the Fraunhofer Institute for Open Communication Systems FOKUS launched the NET4DC project. This international center for information and communication technology in developing countries is now working alongside partners in the target regions to develop and make available tailor-made IT infrastructures and communication networks.

Professor Ulrich Buller, Senior Vice President Research Planning at the Fraunhofer-Gesellschaft, sums up as follows: "The promotion of sustainable economic concepts is a global challenge. We see our contribution as being to provide mobile communications applications and to build modern IT infrastructures in developing and emerging countries." The Fraunhofer specialists are offering an open platform. NET4DC is seeking to cooperate with established partners on the ground, be they organizations, research establishments or commercial enterprises, and will amalgamate the expertise contributed by all who get involved.

www.net4dc.org

Solar cell know-how

The future belongs to solar electricity. More and more people are using environmentally-friendly solar power. Solar cell production is increasing globally, whereby modules made of silicon are still the most common . It is not easy, however, to produce these modules on a large scale, as the silicon wafers are very fragile and the robot arms used in mass production are often too 'clumsy'. Researchers from the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart are currently developing new technical solutions in the HighSol project, funded by the EU's Sixth Framework Program. In a recently opened Demonstration Center, engineers and scientists can test various grip techniques and examine them with high-speed cameras. Initial results are now available. "Whereas the entire production has until now often been carried out using a single type of gripper," explains Christian Fischmann of the IPA "not all handling methods are not equally well suited to every step of the process. Ultimately, we need to achieve the right balance between sensitivity, speed and operational costs."

Building boom

China's construction business is booming. According to UNO estimates, 350 million Chinese will move from the countryside to towns and cities in the next 20 years. This migration presents the capital cities with enormous logistical and constructional problems.

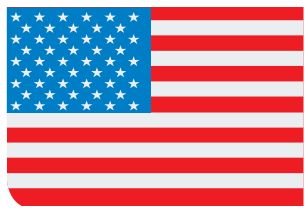
Fraunhofer researchers from the BAU Alliance, an affiliation of 16 Fraunhofer institutes, are introducing solutions at the "Germany and China – Moving Together" event. The presentation is touring the most important centers in China, before making a final stop at the world exhibition in Shanghai in 2010.

At exhibitions, conferences and workshops researchers are showcasing new technologies that can help to build or renovate houses and residential estates in a way that is sustainable and compatible with healthy living. Presentations also demonstrate how flexible commuter transport systems can be integrated.

Across the borders

Europe is growing together, politically, economically and culturally. This has led to a growing tendency for public administrators in towns, municipalities, states and countries to work together across borders. The EU Services Directive, for example, in force since the end of 2009, stipulates that companies must provide a number of services throughout the EU – even in countries in which they do not maintain a branch office.

If information is to be exchanged across borders, IT solutions must be able to adapt to different administrative structures, languages and technologies. "The different linguistic and cultural backgrounds of the partners involved make it difficult to achieve this level of consistency. Misunderstandings are inevitable if terms, data structures and writing conventions are used in different ways, and meanings differ – regardless of what systems are used," explains Lutz Nentwig, manager of the eGovernment group at the Fraunhofer Institute for Software and Systems Engineering ISST. As part of the EU's "SEMIC.EU" (Semantic Interoperability Centre Europe) project, the ISST, together with]init[AG, GEFEG GmbH and France Telecom R&D, is developing software solutions for transnational eGovernment in Europe, operating across administrative, technical and linguistic borders.



Logistics for the USA

Researchers from the Fraunhofer Institute for Material Flow and Logistics IML in Dortmund intend to work even more closely with the Material Handling Institute of America MHIA in Atlanta, Georgia. The two institutes signed a Memorandum of Understanding during a trip by the North Rhine Westphalian Minister of Science, Professor Andreas Pinkwart. TU Dortmund University also gained a new cooperation partner – the Georgia Institute of Technology.

"The agreements strengthen and reinforce the very successful cooperation that has developed between our scientific institutions in the area of logistics. They are both top global institutions and enjoy the highest international renown," concluded Prof. Michael ten Hompel. Prof. Uwe Clausen added, "We will continue to strengthen our existing co-operation on the optimization of transport logistics and air traffic management."

Virtual museum guide

A Fraunhofer software system is bringing archaeological treasures to life in the Netherlands.

Text: Frank Grotelüschen

The Allard Pierson Museum in Amsterdam is one of Europe's leading archaeological museums. Its distinguished halls house Greek statues, Roman amphorae and Egyptian sarcophagi, but one room stands out in particular. At its centre, mounted on a rotary stand, is a flat screen, showing a detail from the picture hanging on the wall: a massive black-and-white photograph depicting the ruins of the Forum Romanum – the center of Ancient Rome.
But when a visitor swivels the screen slightly, a surprising thing happens. It no longer shows the middle of the photograph but a section of it to the left. The visitor realizes that there must be a camera connected to the rear of the swivel display. And suddenly, as if by an invisible hand, information appears on the screen. A text explains that the camera on the back of the screen is pointing to the ruins of the Temple of Saturn. At the same time, a digital animation shows what the temple would have looked like when it was intact. Then the visitor swivels the screen in the other direction and sees information, pictures and videos relating to other ancient structures, including the Via Sacra and the Colosseum.

This is made possible by a software program developed at the Fraunhofer Institute for Computer Graphics Research IGD in Darmstadt. "We have taught the computer to recognize the picture," explains research scientist Michael Zöllner. "As a result, it knows which part of the picture is at the centre of the camera and can insert the appropriate text, video or digital animation." The original picture – the photo of the Forum Romanum – can be seen at all times behind the superimposed information. This means that the visitor always knows where he or she is on the virtual walk through the scene. This technique in which digital information is cleverly added to real images is known as Augmented Reality.

The screen was installed in the Allard Pierson Museum in May, and most visitors are highly impressed. "The response has been very positive," enthuses Museum Director Wim Hupperetz. "The system is easy to use; visitors can navigate for themselves and pick out the information they are most interested in."

Real picture, digital information

The same applies to the second system, set up a few meters away on a stand. Instead of a big screen, in this case the software from the Fraunhofer IGD runs on a minicomputer, operated by touchscreen. The compact installation is an indication of where this technology is heading over the next few years – to the mobile, virtual tour guide. With this version the tourist will simply hold the device in front of a Roman ruin, a baroque castle or a historic timbered house and the matching information will appear on screen – digitally animated and tailored to the wishes of the user.

The Fraunhofer researchers have already tested out a prototype device in a project called iT-ACITUS. Zöllner's team programmed a portable computer to act as an electronic tour guide at the Palace of Venaria near Turin, a UNESCO world heritage site. Images on screen show, for example, what the splendid building would have looked like centuries ago. "Everything

Museum visitors can navigate for themselves and pick out the information they are interested in.
© *Fraunhofer IGD*

functioned beautifully and the system proved to be very stable," says Zöllner. He is currently working on a similar project for Berlin, where at the touch of a button information will be superimposed on the Reichstag building and Brandenburg Gate, including photographs from the Cold War period.

Applications like this will soon break through onto the market, thanks to the new generation of cell phones. Smartphones, like the iPhone from Apple, are perfect for Augmented Reality: they incorporate all the hardware required – a camera, a relatively large touch-sensitive screen, powerful processor and GPS navigation. Their importance in this context is underlined by Michael Zöllner: "Smartphones open up the mass market for Augmented Reality. We have now reached the point where we can take this technology slowly but surely to the end user."

As an example, Zöllner recently wrote a program called TwittARound for the iPhone 3GS, which is able to visualize Twitter messages on the smartphone's screen. "If someone nearby writes a Twitter message on their iPhone my device represents spatially where and at what distance the sender is located," explains Zöllner. To see whether somebody is using Twitter close by, Zöllner simply holds his smartphone above his head and using its video camera takes a look around. If somebody has just written a Twitter message this appears on the screen as a sort of speech bubble. "If you encounter an interesting twitterer you can reply straight away," Zöllner continues. TwittARound will soon be available for the iPhone and Google Android, and the application is already attracting great interest.

Michael Zöllner anticipates that many more Augmented Reality programs for smartphones will come onto the market soon, but advises against expecting too much: "At present the computer power of the devices is not high enough for many applications," he explains. "The batteries are a further problem." If you just use a smartphone to make phone calls and to do a little surfing the battery will last perhaps two days. In Augmented Reality applications, however, the processor uses a lot of power and at the same time the display and camera are in continuous use. This can run down the battery in about half an hour, which is no good for practical, everyday use. But there is hope: "The hardware manufacturers are making great efforts to solve this problem," says Zöllner. "And everyone is hopeful that real progress will be made in the development of better batteries."

Museum Director Wim Hupperetz expresses his confidence: "The principle of Augmented Reality points the way to the future." He envisions that in five years' time every visitor will have a small screen with them as they take a tour of the Allard Pierson Museum. "The younger generation are already referred to as "screenagers". They like to do everything on screen. New technologies like this are therefore important to get young people into museums." ■

History in 3-D

The aim of the European 3D-COFORM project is to document works of art and other exhibits from museums all over the world in three-dimensional form in a vast digital archive.

Text: Tim Schröder

Even Michelangelo's "David" has been scanned in three dimensions for inclusion in tomorrow's digital museums. © *Corbis*

Three-dimensional computer graphics have long since become an indispensable tool for automobile designers. Before a real automobile is produced from sheet metal, engineers create a realistic virtual model on the computer, which can be rotated and viewed from any angle and which even diffracts sunlight in a deceptively authentic way on the finished surface. 3-D has long been routine in such applications, but is still far from common in another domain - in museums. This is about to change as the European 3D-COFORM project intends to spend the next few years developing tools to digitize mankind's museum heritage. Vases, ancient spears or even whole temples will be documented three-dimensionally. In the same way that designers nowadays view prototypes on the screen from all sides, museum visitors will one day be able to rotate Roman amphorae on the screen.

And that's not all. The basic idea of 3D-COFORM is to create a global virtual collection, making it easier for scientists to search for comparable objects or works, which originate from the same artists or peoples and lie forgotten in archives. The project's innovative aspect is that the virtual collection will be so intelligent that it will be able to find the digitized and saved objects itself and create links between them. With just a few search terms researchers will be able to find what they are looking for. Asked to "Show me Greek vases from the sixth century before Christ with at least two arched handles", the database will show a whole batch of exhibits from collections all over the world.

There's still a long way to go though. At the moment, printed catalogs with simple photos or even with just written descriptions of objects are the norm. Only a few collections are available on the Internet in the form of two-dimensional images. And although 3-D scanners capable of scanning paintings or statues and generating corresponding 3-D images have already been on the market for years, there are hardly any 3-D models on the World Wide Web.

Yet there are enormous advantages to the three-dimensional form. In contrast to a photo, a 3-D data set contains the complete spatial information for viewing an object from all sides. It also provides valuable data for art restorers, such as information about the texture of the surface, the finish of a painting or the condition of a pigment. Of course, there are already impressive 3-D animations of art objects today, for example, the three-dimensional portrayal of the statue of David by Michelangelo. "We are, however, a long way off from linking up three-dimensional data of different objects in a meaningful way," says André Stork, head of department at the Fraunhofer Institute for Computer Graphics Research IGD in Darmstadt and partner in the 3D-COFORM consortium. Despite the first-class 3-D scanner, technical hurdles still remain.

As a graphics expert, Stork, together with his colleagues, is responsible primarily for generating 3-D models and preparing them for the digital archive. "A 3-D scan is in the end nothing more than a cloud of measuring points. It's only possible to create a genuine likeness of the object by subsequently applying an appropriate rendering process," says Stork. Researchers develop algorithms, or sets of calculation rules, which construe the actual object from the measured data. They must be capable of determining whether a corner is truly angled at 90 degrees and whether an apparently flat surface is genuinely flat or slightly concave. "The human eye can detect such things immediately, but a computer can only do so after explicit training," explains the scientist. The task of documenting millions of objects calls for software that can detect the structure of each object quickly and reliably. This depends primarily on identifying certain structures correctly, such as the arms of statues or columns in a building. Experts use the term "segmentation" to denote this type of graphic categorization.

Algorithms recognize recurring patterns on vases

The algorithms must also be capable of recognizing specific details of interest to historians, such as recurring patterns on vases, which enable them to be authenticated as the work of specific artists or manufactories. 3-D images will make the work easier for researchers in the future. Segmentation and annotation functions provide the three-dimensional data set with a huge amount of information, such as the length and width of a column or the curvature of the neck of a jug. It's precisely these details which will form the basis of future Internet research. The museum search engine of the future will therefore no longer be restricted to the written description alone. It will be able to trace an object by means of the characteristics contained in the 3-D data set. The researchers in Darmstadt are also investigating what this graphic 3-D fingerprint looks like on the Internet and how it can be selected with search engines. The IGD scientists are also working on browser design.

Searching and finding is one thing. Realistic and detailed depiction is also a prerequisite of virtual presentation. The image of a temple is much more authentic if it also includes the play of shadows on its columns. And the curved surface of a brass object appears lifeless if it does not reflect its surroundings. Stork and his colleagues are using all the tricks of the computer graphics trade to breathe life into the virtual copies of the unique historical artifacts. They utilize a combination of different techniques to simulate light effects. Ray tracing, for instance, faithfully reproduces the reflections visible on mirrored surfaces by calculating the exact source of each pixel in the reflected image. Other techniques are used to reproduce the dark shadows cast by intense sunlight. To perfect the result still further, the shadows become less distinct if an object is illuminated by several light sources at the same time. "We can even go as far as to show a virtual object in the same light conditions in which it was seen at the original excavation site," says Stork. To be sure, this won't be necessary for every object, but a true-to-life portrayal is certainly required each case. Precise 3-D graphics will enable art restorers, for example, to document the condition of an object more accurately. Is the painted wooden frame still intact? Are there cracks in the varnish used to seal the painting? A 3-D image can provide all this information.

Many questions still need to be answered. Not only those concerning the graphics, but also in what form the data will be made available to the users. The time and effort required is also enormous. Millions of objects must be scanned for online display. The members of the 3D-COFORM consortium, led by the University of Brighton in England, have already started to develop initial concepts for digitization centers, which will be tasked with scanning in the exhibits from exhibitions and museums worldwide. But support is also at hand in the form of another EU project, Europeana, in which an initial step towards digitization has been made by preparing all exhibits from European exhibitions and museums for two-dimensional reproduction on the Internet. Stork sees this as a kind of test run for the 3D-COFORM archive of the future. ■

HIV protection from tobacco plants

Genetically modified tobacco plants produce an active ingredient against the Aids virus. © *Fraunhofer IME*

»Pharma-Planta«

The aim of the EU's "Pharma-Planta" project is to produce medication from plants for the treatment of HIV, rabies, tuberculosis and diabetes . The project team consists of biologists, medical scientists and pharmacists from eleven European countries and South Africa. Science and industry are working together to develop a complete production chain, from molecule design through to clinical tests. The European Union has invested twelve million euros in the project, which started in 2004. It is being managed by the Fraunhofer Institute for Molecular Biology and Ecology IME in Aachen. St. George's Hospital Medical School is responsible for scientific coordination.

pharma-planta.org

Every year about 2.7 million people are infected with the Aids virus HIV. Specific antibodies can protect against succumbing to the consequences of infection. Researchers on the EU's "Pharma-Planta" project are working on the production of the active ingredient in genetically-modified tobacco plants.

Text: Birgit Niesing

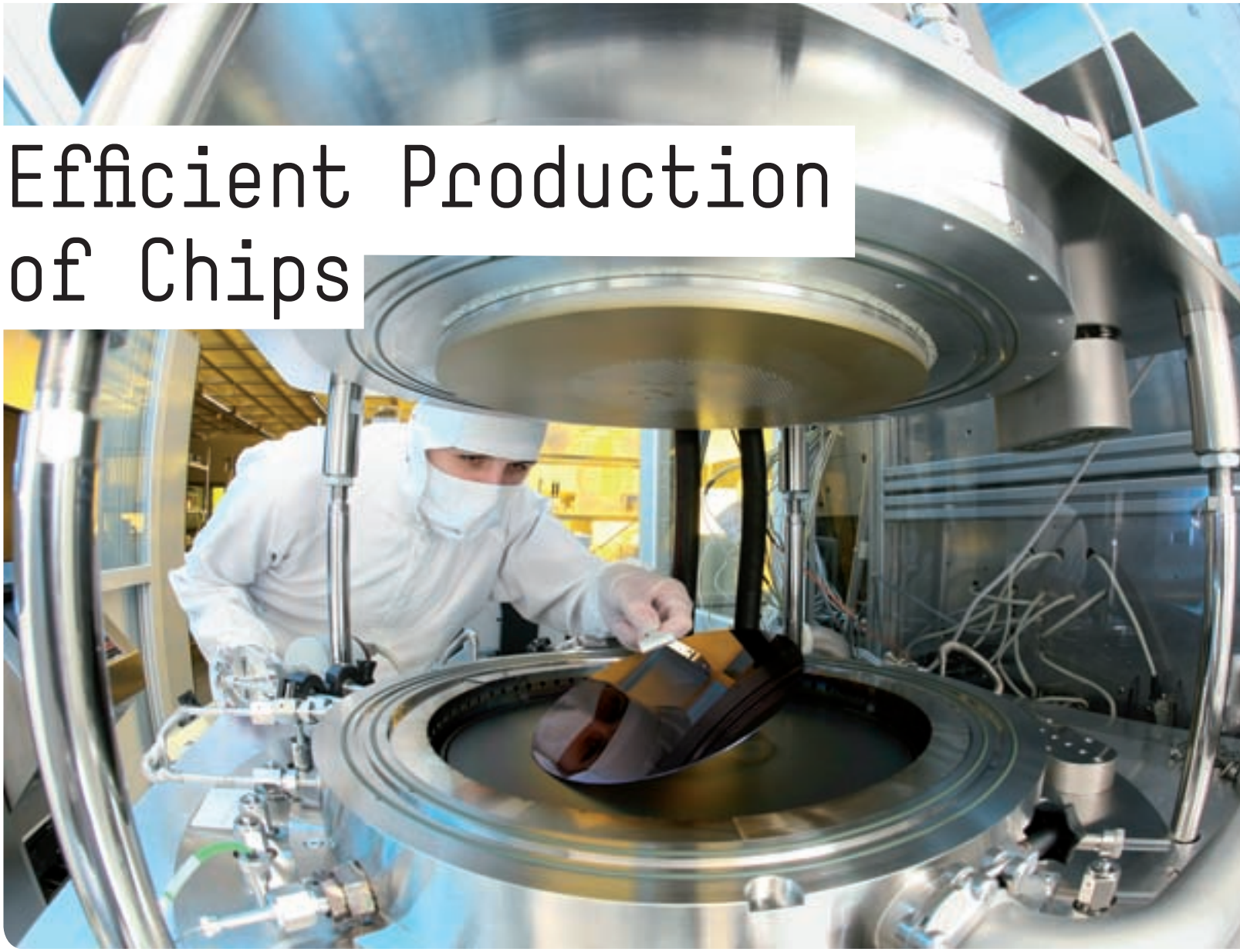
More than 33 million people worldwide are HIV positive and at risk of succumbing to AIDS, the "Acquired Immune Deficiency Syndrome". Every year around 2.7 million people contract the AIDS virus. Antibodies, such as antibody 2G12, can protect them against succumbing to the HI virus . 2G12 binds to protein gp120 on the surface of the virus, preventing it from docking with immune cells. Until now, antibodies have been produced in cell cultures, but this is laborious and expensive. One alternative is "Molecular Farming", by which active ingredients are produced in plants rather than animal cells – and at a fraction of the cost. Researchers at the Fraunhofer Institute for Molecular Biology and Applied Ecology IME in Aachen are using genetically-modified tobacco plants to produce antibody 2G12 economically and safely. "Pharma-Planta", an EU-sponsored project that brings together 39 partners from science and industry, establishes the foundations for work in this field.

The scientists have introduced the gene for the active ingredient into the genetic material of a tobacco plant (Nicotiana tabacum cv Petite Havana SR-1), enabling the antibodies to be harvested from the plants later on. "The new protein is produced as the genetically-modified plants grow," explains Dr. Stephan Hellwig, production manager at IME. But how can these antibodies be extracted from the tobacco plants? In order to isolate the active ingredient from several hundred kilograms of plant material, researchers have developed a special process for preparing the tobacco. Firstly, the harvested tobacco leaves are washed and shredded. The scientists then extract the contents and purify them in a series of filtration and chromatography steps. The scientists tried the procedure for the first time in a pilot test last year and processed the entire 800 kilograms of plant material from the institute's own greenhouse in four runs, or "engineering batches". "In the test runs we collected the logistical and procedural data necessary for developing a pilot facility that would meet the strict requirements for the production of pharmaceutical active ingredients," explains Dr. Jürgen Drossard, quality assurance manager at IME. "The active ingredient was tested in preclinical safety trials at the end of 2008, without any negative effects."

Together with laboratory and process technology provider Sartorius, the scientists have this year opened a GMP-compliant, semi-automated pilot facility at IME. The Good Manufacturing Practice facility can process up to 1000 kilograms of genetically-modified tobacco a week – the most that can be cultivated in the IME greenhouses. It also has the overriding advantage that all components which come into contact with the product are to a large extent "single-use" components and easy to exchange. The facility can therefore be used for extracting other biopharmaceuticals from plants without the risk of cross-contamination.

A first test run of the pilot facility in August 2009 led to it receiving accredited status. "As there are no comparable established processes, we must comply with the relevant authorities in order to eventually be granted a license to produce plant-made pharmaceuticals for human use," Drossard explains. As soon as the production license has been issued, the scientists want to produce the first antibodies under GMP conditions. These active ingredients will then be used in a "Phase 1" clinical trial at one of the partner organisations involved in the EU project. ■

Efficient Production of Chips



Europe is far from losing the global race in semiconductor technology. In the joint research project IMPROVE, chip manufacturers, research institutions, universities, suppliers and service providers are working on increasing the efficiency of the European semiconductor industry.

The semiconductor market is a tough business: Prices drop regularly, and several industry locations compete for market shares on a global basis. But even in the televisions, satellite receivers or mobile phones made by non-European manufacturers, electronics from Europe are frequently tucked away in the inner circuitry. »So anyone who thinks Europe no longer has a meaningful foundation in the chip industry is wrong. The semiconductor industry sets the preconditions for competitiveness and innovative power of an entire series of economic branches,« emphasizes Martin Schellenberger of the Fraunhofer Institute for Integrated Systems and Device Technology IISB in Erlangen. Microelectronics »made in Europe« are frequently deployed in automotive technology, mechanical engineering, medical technology, telecommunications, aerospace or measurement and control technology.

»The European semiconductor industry offers excellent technologies, and the race on the world market has not been decided by a long shot. The key to success is in intelligent products, as well as in efficient production,« says Schellenberger. The EU project IMPROVE is fostering research to heighten efficiency in the semiconductor industry. Its acronym stands for »Implementing Manufacturing science solutions to increase equiPment pROductiVity and fab pErformance.«

The goal of this major European joint research

Research for efficient and competitive semiconductor manufacturing in Europe.
© *Kurt Fuchs*

Researching together

IMPROVE is the largest European joint research project for increasing efficiency in the semiconductor industry. The total budget equals 37.7 million euro. Up to half of the project is covered by funds from national authorities as well as ENIAC (European Nanoelectronics Initiative Advisory Council) and the European Union. One of the largest funders is the federal ministry for education and research BMBF, at 3.5 million euro. The other half is financed by the project partners from business, science and research.

The partners are:

- AP-Technologies
- Atmel
- Austriamicrosystems AG
- Camline
- CEA-LETI
- CNR-IMM
- Critical Software S.A.
- Dublin City University
- Ecole des Mines de Saint Etienne -Centre Microélectronique de Provence
- University of Applied Sciences Vienna-Neustadt
- FAU Erlangen-Nuremberg – Chair for production automation and production systems
- Fraunhofer Institute for Integrated Systems and Device Technology IISB
- G-SCOP
- Infineon Austria
- Infineon Technologies AG
- Infineon Technologies Dresden GmbH
- InReCon AG
- Intel
- iSyst Intelligente Systeme GmbH
- Italian National Council of Research, CNR-IEIIT
- LAM Italy
- Lexas Research
- LTM CNRS
- NUMONYX
- PDF solutions
- Probayes
- STMicroelectronics
- Straatum
- Technofittings
- University of Augsburg: University Augsburg (UAU)
- University of Milano: Università degli Studi di MILANO (UNIMI)
- University of Padua
- University of Pavia: Università degli Studi di Pavia (UNIPV)

project is to strengthen the competitive edge of the semiconductor industry. Europe is far from losing the global race in semiconductor technology. In the joint research project IMPROVE, chip manufacturers, research institutions, universities, suppliers and service providers are working on increasing the efficiency through intelligent solutions. IISB scientists are spearheading the research efforts

IMPROVE represents the amalgamation of 35 partners from six different European nations into one strategic alliance - including major semiconductor producers, companies with production facilities in Europe, research institutions and universities. »This project is not about the infamous costs of labor. Because that component makes up only five percent of total chip costs,« Schellenberger attests. »Our mission is to leap far ahead of the competition through scientific research into production.«

New generations of chips always come with more functions. That requires ever more complex manufacturing processes and ever longer production cycles. According to statements from Infineon, the making of a product wafer today entails up to 550 individual process steps and lasts 12 to 16 weeks. Since manufacturers offer several different products, they have to convert their systems for the production of the next product after producing just 50 to 100 of the same kinds of wafers.

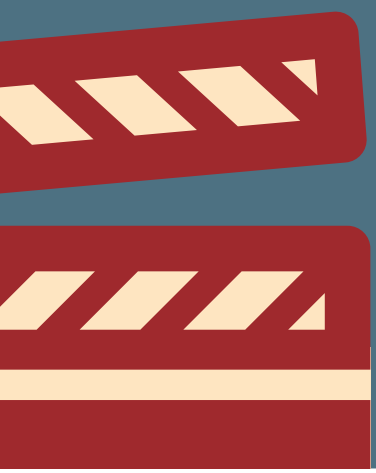
Quality control must be commensurately adapted and implemented to production as well. To prevent the unnecessary loss of time, and to guarantee consistently high quality, specific efforts are needed - through more intelligent monitoring of the production conditions and predictive maintenance of the production equipment. Here is where IMPROVE joins in: The partners investigate and engineer methods and tools so they can better control process fluctuations and optimize processing times.

»With semiconductor manufacturing, massive amounts of data are accumulated, on pressure ratios, temperatures or gas composition, for instance. It would be thrilling to develop a process that fully exploits this information and searches for correlations,« explains Schellenberger. In combination with innovative processes for data evaluation, this can shorten the production term and improve chip production yields. Then it would be possible to use expensive systems and equipment more flexibly and efficiently.

www.eniac-improve.eu

The IMPROVE project is divided into three areas of research: »Virtual Metrology «, »Predictive Maintenance« and »Adaptive Control Planning.« So that the solutions from the three research fields benefit all participating project partners, a generally applicable index of specifications is being compiled under the auspices of the IISB. »The participants want to avoid isolated solutions and ensure the applicability of the results to all industry partners,« explains Schellenberger. Another work package that the IISB researchers are coordinating is the »Equipment Forum.« Here, manufacturers and suppliers are closely integrated into the research processes. As a result, the latest research findings are communicated efficiently, and the necessary modifications are adapted to facilities and equipment early on in the development and construction phases.

IMPROVE runs until the end of 2011, and for Schellenberger, it has a major impact beyond pure research: »The more than 30 partners from six nations are a part of the process of fostering a hitherto unacknowledged spirit of collaboration. Through IMPROVE, an important foundation stone is being laid for the future strength of the European semiconductor industry.« ■



The wonders of 3-D TV

2010 is the breakthrough year for 3-D movies and 3-D TV, and Fraunhofer researchers are working on technologies and standards to drive forward progress in this area.

Text: Stefanie Heyduck

The striker and defender fight furiously for the ball. Suddenly the striker goes down in the penalty area. The referee gives the penalty, and the fans wait with bated breath as the shooter carefully places the ball on the spot. Cut to the goal camera. Like a cannonball, the leather flies over the heads of the spectators, who duck reflexively. Except that these soccer fans are not sitting in the stadium, but in front of a 3-D television at home, far from the madding crowds of the FIFA World Cup in South Africa.

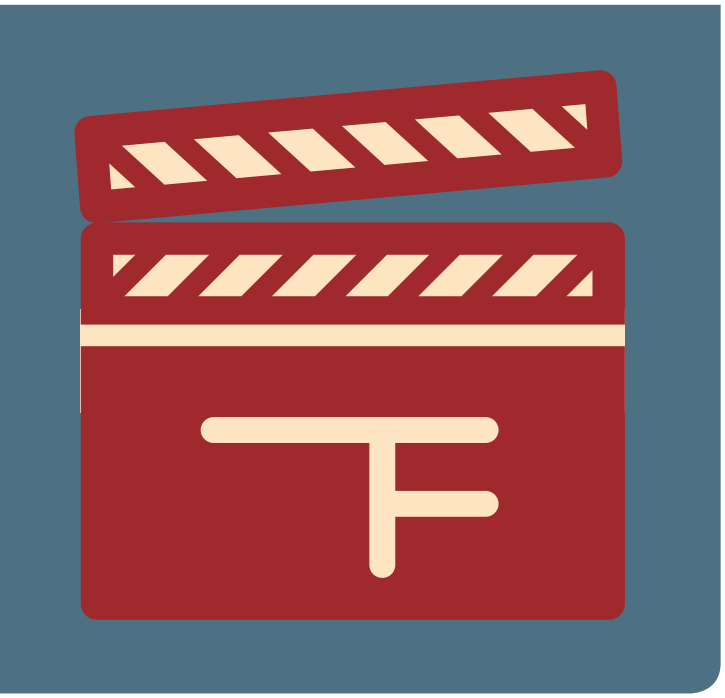
2010 will be the year in which movies and television make the big leap into the third dimension. Blockbusters such as James Cameron's 'Avatar', and Pixar's 'Ice Age' and 'Dawn of the Dinosaurs' have already raked in billions at box offices around the world. And now the 3-D revolution is set to take over the home viewing sector too, as this year's Consumer Electronics Show in Las Vegas made only too clear. The industry is euphoric and has already announced that the first TVs capable of bringing the full movie theater experience into the home will enter series production this summer. Already this year, some of the FIFA World Cup matches will be filmed in 3-D, and Britain's BBC is planning to use the format for its entire coverage of the 2012 Olympic Games.

But hype or no, before 3-D technology becomes the norm in movie theaters and on TV, there are a number of issues that still remain to be resolved. For example, how can the recording and post-production editing processes be optimized, and the associated costs reduced? Cameron's science fiction epic famously cost a massive 250 million U.S. dollars and took four years to make. How can we improve the post-production tools that are used to create such movies? And then there's the sixty-four thousand dollar question: Do we need 3-D glasses or not?

In order to address these issues, nine expert partners from the movie industry, academia and research are pooling their resources within the consortium 'PRIME: Production and Projection Techniques for Immersive Media'. Together, they are developing business models and technologies for 3-D media such as movies, television and video games. The cast list is impressive – KUK Filmproduktion GmbH, Loewe, Kinoton GmbH, DVS Digital Video Systems AG, Flying Eye, the Academy for Film and Television in Potsdam, the University of Duisburg-Essen, the Fraunhofer Institute for Integrated Circuits IIS in Erlangen and the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI in Berlin – and the project is funded by the German federal ministry of economics and technology.

Significant investment of time and effort

Creating 3-D movies poses a tougher challenge than filming in two dimensions, because two images are always needed to create the stereo vision effect. That's just a fact of 3-D vision. The brain requires two pictures from slightly different perspectives in order to create a three-dimensional impression. For this reason, at least two cameras must be used to record the images, and a 3-D screen is needed to display them simultaneously. There's one image for the left eye, another for the right. Stereoscopy has evolved from the popular early viewing device that generated an illusion of depth into



What do viewers want?

Last year, the Academy for Film and Television in Potsdam-Babelsberg conducted a research study entitled 'PRIME – Popularity and Acceptance of 3-D' in order to ascertain what viewers actually want. The aim was to avoid a situation in which technology is developed for its own sake, simply because it is possible, without regard for real-world considerations. The researchers interviewed 1002 people aged from 14 to 64, asking them about their experience with, interest in, acceptance of and wishes concerning 3-D media. The results bear out the current development approach. More than half the people questioned declared an interest in 3-D sport and concerts, as well as 3-D movies (specifically documentaries, science fiction and computer animations). Over 50 percent of them said they would be prepared to pay more at the box office if need be. 3-D glasses are generally accepted as a necessary evil. Members of the younger generation – those aged between 14 and 29 - are keenest to participate in the 3-D movie theater experience.

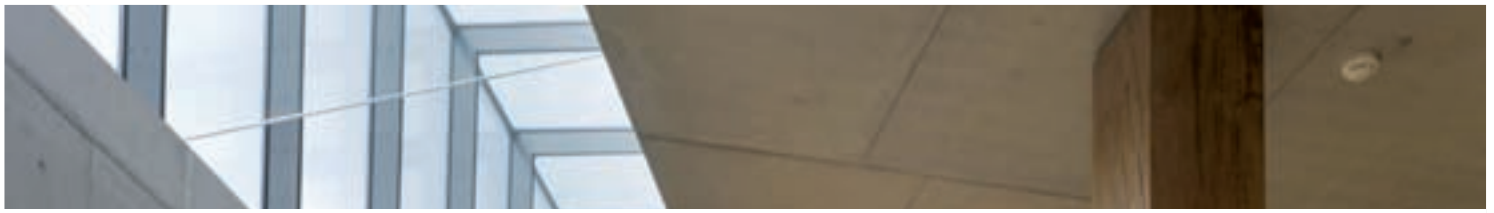
a recording technology for creating a high-definition home movie experience. It demands the utmost precision from both the camera operator and post-production workers, because a separate film has to be produced for each eye. During editing and post-processing, both streams must be processed together in absolute synchrony. "Even the slightest shift or tilt of the camera becomes visible on the screen, and can even make you feel nauseous," explains Stephan Gick, team leader for digital camera systems at the IIS.

Gick and his team at the IIS have been pushing the boundaries of this technology and developed two synchronized micro-HDTV cameras that they use to shoot sample movie scenes. They've devised a specially constructed camera setup in which stereo or side-by-side rigs simulate the distance between human eyes as realistically as possible, thus ensuring both pieces of equipment reliably record digital images for the right and left eye. Genlock technology guarantees that the cameras capture their images in total synchrony; one camera acts as the master, or digital leader, while the second uses identical settings to capture the calibration, color fidelity and geometry.

Camera teams must be able to rely on these settings, particularly if they are transmitting live 3-D broadcasts – and since Germany hosted the World Cup in the summer of 2006, live broadcasts and public viewing have became an integral part of our lives. Those soccer matches were watched simultaneously by millions of people in cities all over the world. STAN, the stereoscopic analyzer developed by the HHI in cooperation with KUK Filmproduktion, is a useful aid when it comes to recording and transmitting three-dimensional data in real time. The system's combined hardware and software records and analyzes stereo images in such a way that they can be processed in real time. The integrated feedback loop sends the values calibrated for the shooting sequence directly to the cameras, so that any errors or incorrect settings can be detected and rectified in real time.

But, as Stephan Gick acknowledges, the real jewel in the crown of the PRIME project is its ongoing work on a rig for producing 3-D panoramas, which is also keeping HHI researchers busy. They have already been able to demonstrate the initial results in a showroom in Berlin. Gick marvels: "A 180-degree, 3-D panorama – now that's a first."

So, whether for the movie theater or television, work on the third dimension is proceeding apace. Gick is convinced of future success, and says: "2010 is definitely the year. We'll be able to buy 3-D TVs with active shutter glasses and new Blu-ray 3-D players for use in the home. However, we may have to wait a little longer for 3-D TV, because as yet we don't have the necessary infrastructure to transmit the signals." He also believes it may be a while before we can enjoy 3-D viewing without the need for polarization or shutter glasses: "Although suitable 3-D displays are already out there, their quality is not particularly good. That said, glassless technology is undoubtedly a promising alternative and will supersede glass systems in the long run, at least when it comes to home viewing." For the time being, then, it seems we soccer fans will just have to continue watching our matches kitted out with club scarf, flag and 3-D glasses! ■



Cultural heritage online

Just a few clicks, and you're on your way to accessing the works of art, literature, film and sound recordings found in roughly 30,000 German museums and collections - right from your home computer. In the future, the German Digital Library will make it all happen.

Text: Tim Schröder

The German Digital Library (DDB) will open online access to art, culture and scientific information to all people.
© *Hagen, Gerhard/arturimages*

Michelangelo's statue of David is well-known and hundreds of photographs can be found of it – especially on the Internet. Lesser known art treasures are consigned to suffer the existence of a forgotten stepchild. Slumbering under lock-and-key, figuratively speaking, are the countless millions of forgotten children in Germany's museums, archives and libraries: the books, documents and art treasures in exhibitions and reading rooms closed to the general public. While cultural and scientific institutions have begun to digitize portions of their inventories in order to present them to a broader public on the Internet, yet a majority remain concealed in the storage rooms of cultural institutes. So for art aficionados and the art-curious alike, it becomes immeasurably difficult to track down interesting objets d'arte, not to mention viewing or to studying them on a home computer.

And that's precisely what arguably one of the most challenging cultural projects in German history is going to make possible: The German Digital Library (DDB), the collective brainchild of experts from research institutions, foundations and government offices. If everything runs according to plan, then starting in the year 2011, a tool will gradually evolve that will provide access from home computers to the artworks, literature, film and sound recordings of roughly 30,000 German museums and collections.

No matter if a history teacher is looking for viewing material for his students, or an art scholar is tracking down original literature for her dissertation on the 30 Years' War: users will be able to retrieve the objects directly on their home computer screens and work with them there. "DDB will be much, much more than an ordinary online catalogue that just tells you where to find a book or work of art, and not deliver any further information," says Thomas Tikwinski, business computer scientist at the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS in Saint Augustin, which was entrusted with the technical implementation of the DDB by officials at the federal ministry for culture and media.

Of course, visitors can still rummage through the stacks of the DDB the old-fashioned way, with key words. But this library will be capable of much more. Experts and lay people will equally be able to use the DDB as an Internet forum, for instance, where information and ideas can be exchanged about technical aspects. Various authors will be able to upload written contributions, that can be reviewed and enhanced by multiple users just like online encyclopedias. Tikwinski: "This should stimulate vigorous discourse that can be tremendously enhanced by the knowledge of lay people, who cannot ordinarily publish in technical journals." The DDB itself is not a commercial facility, but it is absolutely intended to link users with third party providers - publishers, for instance, who at the customer's request can compile a customized volume of art by Caspar David Friedrich or Otto Dix through the DDB archive.

Everyday research tool

"Anything is conceivable," says Tikwinski. "DDB should be at once an everyday research tool that you can use for recreational researching, for ordinary browsing or for a completely targeted search." Currently, Tikwinski and his colleagues are specifying what exactly the DDB should be offering in the future - thereby defining this technical tool. "We won't reinvent the wheel for this. Instead, wherever possible, we'll use software systems that have already been developed." The challenge is in constructing a powerful total system that should be able to access approximately 350 million digitized books, written documents, musical pieces or objects, intelligently and within seconds.

The IAIS researchers have divided the DDB project into three modules. Module 1 involves storing the data into the digital archive. Module 2 will answer the question of how the various services - such as the offers from third party suppliers or chat functions - can be integrated into the DDB. Then in Module 3, the actual website, with all of its input, search and service functions, will be fully developed. "At IAIS, we have experts working on all of these different aspects," says Tikwinski. "That constitutes our collective know-how." The actual high-grade digital works will not be stored in the DDB; these remain under the sovereignty of the museums or collections. Therefore, in one DDB module the methods are being created to bundle and organize Internet-viable copies of these digital originals. The integration of external suppliers is also currently in the works.

The centerpiece of a digital system like this is an intelligent search function that detects the desired object without error. Until now, search machines locate information on the Internet based on metadata. These are tables that contain specific key words - like names or anniversaries - together with instructions on where to find the associated information. But there is still a weak point at the nexus between these metadata sets. The average search machine today still cannot fully comprehend complex connections like "when and where did Friedrich Schiller write his first work?" New search strategies should be put to use in the DDB that can virtually link metadata with each other. This entails processes that were engineered over the past few years in the "Theseus" research program, in which German companies, scientists and the Fraunhofer Gesellschaft worked together on methods for an efficient Internet search in text, image and sound.

"The results from Theseus indicate what is already possible." So for instance, a computer software can automatically detect speakers in radio broadcasts and plays, and suggest other documents where the speaker with the pleasant voice can be heard. Other algorithms automatically detect word groups in spoken texts and can suggest works with similar content to users.

Mobile applicability, too

Some time ago, IAIS researchers worked out in a study which specifications the DDB could already meet. So it is conceivable to connect the DDB information stores to a cellphone with GPS localization function. Anyone travelling by car through Germany can activate the DDB function and the cellphone automatically delivers the information about sights that are rolling by in the distance.

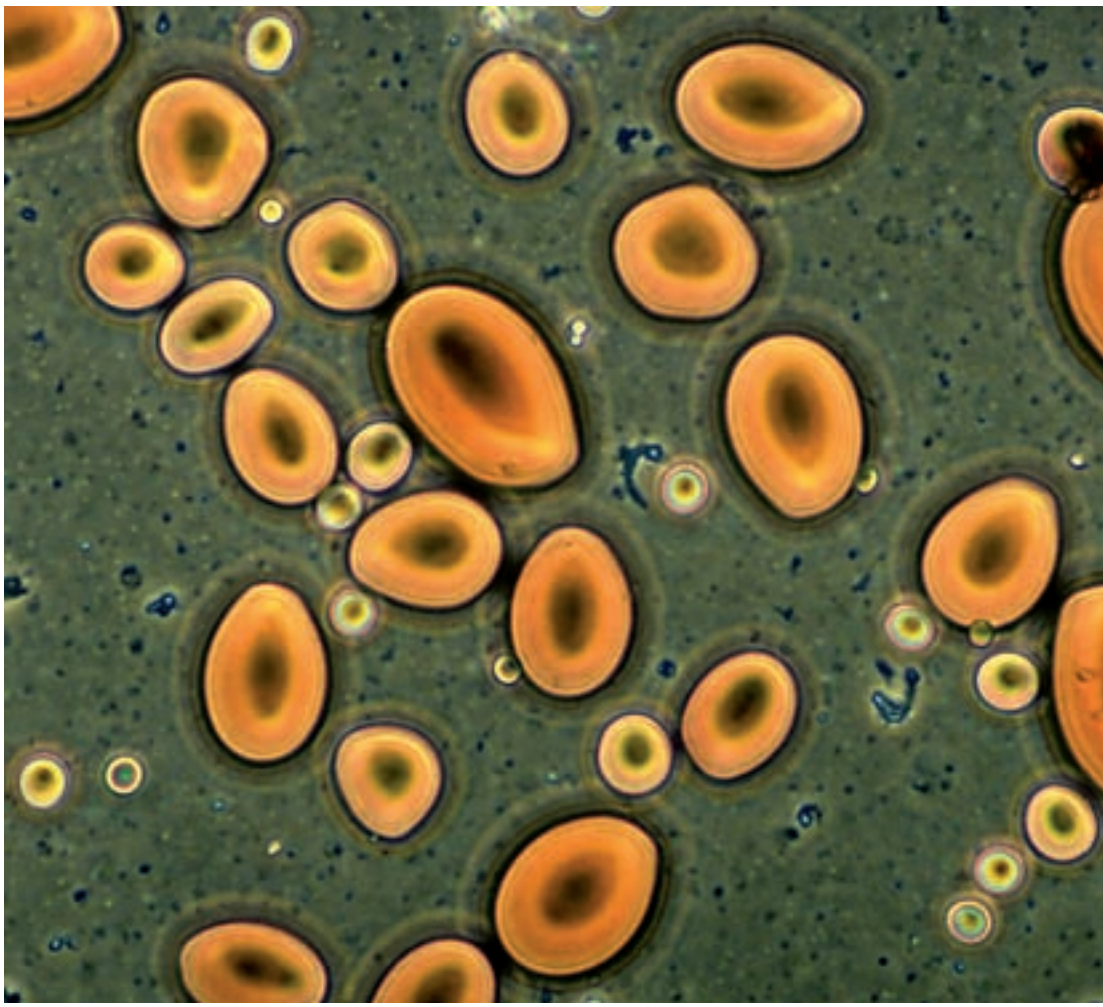
Countries like France or the Netherlands have already established national digital libraries. In addition, the European Digital Library "Europeana" was activated just recently. Here, you can search throughout all of Europe and find the "Mona Lisa" or Mozart's original handwritten Requiem. With the DDB, Germany will soon be making an impressive contribution to Europeana; indeed, it may be the only one of its kind at this time.

"I am unaware of any digital library before with so many functions and additional services like the ones slated for the DDB," says Tikwinski. Over the coming years, the infrastructure of the digital library will be complete. Thereafter, the collections and museums will be connected to the system step-by-step. ■

Lending a helping hand to evolution

Potatoes that contain only high-quality starches, soybean plants that withstand drought and tomatoes that thrive in saline soils - researchers have now developed a new method of cultivation that allows them to create plants with amazing properties. They call it turbo-evolution, and it has nothing to do with genetic engineering.

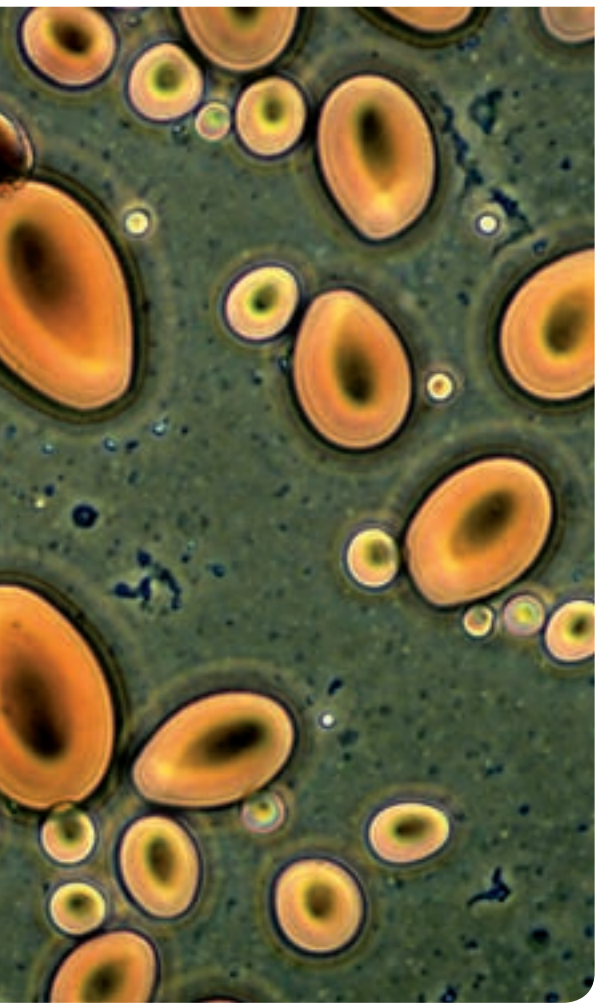
Text: Monika Weiner



The new super-potato, which produces high-purity amylopectin starch, has been welcomed by the industry. Each year, 500,000 metric tons of the substance are required (photo left). © *Fraunhofer IME*

Global warming is real – all the experts are agreed on that. But so far, no-one can say for certain exactly what consequences climate change will have on the different regions of the Earth. Precisely how far will the water level rise in the South Seas? How much more of Africa will be transformed into desert? How much hotter will average summer temperatures in Central Europe become, and how much more precipitation will fall? While scientists are busy employing elaborate simulation programs to make detailed predictions, farmers on the ground are already beginning to feel the effects of climate change in many areas of the world. Droughts and floods are depleting harvests, and in extreme circumstances, causing them to fail altogether. Time and again, traditional varieties of cereals and vegetables are proving incapable of withstanding current climate stresses.

If we left nature to take its course, plants and animals would gradually adapt to the changing conditions. Over millions of years, mutation – the term biologists use to refer to sudden changes in genetic make-up – and natural selection have repeatedly produced new species of plants and animals that are perfectly adapted to the prevailing environmental conditions. Species that are unable to adapt die out. Ultimately, all living and extinct species – from the



The new potato starch under the microscope: Here we see that the variety contains only one type of starch. It turns orange on reaction with iodine.
© *Fraunhofer IME*

humble alga to the cartilaginous fish, from the mighty dinosaur to man himself – owe their very existence to this combination of mutation and selection, or in other words, evolution.

But the evolutionary process is a slow one. And Homo sapiens – a species impatient by nature – are always keen to lend a helping hand. Even 10,000 years ago, when our forefathers gave up the nomadic life and established permanent settlements, they domesticated wolves and chickens, gathered wild cereals, and then selected the plumpest grains among them to sow the following year – in the hope that plump grains would produce a good harvest. The most faithful dogs and the strongest chickens were bred; the best cereal plants were propagated. Over generations, this approach gradually gave rise to obedient herding and guard dogs, chickens that were prolific layers, maize plants that produced sweet ears and good-sized potatoes. But that was just the beginning. Professor Dirk Prüfer of the Fraunhofer Institute for Molecular Biology and Applied Ecology IME says: "Growers began deliberately altering plant genomes as early as the first half of last century, using radioactive radiation and/or chemical mutation. In principle, these cultivation methods are really no different to the natural evolutionary process. In nature, sunlight triggers changes in genomes. With chemistry, we accomplish the same thing – only faster. We can use chemicals to shut off individual genes, and thus obtain a vast number of mutations very quickly."

This kind of turbo-evolution is referred to as TILLING, which stands for "Targeting Induced Local Lesions in Genomes". Growers have been using chemical mutagenesis to develop new plant varieties for decades. In the past, however, it would take a significant amount of time to find the desired mutation, because a treated seed gives no indication of what it harbors. "The growers had to plant the seeds and wait until the end of the growing period. It was only after the harvest that they could see whether one of the mutations had produced the desired result. Of course, the majority were completely undetectable, because it's only possible to see characteristics if they're dominant," explains Dr. Jost Muth, who helped to develop a new super-potato. Working in a laboratory, and without the need for lengthy field trials, he and his team succeeded in rooting out a seed that has the specific characteristics desired by the grower.

Customized cultivation – benefiting the starch industry

Sponsored by the Fachagentur Nachwachsende Rohstoffe (Agency for Renewable Resources) in Gülzow, the Fraunhofer researchers set about finding a potato that contains only the high-quality starch amylopectin. "Normally, potatoes produce both amylopectin and amylose, and the industry has to separate these two types of starch in a costly and energy-intensive process," says Muth. A potato containing only amylopectin would be a great boon to the industry – 500,000 metric tons of the high-quality starch are needed each year, as it is used for smoothing paper, sizing yarns and producing pastes and gelling agents.

TILLING for potatoes – no need for genetic engineering

In order to find this super-potato, the IME scientists examined leaf samples from 2,748 mutated seedlings. By analyzing the cell samples, they were eventually able to identify the seed with the genome that encodes for the production of amylopectin only. The growers then propagated this valuable seedling, and in the summer of 2009, the new potato was cultivated on a large scale for the very first time – 100 metric tons were harvested in the fall. The Emsland Group is currently processing the crop, and Muth reports: "Because TILLING potatoes are completely standard varieties that contain no genetically modified material, the new potato can be processed as normal on the production lines. No special provisions need to be made."

This example shows that a great deal can be achieved through cultivation. However, the prerequisite for both traditional and modern precision cultivation is that the gene responsible for the expression of the desired characteristic is already present in the plant, and known – like the gene for the production of amylose in potatoes. American growers are currently working on the development of drought-resistant soybeans, and scientists in the Netherlands are examining the genes of tomato plants that have been subjected to TILLING – their aim is to develop plants that will thrive in salt-laden soils. Potential new varieties could encourage farmers to bring more land under cultivation in the future, or enable them to continue growing crops despite ongoing climate change.

"However," says Prüfer, "one thing is perfectly clear. In many instances, TILLING will not and cannot replace genetic engineering. If we want to introduce foreign genes into a plant, for example in order to create a tobacco plant that will produce pharmacological agents, it is both essential and sensible to use genetic engineering methods to do this. But when it comes to dealing with genes, there's one rule we should all remember: As much modification as necessary, but as little as possible." ■

Healthier with lupines

Lupines bejewel gardens with their blossoms and enrich fields with organic nitrogen. But it doesn't stop there: The seeds of these legumes are rich in healthy proteins and dietary fibers. Prepared properly, they are just the right ingredients for making high-quality food products.

Text: Monika Offenberger

The seeds of lupines are nutritionally valuable.
© FAN/Eisele-Hein

"As for me, I also believe that if the farmer were to lose everything else, there is always the reliable lupine to come to the rescue." What the Roman scholar Columella wrote 2,000 years ago about the agricultural significance of the legume points to a highly common practice throughout antiquity: In ancient Greece and Italy, lupines were used as green manure and additionally used for livestock feed and medicine. And in the southern hemisphere, the benefits of these plants were appreciated in early history. So for example, the lupine was an important staple food to the Incas. But these aboriginal lupines contained considerable amounts of poisonous bitter substances - which severely limited their use as a food source.

By contrast, the sweet lupine varieties of today contain only 0.1 percent bitter substances. "And of this extremely low residual component, we can again remove more than 90 percent," says Dr. Katrin Hasenkopf of the Fraunhofer Institute for Process Engineering and Packaging IVV in Freising. The extraction of irritant content and taste substances, however, is just one of several tasks for which the processing techniques adapted at IVV were developed. At the forefront is the gentle extraction of components, like functional protein isolates and dietary fiber concentrates, that are high quality in terms of nutrition physiology. The latter in particular can benefit those consumers who are not especially fond of the conventional high fiber food sources – in other words: whole-grain products. Because the fibers of the legume are not as rough and dry as cereal fibers, and provide for an orally appealing texture.

Extracting and processing proteins meticulously

"At first, we were primarily interested in the proteins. We wanted to make them useable for different food recipes," recalls Hasenkopf. Through special extraction and filtration processes, through the gentlest drying process possible and also through modifications, such as by the controlled enzymatic cleavage of the proteins, or their crosslinking: IVV researchers achieved a targeted influence on the important functions of the lupine proteins, such as solubility, emulsification and foaming. This "tailoring" of lupine proteins opens up an extraordinarily broad range of potential for food production: In cakes, biscuits and waffles as well as in mayonnaise and dressing-type delicatessen products, these vegetable protein isolates can substitute for whole egg or egg yolks either partially or entirely.

To produce foamed confectionary, like marshmallows, waffles and praline fillings as well as cream-foam foods, quark-based and yoghurt-based desserts, they are perfect whipping substitutes to replace egg whites. And even cooked and boiled sausages can be made with a reduced proportion of animal proteins without compromising taste, aroma or appearance.

Isolated lupine proteins not only possess superior technological properties, they are also neutral in taste and more cost-efficient than proteins of animal origin. Added to this long

list of pros is another positive that makes these legumes increasingly appealing as a raw material for foods: They lower cholesterol levels, and therefore may help in the prevention of vascular disease - as indicated by the results of a research collaboration between the IVV and the University of Halle-Wittenberg, funded by the federal ministry of economics. "Our partners in Halle were able to demonstrate that lupine proteins lower the concentration of undesirable triglycerides and LDL cholesterol in the blood of rats, while desired HDL cholesterol stays the same," explains Hasenkopf.

Positive effect with elevated blood lipid values

Lupine proteins also have similar positive effects on the relationship between LDL and HDL cholesterol in humans with slightly elevated blood lipid levels, as Gabriele Stangl, professor for human nutrition at the University of Halle-Wittenberg, was able to prove. Among men, this effect leads to a decline in LDL cholesterol first and foremost; among women, the effect is more of an increase in HDL cholesterol. With mice, which are especially susceptible to arteriosclerosis due to a gene defect, another effect was shown: The calcification of blood vessels advanced markedly slower if they were fed lupine proteins instead of the animal protein casein.

Yet while the proteins from lupine seeds helped cause a reduction in blood lipid levels, the dietary fiber that they contain also played a role here as well. This is substantiated by a joint research project on functional nutritional research funded by the federal ministry for education and research, with the IVV, numerous food manufacturers and the University of Jena participating. In the course of this project, Jena-based nutritional scientist, Anita Fechner, headed a clinical study of 60 men and women in their senior years with slightly elevated blood lipid levels, who received three different diets each for four week periods with a one week break in between.

The foods chosen - including boiled sausage and cold cuts, vegetable burgers, flatbread, baguettes and tortellini with different fillings and sauces – were specially manufactured by the industrial partners, and either contained no added dietary fibers or those from lupines or citrus fruits. "The study substantiated a clear connection between the fiber source and the blood lipid level of the study participants," says Hasenkopf. "If the test subjects had eaten lupine fibers, they showed lower levels of unwanted triglycerides and LDL cholesterol in their blood - and also significantly less than the group given a control diet with citrus fiber."

These medically significant connections will now be examined in greater depth within the framework of another research project with the Universities of Jena and Halle, according to Hasenkopf: "In addition, we want to clarify the mechanism behind the cholesterol-lowering effect of the lupine proteins. We at IVV will break down the protein mixture further, so that our cooperation partners can test the various components on an animal model. Beyond this, protein-rich foods are developed whose efficacy should be shown in a clinical study." ■

Intelligent crutch

Contact: Dr.-Ing. Jan Stallkamp
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How much weight can the injured leg bear? An intelligent crutch from the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart provides precise information during the rehabilitation process. Research scientists at the Institute integrated a multimodal sensor system in a commercially available walking aid. This enables the supporting forces, movements and accelerations to be precisely measured and correlated.

In cooperation with colleagues at the University Hospital of Tübingen, the scientists are working on the 'Walking Officer', which generates diagnostic information for the physiotherapist and warns the patient if they are putting too much or too little weight on the crutch. Orthopedists and physiotherapists at the University Hospital will now test the prototype in practice.

An intelligent crutch will assist patients in their r ehabilitation process. © *MEV*

Optical microscopic examination of sawn silicon wafer surfaces. © *Fraunhofer IWM*

Wafer-thin sawing

Contact: Dr. Rainer Kübler,
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Like an egg slicer the filigree wire – wetted with a sort of grinding paste – cuts through a block of silicon. At a speed of up to 60 kilometers per hour extremely thin wafers, which form the basis of solar cells, for example, are sawn from the block. The technique has one disadvantage: when wafers with a thickness of just 180 micrometers are cut, an equal amount of waste material arises. This means that only half of the valuable material can actually be used.

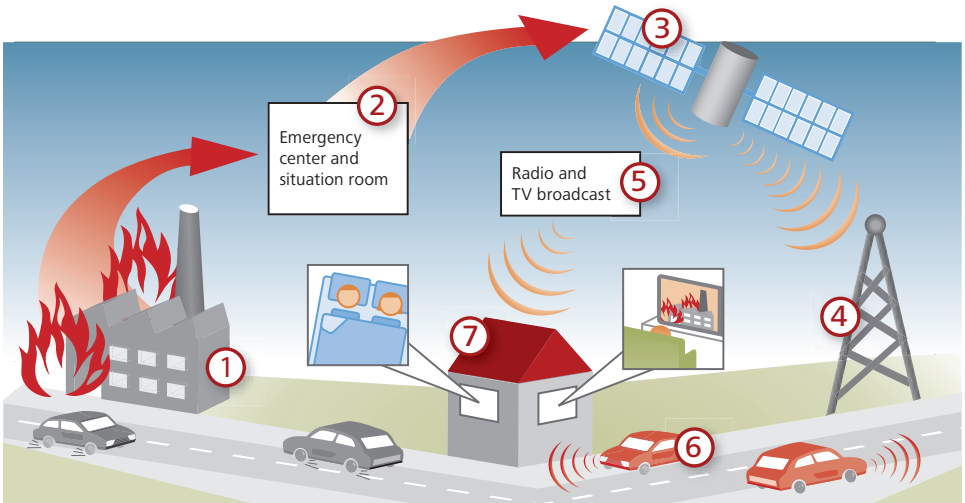
Research scientists at the Fraunhofer Institute for Mechanics of Materials IWM in Freiburg are now conducting work on reducing the saw gap width in order to cut the amount of waste. To this end, all the production parameters must be optimally harmonized. In a project financed by the German Environment Ministry (BMU) the scientists are examining the material-removal mechanism using a single-wire saw and are conducting computer simulations. They are currently achieving gap widths of 90 micrometers, which means that the amount of waste material is reduced by half.

Carbon footprint of packaging

Contact: Dr. Kathrin Hesse, kathrin.hesse@iml.fraunhofer.de

Is the packaging for the product environmentally friendly? How much greenhouse gas is caused by its production, distribution and disposal? These and other questions are being examined by research scientists at the Fraunhofer Institute for Material Flow and Logistics IML, who are determining the carbon footprint of packaging. Lighter materials and the use of recycled materials can significantly reduce CO_2 emissions.

For the company Henkel the experts have already examined the environmental impact of various types of packaging used for detergents and cleaning agents.



1. Fire breaks out in a factory
2. The emergency center and situation room activates an alarm
3. The SatWaS satellite system deployed by the Federal Office for Civil Protection and Disaster Response currently distributes information and in the future will activate warning systems
4. Vehicle alarms are activated via the radio network
5. Radio and TV broadcast instructions to the population
6. Only horns in parked cars are activated
7. Residents are alerted and can get further information on the radio and on TV

© Source: Fraunhofer/SÜDKURIER Medienhaus

New public warning

In the past, sirens would howl to alert the population of floods, large fires or chemical accidents. Today, however, Germany lacks an extensive warning system, as most sirens were dismantled after the Cold War. Researchers at the Fraunhofer Institute for Technological Trend Analysis INT in Euskirchen are now aiming to use car horns as public alarms in future.

Text: Stefanie Heyduck

In Batman's hometown of Gotham City, a gigantic searchlight projects the Bat Signal into the sky whenever disaster strikes, calling the superhero to action and alerting the population. In Germany, an extensive network of sirens once warned the population of disasters such as forest fires, industrial accidents or imminent flooding. Civil protection agencies triggered unmistakable sirens, while detailed information was broadcast by radio and television. However, in the mid-nineties, after the end of the Cold War, most sirens were dismantled and replaced by the satellite-based warning system, SatWaS, leaving the population with only the radio and television as sources for public warnings in case of emergency. The disadvantage is that when TVs and radios are switched off, any such warning goes unheard.

In recent years various individual solutions for warning systems have been explored, including cell-broadcast systems that send mass SMS messages to mobile phones. Smoke detectors in buildings, radio-controlled clocks and weather stations equipped with radio receivers can also serve as components of public warning systems. Yet while these devices are in wide circulation, they can not ensure that warnings will reach the entire population. Such systems are only suitable for alerting individual persons and households, and only providing the devices are on standby 24/7/365. Today's fire brigades and disaster protection agencies would ideally have the sirens back. However, the resulting costs would amount to several 100 million Euros for German federal and state governments, who share responsibility for civil protection.

Car horns to sound public

In 2009 researchers at the INT submitted a patent application for a technology which allows the horns of parked cars to be activated in case of disaster. The technology is based on the European eCall emergency system. An initiative by the EU commission to reduce the number of road traffic fatalities stipulates that cars from September 2010 be equipped with an electronic module. It consists of a GPS sensor and a mobile phone component which can transmit data to an emergency call center, providing details of the time of the accident, the exact location of the vehicle and the direction of travel. The INT researchers have discovered that parts of this system can also be used as a public alert system. The GPS module allows each vehicle to check its own location.

Other components of the eCall system need not be used. In an emergency, alarm centers and situation rooms would send a signal to vehicles to the effect that any vehicle equipped with the alarm receiver, within the boundaries of a given GPS position and not in motion should start sounding its horn. As there is no feedback channel it is impossible to locate the vehicles – an important factor in terms of data protection law.

"All solutions suggested so far, such as mobile phones or smoke detectors, only inform the respective device user. You can only reach the entire population if 100% are equipped with these devices," explains Guido Huppertz, an engineer in the Technology Analyses and Forecasts TAV department working on the system, describing the advantages of using car horns. The INT suggestion has a clear statistical advantage: A mere 14% of the registered vehicles using their horns would already suffice to sound an area-wide alert. "If all new vehicles are equipped with eCall from the end of next year, the warning system may be ready for use after a set-up phase of two to four years," Huppertz predicts.

The new system is meant to complement rather than replace the other options, without substantial additional expenditure. "Investment is limited to the integration of a small electronic module into new vehicles," Huppertz explains. "As far as the authorities are concerned, the whole infrastructure is already in place." ■

Remote-controlled life-savers

Sensors, miniature aerial equipment and mobile robots will in the future provide emergency services with important information in the event of a catastrophe.

Text: Klaus Jacob

The quadrocopter should help tomorrow's emergency team to get an immediate overview of major accidents.
© *Steffen Jahn*

A gruesome image faced visitors at an exhibition hall in Karlsruhe in October. A mountain of debris – the remains of a collapsed building – was piled on the floor, a nearby Ford Fiesta demolished by the weight of the bricks. Amongst all the chaos lay a casualty – fortunately just a doll. This improvised scenario at the "Florian Trade Fair for Fire Brigades, Fire and Disaster Control" served a good purpose. It was meant to show how tomorrow's emergency services can quickly find and rescue casualties with the help of remote-controlled surveillance equipment: a robot the size of a wheelchair circles around the disaster site while a captive balloon and a lightweight remote-controlled aerial unit hovers above it. These vehicles, fitted with numerous sensors, belong to the Fraunhofer Institute for Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB in Karlsruhe.

The Fraunhofer experts are not only refining the sensors which rapidly check out a disaster site. They are working even harder on finding a sensible way to process the huge quantity of data that accumulates during coordinated surveillance. Quick information can mean the difference between life and death in the event of a catastrophe. Are there casualties? Where are they? Have poisonous or explosive gases been released? Can aid workers step on the rubble, without being at risk themselves from sliding rocks and stones? The people heading the operation need a clear picture quickly. On the other hand they don't want to be overwhelmed by data. "Too much information is as bad as too little", explains IOSB electrical engineer Thomas Partmann. The more surveillance equipment is in use, the greater the emphasis place on effective data processing. Firefighters and emergency services should only get to see what they really need – and understand it at first sight.

All equipment fits in a suitcase

The Fraunhofer researchers have come up with a clever way of achieving this goal through the coordinated operation of a wide variety of high-tech equipment. An "AMFIS" ground control station first collects and collates data from the different sensors. The monitor screens and keyboards fit into an easily portable suitcase the size of a piano keyboard. "AMFIS" combines reconnaissance and surveillance with miniature aerial vehicles and sensors. The "quadrocopter", an aerial vehicle reminiscent of a Frisbee, inspired the basic idea. With a diameter of around a meter it weighs just one kilogram and carries a maximum load capacity of 250 grams – enough to carry various cameras aloft. Four horizontal propellers, arranged in a square, provide the necessary lift. The ground control station can not only attend to several of these miniature aerial vehicles at the same time, it can also process data from other surveillance equipment – robots on wheels, mini submarines or balloons.

On Land, airborne or on the water

At the Karlsruhe Trade Fair the AMFIS ground control station gave an impressive demonstration of how it controlled the different vehicles and visually conveyed sensor data. On a monitor, for example, the casualty could be seen in dazzling color between the rubble. The infra-red camera employed to capture the image reacts to heat and is not impaired by thick fumes. The doll in this case was wrapped in a warm blanket. At a click of mouse the scenario on the monitor changed to show a high-resolution aerial picture of the area around the exhibition hall. Travelling on its pre-define flight path, the

quadrocopter had taken individual photos which the computer then fitted together to create the overall picture.

If the disaster zone is very large, such as in the case of an earthquake or a flood, a single aerial vehicle would not be able to produce an overall picture. The number of remote-controlled vehicles – whether on land, airborne or in the water – can be increased as required with the IOSB's equipment. This requires several ground control stations. The data from these is then passed on to the situation center, where the work of all the emergency teams is coordinated. The IOSB has again come up with a clever solution in the form of a "digital situation table with Fovea-Tablet." Despite its cumbersome name, this table simply refers to a large horizontal display, showing a map of the whole disaster zone. Yet it is ingenious: PC tablets (screens the size of an exercise book) can be moved randomly over it. As they pass over the map, the Fovea-Tablets show the respective sections underneath them in high resolution, acting as a magnifying glass. They can also be used, however, for additional functions, such as indicating water and gas mains, hydrants and other utilities. The digital situation table is also equipped with a large vertical monitor, onto which further information can be projected, such as the current weather map, the runoff characteristics of a swollen river or live images from the quadrocopter.

Electronics helps to save lives

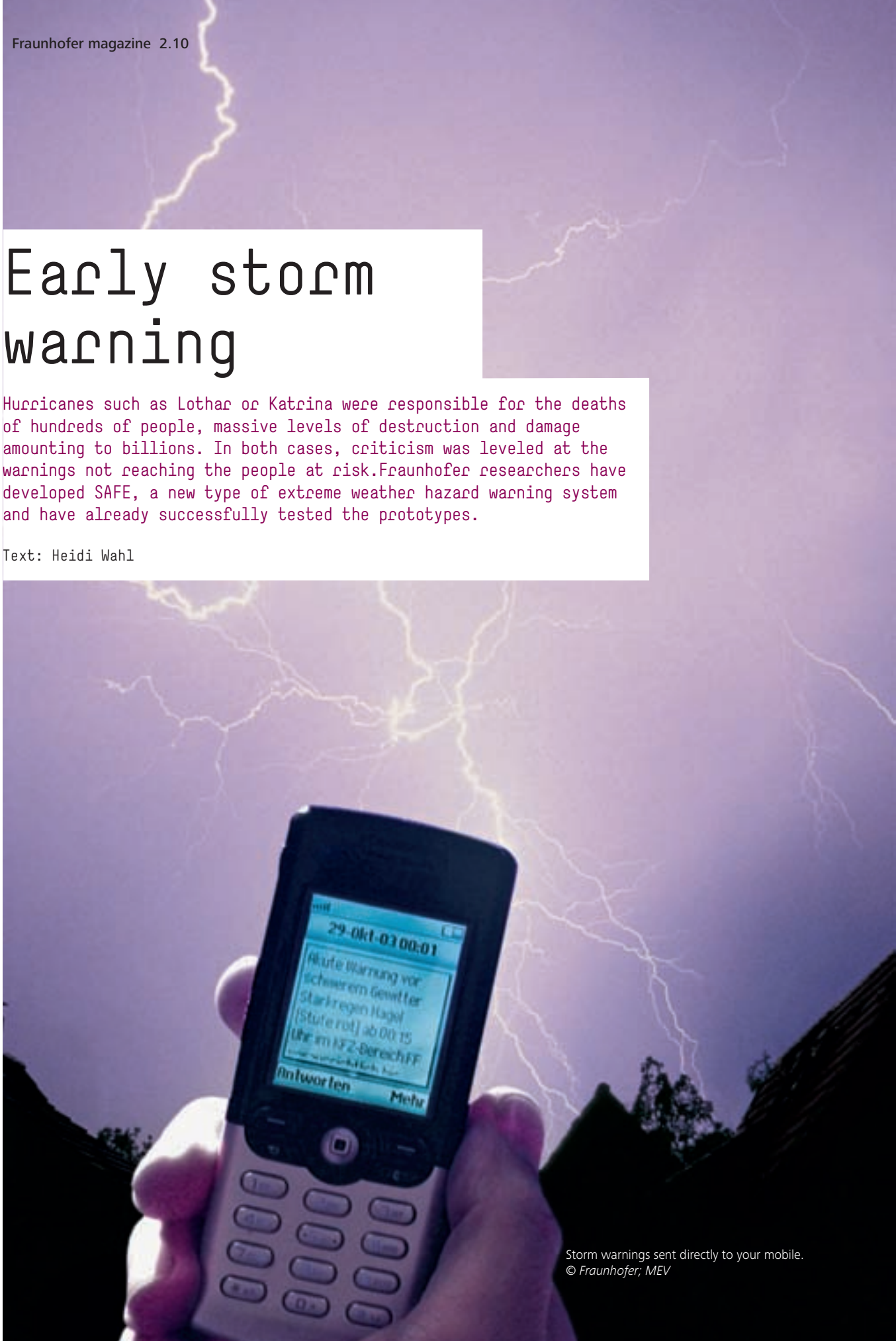
Again and again, disasters make headlines – as recently as the beginning of October an earthquake in Indonesia destroyed entire villages, whilst a flood in Sicily swept away a number of buildings. Germany, too, is exposed to the threat of floods and earthquakes. Aid workers can only now get a picture of the situation if they can see it with their own eyes. Electronics could help them to save lives. The IOSB's high-tech equipment is equally useful for other applications. The German armed forces already make use of the digital situation table and it might also soon assist surveillance at large sporting events and state visits. A downgraded version is sufficient for more straightforward deployments - involving only the AMFIS control station and its vehicle fleet fitted with sensors. If there is a fire, for example, the "AMROS" rolling robot (Autonomous Mulitsensorial RObot for Security applications) detects whether poisonous gases are escaping and whether there are still people in the smoke-filled building. Surveillance of company or private property is another field of activity, where the quadrocopter can detect intruders who soon find the AMROS robot hot on their heels. Thanks to its smart software - the "visual-optic shaft" - the robot always maintains the same distance from the intruder. "It sticks to the intruder like a limpet," says IOSB expert Thomas Müller.

Further work is still needed on some parts of the equipment. The sensor carriers employed also serve the purpose of developing the software further, since the AMROS robot is neither weatherproof nor off-road and must be aware of every step or stair. And a strong gust of wind will certainly knock the quadrocopter off-course. These vehicles are of course only intended as a platform for the further development of the software. The sensors, too, still require further research: even the best infrared camera will not find casualties completely buried in the rubble. As a possible alternative Thomas Partmann is considering a smell sensor that is as sensitive as a sniffer dog's nose, but doesn't need to stop for a break every ten minutes. Work is already underway on such a device. ■

Early storm warning

Hurricanes such as Lothar or Katrina were responsible for the deaths of hundreds of people, massive levels of destruction and damage amounting to billions. In both cases, criticism was leveled at the warnings not reaching the people at risk.Fraunhofer researchers have developed SAFE, a new type of extreme weather hazard warning system and have already successfully tested the prototypes.

Text: Heidi Wahl



Storm warnings sent directly to your mobile.
© Fraunhofer; MEV

The wind is getting perceptibly stronger as dark clouds gather overhead. In the middle of the afternoon, it feels as if the world is coming to an end. Bright flashes of lightning shoot through the sky, accompanied by more frequent rolls of thunder. A quarter of an hour later, squalls whip across the countryside, hailstorms mow down fields and heavy rains flood subways and cellars. After a few hours the horrific episode has passed, but the damage from the storm is enormous - fallen trees have crushed cars, workshops and houses stand exposed without roofs and entire tracts of forest have been devastated. Fortunate are the house owners and companies who insured their possessions against acts of nature, such as Hurricane Lothar in 1999, Hurricane Katrina in 2005) or Hurricane Kyrill in 2007.

Storms and hurricanes are occurring more frequently and are much more extreme, just one of the consequences of the now all-too-perceptible climate change. This is indicated by a fourteen-fold increase worldwide in damage insured against acts of nature, such as extreme weather, over the past 50 years. In Germany, for instance, damage caused between 1970 and 2007 amounted to around 42 billion euros.

"While there's obviously not much we can do to prevent storms ," explains Ulrich Meissen from the Fraunhofer Institute for Software and Systems Engineering ISST in Berlin, "in many cases collateral damage could be avoided or reduced, if the residents, public authorities and rescue services concerned were given advance warning and initiated appropriate protective measures." This is exactly where SAFE comes into play - a sensor-actuator-based early warning system for extreme weather conditions, developed under the leadership of Fraunhofer researchers with various project partners.

"The advantage of SAFE," explains Project Manager Meissen, "is that the system not only detects danger, but also immediately sets specific measures in motion. The prototype has been in use in Mering, Bavaria since October 2008 and showed what it was capable of under extreme weather conditions for the first time on 26 May 2009. We'll go back to that later, after a look at how it all began. When Hurricane Lothar struck south-west Germany in 1999, Meissen was in Munich. At the time he wondered, "whether it would be possible to use established methods to forecast more precisely the timing and strength of a storm at a given location." According to Meissen, who holds a degree in industrial engineering, there were only nationwide warning messages in those days; "But we wanted to create a storm warning system with postcode accuracy, one that would make sure the necessary information reached the right place at the right time with the help of modern information logistics."

Warnings by mobile, email or fax

The first step was accomplished in 2001 when, together with insurance companies and weather forecasting services, Meissen and his colleagues developed WIND (Weather Information on Demand). WIND now sends storm warnings via mobile phone, fax or email to around 430 000 users in Germany, Hungary, Poland and the Czech Republic at three warning levels – symbolized by their color. "Orange signifies a normal storm, red tells you it's more severe," explains Meissen. "And when it's violet you should stay at home, because that's a once-a-century event."

The accuracy of WIND forecasts is between 80 and 90 percent. Admittedly, established forecast methods can detect general storm dangers over a wide area 24 hours in advance, but it's difficult for meteorologists to predict exactly where and when, and with what force, the storm will hit. "People are unsettled each time they receive a false warning ," explains Meissen, "and their motivation to act weakens with time." The ISST researchers recognized the need to optimize the level of accuracy provided by the forecast methods, and SAFE was born. The place- and time-specific early warning system is based on a tight network of local weather sensors, forecast modules and distribution systems which communicate effectively between sensors and actuators, in combination with automated techniques that initiate processes to avert danger.

Meissen describes the pilot system in Mering: "We have a close-meshed protective screen of low-cost sensors, situated between two and five kilometers from one another, extending around the municipality." Together with radar and satellite data these local weather stations can predict specific local effects such as hail, wind speeds and heavy rain with far greater accuracy in terms of exactly when and where they will occur. As in the case of WIND, private residents, emergency services and companies taking part in SAFE are informed by email or mobile phone of meteorological developments, so that they can still take effective precautionary measures in good time, such as putting the car into the garage, or closing backflow air traps or shutters in cellars.

It's vitally important the information made available by early warning systems is received on the devices "people already have." Otherwise, according to Meissen, the system makes no sense. Together with his team, the deputy head of Location-based Services at ISST had to adapt information logistics to the needs of the users, creating situation-and location-based models. In Mering, residents receive individual warning messages by mobile, television or by email. SAFE's core feature, the information logistics platform, automatically sets precautionary mechanisms in motion when the sensor data has been evaluated and warning messages have been sent. "In buildings, for example, automatic roller blinds are raised and windows closed," explains Meissen, refering also to the second pilot location, Wacker Chemie AG in Burghausen.

Up-to-the-minute storm warnings

SAFE proved its worth on 26 May, 2009 in the market town of Mering. "The storm prediction was accurate to the minute," remembers Richard Sedlmeir. "We were able to secure our flower tubs in good time and let down the roller blinds." Sedlmeir is responsible for the municipality's EDP and internet services in Mering and helped to choose the locations for the SAFE sensors. As the local early warning system works well and the costs are reasonable, SAFE could be extended throughout Bavaria in the next few months. "We wanted to produce an intelligent, expandable and event-based concept, rather than a process model that would never be implemented," says Meissen, who is pleased about the positive feedback from Mering. Despite the intensive development work, however, there is still one thing that SAFE will never be able to do: stop storms. ■

The Fraunhofer lounge takes the form of a circular seating arrangement that encloses a space offering visitors an information console (including a digital guest book) and a display column. © *Jens Burde*

Center for new technologies

The Deutsche Museum in Munich has an exciting new attraction – the Center of New Technologies (ZNT) presents the latest in developments from the natural sciences and technology on an an ultra-modern platform. A permanent 600 sq.m. central exhibition takes a look at discoveries made in bio- and nanotechnologies and aims to further understanding of the process of scientific research. In doing so it addressesthe different standpoints and expectations of scientists, political representatives and society at large. Besides the permanent exhibition, other topics are grouped together and presented in clusters, or display 'islands'. The museum's partners are also showcased, including presentations by Germany's three large scientific organizations: the Helmholtz Association, the Max Planck Society and the Fraunhofer-Gesellschaft.

Fraunhofer has supported the creation of the Center for New Technologies with exhibits on five projects - "A Machine for Cell Programming" from the Fraunhofer Institute for Biomedical Engineering IBMT, "Process Engineering for Cell Cultures" from the Fraunhofer Institute for Facial Engineering and Biotechnology IGB, "EUV Technology for the Chips of Tomorrow" from the Fraunhofer Institute for Laser Technology ILT, "Molecular Recognition with Nanoparticles" from the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB, and "Ideas from the ORMOCER Kitchen of Materials" presented by the Fraunhofer Institute for Silicate Research ISC. In addition to various exhibits on the partner stand, the Fraunhofer-Gesellschaft also displays a repository of innovative materials.

The need for techniques in water management is great in China because many Rivers are polluted. Here the Changzhou. © *ZeBlackRider*

Developing technology for China

The Chinese metropolises have an enormous thirst: Beijing's almost 20 million people, for example, need water for drinking, showering and cleaning each day. Supplying this water is a challenge because the city is situated in the middle of a semi-desert. But new techniques in water management and water treatment can help ensure the supply even into the future. In his trip through China, Fraunhofer president Prof. Hans-Jörg Bullinger, accompanied by experts from six Fraunhofer institutes, discussed possibilities for sustainable development. One such discussion was with the Professor Wan Gang, Chinese minister of research. The Fraunhofer president also signed a number of Memorandums of Understanding involving Fraunhofer and Chinese partners.

Fraunhofer reinforces European innovation networks

Europe is growing together - including research and development. Within the European Union, there are several companies and scientific institutions that are developing new, highly important technologies. But the competition on the global market is immense. For European success in global competition, it is important to bundle strengths within the EU, and to implement as many research findings as possible into products and services with a viable future.

To accelerate the innovation process in a joint European research area, the European Commission founded the European Institute of Innovation and Technology (EIT). The initiative is being financed until 2013 with 308.7 million euro for the first phase. The goal of EIT is to advance European innovation policies. Teams of research institutions, universities, technology centers and companies are coming together as „knowledge and innovation communities" under one roof for each discipline. The first three scientific and innovation communities were recently selected: Sustainable energy, climate change, and the future of the information and communications society. Fraunhofer institutes are participants in all three networks.

Fraunhofer in Italy

In December 2009, the Fraunhofer-Gesellschaft established its third subsidiary in Europe: Fraunhofer Italia Research Konsortial-GmbH, domiciled in Bolzano. The South Tyrol Employers' Association is a partner with the new limited liability company.

The collaboration has already proven its value. Numerous Fraunhofer institutes are collaborating on research projects with partners in Italy. "Italy is one of Europe's largest national economies, so it is strategically significant as a partner nation," explains Dr. Georg Rosenfeld, head of the corporate development department at Fraunhofer. "By establishing the Fraunhofer Italia subsidiary, Fraunhofer now has a new platform available which will considerably facilitate the establishment of additional branches in the future." Like the Fraunhofer-Gesellschaft in Germany, Fraunhofer Italia will operate as an umbrella organization for various Fraunhofer Research Institutions.

The first Fraunhofer Research Institution in Italy is the "Fraunhofer Innovation Engineering Center IEC" in Bolzano, which is currently organized by the Fraunhofer Institute for Industrial Engineering IAO, together with the South Tyrol Employers' Association and with the support of the Free University of Bolzano. The Center is primarily intended to support the numerous small- to medium-sized enterprises located in the Bolzano region that until now have had almost no access to applied research. "We view ourselves as an interface to the vast array of offerings from the Fraunhofer-Gesellschaft," explains Prof. Dominik Matt, who will assume the management of the new Fraunhofer Center. The mechanical engineer, who earned his doctoral degree under the mentorship of Professor Dieter Spath, head of the IAO, was appointed to the Turin Institute of Technology in 2004, and then to the Faculty for Natural Sciences and Technology of the Free University of Bolzano in 2008.

The first Fraunhofer reseach unit of Fraunhofer Italia will be the Fraunhofer Innovation Engineering Center IEC in Bozen. © *Norbert Eisele-Hein*

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