Pictures of the Future

The Magazine for Research and Innovation | Fall 2012

www.siemens.com/pof

SIEMENS

Solutions for Tomorrow's World

The Energy Puzzle

The evolving transition to renewables

The Internet of Things

Birth of an automated economy

Technologies that Touch Lives

Developing what people really need

The Puzzle of our Energy Future

Achim Steiner is UN Under-Secretary General and Executive Director of the UN Environment Programme (UNEP)

Imagine a world of endless, cheap electricity powered by solar systems mimicking the way plants harness sunlight to photosynthesize — a world, like nature, where carbon dioxide is no longer a pollutant but a key component of the fuels needed to drive this energy revolution.

Across the globe, research teams are moving ever closer to this vision. Just recently a group at the Massachusetts Institute of Technology announced they had found a very simple way to extract photosynthetic materials from old grass clippings and agricultural wastes. The mixture, supported by a network of nanowires, can be 'painted' onto roof tops and other structures to generate electricity, especially in remote, off-grid locations. The big challenge is to now significantly boost the efficiency of such emerging technologies.

MIT is not alone in pursuing such pathways. From Germany, Japan, the Netherlands, Sweden and the UK to Brazil, China and Singapore a myriad of technological research programs are underway to transform our energy systems and thus guide us to a more sustainable energy future.

There can be no doubt about the urgency of the need to act. Energy-related carbon dioxide emissions from fossil fuel burning, which need to begin falling by around 2020 if the world is to avoid dangerous levels of climate change, climbed by three per cent to an unprecedented 31.6 billion tonnes in 2011.

Meanwhile, around 1.3 billion people are without access to electricity and some 2.7 billion are without access to clean cooking facilities, mainly in the developing world, including sub-Saharan Africa. This is not just a challenge to development and eradicating poverty — air pollution linked to fossil fuel burning from cars and trucks to power plants and stoves kills up to six million people each year.

While the world will continue to consume fossil fuels, there is an urgent need to shift towards alternative forms of energy and to make better use of the fossil fuels used, including through significant improvements in energy efficiency in power production, transmission and usage in buildings, and industry and transportation. Many measures have to be taken that must fit together like the pieces of a puzzle.

Nevertheless, the world is not starting from ground zero. The latest assessment of investments in clean energy, coordinated by UNEP, Bloomberg New Energy Finance, and the Frankfurt School of Finance and Management, shows that in 2011 $257 billion was invested in renewables, up 17 per cent from 2010. Indeed, this figure was higher than its counterpart for new investment in fossil fuels, and more people are now employed in the clean energy sector than in the fossil fuel industry. Much of this growth has been driven by the targets and timetables under the UN climate convention and its Kyoto Protocol, which are allied with creative public policies by an increasing number of nations.

Kenya, UNEP's host country, is seeing a boom in both wind and geothermal generation after replicating Germany's feed-in tariff. The largest wind farm in sub-Saharan Africa is about to be built in Turkana — one of Kenya's poorest regions — and geothermal generation is growing there as part of an overall goal of generating 5,000 MW by 2030.

Other sustainability factors are coming into play. South Africa, for example, is looking to solar power as a water-saving measure. Limited freshwater supplies will be challenged by coal and nuclear power and their cooling requirements. Solar PV parks, on the other hand, require minimal water to operate, except for washing the panels' surfaces.

Formidable challenges to our energy future remain, including more than $600 billion worth of fossil fuel subsides. Countries such as Ghana, Indonesia and Iran are moving to phase out such subsidies and others should consider the opportunities. Transparency, governance, exchange rates, and up-front costs are all areas that need to be addressed by international and bilateral donors. The development of smart, regional grids able to manage power from large to small power sources in a seamless way will also be essential.

The Future of Energy (see pages 8-39 in this edition of *Pictures of the Future*) goes to the heart of a Green Economy and whether societies can achieve a sustainable 21st century. Wind, both on shore and off shore, solar, geothermal, and now wave and tidal systems, are growing globally, and fuel cells, electric drives and other technological breakthroughs for vehicles are no longer a novelty.

Maintaining research and development while supporting smart policies and creative finance will also be essential. Maybe one day photosynthesis will not only produce our food and beautify our landscapes with trees, shrubs and flowers. It may also reveal how mimicking nature can meet one of the biggest challenges seven billion people, rising to over nine billion by 2050, will face.

Cover: Curiosity, which landed on Mars in August, was the most complex project in NASA's history. All of it, including its landing, was developed and tested using Siemens design and simulation software. For more, see page 55. Image courtesy of NASA/JPL-Caltech

The Energy Puzzle

The Internet of Things

Technologies that Touch Lives

Features

The world's longest windmill rotor blade heads for testing in Österild, Denmark.

Skilled Truckers Needed!

Siemens' newest rotor blade is 75 meters long — a world record. The gigantic rotor blades, which are made from glass fiber and balsa wood, will be used in the latest generation of windmills, which boast an output of six megawatts (MW). A wind turbine's energy yield depends on the area swept by its rotor blades as they rotate. In the case of the new Siemens rotor, that amounts to some 18,600 square meters, the equivalent of around two-and-a-half soccer fields. The blades will be tested in Österild, Denmark, on the latest prototype for the 6 MW machines. To this end, the giants were driven 320 kilometers from the port city of Esbjerg in Denmark by trucks that were 85 meters in length. The trip took up to eight hours because the trucks were limited to a maximum speed of 60 kilometers per hour due to their 25 ton cargoes. Transporting the huge rotor blades was not only a technological and logistical challenge; it also required all the skills the truck drivers could muster. There were several tricky sections along the route. The trucks had to navigate their way around nine traffic circles. Along the way, six light poles and 11 traffic signs had to be removed so that the trucks could pass. Wind turbine components also have to travel long distances in Asia (see p.22). In fact, in one case, manufactured components are shipped all the way from China to Thailand. On arrival at a port south of Bangkok, they are then transported 450 kilometers by truck to the northern city of Korat, where 90 Siemens wind turbines are being installed. As the largest road freight delivery in Thailand's history, this trip is also unique.

Components are driven 450 kilometers through Thailand.

Drones can keep chronological tabs on construction sites.

Eye in the Sky above Vienna

Siemens Corporate Technology (CT) is using a new imaging technique to document progress in the Aspern lakeside construction project in Vienna, Austria. Developed by CT researchers from the Sustainable Cities lighthouse project, the technique makes it possible to photogrammetrically analyze construction sites, buildings and infrastructure projects from above, thus optimizing processes and saving time and money. Up until now, such sites have either been surveyed at ground level — for example, using laser scanners — or monitored with webcams. In order to analyze a future system that will document construction phases, the research team recently conducted a test flight using a small drone. Its camera took photos of the southern section of the Aspern site and of all sides of a building being built there. The collected data will form the basis of a photogrammetric, chronological analysis that can be used to create a 3D model. The model will then be combined with planning and logistics data, resulting in a hybrid model that can be referred to for a range of questions. The system is not only suitable for external areas, but can be applied to overall condition evaluation, maintenance, and service of interiors as well.

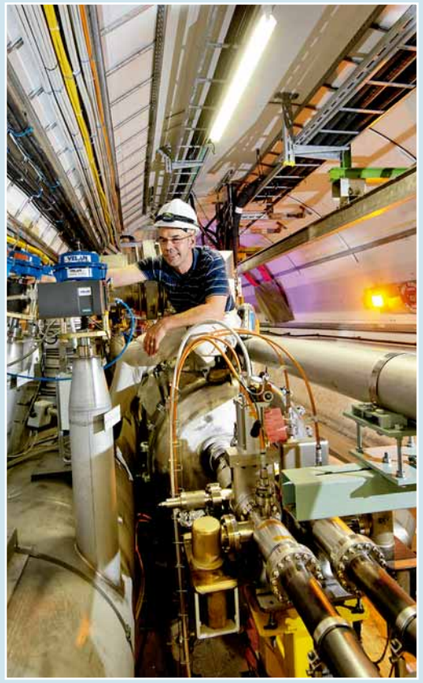
Trackside Stethoscope

Trains need to be as safe and reliable as possible. Wheelsets are often a problem because they are particularly susceptible to defects and wear and tear. In cooperation with Track IQ of Kent Town, South Australia, Siemens has developed a monitoring device known as Rail BAM (Rail Bearing Acoustic Monitor) that can detect damage to wheelsets at an early stage. Perhaps it would be more accurate to say that the device "hears" rather than detects damage. After all, it consists not only of signal processing electronics housed in cases at the side of the tracks but also sound-wave sensors mounted on railroad ties. The sensors record the sound waves from passing trains. These are sent to a processor that compares the signals with predefined target patterns. The processor immediately reports acoustic deviations that indicate wear or a defective component. If an anomaly is detected, the train in question can later be brought to a repair yard without interruption to normal service. The system is currently being used near Southampton, in the United Kingdom.

Tracking wheels with a Rail Bearing Acoustic Monitor.

Icy Path to the Secret of Mass

What is probably the world's largest research machine is located at CERN in Geneva, Switzerland. The goal of the CERN research center is to discover and study new particles. The facility's centerpiece is the Large Hadron Collider (LHC) particle accelerator, which is 27 kilometers long and housed in a tunnel system 100 meters below ground. The LHC causes protons to collide at near-light speeds. On July 4, 2012, LHC researchers discovered a new particle that is 133 times heavier than a proton. They believe their discovery could be the Higgs boson — a particle that physicists have been trying to find for 50 years. The Higgs boson could explain why elementary particles possess mass. Trying to detect this particle during collisions was like looking for a pair of sand grains with specific properties in an Olympic-sized swimming pool full of sand. For their experiments, scientists need to use powerful magnets that are chilled to minus 271 degrees Celsius with superfluid helium. To precisely regulate the helium distribution using special valves, Siemens developed a totally new automation system with 1,800 individual controllers. It will also be used with the giant ATLAS detector, which is as big as a church nave.



Magnets at CERN stay cool thanks to Siemens automation.

Driving the Advent of Hydrogen Filling Stations

In September 2012, Siemens joined Europe's most extensive demonstration project in the area of hydrogen mobility: the Clean Energy Partnership. Siemens' role in the project, which includes leading industrial companies, will be to equip hydrogen filling stations for vehicles with an electrolysis system based on proton exchange membrane (PEM) technology (see *Pictures of the Future*, Spring 2012, p.100). Electrolysis is the process by which electricity is used to split water into hydrogen and oxygen. Siemens' electrolyzer works much faster than conventional systems. It can react to changes in the availability of electricity in milliseconds. The Siemens system supplies clean hydrogen gas, meaning at least half of the material is produced using electricity generated from renewable sources. Siemens will supply its PEM electrolyzer to one of the 50 filling stations now being set up as part of a German government program.

Testing a PEM-equipped electrolyzer at Siemens.

A pump, a couple of small tubes and, of course, water — that's about all it takes to explain the principle behind a pumped storage electrical power station.

With teddy bears as patients, young visitors were able to discover first hand how doctors use minimally invasive navigation techniques to perform heart procedures.

The world's most efficient gas turbine power plant looks pretty small here. But in real life, the 13-meter-long gas turbine achieves an efficiency of more than 60 percent in tandem with a steam turbine.

Technology You Can Touch

Getting young people interested in technology is essential for our society. That's why the IdeaPark in Essen allowed visitors of all ages to experience technology up close over a 13-day period.

Some 320,000 people flocked to Essen, Germany in August 2012 to experience the IdeaPark, an event with over 400 experiments and exhibits from the world of technology. The IdeaPark was organized by ThyssenKrupp AG in conjunction with the state of North Rhine-Westphalia and more than 200 research, science, education, and business partners.

Siemens was also on hand with 25 presentations, which made it one of the biggest exhibitors. Visitors were able to enjoy a wide range of highlights. They included state-of-the-art mobility solutions, experiments with living cells, environmental technology systems, a presentation of technological milestones, and energy supply systems that will pave the way for Germany's energy transition. Visitors also received answers to questions such as: How do you build a wind power plant and how much electricity does it generate? How do surgeons use minimally invasive navigation to conduct operations more quickly and safely? What does it feel like to be at the controls of a train traveling at 300 km/h?

By putting around 70 trainees and students in charge of its exhibits and experiments, Siemens attracted many young visitors who were interested in careers in science and technology. The IdeaPark also featured the first-ever youth issue of *Pictures of the Future,* which is oriented to teenagers over 14 years of age (see *www.siemens.de/yourpof,* in German).

■ *Nicole Elflein*

The "magic mirror," which was developed in cooperation with the Technical University of Munich, overlays real and virtual images of the body — in this case the body of Germany's Economics Minister, Philipp Rösler. Such systems will facilitate the work of surgeons in the future by enabling them to use hand gestures to change the patient images they see on screen during an operation.

Klaus Helmrich, Chief Technology Officer and a Siemens Board Member (right), learns about an electric vehicle built by Dual Bachelor program students at Siemens' Technology Academy in Berlin.

Siemens' exhibition at Rio+20, where students led by a Siemens engineer built a wind power plant. Some 300 Osram LEDs bathed Rio's "Christ the Redeemer" statue in a green glow.

Optimism at Rio+20? Yes!

Is it possible to reach a globally binding agreement on sustainability during a period of economic uncertainty? That was the big question at the 2012 Earth Summit in Rio de Janeiro.

In 1992 an agreement was signed by participants at the Rio Earth Summit. Now, 20 years later, more than 44,000 representatives from governments, non-governmental organizations (NGOs), and the business world have discussed a possible follow-up agreement at the same location. In addition to organizing numerous activities, Siemens also presented a "Technology in Action" exhibition at a shared United Nations Environment Program (UNEP) pavilion. Siemens is a partner of UNEP, which has called for the establishment of a Green Economy (see UNEP Director Achim Steiner's commentary on p.2).

Negotiations at Rio+20 quickly revealed that conflicts of interest would make it impossible to reach any major inter-governmental agreements. The NGOs and the private sector will therefore have to play an increasingly important role if the objective of a green economy is to be achieved. Some companies are already taking action. At its exhibition, Siemens showed how economic growth and environmental efficiency can be two sides of the same coin — for example, by pointing out how efficient power plants generate more electricity than conventional units using the same amount of primary energy. This reduces CO_2 emissions and increases power plant operators' returns. Intelligent infrastructure can be used to solve traffic and logistics problems in cities, while conserving resources. Cities then become more attractive to residents and commercial enterprises alike. Targeted government regulation can create economic incentives for developing and expanding the use of efficient technologies. Many of the required technologies already exist; they just need to be implemented consistently.

Nor does all of this apply just to industrialized nations. In the "Technology in Action" exhibition, which was organized in cooperation with the Siemens Foundation, 11 organizations from developing countries and emerging markets presented concepts and demonstrated successful projects. Simple innovations adapted to local requirements help solve problems related to issues such as energy and drinking water supplies. WindEmpowerment, for example, is an organization that teaches residents of remote villages not only how to build wind turbines from locally available materials but also how to operate and service them. "Access to electricity is crucial for development," says Piet Chevalier, a Siemens engineer and one of the founders of WindEmpowerment. "The participants in my first workshop in a small village in Mali have already built their seventh turbine — without any external help" (see *Pictures of the Future,* Spring 2011, p.72). During his stay in Rio, Chevalier also taught a group of Brazilian students and NGO members how to use this simple yet effective technology and pass it on as multipliers.

The "Students for Sustainability" competition initiated by Siemens focused on concrete measures as well. The six international student teams in the competition presented concepts for addressing challenges in their home countries. The best concepts can now be realized with the help of €10,000 in prize money.

Although only modest progress was made at the event, the last day of Rio+20 was marked by a new spirit of optimism. More and more groups and companies are seizing the initiative themselves — as evidenced by the workshop participants who built a wind turbine just outside Rio and cheered as it went into operation. "I hope this summit teaches us how to make the dialog between different stakeholder groups more effective in the future," says Chevalier, summarizing his thoughs regarding the event. "We can't just sit around in between these conferences and wait and hope that governments will solve the problems. We already have the technology we need to change things — so let's do it!"

■ *Stefan Schröder*

More information on Rio+20 is available in a special edition of Pictures of the Future at: www.siemens.com/pof

Highlights

On a trip around Germany, Andy and his wife visit the home town of Andy's grandfather. In the Energy Museum, the town's main tourist attraction, the couple learn how Germany has been converting to green energy sources over the past 40 years. A small robot acts as their museum guide. But as the guide begins to point something out, Andy discovers that the panoramic window in front of him is an interactive multimedia display…

A Visit to the Future

Germany, 2050. In the observation platform of an energy museum, two visitors from abroad find out about the most ambitious energy system transition achieved to date.

This is unbelievable! Andy is standing on the visitors' platform of the municipal Energy Transition Museum. He's pressing his nose against the panorama window and enjoying the fabulous view of the city where his grandfather grew up. "Look at this!" he calls out in delight to his wife Jennifer. "In front of us we can see the entire history of the energy transition over the past 40 years. The abandonment of nuclear energy, an 80 percent proportion of renewable energies in the electricity mix, and 80 percent reduction in greenhouse emissions. But the result doesn't look as futuristic as I had expected." Andy's gaze sweeps across the city and suddenly stops. "I don't believe it!" he exclaims. "That building down there with the two little towers must be my grandfather's school. I recognize it from his photographs."

"Please don't press your nose against the glass," grumbles a voice behind them suddenly. "That gets spots on the multimedia window." Andy and Jennifer turn around in surprise. Standing in front of them is a small robot

whose appearance reminds Andy of old science fiction classics. "Who are you?" Jennifer asks the tiny tin man. "Who am I, and why is there only one of me? That's a good question," he answers. "My name is Energon, and my job is to answer the questions of the visitors on this platform. If it's okay with you, please ask only questions about the energy transition."

"This pile of tin has got some nerve," Andy thinks, and decides to test the tiny metal man immediately. "Down below us we see the old school my grandfather used to go to," he says. "According to the stories he used to tell, this school was heated with a smelly oil furnace that was almost impossible to regulate. In spite of the furnace, the school was always cold. After all, its insulation was poor and there was so little fresh air that the windows had to be kept open all the time." "State your question, please," Energon reminds him, rolling his glowing blue eyes. Andy continues his story: "We're told that as a result of the energy transition, buildings in Germany were made as energy-efficient as possible. But that certainly hasn't happened to this school, because it looks just the way it did many decades ago. I'm not making a mistake here, am I?"

Energon smiles at this. "Thank you for asking this question," he says. "But before I give you an answer, show me the building you mean." Andy points to the building far below. A second later he rears back in amazement. Just at the point where he had pressed his nose against the glass, the facade of the school has suddenly appeared at eye level. Energon emits a tinny giggle. "That's the latest installation we have here. Thanks to gesture and gaze recognition, the multimedia window registers which building a visitor is pointing to. And here you can see all of the energy-relevant information about this building."

Jennifer points to the display and asks, "This is probably a comparison of the old school's status before and after the modernization process, isn't it?" Energon blinks his eyes appreciatively and continues his lecture. "As you can see, the problems have been solved. Today all of the city's public buildings and almost all of its private buildings are practically energy-independent, thanks to photovoltaic modules, transparent solar film windows, heat pumps, combined heat and power units, and — of course — very good insulation. An energy management system ensures that only as much energy as necessary is used. Rooms are equipped with occupancy sensors. These are used to power down or switch off systems in building areas that are not occupied, depending on their use profiles. Sensors also ensure that each room has a comfortable atmosphere in terms of temperature, lighting, fresh air and so on. Outside, rainwater is collected and transformed into drinking water by means of membrane filters. All of the systems taken together result in maximum efficiency without any sacrifice of comfort."

"And the architecture has hardly changed at all, as far as I can see," says Andy in surprise. Jennifer is enthusiastic. "Let's do the same thing at home," she says. "I think we're still using more resources than we need to!"

But Andy has another question for the clever little robot: "How did they manage to get 80 percent of the energy for these buildings from renewable sources?"

"Does every visitor have to ask the same question?" Energon groans. Nonetheless, he's a professional museum guide, so he continues his narrative. "The challenge was primarily to maintain a balance between supply and demand in the electricity grid, in spite of fluctuations of wind and solar power. It's like a puzzle — the necessary measures have to fit together perfectly. Prices fluctuate in line with supply and demand. You also have to be able to influence demand. In addition, you need storage units and smart network agents that market the electricity offered by thousands of small producers and adjust the amounts available to the needs of consumers. The whole process takes place in real time through an internet-based electricity exchange."

"What happens when producers generate more electricity than people need?" Jennifer asks. "Finally, an expert question!" Energon exclaims. "In that case, the price drops and electric vehicles start recharging, cooling units start up, pumps start to run, electricity storage units offer storage room and so on. Dedicated lanes for electric vehicles have been set up on the city's beltway, on truck routes, and on major highways. Trucks on such roads can use the pantographs on their roofs to operate in electric mode and thus save even more energy. If all this is not enough, electrolysis transforms excess electricity into hydrogen gas — an excellent energy-storage agent. We can store this hydrogen in the natural gas network and use it for heating, convert it once again to electricity in gas turbines, or use it in fuel-cell vehicles."

"Wow, — all these measures really do fit together like a puzzle," Andy says. "Planners have created an outstanding sustainable energy system, helped to combat climate change, and conserved resources. In view of today's oil prices, that's a very good move." "Well, we can't do entirely without oil," Energon points out." We may not burn it any more, but many plastics are still being made from petroleum. And as for me…" Here he makes a dramatic pause and grins in a way that's almost human before adding, "My joints often need some lubricating oil, what with the crowds of visitors this museum attracts!" ■ *Sebastian Webel*

A sign at Berlin's Brandenburg Gate announcing "Energy Transition Now!" reflects Germany's enthusiasm for a plan to transition to renewable energy, efficiency, and new mobility solutions.

The Energy Puzzle | Trends

The Project of the Century

Increasing resource scarcity, the nuclear accident in Japan, and the beginning of global warming are making it clear that the worldwide energy system is not sustainable. Ambitious plans are being made to change the picture. Germany, for example, intends to switch to a sustainable energy supply, with all of its challenges, but also a world of opportunities for people, the environment, and the economy.

It sounds like science fiction. Asteroids are drawn into orbit around the moon, and then machines and equipment land on them to extract raw materials such as iron, platinum, and rare earth elements. People around the world were flabbergasted when a largely unknown U.S. company first presented this business model in April 2012. What sounded at first like an April Fools' Day joke is actually a serious plan. The company that has declared its dedication to achieving this goal is called "Planetary Resources." And feasibility studies from several institutes show that a project of this kind could be realized as early as 2025.

The underlying intention seems logical. The think tank "Global Footprint Network" has calculated that we will need two to three Earths by 2050 if we don't curb our current rate of resource consumption (see *Pictures of the Future,* Fall 2011, p. 84). At the same time, huge deposits of metals and ores are passing by the Earth in the form of innumerable asteroids. Would mining them mean the end of our resource shortfall? Maybe — but it's more likely that it would be too expensive and too complicated. The far logical and natural thing to do is to use existing resources more economically.

But for many countries, that will be a mammoth task. The reason this is such a big challenge is that ultimately the two biggest challenges of our age will have to be overcome at the same time: climate change and resource scarcity. Accomplishing this will be possible only through a huge reorganization of our economy and our energy system with the aim of achieving more sustainability. The reorganization of the economy requires greater reuse of raw materials, recycling, and closed-cycle waste management. The reorganization of the energy system requires a large increase in the proportion of renewable and, whenever possible, use of zero-carbon energy sources. In addition, the production and use of electricity must become much more efficient. And all of these measures have to be taken not by 2025, but as soon as possible.

What a sustainable energy system of this kind would look like is becoming apparent in Germany. Following the nuclear disaster in Japan in 2011, Germany became the first country to set itself ambitious goals for a sustainable energy supply. In addition to forgoing nuclear energy entirely by the year 2022, the German plan calls for a massive expansion of renewable sources such as wind and solar energy (to account for 80 percent of power generation by 2050) and the reduction of greenhouse gases (an 80 percent reduction by 2050 relative to 1990). "The realization of a sustainable energy supply is the project of the century for Germans. It is right, and it is important," says Michael Süß, CEO of the Siemens Energy Sector. "People abroad are closely watching how Germany goes about it."

Accomplishing this project will require not just the right political conditions but also, above all, the right technical solutions. "It involves innovations in every field: energy efficiency, power transmission, generation, and storage," says Jochen Homann, President of the Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railways, in an interview with *Pictures of the Future* (p. 15). "German industry is one of the guarantors of a successful transition to a sustainable energy supply." Moreover, if the reorganization of the energy system in Germany is successful, the solutions used here could become major exports on the global markets.

The good news is that successfully realizing a plan as ambitious as the transition to sustainable energy doesn't mean the technological wheel has to be reinvented. Many of the required technologies and solutions are already available for the most part, or are now being developed. The steps that must be taken to make energy systems sustainable come from nine different fields and fit together like the pieces of a puzzle.

Renewable energies are one example. "At this point, renewable energies are no longer a niche technology; they are an important factor

in the power market. So over the short to medium terms they'll increasingly have to compete on equal terms in the market," says Homann — particularly if the bulk of the power is supposed to come from renewable energies. In the case of wind power especially, this economic viability can be attained relatively quickly. Thanks to innovations currently being developed in Siemens' Wind Power laboratories, wind-based electricity is expected to become as cheap as coal-based power in the medium term, even without subsidies (p. 22).

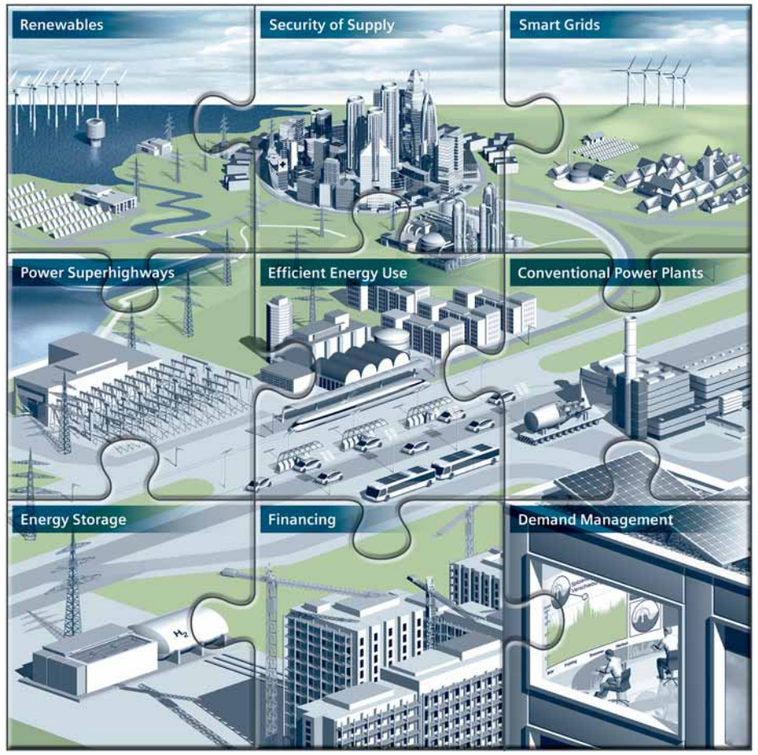
Electricity Highways. But because power from renewable energy sources is mostly generated in the places where they are found in abundance — the sun in sunny areas, and the wind on the open seas — transport grids will have to be expanded into highways for electricity, both nationally and across international borders. Here, high-voltage direct-current (HVDC) transmission is ideal for this purpose (pp. 24, 26). Over long distances, HVDC lines can transmit electrical power much more efficiently than classic high-voltage three-phase lines.

At the end of May 2012, the German government and the country's largest power companies published a Grid Development Plan, which outlines the basic parameters of the reorganization of the long-distance transmission networks and envisages 3,800 kilometers of new lines. "We're experiencing a boom in renewables. To bring wind energy to consumers, we urgently need new highways for electricity from north to south," says Michael Süß.

In this context, however, it's important that citizens aren't left with the feeling that the transition to a sustainable energy supply and the expansion of transmission networks is being decided without any regard to them or their views (pp. 14, 32). "The shift to sustainable energy has to take place in the minds of the people too," warns Süß. "We can't have a situation where every electrical pole is fought over. People do want to increase the use of renewable energies, but it can't be done without additional infrastructure."

The heavy use of renewable energy requires more than just an expansion of the electrical grid, however. That's because power from the wind and sun fluctuates according to weather conditions. Over the long term, therefore, there will be a need for power storage systems that can hold excess energy for hours, days, or even weeks, if necessary, and feed it back into the grid during calm periods. Examples of such systems include the hydrogen electrolysis and storage plants currently under development (see *Pictures of the Future,* Spring 2012, p. 100) as well as the Siestorage power storage technology of the Siemens Infrastructures & Cities Sector. Siestorage is a modular system based on lithium-ion batteries that can store 500 kilowatt hours (the average daily consumption of 50 households) and serve as a buffer against short fluctuations — for seconds or minutes — in the power from renewable sources. But a massive expansion of storage technologies won't be enough either.

The transition to a sustainable energy supply will require taking a variety of perfectly coordinated steps. German Federal Minister for the Environment Peter Altmaier holds this "Energy Puzzle" in his hands.



At the same time, conventional power plants have to be available to provide a certain base load and serve as a backup solution, quickly feeding power into the grid when there is a deficit. Fast-starting, high-efficiency gas-fired power plants are particularly suitable for this function (p. 17).

Millions of Energy Producers. Whether it's solar, wind, or biomass plants, small-scale combined heat and power plants or large conventional power plants — in the future, millions of generators will feed power into the German grid, rather than just the few hundred of 15 years ago. The people who used to be consumers of energy will increasingly also become producers of it, or "prosumers." This fact, as well as the fluctuating feeds of renewable energies, necessitate intelligent electrical networks or "smart grids" that keep distribution networks stable and enable clever power management (pp. 66, 98 in this issue and *Pictures of the Future*, Spring 2012, p. 46).

The big pictures also includes smart management of demand. For the reasons mentioned above, regenerative energy sources demand smart use of available energy. There are many ways of lowering power demand. One key lever is real-time pricing. If prices rise with demand, consumers will cut back on non-essential demand. It makes little difference, for example, if refrigerated warehouses, air conditioning systems, or household appliances are powered down for brief periods (p. 37, 98).

This shows that the cleanest power is always the power that isn't consumed. Efficient use of energy is therefore one of the most important pieces of the puzzle for a sustainable energy system. This applies especially to industry, which can increase its competitiveness by achieving a high level of efficiency that reduces its energy costs.

Transportation and buildings have to become more efficient too. The latter are responsible for 40 percent of global energy use, but this could be reduced by approximately one fourth through simple energy-saving measures. Siemens is equipping buildings with energy-efficient technology in many countries and is thereby creating some of the most sustainable structures in the world (p. 35).

When Siemens modernizes buildings, it often finds that important increases in efficiency can be managed only with the help of smart financing options. That's especially true for cities and municipalities, which may want to lower their energy demand despite tight budgets. One form of smart financing is the energy-saving contracting used by Siemens. In such cases, customers don't have to make any initial investments in the modernization of their buildings. Instead, they pay for improvements in installments using nothing but the money they have saved on energy costs (see *Pictures of the Future,* Fall 2009, p. 60 and Fall 2011, p. 40 and Spring 2012, p. 36).

Top Objective: Reliable Supply. In all the steps that have to be taken for a sustainable energy system, one objective must always have very high priority: security of energy supply. In the future, energy will have to remain reliably available and affordable. "We can assume that grid charges, and therefore electricity prices, will increase," says Jochen Homann. "But the costs have to be kept as low as possible; distribution networks have to be expanded only as much as needed to ensure a secure supply. Furthermore, costs have to be transparent and distributed fairly among customer groups."

At the same time, the energy supply also has to be reliable under all circumstances — especially in a highly industrialized country like Germany. The competitiveness of German business and industry would be jeopardized by an energy grid that was prone to breakdowns or major blackouts like the one that occurred in India in July 2012, during which approximately 600 million people went without power for as long as two days.

All measures must therefore fit together like the pieces of a puzzle. Within the appropriate framework — that is, with the right political support for renewable energy, energy efficiency, expansion of the distribution grid, network charges, and R&D — this can result in a harmonious overall picture. That's how the transition to a sustainable energy supply can be achieved — and the products developed for it can become major exports on global markets, because sooner or later other countries will have to find their way to a sustainable energy supply as well.

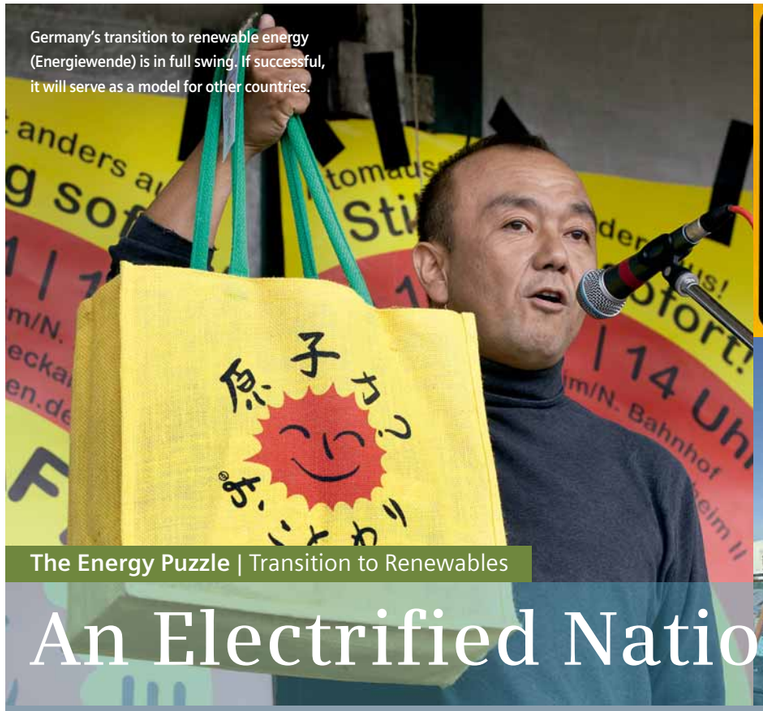
One example of a sustainable energy system is now being implemented and tested in the Harz Mountains in Germany. Renewable energy dominates in this region, contributing over 60 percent of the power supply. But how can sustainable mobility be achieved at the same time — while maintaining very stable electrical grids and the economic viability, reliability, and security of the distribution system?

The Harz.EE-mobility research project is supported by several German government ministries and includes among its participants Siemens, cell phone service provider Vodafone, the utility company E.ON, and the German rail system. The participants are studying how regionally-generated renewable energy can be used for electric vehicles and integrated into a smart electrical grid. Although geographically limited, the project is demonstrating how transportation can be integrated into the broader sustainable energy picture — without any help from space ships or asteroids.

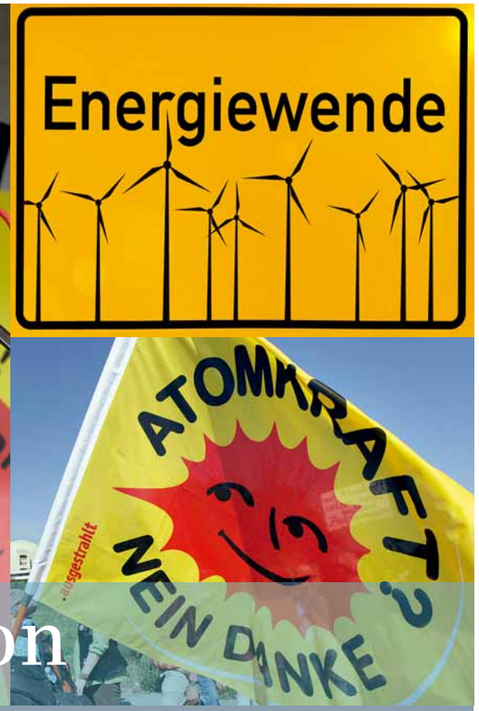
Sebastian Webel

The Power Matrix

Mankind's energy needs are steadily increasing. Electricity makes it possible to overcome this challenge in a way that is economical, clean, reliable, and resource-efficient. However, demands for energy differ from place to place, and so do the various forms of power use. Furthermore, our energy systems are becoming increasingly complex. They are no longer based on monolithic standard structures and an energy conversion chain that extends in a straight line from raw materials to the processing of those materials, the extraction of usable energy in large plants, and onward to the individual consumer. Today, energy resources vary just as much as regional demand and the market conditions. Siemens Energy therefore regards today's energy system as a limitless matrix; its demands require solutions that make possible the optimal use of all available energy resources — independently of the particular energy sources involved, the various forms of power generation, and the transmission distances. The company's matrix-based energy concept includes conventional power plants as well as decentralized power generation through photovoltaics, wind, water, and biomass. Energy storage systems and electric mobility are likewise parts of this power matrix. The products, solutions, and services of Siemens Energy are focused on this matrix, and thus they make possible a forward-looking energy system that permits a highly economical, sustainable, resource-efficient, and reliable use of energy.



Germany's transition to renewable energy (Energiewende) is in full swing. If successful, it will serve as a model for other countries.



The Energy Puzzle | Transition to Renewables

An Electrified Nation

Germany's transition to renewable energy is a huge project. Never before has the power system of an industrialized country been so extensively upgraded. The project offers opportunities for environmental protection, the economy, and citizen participation — but there are many challenges ahead.

People in many countries have stickers and posters that show a red smiling sun and a slogan that says "Nuclear Power? No thanks!" A symbol of the global protest against nuclear power for decades, the red sun may soon be a thing of the past — at least in Germany, whose government plans to phase out all of the nation's nuclear power plants by 2022. Among other things, this policy is a response to the nuclear accident in Fukushima, Japan, in March 2011. Germany's energy transition also includes plans to reduce greenhouse gas emissions by 80 percent relative to 1990 levels between now and 2050, increase the share of energy from renewable sources in the electricity mix to 80 percent, and implement major energy efficiency improvements.

It sounds great. Lower emissions help fight climate change and greater efficiency will save money and conserve resources. The energy transition also offers great opportunities for industry because the highly efficient technologies needed to implement it can open up new markets around the world. But there are also tremendous challenges involved. For example, Germany will need to replace the combined 20-gigawatt output from its fleet of nuclear power plants in less than ten years — mainly by expanding renewable energy sources. A lot has already been accomplished. For instance, the share of electricity from renewable sources increased from 16 to around 20 percent between 2010 and 2011. But the real challenge is reliability of supply. After all, electricity from the wind and the sun is dependent on the weather, which means that output fluctuates sharply.

Modernization without Interruptions. It's a huge project — one that marks new territory for policymakers, electricity providers, infrastructure suppliers, and the public. "That's mainly because the energy transition is not about building a new system from scratch — it's about modernizing a working system while it continues to operate," says Dr. Udo Niehage, who is in charge of energy transition issues at Siemens. "Moreover, all of this must be done in a country in which even the slightest blackout can cause huge economic damage."

The energy transition cannot be achieved just by increasing the use of renewable sources and introducing energy-saving technologies. The key is to implement a number of measures that fit together perfectly like the pieces of a puzzle (see p.12). For example, there has to be greater use of energy from renewable sources at competitive prices and, at the same time, the power transmission and distribution grids also have to be expanded. The same applies to the development of energy-storage technology and energy-efficient solutions for conventional power plants, buildings, transport systems, and industry. Intelligent financing options need to be made available to private citizens, cities, and regions — and all these measures must be implemented within the framework of reliable long-term conditions yet to be established by policymakers.

"Achieving these goals will require extensive cooperation on the part of everyone involved," says Niehage. "The whole process must be closely coordinated at the federal level, preferably by a single agency. This is especially true with regard to expansion of the grid. For instance, electricity produced at wind farms in northern Germany will have to be transported to major consumer centers in the south." An initial step in this direction was taken in June 2012, when the German federal government and the country's major electricity suppliers published a grid development plan that provides the key data for this huge project. The plan calls for up to four new transmission routes to be built from north to south.

So is the energy transition proceeding as planned? "Very good technical solutions have now been developed for nearly all the areas in which measures need to be taken — but technical feasibility isn't everything," Niehage explains.

"Another important factor for the success of the project is public acceptance." That's anything but a given. It's true that the goals of the energy transition have won broad acceptance among the German people and across all political parties. The German Renewable Energies Agency also reports that 75 percent of Germans would like their electricity to come from renewable sources. Nevertheless, many Germans feel the government is making decisions without consulting them — on issues like where to build new power masts, which of course nobody wants in their backyard.

The Customer is King. The social dimension of the energy transition also needs to be kept in mind. Many Germans fear that electricity might become more expensive. After all, the country's Renewable Energy Act (EEG) stipulates that higher rates and fees must be paid for electricity fed into the grid from renewables. The fees are basically a consumer subsidy for renewables. Subsidies for photovoltaic facilities (PV), for example, have generated over €100 billion in costs for consumers due to the EEG stipulations — despite the fact that PV plants only account for three percent of all the electricity produced in Germany.

That's one of the reasons why the average annual electric bill for private households in Germany rose by around 25 percent between 2007 and 2012, putting a major burden on low earners and seniors in particular. According to the *Die WELT* newspaper, up to 15 percent of the German population is now struggling with continually rising energy costs. The government, energy suppliers, and industry must work together to develop solutions here. "We're already working hard on technological innovations that not only can make electricity from renewable sources as cheap as power from coal, but can also transform buildings and factories into energy misers," says Niehage. Factories in particular need to factor in the value of cost-cutting technologies because "the industrial sector is worried that sharply rising electricity costs could make manufacturing in Germany too expensive."

Still, most Germans seem to agree on the most important point — namely that the energy transition is crucial. The main concern is that it should not become a money pit. There also needs to be more transparency and more information in order to move away from an emotionally charged atmosphere to a rational environment in which decisions can be implemented. That such a scenario is possible is being demonstrated by citizen initiatives that operate their own wind farms and are thus already part of the energy transition (see p. 32). After all, when the country's citizens become the driving force behind this massive project, there won't be any need for protest logos like a smiling red sun. ■ *Sebastian Webel*

The Energy Puzzle | Interview

Building an Infrastructure that will Benefit Coming Generations

Jochen Homann , 59, has been President of the Federal Network Agency for Electricity, Gas, Telecommunications, Post, and Railways in Bonn since March 2012. Prior to that, Homann, an economist, was a State Secretary in Germany's Ministry of Economics and Technology, where he was responsible for energy, industrial, technology, and foreign trade policies. The Federal Network Agency oversees competition in the sectors mentioned in its title. In 2011, it was also given responsibility for tasks related to the grid development plan. If, for example, the plan requires an expansion of the high-voltage network, the agency will ensure efficient implementation by streamlining planning and approval procedures.

The transition to renewable energy is broadly accepted throughout German society. It's not so much the goals that are controversial but rather the speed at which they should be achieved. Are we on the right track, or do we need a master plan for this project of the century?

Homann: The energy transition is a project that will take more than one generation to implement. We don't require a master plan; instead what we need are well founded decisions that are understood by the public and can be clearly communicated to society. If the target is 2050, you can't expect to see implementation in a couple of years. You can't plan technological advances and innovative breakthroughs in advance, so appropriate incentives for all parties involved are more important than central planning.

What needs to happen next?

Homann: It's important to make a clear distinction between an energy policy vision and short-term requirements. The Federal Network Agency is not only interested in the long-term perspective; for example, a secure supply of energy for next winter is also an issue as far as we're concerned. The point is to develop power generation capacity, although rapid expansion of the high-voltage network is also a top priority.

As early as 2030, around half of Germany's electricity is expected to come from renewables.

Do we have all the necessary technologies for this?

Homann: We need innovations in all areas — from power generation and transmission to energy efficiency and electricity storage. You need to keep a lot of options open, and the government should remain as technologically neutral as possible. In the end, competition will decide which technologies are the most efficient and cost-effective as far as the energy transition is concerned. The ingenuity of German industry will help ensure that the project is a success.

What steps can be taken to ensure that electricity remains affordable in the future?

Homann: I've always said that the energy transition won't come cheap. Still, no one can seriously predict today how electricity prices — whose components include purchasing costs, eco-subsidies, and taxes — will develop in the future. We can assume that the electricity price component of grid operator rates will increase. The cost of the energy transition must be kept as low as possible. In other words, the grid should only be expanded to the extent that the supply is safeguarded. Costs also need to be transparent and distributed fairly among consumer groups.

How can renewable energy be made more competitive without subsidies?

Homann: The funding provided in support of renewable energy was always meant to facilitate its market entry. And in that sense it has been very successful. However, renewables are no longer a niche sector; they're also an important factor in the German electricity market. That's why they will be exposed to more competition over the short and medium term. The Renewable Energy Act, with its set feed-in tariff and guaranteed feed-in priority, must be carefully refined with the goal of establishing a feed-in policy that meets actual needs.

Are distributed power systems making more and more regions self-sufficient when it comes to energy?

Homann: It's almost impossible to be self-sufficient in small areas because there's sharply fluctuating energy consumption on the one hand, and a weather-dependent electricity supply from renewables on the other. It's also questionable whether energy independence would work at the state level. It's still not possible to store electricity economically. As a consequence, load compensation must be carried out via the grid. We need to expand the grid in order to deal with this issue and prevent power outages. Distributed power systems actually increase the need to expand the grid because electricity from renewables first has to be collected before it can be sent to consumer centers.

How many new electricity highways do we need in Germany?

Homann: Back in 2009, on the basis of the Energy Line Extension Act, it was determined that approximately 1,800 kilometers of priority high-voltage lines should be built . Altogether, 214 have been built to date and 100 of these are in operation. This low number is not so important. It's normal for a planning phase to take a relatively long time. The important thing is that more people should understand the necessity of the project and become more willing to make important decisions. The situation is better now in this respect than it was before — in part due to the pressure created by the new legal framework. In December 2011, the Federal Network Agency approved three scenarios that describe the likely development of power generation and consumption between now and 2022 and now and 2032. The grids must be modified in a way that ensures they'll be able to handle these scenarios. This was the basis on which a draft of a new grid development plan was drawn up by operators. The plan calls for existing lines to be optimized or new ones to be constructed on existing routes. Such an approach would significantly reduce the need for new routes. The transmission system operators (TSOs) report that they have received more than 1,500 responses to the draft proposals from the public. The TSOs will send us a new draft that takes the opinions of these citizens into account. We will examine it and then begin our own deliberations, in which interested parties can participate as well.

How do you plan to achieve public acceptance?

Homann: The energy transition hinges on grid expansion — and that in turn will depend on the level of public acceptance. We have learned a lot from other projects and have decided to get the public involved from the beginning. A key element of the Grid Expansion Acceleration Act is to have extensive public participation at an early stage in order to ensure greater acceptance and therefore faster implementation. The Federal Network Agency also invites the public to attend dialog platforms on technology and the environment. The goal is to attain greater public approval through openness. In the end, transparency leads to acceptance.

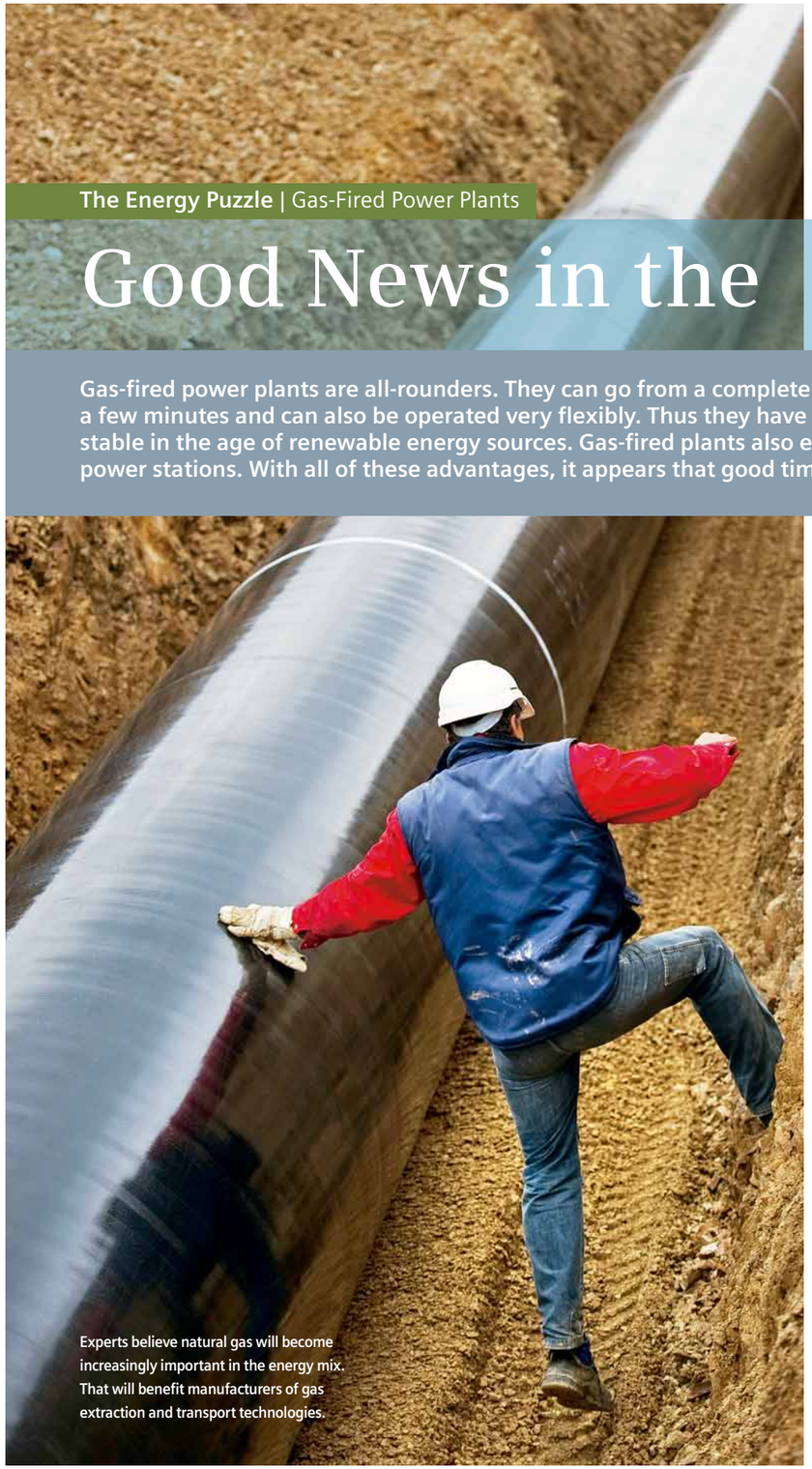
It's now time to make a prediction about the future. Do you think that Germany will be proud of its sustainable energy system in 2030?

Homann: I'm absolutely convinced that everyone will benefit from the energy transition in the long run. It's an investment in the future that doesn't come cheap, and most of its advantages will be enjoyed by the generations that come after us.

■ *Interview conducted by Florian Martini.*

Good News in the Pipeline

Gas-fired power plants are all-rounders. They can go from a complete standstill to maximum output in just a few minutes and can also be operated very flexibly. Thus they have what it takes to keep power grids stable in the age of renewable energy sources. Gas-fired plants also emit a lot less carbon dioxide than coal power stations. With all of these advantages, it appears that good times are ahead for natural gas.



Experts believe natural gas will become increasingly important in the energy mix. That will benefit manufacturers of gas extraction and transport technologies.

Three months after the accident at the Fukushima Daiichi nuclear power plant in Japan, the International Energy Agency (IEA) was predicting that the golden age of natural gas was about to begin. In 2035, according to the IEA, natural gas will account for 25 percent of the global energy supply; the current figure is 20 percent. In fact, some experts are predicting that gas might surpass coal as early as 2030, while the share of nuclear power is expected to decline.

Such a scenario would be a good thing for the global climate. That's because gas-fired power plants produce much lower carbon dioxide emissions than facilities that burn coal, which is currently the most widely used raw material for electricity production. Today's state-of-the-art combined cycle power plants release only around 330 grams of CO_2 per kilowatt-hour of energy. Even the best coal-fired plants at the moment produce more than twice that amount. Siemens would also benefit from a new gas boom. The company offers technical solutions for everything from gas extraction to the construction of entire power plants.

How likely is a scenario such as the one described above? "All indications point to natural gas playing a more important role in the energy mix of the future," says Volkmar Pflug, Chief Market Analyst at Siemens' Energy Sector. Pflug's belief is based on scenarios of the future energy mix that Siemens develops annually with customers in 55 countries. The studies take into account the conditions in individual countries, because energy suppliers in different regions decide to build combined cycle plants for different reasons.

In regions where the share of renewable energy sources is high, suppliers are attracted by the great flexibility of gas power plants, whose output can be stepped up very quickly when there's not enough sunshine or wind. The Irsching 4 power plant unit, for instance, which was built by Siemens, can increase its

Siemens has expanded its turbine plant in Charlotte, North Carolina. More and more gas power plants are being built in the U.S., where gas prices are low.

Turbine design and materials are continually being improved. The higher the efficiency, the lower the fuel use and costs.

output by 35 megawatts (MW) in just one minute. Although modern coal-fired plants can also change their output this quickly, they can only do so if they're already up and running, and it can take hours to warm them up. The gas plant in Irsching, Germany, on the other hand, can produce 350 MW of power just ten minutes after a six to eight-hour pause. This is achieved by initially decoupling a slower steam turbine and operating the gas turbine alone. As soon as enough heat is generated, the plant is switched to combined cycle mode (see *Pictures of the Future,* Fall 2011, p. 96).

Security of supply is the main consideration in the U.S. and booming Asian nations, such as India and Vietnam. These countries don't want to rely on one source of energy, even though coal is still generally a cheaper option than gas is today.

South Korea offers another example. The country has very few energy reserves and is the world's second-biggest importer of liquefied natural gas (LNG). The South Koreans want to use all that imported gas as efficiently as possible. To this end, the country's first H-class combined cycle power plant will enter service in the summer of 2013. The facility will feature an H-class turbine — the same type of turbine that makes possible a world efficiency record of 60.75 percent, which has been set in Irsching. Siemens has already sold seven of these gas turbines to South Korean companies.

Unconventional Sources. The tremendous boom in demand for gas power plants in the U.S. is due mainly to low gas prices. Natural gas in the U.S. is increasingly being obtained from so-called unconventional sources — methane deposits that formed from decayed organic material trapped in fine-grained layers of sedimentary rock and coal seams rather than in large hollow chambers, which is usually the case with natural gas. Until recently, extracting gas from such sources was too expensive and therefore not worth the effort. But technological advances have now made extraction profitable. For one thing, directional drilling now makes it possible to bore horizontally to a depth of as much as one kilometer below ground, into what are often thin rock layers of only several meters. Gas can also be forced out of rock pores by pumping water at a pressure of up to 1,000 bars in a process known as fracking.

To date, some 100,000 shale gas bores have been drilled in the U.S. — with the result that it has now become more financially attractive to invest in gas-fired plants than in coal power generation facilities. This drilling boom will eventually reach the rest of the world. The IEA expects to see up to a million bores by 2035 because nearly every country has unconventional gas deposits on its territory. Such drilling is controversial, however. Among other things, environmentalists are worried that the chemicals used in fracking can contaminate groundwater. Fracking experts counter by pointing out that bore shafts are lined with cement, which ensures that no contaminants can get into the perpendicular layers where groundwater flows.

"The success that combined cycle power plants will ultimately enjoy also depends heavily on political factors," Pflug explains. Germany, for example, wants to build new gas-fired plants to compensate for supply gaps that occur when an insufficient amount of energy is produced at solar and wind facilities. As part of the country's energy transition policy, Germany plans to increase the share of renewables in its energy mix to around 50 percent by 2035 — and to 80 percent by 2050. At that point, gas power plants might in some cases operate at full capacity for only 1,500 to 2,000 hours per year. By comparison, such plants are usually run at medium capacity today, which corresponds to between 4,000 and 5,000 hours of full capacity operation per year. To ensure that investments in gas-fired plants nevertheless pay off, a new market concept must be developed — one that assigns the operating costs for such plants on an ad hoc basis to the entities that require their services. In other words, in order to ensure a stable supply of electricity, these additional costs for electricity required by the use of fluctuating renewable sources must be borne by those producers that generate power from fluctuating sources.

In any case, the power plants used in future energy systems will have to be extremely flexible. Energy supplier E.on is now retooling its combined cycle plants in the UK to allow them to operate even without a steam generation process after a cold start — a technical feat that state-of-the-art combined cycle plants from Siemens can already achieve. Politics plays a major role in decisions regarding the kinds of power plants to be built in the U.S. as well. Officials in the U.S., for example, are considering an upper limit of 450 grams of CO_2 emissions per kWh of electricity produced.

Coal-fired plants can only comply with this restriction if they are equipped with CO_2 separation and storage systems. The associated technologies are also being tested by Siemens (see *Pictures of the Future,* Spring 2010, p. 111), even though their use reduces a plant's efficiency and thus its profitability as well. Experts also suspect that these technologies will limit the ability of coal-fired plants to rapidly alter their output. Combined cycle plants, on the other hand, can easily meet such an emission limit (or produce fewer emissions) even without CO_2 separation.

Exploiting Heat. The efficiency of combined cycle plants can be further increased by using heat from a plant's combustion process to supply homes, apartments, and industrial facilities with heat. Such a measure raises a plant's overall energy efficiency rating to more than 80 percent. This approach can ensure a reliable supply of energy — and lower CO_2 emissions — over the next few decades, as it will take some time before renewable energy sources can completely replace fossil fuels. With this in mind, the European Parliament called on EU member states back in 2004 to present individual plans for expanding their use of cogeneration (combined heat and power — CHP) facilities. Germany subsequently announced a plan to double the share of energy generated at its CHP plants to 25 percent by 2020 — a very ambitious goal, given that effective heat exploitation requires a plant to be situated as close as possible to energy consumers, i.e. to cities.

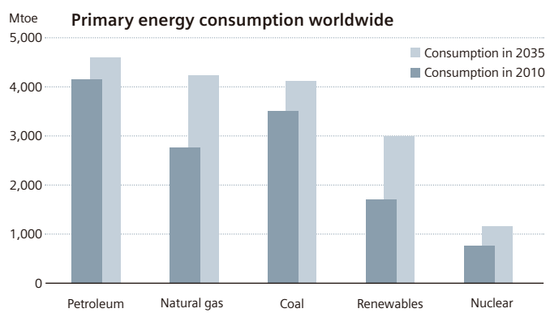
Nonetheless, a new project in Düsseldorf shows that such an approach can in fact be implemented. In July 2012 Siemens announced that it had been awarded a contract for the turnkey construction of a new combined cycle plant to be known as "Lausward F." When the new plant in the port of Düsseldorf goes on line, it will immediately set new world records in three categories. First, it will have an electrical output of 595 MW, the highest ever for a single combined cycle unit. Secondly, its electrical efficiency rating will reach more than 61 percent, while the overall capacity factor for natural gas as a fuel will total roughly 85 percent. Finally, the facility will decouple an unprecedented 300 MW of district heating capacity from a single combined cycle unit for use in a cogeneration system.

The increase in electrical output and the efficiency gain from over 60 percent in Irsching to more than 61 percent in Düsseldorf might not seem like much at first. "However, you also have to consider that fuel accounts for 75 percent of a plant operator's total costs," says Lothar Balling, who is responsible at Siemens for sales of combined cycle plants in Central Europe and Asia. A mere 0.25 percent increase in electrical efficiency can increase electricity production by around 15 million kilowatt-hours each year — with both fuel costs and CO_2 emissions remaining unchanged.

Regardless of where and for what purpose new combined cycle plants are built, Siemens is likely to benefit. The company has consistently developed its gas turbine manufacturing network into a global operation over the past few years. Siemens also recently invested more than $350 million in its plant in Charlotte, North Carolina. The investment added 700 new jobs to the existing workforce of 1,400. And plans call for the Charlotte facility to manufacture components for export.

Siemens is now also planning a new production center for gas turbines in Saudi Arabia in order to serve that country's market, and at the end of 2011 the company signed a contract to create a joint venture that will begin manufacturing gas turbines in St. Petersburg, Russia, in 2014. All of these developments add up to good prospects for a new golden age for gas. *Johannes Winterhagen*

Natural Gas: Expected to Outshine Coal by 2035



Depicted here is the share of global energy consumption accounted for by various primary energy sources in 2010 and 2035, as calculated and projected by the International Energy Agency (IEA)

1 Mtoe = 41.868 PJ = 11.63 TWh

Source: International Energy Agency

Renewable Energy Sources: Broad Global Growth

Sustainable energy systems require measures that are as precisely aligned with one another as possible (see p.10). Such measures should include not only technological solutions but also the creation of appropriate conditions by government policymakers. Germany's energy revolution will be the most ambitious program in the energy sector over the next few decades. Germany is not alone here, as other countries are also trying to make their energy systems more sustainable.

According to the Renewables 2012 Global Status Report published by the REN21 international policy network, renewable energy sources (including hydro power) now account for 16.7 percent of global final energy use and 20.3 percent of worldwide electricity use. The OECD and the International Energy Agency (IEA) estimate that global electricity production from renewable sources plus hydro power will increase by nearly 60 percent between 2011 and 2017, when it will reach almost 6,400 terawatt hours (TWh) per year — around ten times the current electricity consumption figure for Germany.

Siemens believes the share of renewables plus hydro power in the electricity mix will rise to 28 percent by 2030, with coal and gas power plants still accounting for 58 percent of the electricity generated in that year. Global power plant capacity is likely to increase by more than 7,000 gigawatts (GW) between 2012 and 2030, whereby 1,084 GW will come from wind parks alone and 642 GW from photovoltaic facilities. One out of every four newly installed gigawatts of electrical output — or a total of 1,683 GW between now and 2030 — will be produced in China, followed by the EU (983 GW), the U.S. (847 GW), and India (763 GW).

Solar energy is the most heavily funded renewable. According to IMS Research, 23 countries will add at least 100 megawatts (MW) of photovoltaic (PV) power each in 2012. Germany will remain the world's biggest PV market, followed by China and Italy. Bavaria is the biggest PV market within Germany. The E.ON power company estimates that the total output of PV facilities connected to its grid in Bavaria is more than 4.3 GW. That's nearly 20 percent of the total installed PV output in Germany, and also much more than the 3 GW of installed output in the entire U.S.

Germany's Renewable Energy Act (EEG), which went into effect in April 2000, has played a key role in the country's renewable energy boom. The law has since been copied by 50 countries, according to the Fraunhofer Institute for Wind Energy and Energy System Technology. The EEG requires grid operators to purchase electricity from renewable sources at a set price from those who produce it. The German Renewable Energies Agency says countries that use a feed-in tariff system (e.g. Germany, Spain, France, and Portugal) pay much less then ten euro cents per kilowatt hour (ct/kWh) for onshore wind power.

Other nations have quotas for the share of national energy consumption that must be accounted for by renewables. In this setup, energy suppliers must purchase electricity produced from renewable resources until the quota has been met. This is being done in the UK, Poland, Belgium, and Italy, for example. With prices of 11 to nearly 15 ct/kWh, onshore wind power in these countries is much more expensive than in nations that use a feed-in tariff system. Experts say the EEG urgently needs to be reworked, however. For one thing, more than 50 percent of EEG subsidies go to PV facilities, but these only supply three percent of total electricity. The RWI institute for economic research reports that the accumulated subsidies for solar power reached €100 billion in Germany in 2012.

The EU, for its part, has agreed on a new directive concerning energy efficiency that will require its member states to take measures to reduce their annual energy sales by 1.5 percent. This could be done by instituting requirements for saving energy or by offering tax breaks for investments aimed at improving energy efficiency. The American Council for an Energy-Efficient Economy (ACEEE) has developed an international energy efficiency scorecard that focuses on buildings, industrial facilities, and transport systems. European countries including the UK, Germany, Italy, and France performed much better on the scorecard in 2012 than the U.S. or Brazil.

Still, the U.S. has set aside a substantial amount of money in its 2012 budget for promoting energy from renewable sources. The U.S. Department of Energy will provide approximately $3 billion for energy efficiency measures and renewable energy, for example, while the Department of Agriculture will spend a further $6 billion to promote the use of energy from renewable sources to generate electricity in rural areas. Cash grants will be a key incentive for developing the solar energy sector, as they will provide funding for 30 percent of the installation costs of solar facilities.

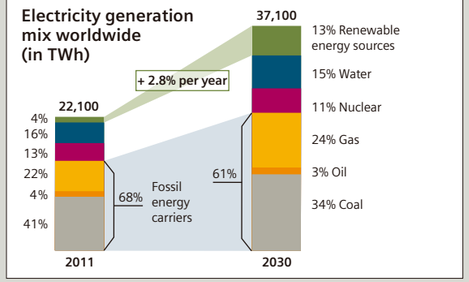
Germany Trade & Invest, the foreign trade and inward investment agency of the Federal Republic of Germany, reports that the temporary shutdown of all nuclear power plants after the accident at Fukushima, as well as the energy conservation measures that were taken as a result, have led the Japanese to rethink their approach to power generation. For example, Japan now plans to subsidize solar energy in line with the German model by introducing a feed-in tariff of 40 ct/kWh. A total of 10 GW of installed PV output will be added to the grid by 2014. Japan is also moving ahead with the creation of smart grids. The focus in this area includes efficient energy management systems for buildings and the integration of electric vehicles and batteries into intelligent networks.

China also launched its first feed-in tariff system for solar power in July 2011 — and raised its PV expansion target to 50 GW, to be installed by 2020. Wind power is also a big issue in China, which had only 2.6 GW of installed wind output in 2006 but plans to increase that figure to roughly 150 GW by 2020 — the equivalent of the output of all the power plants operating in Germany today. China is relying on smart grid solutions as well. The first pilot projects are under way for smart metering and electric vehicle charging stations. China's twelfth Five-Year Plan (2011–2015) also focuses on increasing energy efficiency in all areas.

Sustainable energy systems don't come cheap. A survey conducted by a number of consumer protection associations found that energy suppliers in Germany cut off power to some 600,000 households every year due to unpaid bills. "Approximately ten to 15 percent of the population is struggling to pay for constantly rising energy costs," says Klaus Müller, Director of the Central Consumer Protection Association in the German state of North Rhine-Westphalia. In a study conducted in 2012, the Karlsruhe Institute of Technology predicted that electricity prices in Germany could rise by 70 percent between now and 2035. The cost drivers of this increase include the expansion and subsidization of renewable energy, grid expansion, and the phasing out of nuclear power.

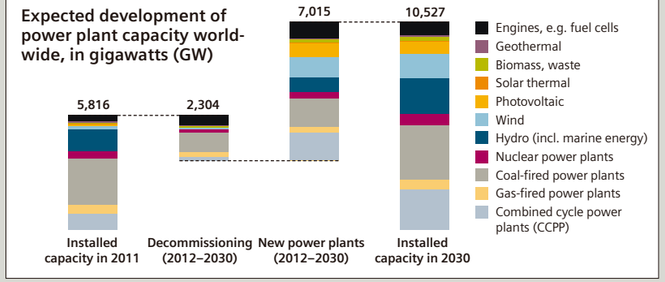
Experts at Roland Berger Strategy Consultants believe that electricity-intensive industries in particular could be hit by price increases of nearly 70 percent in the course of the next 20 years. The industries in this category paid 6.8 ct/kWh in 2010; this figure will increase to roughly 10.5 ct/kWh by 2030. Still, the Roland Berger researchers also point out that efficiency-enhancing measures such as the optimization of manufacturing processes could lead to a 40 to 50 percent reduction of electricity costs in such industries in the course of the next few decades (see *Pictures of the Future*, Spring 2012, p. 94). The danger posed by price increases to industry, especially to large companies, is limited in Germany due to the EEG's compensation rule, whereby companies pay the full EEG surcharge only on the first million kilowatt hours of electricity they consume. They then pay just ten percent of the charge for every additional kilowatt hour, and this figure is reduced to only one percent after 10 million kWh. According to Germany's Federal Network Agency, such companies will account for 18 percent of total electricity demand in 2012, but they will only contribute 0.3 percent of the total surcharge. *Sylvia Trage*

Demand for Power



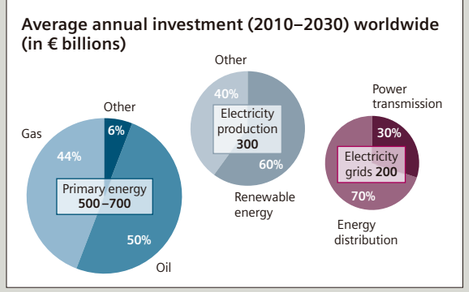
Source: Siemens

Power Plant Capacity: Expected to Double



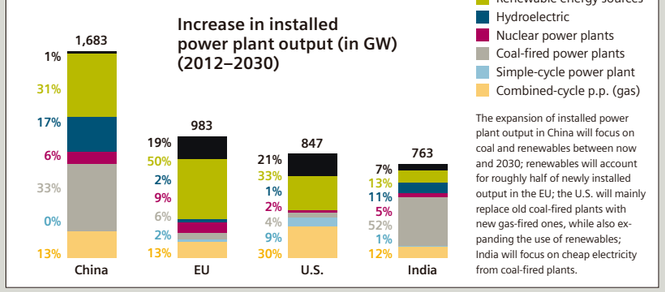
Source: Siemens

Energy-Related Investments



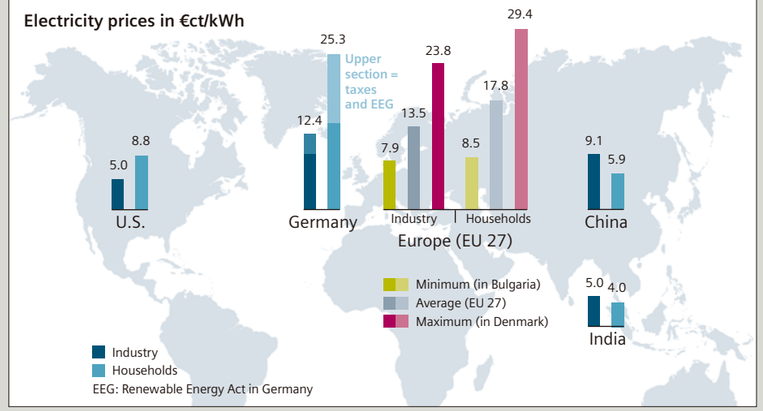
Source: IEA 2010; Siemens

Expected Energy Mix by 2030



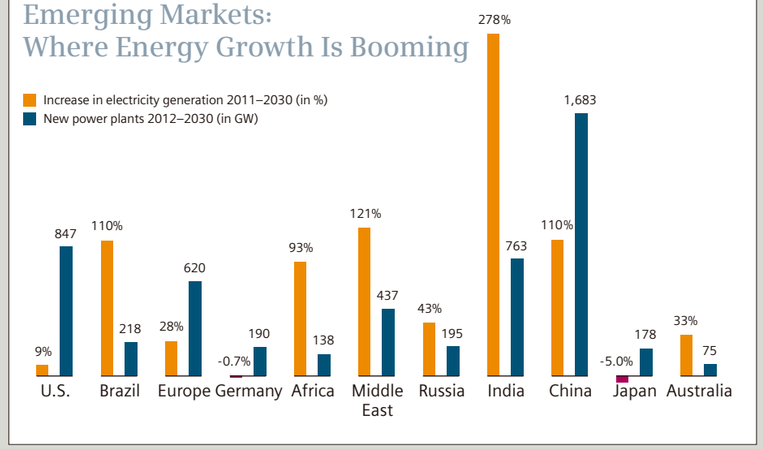
Source: Siemens

Electricity: Twice as Expensive in the EU as in the U.S.



Source: BDEW; Eurostat; Indiastat; National Bureau of Statistics of China

Emerging Markets: Where Energy Growth Is Booming



Source: Siemens

Bigger Blades in the Wind

Siemens' Wind Power division used to be a very Danish operation. But these days its activities span the entire globe. Its international expertise is taking Siemens a major step forward toward its goal of making wind energy cheaper than conventional fossil-fuel energy sources.

Siemens' new 75-meter B75 rotor blade is the world's longest. Made of fiberglass, the blade weighs 25 tons and is designed for installation on a 6-megawatt wind turbine.

Back in the 1990s, engineers came up with the daring concept of building a rotor blade that would react elastically in order to shed some of the unwanted loads resulting from atmospheric turbulence or the extreme wind conditions associated with storms. The resulting stress reduction would extend the blades' service life, make larger rotor diameters possible — and thus boost energy production.

For some time, however, specialists weren't able to create accurate models of the intricate interactions between aerodynamics and structural deformations. But then three years ago, a 30-member team at the Siemens R&D Center in Boulder, Colorado, took on the challenge of developing such a rotor blade. Support for their endeavor came in the form of innovative simulation software and the combined expertise of the specialists at the research center, which was established in 2008. "This type of innovative rotor technology and design was completely new to Siemens," says Andy Paliszewski, director of the Siemens R&D center in Boulder. "It promised to reduce the cost of energy produced by wind." The goal of the experts was clear: to exploit innovations that will make wind power cheaper than electricity produced with fossil fuels.

The team in Boulder therefore went right to work in what was a huge creative effort. Thanks to the commitment of all the members of the team and collaboration with colleagues in Denmark, it proved possible to complete the design of a 53-meter-long rotor blade — the Aerolastic Tailored Blade (ATB) — in just a few months. The blade, which is curved like an Arabian scimitar, twists as it deforms under the force of the wind. It thus reduces stress loads on the rotor, the nacelle, the tower, and the foundation. Furthermore, the ATB design makes it possible to build longer rotor blades and thus increase energy output.

In the past, it was possible to fit wind energy facilities in the 2.3-megawatt (MW) output range with blades up to 49 meters in length. But with the introduction of the ATB design, these facilities can now be equipped with new blades that are four meters longer. And that means roughly eight percent more energy. The first prototypes began operating this year under diverse weather conditions at wind farms in the American Midwest. It's therefore no surprise that U.S. energy companies are very interested in the new technology.

Siemens Wind Power is a very international organization today. But it wasn't always that way. Just a few years ago it was very much a Danish operation. Many research and development employees still work in the Danish cities of Brande and Aalborg, but a lot has changed over the last couple of years. The Wind Power division's headquarters has been moved to Hamburg, Germany, for example, and new technology core expertise centers have opened around the world. Whereas Boulder focuses mainly on rotor technology, the division's facility in Keele in the UK specializes in power generation, while the center in Aachen, Germany, focuses on electrical technology, electronics, and gearboxes.

For a long time now, Aalborg has not been the only production location for new rotor blades. In order to be able to serve the world's two biggest wind power markets onsite, Siemens now manufactures rotor blades in Fort Madison, Iowa, and Shanghai, China. The decision to open an R&D Center in Boulder in 2008 was not based solely on the desire to establish a broader presence on the U.S. market. "There were many reasons for choosing Boulder," says the Wind Power division's Chief Technology Officer, Henrik Stiesdal, who works out of Brande. "The U.S. is home to a large number of engineers and scientists with outstanding qualifications in technical fields. Although some of them are themselves from different countries around the world, it's difficult to convince them to come to Europe — not to mention Brande, which has only a few thousand residents. Boulder, however, is an attractive location for such young talents."

The city of Boulder also happens to be a center for wind power technology. In fact, it's home to institutes like the National Renewable Energy Laboratory (NREL) and the National Center for Atmospheric Research (NCAR), both of which work closely with Siemens. Last but not least, the U.S. government offers subsidies for research into renewable energy sources. All told, the Boulder team's mission was clear from the beginning: to optimize the rotors. Development of ATB technology was one of its first major projects, and although it was coordinated with staff in Denmark, the Boulder team mainly ran the show.

"When operating research centers in different time zones — the difference between Boulder and Brande is eight hours — you have to figure out a way to overcome this disadvantage," says Stiesdal. "One of the key solutions is to have the development team, in this case the people in Boulder, have ownership of specific technologies. This approach has also worked very well at our other international centers of expertise."

Cooperation across Time Zones. The team led by Kevin Standish, a rotor technology engineering manager from the Siemens R&D office in Boulder, has impressively demonstrated that the trust placed in them was well deserved. The largest challenge has been communication with headquarters in Denmark. Many of the experts from Denmark traveled to Boulder for longer stays. What's more, the engineers in Boulder frequently came in to work earlier and their colleagues in Denmark stayed later in the office. In this way, at least two hours a day were available for phone calls or videoconferencing to discuss pressing issues.

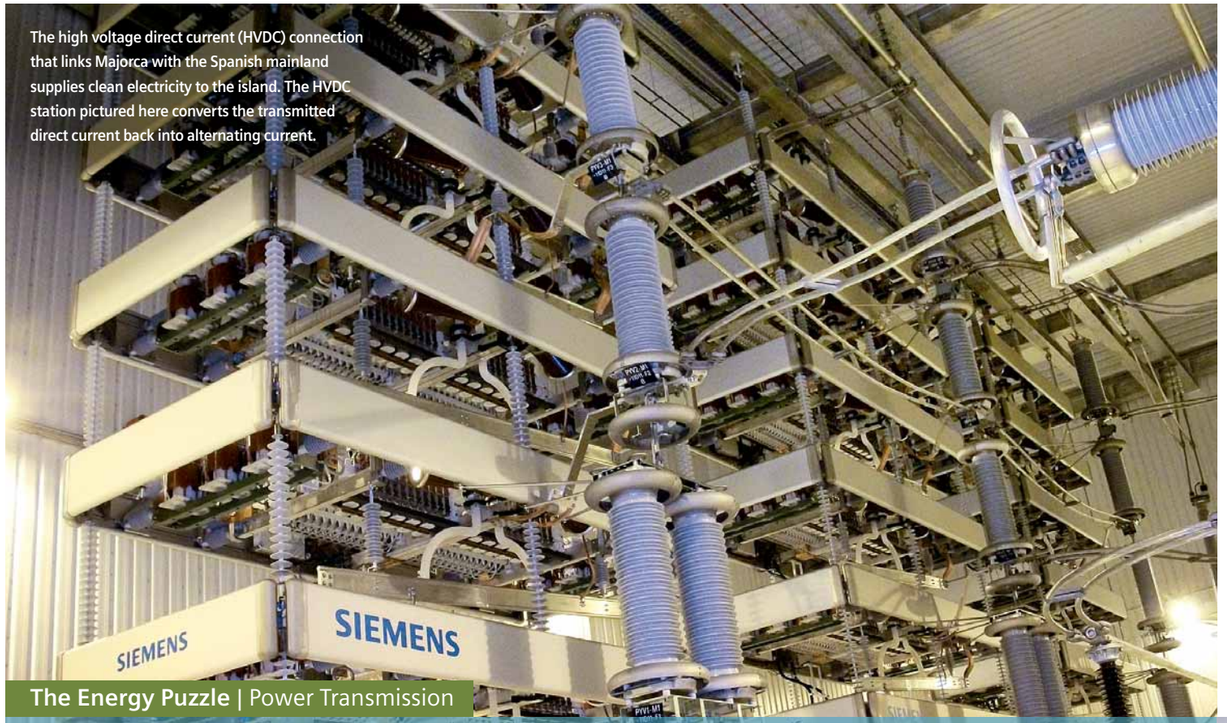
Other challenges the team faced included the creation of new design tools and finding new ways to integrate areas as varied as aerodynamics, software, and materials science. Last but not least, the new ATB technology had to develop from the concept stage to a prototype blade in Aalborg within a few months without compromising quality. But the Siemens-experts succeeded — not least thanks to close collaboration across department borders and a combination of existing technologies, such as proprietary Integral Blade single-shot infusion technology. To achieve their goal they also incorporated a number of new materials and manufacturing techniques. "The team has only just begun to explore ATB technology," says Standish. "Its full potential will play a significant role in helping to further reduce the cost of energy produced by wind."

The height of wind turbines continues to increase — giant white towers with rotor diameters well over 100 meters are no longer a rarity. Moreover, the first Siemens blade design to incorporate some elements of ATB technology resulted in the "B75" — the world's longest — for its flagship 6 MW direct-drive wind turbine (photo p. 22). "Without the early advances in design tools and processes resulting from ATB technology exploration, the design of the B75 would never have been possible," Standish reports.

The first B75 blades were mounted on a turbine off the coast of Denmark in August 2012 — but this achievement by no means marks the end of the development process. "Sometime in the future we will probably see a 10 MW turbine with 100-meter rotor blades," says Stiesdal. "Without a doubt, ATB technology from Boulder has played a key role in getting us to this point." ■ *Hubertus Breuer*

Thailand's Growing Power

It's the largest road freight delivery in the history of Thailand. It will take until spring 2013 and involve around 1,100 trips to transport a total of 90 dismantled Siemens wind energy systems from the port city of Laem Chabang to a new wind farm in the province of Nakhon Ratchasima in the northeast of the country. The trucks, with their cargo of 60-meter-long rotor blades, face a 400 kilometer trip over roads that have had to be specially improved and adapted in many places. The project is part of Thailand's effort to obtain a fifth of its energy requirement from renewable sources by 2022. For Siemens, these 2.3 MW turbines represent the first large wind power contract in the kingdom. The wind farm is scheduled for completion in 2013. Once installed, the turbines, with their 101-meter-diameter rotors, will cover 1.5 percent of the country's electricity demand. Siemens China and Siemens Thailand negotiated and planned the project and handled its implementation. To strengthen is presence in the region, Siemens built rotor-blade and machine-housing plants near Shanghai, which also supplied the new wind farm in Thailand.



The high voltage direct current (HVDC) connection that links Majorca with the Spanish mainland supplies clean electricity to the island. The HVDC station pictured here converts the transmitted direct current back into alternating current.

Electricity Superhighways

The creation of a sustainable energy system requires the expansion of long-distance power transmission networks. The problem is that transporting high voltages over long distances with conventional alternating current causes prohibitively high losses. What's more, new lines often meet with considerable public resistance. *Pictures of the Future* examines some surprisingly efficient alternatives.

Renewable energy sources should be used wherever they are abundantly available — from wind power on the high seas to solar energy in sunny regions. Germany, for instance, plans to build wind farms with up to 30 gigawatts of capacity in the northern part of the country between now and 2020. But most of its energy consumption is in the south. So the real question for Germany is how to get its renewably-generated electricity from the north to the south. Existing power lines can't do the job; already, clean electricity from the north often has to be redirected through Germany's eastern and western neighbors in order to get to the south. A huge expansion of the grid therefore appears to be unavoidable. In response to this challenge, Germany's federal government and the country's four power transmission companies presented a grid development plan in May 2012. The plan calls for the construction of 3,800 kilometers of new transmission lines over the next ten years. After it's completed, this colossal project could serve as a model for sustainable energy supply systems in other countries, especially if, as is the case in Germany, a large share of renewable energy sources is situated far from major energy consumption centers.

Can the German grid be expanded as quickly as planners would like? "Losses over just a few hundred kilometers would be too high with the alternating current technology that's generally been used to date," says Professor Dirk Westermann, Director of the Electrical Energy Supply Department at Ilmenau University of Technology (east of Frankfurt, Germany) and a member of the Advisory Council for the "Future-Oriented Grids" platform at Germany's Ministry of Economics and Technology. "The most efficient approach would be to expand the system using high-voltage direct current (HVDC) transmission technology," he says. HVDC makes it possible to transport electricity over a distance of more than a thousand kilometers with low losses. "Direct current lines reduce transmission losses by 30 to 50 percent as compared to alternating current lines," says Jörg Dorn, Director of HVDC Systems Development at Siemens Energy.

Siemens has been demonstrating the effectiveness of the technology since 2010 in China, where an HVDC connection now supplies megacities in Guangdong province with clean electricity from a hydroelectric plant located 1,400 kilometers away (see *Pictures of the Future*, Fall 2009, p. 24). Other reference projects in New Zealand, New York City, and Spain also highlight the advantages the technology offers. The island of Majorca, for example, now receives electricity from renewable sources on the Spanish mainland via an HVDC connection. The system is designed to provide extra capacity during peak loads during the vacation season and spare the island the burden associated with construction of new power stations. Siemens, one of the leading suppliers of HVDC systems, currently has a world market share of around 40 percent.

Transmitting More Power. An HVDC connection is similar to a pipeline that links two locations. At one end, a converter station transforms alternating current into direct current at a very high voltage — for example, 400,000 or 800,000 volts. A second converter at the receiving point then transforms the DC into AC current that can be supplied to consumers. "The converters are very expensive, but the lower transmission costs begin making up for that after a distance of 600 kilometers," Westermann explains.

Another benefit offered by HVDC is that it can transport two to three times more power than an AC transmission line with the same route width. Existing lines can also be converted into high-capacity electricity superhighways. The idea becomes exciting when one considers that virtually all the conducting cables in Germany are supported by masts with two cross-arms. These run an independent three-phase alternating current connection on each side (left and right), which makes the system redundant. "That's why, instead of building completely new lines, we're thinking of equipping existing masts with a common line, with one connection each for AC and DC current," says Dorn. In addition to this upgrade, all that would be needed would be to add HVDC converters at the beginning and end of each line. Such a solution would also meet with greater public acceptance because, rather than building new masts, we would only need to upgrade existing ones," says Dorn. "These modifications could be carried out much faster than it would take to build a new transmission route. However, there are major technical challenges involved; these have to be studied and potential solutions have to be tested."

Amprion, a grid operating company, would like to complete a roughly 430-kilometer parallel AC/DC connection from Germany's Rhineland region to the state of Baden-Württemberg before 2019; only 10 percent of the route would require new construction. Parallel transmission of AC and DC has not been sufficiently tested in practice, but research in this area has produced promising results. Siemens is working closely with various colleges and universities in order to determine whether and how the AC and DC systems might affect one another, for example.

HVDC lines could also improve networking between different energy systems in Europe. The coming expansion of the European power grid is focused on the east and south — all the way to Russia, the Middle East, and Africa — and the network will soon reach a point where it can no longer function as a long-range synchronous grid. That's because the alternating current networks in these regions are not directly compatible with the inner-European grid in a technical sense. HVDC converter stations could offer a solution here, because HVDC transmission systems make it possible to link different AC grids over long distances. In addition, the converter stations act as a firewall by blocking the cascade-like expansion of system disruptions — thereby reducing the chances of blackouts. HVDC can also help to end blackouts quickly. As Dorn explains, "We've refined HVDC technology to enable it to rapidly get a failed grid back on line."

In the future, it will even be possible to add a spur to an HVDC link, which would allow metropolitan areas located at the periphery of a planned line, such as Germany's Ruhr district, to benefit from the technology as well. Such "multi-terminal" HVDC systems will also be needed if a European Super Grid is to be built in the future.

Involving the Public. Once technical challenges have been addressed, nothing more will stand in the way of grid expansion. Still, technical feasibility isn't everything, since the expansion of the energy system will also require widespread public support for the construction of new overhead lines (p. 29). Success here will hinge on providing accurate information, getting the public involved in the planning process as early as possible, simplifying approval procedures, and ensuring a high level of transparency.

It's also important to remember that some locations are not suitable for high-voltage masts — for example, major cities and the areas surrounding airports. In such areas, gas-insulated transmission lines (GILs) can provide a practical alternative. GILs are equipped with a mixture of nitrogen and sulfur hexafluoride (SF6) as insulators, rather than the paper or

Gas-insulated transmission lines can carry high voltages in environments where masts are impractical.

plastic-based materials used in underground cables. The conductor is a tube around 18 centimeters thick surrounded by a protective second tube with a thickness of 50 centimeters. Transporting high voltages is not a problem here — all you have to do is to increase the diameter of the tubes as needed. A direct ground line today can move around 3,200 amperes, while an airborne line can transmit up to 5,000 amperes — at 550,000 volts.

A further advantage of GILs is that virtually no electric or magnetic fields can be detected in their immediate vicinity, which means that they do not disrupt telecommunication networks or air traffic control systems. GIL technology also complies with even the most stringent European guidelines, which explains why there have never been any problems regarding people standing or walking above GIL tunnels. Thus it's clear that underground lines now offer a good alternative to masts — although they're still approximately four times more expensive than their free-standing counterparts. That's why they will mainly be used when high voltages need to be transmitted in places where space is limited or where local environmental regulations must be adhered to.

Experts are now thinking about linking electricity and data lines in order to reduce the high costs that grid operators will incur as a result of network expansion. The idea here would be to bury both types of grids side by side in accessible tunnels next to highways, canals, and rail lines. ■ *Bernd Schöne*

Preparing for a Borderless European Electricity Grid

In the future, European borders will be eliminated not only for people, goods, and financial transactions, but also for electricity. An expanded European electricity grid will go beyond the existing ENTSO-E (European Network of Transmission System Operators for Electricity) system, and possibly extend all the way to Iceland, Russia, the Middle East, and Africa. In order to explore associated possibilities, the European Commission launched the "e-Highway 2050" study in mid-2012. "Up until now, grid planning was carried out by individual countries — but what we need now is a European-wide concept," says Dr. Andreas Luxa, who represents Siemens in the ongoing discussions. "The Commission's study will define the technical framework here and propose appropriate policies for Europe. We still don't have any binding rules regarding which technologies should be employed to put electricity into the grid and how they might be used." Luxa is referring here to the netcodes that regulate traffic on electricity highways and ensure a smooth exchange of energy. The codes provide precise information on how quickly a grid operator needs to react to the failure of a transmission segment or an entire power plant. Grid operators in Europe formulate the rules for energy exchange through the ENTSO-E grid operator association. This energy exchange is enormous. In 2006, for example, 25.7 billion kilowatt-hours of electricity (TWh) were exchanged across national borders within the western European grid system; the total energy exchange amounted to 30.2 TWh. The grid, which is operated by companies in the ENTSO-E association, stretches from the North Cape to Sicily and from the mouth of the Tagus River to the Danube River delta.

Siemens is building converter platforms that are as tall as a ten-story building. The platforms will convert wind farms' alternating current into direct current.

The Energy Puzzle | Wind-to-Grid Connections

Giants of the North Sea

In order to connect offshore wind farms to the power grid, Siemens is building huge converter platforms that will make high-voltage direct-current transmission possible. The result: Lower transmission losses and increased incentive to develop wind parks on the high seas.

It's incredibly stuffy in the dim interior. In fact, without a guide, you could easily get lost in the huge structure — a converter platform that is being built at the Nordic Yards shipyard in Wismar, Germany, on the coast of the Baltic Sea. A tour of the facility is like a visit to the Egyptian pyramids. Indeed, the building's dimensions are comparable to those of the pharaonic tombs. Thirty-five meters high, 70 meters long, and 50 meters wide, the structure weighs up to 15,000 metric tons. To put it another way, the facility is as tall as a ten-story building and weighs as much as 25 fully fueled and fully loaded Airbus A380 jets.

Workers are visible between the scaffolding in the interior. They wear white uniforms as well and protective goggles. They are welding components and installing sophisticated technology, bringing electrical engineering together with the maritime world to assemble the foundations of a transition to a renewable energy economy. What's taking shape is the first of three offshore converter platforms that Siemens is building in the coastal cities of Wismar and Warnemünde. The platforms will make high-voltage direct-current transmission (HVDCT) possible. Specifically, they will concentrate the alternating current produced by North Sea wind farms and convert it into direct current, which will be transmitted through submarine cables to the coast.

The platforms are being built because offshore wind power plays a key role in Germany's efforts to bring about what the country calls an "energy transition." As it strives to increase wind energy's share of the total electricity mix to 15 percent by 2025, Germany plans to increase the electrical output of offshore facilities to around 10 gigawatts (GW) by 2020 and 25 GW by 2030. By comparison, Germany currently has only two wind farms in operation (alpha ventus and EnBW Baltic 1), with a combined output of 200 megawatts (MW) or 0.2 GW. Offshore wind facilities have obvious advantages. For example, a 6 MW wind turbine typically generates 23 gigawatt-hours (GWh) of electricity per year when located on land in coastal regions, but 31 GWh if it is used at sea. Thanks to the stronger winds at sea, offshore facilities can operate flat out for more than 4,000 hours, compared to 2,000 hours at peak capacity on land. In other words, much more powerful turbines can be used offshore, and they operate at full capacity almost half of the day. By contrast, high-performance 6 MW turbines generate much less electricity on land, where they generally operate only six hours per day at full load.

Long Distance Efficiency. Until now, offshore wind farms located near the coast have been connected to the grid using conventional alternating current transmission systems. After all, this approach is not only technically feasible but also more economical for distances under 80 kilometers. Over longer distances, however, alternating current lines act like capacitors that charge and discharge 50 times per second. Energy is lost due to reactive power losses at the submarine cable's insulation layer. HVDCT technology, on the other hand, does not suffer from such losses, and can thus outperform AC systems at distances over 60 kilometers. At voltages of 250 to 320 kilovolts, large amounts of direct current can be transmitted over hundreds of kilometers with almost no losses. "Because offshore projects located far from coasts need HVDCT, this technology is a key element of the energy transition," says Tim Dawidowsky, CEO of Power Transmission Solutions, which is part of Siemens' Energy Sector.

At the heart of the new platform is HVDC Plus — a space-saving version of Siemens'

high-voltage direct-current converter. At sea, the system, which Siemens refers to as a Wind Power Offshore Switchgear (WIPOS), can convert up to 1 GW of electricity into direct current. The system is installed on a floating platform that can be pulled to its destination by tug boats. The substructure is placed on the seafloor, generally 20 to 40 meters below the surface. The entire structure is anchored by steel piles driven 40 to 60 meters into the seafloor. Later, the substructure lies below the surface of the water, and the platform's supports are set on top of it and fixed in place.

Soccer Fields in the Sky. "Once installed, the platforms look like soccer fields suspended a good 20 meters in the air, which is enough height to protect them against the sort of very large waves that occur only about every 100 years," says Christian Schmitt, who has overall responsibility for the platform construction project, which he manages from his office in Hamburg. "The helicopter pad at the very top is about 60 meters above sea level," adds Schmitt's colleague Michael Suhr, who has been a shipbuilder and marine engineer for more than 20 years and now supervises the platforms' construction. "You could call it a pioneering achievement. After all, we're basically building a ship without a rudder or a main engine."

Not only do the huge platforms weigh five times as much as their predecessors; they can also be located five times further from the coast. In addition, the platforms can be erected in water that is twice as deep (40 meters) and they can generate twice as much output (730 MW) on average.

One of the new platforms will be installed more than 100 nautical miles from Heligoland. Out here the weather is extremely rough, the water is deep, the air is salty, and the waves are high. But the ability to meet these challenges pays off, given that wind speeds are much higher on the open seas, resulting in higher wind farm output.

Siemens is currently working on four HVDCT platforms: BorWin beta, HelWin alpha, HelWin beta, and SylWin alpha. The platforms' names are derived from the names of Borkum, Heligoland, and Sylt — the nearby North Sea islands. SylWin alpha will transmit 864 MW and connect the DanTysk wind farm to the grid from a site 70 kilometers west of Sylt. That's enough power to cover the needs of 1.5 million German households. "It's comparable to the output of a large power plant," says Suhr.

The 160 kilometer-long line connecting SylWin alpha to the grid will be the world's longest submarine cable for an offshore network connection. A further 45 kilometers of cable will transmit the electricity overland to a connection point in Büttel, where the direct current will be converted back into alternating current for the German power grid. Siemens is building the platforms in cooperation with Nordic Yards; it was commissioned to establish the network connection by the Dutch-German company TenneTTSO.

Offshore wind farms known as Veja Mate and Global Tech 1 are located about 125 kilometers northwest of the island of Borkum and will one day generate up to 800 MW of power. The BorWin beta platform transforms the alternating current supplied by wind turbines from 155 kilovolts to 300 kilovolts before converting it to the same voltage of direct current. The platform houses all of the equipment for the HVDCT converter: the converter itself as well as two transformers, four compensating reactors for the alternating current cables and gas-insulated high voltage switchgear technology.

HelWin alpha and HelWin beta will be used in a similar manner 35 kilometers north of Heligoland, where they will handle capacities of 576 MW and 690 MW, respectively. HelWin beta will serve as a smaller sub-platform, which means it will only have a few emergency shelters instead of comfortable crew quarters like the ones on HelWin alpha. "Staying there would be a bit adventurous, as the platform has no running water and is merely equipped with a chemical toilet," says Suhr with a grin. The platforms are generally unmanned and can be remotely monitored by the grid operator. The crew quarters are occupied only when the platforms are being installed or undergoing maintenance.

Forests of Offshore Platforms for the UK. The offshore switchgear project is an example of the fact that pioneering achievements are rarely accomplished without a hitch. Aside from technical obstacles, the new facilities had to be certified by the customer.

In addition, the approval processes have been more time-consuming than expected. These processes are very protracted for two reasons. Not only do many components have to be approved separately; the standards aren't actually defined until participating organizations begin processing the order. Due to these hurdles, the first platform will be delivered over a year later than planned. Costs will increase considerably as a result.

However, the sector has substantial business potential — and not just as far as Germany is concerned. In fact, the UK's plans for offshore power generation are even more ambitious. The country wants to increase offshore wind energy's share of its total electricity mix to 25 percent by 2020. In a three-stage process, the UK plans to increase its offshore wind power capacity to 48.6 GW. "England is planning so many platforms and wind farms at the moment that in a few years we'll be able to walk there!" quips Suhr.

"We are moving in the right direction and are determined to implement and complete the projects needed to create a truly sustainable energy supply," says Schmitt in recognition of the pioneering work being performed in the North Sea. The first platforms are scheduled to begin feeding electricity into the grid in 2014. The "pyramids" of the North Sea can then be expected to make a big contribution to generating zero-carbon electricity for the future. ■ *Maximilian Heinrich*

Tug boats pull a giant, floating switchgear structure to its destination. Such systems can convert up to 1 GW of electricity into highly efficient direct current.

Siemens researchers are examining methods for the future electrification of road freight at a 1.5-kilometer test track at a former Soviet airforce base north of Berlin.

Ready to Roll

Siemens is using an old airfield north of Berlin to test hybrid-electric trucks equipped with pantographs like the ones on streetcars. The trucks could be used between logistics centers and mines or ports. Heavily-traveled truck routes in urban areas are another possibility. Either way, the technology could help to decouple rising freight traffic volume from carbon dioxide emissions.

Every day, Jörg Grützner is a witness to the ironies of history. A former long-haul trucker, Grützner climbs into the cab of an 18-ton truck and looks out on a runway that cuts right through the pine forest in the Uckermark region of Germany, some 80 kilometers north of Berlin. The irony is that Soviet bombers used to take off from this very spot until around 20 years ago.

But the Russians have gone home and the new civilian tenants of the giant military airfield have put the facility to an entirely different use, transforming it into safety proving grounds and adding a racetrack. What's more, Europe's biggest photovoltaic park is now being built where ammunition depots once stood, and the former military security zone around the airfield has been transformed into the Schorfheide biosphere reserve. "The Russians never let us get close to this place before," Grützner, 55, says with a obvious satisfaction. "But today I'm cruising around on their runway."

Grützner has been driving trucks for over three decades. But for the past year he's been working exclusively at the former airfield as a test driver in ENUBA (Electric Mobility for Heavy-Duty Commercial Vehicles as a Means of Reducing Environmental Pollution in Major Metropolitan Areas), a pilot project that is being jointly conducted by Siemens and Germany's Environment Ministry.

Since the project's inception in July 2010 Siemens engineers have been examining methods for the electrification of road freight traffic. To this end, they have crossed a streetcar with a truck in order to combine the best of both worlds — an electric drive system and the flexibility of a road vehicle.

Tests are being carried out with two standard trucks fitted with standard hybrid drive systems. In this setup, only the electric motor is used to drive the axles. The motor obtains its electricity either from a generator powered by a diesel engine or from an overhead power line, as a streetcar does. Such a line now stretches above the former runway, which Siemens researchers have converted into an

electrified test track. The 1.5-kilometer route has two parallel catenary wires on the right shoulder. These are held in place by poles placed at 65-meter intervals. Engineers equipped the trucks with a new type of pantograph that docks automatically to the wires and is able to counteract the movements of the vehicles within the dedicated lane.

When a driver hits the brakes, the energy thus released is sent back into the overhead line as electricity that can be used by other vehicles in the system. "Unlike their counterparts in trains and trolleybuses, our pantographs are truly intelligent," says Dr. Michael Lehmann, the Technical Project Manager for ENUBA at Siemens' Infrastructure & Cities Sector. "Thanks to sophisticated sensor technology, the system always knows exactly when a truck leaves the electrified lane." If that happens, the pantograph automatically retracts — and can do so reliably at speeds up to 90 kilometers per hour. If the truck goes any faster, the motor automatically shuts down.

Drive System Interplay. Grützner hits the "gas." As soon as he does, the electric motor releases its 4,500 Newton meters of torque and the colossus with a payload capacity of 40 tons begins to glide effortlessly down the track. The only sound it makes is the steady rumbling of the diesel engine that runs at an optimal rotation speed and produces electricity for the electric drive. "The additional 500 kilograms for the hybrid drive hardly make a difference here," says Grützner. "This truck actually accelerates better than a pure diesel vehicle, and it also drives just like a normal truck." Grützner is quite relaxed behind the wheel. He and his colleagues have already clocked up nearly 9,000 kilometers with the new trucks — without any problems.

An electric truck's pantograph can be activated manually with just the push of a button or automatically. It docks to an overhead line and then retracts if the vehicle leaves the electric lane.

"Now I'm going to switch her over to electric power," Grützner announces as he moves his truck onto the section of the track outfitted with overhead lines. He taps a small device mounted on the dashboard that is used for operating the pantograph manually, although the system normally functions automatically. The pantograph rises almost unnoticeably and the diesel rumble disappears. At this point, the truck sounds like a swarm of bees as it rolls down the runway. Grützner hits the blinker and switches lanes; right after that, the pantograph retracts and the diesel engine goes back into action.

Germany's Environment Ministry (BMU) would like to see such trucks on normal highways in the future — in the far right lane with an overhead line. This wouldn't be difficult to do, technically speaking, says Lehmann: "Integrating the system into the existing road network would be relatively easy, and its installation wouldn't restrict other vehicles in any way." More than anything else, the technology could help get the rising CO_2 emissions caused by road freight transport under control. Progtrans, a Swiss transport consulting firm, predicts, for example, that the volume of trucks on highways will continue to increase in the future. The company reports that freight transport (as expressed in ton-kilometers) in Germany alone will increase by 116 percent by 2050 as compared to 2005 levels. According to Germany's Ministry of Transport, nearly 3.4 billion tons of goods were shipped on the country's roads in 2011 — roughly eight percent more than in the previous year.

The expected increase in transport volume will be accompanied by a rise in annual CO_2 emissions, which are expected to climb from approximately 40 million tons today to 100 million tons in 2050 — unless major technological changes are implemented. Without such changes, the EU Commission target of an 80 percent decrease in CO_2 emissions by 2050 (as compared to 1990 levels) will become nothing more than a pipe dream.

The "tram-trucks" from Siemens could prove to be a promising option, according to the German Advisory Council on the Environment. The Council believes the technology could help decouple rising freight transport volume from greenhouse gas emissions. In its latest report, the Council recommended that all German highways with single-digit number designations be equipped with overhead power lines, which would amount to a total of 5,400 kilometers of electrified highways.

A Mixture of Solutions. Today's solutions, which call for building new rail lines, increasing drive system efficiency, and optimizing logistics systems, aren't enough to meet Germany's ambitious carbon dioxide reduction targets. An expansion of the rail network, for example, would mean that rail lines would not only have to absorb the projected increase in truck traffic but also existing highway freight traffic. This would require a fourfold increase in rail network capacity. What's more, the additional tracks would take up space that's not available in the densely populated areas where goods are ultimately consumed. According to a study conducted by Progtrans, the BMU, and the German Ministry of Transport, such measures would reduce annual CO_2 emissions to only about 60 million tons by 2050. But the EU's goal is to limit emissions to approximately ten million tons — a target that can be achieved only by electrifying road freight transport (see chart). Meeting that target, however, requires that the lion's share of the power for electric trucks must be produced from renewable energy sources, which is still a long way off.

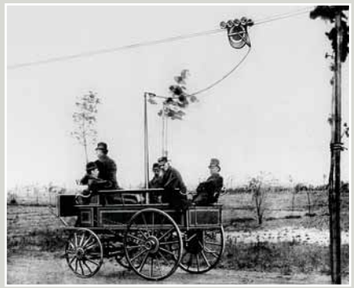
All told, implementing the new technology will take a lot of money. The German Advisory Council on the Environment estimates infrastructure costs at €1.1 million to €2.5 million per kilometer (including guard rails and overhead power lines). However, Siemens experts aren't thinking about electrifying entire highways. "We're initially examining well-traveled routes over short and medium distances," says Lehmann. "These include back-and-forth truck routes that have no rail connections — like routes between logistics centers and ports, or from mines to central storage facilities and transshipment centers." The "tram-trucks" could also play a major role in cities like Los Angeles, where the city government is looking for a zero-emission solution for Highway 710. This chronically congested 30-kilometer road runs right through the middle of Los Angeles, linking the city's port with its main logistics center. It is estimated that Highway 710 sees some 35,000 truck trips every day.

Pollutant emissions have reached such high levels that the air quality authority in LA has considered temporarily closing the road at certain times. Rail system capacity is also stretched to the limit — there's simply no room left in this crowded metropolitan area. Siemens experts therefore believe this is an ideal place to put ENUBA technology to work; they want to submit a tender to Los Angeles that would offer their electric trucks as a solution. To this end, the ENUBA team will set up an initial test system in LA in the near future.

Experts are also thinking of using the electric trucks in Sweden to shuttle cargo from an iron ore mine near the city of Kaunisvaara to a rail station 162 kilometers away. A rail connection wouldn't make sense here because the mining operation is only temporary.

Meanwhile, work continues in the Uckermark region. Scientists there plan to upgrade the test track by installing curves, overhead road signs, and electronic traffic control systems. The technology will then be optimized and tested under normal road conditions. Grützner, for his part, would also like to drive his electric truck outside the confines of the former airfield — and enjoy the quiet sound of the electric drive system for a few hundred kilometers. Doing so might be dangerous, however, as Grützner points out: "That smooth humming sound tends to put you to sleep after a while." *Florian Martini*

A Step Forward and a Look Back



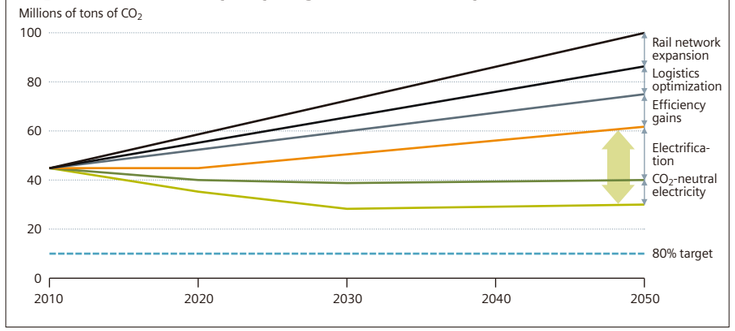
The ENUBA project in Germany's Uckermark region is taking Siemens scientists a step back into the future. It was nearly 130 years ago (and just an hour's drive away) that engineers began testing the grandfather of the ENUBA electric truck. On April 29, 1882, Werner von Siemens officially opened the world's first testing facility for an electrically powered trolleybus in the Halensee district of Berlin — just one year after the first electric streetcar entered service. The "Elektromote" (top left), as this first coach-like electric bus was called, itself had a history dating back even further, as von Siemens was already dreaming of an electric drive system as early as 1847. "If I ever have the money and the time," he wrote, "I would like to build an electric cab."

The first electric cars appeared at the beginning of the 20th century. In 1905, for example, the "Elektrische Viktoria" from Siemens began operating in Berlin as a hotel taxi. The rise of the trolleybus also began at this time. This new development was particularly useful for short-distance trips in suburbs and rural areas. Several inventors and companies came up with their own trolleybus concepts. One of them was an ex-Siemens employee named Max Schiemann, who got most of the electrical components for his trolleybus lines from his former employer. By 1913, Germany had a trolleybus route with a total length of 54 kilometers. Today such buses can be found in more than 300 cities worldwide.

The "tram-trucks" Siemens researchers are now working on are close relatives of the trolleybus. One big difference, though, is that the trucks are equipped with an "intelligent" pantograph that automatically compensates for vehicle movements. Engineers can already imagine doing away with the trucks' current diesel hybrid system. Also conceivable would be the combined use of an overhead power line and a fuel cell to drive the electric motor, which would allow the truck to drive completely emission-free in areas where no overhead lines are in place.

Electric Trucks Promise to Trim CO_2 Emissions

CO_2 emissions from heavy-duty freight traffic in Germany



Sources: BMVBS 2007, progtrans, estimates of the long-term development of freight traffic in Germany, 2005-2050, BMU — Renewable Energy in Germany, status in 2009, development of specific CO_2 emissions in the German electricity mix 1990–2008

All over Germany, private citizens are forming cooperatives for investing in the development and expansion of renewable sources of energy such as wind farms.

Power from the People

The people of Germany want a transition to renewable energy sources. But they want to have a say in how it's implemented, and they want to benefit from renewable energy themselves — including financially. Three examples illustrate how citizens are coming together to take on the job of supplying their own clean energy, and are thus helping to promote a cleaner future.

Lush green fields spread out across the marshlands near the North Sea coast of Germany. Here, where the Elbe River flows into the sea, beaches, bike trails, and nature reserves invite tourists to relax and recuperate. But the region around the Lower Saxony community of Oederquart has something else to offer the local economy — wind. An investor from southern Germany realized this in the 1990s and began negotiating with landowners to develop real estate for a wind farm.

Many people felt that the village's tranquility was threatened. Would they have to listen to giant wind turbines from now on, while only a few people in town would profit from them? The investor was turned down. Instead, the community of 1,150 people quickly formed a cooperative that subsequently became a company called the Citizens' Windpark Oederquart Management Society mbH. The objective was for the community to harvest the wind. Soon, all suitable pieces of land were identified in line with the town's land use plan. Every citizen could participate in the wind farm by investing DM1,000 (€511) or more. Informational events, press releases, and advertising campaigns helped to sell the residents on the project.

"We had no idea of what we were letting ourselves in for — not in terms of the dimensions, the money, the construction or the legal aspects. We went into this like a group of Boy Scouts," recalls Jürgen Goldenstein, who today is the Executive Manager of the town's wind park. The community brought in a planning office. Measurements of wind potential, environmental impact studies, and licensing procedures were carried out before the first wind turbine entered service in December 1997.

In the following years 15 more units were added, including some from Siemens. The current installation can generate up to 28 megawatts in total. But it was a pretty rough road before the wind farm got to where it is now. The wind estimates were too optimistic, for example, which meant that during some years the yield was below expectations. These days, though, the mood in the community is positive. Almost 400 shareholders have invested in the town's wind park since 1994. Partly as a result of the energy transition and the phase-out of nuclear power in Germany, people in Oederquart feel they've been doing things right.

Achieving something as a group that would be impossible for individuals to do — that's the idea behind citizen-owned energy parks. In Germany, the birthplace of the cooperative, this idea is more alive than ever. In many cases, citizens can participate with only modest sums of a few hundred euros. The trend these days is toward self-reliance. From 2007 to 2011 the number of registered energy cooperatives in Germany rose from 101 to 586. In the course of a year more than 80,000 Germans cover all of their household electricity needs from these cooperatives, according to the German Cooperative and Raiffeisen Confederation (DGRV). In 2010, 40 percent of renewable energy production capacity in Germany was in the hands of private individuals, and an additional 11 percent was owned by farmers.

By comparison, according to the trend:research market institute and the Klaus Novy Institute and supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, only 6.5 percent of capacity was owned by the four biggest German energy suppliers.

Through this development, individual citizens have become pioneers in Germany's energy transition. "Energy cooperatives are an ideal way for citizens to engage in the restructuring of the electrical infrastructure where they live. In the process they increase the level of acceptance for regional energy projects," says Dr. Eckhard Ott, CEO of DGRV. People have many reasons for getting involved. They want to make a difference in their own region, they want to be independent from fossil fuels or they want to make sure that money stays in the region — for example, through citizens operating a wind farm themselves, hiring regional contractors, and making sure business taxes flow back into the local community.

The risks are few. According to Germany's Renewable Energy Act (EEG), green electricity produced by "self-made" power plants must be fed into the grid. To be successful, the facility's location must be well chosen, the costs must be calculated realistically, and there has to be enough interest in participation to support the project. The network operator and the local energy company must also be involved in the enterprise to make sure that the electricity can ultimately flow into the power grid.

Reliable Income. Citizen-based energy projects can mean extra income for regions with underdeveloped infrastructures in particular. A successful example of this is the Bassens wind farm. In this Lower Saxony community, which is only 500 meters from the North Sea, the construction of numerous individual wind units was planned in the 1990s. Resentment arose among citizens, however, who were primarily opposed to the number of planned wind turbines. Preliminary projections indicated that the project was viable. But the community wanted the wind energy facilities to be planned in an orderly way, thus requiring the creation of a land use plan. The local farmers eventually accepted the development as proposed in the plan, but only on one condition: "When the wind turbines are built, we want to operate them ourselves and get the profits, instead of just having to look at them," said Johann Dirks, a co-founder of the initiative. Today Dirks is one of the managing directors of Windpark Bassens GmbH and Bürgerpark KG.

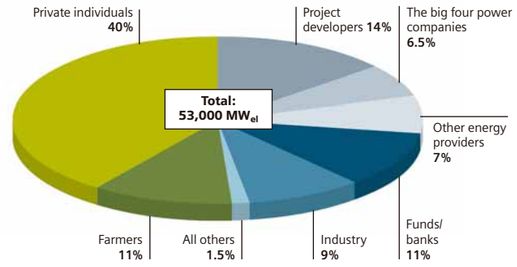
A total of 16 farmers gave the go-ahead and visited residents of the surrounding area to encourage them to back the new wind farm. In the end, around 120 households came together to put up about a fourth of the needed capital. A planning firm helped out by hiring contractors and supervising construction. Every year now, the raw North Sea wind ensures that the shareholders receive their promised payment. The 34 units with their output of 20.4 megawatts provide around 45 million kilowatt hours a year to meet the needs of some 10,000 households. These examples show that, especially in the case of wind energy, acceptance by citizens is significantly higher if they actively participate in projects — both financially and in terms of decision-making.

Germany also has citizen cooperatives for heat generation. One of them is in Honigsee, a small community of 450 inhabitants southeast of Kiel. In 2006 two farmers built a biogas facility there and declared that they were willing to make the waste heat from the attached cogeneration plants available to the citizens for free. The only condition was that the citizens themselves would have to install a local heat distribution network.

At first no one in the village knew how to make such a network a reality. "After all, we weren't engineers or network builders. When we brought in the local energy provider, the company politely declined to get involved in the project, on the assumption that the network would be too expensive and wouldn't be financially feasible," says the initiative's cofounder Dr. Frank Heblich, who is also a former member of the cooperative's Board.

Share of Renewable Energy in Private Hands

Ownership distribution of installed capacity for electrical generation from renewable energy sources in Germany



Source: trend:research; Status: 10/2011

But the group that initiated the project just couldn't let go of the idea — to take the waste heat that was readily available and make use of it while at the same time saving on fossil fuels and costs. They worked out how expensive the network would be to build, how much of the energy they could expect to be consumed, and the most money the project could ultimately cost each shareholder while still remaining attractive to consumers.

Making such a project a reality depends on the number of households that are connected to the network. So a meeting of local residents was called to win them over to the project. "Their biggest worry was that, since the old heating system would ultimately have to be completely dismantled, the heat might run out in the winter," says Heblich. What finally convinced local residents were the cost savings they would see.

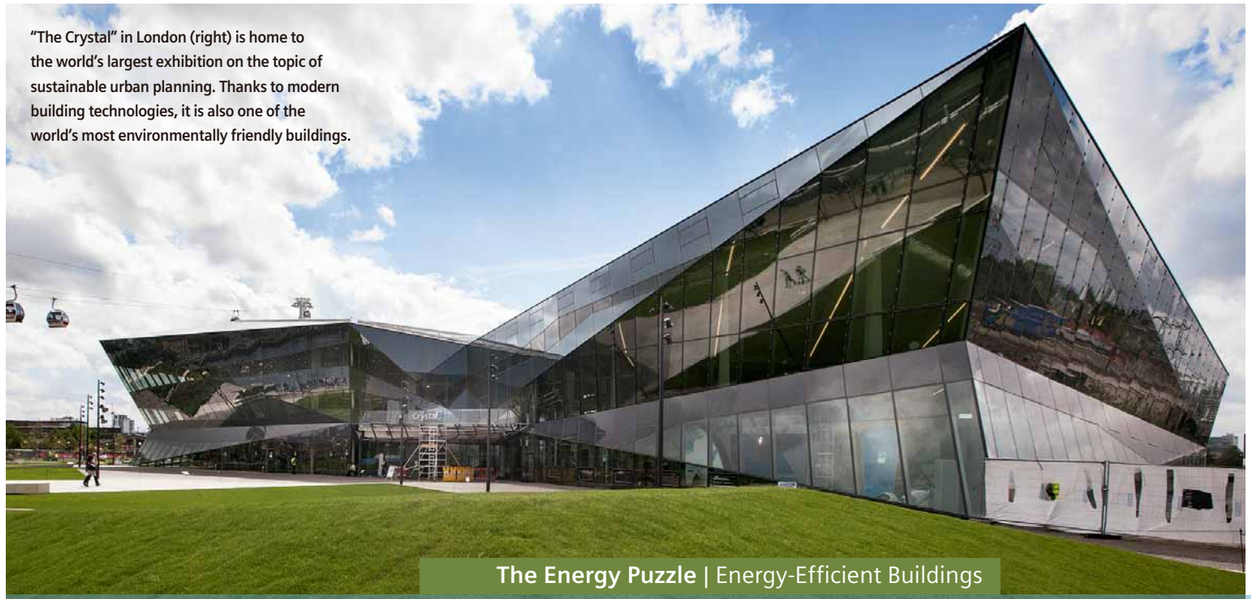
They decided to found a cooperative, which would provide 30 percent of the investment costs; the rest would come from loans and a government support program. An engineer gave professional support to the program and helped to solicit construction bids. The groundbreaking ceremony took place in June 2007. One hundred days later the first household was connected to the network. Today, most of the village is hooked up. The big heating failure that some had feared never occurred, and there have only been three instances when the operators had to rent a mobile heating unit, which distributed heat within a few hours. Today a biogas burner is ready if there should be another failure. Around 1,500 metric tons of CO_2 emissions have been obviated in Honigsee since the local heating network was installed.

This is another example that shows that every citizen can contribute to the expansion of renewable sources of energy — but only if people work together as a community. The bottom-up energy transition has begun.

Citizen Participation Worldwide. Denmark and Germany have traditionally considered renewable energy a priority, and their people are among the pioneers in citizen-owned-and-operated energy facilities. Since 1991, Germany's Act on the Sale of Electricity to the Grid has enabled people to feed energy generated from renewable sources into the power grid and be paid for it. In Denmark, as a reaction to the energy crises of the 1970s, private citizens were given tax breaks for generating their own energy. The program was a success. In 1996 there were already more than 2,000 wind energy cooperatives in Denmark. By 2004 around 150,000 families belonged to wind energy cooperatives, and today approximately one fourth of Denmark's electricity needs are fulfilled by wind energy.

North America has begun to imitate this approach. Since 2009 the Canadian province of Ontario has been encouraging its citizens to generate their own energy. For a fixed feed-in tariff, private citizens can feed their clean, self-generated electricity into the grid for a specific contract period. Contracts of this type account for more than 3,500 MW of generated power — the equivalent of four large power plants. Citizen participation is also being encouraged in Minnesota, where approximately 27 percent of the wind capacity is owned by cooperative ventures, compared to a national average of only one percent. ■ *Nicole Elflein*

Farmers earn supplemental income from renewable energy.



"The Crystal" in London (right) is home to the world's largest exhibition on the topic of sustainable urban planning. Thanks to modern building technologies, it is also one of the world's most environmentally friendly buildings.

Showcases for Sustainability

One of the most sustainable buildings in the world is being built in London. Mexico now has its own "greenest" office building, and New York is transforming a 120-year-old concert hall into a showcase for state-of-the-art building technologies. What all of these structures have in common is that they've got "Siemens inside."

It's summer in London. The few stubborn clouds that remain in the sky are slowly giving way to sunshine, which bathes the still-wet Royal Victoria Docks in a warm glow. A bizarre-looking shape protrudes from a skyline of residential buildings, hotels, warehouses, cranes, and the harbor basin — a sweeping structure made of glass and steel that recalls the works of the Cubist movement.

From under the building's pointed corners, its smooth surface reflects the surrounding area in all of its numerous facets: the silvery water of the port, the green parks, and the red-and-white cable cars carrying passengers to the nearby O_2 Arena.

The roof of this unusual building is covered with photovoltaic panels that collect sunlight and use it to generate electricity. Meanwhile, the sprawling shape of the upper part of the edifice protects the lower levels from excessive sunlight, thereby preventing the building from heating up too much.

Nothing has been left to chance in the "Crystal" — the new Siemens urban sustainability center that is meant to harmoniously combine state-of-the-art technology with sophisticated design and utilize every bit of energy it can exploit. "The Crystal is one of the world's most sustainable buildings," says Project Manager Dr. Werner Kruckow from the Siemens Global Center of Competence (CoC) Cities. "It's a fully electric building that uses no fossil fuels whatsoever. In addition, it completely recycles all of its process water and uses every drop of rainwater it collects. We also monitor all of the building's data to ensure that we can operate the structure as efficiently as possible."

The inside of the Crystal is all about sustainability as well. It's a model for the future of cities and all their associated challenges. That's why the Crystal, which covers all aspects of life in cities, houses the world's biggest exhibition of ideas for sustainable urban planning.

Buildings now account for roughly 40 percent of global energy consumption. What are the best strategies for reducing their environmental footprint? How can we reduce pollution, conserve the Earth's resources, and prevent our cities from suffocating in traffic chaos in the future? The Crystal, says Kruckow, will not only give its visitors answers to such questions, but also demonstrate what can already be accomplished with technologies that are available today. The best example of this is the spectacular building itself, which utilizes the most advanced technologies throughout its almost 7,000 square meter interior.

From the moment Siemens began planning the Crystal, the goal was to achieve the highest possible certification on the basis of LEED and BREEAM — two stringent standards for environmentally friendly and sustainable design and architecture. This placed huge demands on the architects and designers. Nevertheless, the Crystal is meeting these demands. It uses roughly 50 percent less energy and emits around 65 percent less CO_2 than similar office structures.

This has been made possible by the interaction between individual building technologies, as well as between the building and its surrounding environment. "The special shape of the Crystal makes it an outstanding rainwater collector," says Anokhee Shah, an environmental engineer at the Arup consulting firm. "Water is collected on the roof and then passes through several filters before flowing into a gigantic underground tank. Membrane and carbon filters and UV radiation are used to purify it until it has the required quality for drinking water." This sophisticated technology from Siemens, along with London's famously reliable supply of rainwater, ensure that 85 percent of the building's drinking water requirement can theoretically be met using rainwater. Some of the water is also heated by solar-thermal installations on the roof, which cover approximately 20 percent of the Crystal's hot water needs. Nor is used water channeled into sewers; instead, it's collected and purified again for use in toilets and for watering the

Carnegie Hall: Managing a Symphony of Systems

When a new building is designed, architects and planners can plan sustainable structures and integrate highly efficient technologies right off the drawing board. But what happens when you need to transform a 120-year-old concert hall into a green building? Carnegie Hall, a famous New York landmark, is now being modernized from the ground up in the Studio Towers Renovation Project, whose budget is close to $220 million. Almost 15,000 square meters of space will be modernized, and energy consumption and CO_2 emissions will be reduced.

Siemens is supplying a sophisticated building management system for the project. Like a symphony orchestra, building modernization also requires perfect interaction — in this case between all the devices involved. The Siemens system is thus linked with the heating, ventilation, and air conditioning (HVAC) units, as well as the lighting controls and the alarm and security systems. Integrating these technologies will enable the Carnegie Hall team to better manage the facility's energy demands. Building managers can view all the data on a single monitor and set the system to send e-mails or text messages if a problem is detected — for example, if a fire alarm goes off or the HVAC system is not operating properly. These measures will make Carnegie Hall safer — and help to save energy. Once the building management system is completely installed, Carnegie Hall will apply for LEED Silver certification. Success here would make the venerable hall one of the oldest buildings with such a distinction — and that would be good news for music lovers as well as the environment.

Siemens' Mexican Headquarters: Building a Benchmark

When it designed its Mexican Headquarters, Siemens decided to create a building that would serve as a benchmark. The building was completed in just 14 months and is now seeking a LEED Gold certificate in the categories "Commercial Interiors" and "Shell," which would make it the greenest office building in Mexico. The new headquarters uses about 30 percent less energy than comparable buildings — thanks in part to a state-of-the-art building management system from Siemens that monitors all of the key data, such as interior temperatures and ventilation. The complex contains 105,000 light-emitting diodes from Osram that provide energy-efficient lighting throughout the building's 17,000 square meters. The building's architectural design also allows it to exploit sunlight as long as possible, and, thanks to a modern water treatment system, the building's water use is 20 percent lower than normal.

building's gardens. The Crystal actually has its own wastewater treatment plant for this purpose.

The building supplies not only its own drinking water but also its own heat, which it obtains from the natural environment. "When we have to cool rooms in the summer, we channel the heat out of the building and into the ground below," says David Richards, an Arup employee. "Then, in the winter, we extract the heat from the earth and use it for the building." The pipes for this process, which extend 150 meters below the ground, enable the system's heat pump to supply 100 percent of the building's heat requirement, around two thirds of its hot water, and also roughly two thirds of the energy needed for the air conditioning system.

The Crystal covers 20 percent of its electricity needs with the help of its rooftop photovoltaic units; the rest comes from the public grid. Rapid developments in the photovoltaic industry posed a challenge here. "Up until the last minute, we had planned for modules with an efficiency rating of 17 percent — but then new panels came on the market that had efficiency ratings of 19 percent," Richards explains.

It's also important to use electricity as efficiently as possible — which is where Siemens' Desigo building management system comes in. Desigo uses a weather station on the Crystal's roof and numerous building sensors to collect up-to-the-minute information on interior and exterior temperatures, room occupancy, air quality, and much more. It can then, for example, determine whether it makes sense to naturally ventilate rooms via windows, or if heat should be turned off in unused offices. This reduces both costs and energy consumption, which is important for LEED and BREEAM certification.

The contribution made by architects to the building should not be underestimated. In order to ensure optimal use of solar energy, they distributed the building's glass elements in such a way as to ensure that the interior is flooded with daylight but doesn't get too hot in the midday sun. They also utilized a lot of recycled materials, while nevertheless making sure that as little material as possible went into the construction of the Crystal.

Night is falling in London. The last workers and visitors leave the Crystal and head home. As soon as the temperature falls below 20 degrees Celsius, the building's windows open automatically, allowing fresh air to enter. This air also cools a massive concrete slab underneath the building, which helps to cool the air in the building's interior the next day. It all adds up to a remarkably pleasant example of how all buildings might someday be. ■ *Nicole Elflein*

At power exchanges traders deal not only in generated power, but also in offers from large-scale customers to reduce loads in order to prevent supply shortfalls.

The Energy Puzzle | Demand Management

Balancing Act

Renewable energy generation calls for astute handling of energy supplies. That means that not only must energy production be managed; demand must be as well. The solution: intelligent networks and meters. In Austria, Siemens is putting both to the test.

According to a saying at the power exchange in Leipzig, Germany, when brokers are frantic, kilowatt-hours sell for a premium. Indeed, during demand peaks, electricity has to be generated immediately in order to stabilize the grid. And that can call for switching on "peaking plants," which is extraordinarily expensive. Demand peaks are often the result of chance events such as too many consumers turning appliances on at the same time, a problem at a power plant, or a downed transmission line. In such cases, power suppliers often have to pay ten to 20 times as much for electricity — and that can mean higher prices for consumers. Conversely, prices at power exchanges can go through the floor when electricity generation exceeds demand. Example: a wind park on a stormy night. With lots of electricity and virtually no buyers, a kilowatt-hour may go for nothing — or less. In fact, negative power prices were offered five times in Germany during the first quarter of 2012.

The underlying reason for such anomalies is technical. In order to ensure grid stability, the amount of electricity produced needs to be very nearly equal to demand. But that doesn't necessarily mean that the only answer is to crank up or shut down power plants. A more efficient solution is to reduce demand. For instance, since 2011, the Paulaner brewery in Munich has worked with service provider Entelios AG in the context of a "demand-response" relationship.

When there are supply shortfalls in the producer's network, the brewery can remove cooling units, which are large power consumers, from the grid for a short period. If, for example, "weiss beer" is being brewed, it doesn't matter if the units aren't running for a while. With this approach, Paulaner earns money in two ways: by cutting its energy costs, and by receiving part of the fee that Entelios gets from the power producer for demand management.

In the U.S., procedures of this kind have long been commonplace. In fact, Siemens is testing an automated demand-response system in which thousands of buildings can take part (see *Pictures of the Future*, Spring 2012, p. 84). In aggregate terms, this greatly reduces the load on the grid.

Projects like the one at Paulaner could play an important role in Europe in the context of a restructured power generation system based on a growing proportion of renewable energy

Near Salzburg, Austria, engineers are testing the suitability of smart power meters for daily use — in grids with renewable energy sources and electric cars.

sources. Together with a system of power plant management that takes current generation and demand forecasts into account, demand management could help to keep the electrical grid both stable and economically efficient. This is known generically as DSI — demand side integration.

In some cases, it is already common for large industrial consumers to power down or switch non-essential parts of their installations on and off by arrangement with power producers. But in the future, the same could be true for businesses and private households.

Smart meters and intelligent energy management systems might then perform this task practically automatically. As a first step in this direction, the European Union is encouraging rapid implementation of smart meters. By 2020, the majority of households are expected to have them. These offer many benefits compared with their conventional electromechanical predecessors, including a data interface with the utility company that allow remote reading.

Smart meters also enable communication in the other direction, to the consumer. For example, suppliers can inform customers of the real-time price of electricity. This multi-tariff functionality could then become the basis of new business models. Based on the preferences entered by the user, intelligent meters could decide how to respond to tariff changes. They could power appliances down, switch them off, or re-start them when electricity prices are lower. They might operate with rules such as: "Start the washing machine if power is below X cents per kW — but in any event, before tomorrow evening."

Building automation systems plays an important role in intelligent demand management. A study on "Demand Side Integration" published by Germany's Association for Electrical, Electronic, and Information Technologies (VDE), for instance, estimates that every day around 8.5 gigawatts (GW) of power could be managed in Germany with minimal sacrifice of comfort by consumers. Households, businesses, industries, and services account for half this sum. But theoretically, according to the study, up to 25 GW could be managed if all conceivable loads were added up.

According to the study, the potential for power management will continue to grow through 2030 because of the increased use of heat pumps, air-conditioning systems, and electric cars. A considerable portion of daily demand would then be available to shift around as appropriate. After all, Germany needs an average of around 60 GW of electrical power over the course of an average day. Of that amount, about a fifth currently comes from fluctuating renewable energy sources, which represent a special challenge for grid stability.

Identifying Power Hogs. Without practical experience, however, all these scenarios remain nothing more than theory. Since the end of 2009, Siemens Austria has therefore been taking part in the Smart Grid Model Region project in Salzburg, where the local power company, Salzburg AG, has already installed about 1,000 smart meters from Siemens. How are people reacting to the new opportunities? With the approval of participants, a group of scientists from the Vienna University of Technology and the AIT (Austrian Institute of Technology) are monitoring the behavior of smart meter users and the effects of demand management.

Through a Web portal developed by software specialist Green Pocket, project participants use smartphones or tablet PCs to keep track of their current electricity consumption. This allows them to uncover power hogs. The software issues a warning when the electricity bill exceeds a pre-established amount, which helps the researchers determine if this feedback changes the behavior of the people involved. There are also plans to move toward a smart grid based on associated consumption rules. Here, a smart meter takes care of everything. "Ideally, users won't notice any of these processes and comfort and convenience won't suffer," says Wolfgang Schneider, head of the Siemens branch in Salzburg.

"Siemens has developed a method for communication between smart meters and the power company, whereby data packets piggyback on the electrical lines. This ensures a robust and reliable data transfer," adds Wolfgang Bauer from Siemens Austria. "It also provides sufficient scope for integration into future smart-grid functions as well as into existing network automation and energy management infrastructures." While one project in the study involves shifting electrical loads in ten buildings, in another project, researchers are equipping the small community of Köstendorf, near Salzburg, with a critical mass of photovoltaic systems and electric cars in order to test their interactions with the grid.

And the first results are in. The management of private demand — by scheduling a washing machine to start at night, for example — is basically only of importance psychologically. "You can't affect more than three percent of demand that way," says Schneider. The buildings themselves are in a different league, however. Up to 85 percent of the energy loads in a building can be shifted if the heating or air-conditioning system uses electricity. This is due in part to a concept called thermal inertia, which Schneider explains as follows: "When the temperature outside is ten degrees Celsius, a building with average insulation cools down by only two degrees in about 40 hours when left unheated. Most people don't notice that sort of change."

In addition, in a future-oriented project, new buildings full of sensors are being built in Salzburg. For instance, an 18-meter-high hot water storage tank is being used to improve the thermal inertia of a building and to respond to demand peaks. The first detailed findings of the overall project should be available in the spring of 2013.

Everything now becoming a reality in Salzburg could be a part of everyday life everywhere within a decade. However, first it will be necessary to develop clear guidelines and, above all, achieve interoperability among the devices involved. Without standards, there won't be a mass market. In 2012, the EU standardization mandate for smart grids is expected to inspire the leap from intelligent meters to intelligent grids at the European level. Experts are tweaking device standards and application scenarios alike — while giving special consideration to information security and data protection. The technology being used by Siemens in Salzburg is playing a key role in discussions focused on new standards.

In Germany, there is also lots of talk about a "smart meter gateway" through which it will be possible to not only acquire data, but also manage appliances. The next step has already been taken in this context in the U.S., where Siemens customers are using a device not unlike a smart meter. This "Smart Energy Box" reacts to fluctuations in electricity prices by itself. Here as well, the rules saved in the memory of such devices constitute the key to the piggy bank, as it were. In the future, this box will help to prevent unnecessary load peaks such as those associated with the cooling units at the Paulaner brewery. ■ *Bernd Schöne*

Marketplaces for Electricity

In the future, commercial and even private users of electricity could take advantage of the lowest tariffs at any given time through "smart markets" — intelligent, local marketplaces — according to scenarios envisaged by the European Union. Such markets could help to reduce demand by powering down or shutting off equipment, or delegating this task to an "aggregator." The aggregator would pool the stated willingness of customers to shift their power consumption to a different time. The rules according to which these markets would operate are still vague, as are the tariffs. It is also conceivable that software agents (p. 59) could trade storage capacity as well as electricity and switch-off capacities. Electric car batteries would be ideal intermediate storage devices. Owners could account for wear on their batteries either via electricity prices or through bonus payments.

In Brief

■ Increasing resource scarcity, the nuclear accident in Japan, and the onset of global warming are making it clear that the global energy system is anything but sustainable. Ambitious plans are being made to change that. Germany, for example, is planning a transition to a sustainable energy supply. That means challenges but also opportunities for mankind, nature, and the economy. The required measures have to fit together like the pieces of a puzzle. (pp. 10, 14, 32)

■ In order to connect offshore wind farms to the grid, Siemens is building huge converter platforms equipped with high-voltage direct current transmission technology. At the same time, with its international expertise, Siemens is moving closer to achieving a key target: making wind power as inexpensive as electricity generated using fossil fuels. (pp. 22, 26)

■ If the transition to renewable energy is to succeed, it will be necessary to expand long-distance power networks. However, power losses are too high when high voltages are transmitted over great distances with conventional alternating current lines. In addition, public acceptance for new lines is often not forthcoming. Siemens offers solutions. (p. 24)

■ To the north of Berlin, Siemens is testing hybrid-electric trucks equipped with pantographs such as those used by streetcars. The trucks could carry freight between logistics centers and mines or ports, for example. In the future, they could also operate on specially modified highways — and thus decouple the growing amount of freight traffic from CO_2 emissions. (p. 29)

■ One of the most sustainable buildings in the world is being built in London; Mexico now has its own "greenest" building; and New York is transforming a 120-year-old concert hall into a showpiece of state-of-the-art building technology. Besides being very energy efficient, all of these structures have "Siemens inside." (p. 35)

■ Renewable sources of energy require energy-efficient solutions as well as a smart way of dealing with the available supply of energy. In other words, smart grids are a must — as are equally intelligent power meters. In Austria, Siemens is putting both to the test. (p. 37)

PEOPLE:

The energy transition at Siemens:
Dr. Udo Niehage, Siemens GA
udo.niehage@siemens.com
Energy systems strategy:
Volkmar Pflug, Energy
volkmar.pflug@siemens.com
Natural gas power stations:
Klaus Eurich, Energy
klaus.eurich@siemens.com
New wind power plants:
Hendrik Stiesdal, Energy
henrik.stiesdal@siemens.com
Andy Paliszewski, Energy
andy.paliszewski@siemens.com
Kevin Standish, Energy
kevin.standish@siemens.com
Offshore converters:
Tim Dawidowsky, Energy
tim.dawidowsky@siemens.com
Michael Suhr, Energy
suhr.michael@siemens.com
Electricity superhighways:
Jörg Dorn, Energy
joerg.dorn@siemens.com
Dr. Andreas Luxa, I&C
andreas.luxa@siemens.com
Electric highways for trucks:
Dr. Michael Lehmann, I&C
lehmann.michael@siemens.com
"The Crystal" in London:
Dr. Werner Kruckow, I&C
werner.kruckow@siemens.com
Stefan Denig, I&C, stefan.denig@siemens.com
Electrical demand management:
Wolfgang Schneider, Siemens Salzburg
wolfgang.k.schneider@siemens.com

External:
Jochen Homann, President of the Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railways
info@bnetza.de

LINKS:

Future of Energy:
www.siemens.com/future-of-energy
Efficient Power Generation:
www.powergeneration.siemens.com
www.siemens.com/energy
Federal Network Agency:
www.bundesnetzagentur.de/cln_1931/EN

At first glance, the capital of Denmark — Copenhagen — and the South African city of Durban seem to have little in common. But there is a connection between them, as both cities want to become CO_2-neutral. Copenhagen has set itself a target date of 2025 for this; Durban is aiming for 2050. Both cities now understand that environmental protection is no longer a luxury, but rather a necessity in rapidly growing cities around the world. Around half the world's population now lives in cities, and that percentage is expected to increase to two thirds by 2050, when as many people will be living in cities as now populate the entire Earth.

The world's cities are marked by different conditions. For example, Asian cities have twice as many people on average as European urban centers. Income levels also vary sharply. Whereas the U.S. and Canada have a per capita gross domestic product (GDP) of US$46,000, residents of cities in Latin America live on an average income of $11,100. However, comparisons of the city indices also show that many metropolitan areas have already improved their environmental performance by making infrastructure more efficient or implementing ambitious policies — and their achievements can serve as an example for other cities around the world. Still, one must keep in mind that each City Index takes into account specific aspects of the region in question, which means direct global comparisons can be made for only a few parameters.

Pictures of the Future | Green City Index

How Cities Can Learn from One Another

Over the past three years, the Green City Index has been examining the environmental performance of cities around the world. With more than 120 cities already studied, it's worth taking a look at global comparisons and trying to isolate the factors for success.

More and more people will need water and electricity, the amount of waste will increase, traffic will become more congested, and sewage systems will be stretched to the limits of their capacity. All of this will negatively impact the environment and the economies of urban centers — as well as the health of their residents. Addressing these problems requires a fundamental understanding of where the challenges lie and how different cities are dealing with them. This is exactly what the Green City Index — a series of research projects carried out by Siemens and the *Economist* Intelligence Unit (EIU) — has been trying to achieve for three years now. The index examines the entire range of environmental sustainability issues, including CO_2 emissions, energy, land use, buildings, transport, water and wastewater, waste management, air quality, and environmental policy. Green City Index studies have been published for Europe, Latin America, Asia, the U.S., Canada, Germany, and Africa — and *Pictures of the Future* has presented the most important results in past issues. A new study for Australia and New Zealand is now being developed.

Population Density

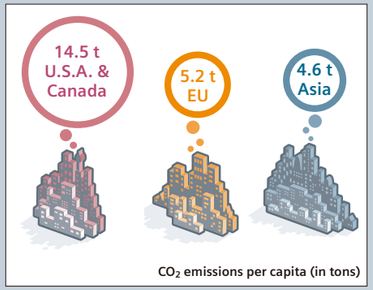
- High population density makes it easier to build infrastructures such as public transport.
- The most densely populated cities are in Asia, where average density is around twice as high as in cities located in the other regions studied. Mumbai, for example, has 27,000 people per square kilometer — the highest level among all the cities studied.
- Urban sprawl is a problem that is especially widespread in North American cities.

Green Areas

- Latin American cities have many parks and recreational areas. The region has around 255 m^2 of green space per person; the figure for Asia is only 39 m^2.
- New York and Singapore are role models for spatial planning, as both have been able to combine extensive green spaces with high population density.

CO_2 Emissions

- Cities in Canada and the U.S. generate more per capita CO_2 emissions on average than European and Asian cities combined.
- The best city in the industrialized world in this category is Oslo, which has emissions of 2.2 tons per person.



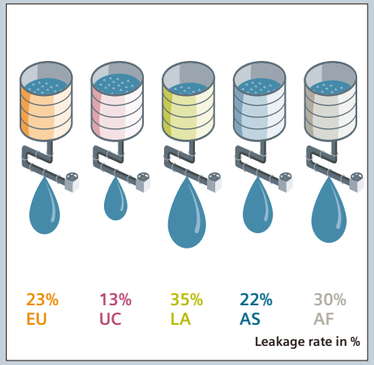
CO_2 emissions per capita (in tons)

Waste Production

- Europeans produce the most waste. Only ten percent of the European cities that were studied generated less than 400 kg of waste per person each year.
- The best city in the industrialized world is Yokohama (300 kg per person and year).
- The best result in the global comparison was achieved by Delhi, with only 147 kg of waste per person each year on average.

Recycling

- With a recycling rate of 81 percent, the city of Leipzig in Germany is the world recycling champion, although North American cities boast the best overall performance in this category.
- San Francisco recycles 77 percent of its waste; Los Angeles has a recycling rate of 62 percent.

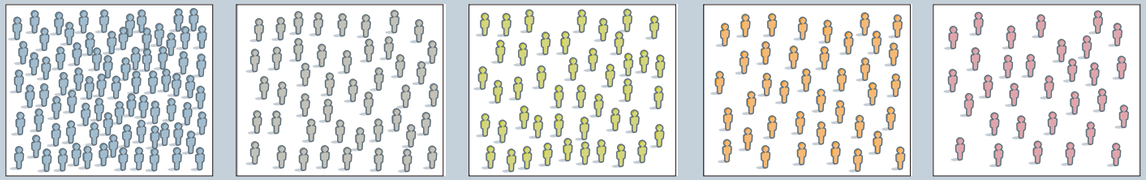


- Chicago, Tokyo, Amsterdam, and Berlin had the best results in the global comparison for this category, with each losing only around three percent of its water.

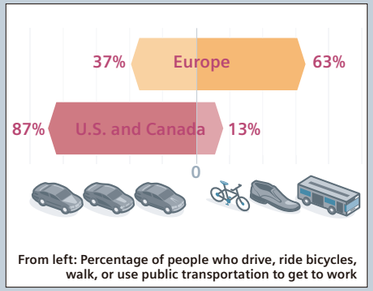
Water Consumption

- Africa consumes the least amount of water, because many people there have only very limited access to drinking water.
- Tallinn (Estonia) and Amsterdam consume the least water in the developed world — only around 140 liters per person each day.
- However, three cities in the U.S. and Canada consume more than 800 liters of water per person per day.

Nicole Elflein / Karen Stelzner



All data from the Green City Indices



From left: Percentage of people who drive, ride bicycles, walk, or use public transportation to get to work

Transport Modes

- Urban residents in Europe mainly use public transport, bicycles, or their legs to get to work, with Stockholm taking the lead here (93 percent).
- The situation is different in North America, where 87 percent of city dwellers drive to work. New York is a positive exception, as 37 percent of its residents use public transport.

Water Losses in Pipe Systems

- Leaky water pipes are a major problem in developing countries and emerging markets especially. Rio de Janeiro loses 58 percent of its water through leaks.
- Bad pipes aren't as much of a problem in U.S. and Canadian cities, however, as 15 of the 27 cities studied there lose less than ten percent of their water through leaks.

Seven Factors That Make Cities Greener

Siemens, the *Economist* Intelligence Unit, and several renowned urban planning experts, used the data produced for the Green Cities Indices to identify seven key factors that make for greener cities. It should be clear, however, that there is no perfect master plan that can be applied to all cities.

1. Environmental planning at the city level
The cities with the best rankings in the Green City Index all have one main thing in common: They do their own planning. National regulations can offer incentives for introducing environmental protection measures, but cities must also be given enough responsibility to enable them to set the right priorities.

2. A holistic approach
Every city has interrelated environmental and infrastructure issues that must be addressed in a holistic manner by policymakers. The Brazilian city of Curitiba, for example, has long since recognized that a smoothly functioning public transport system significantly improves air quality — which is why Curitiba has been pursuing a holistic strategy for many years

3. Wealth isn't everything
Environmental protection is not a luxury that only the rich can afford — as evidenced by cities like Bogotá, Delhi, Berlin, and Vancouver, all of which have a relatively low GDP but nevertheless performed well in the indices. They did this by taking relatively inexpensive measures in the area of education, for example, and focusing on environmental policy improvements. In many cases, a high level of income actually leads to a poorer index result, particularly when resource consumption rises or more people are able to afford their own cars.

4. Public participation
Environmental protection measures are easier to implement, and more successful, if they are supported by citizens. The public should therefore be included in important decisions. Cities like Delhi and Porto Alegre encourage school children to do more for the environment, and they also allow citizens to vote on certain measures.

5. The right technologies
Technologies available today can substantially reduce CO_2 emissions and energy consumption. London, for example, could lower its CO_2 emissions by 44 percent solely through the use of efficient technologies, and without residents having to change their energy use habits. Cities are often apprehensive about the high initial costs involved, but experience has shown that the investments pay off over the long term.

6. People and the environment
Health issues and poverty are closely linked with environmental problems — so all three aspects have to be viewed together. A city that properly disposes of waste and sewage, or provides more people with access to electricity and drinking water, will help reduce illness among its population. Building the associated infrastructures also creates jobs and prosperity.

7. Informal settlements
The African Green City Index reveals a clear connection between the percentage of people living in informal settlements and a city's overall performance in the study. A high share of people living in such settlements correlates with a lack of drinking water, electricity, and waste management and sewage systems. Poverty and environmental pollution can only be brought under control with an expansion of infrastructure.

Highlights

2060

Scientists are conducting final tests on a space elevator complex that will ferry passengers and freight to a vast research and residential station some 22,000 miles above Earth. Every part of the facility has its own IP address — including every ant-like service robot. One day a robot vanishes — apparently the first step in an invisible optimization plan.

Internet of Things | Scenario 2060

What Will THEY Think of Next?

The head of the world's first space elevator has discovered that one of the project's Autonomous Networked Systems (ANS) has been cannibalized by its coworkers...

"What a view!" she gasped. We were standing in one of the station's glassed-in observatories some 22,000 miles above the Earth, a bright blue and white disc about the size of a tennis ball, much of it baking under cloudless skies, half of it in darkness. "Yes," I said. "As often as I come here, the view is always mesmerizing."

"So what's the story?" she asked. "You sounded concerned when you called."

"I am," I said. "And I didn't want to discuss it any other way but face to face."

Marisa and I go back decades. In fact, we grew up together in a small town near Milan and studied electromechanical engineering together. After grad school, I joined the European Space Agency, and "Risa," as I call her, took a job at a company that specializes in industrial simulation technology — the same technology that was used to design and test every part of the space elevator complex and its sky-high "Exploratorium" where we were standing, a vast complex of laboratories and offices, residential facilities, and launch and docking systems for future missions throughout the solar system. For the last five years my job has been coordination of the space elevator project.

"Something very strange happened a few days ago," I began. "We believe that several of our ANS — you know, those ant-like Autonomous Networked Systems that we use for every kind of maintenance work out here — well, it seems that four of them — there's no other way of describing it — cannibalized a seventh one.

"Cannibal…What do you mean?" asked Risa. "I mean there are a few seconds of video when a small swarm of ANS approached the lone victim, who was performing routine surface analysis operations for evidence of micro impacts," I explained. "The victim's eye-stream video then goes blank, and the attackers' video feeds show nothing — as if the victim had been digitally removed from the images to avoid leaving a trail. But the RFIDs embedded in each piece of the victim have turned up in parts of the six attackers — and those attackers appear to be functioning more efficiently than any other ANS. How could such a thing happen?"

Marisa looked down at the seemingly endless meter-thick carbon nanotube cables that stretched downward from the Exploratorium, already allowing a steady stream of freight and passenger modules to ferry supplies and service personnel back and forth. The elevators, which were still being tested, would radically change the economics of space travel. Until recently, it cost as much as $20,000 per kg to carry materials into geo-stationary orbit on old-fashioned rockets. Once in full operation, the space elevator was expected to slash that to about $100 per kg.

"You guys did the simulation and testing. We just provided the software to do it with," said Risa. "That's right," I answered. "And you know that we performed exhaustive simulations on everything from the materials to the individual parts of every system. We simulated how those materials and parts would hold up under the temperatures, radiation levels, and stresses they would be subjected to up here. We simulated their functional interactions, and even the manufacturing procedures for all the parts we used — including the ones used in the ANS. But Risa, there was always that business of uncertainty quantification. What we studied back in college about predicting crack propagation and determining associated levels of risk, which was hard enough to figure out, has given way to a much thornier question — the uncertainty of predicting how networked systems function when they acquire intelligence, communicate, and learn from one another."

"You said these attacker ANS have become more efficient," said Marisa. "What did you mean by that?" "See for yourself," I said, touching the transparent surface of the observatory. In a direct line of sight behind my finger we could see a group of ANS combing the surface of the elevator complex for micro impacts and cracks. As I touched the glass-like surface, it's OLED interface came to life like a giant monitor, instantly recognizing my fingerprint and genetic signature thanks to an embedded electrophoretic layer, thus giving me secure access to a world of data.

I zoomed in on the area of interest so that we could observe the ANS' appearance and behavior. "Most of our ANS work alone or in pairs," I explained, "and these ANS used to as well. But now, look at them — all of them are moving in unison. If we interrogate their data exchanges, which include real-time compressed video, ultrasound, X-ray, thermal sensing, and of course self-diagnostics, they are all operating in perfect synchrony. They are collectively analyzing the surface for any sign of damage. It's as if they had formed a single, mobile multi-sensor. "What's more," I added, "if you look at their RFID signatures," — I made a few quick movements of my fingers to change the perspective — "you see anomalies, chips, for instance, that were originally in the victim. Each manufactured part, after all, has its own IP address. These ANS have upgraded themselves!"

"Fascinating!" Marisa said, almost to herself as she watched the ANS assiduously working their way over the surface of the complex. "To be perfectly honest, one of our newest research projects has been examining the probability of so-called spontaneous origination of behaviors among different classes of smart, networked devices. But now it's happened! The ANS' mission, if you think about it, is not just to identify anomalies that could turn into problems, but to optimize whatever they come in contact with. And now they've taken a step toward self-optimization in order to make a process more efficient. It's swarm intelligence and more, it's the essence of the Internet of Things. What we're witnessing is simply a system that's doing what it's supposed to do."

"So you don't think we need to be too concerned about what's happened?" I said. "I mean, isn't there a possibility that this sort of thing might pose a risk — that the ANS might surprise us in ways that are not optimized for us?" "Oh come on," said Risa, "they're just machines. And if you really get nervous, just press the ANS System Central Reset in the control center, take the four so-called offenders out of the loop for study, and everything will go back to normal."

"Risa," I said, "that's why I wanted to discuss this with you face to face rather than using any electronic communication. "I've already pressed the Reset. Nothing happened. What will *they* think of next? ■ *Arthur F. Pease*

Internet of Things | Trends

Perpetual Optimization

Machines are talking to each other in unprecedented numbers. Not only are they doing simple things like managing our boarding passes and seating assignments; they're also about to start streamlining smart grids and entire supply chains. It all adds up to an economy based on perpetual optimization.

They will soon be everywhere — in the bar code readers at the corner grocery store, in street lights, traffic lights, and your car's navigation and braking systems. They will zap messages back and forth between buildings and the smart grid (p. 66), notify factories when a supplier's production line runs into trouble, and report on, learn from, and predict the maintenance needs of everything from jet engines and off-shore wind parks to pacemakers and programmable logic controllers. They are software modules — sometimes referred to as agents — and they are part of a new, invisible economy in which objects speak with other objects — in short, the Internet of Things.

So rapidly is the Internet of Things growing that on June 6, 2012, the Internet Society, a global standards-setting organization with headquarters in Geneva, Switzerland and Reston, Virginia, officially launched a new Internet Protocol (IP) standard called IPv6. Thanks to this development, "there are now enough IP combinations for everyone in the world to have a billion IP addresses for every second of their life," reported CNN Money as the Protocol was launched. That amounts to over 340 undecillion addresses (3.4×10^{38})! The idea that so many addresses could ever be needed may sound ludicrous when thought of in terms of the current world population of around 7 billion people and 4.3 billion IP address; but it's not so outlandish when you think of the population of things. Indeed, according to Cisco Systems, Inc., by 2020, there will be some 50 billion networked devices (p. 46), billions of them invisibly embedded in everyday objects

ranging from clothing and cell phones to automobile parts (p. 48).

Automated Economy. "We are witnessing the birth of an economy that, with the help of sensors, will be automated," says Prof. W. Brian Arthur (page 53), an economist and technology thinker at the Santa Fe Institute. For instance, he points out, a truck equipped with radio frequency identification tags (RFIDs) can optimize its arrival timing as its navigation system talks with roadside sensors that, in turn, compare the vehicle's position with real-time traffic flows in coordination with computers in the supply chain to which the truck is making its delivery. Each part of this communications network used to require a human participant — along with associated costs and errors. But today, and to an ever increasing extent, such processes are taking place among machines — with significant benefits for the general economy — and potentially profound challenges for labor markets around the world.

Just as our vehicles are beginning to communicate with systems around them, systems within them will also hold their own conversations (p. 64). Supported by a 10-million Euro grant from Germany's Federal Ministry of Economy, Siemens and other companies are investigating the software needs of tomorrow's electronic vehicles in the context of the "Robust and Reliant Automotive Computing Environment for Future eCars" project.

Somewhat further down the road is a world of automated communication and optimization that may one day link — and optimize — entire supply chains (page 58). That's the goal of a 20-million Euro project sponsored by Germany's Federal Ministry of Economy. Known as the RFID-based Automotive Network (RAN), the program is heading for development of a standardized parts and information management system for the automobile industry. The idea is that supplier production lines will automatically advise their customers — original equipment manufacturers or OEMs — of any significant slowdowns. Intelligent systems at OEMs will then evaluate the information and adjust production schedules flexibly. The potential economic benefits of real-time communication between different levels of suppliers and OEMs are expected to be enormous.

Merging Real and Virtual Worlds. One of the most spectacular events in the short history of the Internet of Things was the seamless development, testing and manufacturing of the Mars Science Laboratory, also known as Curiosity (see page 55). With the help of Siemens PLM Software solutions, individual parts, subsystems, and even the entire assembly were so accurately produced in the virtual world that, following exhaustive simulations, the same data sets were used by computer numerically-controlled (CNC) machines to manufacture the parts' real-world counterparts. Says Siemens Industry CEO Prof. Siegfried Russwurm, a member of Siemens' Managing Board, "What NASA was able to do with the Mars rover was a paradigm shift, an integrated database, an integrated approach from product design to production design — a seamless transition from the virtual world to real production in one consistent database."

Daren Rhoades, a Senior Product Development Manager at PLM Software's Cypress, California development center who, until recently, was a member of the NASA team that developed the Curiosity rover, adds that "Developing something new for a space mission is incredibly expensive because of the amount of engineering and testing involved. But with our technology, NASA will be able to easily find and reuse any of the pertinent information and knowledge gained from Curiosity's development and testing phase. That can save a tremendous amount of money."

NASA is of course not the only organization to have discovered the extraordinary efficiencies associated with precision development and functional testing of parts and systems in the virtual world. In China, for instance, a transition from low-wage, low-tech industries to higher-wage, high-tech industries is driving growing interest in virtual world development. The country's nascent automobile industry — particularly Chery and FAW — have embraced Tecnomatix, a Siemens PLM Software technology that links product development units to manufacturing locations, from process definition and planning to simulations and production (page 62).

The connection between virtual and real worlds will not be limited to industry. According to Prof. Elgar Fleisch, Director of the Institute for Technology Management at the University of St. Gallen, Switzerland, "As the Internet of Things connects the physical world with the Internet, we will see an explosion in the number of devices that have their own home page and associated apps." As Fleisch sees it, in the future, virtually every object, from toys to medications, will be able to provide real-time information regarding its age, constituent materials, and condition. (p. 52).

Indeed, thanks to a process called SIPAT (Siemens Process Analytical Technology), pilot projects now under way in the pharmaceuticals industry indicate that, in the near future, it will be possible to track the origin and quality of the substances used in every pill (p. 61). Who knows — maybe we'll need all those billions and billions of IP addresses after all!

Arthur F. Pease

Internet of Things | Facts and Forecasts

Growth Market of the Future

Virtually invisible to most of us, powerful software modules have long since become indispensable for managing the flood of information on the Internet. According to an analysis of the U.S. company Cisco, over 50 billion devices will be connected to the Internet by 2020, ranging from smartphones, PCs, and ATMs to manufacturing equipment in factories and products in shipping containers. Market research firm Gartner regards the Internet of Things as one of the strategic technologies of our time. Meanwhile, solutions for identification, analysis, and communication are expected to reach a critical mass in the next five years and become useful economically. According to Gartner, the essential elements of the Internet of Things include integrated sensors in devices and objects, image recognition via handset cameras, and payment by means of near field communication (NFC). In NFC payment systems, users place their cell phones in the vicinity of an NFC reader in order to pay for purchases.

The first applications for the Internet of things already exist — in toll collection, navigation systems, remotely readable meters in decentralized energy systems, and in automated warehousing. There is now even a Dutch start-up company that equips cows with sensors that report illnesses or pregnancy. According to the Fraunhofer Institute for Microelectronic Circuits and Systems in Duisburg, an active transponder system located in the stomach of the cow identifies relevant parameters, such as the pH value of the blood and the temperature, and transmits this data to an external receivers on the cow's collar. From there, the information is forwarded to a central database through a wireless network of sensors. If the cow's blood pH value is too low, for instance, the farmer receives a warning message on his PC. In human beings as well, ECG sensors on the body could monitor cardiac activity and display up-to-date data on the condition of an individual through a smartphone.

According to the Association of German Engineers (VDI), the most promising applications include health telematics, house and building automation, industrial production, and logistics.

Market researchers at Forrester Research likewise see considerable potential in the logistics industry. "In recent years, the costs for a simple fleet management device have fallen by 50 percent to an average of $100," explains Forrester analyst Michele Pelino. In the system envisaged by the Fraunhofer Institute for Material Flow and Logistics (IML) in Dortmund, Germany, each package and each shipping container will find the right path to the recipient by itself. The destination will simply be written into intelligent labels. "This way, each package knows where it has to go, and it reserves its own spot in a transport vehicle," says Professor Michael ten Hompel, Director of the IML.

The technical foundation for connecting everyday objects to networks is radio frequency identification — RFID. In this technology, the data carried by the chip attached to an object is transmitted via wireless links (p. 48). As the VDI puts it, this turns "low-cost articles into smart objects." RFID systems can be used wherever automated labeling, identification, registration, storage, monitoring, or transport are necessary.

According to a study conducted by Frost & Sullivan in 2011, the global RFID market of $3 billion to $4 billion (in 2009) will grow by twelve percent per year through 2016 and reach a volume of approximately $6.5 billion to almost $9 billion. "In coming years, every device will be connected to the Internet. The trend will extend to every industry and every sphere of life," says Cisco Chief Futurist Dave Evans, who predicts a boom for the Internet of Things.

Market researchers expect that smartphones in particular will play a major role in bringing the Internet of Things to consumers and that they will foster the development of many attractive new applications. "Suppliers of smartphones are making a very noticeable effort to enhance the functionality of these devices with sensors in order to support new business models," says Dr. Gerrit Tamm, a professor of information systems at SRH Hochschule Berlin.

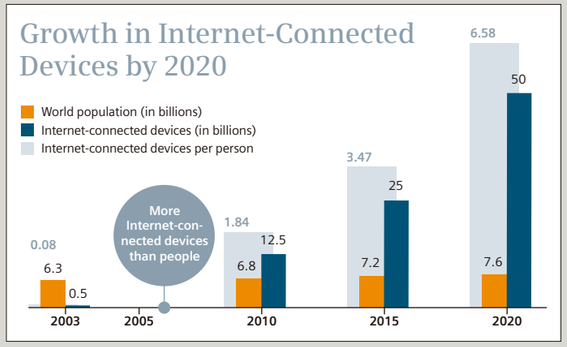
What's more, 80 percent of all households in the European Union are expected to have intelligent power meters by 2020. If an intelligent control unit is added to such meters, they can start up washing machines, cooling systems or heat pumps all by themselves during times when electricity rates are low (p. 99).

In "intelligent houses," wireless sensors will control lighting, energy management, and security systems. An analysis carried out by market research company Marketsandmarkets predicts that the need to save energy will be a primary driver of the market for smart homes. A building's energy management can then be monitored and administered remotely via a smartphone or a PC. Market experts predict that this global market, which represented $5.3 billion in 2010, will grow to $11 billion by 2015.

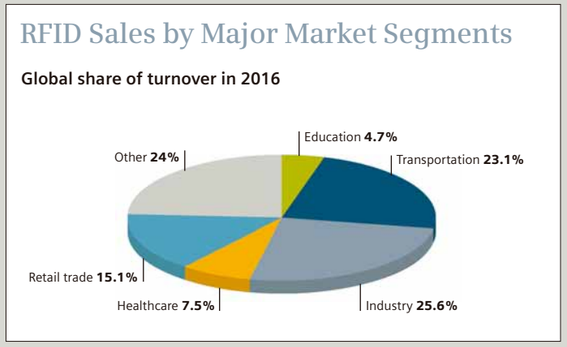
The Internet of Things is considered an important issue for the future in China as well. In February 2012 the Chinese government therefore decided to set up a fund of approximately $775 million to support this field in the next five years.

The official Chinese market for the Internet of Things, which comprises a broad field that includes safety, security, and environmental technology as well as health monitoring equipment, had a volume of approximately $31 billion in 2010. This sector is expected to grow to $116 billion by 2015, according to a report published by the Xinhua News Agency in late 2010.

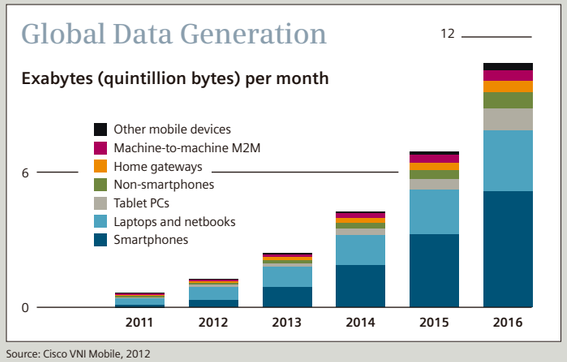
In May 2010 a group of experts named "EU-China Internet of Things" was established. Its objective is to promote technological innovations and uniform standards in Europe and China with regard to the Internet of Things. However, in addition to discussing the opportunities opened up by this new field of technology, experts in Europe are also devoting considerable attention to potential effects on data protection and privacy. Plans also call for these issues to be investigated and addressed on the international level. *Sylvia Trage*



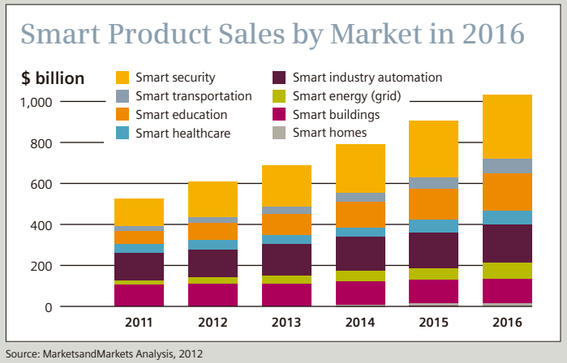
Source: Cisco IBSG, April 2011



Source: Frost & Sullivan, 2011



Source: Cisco VNI Mobile, 2012



Source: MarketsandMarkets Analysis, 2012

Incoming deliveries at a Siemens logistics center are automatically registered via RFID chips. Right: An RFID system keeps an eye on production at Rehau AG, a plastics processing company.

Internet of Things | M2M

The Next Network

Many everyday objects and machines contain micro computers that control their operations and enable useful applications. These embedded systems are increasingly being joined together into an "Internet of things." In the future, machines that are linked together in networks could revolutionize manufacturing, energy distribution, and transportation systems.

Microcontrollers are everywhere. Essentially tiny computers that are embedded in machines, they supervise a rapidly-expanding universe of functions. In washing machines, for instance, they may access information embedded in electronic tags in clothing labels, allowing them to know whether items are wash-and-wear or wool. Other sensors may tell them how soiled the items are. They may also control water valves, and ensure that the door is securely closed.

Embedded microcontrollers can be found in practically all machines, ranging from DVD players and power tools to automobiles and computed tomography scanners. They differ from PCs in their size and processing power. Embedded systems typically have a microprocessor, a memory, and interfaces with the external world, but they are considerably smaller than their PC counterparts. Frequently, the bulk of the electronic circuitry can be found in a single chip. Although microcontrollers of this sort are tiny, they can easily control even complex machines via their software.

"In a few decades there will be hardly any industrial products that don't have computers inside them," predicted German computer scientist Karl Steinbuch in 1966. His vision has long since become reality, and the global market for embedded systems is now worth approximately €200 billion and is growing fast, according to estimates in a study conducted by the German industry association Bitkom and the Roland Berger management consulting company.

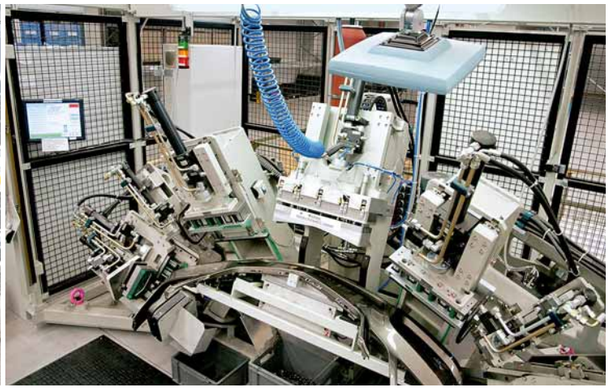
Embedded systems are especially important for Siemens, because these virtually invisible mini-computers are built into almost all the products sold by the company, from medical equipment and automation technology to building management systems, trains, power distribution systems, and turbines.

Like computers, microcontrollers run on software — an area in which Siemens has built up significant expertise. Indeed, the company employs some 17,000 programmers and invests approximately €2 billion per year in software research alone. Nor are Siemens' activities in this area restricted to embedded systems. "After SAP, we're the second largest software company in Europe," says Gerhard Kress from Siemens Corporate Development.

Increasingly, the company's focus in this field is so-called "vertical IT" — information technology solutions that "are specially tailored for individual sectors," explains Kress. He points out that "horizontal IT, on the other hand, is suited to many sectors at the same time. Examples include Microsoft Office programs, as well as software for purchasing, sales, resource scheduling and database management. Siemens doesn't focus on solutions and applications in these areas."

Frequently, vertical IT builds on embedded systems and in the process offers users additional features. For instance, thanks to embedded intelligence, a doctor using a modern CT scanner can view the images created by the machine on a local monitor, or the data can be transferred to a diagnostic software package such as Siemens' *syngo*.via by means of an integrated external interface. The software helps doctors diagnose conditions by, for example, comparing a patient's latest scans with previous images. "It offers doctors extra value and helps us to sell hardware," says Kress. "In this way, vertical IT becomes a competitive advantage for Siemens."

Customers too benefit from vertical IT's advantages. For example, one automaker has succeeded in cutting its development time almost in half by using end-to-end engineering solutions from Siemens. These solutions included NX software for design, computation, and simulation; Teamcenter software for managing product data throughout the lifecycle; Tecnomatix and Totally Integrated Automation for factory design and the automation of production; and the SIMATIC IT system for real-time processes in its factories.



In parallel with product development, automakers can also use these systems to design new factories, optimize their productivity, and program machines in the virtual world. That saves time and money and avoids errors. In addition, information from manufacturing flows back into the development process, which helps to further improve products.

"The market for horizontal IT is growing by about four percent each year, but vertical IT is expanding at a rate of nine percent," says Kress. That's why vertical IT is at the center of the "Siemens IT revolution," which is designed to tap into new markets that lie between traditional Siemens solutions and horizontal IT.

When Trees Talk. Human beings mastered the global data network (otherwise known as the Internet) a long time ago. Now, machines are beginning to do the same thing. In a trend that is opening up broader horizons in the Internet of Things, intelligent control centers, for instance, are starting to use their interfaces to communicate directly with one another (see p. 52). "We expect that by 2020 there will be 50 billion connected devices," says Ericsson CEO Hans Vestberg. The company has even equipped a tree with an embedded system so that it can send messages to the Internet. "Let's suppose you have a forestry company," says Vestberg. "Wouldn't it be helpful to know how the trees feel?"

In the summer of 2011 Siemens and German science magazine "Spektrum der Wissenschaft" likewise equipped a 150-year-old oak tree in the Botanical Gardens of Erlangen with measurement technology. A particulate matter sensor and an ozone meter record environmental data, with backup from a weather station and a webcam. Thanks to WiFi, the tree sends its data to a computer that evaluates it and can detect how the tree is doing at any given moment. Internet users can take a look for themselves — the "Talking Tree" is active on Facebook and Twitter; it also uploads photos to Flickr and videos to YouTube.

Naturally, there is much more to the Internet of Things than interactive oaks. Indeed, entire wind farms can strike up a machine-to-machine conversation. For example, in one farm, rather than maximizing each turbine's output, Siemens software allows turbines to trade data with a view to maximizing the farm's total yield and minimizing wear and tear on a range of components.

The Internet of Things is also heading for the smart grid. In the future, for instance, energy users such as washing machines, and cooling systems will communicate with the network in order to balance out supply and demand. Siemens and utility company Allgäuer Überlandwerk GmbH have been testing an intelligent electrical grid of this sort for over a year. "The conditions here are like those we expect to see throughout Germany in 2020," says Michael Fiedeldey, Allgäuer's Chief Engineering Officer *(Pictures of the Future*, Spring 2012, p. 46).

By that time, cars may also be able to communicate with one another and with their environment in order to avoid accidents and optimize traffic flow. If traffic is backed up beyond a curve, for example, cars would warn oncoming vehicles via wireless networks. Machines will thus be talking with other machines in order to save lives.

Revolution in the Making. Many branches of industry are likewise interested in the Internet of Things, because it could lead to a true revolution in manufacturing. This view is shared by advocates of "Industrie 4.0," an initiative that is part of the high-tech strategy of the German federal government and includes Siemens as a participating member. The initiative foresees a scenario characterized by distributed intelligence in which factories no longer require centralized management.

In such a scenario, raw parts and production machines would enter into a dialogue in order to optimize manufacturing processes by themselves. "Each raw product will contain a small embedded system equivalent to a miniature Web server with a wireless interface that serves as its digital product memory," explains Prof. Wolfgang Wahlster, Managing Director of the German Research Center for Artificial Intelligence (DFKI) in Saarbrücken. "The embedded system will know exactly what the raw product is supposed to become, and will independently

request the services it requires from individual machines in the factory."

In what could amount to a fourth industrial revolution — following the introduction of mechanical production, mass production using electrical energy, and the electronic automation of production processes — the Internet of Things and decentralized control could make such a high level of flexibility possible that single-piece manufacturing will become profitable. Such a trend could help to safeguard jobs and competitiveness in high-wage countries.

Physicians can observe images on a touchpad for non-diagnostic purposes or a monitor and transmit them to other locations.

In addition, machines that perform the same duties in factories will be able to flexibly switch from one production run to another without central control system intervention. Wahlster calls this "Plug and Produce," is analogous to the "Plug and Play" technology in PCs.

Siemens is coordinating a European Union project called "Internet of Things at Work," which is designed to make precisely this type of new flexibility possible in production. Within the framework of "Industrie 4.0," the company is also participating in the RES-COM project (resource conservation through context-activated machine-to-machine communication). This project, which is being directed by Wahlster and funded by the German Federal Ministry of Education and Research, is designed to ensure that valuable resources such as energy, water, air, and raw materials are used efficiently.

"But it would be wrong to assume that the Internet of Things is exclusively focused on collecting sensor data," says Joachim Walewski of Siemens Corporate Technology. "Actionable knowledge must be generated from the data." It's not enough, for instance, for a sensor in a materials-handling vehicle to be able to identify a red circle. The system has to know that the vehicle is moving in a certain direction and approaching a traffic light — and it has to draw the right conclusion, in other words, that it's time to brake.

Prof. Michael ten Hompel, the Managing Director of the Fraunhofer Institute for Material Flow and Logistics in Dortmund, likes to compare data packets to freight containers, and refers to "logistics à la Internet." In the future, packages will find their way through logistics networks by themselves, by engaging in negotiations with their environment. "Urgent shipments would then be transported faster, while other packages would have to wait," he says. Embedded systems in containers, equipped with a microprocessor, sensors, and a wireless connection, would not only find the right transport routes but also use temperature sensors to monitor perishable goods, for instance, and thus serve as a product memory (p. 61).

The "cloud" will play a central role in the future of logistics as well — that is, the idea of accessing processing power, software, and memory on demand via the Internet. "All IT processes for the handling and delivery of freight could be shifted to the cloud," says ten Hompel. "Then an RFID scanner, for instance, would be connected not to a server in a warehouse but to a computer somewhere in the cloud." There, shipments would access a whole marketplace of services as they made their way from their point of origin to a recipient — much like a software module that records the arrival of goods and stores that information in a database. Small applications of this kind could be assembled like Lego blocks into more complex services as needed, and a variety of providers might offer such services.

In the future, packages will find their way through logistics networks by communicating with their surroundings.

Services for Everyone. This is precisely the idea behind the "Internet of Services." Here, the global computer network is transformed into a concourse of software modules that can easily be combined to form higher-grade services because they use standardized interfaces. In pursuit of this goal, Michael ten Hompel's institute has already converted a distribution warehouse in Duisburg, Germany to cloud technology.

"Our cloud server offers 31 different 'business objects' as software modules. These range, for example, from warehouse management and receiving. They come from about a dozen different vendors, and it will be easy to combine them, because they all adhere to binding standards," ten Hompel says. The warehouse was ready for business after only two weeks — instead of the months-long lead time that is normally needed.

Tomorrow's Internet of Services may also be able to make our lives easier. Some researchers, for instance, envision an online marketplace that can supply and combine services for everyone. Thus, in the event of a breakdown in a home's heating system, a homeowner would no longer have to arrange visits with workmen. Instead, a call for help on a service platform would be enough. Using semantic technologies, the system would recognize the problem and the seriousness of the situation depending on the season and on weather predictions. The system would then automatically find the right workmen and — based on the calendars of all those involved — coordinate the job. The prerequisite for this is a standardized description of services of the sort provided by the "Unified Service Description Language" (USDL). USDL was developed within the framework of Germany's "Theseus" IT research program in which Siemens played a leading role.

Similarly, autonomous services in the Internet will play an important role in the intelligent electrical grid of the future — in the form of software agents that independently buy and sell energy on behalf of consumers and power producers. Prices on such a virtual power exchange would not depend solely on supply and demand (as is now the case), but would also take into account past experience and forecasts (p. 68, and previous issue, page 99).

In the future, the enormous amount of data on the Internet will become the foundation for new services. There may be services for buildings and homeowners based on patterns of daily electricity demand according to season, services for traffic planners based on traffic volume depending on the time of day, and services for building automation systems based on weather forecasts. For instance, if a building knows ahead of time that a warm front is approaching, it can slowly begin to turn down the heating in advance.

A network augmented with experience can even detect the imminent failure of a component. For example, using thousands of sensors that feed their data to neural networks, gas turbines from Siemens can monitor their own operations in order to optimize the effectiveness of turbines.

Siemens collects this data from approximately 400 plants around the world and uses it to predict wear on parts and to ensure that they are replaced before they break down. Preventive repair instead of a sudden failure — it's to everyone's advantage to give machines a say about what happens! ■ *Christian Buck*

Wind turbines "talk" with one another to optimize their output. In Erlangen, an oak tree equipped with measuring devices "twitters" information about its current state.

Coming Soon: Plugging the Internet into the Physical World

Prof. Elgar Fleisch, 44, is a Director at the Institute of Technology Management at the University of St. Gallen and also holds the Chair for Information and Technology Management at the Swiss Federal Institute of Technology (ETH Zürich). His research work focuses on the economic impact and the infrastructures of ubiquitous computing. Together with a global network of universities, Fleisch and his team are studying possible infrastructures for the "Internet of Things." The researchers in his laboratories are also testing solutions for reducing electricity and water demand, and they are developing technology-based innovations for the insurance industry. Fleisch is the co-founder of several spin-offs and a member of various management boards and academic steering committees.

What will the world be like when the Internet of Things (IoT) becomes a reality? How will the way we communicate change — and the way we manufacture goods?

Fleisch: The IoT will mark the third wave of innovation — the first two were the Ethernet and the Internet. However, it's extremely difficult to predict what types of applications it will result in. We can predict technologies but not the success of an application. That was the case with the Internet as well. Virtually nothing that has come out of it — like social networks, for example — was predicted by anyone. I am sure, however, that the IoT will make the world appear more natural again. Computers will disappear and computer intelligence will make its way into objects. The smartphone will be the computer of the future. Because the IoT will link the physical world and the Internet, there will also be a large number of devices with their own websites and applications. Basically, physical objects will become part of the Internet.

For instance?

Fleisch: Just imagine a watch you can use to call for help in an emergency, dolls in children's rooms that analyze the ambient air, walls that are also display screens, windows that generate energy, counterfeit-proof medications, products that know how they need to be assembled, machines that call in maintenance engineers, and much more. The possibilities are endless — our imagination alone will determine what we can accomplish. Remember that some of the fantastic things we used to see in James Bond movies are now a reality. The IoT will make the world more measurable because every object will be able to communicate its location and condition.

What benefits will all of this offer?

Fleisch: We will be able to measure everything exactly because we'll always know where products and components are located at a given time and what condition they are in. This will enable us to manage things much more precisely. Patients will always get the right medications, farmers will always know what each of their 5,000 cows needs, and buildings will ventilate rooms in line with the conditions at a particular time. All of us will benefit from greater simplicity, convenience, accuracy, enjoyment, and safety. There will be drawbacks, however. For one thing, we'll become more dependent on technology. We'll also have to be more careful with the issue of privacy because we need to ensure that individuals maintain ownership of their data and can decide for themselves what's done with it.

So you see a risk here in terms of our data becoming transparent?

Fleisch: It's true that the line between the private and the professional realms will become increasingly blurred. But our world has always been marked by tension. Trends never move solely in one direction. If one trend starts to dominate, there will immediately be a countertrend. In other words, people will find ways to protect themselves, but we still need to ensure that we always have freedom of choice. Whether or not it will be easy to deal with such freedom is a different question.

You view the IoT as a Europe-centered technology — why?

Fleisch: Because the Internet of Things actually began in Europe. There were forward-looking thinkers in the U.S. in the 1980s — for example, at the Rank Xerox Research Institute and the Massachusetts Institute of Technology. But it was the Europeans who got things moving. The Chinese are now heavily involved as well, because their economy still focuses on the production of physical goods. Remember, the IoT involves the merging of the physical and computer worlds. To accomplish this, you need real products, electrical engineers, automation experts, and software developers — and the expertise for all of this is centered in Europe. This is a great economic opportunity, and the nations that take on a leading research and development role in the IoT will be able to safeguard jobs over the long term.

How will the IoT change learning and studying? What might an IoT university look like?

Fleisch: I'm quite certain that educational systems will change dramatically. The simple communication of knowledge will become automated in order to benefit everyone. A likely development will be well-structured video lectures. But students will still need to have personal contact with instructors in order to cover many complex subjects. I would imagine that an IoT university would allow students to obtain knowledge at a pace that suits them. A lot can be done in an IoT environment. For example, people will be able to point their smartphones at paintings, buildings, machines and so on. The target device will then collect information about the object from the Web — but the degree of detail will be adjusted in line with the user's age and education level.

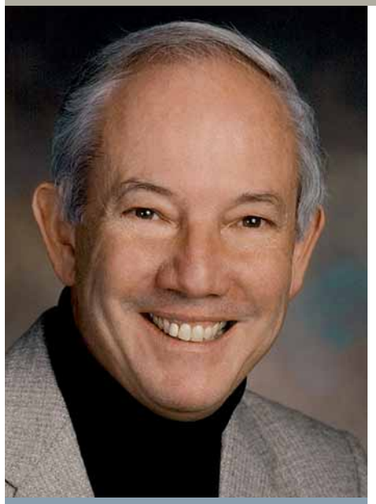
Might Internet 2.0 widen the gap between rich and poor?

Fleisch: Technology has always been used as an instrument of power. There's no doubt that dictatorships will try to establish new trends that increase their power — but democracies can also benefit significantly from technologies that enable their citizens to participate in social processes. I'm convinced that mobile communication technology will give a lot more people access to the Internet in the future. I also believe that the IoT will generally have a democratizing effect and that it can increasingly benefit less prosperous segments of society.

In what ways do you expect the IoT to be linked with social media?

Fleisch: It will be linked to them very closely. For example, you will be able to choose the kinds of information that will appear on your Facebook page, and you will also make your physical surroundings visible to others by posting an image of a cafe, a book, a car, or a doctor's office. All you will need to do is to point your smartphone and click on "Like" — or not click anything. ■ *Interview by Susanne Gold.*

Next: An Automated Economy



Professor William Brian Arthur, 67, is a mathematician and economist. At present, he is serving as a guest scholar in the Intelligent Systems Lab at the Palo Alto Research Center (PARC). His work focuses on fundamental economic and technology development issues. While working at the Santa Fe Institute, Arthur developed a theory that views the economy as a complex system that develops within the framework of an evolutionary process. In his latest book, "The Nature of Technology," Arthur examines the question of how innovations are created. He believes that networked computers and sensors are forming a digital nervous system that will autonomously control our economy in the future.

Professor Arthur, what does the term "Second Economy" mean?

Arthur: Right now, I'm sitting in an office at Xerox PARC in Palo Alto — in other words, in the middle of Silicon Valley. It therefore makes sense for me as an economist to take a closer look at the so-called digital revolution, which most people associate with two things: computers and the increasing level of networking between them. Still, it seems to me that something more complex is going on, namely that more and more business processes are being carried out by machines without any human involvement whatsoever. In other words, a second digital economy in which servers "talk" to each other and conduct transactions is now taking shape alongside the economy we're familiar with — the one that involves physical objects and services provided by people. That's what I mean by the "Second Economy."

How does this business world of machines work in practice?

Arthur: When you went to an airport 20 years ago, you walked up to a counter where someone checked you in. Today, you insert a frequent flyer or credit card in a terminal and immediately trigger a "conversation" between computers all over the world: Once your name has been recognized, computers check the status of your flight and gather data on your past flights, after which your information is compared with the databases of government authorities. The machines then assign you a seat, update your mileage status, and determine whether you're entitled to access airport lounges. These "conversations" are carried out by servers, routers, satellites, Internet computers, and other machines. It is only after all these operations have been carried out that you're issued your boarding card. The entire process is largely autonomous without any human involvement. After it's completed, the results "appear" in our familiar physical world.

What role does the Internet play here?

Arthur: It plays a major role, but not all machine-to-machine communication is carried

out via the Internet because most internal digital business processes are conducted via private networks, for example. So the Internet does play an important role in the Second Economy, but it's not the only system involved.

What's driving the Second Economy?
Arthur: Networked machines help make many processes faster and less expensive. They also make it possible to distribute processes worldwide. Moreover, it's not just computers but also an increasing number of sensors that are being linked around the world. Trucks carry cargo with RFID tags that communicate with sensors, for example, and those sensors talk to computers that themselves are networked with other computers in a system that optimizes supply chains. What we're seeing is the dawn of an economy that's becoming increasingly automated thanks to sensors. This is also having a real effect on our everyday lives and will continue to do so. For example, I believe that in around ten years, you'll be able to drive in Los Angeles in vehicles with an autopilot function whose sensors allow them to determine the position of other cars. There will also be intelligent traffic lights that optimize traffic flows. Once again, all of this involves machines that communicate with other machines — automobiles with other vehicles in their vicinity, and automobiles with traffic guidance systems. In other words, we're moving toward an autonomous economic system that can be compared to the human immune system, which also operates autonomously rather than being centrally controlled by the brain.

What impact will all of this have on the economy of tomorrow?
Arthur: Take production, for example. Here we'll be seeing robots whose sensors enable them to recognize specific situations and respond flexibly to them. They will no longer be blind, so to speak. And that means they won't be limited to rigid predefined tasks. This will increase efficiency and cause manufacturing industries to expand once again in the U.S, and Europe, which in turn could create and safeguard jobs in high-wage regions.

But isn't it also true that increasing levels of machine autonomy will result in a loss of jobs?
Arthur: Yes, those people that used to check you in at the airport immediately come to mind. We're moving toward an economy that will produce more things than we ever could have imagined. The economist John Maynard Keynes predicted 80 years ago that we would be able to manufacture a tremendous volume of products and provide a huge number of services in the future. He said that the problem would be how to distribute this wealth. We will probably have more free time in the era of the Second Economy because machines will do a lot of the work for us. Society will need to address this challenge, whereby one answer might be to subsidize new jobs — for example, in the social services sector — for the interest of the public at large. Perhaps we'll also have shorter working hours and more vacation, which would allow the work that remains to be better distributed. The road might be quite rough here because a lot of jobs considered secure could disappear as we move through the transition.

How quickly do you expect the Second Economy to grow?
Arthur: It's already important because many processes are now carried out autonomously on Wall Street and in other financial markets, for example. Still, no one knows exactly how big the Second Economy is at the moment. I would estimate that it's already half the size of the traditional economy and will catch up to it by 2030. It's going to be a huge upheaval.

You've described this as the biggest upheaval that the global economy has ever experienced. Why?
Arthur: I'm more or less skeptical by nature — but the changes that will be brought about by the Second Economy are simply huge. We're not just talking about greater productivity; instead we're looking at a transformation of the character of the economy. During the industrial revolution, steam engines and electric motors increasingly took over production — machines suddenly became the "muscles" of the economy. Today's networked sensors and computers are creating a "nervous system" that autonomously and intelligently controls these muscles without human intervention. That's why I think the upheaval will be at least as big as the industrial revolution, probably even bigger.

Will this new world be better than the one we live in now?
Arthur: There's definitely a very good chance that it will be — provided we address certain issues like ensuring a good education for broad segments of the population and a fair distribution of jobs. However, if we simply observe this development without doing anything, we may see social tensions rise. We could learn a lot here from the problems associated with the industrial revolution as described in the novels by Charles Dickens. Society ultimately solved these problems, and I'm optimistic that we'll succeed in doing so in the future as well.

■ *Interview conducted by Christian Buck.*

A Nervous System of Networked, Intelligent Things

Source: Based on a model by Frost and Sullivan

In August 2012, Curiosity landed on Mars and began to explore the planet's surface. The entire system was developed and tested using Siemens simulation software.

Images courtesy of NASA/JPL-Caltech

Internet of Things | Virtual Worlds

Meeting on Mars

NASA's Mars Science Laboratory mission — which includes the latest rover, popularly known as Curiosity — is the most technologically complex project in the space agency's history. Developed and tested using Siemens design and simulation software, it is an example of the seamless communication that is developing among machines — the meeting of the real and virtual worlds.

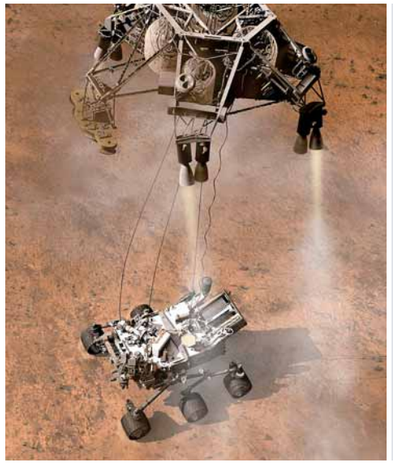
Thirty-six weeks in the unspeakable cold of outer space and a 567-million-kilometer voyage at speeds of over 76,000 km per hour were just the beginning. As the Mars Science Laboratory (MSL), a $2.5 billion, 900 kg rover the size of a small car streaked into the Martian atmosphere on August 5, 2012 it was still traveling at 21,000 km per hour. At that moment it had seven minutes to reach a landing speed of less than two kilometers per hour — or crash.

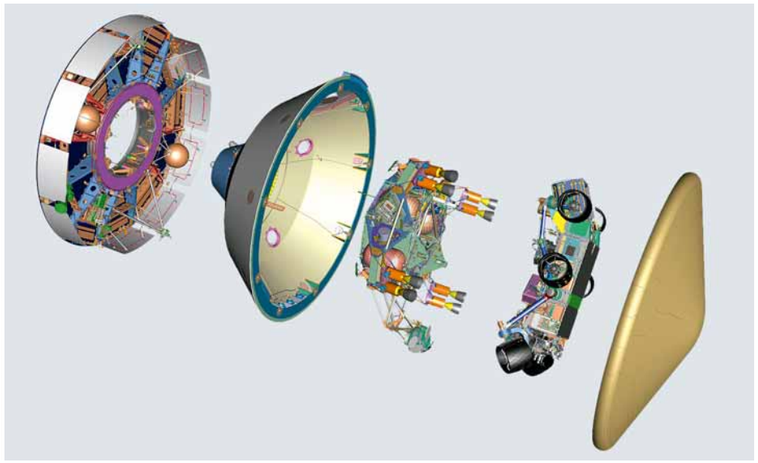
In order to touch down gently enough to avoid damaging instruments designed to search for the chemical ingredients of life, hundreds of complex steps had to be executed flawlessly and without human intervention. How did engineers prepare for such a challenge — one that could not be tested on Earth because our atmosphere is 100 times thicker than that of Mars? "Well," says Chuck Grindstaff, President and CEO of Siemens PLM Software (product lifecycle management), a business unit of the Siemens Industry Automation Division, "NASA's Jet Propulsion Laboratory (JPL) designed the whole thing using our simulation software — everything from thermal analysis to the multi-physical interactions the vehicle would encounter as it entered the Mars atmosphere. Our software was in the center of solving all of it."

Daren Rhoades, a Senior Product Development Manager at PLM Software's Cypress, California development center who, until recently, was a member of the NASA team that developed the MSL (Curiosity) mission, adds that, "There were subsystems that I worked on where simulation allowed us to go from concept to detailed parts, to assembly and testing entirely within the virtual world." MSL's crucial landing sequence — what NASA called "7 Minutes of Terror" — for instance, was optimized in the course of 8,000 simulated landings. "The significance of being able to go from simulations to real-world deployment," says Rhoades, "is huge."

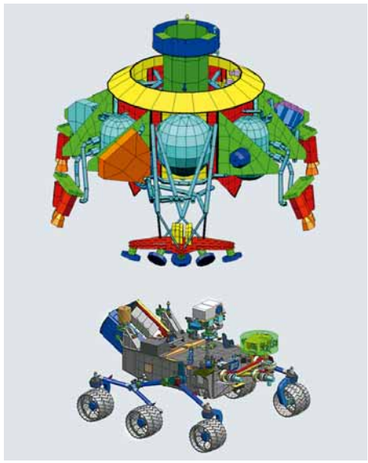
It really is. Consider, for instance, the Sky Crane, a never-before-used system designed to brake the Rover's final descent and gently lower it to the Martian surface. PLM software simulated the dispersion of the plumes of fire from the Crane's rocket engines to ensure that they would not damage the rover or the harness it was attached to. "Not only did the cables have to let the rover down flawlessly without interference from the flames," explains Joel Rooks, PLM Account Executive for NASA, "but there was a kind of umbilical cord that kept the rover tethered to the Crane until the split second before the crane took off. Everything had to separate at once. To do this, there were little guillotines that had to simultaneously sever all those lines. All of that was simulated using our software."

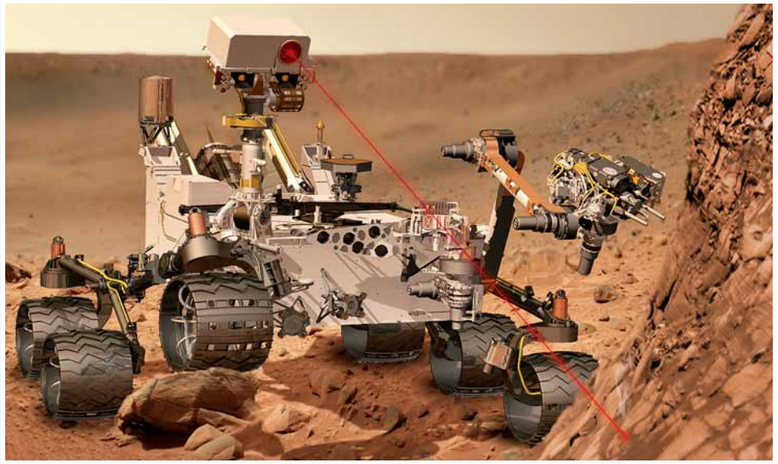
Complexity was also a major issue. The entire assembly consisted of approximately 90,000 custom-made parts, many of which were allowed to deviate from design by only 100 micrometers — about the width of a human hair. What's more, to minimize wasted space, those parts had to be folded into an ex-





Seven Minutes of Terror. Lowering the rover to the Martian surface on cables was a particularly delicate maneuver. The landing phase was simulated 8,000 times.





Images courtesy of NASA/JPL-Caltech

The entire unit consisted of around 90,000 parts, many of which were allowed to deviate from design by only 100 micrometers — about the width of a human hair.

traordinarily dense package, while nevertheless allowing just enough wiggle room for the extreme shaking of launch and reentry, as well as the expansion and contraction of different materials under temperature variations of as much as 1,648 degrees Celsius. "To design things that are that densely packed requires new capabilities and new techniques," says NASA Director of the Mars Exploration Program Doug McCuistion. "We used a lot of systems from Siemens to help us do this."

"It was important to design all system parts so that they would not touch each other and potentially cause damage," adds PLM Solutions Consultant Kent Rash. "The only way to ensure that, given the different materials involved, was to have a finite element model — FEM — of each, which is a method for dividing complex surfaces into small elements that can be calculated in relation to each other."

From Models to Manufacturing. And that's where one of PLM's primary software tools — NX — comes in. NX brings products to life by not only producing CAD (computer-aided design) models, but also through the use of computer-aided engineering (CAE), a process that imbues a design with related functional and physics-based data, such as how much stress or heat a part can safely withstand given the material it is made of. And because many parts in machines are designed to move and interact with each other, NX can perform so-called "kinematic simulations," allowing engineers to "animate and test even very large assemblies in the context of events that might happen in the real world — such as a rover landing on a rock, and figuring out the stresses that would impose on the entire structure," says Rhoades. NX is also a computer-aided manufacturing (CAM) tool. "NX programs were used to generate the code that drove the machines that manufactured the parts for the MSL mission," says Rhoades. "You start out with the original NX CAD model of a part in the virtual world, define which tools will produce it, and then actually run a machine using the NX CAM software based on the original CAD model that you used for your finite element analysis." This process offers many advantages, the most meaningful of which for a multi-billion dollar space mission is accuracy. "The accuracy you can achieve from using a digital model combined with computer numerical control (CNC) in parts production is tremendous," adds Rhoades. "By the time the MSL had been built, many of its machined parts were off by no more than the width of a human hair."

Connecting Desks...and Industries. Not only do complex projects require exceptional simulation software, they also demand systems that allow large teams of engineers to collaborate securely on the same project. And when it comes to "connecting the desks," nothing beats PLM's Teamcenter software. "Teamcenter is the critical supporting system that permeates the entire engineering design process," says PLM CEO Grindstaff. "By providing a set of applications for things such as requirements management, project management, regulatory compliance, and design data management, it is the backbone of the design process." Indeed, as is the case with NX, Teamcenter is used not only for all of NASA's Jet Propulsion Laboratory flight missions, but by SpaceX, which, in May 2012, made history when its Dragon spacecraft became the first private commercial vehicle to successfully dock with the International Space Station.

Why do organizations like NASA and SpaceX turn to Teamcenter? "Simple," says Rhoades, "because no part in a space vehicle is unimportant. Not only does Teamcenter minimize the possibility of human error by ensuring that each authorized participant sees only the latest version of the project data he or she is working on, but it makes it possible to trace every single part back to its original design, analysis, and manufacturing data. And when a design is approved for manufacturing, it is documented as such by Teamcenter. All of this can add up to huge potential savings."

Not surprisingly, high-flying industries are not the only ones to have taken notice of the competitive opportunities offered by virtual prototyping and collaborative development. "We have 70,000 customers," says Grindstaff, who points out that the total market Siemens PLM Software addresses is around $20 billion per year and is growing at an annual clip of five to seven percent. "We are the leaders in collaboration and data management. We are the leaders in digital manufacturing, and we are a strong number two in mechanical CAD/CAM," he says.

What's more, the company is on an impressive run with major new contracts. It recently signed a ten-year agreement with Boeing to expand the use of PLM technology, as well as a worldwide agreement with Daimler to develop all its products and factories in a Teamcenter and NX environment. "The introduction of parallel processes in development, design, production planning, and production will further optimize Daimler's entire value chain, allowing it to produce better products faster," says Grindstaff. The company has also recently signed major contracts with Chrysler and Johnson Controls, a top-ten, tier-one automotive supplier and the automotive industry's largest seating supplier.

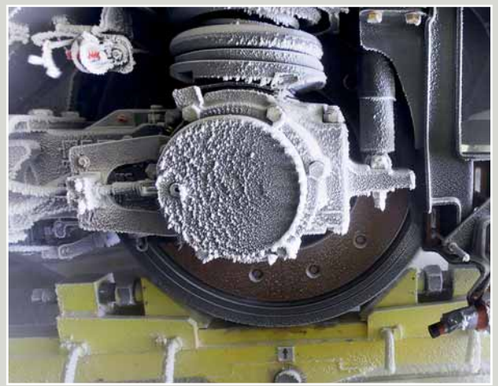
Out-of-this-World Advantages. Among the many reasons for such successes is the fact that Siemens PLM Software helps its customers to cut costs and become more efficient. For instance, as it has integrated PLM technology with its manufacturing operations, Samsung Electronics has been able to reduce its use of physical prototypes by 30 percent, thereby cutting errors by 50 percent in first production runs, and accelerating development time by 30 percent, says Grindstaff.

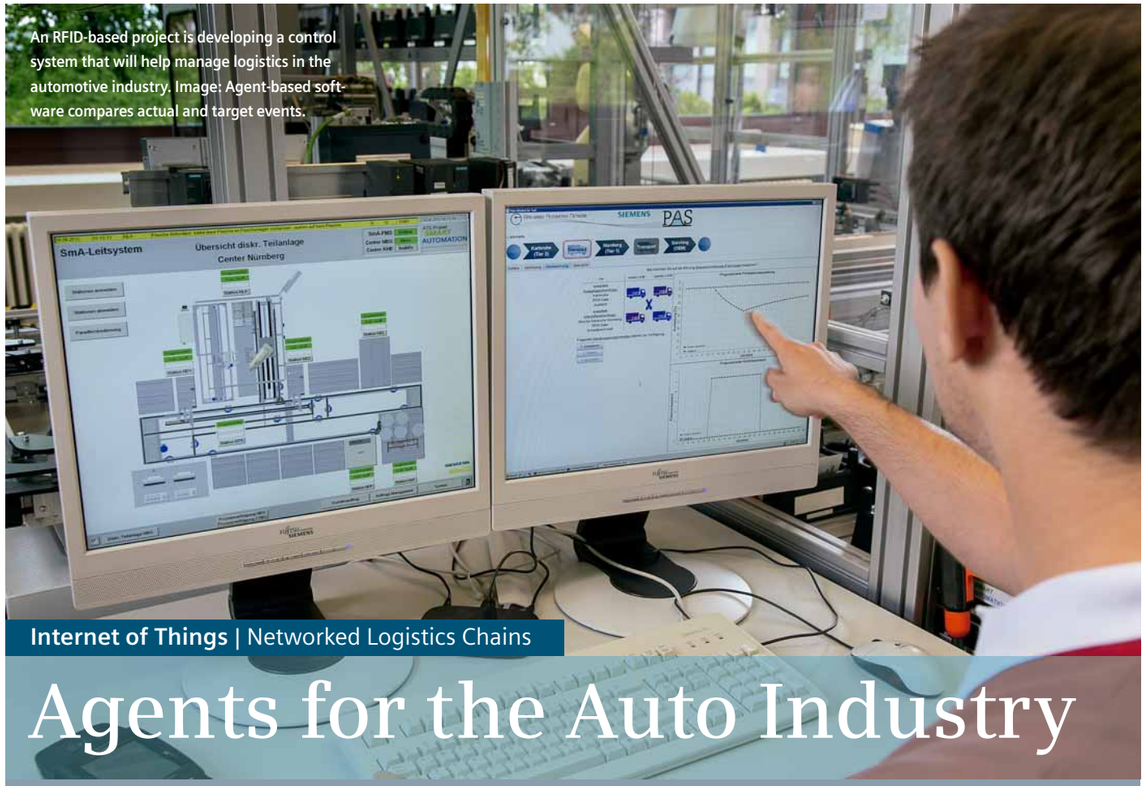
So how much productivity did NASA gain on its latest ticket to Mars? The amount, says Rhoades, is impossible to quantify because, unlike virtually every earth-bound product, MSL is one-of-a-kind. "It isn't as though they started out with a two-ton version and cut it to one," he says. What is clear is that the Curiosity / MSL mission has set a new standard for integrating everything from concept to production and testing. Says Siemens Industry CEO Prof. Siegfried Russwurm, a member of Siemens' Managing Board, "In the past, processes were sequential. What NASA was able to do with the Mars rover was a paradigm shift, an integrated database, an integrated approach from product design to production design — a seamless transition from the virtual world to real production in one consistent database for hundreds of engineers working on one consistent model."

Adds PLM Account Executive Rooks, "MSL was the most technologically-complex project NASA has ever had. What's important is that our tools helped them to simulate and optimize everything, and when they tested it and flew it to Mars, it worked." ■ *Arthur F. Pease*

Uncertainty Quantification: The Next Step in the Science of Simulation

Whether you're sending a laboratory to Mars or crossing Europe in a high-speed train, there are innumerable phenomena that are virtually impossible to predict, and they all add up to one overwhelming factor: uncertainty. So why not try to quantify uncertainty itself? That's what Dr. Utz Wever and Dr. Meinhard Paffrath, both specialists in simulation and mathematics at Siemens Corporate Technology (CT), are working on. Their focus: railway wheelsets. "Wheelsets — including axles — are the top safety item on a train," says Wever. "They also account for a significant proportion of operators' maintenance costs." With this in mind, the researchers are developing a new way of looking at these crucial parts — a method that amounts to a virtual inspection. Normally, inspections rely on ultrasound to determine whether cracks are present. If a crack is found, the part at fault is scrapped. But a lot of the time inspections don't find anything because the probability of finding a crack with at least the minimum depth during an inspection is itself a random number. After all, the factors that cause cracks — things like loads, speeds, and temperatures — constantly fluctuate. "Our approach is radically different," says Wever. "What we want to do is to predict crack size so that inspections take place only when the probability of discovering a crack is high enough to warrant the cost of an inspection." Adds Paffrath: "As we move toward that goal, we are currently computing failure probabilities for fixed inspection intervals." To do that, Wever and Paffrath started out with a program from Germany's Fraunhofer Institute that computes crack growth without consideration of uncertainties and inspections. They then "added sophisticated algorithms to the program in order to compute failure probabilities for different inspection scenarios." And the result? The software is now being evaluated on a pilot basis by Siemens Rail Systems in Graz, Austria. "We are now at the point where we can develop predictions of crack sizes, thus reducing the uncertainty of expensive but unnecessary real inspections," says Wever. "We will then compare the results of the real inspections with our predictions. The initial results look promising."





An RFID-based project is developing a control system that will help manage logistics in the automotive industry. Image: Agent-based software compares actual and target events.

Internet of Things | Networked Logistics Chains

Agents for the Auto Industry

The automobile industry is characterized by complex supply chains. To head off potential disruptions, researchers at Siemens Corporate Technology have developed an ecosystem of software agents that use RFIDs to detect and evaluate production problems and communicate with downstream systems.

The idea is as simple as it is brilliant. A reader generates a high-frequency electromagnetic field. When a transponder (tag) gets close to the reader, the special structure of the tag alters the magnetic field and in doing so sends specific information about itself. This is the principle behind Radio Frequency Identification (RFID), which enables objects to be identified using electromagnetic waves.

These days, RFID tags can be as small as a grain of rice and it's already impossible to imagine life without them. You'll find them in supermarkets, brand-name jeans, government identity cards, and even implanted under the hide of dairy cows, where they provide a wide range of information about the best nutrition for each animal. RFID tags are also implanted in people — for example, in the U.S. in order to rapidly call up vital patient data in emergency rooms.

"Nevertheless, we have yet to fully exploit the potential of RFID technology, especially in manufacturing," says Dr. Raffaello Lepratti from Siemens Industry Automation in Nuremberg, Germany. "Our RFID-based Automotive Network (RAN) project goes far beyond simple product identification. In fact, we're developing a cross-company RFID-based material flow control system for the automotive industry, which plans to become the first sector to introduce this technology as an industry-wide standard."

The RAN project is receiving more than €20 million in funding from the German Ministry of Economics and Technology. "RAN is a consortium of 18 partners," says Lepratti, who also serves as RAN's Project Manager. "It includes automakers Daimler, BMW, and Opel; automotive suppliers such as Bosch and Rehau; logistics companies such as BLG and DHL; software firms such as IBM and SAP; and research institutes such as the Institute for Machine Tools and Industrial Management at the Technical University of Munich. In the consortium, Siemens is responsible not only for production planning and control but also RFID infrastructure. As a consequence, it is developing specifications for tags, readers, and the software agents needed to manage the systems." Software agents are software modules that work autonomously and can communicate with one another (see p.68).

Sensitive Supply Chains. The automotive industry has undergone a huge transformation over the last few decades. In particular, over the years it has been compelled to develop and produce ever more complex vehicles that are offered in an increasing number of versions. In order to master this challenge, automakers have had to transfer large portions of the value chain to suppliers that themselves obtain components from external companies.

Every automaker thus operates a highly complex value and supply chain that typically encompasses around 50,000 links in the form of suppliers and sub-suppliers. The result is a system in which even the slightest disruption can have an impact on the assembly of the final product. "In extreme cases, the entire production process can come to a halt because a supplier's truck carrying a part that costs less than a €100 gets caught in traffic," says Dr. Steffen Lamparter from Siemens Corporate Technology (CT) in Munich.

The RAN consortium includes both automakers themselves (OEMs — original equipment manufacturers) and first and second-tier suppliers. "Let me give you an example of a very basic supply chain," says Lamparter. "A tier 2 supplier provides a tier 1 supplier with parts for car seats. The tier 1 supplier then puts together the seats and sends them to the automaker's plant, where they are fitted into vehicles on an assembly line."

Such supply chains are planned down to the last detail and chronologically coordinated. Some supplier products are delivered "just in time" — in other words, exactly when they need to be installed. This approach has the advantage of keeping warehousing costs low. "However, if there's a problem while the parts are being delivered, the next link in the chain usually doesn't find out about it until the component arrives late," Lamparter explains. "At that point, it's almost impossible to re-plan the production operation."

RAN's goal is therefore to eliminate the communication deficit between supply chain partners through a unique new approach. The concept involves establishing an RFID-based information infrastructure that enables the production lines in all the links of the chain to talk to each other in real time. That means being able to recognize and receive information about supply-chain disruptions at an early stage. "With RAN, automakers can see beyond their own operations," says Lamparter. "They can then analyze disruptions to a supplier's operations soon after they occur and take appropriate action."

This feat is made possible by software agents that allow individual production lines to communicate across company boundaries and automatically coordinate their activities. These software agents act like virtual robots in accordance with the principle of "receive, think, and act." The agent receives data, processes it, and forwards new information to a system that takes the required actions.

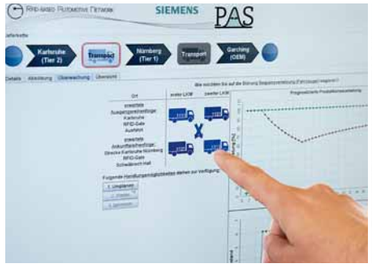
"We've already created the RFID infrastructure with tags, readers, and agents," Lamparter reports. "To show our partners how the system works, we've also built a prototype facility that consists of a simple chain including a manufacturer and tier 2 and tier 1 suppliers."

The role of the suppliers and sub-suppliers is played here by two SmartAutomation test facilities operated in Karlsruhe and Nuremberg by the Siemens Industry Sector's Advanced Development department. A facility at the Technical University of Munich in Garching serves as the OEM.

To make things easier, the facilities don't actually produce real automobile parts but rather bottles that stand for transmission components. "Karlsruhe manufactures and packs glass bottles that are then virtually transported to Nuremberg in a simulated truck shipment," Lamparter explains. "After the bottles arrive, they are filled with solid materials of different shapes and colors. Every bottling operation represents the installation of a certain transmission component." The filled bottles are virtually sent to Garching, where they are replaced by real transmission components that are then assembled.

Software Agents at the Factory Gate. The tier 1 supplier operation in Nuremberg clearly demonstrates how RAN works. All of the pallets loaded with empty bottles are fitted with RFID tags that each have their own unique code number. The parts are scanned at the "entrance gate," then again with hand scanners during production (bottling), and a final time at the "exit gate." Software agents near the gates and scanners record the identification codes and forward the data to a central collection unit known as an information broker. Each code entered is supplemented by information on where a specific part was located at a certain time. The complete information package is known as an "RFID event."

"The big advantage of RFID tags compared with conventional barcodes becomes clear when you consider that a barcode scanner needs to have direct optical contact with a code," says Lamparter. "With RFIDs, we can scan entire pallets while they're still on a forklift. In other words, we don't have to unpack



In a lab test, a truck is late, resulting in an immediate predicted drop in production capacity utilization (red curve). Right: Merchandise undergoes RFID scanning.

During production, merchandise is constantly scanned, producing a real-time overview. All data flows into a central collection point for processing.

Opening the Door to Automated Machine Tool Prognostics

From milling to drilling — machine tools are used worldwide to manufacture metal components for cars, engines and other equipment. But when these machine tools malfunction, they can disrupt production and create substandard products. A solution called Plug & Prognose is currently under development by Corporate Technology (CT) to resolve this problem. Machine tool operators are faced with increasing pressure to reduce downtime and maintenance costs while upholding high standards of product quality," says Linxia Liao, a research scientist at CT in Princeton, New Jersey, who initiated the project while at Siemens' Technology to Business Center in Berkeley, California. "Plug & Prognose effectively responds to this challenge by streamlining the workflow for machine prognostics."

Plug & Prognose identifies emerging faults without the need for machine physics modeling or special machine test cycles. The prototype software communicates with a machine's controller to understand which conditions the machine is operating under by collecting data from the machine and its sensors. It customizes the analysis based on historical data related to associated operating conditions. Plug & Prognose builds new analysis models when new conditions are identified. "Our prototype software adapts to different machine usage, ensuring that the results are as accurate as possible," says Zachery Edmondson, Research Group Head at CT.

The system's innovators are exploring applications in additional sectors. For example, the Plug & Prognose model can be installed in wind turbines. Here it not only helps to maintaining turbine health, but minimizes energy loss for customers. Healthcare applications are also imminent — paticularly in equipment used in hospitals, clinics and private practices, where the system could ensure that all machinery is functioning properly. "Although its current focus lies in industry, we are confident that Plug & Prognose will efficiently and economically revolutionize machine prognostics across all sectors," Edmondson notes. "In essence, we are developing tomorrow's machine prognostics solutions." ■ *Carolyn Joiner*

the pallets to perform the scanning operation. It's also possible to add information to RFID tags. In contrast, a barcode contains only a serial number and nothing else."

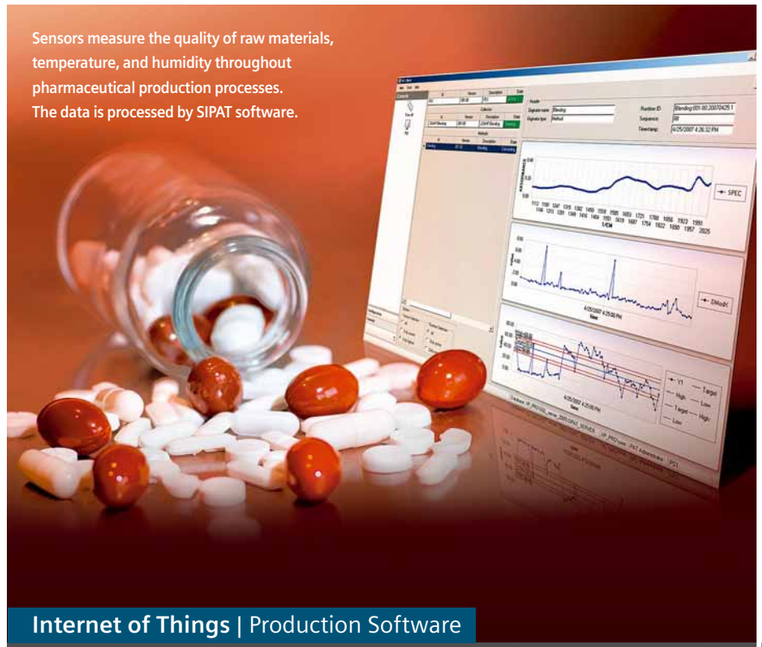
The RFID events collected by the information broker are called up by a host agent known as the Production Assistance System (PAS), which analyzes the events and compares actual and target values. The PAS agent can thus determine if the delivery in question is proceeding on schedule or whether it's late. If there's a problem, the agent can decide whether it's of a critical nature or whether it can be corrected — for example, by using stockpiled parts in the next link in the chain. If a correction is not possible, the agent calculates new production commands that limit the damage to a minimum — for instance, it moves forward other production tasks that don't require the missing parts. The newly calculated commands are then forwarded by the host agent to the local production control system. In Nuremberg, SIMATIC IT from Siemens is used for this purpose.

This system processes the new commands and sends them to individual production units. "In other words, the supervising PAS agent is one of the core components of the networked supply chain," says Lamparter. "It's the intelligent switching station between the information broker and SIMATIC IT — the reader and the executor." With RAN, RFID events at all the participating suppliers are now sent to the central information broker. As a result, the automaker's PAS agent can — for the first time — transcend the boundaries of its own location. It receives information about supplier delays at an early stage and can re-plan its own production commands accordingly. The entire system functions smoothly even in today's global logistic networks. Whether the carrier is a ship, truck, or plane — RFID scanning at transshipment centers or GPS-based cargo tracking can register the entire value chain in a type of "Internet of Things." The network, in short, is made up of invisible robots consisting of bits and bytes — the software agents.

"The RAN project will end in late 2012," says Lamparter. "After that, RAN will have to prove itself in normal operations." Plans call for long-term tests in conjunction with the automakers involved in the project. "If the system demonstrates its effectiveness, RFID-based logistics chain management could become the standard for an entire industry for the first time," adds Lamparter.

And beyond the auto industry? "Theoretically, our system can be utilized in any manufacturing sector — even in the pharmaceutical and food industries," says Lamparter. "All you need is a place to attach an RFID tag."

■ *Nils Ehrenberg*



Sensors measure the quality of raw materials, temperature, and humidity throughout pharmaceutical production processes. The data is processed by SIPAT software.

Internet of Things | Production Software

Pills with Memories

SIPAT software from Siemens helps pharmaceutical companies manufacture medications continuously rather than step by step, thus increasing speed and efficiency. The program doesn't just monitor and manage production — it also enables complete retracing of the stages of the manufacturing process.

Granulating, drying, grinding, mixing, and pressing — every batch of a medication, in the form of capsules or tablets, undergoes many different manufacturing steps in a predefined sequence. Unlike the processes in other sectors, manufacturing operations in the pharmaceutical industry are periodically interrupted in order to take samples, send them to labs, and have them checked for quality. This can take a long time, because each batch must remain in quarantine for up to two weeks as it awaits approval for the next production step. And if it's determined that a drug's homogeneity or active agent concentrations do not correspond to internal requirements, the whole manufacturing effort may turn out to have been in vain. The semifinished medications will then end up in the garbage.

This type of stop-and-go manufacturing is called batch production, and it's standard in the pharmaceutical industry today. However, because it's so drawn-out and fundamentally inefficient, regulatory agencies such as the U.S. Food & Drug Administration (FDA) have begun to look for alternatives. Their goal is to put in place systems that continuously monitor and control the quality of raw materials, process media, and intermediate products throughout the manufacturing process.

To this end, Siemens has developed a software system known as SIPAT (Siemens Process Analytical Technology). SIPAT can manage the traditional batch production process while also ensuring the prerequisites for continuous production. It does this with sensors that constantly evaluate the quality attributes of every batch. For example, it measures the even distribution of active agents and substrates in pharmaceutical mixtures through optical monitoring in real time. "The absorption and reflection of light rays tell us when the mixing process can be concluded," explains Jürgen Manz from Siemens Industry Automation. "Regulations used to require that batches always be mixed for one hour — but now we can stop mixing a lot earlier if our sensors give us the O.K."

Production Costs: Heading South. SIPAT is the centerpiece of continuous process control. It constantly calls up measurement values for parameters such as humidity, temperature, density, and the range of grain sizes. This enables the system to determine during production whether values are within the stipulated range and implement countermeasures in the event of deviations (closed loop control). In the worst case, a defective batch will have to be scrapped. "We save a lot of time because we no longer need to carry out complex lab analyses after each production step," says Manz. "The production of a batch now takes only ten days instead of two months, and because there's no longer any quarantine time, capacity utilization also increases."

SIPAT reduces manufacturing costs for tablets and capsules by around 20 percent. It's therefore no surprise that pharmaceutical companies like Merck and GlaxoSmithKline use the software for research and production.

The system can check the quality of each tablet, thus making it possible to completely retrace the manufacture of individual products. This means the Internet of things has now made its way into pill bottles as well, enabling digital product memory. Moreover, the large amount of data collected from each production plant gives pharmaceutical manufacturers valuable knowledge about their globally distributed processes. "Spectral data from optical sensors can be combined with mathematical models to calculate the quality of specific mixtures," Manz explains. "Until now, such information about methods and models was available only locally at individual production sites. In the future, however, all of it will be stored in a central SIPAT database that will enable pharmaceutical companies to share the extensive resulting knowledge to further improve their products." ■ *Christian Buck*

Increasing numbers of Chinese automakers — including Chery Automobile and Geely (right) — are using Siemens' solutions to optimize their production processes.

Great Leap in the Making

Cheap labor is no longer China's main strength. Having launched a process of fundamental structural change, the onetime "workbench of the world" is now achieving success with complex products that require sophisticated solutions for associated automation and information management systems.

China has evolved into the world's second-largest economy. And many signs indicate that it will overtake the U.S. to become the world's number one economy before the end of this decade. During the first phase of this tremendous economic transformation, one of China's greatest strengths was a seemingly bottomless pool of labor that gave the country its reputation as the "workbench of the world." However, all that success has created a new situation. The country is now more affluent and will soon lose interest in lingering at the lower end of the value chain.

As early as 2001, the provincial government in Guangdong began implementing a structural transformation program that provided incentives to companies in technology-intensive sectors. This strategy has led to sharply rising wages. The average monthly salary of an industrial worker in the Shenzhen region is now approximately €320, for example. By comparison, the legally mandated minimum wage in Cambodia currently totals only €50 per month. One of the consequences of this development is that labor-intensive industries are now leaving Guangdong and even the country. Sneakers and T-shirts are more likely to be produced in Bangladesh, Vietnam or Cambodia today than in the Pearl River Delta. Meanwhile, China is manufacturing more and more sophisticated products, such as high-speed trains, computers, machinery, and automobiles. Cheap labor is no longer the key to success in these sectors. Instead, it's China's efficient processes, technical expertise, and organizational skills that are giving the country its edge. The best example of this is the Chinese automotive industry.

"Vehicle development is an extremely sophisticated process," says Zhou Kehu, Senior Business Consultant at Siemens Industrial Software in Shanghai. "For one thing, it requires cooperation among a whole range of functional teams. What's more, each of these teams has to deal with huge amounts of data. So you can imagine that coordinating this data volume alone is a tremendous challenge." In order to prevent miscommunication and to ensure smooth production processes, it is crucial that engineering teams not only manage their own data, but also remain abreast of what their counterparts in the manufacturing and quality teams are doing.

Siemens software solutions for Product Life Cycle Management (PLM) applications enable operators of industrial facilities to meet this challenge. PLM helps to bring together all the relevant information — on everything from initial drafts and detailed design processes all the way to manufacturing operations. It then makes all this data available for the optimization of design and production processes.

When applied to the automotive industry, PLM leads to much higher levels of design maturity and to significant improvements in quality management. This is one reason why China's top automakers and supplier companies began adapting their product development and production planning to PLM requirements quite some time ago.

Chery Automobile is an example. The company manufactured approximately 670,000 vehicles last year, of which roughly 170,000 were sold abroad. This makes Chery China's top vehicle exporter. Chery — like all other Chinese automobile manufacturers — is a very young company. It was established in 1997 and has been using PLM solutions from Siemens since 2003.

One of the most important PLM tools at Chery is Tecnomatix, which links all manufacturing operations to product development units — from process definition and planning to simulations and actual production. Chery utilizes this PLM tool for dimensions analysis. "This analysis plays a key role when it comes to designing vehicle bodies," says Wu Shiqiang from Chery's Institute for Technical Planning and Design. "Dimension analysis allows us to determine in the early stages of body design whether the structure and production methods will meet technical requirements. This enables us to develop solutions early on in order to optimize these factors."

An important additional component of Siemens' Tecnomatix software is variation analysis, or VSA, which is a form of dimension analysis that simulates manufacturing processes with the help of three-dimensional computer-generated models. VSA is designed to identify weak spots in the production process before manufacturing operations begin. Chery, for example, used VSA to identify a problem in the production of a headlight for a certain model — and this single software diagnosis ended up saving the company roughly $150,000. "This also enabled us to avoid production delays, of course," says Wu.

Chery examined a variety of software solutions before choosing Tecnomatix from Siemens. "It was the variety of functions Tecnomatix offers that impressed us the most," Wu explains. Other factors that Chery considered important were Siemens' status as the world market leader in this software sector, its first-class customer service, its years of experience in the field, and its long-term partnerships with leading automakers around the world. "That's why we finally decided on Siemens," Wu says. Many other automobile manufacturers and suppliers have made the same decision. That's why Siemens is the number one supplier of PLM solutions for the Chinese automotive industry. The company had a market share of 27 percent in China in 2011, according to CIMdata, an independent global PLM consulting firm.

Why China is Turning to Automation. The benefits Siemens offers to automakers are significant. For example, the FAW Car Company, one of China's leading automakers, has used Siemens PLM solutions such as Tecnomatix to shorten its planning processes by several months, while at the same time substantially improving the precision of its work processes. "We achieved a 35 percent increase in planning efficiency," says Yuan Xueyu, Deputy Technical Director at FAW Car. "We also cut the number of process planning corrections we had to make by 18 percent, boosted assembly line productivity by 25 percent, and significantly improved our efficiency in utilizing all the relevant resources."

Automation solutions and work processes like these are a far cry from the old image of China as the workbench of the world. Indeed, automation is becoming increasingly important for China. After all, the country's labor pool no longer seems as inexhaustible as it once did. It is already becoming difficult for companies in China's main industrial centers (in the Pearl River Delta region between Hong Kong and Shenzhen and at the mouth of the Yangtze River near Shanghai) to find enough suitably skilled workers. This problem will only increase over the next few years. Demographics alone will have a significant impact here, as China's population is aging rapidly. The average age will be a little over 48 by 2050 — four years higher than the current figure in Japan, which along with Monaco now has the world's highest average population age.

"One of the advantages of automated processes is that they enable a degree of quality consistency and planning security that simply can't be achieved — not even when a mass labor pool is available," says Chen Wei, System Application Manager at the Siemens Automotive Industry Competence Center in Shanghai. "That's why there's a direct link between investment in automated production processes and product quality."

The degree of sophistication of the solutions required varies with the level of production complexity. The automotive industry is currently at the high end of the complexity scale, as numerous robots, sensors, human-machine interfaces, and other devices need to be coordinated on manufacturing lines. Such coordination is achieved by means of programmable logic controllers (PLCs) — powerful computers that are the nerve center of automated production facilities. Leading automakers such as Chery, Geely, and the Israeli-Chinese joint venture Chery Quantum Auto utilize these high-performance components from Siemens.

Siemens produces components for the upper-range market segment — for example, for customers like Chery — in Germany. However, Siemens is now also developing other PLCs and similar devices in China itself, not just for the Chinese market, but also for export to other countries, especially emerging markets. All of this is part of the Siemens strategy of strengthening its innovation network by establishing research and development units around the world. It's also in line with China's strategy of transforming itself from the workbench of the world into a location that not only uses sophisticated automation solutions but also develops them. China has indeed come a long way in just 30 years. ■ *Justus Krüger*

Thanks to sensors, embedded computers, and communications technology, the car of tomorrow will increasingly become a robot on wheels. But for this to happen, cars will need new hardware and software architectures.

Internet of Things | Automotive Software

Road to a Digital Future

More and more automotive systems are driven by software. Driver assistance systems and electric vehicles are accelerating this trend to such an extent that developers are envisioning a completely new architecture for tomorrow's cars. In a research project called "RACE," new concepts are already being developed and tested in prototypes.

Our cars are rolling computers. High-end automobiles contain up to 100 control units and dozens of sensors. Engines, transmissions, brakes, airbags, and even power windows are equipped with intelligent electronics, which can recognize, for example, when a child's hand is between the window glass and the window frame. There are systems that help drivers stay in their lanes and park, warn them that they might be getting too tired to drive, and coordinate the wheels when driving on slippery surfaces.

Some types of cars are already equipped to brake automatically in critical situations. This action involves not only the electronic stability control system but also a kind of cerebellum in the transmission that automatically causes it to downshift while the passenger safety equipment pulls the seat belts tight. Since all of the control elements on board modern cars are heavily interdependent, the result can be a kind of anarchy that can put excessive stress on an automobile's communication system, or "bus." This is the component that makes it possible for subsystems to exchange data with one another.

As more and more functions become increasingly autonomous, it will become difficult for the current standard of decentralized intelligence — electronics and software modules distributed throughout a car — to perform adequately. Despite ever faster connections and protocols, there will eventually be a traffic jam in the data flow. "We have to deal with the causes of these problems and not just the symptoms," explains Professor Gernot Spiegelberg, who is responsible for electromobility concepts at Siemens Corporate Technology.

Spiegelberg's suggestion for a solution is based on the way the human brain works. In the same way that the brain has specific regions that are responsible for functions such as sight, motor control, and memory storage, so too must a central computer have a function-oriented software architecture that drives a car. This approach would allow data processing resources to be efficiently applied, as well as the rapid evaluation of complex traffic situations. Individual functions could be upgraded or replaced at any time, and only minimal effort would be needed to transfer the software package from one type of car to another.

As simple as this may sound, it would be a revolution for the auto industry. It would mean that every supplier of electronic parts would have to deliver associated software modules that could speak to one another through logically predefined interfaces.

Evolution and Revolution. How might the electronic architecture for tomorrow's automobile look? That's what's being researched by the RACE project, which is being coordinated by Siemens — the acronym stands for "Robust and Reliant Automotive Computing Environment for Future eCars." In addition to Siemens, automotive supplier TRW, service provider AVL, and five renowned academic institutes are also participating in the project, which is supported by the German Federal Ministry of Economics and Technology to the tune of around €10 million. By the end of 2014 the partners plan not only to have worked out a theoretical description of the hardware, software, system schematics, and sensor integration, but also to have built two prototypes.

The first prototype, known as "Evolution," will primarily demonstrate the transition from today's architectures to those of the future. The biggest challenge is the high cost of developing completely new software. As Professor Manfred Broy of the Technical University of Munich confirms, "It's obvious that in the long run we'll need a different system architecture for automobiles. But we also have to be clear about how much money has been invested in current vehicle software and how expensive it will be to rewrite it and partly redesign it." The Evolution subproject is also intended to show that a function-oriented architecture makes significant savings possible over the long term. For example, if a component, including its software, has been certified in accordance with the strict ISO 26262 safety standard, then it should be transferable to another vehicle from the same manufacturer without modification or further testing — as is already the case in the aviation industry.

The second prototype, by contrast, will show what a "Revolution" could look like. Here, a completely redeveloped system architecture will be fully implemented in a vehicle. The goal is to ensure that the electric drive, brake system, and all other functions relevant to driving will work so well that the car could be licensed to operate on public roads. According to Spiegelberg, "We'll see that cost savings will be possible here as well, as the entire vehicle architecture will be designed in a completely different way from today's cars." All in all, this will make it easier to implement completely new vehicle concepts.

For example, the prototype will be equipped with wheel hub motors on the rear axle. They will not only give the vehicle excellent acceleration but also be able to generate so much braking power that a braking system that uses ablative brake pads will only be necessary on the front wheels. That would cut costs. And it wouldn't require two control units — one for the brakes and one for the motors — to deal with longitudinal dynamics. The concept car will also have steering "by wire," which means that the steering column as a mechanical connection between the steering wheel and the front axle will be omitted.

The exact structure of the software will be determined over the course of the project, which started at the beginning of 2012. Broy, the software expert, expects that client-server structures, service-oriented architectures (SOA), and layered architectures will all play a big role. All three ways of structuring complex software boil down to the adoption of a rigid hierarchy. In a layered architecture, components no longer have equal authority, which means that components from higher layers may use the elements of lower layers, but not the other way around. In a client-server structure, the software is distributed among different hardware components, but there is a clear definition as to which components have what authority. With service-oriented architecture, the software is structured according to areas of responsibility.

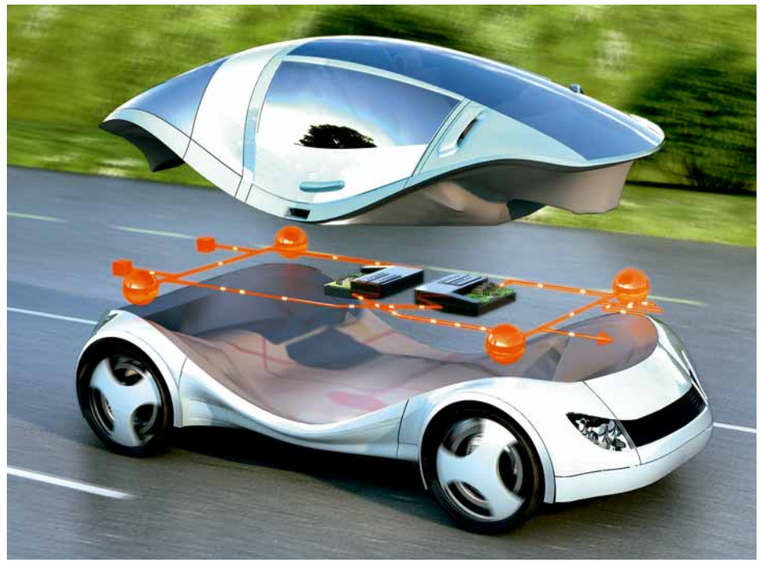
This applies to hardware in an analogous way, as increasingly intelligent sensors are being installed in cars. This is because current and future assistance systems rely on vehicles being aware of their environment. Stereo cameras, laser, radar, and — for close range — ultrasound sensors, will give tomorrow's cars a 360° view, not to mention the fact that they will be equipped with decentralized intelligence. These "nodes" in the vehicular autonomic nervous system will take over the job of signal processing, while the vehicle's "brain" will be responsible for situation recognition and, when necessary, for taking action.

RACE is also researching the interesting question of what control loop configuration would allow intelligent sensors to be directly connected to intelligent actuators so that the vehicle's brain would not need to take action in most cases, but would merely monitor situations. One situation where the brain might intervene would be modulated breaking.

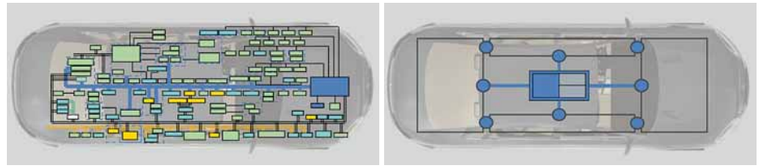
Upgrades for Older Cars. But what about the driver? He or she would profit most from new software structures that would make it easier to integrate functions retroactively. Updates for the infotainment system are already standard today, but when a luxury automaker introduces a new assistance system for collision avoidance, it is only available in new cars. In the future, on the other hand, the new information architecture from Siemens would allow older models to be retrofitted with the new software.

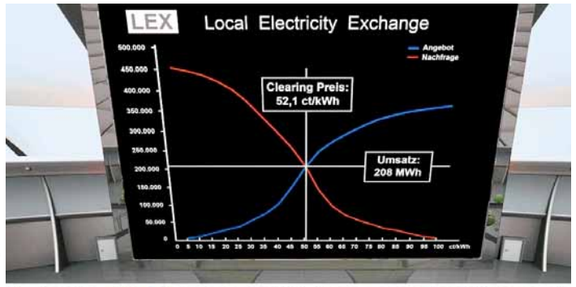
To protect such an open system from hackers, RACE is also examining the security of the new architecture. But Broy doesn't see any fundamental problems. "In principle, we already know how to design software updates that are secure," he points out. "It means building in a firewall, the introduction of clear security requirements, and developing a general security concept for the systems in an automobile."

The race is now on to create a future-oriented, sustainable electronics structure for cars. ■ *Johannes Winterhagen*



In the context of the "RACE" research project, Siemens and its partners are examining a new software architecture for tomorrow's vehicles. The concept envisions a dramatic simplification from the multitude of control elements in today's cars (below left) to the architecture of the future (below right). The growing number of software functions will be distributed over fewer hardware components.





Internet of Things | Software Agents

How to Simulate a Smart Grid

Substantial research is still required in order to develop technologies for tomorrow's smart grids. Engineers from Siemens Corporate Technology are devising the software needed to incorporate diversified and distributed power generators into the electricity network.

How will tomorrow's grids handle fluctuating energy from vast numbers of solar and wind-based electricity producers? The honest answer is that no one know. Major questions include pricing uncertainties and increasing variability of supply and demand. Yet help could be at hand in the form of software developed by Christian Glomb from Siemens Corporate Technology (CT). Glomb's software simulates a smart grid in its capacity both as a network for transmitting electricity and as a communications network. The project is Siemens' contribution to "Software Platform Embedded Systems 2020" (SPES), a program funded by the Federal Ministry of Education and Research in which Siemens simulates a hypothetical smart grid in Siegen, Germany. SPES's goal is to develop processes for the embedded systems market, i.e. control software that is installed in equipment and manages transport systems and power grids (p. 48).

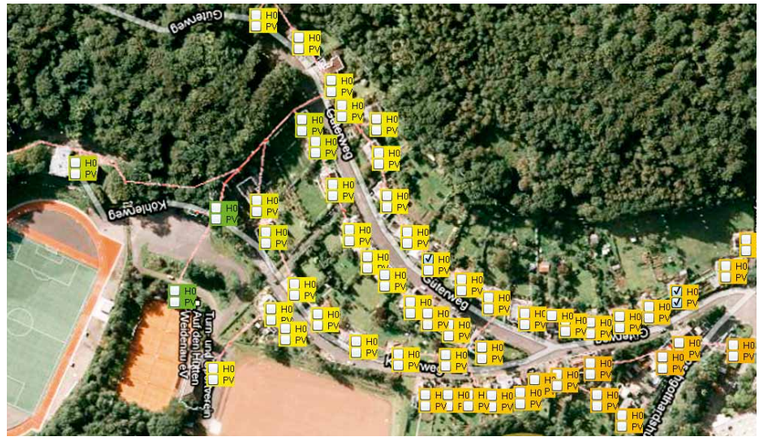
The software builds on a conventional power grid simulation and enriches it with a realistic emulation of communication between various system components and a simulation of control functions for the system as a whole. It comprises all the major elements and processes that are required for proper and stable functioning of the grid. Given, for example, that communications networks can be susceptible to problems, it is important to make this aspect of the system as robust as possible.

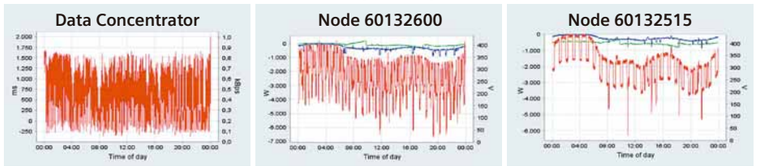
Using data regarding transmission and communication networks, power generating plants, and consumers, the software calculates the probable behavior of system components. On a sunny Sunday, for example, when lots of power is produced by photovoltaic plants but little is consumed by industry, the software can recognize when maximum voltages are exceeded and a tap transformer is required to deal with the surge. "The software tells us how the system will behave before it even goes into operation," says Glomb.

The simulation does not extend down to the level of individual appliances, even though this would be feasible. Instead, it assumes an overall load profile for the connection points of households or commercial enterprises. Otherwise the complexity of the control functions would become unmanageable. It took a year for Glomb to program the basic simulation, followed by a couple of weeks to model a concrete grid. Initially, Glomb and his Siemens colleagues in Vienna modeled a smart grid in Eberstalzell, Austria, which is scheduled to go on line in 2013. This grid will comprise between 150 and 200 connection points, as many as 70 photovoltaic plants, and about the same number of electric vehicles. The simulation is, however, constructed in such a way that it would also be possible to create much larger grids that comprise several thousand connection points.

When it comes to smart grid technology, the future has already arrived in Wildpoldsried. Using photovoltaic, wind, and biomass generation, this picturesque town in southern Germany produces over three times the power required to cover its own demand. In a project named IRENE, local utility Allgäuer Überlandwerke (AÜW) and Siemens are investigating how smart grids can cope with a massive infeed of renewable energy (see *Pictures of the Future*, Spring 2012, p. 46). According to Michael Fiedeldey, Head of Technology at AÜW, power grids need to become more intelligent in order to smooth the transition to a new energy age. He calls for "smart technology rather than more copper." That will not only spare the expense of installing new transmission lines but also create new services and new value-added chains for his company.

At the heart of the field test is a smart software system developed by Siemens. This energy automation system, named SoEasy, creates a virtual market that enables operators of biogas-fired and photovoltaic power plants to sell their product to a central purchaser — in this case, AÜW. In the case of IRENE, the main focus is on the integration of distributed power plants and electric vehicles. Here, the system optimizes the management of energy storage facilities — for electricity, heat, and gas — connected to the grid, with the aim of avoiding peaks or overloads.





Left: An energy automation system known as "SoEasy" works with Personal Energy Agents (PEAs). The agents automatically broker power capacity and prices.
Above and below: Simulation of a section of a smart grid in Siegen, Germany.

SoEasy functions by means of software agents that automatically broker power capacity and prices. The following agents exist:

Personal Energy Agent (PEA): Every facility in the smart grid, whether a power producer or consumer, is equipped with this small device. It contains a computer with interfaces to the facility and to the Internet. Using a PC, plant operators can stipulate how much power the owners want to sell, at what time, and at what minimum price. Every 15 minutes — other intervals can be set — the PEA brokers power capacity and prices with a Balance Master.

Balance Master: This software agent, installed at a utility, decides which PEA offers it will accept in order to cover demand in the grid. Details regarding the technical operation and pricing strategy of power plants connected to the PEAs are not provided to the Balance Master; this information remains in the hands of the plant operators. As a rule, planning is conducted for the coming 24 hours, though shorter periods to permit participation on the intraday market are also feasible.

Area Administrator: This agent helps the grid operator maintain network stability. The software only intervenes when maximum voltages are exceeded. For example, if too much solar power is being fed into the grid, the area administrator can either modify the infeed from other plants via commands to their PEAs, or adjust the ratio of a distribution transformer. This is now being done for the first time in Wildpoldsried.

Network Transport Agent (NTA): This agent collates data from plants, electricity meters, and the grid and displays it in visual form in the network operator's control room. The NTA supplies this information to the Area Administrator, which decides whether intervention is necessary, and to the Balance Master, which decides which offers of power can be accepted without overloading the grid.

Personal Energy Agents broker generated power.

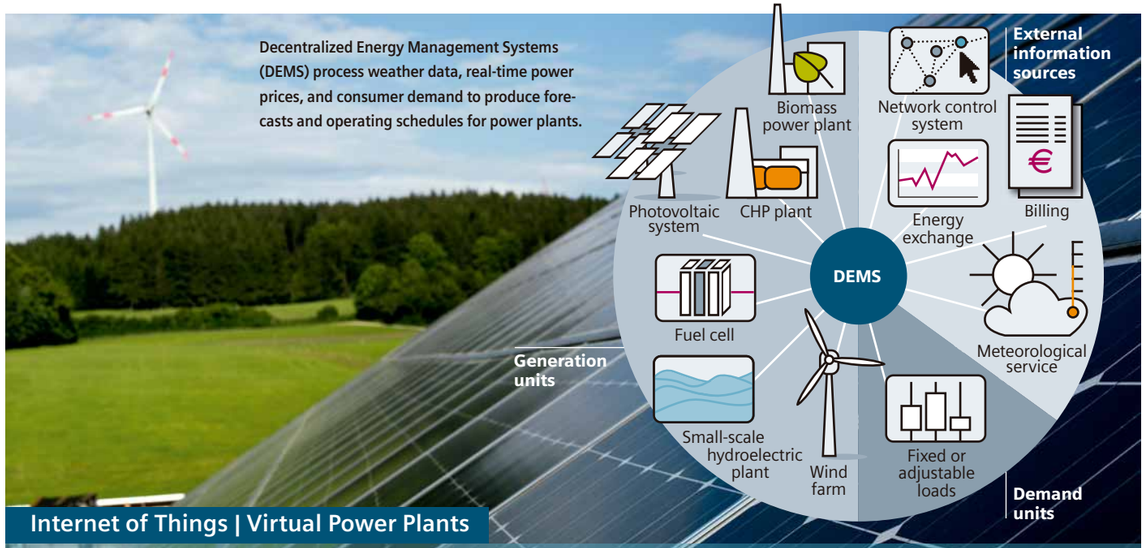
Energy Police: This agent ensures that all agreements are kept, that plant operators supply the power promised by their personal energy agents, and that no power is illegally siphoned off.

"The IRENE project's software agents don't deal with real money," says CT engineer Dr. Michael Metzger, who played a big part in developing the system. "But SoEasy is technically capable of networking hundreds of thousands of power plants, so in the future it could be used for trading on real power markets."

Working with colleagues from Siemens' Smart Grid Division, Metzger is now busy turning the functions and components from field test into products and services for the Siemens portfolio. For example, elements of IRENE are already in use in other reference projects, including one on the Danish island of Bornholm. At the same time, IRENE profits from technology from other CT research programs. For instance, a similar project in the Harz region of Germany has provided modules to incorporate and automatically implement communication protocols.

In the Harz project, CT researchers are now testing a tiny box called a "power bridge," which provides a communications interface between the grid and a whole variety of distributed, independent power generators and consumers. These include combined heat and power plants, fuel cells, and swimming pools. Power bridge is used wherever power plants feed electricity into the grid and also wherever energy storage facilities or power loads can be switched on to stabilize the network. These facilities automatically log on to the smart grid. "We looked at how the Internet service providers do it with their self-configuring DSL routers," explains Jörg Heuer, Head of the Embedded Networks Research Group.

Power bridge has two interfaces: one to the power producer or consumer, and one to the public grid. Plant operators inform their specific power bridge whether they have extra capacity in either power generation or power demand. This data is then transferred to the control center in the form of a data model that is uniform for all plants. The control center then informs the respective power bridge how much extra capacity it wishes to accept. The power bridge receives no information as to how the plant operator actually meets this order. It knows neither the exact operational details, including any readings from the plant, nor how the operator calculates costs. Neither does it have any direct control over the plant. Instead, it serves as a gateway that guards the plant's operational details and operating security against outside observation, but nonetheless provides the operator with a facility to market its current capacity. ■ *Bernd Müller*



Internet of Things | Virtual Power Plants

Energy from Everywhere

Fifteen years ago, only a few hundred power stations fed electricity into the German grid; in the future, millions of solar, wind, biomass, and small-scale combined heat and power plants will form a diverse energy network. To harness these disparate sources, German utility providers RWE and Stadtwerke München have set up virtual power plants based on technology from Siemens.

In line with Germany's transition to alternative sources of energy, plans call for the country to generate 80 percent of its electricity from renewables by 2050. The associated expansion of wind, photovoltaic, and biogas generation will necessitate a completely new grid infrastructure to distribute electricity. To date, power in Germany has come from a limited number of large-scale plants; in the future it will be supplied by millions of small-scale distributed generators. This will have repercussions for the current power market. Anybody with a couple of voltaic panels on his roof can become a "prosumer" — both a producer and a consumer of power.

This in turn will require new software systems to control and coordinate such a complex infrastructure. Here, the industry buzzword is "virtual power plant," which refers to a cluster of small-scale generators that collectively act like a single large power plant, thus avoiding the fluctuations that characterize individual wind and photovoltaic power facilities. According to a study by the corporate consultants PricewaterhouseCoopers (PwC), virtual power plants are a vital part of the transition to alternative energy sources.

As the name suggests, a virtual power plant does not physically exist as a power generator in the conventional sense. Instead, it pools a cluster of small-scale plants, using sophisticated software to operate them collectively as if it were a single large facility. In the future such virtual power plants will play a vital role in the transition to alternative sources of energy, serving to aggregate the output of countless wind generators, photovoltaic plants, biomass facilities, and combined heat and power (CHP) plants. RWE, a major German utility, was quick to recognize the strategic significance of virtual power plant and has been operating one in Dortmund since 2008. Its "brain" is the Decentralized Energy Management System (DEMS) from Siemens. It processes weather bulletins, the latest power prices, and consumer demand in order to produce hourly forecasts and operating schedules for the virtual facility's constituent generators.

Today, this virtual power plant pools a generating capacity of 150 megawatts, mainly from wind power, but also from photovoltaic and biogas plants. RWE sells the power for the plant operators either on the European Energy Exchange (EEX) in Leipzig or on the spot market for balancing energy, where higher prices are paid for power that's available at short notice. The individual generators, which are too small to trade on the EEX, receive a premium on the normal feed-in tariff per kilowatt hour specified in Germany's Renewable Energy Act.

In the future, virtual power plants will pool not only generating capacity, but also power consumption, i.e. individual loads. From the perspective of the power grid it makes no difference whether a load goes off-stream — e.g. a refrigeration unit switches off in a cold-storage warehouse — or a generator comes on-stream — e.g. a standby diesel generator is switched on. As soon as a load goes off-stream, more energy is available for other consumers. "In the future we will see virtual power plants that consist exclusively of switchable loads," says Dr. Thomas Werner, the product manager for virtual power plants at the Smart Grids Division of Infrastructure & Cities at Siemens in Nuremberg.

Harmonizing a Diverse Mix. A smaller virtual power plant is operated by Munich's municipal utility, Stadtwerke München — here too with DEMS. The entity aggregates plants with a combined generating capacity of over 20 megawatts, including the utility's own hydroelectric plant on the Isar River, five CHP plants, a wind power plant, a photovoltaic plant, and several standby diesel generators. The smallest unit delivers 30 kilowatts. Next in line to join the conglomerate are a biogas plant, a geothermal plant, and several switchable loads such as large-scale pumps and cold-storage warehouses. According to Markus Henle, head of Stadtwerke München's virtual power plant program, the project isn't aimed at reaching large-scale operation. Instead, its priority is to gain experience in the coordination of as many different types of energy source as possible and in the day-to-day management of the organizational and operational processes. DEMS enables more reliable forecasting and planning, thus creating new opportunities for value creation, since planned power generates greater revenue on the electricity market.

The more energy sources are pooled, the easier it is to balance supply and demand. This has led to the emergence of more and more companies acting as electricity aggregators, which combine small-scale power generators — sometimes by offering tariffs significantly higher than those mandated by the Renewable Energy Act. This is a thorn in the government's side, because it means that plant operators earn twice for their power. The next amendment to the Renewable Energy Act, scheduled for early 2013, should put a stop to this, but could thereby make the market for virtual power plants more difficult. ■ *Bernd Müller*

In Brief

■ Software often pervades our daily lives without us even realizing it. The "agents" that reside in smartphones, PCs, production machinery, vehicles, buildings, and power plants are now also taking the Internet by storm. The "Internet of Things" already networks billions of different devices from all areas of our daily lives, enabling them to share information. The aim is to better coordinate processes — and thus save time and money. (pp. 44, 48)

■ Data can be transmitted wirelessly by RFID chips that are attached to objects. The advantage of these chips is that they can contain more information than barcodes. As a result, logistics teams can detect supply chain disruptions early on. In this way, all of the participants — for example, various automotive suppliers — can coordinate their activities in real time, regardless of which company they belong to. (p. 58)

■ With the Mars rover Curiosity, researchers and developers achieved a smooth transition from the virtual world to real life. The project's extremely demanding technology was developed and tested with PLM software from Siemens. Simulations created on earth were subsequently turned into reality on Mars. The software's potential has also been recognized by China's young automotive industry, which uses it to optimize design and production processes. (pp. 55, 62)

■ Our energy supply system will become increasingly sophisticated in the future, because millions of power producers will feed electricity into the grid. Smart grids will thus be needed — as will virtual power plants that combine and manage many small electricity producers. In buildings, sensors could help to automatically control, for example, the lighting, energy demand and security systems — or enable remote operators to do so manually through the Internet. Researchers at Siemens are currently testing smart grids. (pp. 66, 68)

■ Professor William Brian Arthur believes that networked computers and sensors are forming a kind of digital nervous systems — an automated "Internet of Things" — that parallels the physical economy. According to Arthur, the "Second Economy" is making many services cheaper, but also obviating many jobs. (p. 53)

PEOPLE:

Internet of Things:
Gerhard Kress, Corporate Development
gerhard.v.kress@siemens.com
Dr. Joachim Walewski, Corporate Technology
joachim.walewski@siemens.com

Siemens Product Lifecycle Management Software (PLM):
Chuck Grindstaff, Siemens PLM Software
chuck.grindstaff@siemens.com
Daren Rhoades, Siemens PLM Software
daren.rhoades@siemens.com
Kent Rash, Siemens PLM Software
kent.rash@siemens.com

Uncertainty quantification research:
Dr. Utz Wever, Corporate Technology
utz.wever@siemens.com
Dr. Meinhard Paffrath, Corporate Technology
meinhard.paffrath@siemens.com

RFID technology:
Dr. Raffaello Lepratti, Industry Automation
raffaello.lepratti@siemens.com
Dr. Steffen Lamparter, Corporate Technology
steffen.lamparter@siemens.com

SIPAT for pharmaceutical industry processes:
Jürgen Manz, Industry Automation
juergen.manz@siemens.com

Automation in China:
Zhou Kehu, Siemens Industrial Software
kehu.zhou@siemens.com

RACE / Future vehicles and software architectures: Professor Gernot Spiegelberg, Corporate Technology
gernot.spiegelberg@siemens.com

Virtual power plants:
Dr. Thomas Werner, Infrastructure & Cities
thomas.werner@siemens.com

Smart grids research:
Christian Glomb, Corporate Technology
christian.glomb@siemens.com
Dr. Michael Metzger, Corporate Technology
michael.metzger@siemens.com

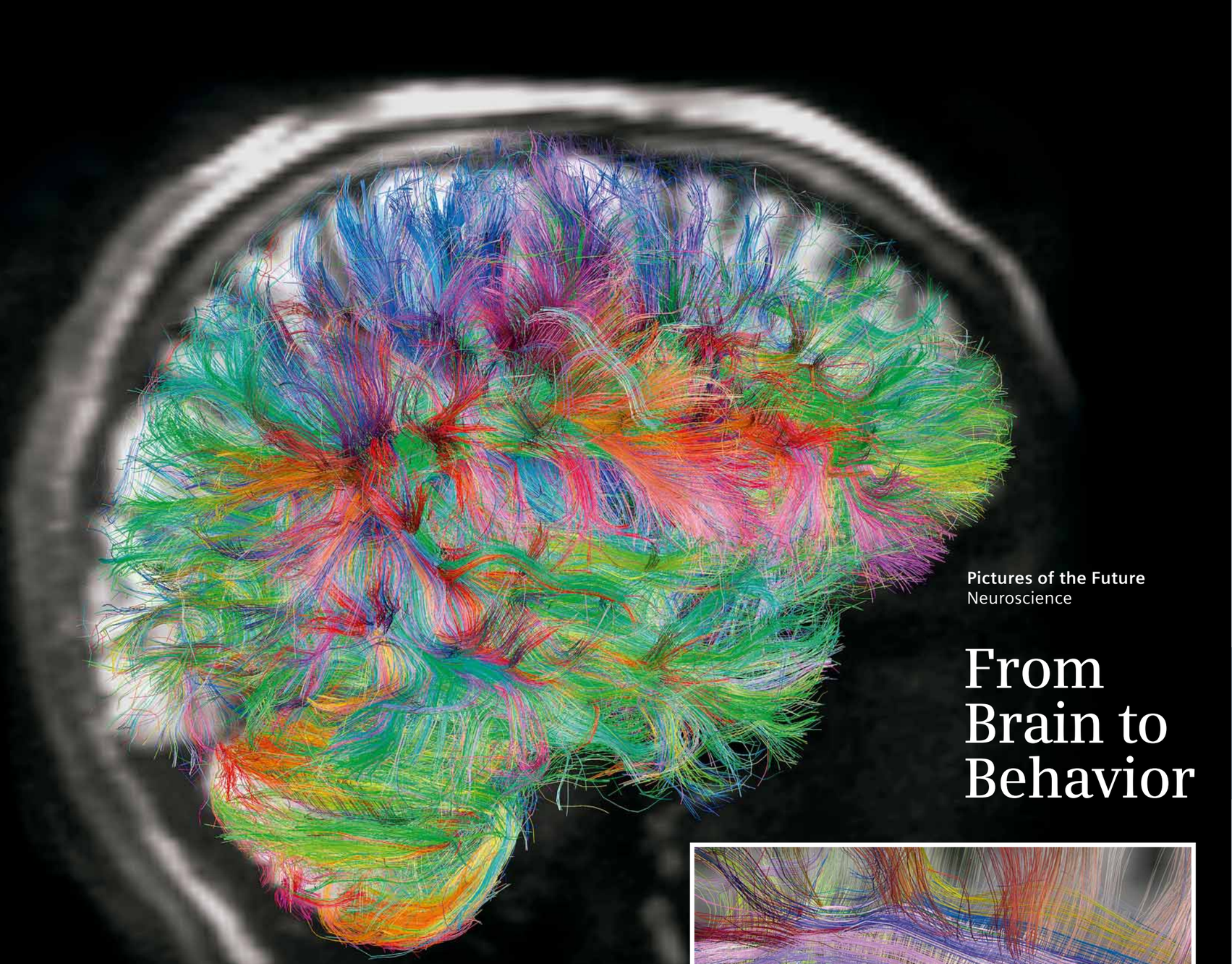
External:

Professor William Brian Arthur:
niamhlet@hotmail.com

Professor Elgar Fleisch: efleisch@ethz.ch

LINKS:

Cisco: www.cisco.com
Gartner Technology Research: www.gartner.com
Internet Society: www.isoc.org



Pictures of the Future
Neuroscience

From Brain to Behavior

Using a new imaging technology on an experimental 3-Tesla Siemens MRI scanner, researchers have uncovered the fabric-like structure of cerebral white matter in the human brain.

Images courtesy of Martinos Center for Biomedical Imaging, MGH-UCLA, NIH Human Connectome Project

What does a normal human brain look like? From a functional point of view, the picture is unclear. But if we knew, it might be a first step on the road to a completely new way of diagnosing and managing mental illnesses. Using experimental magnetic resonance imaging technology from Siemens, two groups of U.S. researchers are beginning to uncover the wiring patterns behind our behavior.

Like astronauts on a voyage to a perpetually shrouded planet, scientists at major universities across the United States and Europe have embarked on a mission to make sense of one of the most complex regions of the universe — the 100 billion neurons and 150 trillion synapses that comprise the human brain. Funded with $40 million from the U.S. National Institutes of Health, the effort, which is known as the Human Connectome Project (HCP), is designed to discover the relationship between the structure and function of the brain. "The idea is to decipher as much as current imaging technology can about the wiring of the human brain and about how that wiring contributes to our behavior and to the differences in behavior between people," says David Van Essen, PhD, Edison Professor and Head of the Department of Anatomy and Neurobiology at Washington University School of Medicine in St. Louis.

"The hypothesis driving this project," says Dr. Bruce R. Rosen, Professor of Radiology at Harvard Medical School and Director of the university's Athinoula A. Martinos Center for Biomedical Imaging in Boston, Massachusetts, "is that if we understood the relationship between structure and function we would begin to understand diseases such as autism, and to more effectively treat injuries such as those caused by stroke."

To accomplish this goal — a vision that, if realized, might revolutionize the diagnosis and management of mental illnesses, neurodegenerative diseases, and brain injuries, researchers must do two things: implement technologies capable of mapping the brain's three-dimensional architecture both functionally and structurally on a near-micron level, and define — taking into account the vast differences between healthy brains — what is normal. Thanks to the development of two experimental 3-Tesla magnetic resonance imaging (MRI) scanners from Siemens, the first of these goals has been realized, and the second is the subject of a major study centered at Washington University in St. Louis together with the Center for Magnetic Resonance Research (CMRR) at the University of Minnesota Medical School.

One of the scanners* (see disclaimer, back cover), which has a gradient that is up to 2.5 times stronger than that of clinical MRI scanners, was developed for the CMRR and was recently relocated to St. Louis. (Gradients are used for spatial encoding.) The other scanner, which has a target gradient of up-to 7.5 times that of the latest clinical 3-Tesla MRI scanners, was developed on the request of the Martinos Center in Boston in cooperation with the University of California Los Angeles.

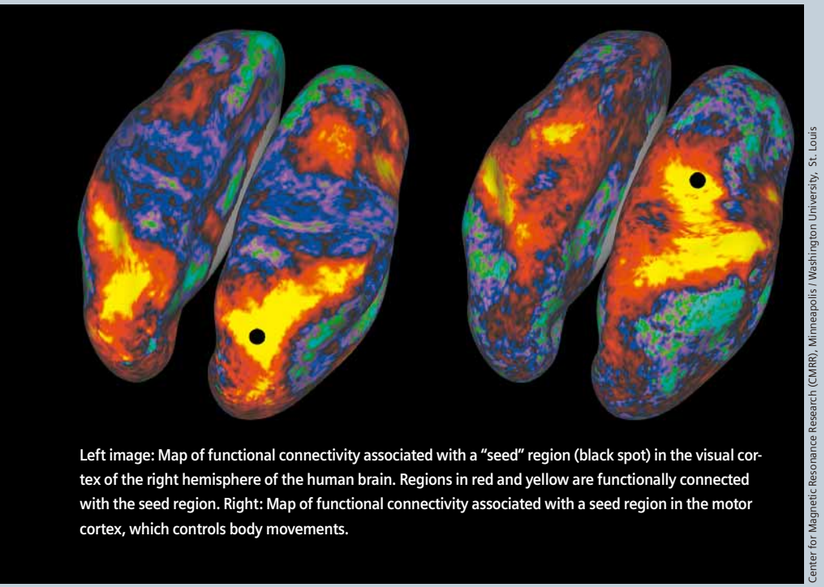
"The Human Connectome Project is designed to help us answer fundamental questions about the human brain," says Prof. Kamil Ugurbil, Director of the CMRR. "Steady progress in MR techniques such as functional brain imaging (fMRI) and diffusion imaging over the last two decades have made the project possible. However, additional improvements in hardware and image acquisition methods are still necessary — and we are addressing them."

Breakthrough Technology. Researchers have been imaging neuronal pathways in the human brain for years (see *Pictures of the Future*, Fall, 2005, p. 62). Key to this have been technologies such as MR Imaging of anisotropic diffusion of water in the brain, and, most recently, resting state fMRI. Resting state functional MRI and high angular resolution diffusion imaging (HARDI) — a special diffusion imaging technique — are favored at Washington University & the University of Minnesota (WashU-Minn) consortium. On the other hand, Diffusion Spectrum Imaging (DSI) — a general form of Diffusion Tensor Imaging that was pioneered in 2005 by Dr. Van J. Wedeen, Professor of Radiology at the Massachusetts General Hospital and Director of Connectomics at the Athinoula A. Martinos Center for Biomedical Imaging, is being pursued at the MGH/UCLA consortium. Here, the idea is to reveal the fabric-like structure of pathways within each MRI voxel (a voxel is a 3D pixel), thus differentiating between intersecting pathways.

The diffusion imaging approach capitalizes on the fact that water molecules wiggle in tissue and that this motion can be measured as their hydrogen nuclei (protons) produce radio

signals in response to radio-frequency pulses in combination with rapidly changing static and dynamic magnetic fields. "Considering the fact that these molecules naturally tend to move along axons — the white matter fibers that connect brain cells — the technology essentially produces an image that duplicates the paths of axons," explains Wedeen. "When you stitch thousands of voxels together," he adds, "you wind up with what we call a tract — a white matter pathway. But the important thing is that when two pathways intersect, the system must stitch through them correctly, and DSI is what makes that possible. Thanks to this technology, we are finding that 3D white matter grids are ubiquitous in the human brain."

Achieving the current state of visualization was not easy, however. It required a huge increase in MRI sensitivity, as well as much higher processing speeds to make sense of the flood of spatial data from water molecules. No commercial scanner could come close to what was needed. The Boston team had already come to the conclusion that the key to higher resolution imaging of neural pathways is not necessarily, as had been previously assumed, higher field strength than 3Tesla of the main magnet, but rather, higher field strength of the much smaller magnetic gradient coils that modulate the main magnet's field. "The gradient (coil) is the part of the MR machine that encodes the spatial characteristics of water molecules. It tells you where things are," explains Rosen.



Left image: Map of functional connectivity associated with a "seed" region (black spot) in the visual cortex of the right hemisphere of the human brain. Regions in red and yellow are functionally connected with the seed region. Right: Map of functional connectivity associated with a seed region in the motor cortex, which controls body movements.

Center for Magnetic Resonance Research (CMRR), Minneapolis / Washington University, St. Louis

The more powerful the gradient coil is, the faster one encodes the diffusion of water molecules, resulting in a sharper picture of angular resolution, which is the key factor in differentiating between intersecting fibers. "It's like a camera — the faster the shutter speed, the sharper the picture. The result is that even though we are not directly imaging axons, we can, in effect, see them by inferring how water molecules move," adds Wedeen.

But why, one might ask, do water molecules follow axonal paths? "The answer," says Lawrence L. Wald, PhD, Director of the MRI Core Facility at the Martinos Center, "is that since axons are long, thin tubes, water molecules naturally tend to wiggle inside and along them, rather than perpendicular to them. What's more, they do so in distances that are about the same size as the separations between the axons or about 10 to 20 microns during the time period used to measure our MRI signals. So if we are sensitive to those water molecules, we can be sensitive to the directions in which the axons are aligned."

Most commercial 3 Tesla MRI scanners for in-vivo clinical imaging have a top gradient strength of 40 to 45 milli-Tesla per meter (mT/m); but Wedeen's studies on primates had indicated that higher gradient strength than this would be advisable to produce sharp diffusion images of an adult human brain's wiring patterns. With this in mind, the MGH/UCLA and Minneapolis/St. Louis researchers asked the Siemens MR engineering team, which was led by Eva Eberlein, if they could develop a gradient stronger than anything currently available. "What they came up with was two prototypes that could achieve from two times to nearly eight times the gradient strength. "It was an engineering tour-de-force,"** recalls Wald. With a scalable gradient strength of 80 mT/m up to 300 mT/m, the density of electromagnetic energy can increase up to a maximum factor of 56. (**: see disclaimer, back cover)

Nevertheless, this presented a challenge. Knowing that higher gradients would allow higher resolution imaging, more MR slices would have to be acquired to cover the same anatomical region. But doubling the resolution would in turn increase the scan time by a factor of four or more. Therefore, a technology* had to be developed to accelerate encoding and thus reduce scan times. Based on earlier ideas developed by CMRR, such as "Multiband Multislice" imaging, the MGH researchers came up with a refinement called "Simultaneous Multislice," that allowed the acquisition of several MR slices at the same time, yet would keep them separate with minimal sensitivity loss. The technology "accelerates imaging by a factor of three, but when combined with stronger gradients, the result is actually a factor of four in image acquisition acceleration," says Wald. "All in all, we have cut the average scan time from about one hour to approximately 15 minutes."**

Building a Brain Database. While the Harvard-UCLA team's role in the Connectome project has been the development of a scanner that pushes the boundaries of what is possible with current MRI diffusion imaging technology to the limit, the Washington University / University of Minnesota consortium has not only undertaken methodological developments for improved data acquisition, but also addressed the challenges of understanding functional connectivity in a large-scale study. "Functional imaging approaches, particularly those that utilize resting state fMRI — in which the entire brain is imaged during a period in which the subject is not performing an explicit task — are highly complementary to diffusion imaging since they provide information regarding functional connectivity rather than just hard-wiring," says Washington University's David Van Essen, who co-leads the consortium with Prof. Kamil Ugurbil.

Motivated by their high-resolution functional imaging work carried out at an even higher field strength — with a 7 Tesla MR system from Siemens — the CMRR team had been pursuing innovations to accelerate scan times since 2008. Now, in the context of the Human Connectome Project, they turned to adapting these techniques, dubbed "Multiband Multislice Imaging," to the customized HCP 3 Tesla scanner and managed to speed up data acquisition for functional connectivity by factors of up to nine.

Having overcome these limitations, the team's next goal is to begin scanning 1,200 genetically-related people with this technology. "The idea behind our side of the project," explains Ugurbil, "is to acquire data with a previously unavailable level of quality in order to generate a database of brain connectivity patterns and develop tools to perform data mining on that database."

Additionally, the Van Essen-Ugurbil team will scan many of the subjects at ultrahigh magnetic fields (7 Tesla*), an approach pioneered by the University of Minnesota group. "Seven Tesla will be far superior for resting state fMRI and anatomical imaging and is also expected to perform well for diffusion imaging," says Ugurbil.

Indeed, the project's emphasis on closely-related people sets the stage for eventually creating and tapping entirely new databases in an emerging field called "imaging genomics." By exploring the possible connections between imaging information and genetic information, the researchers hope to uncover some of the mechanisms behind mental illnesses. "There are already many published studies along these lines. For instance, some have shown that brain circuits are abnormal — that is, have reduced functional connectivity — in autism," says Van Essen. "But we are trying to push this research to a different level. Just as the Genome Project opened up a world of bio-informatics, we are looking to open a new world of neuro-informatics that will capitalize on the vast amount of information that is being generated by imaging modalities."

A first step in that direction has already been taken. In a project that combines data acquisition, data analysis, informatics, and visualization, Van Essen and Ugurbil have developed an interactive composite dataset of the left and right cerebral hemispheres obtained in a pilot study of healthy adults (see images, page 72). The images it produces are based on resting state functional MRI, which, in the context of the database, show an average of which brain regions are actually communicating with other specific areas, when one area, represented by a black dot, is probed. Red and yellow sections are strongly related to the seed location. By merely clicking a location in the dataset, a user is interrogating 30 gigabytes worth of data. "This is the first time such a tool has been developed," says Van Essen. "As our database expands, it will become extremely powerful. But it's just a preview of what will come out the Human Connectome Project."

Arthur F. Pease

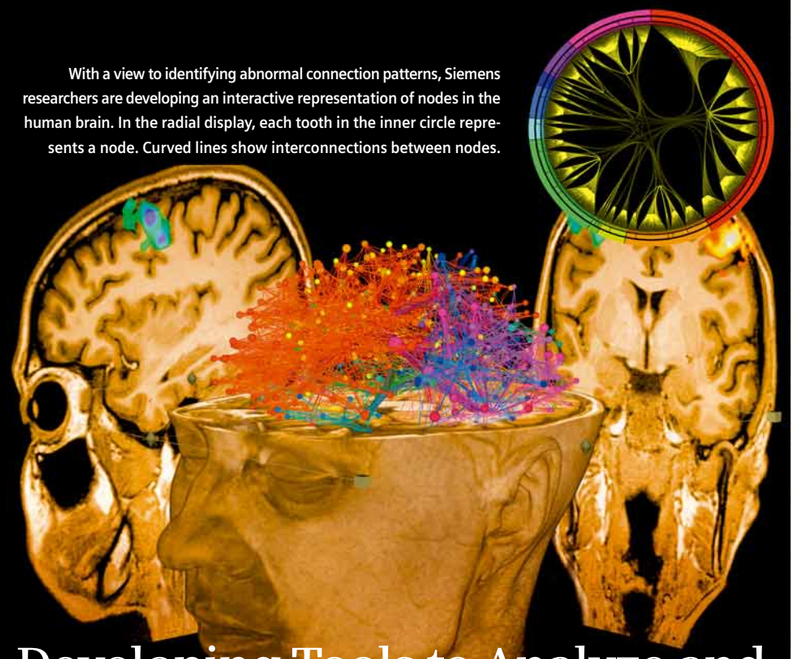
Siemens' Role in the Human Connectome Project

The Human Connectome Project (HCP) is a five-year initiative funded by the National Institutes of Health (NIH) in Bethesda, Maryland (USA), to map the brain's long-distance communications network. It represents the first large-scale attempt to collect and share data of a scope and level of detail sufficient to begin the process of addressing fundamental questions about the human cortex's connectional anatomy and variation. The project's goal is to construct a map of the complete structural and functional neural connections in vivo within and across individuals.

The HCP comprises two research efforts: A five-year project at the Center for Magnetic Resonance Research (CMRR) in Minneapolis, Minnesota in collaboration with Washington University, St. Louis, Missouri. The other one is a 3-year project at the Massachusetts General Hospital's (MGH) Martinos Center in cooperation with the University of California, Los Angeles.

Neuronal connections in the human brain are immensely complex and barely understood. To make them visible, high-end imaging equipment is needed. The HCP uses various MRI applications, including resting-state fMRI, diffusion MRI, and task-related fMRI. Specialized research MRI scanners were developed for each of the two HCP projects. The Siemens experimental 3-Tesla MR scanners are unique prototypes, which were designed specifically for the HCP project and are not commercially available.

The experimental 3-Tesla MR scanner from the CMRR has a gradient performance between 70 mT/m and up to 100 mT/m that is up to 2.5 times stronger than state-of-the-art clinical 3-Tesla MR scanners, and is thus optimized for functional and diffusion MRI studies with higher resolution. The experimental 3-Tesla scanner at MGH is a new diffusion-dedicated research scanner dedicated to diffusion MR protocols with a gradient performance of up to 300 mT/m that is up to 7.5 times that of the latest clinical 3-Tesla MR scanners. It is optimized for the collection of fiber-tracking data in the brain. Due to its massively-increased gradient strength, which is applicable for research purposes only, the scanner is sensitive to extremely faint diffusion-weighted signals and enables higher resolution functional brain MRI studies than state-of-the-art clinical scanners. "We are very proud to contribute our innovative MR technology and know-how to the Human Connectome Project, which is aimed at developing a better understanding of the human brain," says Dr. Bernd Ohnesorge, CEO, Siemens Magnetic Resonance, Erlangen, Germany. "Our research results will stimulate technological development at Siemens by translating knowledge gained from the project into new MR technologies that may find their way into clinical applications in patient care. We strongly believe that close collaboration between academia and Siemens bring both to the frontier of medical research, ultimately finding paths to improved diagnostics and therapies, and thereby advancing human health."



With a view to identifying abnormal connection patterns, Siemens researchers are developing an interactive representation of nodes in the human brain. In the radial display, each tooth in the inner circle represents a node. Curved lines show interconnections between nodes.

Developing Tools to Analyze and Visualize Neuro Imaging Data

A deeper understanding of neurological disorders such as Major Depressive Disorder (MDD) and neuro-degenerative diseases such as Alzheimer's Disease (AD) could open the door to improved clinical management. Such understanding could come from insights regarding the brain's connectivity (wiring) patterns that are emerging from the Human Connectome Project (see page 70). As the Connectome Project generates ever more data from specialized magnetic resonance imaging scanners, advanced technologies will be needed to process, analyze and visualize the resulting information, much of which will come from so-called "resting state" functional MRI scans (in which the entire brain is imaged during a period in which the subject is not performing an explicit task) and diffusion MRI scans.

With this in mind, researchers led by Mariappan S. Nadar, PhD, at Siemens Corporation, Corporate Technology in Princeton, New Jersey, are developing a portfolio of tools that can leverage the results of the NIH Connectome Project for new, clinically-relevant algorithms and software. Recently, they have applied these tools to analyze resting state functional MRI and have obtained promising results in differentiating a normal control group from those with ADHD (attention deficit hyperactivity disorder). The algorithm that made this possible uses data generated from resting state fMRI scans and non-imaging data. "The idea behind the algorithm," explains Mariappan, "is that as the Connectome Project begins to generate large quantities of information we will learn which brain regions interact with one another and the strength of these interactions. In our research, each brain region is represented by a node in a network and the interactions by edges. Nodes are mathematical abstractions representing interconnected brain regions, and edges represent the links that connect some pairs of brain regions. As we develop a database along these lines, we will find out, for instance, that region A is normally linked to region B. The absence of such a connection — or a weak connection — could indicate a potential abnormality. Alternatively, the presence of a 'normally non-existent' connection — or a strengthened connection — could also indicate a potential abnormality."

With a view to facilitating and accelerating the understanding and identification of abnormal connection patterns, the team has developed tools for interactive 3D network visualization, which make it possible to intuitively work in a 2D space while navigating in the 3D space. In a radial display (above) each tooth in the comb-like inner circle represents a node in the 3D network. The curved lines show interconnections between nodes. The outer circles depict the hierarchy of clusters of the nodes.

■ *Arthur F. Pease*

Overfishing is reducing the natural population of bluespotted ribbon-tail stingrays. That's why biologists are using ultrasound to monitor unborn rays.

Prenatal Care for Aquatic Species

Siemens is making an unusual contribution to the protection of threatened species. The company has supplied an ultrasound device that was developed for use in human medicine to the Oceanário de Lisboa in Portugal, where biologists are using it to monitor pregnant stingrays.

The major highlight at EXPO 98 in Lisbon was the Ocean Pavilion. The structure, which was built in the middle of an artificial harbor basin and can only be reached via a narrow pedestrian bridge, reminded visitors of a futuristic research platform. Most of the buildings were torn down after the exhibition, but the giant aquarium was left standing and has been used successfully ever since. Today, the Oceanário de Lisboa draws around one million visitors a year, making it the most frequented cultural facility in Portugal.

At the center of the Oceanário is a gigantic tank containing 5,000 cubic meters of saltwater that is meant to symbolize the global ocean. Several large panoramic windows offer visitors a look at the species inside the tank — sharks, rays, moray eels, and ocean sunfishes. The central tank is surrounded by four smaller basins that represent the rocky coasts of the North Atlantic, the icy Antarctic, the kelp forests of the Pacific, and the tropical coral reefs of the Indian Ocean.

"Siemens has been working with the Oceanário for quite some time now. For example, we supply a large part of the infrastructure — in other words, operation services and equipment for security and maintenance," says João Seabra, Healthcare Sector CEO from Siemens Portugal. "Now, this collaboration has been taken to a whole new level that goes beyond a purely business relationship." That's because Siemens has donated an ultrasound system that was originally developed for use in human medicine to the Oceanário. Biologists at the aquarium are using the device to monitor the pregnancies of bluespotted ribbontail rays (*Taeniura lymna*), among other species.

As a result, the gestation of these stingrays, whose blue spots make them very popular, can now be studied better than ever before. "Compared to our old equipment, the image quality is so good that we can now view and examine the rays' reproductive organs and the fetuses at a level of detail never achieved before," says Dr. Nuno Marques Pereira, a veterinarian at the Oceanário. "We can also record the examinations for later study. Previously, we had to carry out the time-consuming image analyses during the examinations. The new device speeds up the process and makes things a lot easier for our 'patients.'"

Incubation Pouch. Bluespotted ribbontail rays are aplacental viviparous, which means their eggs remain in an incubation pouch inside the mother's body, where up to seven babies then hatch and are born "live." The pregnancy lasts for anywhere between four and 12 months and the baby rays are around 14 centimeters long when they emerge. In order to monitor the pregnancies, staff at the Oceanário regularly remove the Blue spotted ribbon-tail rays from the large basin and place them into smaller plastic containers. As with a normal ultrasound procedures in human medicine, they run the probe along the ray's body, which can be up to 70 centimeters long. Both the probe and the cable are wrapped in plastic to protect them from the water. The biologists can view the babies inside the mother's pouch on a monitor and draw conclusions about their health and development on the basis of their size and movements.

Thanks to the ultrasound unit, the biologists can now analyze how different conditions in captivity affect the pregnancies of the bluespotted ribbon-tail rays. The results of their studies will be disseminated to the well-networked European aquarium community. Staff members who provide care for the rays can also detect complications at an early stage of pregnancy. For example, if a fetus dies inside the mother's body (i.e. no movement can be seen on the monitor), specialists can perform an operation in time to prevent the deaths of other babies — or even the mother.

Such high-tech efforts are helping to safeguard ray populations. "In response to overfishing and the deterioration of coral reefs, the bluespotted ribbon-tail ray has been placed on the Red List of the International Union for Conservation of Nature, where it is classified as 'near threatened,'" says the Oceanário's Curator, Dr. Nuria Baylina. The rays' natural habitat is the tropical coastal regions of the Indian and Pacific Oceans. During high tide, they swim in small groups to shallow waters near the shore to feed. They then return during low tide to the safe coral reefs off the coast.

The Oceanário is monitoring the entire population of bluespotted ribbon-tail rays in European aquariums on behalf of the European Association of Zoos and Aquaria (EAZA). The main goal is to use the newly gained husbandry and breeding knowledge to improve breeding and thus reduce the number of captures in the wild. "If the situation worsens for this species, the importance of having a sustainable population in aquariums will increase," says Baylina. "And more successful breeding means better research and improved monitoring of stingray pregnancies." The ultrasound unit donated by Siemens could thus play an important role in helping to maintain the species. "We also plan to use the device with other fish species, reptiles, and penguins," Baylina adds. As a result, Siemens' donation might end up benefiting every resident of the Oceanário aquarium. ■ *Nils Ehrenberg*

Highlights

2040

Island life with a difference: Only a few years before this scenario, the Uru people living on the floating islands on Lake Titicaca in Peru did not even have electricity for light bulbs. That was before the Peruvian government launched a development program designed to radically change their lives. The program has had a major impact on many areas of life, including education, healthcare and power supply.

Oracle from the Lake

Peru 2040: The Uru people in the highlands of Peru used to be known for their simple lifestyle. But, as experience has often shown, nothing stays the same for long. Four years earlier, the government launched a development program for the floating islands of Lake Titicaca that has radically changed the lives of these previously isolated people.

The sun is rising from behind the mountains of Peru and making the waters of the lake sparkle like a sea of diamonds. The 80-square-meter floating island of reeds on which Juán, the tribal elder, lives with three other families rocks gently in the morning breeze and makes small rippling waves in the water. Women wearing bowler hats, colorful skirts, and hip-length braids are sitting at their looms. Nearby, men are weaving bundles of reeds together in order to expand their floating home. Juán is not only the head of the tribe but also its shaman. His people believe he can foretell the future by reading coca leaves.

The old man picks up a couple of the fibrous green plants, shakes them, and spreads the leaves on the ground. "Today the doctors will be coming again," announces the oracle with a sly wink. Around him, the children listen to his words with wide-open eyes. What they don't know is that Juán himself has arranged this visit from the doctors.

Just a few years ago, this island did not even have electricity, and its inhabitants — the

Uros — all earned a living from handicrafts. But those days are long gone. Four years ago the Peruvian government launched a development program here. As part of the program, highly efficient solar panels were installed on the pointed roofs of the Uros' huts. This enabled them to produce electricity, which powers, for example, the organic LEDs that were donated to the village. The LEDs, which are attached like paper-thin tiles to the ceilings, now provide warm light inside the huts. The solar panels also power the two small electric outboard motors that are used to steer the floating island along the lake shore.

Because each hut now also has WLAN and tablet PCs, the children can participate in a distance learning program. "I'm a fisherman and a boat builder — but we have to be realistic. Fish stocks are decreasing, and life on these islands is getting harder. We want things to be better for our young people," says Juán. In the future, the best students will receive scholarships so that they can go to universities in other parts of the country. The state-owned energy supplier has also connected the islands with Peru's smart power grid via a sea cable, so Juán can now feed surplus solar electricity into the national grid and earn some money.

Juán is also a medicine man — in other words, one of the shamans who have been respected for centuries on the many islands of Lake Titicaca for their knowledge of the gods and natural medicine. But Juán admits, "I can't keep up with modern medicine." That's why he was delighted when the "Mobile Doctors" project was launched six months ago. In an initial step, the island inhabitants' medical data was registered in the national gene and proteome database. Using this data, doctors located far away were able to create profiles of individuals with illnesses and develop customized therapies for them. In the meantime, doctors have been traveling to the islands to implement these therapies. Juán helps them draw up a schedule for their visits.

"There they are, children! Luíz, bring Grandma and Grandpa to the doctors' bus," Juán calls out, pointing to a vehicle more reminiscent of a rocket than a bus. The cockpit is jammed with computers, sensors, and cameras. Navigation devices use entered target coordinates to drive the vehicle as though by magic. A driver is no longer needed, strictly speaking, but in view of the condition of the roads there is always one on hand.

The vehicle, which serves as a mobile hospital, also has another advantage — an independent electricity network. Thanks to this feature, doctors can travel to even the remotest regions and still have enough power for onboard medical equipment. The vehicle is equipped with rooftop solar cells, several electric motors, an emergency generator, and a wind turbine that can be folded out when needed. In other words, it doesn't need an external energy supply.

Luisa, the doctor, turns to Grandma Viviana and says "Kamisaraki," by way of a greeting. But instead of answering, the old lady just giggles. Luisa taps on her paper-thin tablet PC and points to the hologram of an ear that suddenly appears. "Can you see this, Viviana?" she asks. "Today we're going to set tiny bio-tabs into your ears right here," she says, pointing to a spot on the hologram. "You won't feel anything, and tomorrow you'll hear as well as a 16-year-old." She is speaking very loudly, because she knows that Viviana can hardly hear anything. The bio-tab is a state-of-the-art hearing aid that is set into both ear canals and has brought stereo hearing to a state of perfection. Viviana smiles shyly and nods.

In the meantime, Harvey, a doctor in the bus, is scanning the head of 70-year-old Pedro, after having first injected him with a biomarker. During a previous visit, Pedro was informed about Alzheimer's, because the gene and proteome database had provided the initial indications that he had a genetic predisposition to this disease. And in fact, the first signs of Alzheimer's can already be seen on the MRI scan. "These are the spots where the amyloid plaques caused by Alzheimer's will show up if we don't take the necessary steps right now," says Harvey. "With your permission, I'm going to implant a medicine dosage device in your body that will release certain substances at predefined times. These will slow down the progress of the disease or may even halt it completely. The device is also connected with our hospital via a data interface so that we can regularly check that it's working okay." But Pedro isn't listening — he is much too fascinated by the projected image of his brain. Wide-eyed, he is trying to get hold of the hologram — unsuccessfully, of course, because his fingers are literally whisking through the projection.

In the course of the day, the team performs 20 lab tests and notes the results in digital patient files. It also compares the results with those of other patients as well as with the data in the gene and proteome database. Finally, Adam, a specialist in respiratory diseases, unpacks a device about the size of a mobile phone. Using this device, he examines the children's breath for signs of asthma or tuberculosis with the help of gas sensors. The aim is to reduce the occurrence of these diseases by 30 percent by the end of the year.

As the hospital bus departs, the moon has already risen high above the lake. Juán waves goodbye as his island disappears in the wisps of fog winding through the ice-cold night.

■ *Hülya Dagli*

Flying freight capsules, self-driving cars, holographic displays that can be controlled by gestures, and a method for predicting and thus preventing a murder — these were some of the technological visions of the year 2054 presented by a team of futurologists that advised Steven Spielberg while he was making the film "Minority Report." It's anyone's guess as to whether, in a few decades, our daily lives will actually turn out to be the way MIT scientists like John Underkoffler have described, or the way Douglas Coupland presented them in his novel Generation X from 2001. Visions of advanced technologies are nothing new. The Mayas, for example, decorated the walls of their temples with ornaments that look like flying machines. But what leads to such visions? Is it the urge for progress, the craving for something new, plain curiosity? Or is it perhaps simply the wish to make life better and easier for people? These days, the challenges of the time demand new solutions — technology in the service of humankind.

One example is healthcare. As Dr. Norbert Hültenschmidt from Bain & Company, a consulting firm, explains, "All healthcare systems face the same challenges, namely sharply rising costs due to increased demand for services — a process that is in turn being driven by greater prosperity and aging populations." Diabetes and cancer, for example, are no longer problems exclusive to industrialized nations. The numbers speak for themselves, as 36 million people around the world die every year from these diseases. According to the World Health Organization, 80 percent of such deaths now occur in developing countries and emerging markets. Healthcare costs are also being driven by an increasingly aging society. Alzheimer Disease International (ADI) reports that dementia-related illnesses generated costs of approximately $604 billion in 2010 (see pp. 82, 92). What can be done about this?

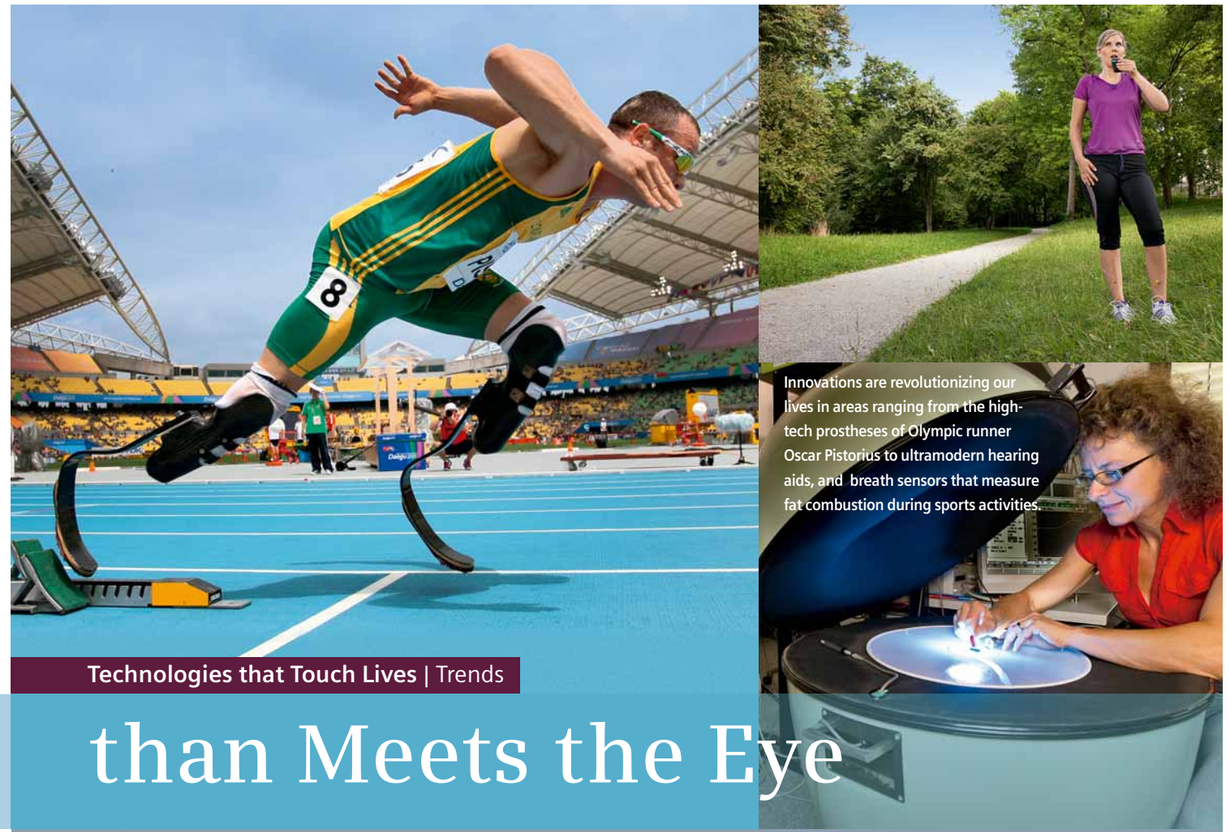
For one thing, many countries need to reform their healthcare systems. Technological advances could also lower costs and improve treatments — through personalized medical care, for example. June 26, 2000, represents a historic date here, since it was on this day that a press conference was held with U.S. President Bill Clinton, Craig Venter, and Francis Collins, two researchers who had just succeeded in deciphering the human genome. To this day, a major scientific goal is to open the door to individualized healthcare. Such a system would utilize knowledge about an individual's genetic makeup together with early detection methods to identify diseases at a sufficiently early stage that prevention or effective treatment would be possible. The establishment of such a system could in fact improve the chances of patient recovery and survival while also lowering healthcare costs.

This is exactly the goal researchers in Siemens' Translational Biotechnology project are trying to achieve. Together with partners at Heidelberg University, the scientists have developed software for analyzing the genes of individuals suffering from myocardial insufficiency (see p. 98). There are also other methods for detecting diseases at an early stage. Dr. Maximilian Fleischer from Siemens Corporate Technology (CT) is working on the development of a device that uses sensors to "sniff out" not only cancer but also allergies and infections from samples of exhaled air.

Meanwhile, other researchers are working on a device that weighs about as much as a cell phone and is equipped with a sensor that may make it possible for amateur and professional athletes to determine how much fat they're burning when exercising (see p. 88).

The fact that people are now living longer is good news, but it also means more people are getting sick. Aging doesn't have to be a negative experience, however — tomorrow's seniors could be networked, mobile, and independent. To this end, Siemens and its partners are conducting a three-month practical test of assistance systems that is designed to help older people live independent lives. The technology includes room sensors that detect potential emergencies and automatically call for help, and wrist watches that notify users if lights are on or if a window is open (see p. 84).

These technologies are still in the research stage, but others that make our lives easier are already available. Example include weather forecasting systems, the mobile Internet, traffic and transport information systems, and new types of household appliances (see pp. 94, 113). The list of such technologies will certainly grow. Siemens, for example, is now conducting a field test with partners in the German state of North Rhine-Westphalia in order to find ways of using intelligent information



Innovations are revolutionizing our lives in areas ranging from the high-tech prostheses of Olympic runner Oscar Pistorius to ultramodern hearing aids, and breath sensors that measure fat combustion during sports activities.

Technologies that Touch Lives | Trends

More than Meets the Eye

What do cars, telephones, water filters, and hearing aids have in common? Perhaps not much at first glance — but they are things that people depend on every day. Though we take many of these items for granted, they are often driven by complex technologies.

and communication technologies to automate the electricity supply in private households. Among other things, this would lower electricity costs for consumers (see p. 100).

According to Dr. Patrick Baudisch, who is conducting research into new and unusual operating concepts at the Hasso Plattner Institute in Potsdam, Germany, smartphones might soon be a thing of the past. "Desktop computers and mobile devices will merge until at some point we'll only be carrying one com- puter around with us that has the shape and functionality of a cell phone," Baudisch predicts. This is just one of the many developments Baudisch is examining. Another one involves new operating interfaces such as "touch floors" that report emergencies much in the same way room sensors in the SmartSenior system do. Yet another project focuses on implanted medical devices like pacemakers that can be operated through the skin without any need for assistance from a physician (see p. 108).

and speed up operations. Similar apps for smartphones and tablet PCs will probably be used more extensively in the future in many different places, such as hospitals and industrial plants, where they will make work processes more efficient.

Doing a Lot with a Little. Technologies that make our lives easier are truly wonderful — but they aren't accessible to everyone around the world. Around 70 percent of the people in India, for example, live on only two dollars a day. For them, it's the necessities that are missing — things like clean drinking water, hygiene systems, and electricity. This lack of services has a huge impact on living conditions, especially in rural areas. But there are nevertheless reasons for hope.

In Amla, a village 130 kilometers north of Mumbai, Siemens installed solar power facilities and water filters in the summer of 2012 (see p. 102). Since then, the villagers have

Siemens has equipped a remote village in India with water filters and other equipment to improve health.

If such innovations are to be successful, they need to be as user-friendly as possible, so ease of operation is the top priority for Siemens researchers. In line with this philosophy, Werner Chmelar and his team at the Siemens Mobility plant in Vienna, Austria have developed new grab handles for the Inspiro subway system (see p. 115). The handles look like tree branches, which brings to mind the concept of sustainability. Moreover, because they are of varying heights, they can be used by people of all sizes. The new subway will also be handicap-accessible. Klaus-Peter Wegge, who is himself blind, is testing different components and making suggestions for improvements. Usability experts from Siemens are also taking a close look at the user-friendliness of the work environment (see p. 111). Among other things, they are now developing an app that will allow train conductors to communicate with one another in real time, regardless of where they happen to be. This will save time been enjoying 20,000 liters of clean water per day and no longer have to make a long trip by foot to the next well. Illnesses such as diarrhea have all but vanished, although in India as a whole around 1,600 people still die from it every day. The residents of Amla now have electricity and light as well, which is helping to improve education because children are able to study at night. Project manager Prashant Chandwadkar believes this project is extremely important. "These technologies could be used to transform every village in India in a similar way," he says.

Such examples make it clear that technologies that are useful to people don't necessarily have to be as exciting as those presented in the movie "Minority Report." Small and inexpensive solutions can also be very helpful. Sometimes even a 1.5-meter-long water filter can be enough to change the lives in a positive way. That's what the 300 residents of Amla have discovered. ■ *Hülya Dagli*

Technologies that Touch Lives | Hearing Aids

How to Put Brains in Your Ears

People who have trouble hearing tend to withdraw from their friends and social activities. Today's state-of-the-art hearing aid systems can help hearing-impaired people to live a full life again. Siemens scientists are focusing on systems that create a natural hearing experience by means of computing technologies developed through hearing and acoustics research.

Problems with hearing are increasing worldwide. There are around 55 million hearing-impaired individuals in Europe, and the Center for Disease Control and Prevention (CDC) in Atlanta, Georgia (USA) estimates that one out of every four U.S. citizens over 70 has a hearing deficit. What is more, as the average age around the world continues to grow, the number of people with hearing impairments is expected to skyrocket. In general, not much can be done in terms of drugs or surgery to treat hearing problems. Modern hearing aid technology, on the other hand, can compensate for most types of hearing disabilities.

"Today's hearing aid systems are like extremely compact computers that break up sound waves into various frequency ranges and then reconstruct them into an acoustic pattern that is aligned with the patient's individual auditory ability," says Dr. Torsten Niederdränk, an acoustics expert who, in the course of several positions, has shepherded the development of hearing instrument technology at Siemens. Several hundred Siemens employees at the Audiology business unit in Siemens' Healthcare Sector are developing ever more technically sophisticated and virtually invisible hearing aid systems.

Research and technological advances have always played a key role in the development of hearing aid devices. Back in 1878, company founder Werner von Siemens designed a telephone amplifier for people with hearing problems (see *Pictures of the Future*, Fall 2004, p. 86). Then, around 100 years ago, the company introduced the first hearing aids. The devices consisted of a battery, a microphone, and an earpiece, sometimes elegantly packaged in a small bag or case.

Since then, the units have gotten smaller and smaller. The first behind-the-ear unit was launched in 1959 and was followed in 1966 by the first in-the-ear device. The first digital hearing aid system was introduced in 1997.

Digital signal processing in particular has been a constant source of innovation. In 2004, a team of audiologists, psychoacoustics experts, and chip designers led by Niederdränk achieved a major breakthrough by linking, for the first time ever, two hearing aid units on the left and the right ears via what at the time was the smallest radio system in the world. The two units were designed in a way that enabled them to automatically and simultaneously adjust themselves to new auditory situations. This synchronized system was particularly helpful to people with hearing damage in both ears.

In the years that followed, Siemens built on the knowledge it gained from such synchronized systems to develop numerous new functions that were eventually combined under the heading of BestSound Technology, which now serves as a technical development platform for providing hearing-impaired users with a pleasant and realistic acoustic experience. For example, an active acoustic feedback management system now suppresses annoying peeping sounds at lightning speed, while intelligent filter functions reduce or avoid the "cocktail party effect" (loud background noises that make it difficult to distinguish words).

"Miniaturization of the electric-acoustic components and steadily improving computer performance have enabled us to continuously improve signal processing, even to the point of three-dimensional sound capture and processing," Niederdränk explains.

System developers believe that there is also great potential to be harnessed from chip design improvements for in-the-ear devices carried directly in the auditory canal and for behind-the-ear hearing aids.

Also on the agenda is the further development of binaural hearing aid systems with integrated radio technology. "Our binaural systems have brought us very close to our goal of creating a balanced and pleasant hearing ex-

perience," says Günther Pausch, Director of Siemens Audiology.

Binaural systems work in coordination with the auditory perceptions of both ears because the brain's hearing center needs this information in order to generate authentic stereophonic sound. Working with specialists from Hörzentrum Oldenburg, an audiology center west of Hamburg, Germany, Siemens is learning how different sounds, tones, and voices coming from different directions are perceived. Differences in time and sound intensity have a big impact on such perceptions, as they allow the brain to precisely localize voices and sounds and filter out other signals. "We're working very closely with Oldenburg's "Audiology Valley" community to develop algorithms that can process real-time data from both hearing aids simultaneously, thus creating a three-dimensional, homogeneous hearing experience," says Niederdränk.

Smart Ears. Many hearing aids use a wireless transceiver to meet ever more demanding requirements. Siemens experts have been able to place such a unit, which is only a few millimeters long, directly onto the hearing aid chip.

Binaural hearing aid systems wirelessly exchange huge amounts of data. The data is continuously used to calculate and fine tune acoustic signals to both ears, thus generating a homogeneous spacial sound experience. The systems carry out sound analyses many thousands of times per second; the results are then exchanged between the two units. High-end devices can automatically differentiate between spoken words and adapt their output accordingly, thus resulting in optimized understanding of speech, as well as sound quality that adapts to every conceivable acoustic situation at lightning speed.

Extensive research activities and even finer chip architectures will continue the 100-year-old success story of Siemens hearing aids. In recognition of their forward-looking development of binaural hearing aid systems and the great utility these have offered to hearing-impaired users, the University of Oldenburg nominated Niederdränk and his partners Prof. Birger Kollmeier and Dr. Volker Hohmann in September 2012 for the German Future Prize awarded by the President of Germany. Back in the labs, Siemens scientists are already testing new hearing aid models and classification algorithms that will further improve selective hearing in noisy environments. "The systems will become more intelligent and their auditory output will become more natural, among other things with the help of an automatic acoustic situation recognition feature," Niederdränk explains. ■ *Andreas Beuthner*

How Wealth Affects Health

According to estimates by the World Health Organization (WHO), a child born in Kenya today will have a life expectancy of 60 years. That child's 60-year-old grandmother can probably look forward to another 17 years of life. In China the life expectancy of a newborn is 74 years, while 60-year-olds will reach an average age of 79 years. On the other hand, a child born in Germany today will more than likely live through to the next century — considering that the average life expectancy there is 78 years for boys and 83 years for girls.

This comparison illustrates the stark discrepancies that still affect the lives of children born in different countries. But it also shows that people who reach retirement age have a similar life expectancy all over the world. What's difficult are the earlier stages of life. According to the WHO, 361 out of 1,000 people from the world's poorest countries will die between the ages of 15 and 60. Countries with a low to medium average income will experience 210 deaths per 1,000 inhabitants in this age range (approximately the global average), while only 115 out of 1,000 people in this group will die in nations with very high average incomes.

Why is that? A few years ago the answer would have been simple. Life-threatening infectious diseases such as malaria and measles, which are practically extinct in industrialized countries, were responsible for large numbers of deaths in developing countries and emerging markets. Thanks to improvements in hygiene and vaccination, however, the situation has drastically improved since then, with the exception of some of the world's poorest countries. According to the United Nation's latest report on its Millennium Development Goals, significant progress has been made in the battle against HIV, tuberculosis, and other infectious diseases in many parts of the world — even though progress has been slow in the poorest nations of South Asia and Latin America. The goals for safe drinking water that had originally been set for 2015 were actually already met in 2010. Yet almost 800 million people around the world have access to drinking water of only dubious quality.

Today, people are increasingly suffering from non-infectious diseases, whether chronic or acute in nature. These include coronary and circulatory diseases, cancer, respiratory illnesses, and diabetes. The risk factors are well-known: tobacco and alcohol, an unhealthy diet, high blood pressure, and excessive blood glucose and cholesterol levels. In fact, these unhealthy aspects of modern life are now also beginning to affect developing and newly industrializing countries. Dr. Norbert Hültenschmidt, a health expert from consulting firm Bain & Company, explains one such example: "In India, the improvement in the quality of life is being accompanied by the rise of diseases that are typical of affluent countries, such as obesity."

In China, where 200 million inhabitants have achieved a standard of living that is comparable to that in Europe, a much higher proportion of people die of diabetes and coronary and circulatory diseases than in most industrialized countries, according to WHO figures. In its global status report, the WHO refers to an "invisible epidemic" that has become one of the most underestimated causes of poverty and underdevelopment in many countries. According to WHO estimates, 36 million out of 57 million deaths worldwide were caused by non-contagious diseases in 2008. In poorer countries, mostly younger people are affected: WHO figures show that in these countries 41 percent of adult mortality under the age of 60 is caused by such diseases — three times as much as in the wealthiest countries. Some of the side effects of this development are high treatment costs and losses in productivity totaling $47 billion within the next two decades, according to a study by the World Economic Forum in Davos and the Harvard School for Public Health.

"All healthcare systems around the world face the same challenges — namely, sharply rising costs due to an increased demand for services. This is being driven by increased wealth and an aging population," says Hültenschmidt, who also points out the pronounced disparity between national healthcare costs. In the United States these costs add up to 17.9 percent of the gross domestic product, while in Germany the figure is 11.6 percent, and in developing countries it ranges between five and seven percent. In Kenya, $7 — adjusted for purchasing power — are spent per capita on healthcare every month, according to WHO estimates. In China the figure is $32, in Germany it's $300, and in the United States it's $370.

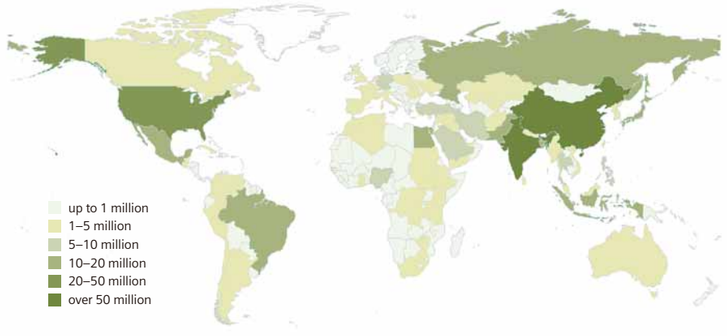
Sooner or later many countries will have to institute sweeping healthcare reforms. One shining example is Denmark, which has introduced a highly efficient system of electronic medical files and tax incentives to encourage visits to the family physician. Another example is Singapore, where every citizen has a right to free basic healthcare. Additional medical services are financed from a kind of personal account that works similarly to life insurance.

But the situation is less promising elsewhere. In Germany, for instance, patients visit two to three expensive specialists on average before finally undergoing treatment. At the same time, the number of family physicians is decreasing while medical specialists are increasing, and there are fewer new doctors than those who are retiring. In addition to rising costs, warns Hültenschmidt, the shortage of doctors is one of the most pressing concerns if we want to create high-quality global healthcare. India, for example, is short of more than a million doctors, and people in some regions don't have any doctors nearby.

Fortunately, modern technology often offers the potential to improve the quality of healthcare while simultaneously lowering costs. This is due to a number of factors. These include the introduction of electronic medical records; close networking among patients, insurance companies, and doctors; more efficient clinical processes; improved preventive check-ups and early recognition of diseases; and treatments and drugs that are tailored to the needs of specific groups of patients, to name just a few.

But will these measures help to lower healthcare costs? "We have to be realistic," says Hültenschmidt. "Only measures that take all parties into consideration will help us achieve increased efficiency as well as improved quality. Ideally, these measures will at least stabilize our healthcare costs and at the same time create room for innovations." ■ *Urs Fitze*

Projected Worldwide Distribution of Diabetes in 2030



Source: International Diabetes Federation, 2011

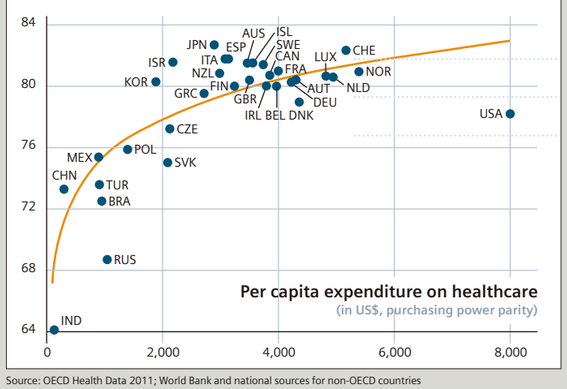
Deaths from Cardiac Diseases and Diabetes per 100,000 Inhabitants

Country	Men	Women
Afghanistan	765	578
Argentina	263	153
Australia	136	89
China	312	260
Denmark	180	107
Germany	207	134
France	128	69
Canada	152	90
India	386	283
Austria	188	124
Russia	772	414
Switzerland	143	86
USA	190	122

Source: WHO, data for 2008

Comparative Value of Healthcare

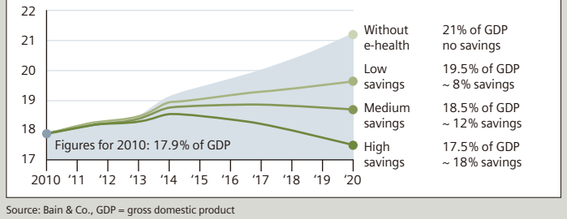
Life expectancy in years



Source: OECD Health Data 2011; World Bank and national sources for non-OECD countries

How E-Health Could Cut Medical Costs

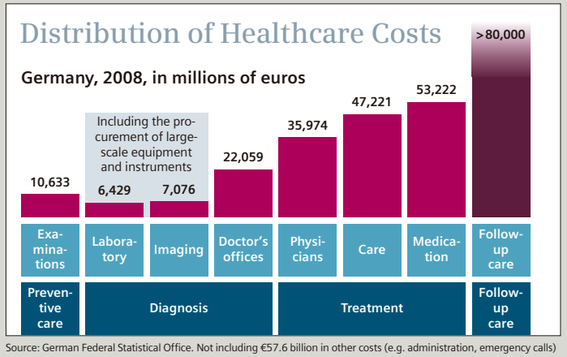
Total U.S. healthcare costs in % of GDP, 2010–2020



Source: Bain & Co., GDP = gross domestic product

Distribution of Healthcare Costs

Germany, 2008, in millions of euros



Source: German Federal Statistical Office. Not including €57.6 billion in other costs (e.g. administration, emergency calls)

Income: A Key Factor Affecting Lifespan

Mortality rates for 15 to 60-year-olds per 1,000 people

	Men			Women		
	2009	2000	1990	2009	2000	1990
World Bank income bracket						
low (under $1,025)	361	407	395	280	324	314
low to medium ($1,026–$4,035)	210	232	248	140	167	188
medium to high ($4,036–$12,475)	239	278	262	128	140	132
high (over $12,475)	115	132	160	61	68	78

Source: World Health Organization (WHO)

Infections: Incidence Related to Income

World Bank income bracket	Cholera	Measles	Leprosy	Malaria
low (under $1,025)	177,106	76,479	35,243	59,559,481
low to medium ($1,026–$4,035)		125,901	169,191	21,396,019
medium to high ($4,036–$12,475)		13,401	39,886	696,248
high (over $12,475)		6,537	297	

Source: WHO, number of global cases in 2009

Some illnesses produce a unique molecular signature in a patient's breath. Researchers are confident that quadrupole mass spectroscopy will make rapid diagnoses possible.

Sniffing out Diseases

Very soon, revolutionary analysis technology from Siemens could be improving the lives of asthma patients, enabling the early diagnosis of life-threatening illnesses, and making surgical procedures safer. The goal is to create a universal device that can diagnose cancer, allergies, and infections.

Professor Maximilian Fleischer has a special reason for visiting lots of doctors these days. A top researcher at Siemens Corporate Technology in Munich, Fleischer observes their work and asks them about their methods for diagnosing and treating diseases — specifically the kind of analysis equipment that might support them. "For example," says Fleischer, "there is still no reliable way to make an early diagnosis of lung cancer. By the time the first symptoms appear it's usually too late. On average, patients live for only about two years after their condition has been diagnosed." Yet lung cancer would be largely curable if it could be recognized early.

The case is similar for tuberculosis, a dangerous lung disease, where late diagnosis can spell fatal consequences. "The patient is contagious for a long time without knowing it, exposing other people to this highly infectious disease," Fleischer explains. In a recent report, the World Health Organization (WHO) estimates that 3,800 people die every day from tuberculosis — mostly in developing nations.

Even though the number of new infections is declining, the explosive nature of new outbreaks is on the rise as more and more of the bacterial strains that cause the disease are demonstrating increased resistance to common antibiotics. An easy and reliable method for the early diagnosis of this life-threatening disease — such as a breath test, for example — is at the top of many doctors' wish lists. That's why Fleischer's team is working on equipment that analyses people's breath.

"Chinese doctors have known for two thousand years that specific illnesses can be identified by changes in the smell of a person's breath," explains Fleischer. Western medicine has been slower to catch on to the significance of this phenomenon. However, ever since the medical journal *Lancet* featured a report about a dog that was able to detect it's owner's skin cancer, things have changed.

In fact, the worldwide search for gaseous bodily emissions that could betray the presence of disease has been in high gear. In most cases, detection is a matter of analyzing "cocktails" made up of a number of highly complex molecules, which are also to be found in the breath or bodily emissions of healthy people, just in different proportions.

Today, most research groups are looking for these suspicious mixtures of substances with detection arrays made up of eight to ten different sensors. "But that hasn't really worked well yet," reports Fleischer.

With this in mind, Siemens researchers are employing a classic analytical method from the chemical laboratory — quadrupole mass spectroscopy. When a breath sample enters this device the first thing that happens is that it is bombarded with ionized mercury particles. This procedure gives an electric charge to the substances in the sample.

The charged particles are then passed through an electric field and are finally slammed into a detector. Because they don't weigh the same, the degree to which the particles are deflected in the electric field varies. The result is that they land in different places on the detector, producing a characteristic impact pattern — a sort of fingerprint that exposes diseases.

The first breath tests from cancer and tuberculosis patients were very promising. "But to be sure that this method really works, we have to do additional testing on samples from several hundred patients," reports Fleischer. It could be that the concentrations in a characteristic gas "cocktail" are also influenced by a patient's sex, age, ethnicity, or eating habits, for example.

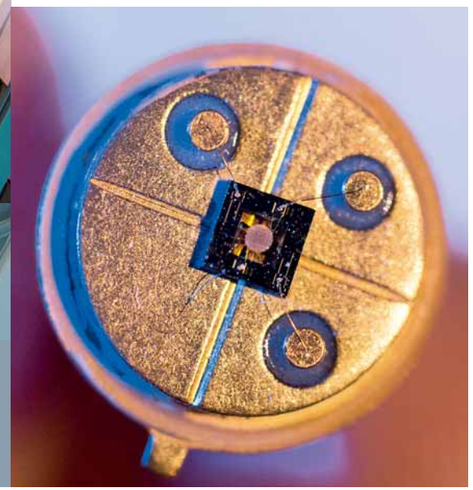
The researchers also want to know if this kind of diagnosis would work with smokers. But if the first results with the new method are confirmed, things could progress very quickly. That's because shrinking the spectrometer equipment down to about the size of a suitcase and perfecting the software for use in a doctor's office or clinic is a matter of pretty routine engineering according to Fleischer. Meanwhile, the scientists want to go ahead and see if the new method can be applied to the diagnoses of other illnesses as well. Their goal is to create a universal device that offers a wide spectrum of diagnostic possibilities. It should not only be able to recognize different forms of cancer, but also detect allergies and infections.

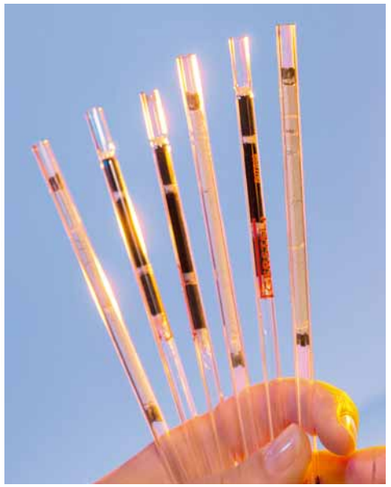
A Test that Predicts Asthma Attacks. A forerunner of Fleischer's breath analyzer is a device designed for asthma patients that should soon be available on the market. The device detects the imminent onset of an asthma attack. What's more, because it is about the same size as a CD box, asthma sufferers can easily carry it around.

"Basically, in order to know the status of a patient's asthma, all that's necessary is to establish the proportion of a single, easily detectable type of molecule in the patient's breath," explains Fleischer. That substance is nitric oxide (NO) and it can rise to five times its normal levels several hours before an asthma attack. The gas is therefore a clear indicator of inflammation processes in the respiratory tract.

Fleischer's new detection device is equipped with a roughly dime-sized sensor that contains the colorant phthalocyanine. This blue dye, which is also used for coloring eggs, binds very selectively with NO molecules thus changing their electrical properties. "And that's something that we can measure very easily," says Fleischer. That's because the dye comes into contact with a microchip equipped with a field-effect transistor (FET). When NO molecules accumulate on the chip, the FET measures high voltages and sends a signal to the electronic evaluation system.

The system is extremely sensitive. Normally, human breath contains, at most, 30 NO molecules per billion other molecules (30 ppb). But if this concentration rises to 100 ppb the sensor can detect the change. For comparison, that's the equivalent of finding the molecules of a sugar cube dissolved in a large swimming pool. The sensing system, which is now at the prototype stage, doesn't react to other things, such as alcohol, acetone or bad breath. With this device, people afflicted with asthma will be better equipped to prevent asthma attacks, against which they can then proactively inhale a large dose of bronchodilators and anti-inflammatory medication.





Sensors (left) react to a range of molecules, including those of acetone. Prof. Maximilian Fleischer is researching new materials applicable to breath diagnostics (center). Test tubes with breath samples are providing the basis for further examinations.

A different sensor that would function in a similarly straightforward way could be designed for use when running or working out. This device would show if the body was not only burning the basic component of carbohydrates, glucose, but also fat — and in the optimal relationship of 40 to 60. Weight-conscious fitness fans would only have to exhale into a cell phone-sized device that would measure the concentration of acetones in their breath.

Most people probably know acetone as a solvent, but it is also a by-product of our metabolism. "Achieving a concentration of about one ppm — meaning one molecule of acetone per million other molecules — in a breath sample, is the ideal way to actually lose weight when exercising," says Fleischer. Building such a sensor won't be a problem, either. In fact, the researchers are already on the lookout for a

Siemens researchers are developing a range of sensitive breath analysis tests.

partner company that will mass produce the small devices.

Tissue Analysis with Light. Another point of focus for Fleischer's team is measurement technology that would literally shed light on things during difficult operations. "For example, in the case of brain tumor operations, such a feature would make it easier for surgeons to tell the difference between healthy and diseased tissues," says Fleischer.

With a normal surgical microscope, it is extremely difficult to make this distinction, which can have serious consequences. If the surgeon doesn't remove enough tissue, the cancer can grow back. But if too much is removed, function could be compromised. According to Fleischer, better insight into tissue structure is important for other operations as well, such as those involving the throat, where the vocal chords could be at risk, or during prostate surgery, where a mistake could mean incontinence.

Help in achieving improved accuracy may come from a device developed by Siemens' measurement technology center that is used in food quality control. The device can reveal how fresh a meat sample is, or what animal it came from (see *Pictures of the Future*, Spring 2010, P. 70). But it might also be used in the operating room. About the size of a ballpoint pen, the probe contains fiber optics that direct light from the near infrared spectrum onto a point of interest. Near infrared light penetrates the topmost millimeters of the tissue and, unlike X-rays, is completely harmless.

A light sensor directs near-infrared rays onto the spot under examination.

Information about tissue structure is provided by the light that is reflected back to the testing probe, which directs it to an infrared spectrometer. "Which wavelengths of the light are absorbed and which are reflected is, in part, determined by the molecular organization of the cell walls," explains Fleischer. "Because tumor cells grow so fast, their cell walls are less uniform than those in healthy cells — a feature we can make visible with our method." When light from the sensor reaches the edge of the tumor, the interface can be pinpointed with an accuracy of less than a millimeter.

The light sensor has already passed the acid test. With the help of this device, surgeons have been able to discern the difference between healthy and diseased tissue in throat cancer patients. What is more, tests on laboratory rats show how well the device can identify the boundaries of a brain tumor. However, the new method can not be tested on people with brain tumors because the laboratory device for this type of operation can not currently be adequately sterilized. "It has to be cleaned under high pressure and at high temperatures; the connections for the optical elements can't survive that yet," says Fleischer.

Should upcoming tests prove successful, scientists intend to build a version of the machine that can be sterilized quickly. Clinical trials could then begin. If everything goes as planned, the first models of the new surgical assistants could be available in a few years.

■ *Andrea Hoferichter*

Volumes of data regarding our vulnerability to diseases are stored in each person's genes. Researchers examine blood samples in a search for micro-RNAs that form after a heart attack.

Technologies that Touch Lives | Biotechnology

Paths to Personalized Care

A medical revolution is in the making. Scientists plan to use the huge amount of data contained in genes to place the diagnosis of illnesses such as heart disease on a new foundation. Working in close cooperation with Heidelberg University, Siemens researchers have developed software that puts genetic information to work.

The numbers speak for themselves. At least 200,000 people in Germany alone suffer from cardiomyopathy, an often genetically-triggered deterioration of the function of the myocardium — in short, the heart.

To date, researchers have identified more than 50 genes that can cause the disease or increase its severity if they are defective. Currently available diagnostic techniques cannot definitively isolate the genetic causes of this cardiovascular disease.

Dr. Benjamin Meder, a physician at Heidelberg University Hospital, believes this represents a huge challenge. "In general, modern diagnostic methods, such as magnetic resonance tomography, can only detect weaknesses in myocardial performance," he says. "In most cases the precise cause of the condition can not be identified."

Like most other illnesses, cardiomyopathy can have many causes. "It could be genetic, but it doesn't have to be," Meder explains. In fact, the symptoms can also be caused by toxic damage, a virus infection or a circulatory disorder. The problem is that knowing the precise cause is very important when choosing treatments and making medical prognoses. "Some gene alterations can be very dangerous to a patient," says Meder.

With this in mind, in 2011 scientists from Heidelberg University teamed up with colleagues from Siemens Corporate Technology (CT) in Princeton, New Jersey, to develop new software that not only analyzes and manages the huge amount of data generated by genetic tests but also presents it to physicians in a very clear manner. "Here we used tried and tested software as a basis and then recombined the software components in an intelligent way," says Dr. Andreas Keller, a researcher from the Chief Technology Office of Siemens' Healthcare Sector.

Looking for RNA. New techniques now being developed could be used to quickly and reliably diagnose a heart attack. Until recently, the common practice for this was to analyze a patient's blood for proteins that are released by the heart muscle during a heart attack. Here too, the presence of such proteins can have many different causes, which can make it very difficult to quickly differentiate between a heart attack and a heart muscle infection, for example.

A more rapid and possibly better way to diagnose a heart attack would be to look for special micro-RNAs — i.e. ribonucleic acids — in the patient's blood or serum. So-called "micro-RNAs" have been found to play a key role in the complex gene regulation network. This new diagnostic field is very promising, which is why Heidelberg University and Siemens are collaborating to assemble key genetic, clinical, and technological information in this area.

"Micro-RNAs enter the bloodstream via two different mechanisms when a heart attack occurs," says Meder. They are either released when heart tissue dies, or else there is a change in the micro-RNAs in cell types such as leucocytes and thrombocytes that occurs as a reaction to a traumatic event. It is basically possible to identify such markers for diagnostic purposes today, but the laboratory techniques required for this are time-consuming and expensive.

Nonetheless, CT researchers in Erlangen have taken up the challenge. Within the framework of Siemens' "Translational Biotechnology" lighthouse project, they are examining whether a type of "lab-on-a-chip" platform could be developed that would allow such tests to be conducted simply and quickly. The researchers are focusing mainly on better methods for diagnosing heart attacks on the basis of micro-RNAs.

Genetic First Aid. An initial demonstration unit for improved genetic analysis of heart muscle weakness (dilated cardiomyopathy) was recently completed (September 2012) at Heidelberg University Hospital. "We hope to see initial results soon, as the cardiologists in Heidelberg already have data sets for around one thousand patients," Keller explains. He adds that another 150 data sets will be added to the collection each year, which will provide doctors with an increasingly solid foundation for future studies.

"Of course, the challenge is also to make sure that a physician isn't just given simple lab results, as was previously the case," Keller says. Instead, he or she will be issued gigabytes of information on each patient. That won't be a problem, however, given the fact that Siemens has many years of experience and expertise in evaluating large amounts of data. "Our strength here is the ability to extract clinical information that doctors can understand," says Keller.

"Our initial goal for the demonstration unit is to prove that the sequence data we collect corresponds to clinical expectations," explains Dr. Emil Wirsz, a Siemens researcher from CT in Erlangen who heads the Translational Biotechnology lighthouse project. "Our primary focus is to improve the diagnosis of cardiomyopathy, but our systems can also be modified, which means we can use them to detect other cardiovascular diseases — and even apply them to completely different areas, such as the early detection of cancer."

Wirsz says the scientists started with cardiological disorders because they're easier to manage than cancer-related diseases. The latter are more complex, of course. "But that's all right, because we can learn from the cardiology applications and then transfer the knowledge we gain to other areas," he says. To this end, Siemens Healthcare is planning partnerships with several cancer research organizations.

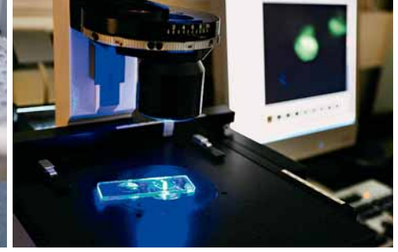
"We'll probably start with tumor diagnosis in children," says Keller. That's because the influence of genetic predisposition in such cases is generally very high. It may be possible over the medium term to examine the blood of cancer patients in a targeted manner designed to identify genetic defects, and then use the results to draw up an optimal treatment approach. The software developed by Siemens will gradually be expanded to accommodate this approach, says Keller.

Although the goal of the Erlangen and Heidelberg research programs is to ultimately revolutionize diagnostic methods, they are already thinking about possibilities for improving individualized disease prediction. "It's conceivable that we'll be able to affordably conduct complete genome sequences in the near future," says Wirsz. This could allow risk factors to be identified for a variety of conditions, such as many heart diseases, cancers, and Alzheimer's disease.

Naturally, with so much sensitive information potentially flowing from tomorrow's genomic tests, the issue of data security will become increasingly important. "We are working on multiple levels to ensure that patient data will remain accessible only to authorized individuals," says Keller. That will be crucial as data is increasingly stored on external servers in the cloud.

Personalized Medicine. Siemens researchers are also taking a close look at the future field of pharmacogenomics, which involves medical treatments tailored to a patient's individual genetic profile. This issue is very important because it's becoming more and more difficult to develop new medications that are effective for large segments of the population yet that have few side effects. The pharmaceutical industry needs to invest billions if such blockbuster drugs are to be created. Up until now, regulatory organizations have refused to approve medications that only help 20 percent of patients on average. Now, however, we know that genetic makeup often determines whether or not a certain drug will work on a patient — and a susceptibility to specific side effects is often inherited as well. The new trend here is companion diagnostics — tests that can be used to determine whether a treatment in a specific case will lead to success, and thus to indicate whether the drug in question should be approved for use with certain patient groups. "This is exactly the situation in which our software can be used as well. In other words, it might help personalized medicine achieve a big breakthrough," says Wirsz.

■ *Rolf Froböse*



Left and center: Researchers are studying fish larvae to understand specialized gene functions. Right: Siemens software helps cardiologists to analyze genetic data.

Networked, healthy, and mobile lives — that's what senior citizens could have if the assistance systems for the elderly used in the three-month SmartSenior test become reality.

Technologies that Touch Lives | Assistance Systems

Senior Living 2.0

Out of the lab and into real life. As part of a major field study, the SmartSenior project and its partners equipped the apartments of 35 senior citizens with assistance systems. The purpose of the trial was to determine how reliably the technologies function and how well they are accepted.

So, that's it," says Sigrid Gorn, 83, who's sitting in a chair in her living room looking at the display of a blood-pressure reader on her wrist. On her TV set she can see the smiling face of Malte Cornils, a computer scientist at the Telemedicine Center in Berlin's Charité Hospital (TMCC), who is in touch with her through a video link. "Everything's OK," Cornils says. "I've received your blood pressure and pulse readings."

Gorn is one of 35 senior citizens in Potsdam who participated in a field test of assistance systems for the elderly. The technologies that were tested in the roughly 50-day trial are part of the "Ambient Assisted Living" program (AAL), a part of the SmartSenior@home project funded by Germany's Federal Ministry of Education and Research (see *Pictures of the Future*, Fall 2011, p. 24).

The project has 28 participating partners from industry, research institutes, and medium-sized businesses. "There's never before been an AAL project on this scale and with so many partners in Germany," says Michael Balasch, the coordinator of the SmartSenior project and Research & Innovation Director for Health at Telekom Innovation Laboratories (T-Labs). "The project's overriding goal has been to move away from isolated solutions and develop a standardized AAL platform. Another key target is to ensure affordable AAL and telemedicine solutions for seniors through a system of open standards."

The "SmartSenior@home" project was carried out under the direction of Dr. Mehmet Gövercin, Head of the Technology and Aging working group at Charité Hospital. Gövercin was responsible for presenting the project plan to an ethics commission; once the clinical study was approved, work was able to begin. After passing the final product inspection phase, the project's technologies were installed in 35 apartments and the participating seniors were taught how to use them.

One of the devices tested in the project was a wristwatch developed by Dr. Asa MacWilliams and his team at Siemens Corporate Technology (CT). The watch notifies users if, for instance, they have left the apartment and forgotten to shut a window or turn off the lights. The test subjects were even able to use the watch to shut off lights in their apartments as long as they were located within the range of their home WLAN system. The watch did this by sending a command to an AAL Home Gateway provided by T-Labs that was placed behind the TV in each participant's apartment. The signal was then forwarded to the home systems control unit.

Also tested were two gas sensors from CT that measure volatile organic compounds in the air. These sensors were installed in Gorn's bedroom and study. The goal of this test was to determine whether gas sensors can provide information on activities occurring in the apartment — e.g. whether a senior is cooking, or if rooms are occupied when visitors have arrived. Such information can be useful for ensuring energy-efficient ventilation and climate control systems, for example. Special software in the AAL Home Gateway collected and analyzed the sensor data in the test. "If seniors are

Sigrid Gorn can use SmartSenior's software portal (right) to access a range of services, such as a virtual personal trainer (left).

to accept the system, the sensor data should normally stay in the apartment," says MacWilliams. In other words, an ambulance should be called only in potentially dangerous situations or if the user's behavior changes.

Although the sensors in the apartment were so well hidden as to be practically unnoticeable, the test subjects' living rooms were packed with technology. Behind Gorn's TV, for example, were four different data transmission and communication boxes; the camera for video transmission was placed to the right of the TV. Also installed was a special service portal that allowed users to access various applications. Gorn used the "Health" and "At Home" features most frequently. The "Health" function enabled her to transmit blood pressure, weight, and ECG readings directly to the TMCC, view the information herself on a display, and videoconference with TMCC staff.

"At Home" gave her a direct link to her building management company if she needed to do things like get a light bulb changed, order food, or make purchases that were then delivered. The "At Home" function also displayed sensor data and information about energy and water use. Participants in the test could choose between a conventional remote control or a small Web pad with a touchscreen to access the portal and use its features. Gorn clearly liked the touchpad best. "I only use the remote control to adjust the volume on the TV," she says. "I like the pad because it's small and easy to read."

A blood pressure reader and a scale were also put in Gorn's living room, and the first ten test subjects were issued a mobile ECG device about the size of a smartphone. All of these devices sent their data via a wireless Bluetooth connection to the "Med-I-Box," which then forwarded it to the TMCC using a new standard for telemedical transmission of vital data (ISO 11073). The TMCC stored the medical data in electronic patient files.

The purpose of all this was not to derive medical treatments from the data but instead to see if the measuring and transmission devices would operate smoothly.

Home Dialysis. Other SmartSenior studies that ran parallel to "SmartSenior@home" did focus on treatment. For example, Telemedically-Assisted Peritoneal Dialysis (TAPD), for example, uses a specially developed system that helps dialysis patients clean their blood at home. Many such patients have to go to a dialysis center several times a week and get hooked up to an artificial kidney by clinic personnel for several hours in order to clean their blood. Peritoneal dialysis (PD) offers an alternative by enabling the patient's peritoneum, which is located in the abdomen and has good blood circulation, to be used as a blood filter. Patients who utilize PD systems connect themselves every day via a catheter to a type of circulating pump known as a "cycler." The pump moves a sterile rinsing fluid back and forth from a small bag to the peritoneum. The advantage here is that the dialysis process can be carried out comfortably overnight and patients only have to visit a kidney specialist for monitoring once every six weeks.

A combined movement and brightness sensor (left) and a WLAN-equipped wristwatch can trigger an alarm if something goes wrong.

"PD is the ideal method for older immobile patients who would prefer to be cared for in their own homes," says Dr. In-Hee Shin, a nephrologist associated with the Vivantes Clinic in Berlin. "The problem is that many seniors are wary about carrying out PD at home because the systems lack any software to guide them and explain how to use it."

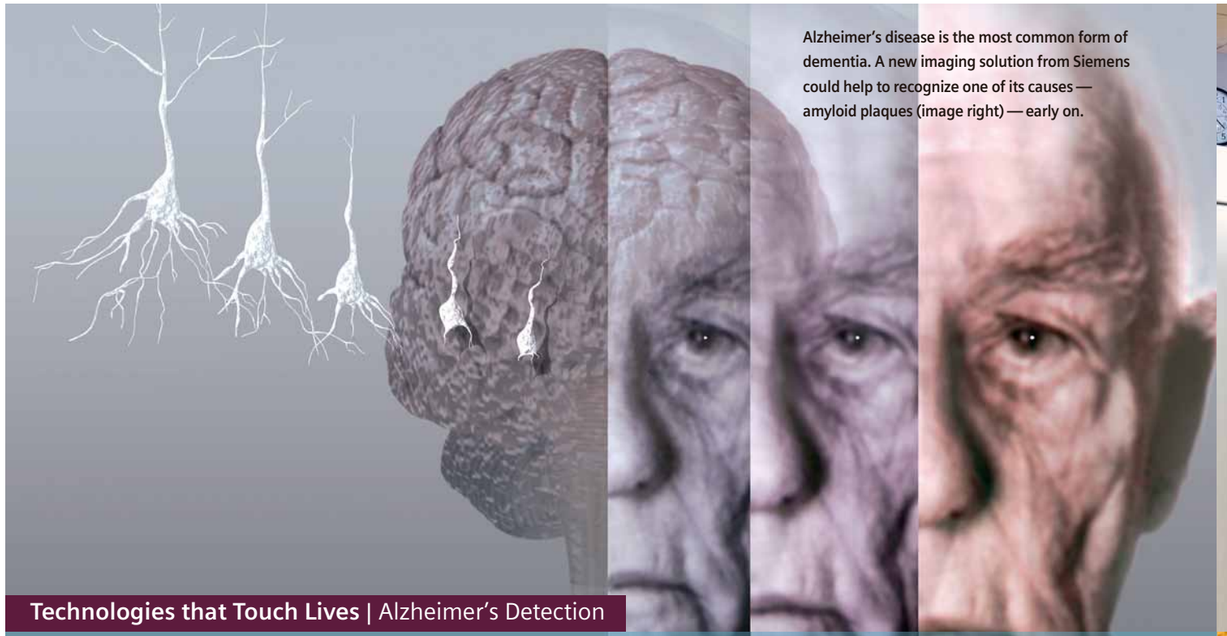
With this in mind, Corporate Technology in Munich developed a PD assistant for smartphones in a project directed by Evelyn Pfeuffer. TAPD has now been tested with the PD assistant for the first time with a patient in Berlin. On the morning after the PD is conducted, the software guides the patient through the measurements of vital signs such as blood pressure, blood sugar content, and weight. After that, the patient answers questions about his or her physical state on a multiple-choice questionnaire, describes the color tone of the exchanged cleansing fluid, and describes the condition of his or her artificial opening. The patient then sends all of the data via the Internet in encrypted form to the TMCC and the dialysis center at the Vivantes Clinic, where it's automatically checked against stored emergency values for plausibility. "I look at the readings once a day and can make quick treatment decisions should that become necessary," Dr. Shin explains.

Gorn is doing so well that she does not need dialysis. Nonetheless, she might soon experience trouble walking, because she has two artificial knee joints. That's why she's taking part in a SmartSenior study that addresses stroke rehabilitation and measures for preventing falls. Technicians have placed a Kinect sensor in front of Gorn's television (see *Pictures of the Future*, Fall 2011, p. 74). Her screen now shows a "virtual trainer" who guides her through various exercises that are important for her well-being. The Kinect sensor and a video camera monitor her as she does the exercises — and the screen shows her immediately whether she's doing them right. All of Gorn's movements are transmitted to the Hospital as well. Her caregiver there not only sees whether she's doing her exercises regularly but also how much progress she's making.

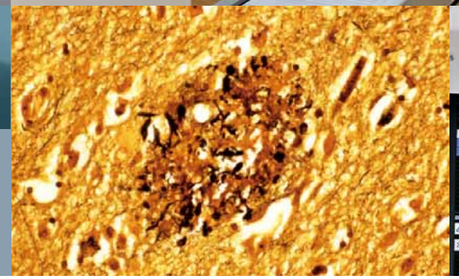
"That was fun," says Gorn. "If I can find the time, I'd like to keep doing it even after the project is over." In her opinion, participating in the project was an interesting experience. "But I don't need this technology yet," this busy 83-year-old also points out. She's got a lot to do, because 180 members of the local tax assistance organization are waiting to receive her advice — and there's also the garden to tend to and grandchildren to see, among many other activities. ■ *Michael Lang*

A video conference function allowed users in a field test to establish direct contact with staff at Charité Hospital's Telemedicine Center.

SmartSenior's service portal allows users to send medical data and room temperature readings directly to the Telemedicine Center at Berlin's Charité Hospital.



Alzheimer's disease is the most common form of dementia. A new imaging solution from Siemens could help to recognize one of its causes — amyloid plaques (image right) — early on.



Evidence-Based Imaging

Alzheimer's disease is the most common form of dementia, accounting for roughly two thirds of total cases. However, it is difficult to diagnose the disease because it becomes noticeable only after brain cells have been irreversibly damaged. Siemens now offers the first amyloid imaging solution, which makes it possible to evaluate Alzheimer's disease.

"What's your name?" — "Auguste." — "Your last name?" — "Auguste." — "What's your husband's name?" — "Auguste, I think." This conversation between the psychiatrist Alois Alzheimer and his patient, 51-year-old Auguste Deter, made medical history. Deter was the world's first Alzheimer's patient. After her death, Alzheimer dissected her brain and found that the parts of the cerebral cortex that are responsible for memory, orientation, and feelings had changed significantly.

Among other things, Alzheimer discovered protein plaques, "matted fibers, and dead nerve cells." Only a few nerve cells had survived the disease. The study Alzheimer published in 1906 was the first to describe this "peculiar disease of the cerebral cortex." His analyses marked the beginning of research into Alzheimer's (see *Pictures of the Future,* Fall 2010, p. 87).

Alzheimer's disease (AD) gradually kills brain cells. Nonetheless, scientists still do not fully understand how this process occurs. Medical researchers agree, however, that Alzheimer's probably results from a great variety of factors.

The changes it produces in the brain include the buildup of a protein known as beta amyloid in areas outside the brain's nerve cells (neurons) and a chemical alteration of the tau protein inside the neurons. Both processes are considered to be among the most likely causes of the obstruction of information transmission through the brain's synapses that occurs in Alzheimer's patients.

Back in 2009, "Alzheimer Disease International" (ADI) estimated that 35.6 million people around the world were afflicted with dementia — a number that is expected to double every 20 years and reach 115 million by 2050. These figures include all forms of dementia; it's estimated that over half of the victims have Alzheimer's.

Alzheimer's cannot be diagnosed in a living patient. Statistically speaking, one out of every five people considered to have Alzheimer's is actually not afflicted with the disease but instead with another type of neurodegenerative illness. Only an autopsy can prove the diagnosis wrong.

But if a reliable evaluation could be made at an earlier stage, it would enable patients and their relatives to prepare for the changes to come and make arrangements for home care, etc. Furthermore, a reliable evaluation tool might make it possible to determine when a patient is unlikely to have Alzheimer's, and therefore likely to be suffering from a different neurodegenerative disease.

Biomarkers in the Brain. Siemens is now supplying an amyloid imaging solution for Alzheimer's evaluation. The solution begins with the positron emission imaging (PET) biomarker manufacturing and distribution expertise of Siemens' PETNET Solutions, which has the largest network of PET radiopharamaceutical manufacturing facilities in the U.S.A. Additionally, Siemens' PETNET Solutions employs appropriately qualified staff and the necessary infrastructure for the production of amyloid imaging biomarkers. As a result, it can offer imaging centers and hospitals a high level of delivery reliability. After a PET imaging biomarker is administered to a patient, he or she is scanned in a PET-computed tomography device (PET/CT), such as the new Biograph mCT scanner from Siemens (see *Pictures of the Future,* Spring 2010, p. 68; Fall 2011, p. 42).

The radioactive substance travels through the bloodstream and concentrates in the part of the body being imaged either because of metabolic activity or because it seeks out biomarkers in tissues specific to a disease. Tracer signals from white brain matter are considered normal, whereas amyloid plaque in gray matter indicates potential neurodegeneration. Thanks to the industry's finest volumetric resolution of up to 87 cubic millimeters and a 400 percent improvement in contrast over previous models, the Biograph mCT helps physicians distinguish between white and gray matter. With automatic daily calibrations and proven PET and CT alignment accuracy, the Biograph mCT supports accurate quantification in dementia imaging.

In addition, quantifying software recently introduced by Siemens for amyloid imaging automatically compares the amyloid PET image with amyloid PET reference images, identifying target regions of interest. Quantification software, although it does not replace visual assessment by a physician, assists physicians in making an interpretation of the PET image. The new software's algorithm correlates with the reference model (now known as the Fleisher method) developed by Dr. Adam Fleisher and his research team at the Banner Alzheimer's Institute in Phoenix, Arizona. Fleisher identified six regions of amyloid plaque buildup and defined a threshold value to distinguish between healthy and AD brains. Fleisher also collected data about healthy and diseased patients in comparative research conducted over many years.

Thanks to Fleisher's research, the new Siemens software offers an intelligent solution — ranging from radiopharmaceutical to PET-CT, as well as quantification software. In this manner, the company contributes to making it possible to depict the presence and buildup of beta amyloid in the brain accurately, while providing additional information to support physicians with their evaluation of Alzheimer's and other forms of cognitive decline.

Britta Fünfstück, Chief Executive Officer of Molecular Imaging at Siemens Healthcare, believes Siemens offers a major advantage to users with its comprehensive amyloid imaging solution. "PETNET Solutions' PET imaging biomarker manufacturing and distribution expertise, Siemens' new Biograph mCT PET-CT, and our *syngo*.PET Amyloid Plaque neurology quantification software will give physicians in the United States additional tools for the evaluation of Alzheimer's disease and other neurological conditions," she says.

The Road Ahead. Siemens is going a step further in its Alzheimer's research. Because the alterations observed in the tau protein are also suspected of causing Alzheimer's (along with the buildup of amyloid), Dr. Hartmuth Kolb, Vice President of Molecular Imaging Biomarker Research at Siemens Healthcare, and his research team in the Los Angeles area — are now developing new imaging biomarkers that will make the affected nerve strands (axons) visible. Until now there have been no such imaging biomarkers on the market. "Approximately 30 percent of all normal elderly people have amyloid plaques in their brains, even though they don't suffer from dementia," says Kolb. "The advantage of focusing on tau is that the amount and distribution of that protein in the brain most probably has more to do with dementia symptoms than is the case with amyloid."

Kolb and his colleagues have developed two imaging biomarkers that dock with tau strands and make it possible for PET technology to visually depict them. Siemens is currently conducting clinical studies with these biomarkers and associated investigational radiopharmaceuticals in the Los Angeles area, where Kolb and his team produce the imaging agents and can immediately make them available for clinical tests. Researchers want to use these tests to determine whether the tau imaging biomarker triggers a stronger PET signal in the brain of an Alzheimer's patient than it does in the brain of a healthy individual. Kolb also wants to find out if the tau protein buildup occurs in the regions of the brain where researchers currently suspect it does, or whether other brain regions might also be affected.

■ *Tanja Berbalk*

Siemens' lightning information service collects data from 150 measurement stations (p. 95 bottom). Modern fire protection systems must respond intelligently to threats in buildings (p. 95 top).

Technologies that Touch Lives | Disaster Prevention

Digital Guardians

People all over the world can be affected by disasters such as levee breaks, major fires, and thunderstorms. In the future, intelligent systems will be able to comprehensively monitor potential threats — and save lives with their sophisticated warning capabilities.

The 30,000 people who attended the "With Full Force" music festival north of Leipzig, Germany won't soon forget July 1, 2012. That's because a severe thunderstorm hit the site at around 2 a.m. that morning. Hurricane-force winds blew away tents and bombarded the field with hailstones. Finally, a bolt of lightning hit the floodlight unit. The discharge from the unit's electrical system made its way through the ground and struck 51 people, three of whom were injured so critically that they had to be taken to a hospital.

"Of course you can't prevent storms," says Stephan Thern from Siemens' BLIDS service. "But if you're warned in time, you can interrupt an event and clear the area, and in that way prevent accidents." BLIDS (a German acronym for Lightning Information Service) does exactly what its name implies. Anyone can take out a paid subscription to the lightning-warning service, which is unique to Germany. When the first lightning strike is registered in a predefined area, users receive an e-mail or SMS. Subscribers can also view the development of the storm on the Internet. Siemens' main customers for the service include energy suppliers, airports, pipeline operators, and industrial firms.

"A lot of companies are susceptible to the type of voltage fluctuations that occur when lightning strikes somewhere in the grid," Thern explains. BLIDS makes it possible for companies to shut down sensitive equipment before lightning strikes. "This is important for a facility like a wind power plant, whose rotor blades can be destroyed by a lightning strike," says Thern, who also points out that work on pipelines, which can conduct electric current over many kilometers, also has to be stopped. BLIDS utilizes data from 150 stations throughout Europe, 15 of which are located in Germany. Every lightning bolt creates an electromagnetic field that spreads out in all directions at the speed of light; in Germany alone, as many as 200,000 bolts are generated on some summer days. BLIDS stations record the corresponding signals at intervals of just a few millionths of a second, and because the stations are synchronized via GPS they can determine the location of a lighting strike to within 200 meters.

The basic version of BLIDS was introduced 20 years ago; since then it has evolved from a simple series of maps into a range of complex tools. At the heart of BLIDS is a geographic information system (GIS) from Siemens. The system links maps with other spatial information, such as fixed data that is rarely updated — for example, land registries, including canals and pipes. With BLIDS, data about the properties of a lightning strike or electric current's strength can be called up immediately. Customers can thus respond quickly to any changes.

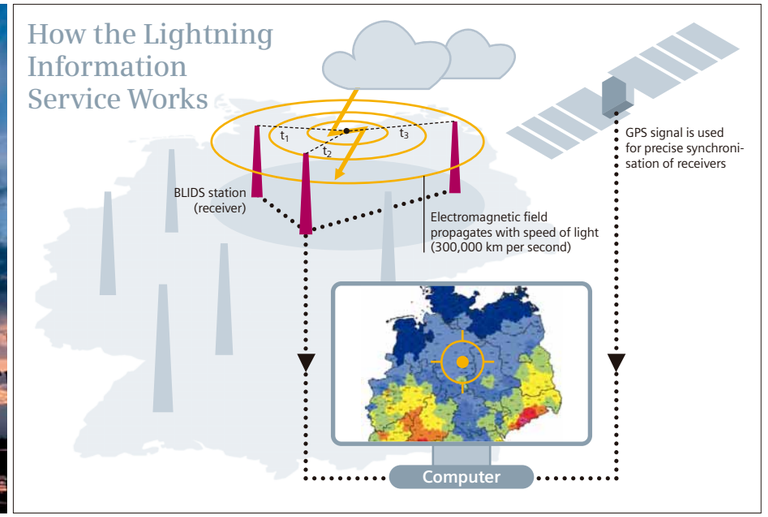
"This information keeps us abreast of the latest developments," says Thern, who plans to link existing geographic information more closely with weather and facility data. Once all the data is incorporated into the GIS, companies responsible for free-standing power lines will be able to discern at a glance whether part of a network is down due to a lightning strike or a fallen tree, for example. Thern can also imagine a BLIDS smartphone app for hikers, spectators at open-air festivals, and soccer referees (who could use it to decide whether a match should be interrupted due to a storm). "We'd be more than happy to get an order from the German Soccer Federation," he says with a broad smile.

Managing Emergencies. But Siemens' technology doesn't just give advance warning of lightning strikes. Whereas lighting strikes kill around a thousand people a year worldwide, heavy floods such as those that occurred in Thailand in 2011 can result in hundreds of deaths in a short period. The Geneva Association, a research organization operated by the insurance industry, estimates that fires in industrialized countries cause financial damage equivalent to one percent of their gross national product. Around 600 people die in Germany every year due to fires in buildings; the figure for the U.S. is over 3,000. State-of-the-art disaster management systems could reduce these numbers.

If a blaze does break out, it's important to have fire protection systems that react flexibly and intelligently. "Living and working conditions are becoming more and more complex," says Markus Niederberger from Siemens Building Technologies in Zug, Switzerland. "Fire alarms aren't enough any more." Niederberger and his colleagues are now attempting to link various safety and alarm systems in a smart overall package. "We want to develop a fully automated system that includes everything from fire alarms to emergency lighting and evacuation," Niederberger explains. Not all the technologies needed are available yet, but the key components already exist. Siemens, for example, supplies complete building management systems that monitor and control various subsystems, such as fire alarms.

Intelligent emergency systems recognize specific situations and autonomously implement appropriate measures. Siemens offers, for example, a mass messaging system that provides information to everyone affected by an emergency situation. "This technology is already well established in the U.S.," says Niederberger. For example, many American universities now have systems that use electronic displays on campus, or send e-mails or text messages to alert students if a fire breaks out or some other catastrophic event occurs.

In addition, smart emergency systems should also be able to guide people away from danger. In the future, a voice-controlled evacuation system is to provide appropriate information in every part of a building. To this end, the system also needs to know where people are located. "In other words, there's no need to use the standard evacuation plan in an office building where only one floor is occupied at night because an event is being staged there," Niederberger explains. He and his colleagues are now trying to devise a viable solution for an occupancy detection system that will automatically locate unconscious people as well. "Various ideas are being considered, such as video cameras, infrared detection, and even smart flooring that can register differences in pressure. At the moment we're evaluating a



range of technologies." The package will also include simulation software that is now being developed by engineers at Building Technologies and Siemens Corporate Technology (CT).

Closer Monitoring of Levees. Unlike buildings, levees are not checked very often, and monitoring tends to be random. "That's not good, given that more than two thirds of all European cities are susceptible to flooding," says Robert Meijer from the Netherlands Organization for Applied Scientific Research (TNO). Meijer, a physicist, therefore launched the EU UrbanFlood project in 2009 (see *Pictures of the Future,* Fall 2010, p. 68).

Together with Siemens and other partners, he developed a system that monitors levees and triggers an alarm when danger threatens. At Siemens Corporate Technology, Bernhard Lang and his team of engineers intend to make flooding protection systems as intelligent as those used for fire protection. To this end, early-warning systems are to be combined, for example, with lock, wastewater and drinking-water supply systems.

ger of breaking. "We use the sensor data and features extracted from the data to create a set of portraits of the levee in its normal state," Mokhov explains.

If an exceptionally strong deviation from the reference data is later observed, the software will issue an alarm. Because the system learns, the more situations it "experiences," the better it gets. That's why it is being trained in experiments at a test levee in the Netherlands and in simulations conducted by researchers at the University of Amsterdam and Siemens CT. The programs are being taught to use physical formulas to determine how the state of a levee changes in different situations.

With a view to bringing such solutions to the public, Siemens and TNO have developed an interactive multitouch levee analysis platform. In visitor centers in Boston and St. Peters-burg, as well as in Siemens' 'The Crystal' city development center in London, people can use their fingers to zoom in on a levee in Eemshaven, the Netherlands, on a map that was put online by the UrbanFlood team. Touching other parts of the screen makes data

A Siemens software package can predict levee safety levels using current measurement data.

Of crucial importance here are the sensors that monitor levees online. Meijer and his colleagues are currently testing various probes that record parameters such as pressure, temperature, water speed, and ground moisture at several levees in Boston (UK), Rees in the Lower Rhine region in Germany, and Amsterdam. However, there is a problem: So far there isn't really enough data to determine what the normal state of a levee should be and thus recognize when things might be getting critical.

A possible solution is the use of computer programs that combine machine learning and signal processing. For instance, Siemens experts working under the direction of Ilya Mokhov in St. Petersburg, Russia, have developed and integrated algorithms that use measurement data to detect when a levee is in danfrom sensors inside the levee visible in the form of curves and time lines.

Still, the UrbanFlood team has a long way to go if Robert Meijers' dream of monitoring all levees in Europe online is to come true. His researchers want to start with a 50-kilometer section of the Rhine levee on the border between Germany and the Netherlands. Meijer believes Europe's biggest river is the ideal test object. "When you stand on the levee in Rees and see just how far away the other bank of the river is, you get a good idea of the huge amount of water that flows through here," he says. In any case, the people who live in the villages protected by the levee will be happy to know that the barrier that keeps their homes safe will soon be precisely monitored around the clock. ■ *Ute Kehse*

To find out how crowds will react during evacuations of huge public events such as soccer games, Siemens researchers are developing ground-breaking simulation programs. Pictures below: red areas indicate potential congestion.

Technologies that Touch Lives | Safety

No Cause for Panic!

Simulation technology is helping safety and security specialists recognize dangerous situations at large public events before they happen — and to plan preventive measures. Siemens researchers want to make building evacuations safer, even in case of fire.

Again and again, disasters strike and cause widespread panic — whether it's fireworks lobbed into crowds during a sports event or a fire at an airport, nightclub or hotel. With a view to understanding crowd dynamics, researchers are examining whether people react to events in specific patterns and whether threats can be recognized and perhaps headed off. One such researcher is Dr. Wolfram Klein, a mathematician who works at Siemens Corporate Technology (CT) in Munich. Together with his team, Klein has developed a model that simulates crowd behavior, thus helping researchers to predict where and when a critical situation may arise.

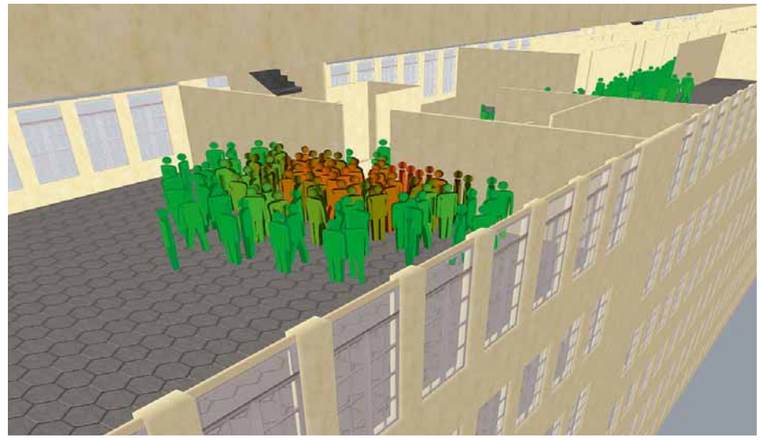
Klein's model can simulate the way in which crowds of tens of thousands of people behave. What's interesting, according to Klein, is that "they move very similarly to liquids or gases." Like molecules, people either attract or repel each other. For instance, family members try to stick together, while they automatically maintain a certain distance from strangers.

In addition, when people move through buildings they have to navigate around walls and other obstacles; and, of course, small, narrow spaces can lead to congestion. "Based on the principles of alternately attracting and repelling forces, we can chart human behavior and produce predictions in terms of mathematical equations," says Klein (see *Pictures of the Future,* Fall 2009, p.101).

The software could help architects plan safer buildings — say a stadium, airport or trade fair hall — because it can identify which spots might give rise to dangerous situations. Klein is certain that comparatively simple procedures and planning steps could prevent many disasters. "Even setting up so-called breakwaters — in other words, artificial obstacles — would suffice to divert crowds early on," he says.

In order to illustrate human behavioral patterns even more realistically, his team has continuously refined its simulation model. For instance, the software now not only uses statistical methods to depict the effects of a person's age and health on their walking behavior, but also takes group interaction into consideration as a factor.

Says Klein: "Elderly people move more slowly, while school children are taught to walk together in groups of two." In addition, the Munich-based researchers have improved their mathematical calculations significantly. According to Klein, the system is now so fast that their crowd simulations can be used to make short-term predictions. "We can tell up to five minutes beforehand what is likely to happen assuming that no one intervenes. This



way, the head of operations at a facility could act quickly, for example by opening additional doors or giving precise warnings in order to influence events and prevent disasters."

This method of crowd control has already been tested in various research projects, including one carried out at Frankfurt's central train station. Based on surveillance camera footage, the software was able to accurately predict the flow of pedestrian traffic — as well as congestion — several minutes before it occurred. The program has also been successfully used in and around the soccer stadium in Kaiserslautern. Evacuating the city's stadium would be a dramatic challenge for the police and fire department. Although the stadium accommodates up to 40,000 people when it is full, it offers only a few escape routes. And to make matters more difficult, all of them lead through the surrounding residential areas. As a part of the REPKA project (Regional Evacuation, Planning, Controlling, and Adaptation), which is funded by the German Federal Ministry of Education and Research, Klein's team has adapted the simulation models in such a way that they can now be used to plan a mass evacuation.

Safe, Quick Evacuations. In the future, the researchers also want to use this knowledge to support their colleagues in Siemens' Building Technologies Division. To this end, in the Swiss town of Zug experts are developing dynamic fire protection solutions for buildings — so-called intelligent response systems (see p. 94). Christian Frey, who is responsible for innovations in Zug, explains: "These are highly professional systems that can react immediately and effectively to dangerous situations or incidents."

Frey points out that in order to get people out of a burning building safely and quickly, the usual green signs along hallways indicating escape routes are not sufficient. In public buildings such as hospitals and hotels, he says, most people aren't familiar with their surroundings. "If you're in a panic, the next emergency exit isn't that easy to find."

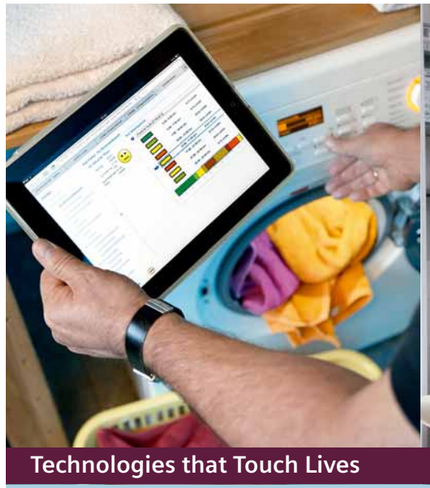
Studies also show that many people fail to react appropriately to conventional warning signals such as honking or sirens. They often think it's just a fire drill or a false alarm — or else they don't know what to do. This is where information technology can help. For instance, office workers could receive automatic warnings and updates on their personal computer screens. At the same time, large electronic screens in the hallways and smartphones would display arrows showing people how to get out of a building. In addition, sensors in ceilings and floors would be able to measure the stream of people.

Based on this information, an intelligent building software system would be able to recognize early on when a particular escape route is in danger of becoming overcrowded. It would then respond by directing people to the fastest and best alternative route out of a building and into the open. Visual systems would also be complemented by voice alarms and mass text messages. "Clear, precise announcements would additionally enable a rapid and orderly evacuation and prevent panic from spreading," explains Markus Niederberger, who is in charge of Business Operations for the intelligent response systems.

Fire Department App. What's more, such systems will be able to improve building management and support rescue workers. "The system analyzes data from a building, recommends immediate measures to defuse the situation, generates dynamic, up-to-date instructions, and helps rescue workers manage the evacuation and direct people to escape routes," says Frey, describing the idea behind the software concept. In the future, he adds, when a fire breaks out, the building management system will immediately link up with the fire department's computer system. Rescue teams and fire fighters would then receive a blueprint of the building on their smartphones. Such a plan would not only display the source of the fire, but also monitor how it is spreading. In addition, intelligent movement sensors would indicate where people are located in the building.

Together with other companies and institutes, Siemens researchers are developing these technologies as a part of the EU DESSiRE (Designing Safe, Secure and Resilient Large Building Complexes) project. Siemens' simulation experts from Munich are also assuming an additional role. Specifically, they have developed a method that allows them to predict the spread of fire in different kinds of buildings. Klein explains how it works: "We can light a virtual fire in order to see how it will affect each building." The researchers can simulate fire in various surroundings and different interior fittings — for example, with or without furniture, or with flammable or flame-resistant materials. By trying out these different scenarios, the heads of operations can learn to predict the spread of a fire more accurately and to thus act promptly and effectively according to a given situation.

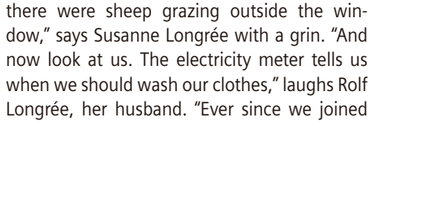
Nevertheless, Klein cautions that it will take some time before these response systems can be combined with intelligent building control. "But until then, our simulations will help improve rescue workers' training, prepare them for an emergency — and thus hopefully save many lives," he says. ■ *Hans Schürmann*



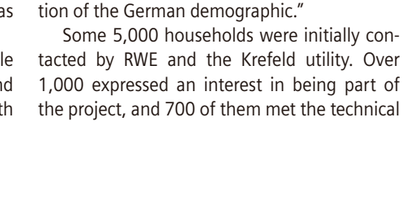
A smart meter displays current power usage. Via an online energy marketplace Rolf Longrée can control appliances in line with the price of electricity. A combined heat and power unit (below) produces electricity and hot water.

Technologies that Touch Lives | E-DeMa Project

When Data Comes Home



For many people, using smartphones, social networks, and online shopping is as normal as driving a car. These inventions have three traits in common: they're fun, easy to use, and part of daily life. Something similar is happening in the way power is supplied to our homes. A major field test in Germany demonstrates why, given the right data, it can be fun to save energy.



It's the start of a new day for 700 households in Krefeld and Mülheim an der Ruhr, two cities in west-central Germany. The smell of coffee drifts through from the kitchen, the buzz of an electric razor is heard from the bathroom. At first glance, there's nothing out of the ordinary here. What we don't see, however, is the work done by smart technology to help these homes save power and prepare the rest of us for a new era in energy management.

Take the Longrée family, for example. They live in a new housing development in Saarn, a suburb of Mülheim. "We were one of the first families to build here 17 years ago. Back then, there were sheep grazing outside the window," says Susanne Longrée with a grin. "And now look at us. The electricity meter tells us when we should wash our clothes," laughs Rolf Longrée, her husband. "Ever since we joined the E-DeMa project, our house has developed a mind of its own!"

"E-DeMa is the largest field test of intelligent power use in private households ever conducted in Germany," explains Michael Hufnagel, project manager at the Siemens Smart Grid Division. E-DeMa stands for the "development and demonstration of locally networked energy systems toward the E-Energy marketplace of the future." As Hufnagel explains, "All of the participating households are connected with our online marketplace via sophisticated information and communication technology (ICT). The technology allows them, for example, to monitor their power consumption, as well as electricity prices."

Back in 2009, companies including Miele (appliances) , ProSyst (software), Siemens, and the Krefeld municipal utility, teamed up with institutes of higher education from Dortmund, Bochum, and Duisburg-Essen to take part in a project led by power company RWE. To date, the project has been a big success. "The actual field test has been under way since March of this year. It was originally scheduled to run for nine months, but now we're thinking about extending it beyond the date when funding from the Federal Ministry of Economics and Technology comes to an end," explains Prof. Michael Laskowski, chief project manager at RWE. "The two pilot regions are located in Germany's most densely populated federal state and provide us with a representative cross-section of the German demographic."

Some 5,000 households were initially contacted by RWE and the Krefeld utility. Over 1,000 expressed an interest in being part of the project, and 700 of them met the technical requirements, which included having a home PC and Internet access. "We're pioneering a technology that may one day be used in all households," says Rolf Longrée, when asked what motivated him to take part. As the managing director of a building supply company, he has plenty of experience in running big projects, whether in Germany, the U.S. or Dubai. Presented with an opportunity to help pave the way for a new era in energy use, he set about the project with a similar level of enthusiasm. Besides, as Laskowski explains, after completion of the field test, RWE and the Krefeld utility will reward participants in Mülheim with up to €25,000 and in Krefeld with up to €10,000 to spend on energy-efficient and social projects in their respective neighborhoods.

As a first step, each household's electricity meter was replaced with a digital smart meter. "The households in Krefeld have all been fitted with AMIS meters from Siemens," Hufnagel explains. These are equipped with a communications module known as a gateway. The module reads data from the smart meter and receives pricing information from the E-DeMa marketplace. That way, households have much tighter control over their power use. Smart meters record power consumption data on an internal memory chip at 15-minute intervals. Once a day these data are anonymized and transmitted via the power lines to an energy-data management system.

Known as Siemens Powerline Communication, this data link operates at transfer rates of over one megabit per second. "EnergyIP is a solution that automatically transmits consumption data from a meter to a power company," says Hufnagel. Participating households in Mülheim are fitted with technology from RWE. "In place of AMIS meters, we use our own multi-utility communication controller, which transfers consumption data to RWE via the GPRS mobile communications network," Laskowski explains.

Energy Marketplace. All the households in the field test have one thing in common: access to an online energy marketplace developed by Siemens. This is the core of E-DeMa. "It enables participating households to monitor their consumption," Hufnagel explains. "At the same time, each day, the power companies determine up to five different tariffs for eight different periods of each day. The prices for the following day can be viewed from 6 a.m. on. This gives participants an opportunity to program their household appliances accordingly." Households with only basic appliances have to switch them on by hand.

Some 100 households that were selected at random have been equipped with smart appli-

ances from Miele. "These appliances automatically choose the lowest tariff for their operating cycle," Laskowski explains. This works by means of a communication module that looks like a standard industrial PC. Inside, however, is integrated software specially developed by ProSyst, which connects the household to the marketplace and is also able to execute concrete instructions regarding operation of appliances. "Each appliance is directly controlled by software installed at the RWE data center. We call this an aggregator control system; it calculates the optimal switch-on time for the appliance on the basis of the current availability of power and the stability of the grid," says Dr. Klaus-Martin Graf, who is responsible for aggregators at Siemens.

In other words, the appliances are switched on only when power is readily available and therefore cheap. Another 13 households, including the Longrée's, were fitted with combined heat and power units (micro-CHPs). In addition to producing hot water, these can also generate electricity. "If demand for power exceeds the amount currently on offer from the utility, the micro-CHPs can be activated via the gateway to feed electricity into the grid," Laskowski explains. Eleven of the 13 micro-CHPs in Saarn were installed by Medl, a local utility. Medl will operate these units for the next five years and provide general support for participating households. "We've got our own heat and power plant in the basement, and, theoretically at least, it's earning us money as well," says Rolf Longrée with a grin.

Valuable Feedback. The savings resulting from the E-DeMa project have not yet had a direct impact on electricity costs. At present E-DeMa is only an experimental game in a virtual power market, with fictional prices and monthly bills that show how much the participating households would have saved in comparison with their normal electricity costs. Yet the Longrées do have one real benefit: They can see when they use the most power and alter their habits accordingly. "As a result, we now turn the washing machine on only when E-DeMa tells us that the power is cheap," says Susanne Longrée. The results are revealing. Compared to an average German household with average use habits and the same power demand as the Longrée family over the same period in 2011, the Longrées have saved over 10 percent simply as a result of enhanced awareness of how to be more efficient in their use of electricity. This is the first step toward smarter use of energy at home. The challenge now is to make this system suitable for widespread implementation. The people of Saarn and Krefeld are certainly ready to make the change. ■ *Hülya Dagli*

The Shisong Hospital in Cameroon has set a precedent for healthcare in Central Africa. The hospital is equipped with a state-of-the-art catheterization lab.

Technologies that Touch Lives | Cardiac Care in Cameroon

Hope for African Hearts

Patients with heart diseases in Cameroon used to have to travel great distances to receive life-saving surgery. Siemens is now helping Cameroon's Shisong Hospital to bring healthcare to places where it's needed by supplying Central Africa's first-ever catheterization laboratory.

It isn't easy to get to Kumbo, a city of around 100,000 residents in northwestern Cameroon. The only road between Kumbo and the district capital Bamenda 100 kilometers away is dusty and full of potholes. It takes five hours to make the trip in the dry season — and, at its worst, three to five days in the rainy season. Nonetheless, Kumbo is a busy place where you'll find motor taxis speeding down red sandy streets and merchants displaying their wares on blankets or in wooden sheds.

Shisong Hospital, which was founded in 1935 by Franciscan nuns from South Tyrol, is located on the city's outskirts. The hospital started out as a small maternity clinic to help combat the high rates of infant mortality and maternal death in the region at that time. Thanks to the nuns' tremendous efforts over decades and donations from Europe, Shisong Hospital now has more than 350 beds and can accommodate about 100 additional outpatients in its various wards. Eleven years ago, a priest from Milan was looking for an African clinic to which he could donate a cardiac treatment center. He ultimately chose Shisong Hospital because of its solid reputation.

Sister Appolonia Budzee, the "heart and soul" of the hospital, believes this is the right approach. "We want decentralization; all the modern facilities don't have to be in Yaoundé or Douala," she says in reference to the political and economic centers of Cameroon. "Kumbo could soon become the capital for medical treatment in this country." The new cardiac center, which was commissioned in 2009, is already something special in the region. "Shisong is the only facility of its kind in all of Central Africa," says Sister Appolonia. "People come here for treatment of cardiovascular diseases from all over Cameroon, as well as from neighboring countries like Nigeria and Gabon — and sometimes even from Ethiopia, which is 5,000 kilometers away."

With the ultramodern cardiac center, which includes two operating rooms and an intensive care unit, doctors in Kumbo could revolutionize medical care in Central Africa. For one thing, patients who previously had to travel to Europe for complicated heart surgery can now be treated and operated on in Cameroon. Because more than half of Cameroonian cardiac patients can't afford to pay for their treatment, the cardiac center at Shisong Hospital runs a fund-raising Heart Foundation. The money helps to ensure that its medical services are available to everyone.

The flagship facility at the cardiac treatment center is a state-of-the-art catheterization lab — a high-tech facility that is used to detect and treat cardiovascular diseases. The core component of the lab is a new angiography device from Siemens, which has sharply reduced the need for open heart surgery. These days, a small incision is made in the patient's groin in a minimally invasive procedure. A catheter, is then inserted into the incision and pushed up to the heart. Surgeons know where the catheter is at any given moment because they can use the angiography device to take digital X-rays of the patient's body in real time from numerous angles during a procedure. They can then view the resulting images on three flatscreen monitors.

The images thus produced at Shisong Hospital are stored in a Siemens IT system. This makes it possible to compare them with images from other stages of an illness, which in turn allows physicians to determine whether an operation has been successful. "Microsurgery techniques help us operate more quickly and accurately, and patients also recover more rapidly after operations," says Dr. Jean-Claude Ambassa, one of the resident cardiologists at Shisong Hospital. "We decided deliberately to go for the latest angiography model," says Sister Appolonia. "Older equipment might seem cheaper in the beginning, but it gives you trouble later."

From Forchheim to Kumbo. Bringing the high-tech unit to Kumbo proved to be a big challenge for Benjamin Wallon and Bruno Peynshaert, two service technicians from Siemens Healthcare. For example, the 9,000-kilo unit first had to be disassembled at its production facility in Forchheim, Germany.

To ensure the heavy equipment's proper transport by ship and truck, it then had to be carefully and securely packaged to make it shockproof during the trip. Wallon and Peynshaert then spent three weeks in Kumbo with technicians from Shisong Hospital, putting the pieces of the high-tech puzzle back together. They worked from dawn to dusk until the unit was ready to operate. During that period, each individual component had to be bolted together and all the mechanical parts, cables, and electronic functions had to be properly calibrated. Wallon and Peynshaert also spent an entire week teaching technicians and physicians how to use the device in order to ensure that they would require as little assistance as possible from outside sources later on.

Peynshaert is confident that the new catheterization lab will be very useful. "In developed countries, such labs generally operate for about nine years before they become outdated. But if the doctors in Kumbo are careful, they can use their device for 12 years," he says. Moreover, even if a software error should occur in the future, service technicians can access the device via the Internet and correct the problem. This function is made possible by the hospital's relatively stable Internet connection and the Siemens Remote Service program, which alerts a service center in Germany before a device fails.

Despite Shisong Hospital's impressive history of success, its officials still have to deal with major challenges. Well-educated Cameroonians prefer to go abroad to work. It is therefore difficult for the hospital to find qualified personnel. Only recently, for example, could a full-time heart surgeon be hired after a long search. And the hospital is still searching for an anesthetist. Ambassa is actually one of the few doctors in Kumbo who decided to return to Cameroon after studying medicine abroad. These days he is also preoccupied by a completely different issue, though. "Cardiovascular diseases could become the number one killer in Cameroon," he explains.

Indeed, the World Health Organization estimates that cardiovascular disorders accounted for 14 percent of all deaths in Cameroon in 2010 and that this percentage is rising. Ambassa attributes this development to poverty and late-stage diagnoses on the one hand and his countrymen's changing lifestyles on the other. "Many people opt for a European lifestyle. They eat more fat, don't engage in sports, and work in offices — that creates a lot of heart problems."

Over 10,000 people have come to Kumbo to be examined since the cardiac treatment center opened three years ago. "That shows how big the need really is," Ambassa says. The hospital plans to acquire a blood bank at some point in the next few years in order to ensure that the cardiac center always has enough of the blood plasma it urgently needs. The Cameroon government also plans to improve the roads. Nonetheless, the people who work at Shisong Hospital know there's still a long way to go before they reach their destination. ■ *Marc Engelhardt*

Working together with the Aroehan NGO, Siemens has equipped a remote Indian village with a solar power plant and a Skyhydrant water filter.

A Village Transformed

A small hamlet in India's Western Ghats mountain range has taken the first step toward integrated, self-sustaining development. The village's achievements offer hope for thousands of other off-grid people around the world who have no access to health, education, water, or electricity facilities.

When you do good, you will find people around you who will try hard to pull you down. Gain strength from this opposition, and continue on your chosen path. They will come round when they see you succeed," says the 'thought of the day' in Marathi — a language spoken in the Indian state of Maharashtra — on a notice board of Amle's only school.

Amle is 130 kilometers north of Mumbai. It is surrounded by a thick forest on three sides and a river on the fourth. It has 58 huts and 295 residents. The nearest town with a semblance of civilization is Wada, at a distance of 27 kilometers. It is — for those heading for Amle — the last outpost of phone connectivity. The entire stretch between the two towns is also devoid of streetlights.

Amle is one among the thousands of blink-and-you-miss-it hamlets that dot the length and breadth of India. During the monsoons, the only way to enter Amle is by wading through the river Gargai, which separates it from the rest of the world. On stormy days, it is impossible for anyone to cross it. In other words, the town is cut off from civilization.

Durga Bai, a wizened lady, who says she is 60 or 70 years old, has seen it all. Her hut is one of the larger structures in Amle. It is propped up by wooden beams. "When someone falls ill, we have two options — a primary healthcare centre and a rural hospital. Both are 20 kilometers away. We require able-bodied men to carry the sick on their shoulders," she trails off. Her thoughts turn to the many fatalities that the villagers have faced due to lack of medical aid. Most recently, in June three villagers died due to lack of prompt medical help.

"Water-borne diseases and ailments related to malnutrition are rampant in Amle. Add to this, social ills like illiteracy, alcoholism and child marriages and you can see that it is far from being a model village," says Shraddha Shingarpure of Aroehan, an award-winning NGO. The latter has not only introduced Siemens to Amle, but has also entered into a partnership with the company to bring about social transformation.

Durga's grandchildren are among the 29 students of Amle's school, a run-down shed-like structure of around 100 square feet. The school sees many dropouts — at present, only 30 adult males (out of 140) and ten females (out of 155) have finished school. A boarding school about five kilometers away offers the only alternative for students who wish to continue studying. Dilip Vare, the head of the village development committee, is the only one who has studied there.

Adopting a Village. For decades, Durga's day would start at 6:00 in the morning. She and her late husband would leave their children home and make their way to a farm just outside their village. They would be back home by 7 p.m. just as darkness set in. Droughts were common, as were the long treks for drinking water during the summers that left the village arid. On moonless or cloudy nights, the only sources of light were torches made of dried wood and twigs. Every home has a silo attached to it to store wood — the source of light and fuel for cooking food. The odds were stacked against Amle seeing any trace of development. It resides right in the middle of a protected forest conservation area. The state electricity board was thus unable to provide power to the hamlet.

All of this began to change in 2012 when Siemens adopted Amle, and Project Asha was launched. In partnership with Samved Energy Systems, an engineering, procurement and construction contractor, Siemens set up a 12-kilowatt peak (kWp) solar power station. The project team installed a simple-membrane water filter to provide clean potable water. This filter system from Siemens Water Technologies purifies up to 20,000 liters of unclean water per day by pumping it through a membrane of ultra-fine fibers (see *Pictures of the Future,* Fall 2011, p. 37). Siemens' partner Aroehan also helped set up bunds — miniature dams — and infrastructure for rain water harvesting, allowing year-round irrigation, and thereby providing a source of livelihood.

Prashant Chandwadkar, who works for the Siemens Infrastructure and Cities Sector — more specifically for the Low and Medium Voltage Division — volunteered as project manager for Project Asha's technology implementation. "I am glad Siemens has adopted the village and is bringing in progress," he says. "Every village in India could be similarly transformed through technology."

Initially, Prashant and his team struggled in the face of a lack of skilled manpower in the village. However, local people were soon trained in the basic skills of handling equipment. A Siemens engineer supervised their worksite. "A big challenge was access to the village. The truck transporting the equipment had to be parked four kilometers away. The villagers took over, carrying heavy batteries, cable drums and inverters on their heads and walking down a rough path, wading through the river and again up to the village. All of this proved that the villagers were as determined as we were to make the project a success," Chandwadkar adds.

The day the 20 streetlights lit up the village, in July 2012, Durga said that it felt as if she was in Mumbai. "Mumbai has come to us, and hopefully in the future nobody from this village will have to move to Mumbai to earn a livelihood." Shraddha agrees. "With power, the villagers are now capable of complementing their meager income by preparing masala (mixtures of spices) and other cottage industry products that they can sell. The water filter will reduce the incidence of water-borne diseases. The village officials had dug a well, but it had limited use until the Siemens solution came along," she says. The additional crops and vegetables that are cultivated also help improve nutritional deficiencies.

Dr. Armin Bruck, Managing Director, Siemens Ltd., adds: "Apart from bringing in solar energy, pumps for irrigation, and a water filter for drinking water, we are also involved in bringing about social change. We are doing so by increasing health awareness among adolescent girls, the empowerment of women, and adult literacy. Agricultural support will also ensure the village sustains itself with year-around farming."

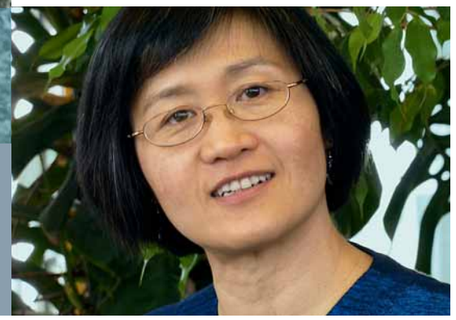
Why People Will Want to Stay. Vilas Erande of Samved adds a word of caution, though. "The children can now see and learn at night, not just listen. But unless villagers are trained and sensitized to the use of technology, the model may fail. You need someone accountable to look after it." The village school's teacher, Janardhan, offers his advice on how to make the model work. "The villagers, like other consumers, will not value what is freely available. They will appreciate the true value of development only when they pay for it," he says. With this in mind, Amle's development committee has decided to charge each household $1 per month. This amount will be used for the upkeep of the system, and will also help make the project self-sustaining.

As the head of the village development committee, Dilip Vare, a wiry youth in his mid-twenties, has the last word. He has been to training seminars and conferences where he learned how even basic technology can transform his village. "The village needs its people. This is just the beginning; eventually we will have enough opportunities here to ensure that they want to stay," he says. Project Asha has brought hope to a village. Amle has gone from being a remote, inhospitable hamlet to a model, not just for the rest of the country, with its 120,000 off-grid villages — but for the rest of the world. ■ *Bijesh Kamath*

Women who earn technical degrees are virtually certain to have great career prospects and enjoy a wide variety of development opportunities.

A Man's World? Think Again!

Technology-oriented companies urgently need well-trained female employees. However, few are available today. And in many countries, huge obstacles still prevent young women from choosing careers in the fields of engineering and the natural sciences. And yet the outlook for young women in these fields could hardly be better.



Lee Ng's commute to work takes her through Silicon Valley. This is where many big ideas and major companies either got started or found a home — firms such as Google, Adobe, Apple, and Facebook, to name just a few. Lee, 49, works for Corporate Technology (CT) — Siemens' global research organization — at the Siemens Technology-to-Business Center (TTB) in Berkeley, California, right in the middle of this start-up paradise. Her job is to spot ideas and innovations that might prove interesting for Siemens' business areas. Lee generally goes directly to the founders of interesting start-ups and offers assistance, but she's also good at sounding them out. "I know how to ask the right questions and what it means to establish something new," she says.

That's largely due to Lee's own experience. A native of Singapore, she first attended a girls' school, then decided to go to a polytechnical academy rather than high school after she turned 16. "When I entered my second year there, I was suddenly the only woman in my entire grade — all the others had given up. At that point at the latest, it became clear to me that my academic interests were unusual for a woman, to say the least." At the age of 20 Lee decided to take her chances in the U.S., enrolling at the University of Texas in Austin to study mechanical engineering. She later went on to receive a PhD from the renowned Massachusetts Institute of Technology (MIT), where she decided to switch her focus from mechanical engineering to materials research. "It was all completely new to me," she says. "I had to work hard to catch up with everyone who had learned the basics in bachelor and master programs. I'm very competitive, though; I can't tolerate not knowing things."

Three years into her career, Lee had her first baby and quit her job at a consulting firm. She took only about eight months off and then worked briefly as a freelancer before catching the Silicon Valley bug and joining an IT company there. She had two more children in the next five years, and despite the great understanding she received from her supervisors, various breaks, and part-time work, she eventually reached the limits of her ability to work effectively. "If you only work half-time, all the routine tasks build up and you don't have enough time to do your real job," Lee explains.

Her husband helped her out by going freelance after the birth of their third child and taking on more responsibility for the household and the kids. The arrangement made sense because Lee's husband, as a freelance IT specialist, could also work in the evenings and on weekends. The children are now 19, 17, and 15 years old. The oldest, a girl, is in college; Lee's two sons are still in high school. "The main thing for me today is that my kids can reach me when they need to and that I'm there to listen when they have problems," says Lee.

Along with her job as a technology talent scout, Lee is now also putting her entrepreneurial skills to work as a trainer in "business boot camps." This involves helping women gain a better understanding of business issues. "There are two important problems here," Lee says. "One is that many women are afraid they'll become absorbed in their jobs and lose more and more control over their lives as they climb the career ladder. The other one is that women sometimes lack the experience they need in order to make firm business decisions."

The new seminars at the boot camps are organized by Siemens' global Diversity Office in cooperation with GLOW@CT (Global Leadership Organization of Women) — the internal women's network at Siemens Corporate Technology. The very positive response to the program has surprised even the organizers, and the Chief Diversity Office is now planning another boot camp in Brazil. Additional camps are planned for various locations around the world.

The boot camp is just one of many initiatives that Siemens is launching within the framework of various projects and programs for women in the MINT professions (Mathematics, Information technology, Natural sciences, and Technology). These programs address the early stages of women's professional development, because although many women have what it takes for training and education in MINT fields, only a few of them plan to pursue a technical career. In Germany, for example, only one out of every five engineering graduates is a woman, but only one out of ten engineers is a woman. "We need and want to benefit from women's potential at every level of the company. In particular, women with college degrees in engineering and the natural sciences have outstanding opportunities at Siemens. We offer them work in pioneering technology fields, exciting assignments abroad, and many opportunities for personal development right from their very first day on the job," says Brigitte Ederer, Member of the Managing Board and Head of Corporate Human Resources.

Networking for Young Ladies. The share of women in engineering professions at Siemens worldwide is currently just under 14 percent; the figure for Germany as a whole is only 8.5 percent. To offset this imbalance, Siemens launched its YOLANTE (Young Ladies Network of Technology) mentoring program ten years ago. The program's goal is to get young women interested in studying technical and natural science subjects and to support them. The network's membership, now at 350, has grown steadily since its establishment in 2002. The fact that the initiative adds about 100 new members every year demonstrates its success. The program offers individual consultations, supports young women in their search for internships at home and abroad, helps students find part-time jobs related to their respective fields, offers special training courses, and provides access to a broad network of active and

Anne Schannong Vinther, Denmark: Between Heaven and Earth

"I feel really free when I'm up there," says Anne Schannong Vinther, 28, who leaves her office for about a third of every year in order to go 70 meters up into the air in a climbing harness. Vinther is an engineer who works at Siemens Wind Power in Aalborg, Denmark, where she helps to ensure the quality of rotor blades for large wind energy facilities. This requires her to rappel herself down from the nacelle so that she can closely inspect the rotor blades. "Although it looks very spectacular, we plan every mission in such detail that things can't get very scary. Safety always has top priority," says Vinther, who forwards the results of her inspections to her colleagues at the development department. The rotor blades of wind turbines have to last for a long time, despite the fact that the wind puts them under a lot of strain. In fact, air masses often subject the blades to pressures of up to 100 metric tons. Vinther began working for Siemens in Aalborg while she was still writing her master's thesis. By now she has become an expert in her area of specialization. "I've always liked math and physics. I liked it when I could achieve palpable results," she says about her schooldays. Although studying industrial management systems in Aalborg was challenging, it was also interesting, Vinther says. "You don't just learn a lot about a specific field — you also find out how to access new areas of knowledge. That helps me in my job, because I always have to keep abreast of the latest developments," she explains. Another aspect Vinther likes about her work is the fact that the three men and three women in her team ideally complement one another. "It's very important to know that we can rely on each other one hundred percent, especially when we're conducting inspections out in the field," she says. Vinther's office is located right next to the plant in which the huge rotor blades are made in one piece. This helps her communication with other departments. Even though the production process is being increasingly automated in order to further reduce the cost of wind power, considerable manual skill is still required to make the rotor blades. Employees are proud of their product, and the task of making the blades is regarded as much more than a job by many of the workers. "I like working for a company that's involved in creating sustainable forms of energy," says Vinther. "The future belongs to natural resources like wind power. Once you've worked for a green company, you don't want to go anywhere else!" ■ *Stefan Schröder*

former program participants at the company. Thanks to this approach, female students get to know Siemens early on in their development and receive an overview of the Group's corporate culture and the environment where they might be working one day. In order to ensure that the potential of young women does not remain undiscovered, Siemens, the Daimler AG Mercedes Benz plant in Berlin, and Deutsche Telekom have launched a project called VITAMINT, which is being funded as part of a Germany-wide initiative to promote equal opportunities for women in business. The project offers continuing education programs for teachers in order to expand the range of career choices for young women. In addition, company representatives and trainees provide information about various training and work-study programs in technical fields and assist young women who are interested in entering such professions. The German system of apprenticeships, which combines practical and theoretical work, is particularly attractive and is arousing interest well beyond Germany's borders. In fact, U.S. President Obama cited Siemens in his State of the Nation address as a model for his training initiative. He specifically referred to a Siemens pilot project in Charlotte, North Carolina, in which young women are completing apprenticeships in line with the German pattern. Siemens, in conjunction with local partners, is also carrying out projects that combine the workbench and the classroom in Brazil, Russia, and the Middle East. It's also carrying out school partnership programs in many regions, including Germany, Brazil, the Netherlands, the UK, Greece, Austria, and Denmark. These programs aim to generate interest in the natural sciences and technology among schoolchildren. In addition, Siemens employees in the U.S. regularly stage a Siemens Science Day at various schools to get children interested in math and science. The Group also works with schools in China, Thailand, Chile, the Philippines, and Turkey to support potential employees and ensure that women are a key part of the world of tomorrow.

■ *Maximilian Heinrich / Christine Auer*

Gerlinde Djumlija, Austria: Mill Technology Expert

Gerlinde Djumlija has long since accepted that she's both respected and feared for her persistent nature. She has achieved recognition in the field of steel manufacturing, where she is responsible for developing global business strategies. In the 1980s Djumlija was one of the few women studying at the technology-oriented University of Leoben in the Steiermark region of Austria. She was an exotic figure among the dozens of tech-savvy males in a field of study that was reputed to require nerves of steel. "I immediately fell in love with the metallurgy curriculum because it included so many natural science subjects," Djumlija recalls. She received her master's degree after six years — and by the time she was done, she already had a job offer. "Right after my last exam, someone from an engineering firm called me and asked me if I wanted to work there," says Djumlija. From then on, she immersed herself in technology, conducted research, calculated designs for industrial facilities, and carried out metallurgical analyses. "A rolling mill consists of hundreds of tons of steel, thousands of technical interfaces, and countless individuals who operate and support it," she says. "I still think it's a technological marvel that we can make all of these elements function together perfectly." The experience Djumlija was gaining led not only to more complex tasks but also to more responsibility. "I regarded every new task as an opportunity to develop personally and professionally," she says. Her persistence paid off. For the past three years she has served as the Head of the Business Excellence department in a Business Segment at Siemens Metals Technologies. In this capacity, her work has shifted toward areas such as strategy, product management, and marketing. About two months ago Djumlija assumed responsibility for Siemens' global business activities with hot and cold rolling mills, for which she now manages all aspects of sales and projects, among other things. Her advice for combining a career and family is simple: "You have to be self-confident and clear about what you want. My bosses let me set my own hours. I stay in the office until the early afternoon and then spend time with my two children. In the evenings I do teleworking, answer e-mails, and prepare for presentations and business appointments. If I have to be away in the afternoon, my husband or my mother watches the kids." For longer business trips, she plans everything in advance — for each day she'll be away and for each child. "Organization is crucial," she says. "But all of this would be impossible if it weren't for Grandma." ■ *Anita Bruckmüller*

Anitha PC, India: Software Development

Anitha PC spent five years teaching the fundamentals of computer technology at the Technical University of Visvevaraya in India. In 2004, when Siemens first opened its Bangalore Research Center, she applied immediately. "I was in the first group of people who were hired by CT in Bangalore," says Anitha, whose unusual last name, PC, is an abbreviation of a very long surname consisting of the name of her place of birth and her father's name. After receiving a bachelor's degree in electrical engineering at Kuvempu University in 1998, she went on to obtain a master's degree in computer science at Manipal University. Both of these universities are located in the Indian state of Karnataka, which is also home to Bangalore — better known as India's Silicon Valley. "While I was studying, I began to realize how important software was becoming in all areas of life," Anitha says. "Embedded software especially became more and more crucial, and today it can be found in everything from electrical engineering equipment to cars and communication systems. That's why Siemens is the ideal employer for me." Anitha still enjoys the fact that she is in charge of developing software for a broad range of products and equipment from all Siemens sectors. She is currently responsible for a research group studying user requirements and design.

Anitha invented a method for automatically translating domain-specific modeling languages (DSM) into a unified modeling language (UML). She eventually obtained a patent for this new technique. In 2009 she took on a management position in a newly formed team for requirements engineering. Its job is to develop precise knowledge of customer requirements at a very early stage in the planning process. This is becoming increasingly important as Siemens places more and more emphasis on developing "smart" products tailored to the Indian market. Anitha coordinates cooperation between her team and the respective product development engineers at Siemens' sectors. "We have to closely examine new products very quickly and be able to recognize potential development problems before they occur," she explains. Anitha immensely enjoys this software development challenge, which she needs to address every day in her work. "Anything else would be too boring for me," she says. She also likes to do different things in her free time. But although she enjoys variation in her routines, she can also appreciate the importance of permanence in life. That's particularly the case when it comes to her husband and young daughter. ■ *Katrin Nikolaus*

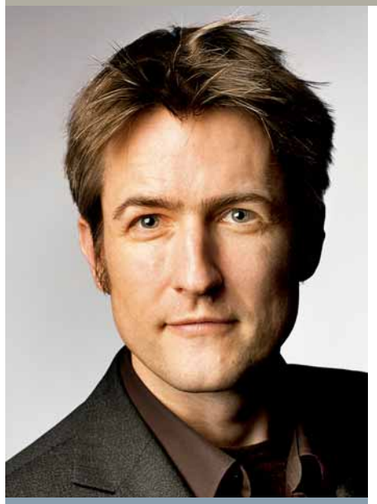
Dr. Anja Stieglitz, Germany: Materials for Rail Vehicles

Dr. Anja Stieglitz has always wanted to know how things work. Even as a small child, technology interested her, and she preferred to play with cars instead of dolls. As a young woman, she pursued her goal with great determination. After she received her high school diploma, Siemens gave her a scholarship so that she could earn a bachelor's degree in mechanical engineering at Niederrhein College in Krefeld. In addition to attending several Siemens design seminars, Stieglitz also took training courses in communication-related topics. During semester breaks she worked in a train assembly department, where she learned more about the company and engineering tasks. She subsequently earned a master's degree and at the same time took part in a work-study program devoted to manufacturing technology. She was promised a permanent position even before she officially obtained her doctorate. Today Stieglitz, 28, works at Siemens' development department for rail vehicles in Krefeld. One of the topics the department addresses is the joining of materials. "The different parts of trains are welded together or joined with screws or adhesives," she explains.

Although Stieglitz was pretty much the only woman among a crowd of men when she attended college, the situation is different at Siemens. "Twenty percent of the people who got Siemens scholarships were women, although only 15 people obtained scholarships altogether. Women even accounted for half of the scholarship recipients in the graduate program, although that's not too surprising since there were only four students in total," she says jokingly. Although women are a minority in her department, some of them occupy leadership positions. What Stieglitz particularly likes about her job is its diversity. She makes plans, conducts research, discusses the work, and documents the results. She also has to travel throughout Germany to evaluate products in manufacturing facilities. What's more, she also has a say in deciding which materials are ultimately used and how they should be correctly designed. In a sense, it's "high-tech handicrafts for grown-ups," she says.

According to Stieglitz, it's not hard to get girls interested in technology; all you have to do is to teach them at an early age that there's more to life than playing with doll houses and braiding hair. "Girls can stay girls, but parents should let their daughters play with cars, trains, and building blocks too," Stieglitz says. Her advice for women interested in engineering is: "Don't become discouraged just because you're in the minority! Women are just as good as men at earning engineering degrees." Anja Stieglitz is living proof of that. ■ *Ines Giovannini*

When Users and Computers Perceive Each Other Naturally



Professor Patrick Baudisch, 44, is the Head of the Human Computer Interaction group at the Hasso Plattner Institute in Potsdam. The group is responsible for developing interactive devices for the future. The researchers' focus is on developing new mobile devices such as cell phones, but also very large display systems such as electronic desks, walls, and floors. Baudisch, a computer scientist who received his doctorate in Darmstadt, previously worked at Microsoft Research in Redmond, Washington, and at Xerox Park in Palo Alto, California.

In one of your courses, you tell your students to design applications that can be operated by foot. What's the point of that?

Baudisch: We initially viewed this as a kind of thought experiment, a possible answer to the question of how computer users might be able to directly interact with large amounts of data. The size of today's multi-touch systems generally ranges from the dimensions of a cell phone to those of a coffee table. The reason why they're not any bigger has to do with the length of the human arm. So the question is: How can you implement the principle of "direct touch" with tens of thousands of objects? Why not use a pressure-sensitive touch-floor, for example? Here users can move between large volumes of data, as the touch-floor recognizes them on the basis of their shoe sole imprints and can also tell whether they're sitting, standing, or lying down. This idea has been developed further toward the concept of intelligent rooms.

Could such a technology make life easier for senior citizens?

Baudisch: That's exactly what we're thinking. Imagine that you're a senior and are able to use a system that allows you to live at home by supporting your daily activities and checking to see whether you're moving around enough or sitting in an ergonomic position. Such a system would also call for help if you fall, for example. Our touch-floor uses 13 million pixels that are analyzed 30 times a second to collect a huge amount of data. It's conceivable that in five to ten years you'll be able to roll out a touch-sensitive carpet that will detect and localize things in the room it's in.

What other electronic wonders do you envision for our aging societies?

Baudisch: A student of mine named Christian Holz is working on implantable interfaces — we're talking about 25 years into the future here. Many people today have implanted devices such as insulin pumps, pacemakers, and hearing aids. However, they cannot operate them. Instead, they have to go to a doctor to get the units configured. Christian is studying how people might be able to directly interact with these devices — right through the skin. It's an unusual perspective, but a very important one for our lives in the future.

What else might be possible in the next ten or 20 years?

Baudisch: One new thing we'll be seeing are ultra-mobile devices. These might be thumb-sized and could be worn as watches, pendants or rings — in other words, as part of normal attire. The devices will provide the wearer with access to digital information anywhere and at any time. The most extreme examples are the "imaginary" devices we are researching now. These have no display and can be as small as the user desires. One of our prototypes — the Imaginary Phone — works like a cell phone. The user interacts with it via a small camera that is worn on the body, perhaps in the form of a brooch. The camera monitors the user's hands, whereby the left hand represents the interactive interface of the cell phone. The user can then "type" with his or her right hand on the left one as if that hand were a touch screen.

Devices like the iPhone have revolutionized the market and the way we think. What type of device will we be using to make calls in 2017?

Baudisch: I can't tell you that for sure, but there's no doubt that desktop computers and mobile devices will merge until, at some point in the future, we will only be carrying a single computer around with us. It will have the shape and the functionality of a cell phone. When you get to the office, you'll connect this unit to a keyboard and a display, and these will then be your PC. Apple, for example, is now working intensely on uniting the functions of PCs and mobile devices to create units with standardized applications and uniform interactive principles.

Smartphones and tablet computers respond to gestures. Does this mean we're on our way to a multi-touch world?

Baudisch: We already have one. Multi-touch has been successful because it enables us to make devices smaller by overlaying the display and the input interface. Multi-touch supports people who are frequently mobile or who have to deal with lots of different people as part of their job — for example, doctors who need to go to many individual patients in a hospital and therefore carry their tablet PCs around with them.

Will we at some point be operating devices solely with gestures?

Baudisch: Definitely not. Certain types of interaction can be carried out very well by means of gestures — like conducting an orchestra or guiding an airplane on a runway. But what kind of gesture should you make if you want to ask an object for help? Intuitive gestures are limited to the applications they're associated with in the physical world.

Which technologies do you believe will ultimately succeed?

Baudisch: Interestingly enough, no specific technologies will dominate. Instead, you'll see an alternation between diversification and unification. An example of unification is Apple's approach of merging PC and mobile lines. Nevertheless, we will still have specialized devices. Fifty years ago writers used typewriters, but today they write on the keyboards of their PCs. This will remain the case, because a PC keyboard is the perfect component for writing. If you want to play the piano, you'll use a piano keyboard. However, despite the great variety of interface devices, you'll probably still have only one computer, which will not only reduce costs but also keep all of your data consistent. At the same time, there'll be different input and output devices, and people who usually work in one place will continue to use the keyboard-mouse setup for a longer period of time than you might think.

Will it be easier or more difficult for us to use technology 30 years from now?

Baudisch: It will be easier. Today's children are already growing up with devices that they understand better than they grasp the physical world around them. You may have seen the YouTube video of a small child who is holding something printed on paper in his hand and tries to swipe his finger over it to move the pages like on an iPad. We used to use metaphors from the physical world, like those related to an office, in order to explain computers. Your e-mail program has an "inbox" because that's where interoffice and outside mail was placed in the days before the Internet. Today's young computer users have never worked in an office, which means they learn such things from computers before they experience them in the physical world. The logical consequence of this is that we now more frequently explain the physical world in terms of computers — like light switches marked with "0" and "1."

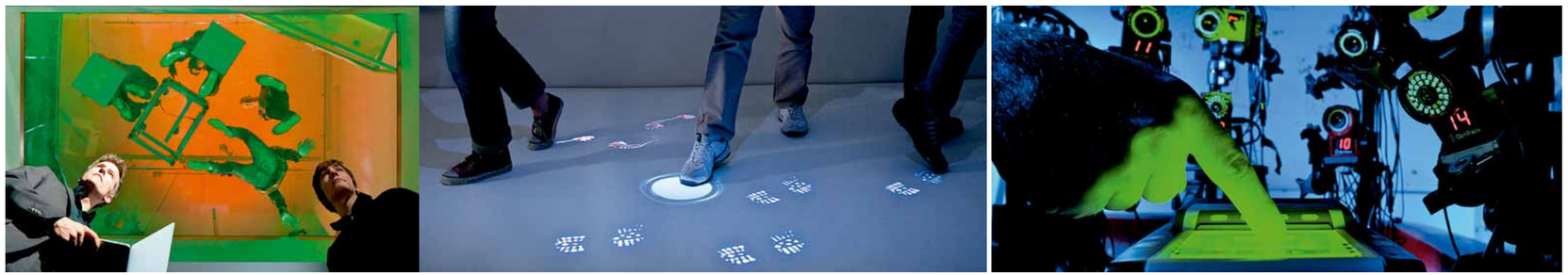
So you're saying we don't need intuitive systems because our way of thinking has adapted to the computer world.

Baudisch: Yes and no. On the one hand, as an application developer I can assume a lot more knowledge on the part of users. On the other hand, I want to make operating a device simpler and more intuitive with the help of natural user interfaces, or NUIs. NUI systems are based on "new" interaction technologies such as multi-touch surfaces, cameras, and microphones. The term NUI actually describes a fundamental development: Whereas the desktop computers of the 20th century perceived users merely as coordinate axes — in terms of the mouse cursor— NUIs enable computers and users to perceive one another in a much more natural manner. Now users see the computer interface in graphic detail — and the computer sees you in just as much detail due to your gestures, facial expressions, and voice. NUI input requires much more extensive interpretation than a conventional input device such as pressing the button for A and the device then gives me an A. In other words, if a computer sees a group of users with raised hands via its camera, the image can be interpreted in many different ways. The new challenge lies in eliminating the resulting ambiguity.

Researchers say that microchip performance will increase another thousandfold over the next 20 to 30 years. Do you see any technical limits regarding human-machine relationships?

Baudisch: The ability to make rapid calculations is definitely useful, but it long ago ceased to be an obstacle to progress in this field. For a certain period of time, there will still be limits regarding the miniaturization of batteries or the levels of brightness produced by very small projectors. The heat emitted by microchips is also often a problem. Nonetheless, the processor in your cell phone today is 350 times faster than the best computer from the 1980s. For quite some time now, the real limits to development have been the limits of human beings — aspects such as the resolution capacity of the human eye and the size of our fingers. In other words, interfaces have to accommodate human senses, which is why the issue of user interfaces is just as important today as it was in the 1970s, when Xerox developed and launched the first-ever user-friendly devices — the Alto and the Star.

■ *Interview conducted by Silke Weber*



Baudisch works on unusual applications — like touch-floors that respond to shoe sole imprints and can call for help in emergencies, and "RidgePads" (right) that are twice as precise as capacitive touch screens.

Envisioning a Simplified, Consolidated Stream for all Experiences

David Hillel Gelernter, 57, a computer scientist at Yale University, is regarded as a computer visionary. In the mid-1980s he developed software that helped to program the Internet and other computer networks. In 1991 he predicted the success of the World Wide Web and developed the concept of cloud computing. Still, the "rock star" of the digital world, as the *New York Times* has called him, is not really happy with the current state of computer affairs. He is calling for a new revolution — the "cyberstream."

You are unhappy with the current state of communications and information technology. Why is that?
Gelernter: The Internet and our modern means of communication still need to be improved. The problem is that humans are expected to adapt to technology, and not the other way around, as it should be.

Are you saying the iPhone and Android phones are not user-friendly?
Gelernter: Sure, they are nice designs, but through these devices we are confronted with an ever faster flow of information. This "cyberpulse" cannot be exactly quantified, but it can certainly be described. A century ago we still received information in the shape of handwritten letters, newspapers, books, and telegrams. Two or three generations ago these media were joined by phone calls, radio, and television. Today there is e-mail, online blogs, news and other websites, text messages, voice mail, and social networks. This speed and information density is not sustainable in the long run — people's receptivity has natural limits.

How should we handle it? Go on an information diet?
Gelernter: It wouldn't hurt, but ultimately the technology itself needs improving, by means of a simplifying level superimposed on all the various news and communication channels we live with. I call it a "lifestream" — it's the story of our lives in digital form. Every digital document I've ever created or received — all of my text documents, photographs, e-mails, my own entries on Facebook, Twitter, and so on — all that will be represented in a single data flow in the cloud, which I can access from anywhere and from any device. My graduate students and I developed these ideas in the early 1990s, but the time wasn't ripe for it.

But wouldn't we have to adjust to that too, since nothing like it existed before?
Gelernter: I don't see any problem there. After all, the lifestream tells stories — and that's one of the most natural human occupations.

Is a lifestream something like a timeline on Facebook?
Gelernter: Yes, but the lifestream should not be owned by any company. In the long run, this would change our understanding of the Web. We wouldn't see it any longer as static, but as a river — like a power grid that provides us with electricity when we need it. When I work on a presentation, I'll see everything related to the project — notes, e-mails, data from the Internet. I can take an e-mail I don't want to reply to right now and push it along the timeline into the future. The current situation, in contrast, is totally unsatisfactory.

Would the Internet of Things also be integrated?
Gelernter: Of course. One idea in my book *Mirror Worlds* (1991), was that the virtual world would reflect the real world. You see that already when your navigation software shows where to expect a traffic jam. In the future, my household appliances could provide me with information in exactly the same way.

And what about robots?
Gelernter: Robotics is physical, so it's developing at a slower pace than virtual space. Also, the pursuit of AI is far less ambitious today than it was 20 years ago. After all, it's very difficult, if not actually impossible, to replicate the human brain in a machine.

If our world is reflected entirely online, what will happen to our privacy?
Gelernter: Social networks have not created the trend toward self-exposure — the environment has long promoted the abandonment of privacy. Autobiographical writings have been bestsellers ever since Rousseau. Facebook etc. have simply given people a new platform for being open about themselves. In 1996 an American college student, Jennifer Ringley, caused an uproar by broadcasting her private life via a webcam in her dorm room for all the world to see, including intimate moments. Today no one would care about that.

How public would this lifestream be?
Gelernter: The way I see it, it would initially be provided by Lifestream Inc. — a company I co-founded in New Haven. We are now completing the first software package, which we expect to launch on the market at the end of 2012. But we don't want to control it. The exact specifications of the software would be public. Some elements in this lifestream are private — what the user decides to make public would be accessible to everyone.

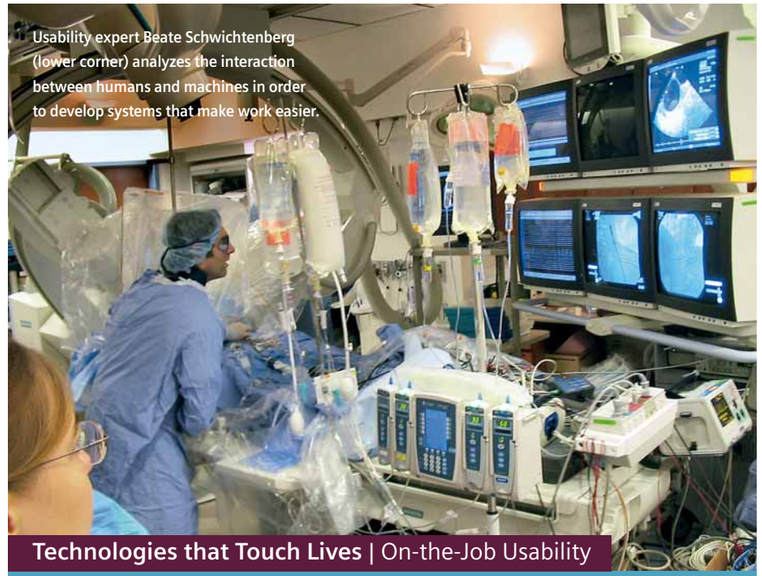
Have we sacrificed something as a result of communications technology?
Gelernter: Yes — immensely. Modern information and communication media promote a short attention span and a superficial understanding of the world. The really important achievements of humanity are the artistic, religious, scientific, medical, philosophical ones. If modern technologies don't help us understand these achievements better, they're ultimately not worth much.

It sounds as if you're promoting a classic conservative critique of modernity.
Gelernter: There have always been reactionary tendencies that oppose new developments. For example, in the 1950s and 1960s many people criticized television. But it's a double-edged sword — there's a lot of garbage on TV, but there are also some good programs. It all depends on how we use things. That's why modern technologies have to be built in such a way that they support us instead of dominating us.

Do you see a risk that the trash could gain the upper hand?
Gelernter: It used to be that almost every student had heard of the Bauhaus; today there are only a few. Wittgenstein, who in the eyes of many is the most important philosopher of the 20th century, is also unknown to many. Today you can look up everything online, but we have to consider what today's young minds never get to know because they are not confronted with it. I believe there is good reason to reconsider the value of books in education and training. A book is easy to use, durable, well adapted to the pace at which we take in and understand information — and there's less room for distraction.

A childhood without computers? Are you kidding?
Gelernter: You have to see it differently. It would be a great loss to forgo books. But as with television, it makes no sense to ban computers or iPads. Instead, we should improve their design. So much emphasis is placed on design in Europe — so I find it surprising that so little momentum comes from there in terms of the design of cell phones, tablet computers, and their user interfaces.

■ *Interview conducted by Hubertus Breuer.*



Usability expert Beate Schwichtenberg (lower corner) analyzes the interaction between humans and machines in order to develop systems that make work easier.

What's the Ideal Interface?

Whether it's work processes in hospitals, production in industrial plants, or a conductor's job on a train — software and interfaces that are easy to understand and operate are needed everywhere. However, in order to find the right solutions, it's necessary to monitor people's activities and behavior at work.

Beate Schwichtenberg is sitting in an operating room and looking as if she's just landed in Papua New Guinea. Everything is so strange here! She can recognize the surgeon — but all those instrument operators, assistants, anesthesiologists... She's absorbed by what she sees: The emergency surgery room at this university clinic looks to her almost like a carpenter's workshop, what with all the drilling and bolting going on. Like a shadow, Schwichtenberg moves around with hospital staff, taking notes on everything they do, every unwritten rule, every minor process.

Schwichtenberg doesn't really belong here, because she's not a doctor. However, as a usability expert, it's her job to watch people at work and then develop systems that facilitate their tasks on the basis of her observations. She learned how to do this by studying cognitive science at the University of California in San Diego (UCSD). Her colleagues in the Usability Lab at Siemens Corporate Technology (CT) in Munich, Germany, studied similar subjects — psychology, computer science, communication design, etc. — generally with a focus on human-machine interaction. Today special programs with names like Human-Computer Interaction, Usability Engineering, and Human Factors are on offer. "That's not surprising," says Dr. Martin Scheurer, Head of the CT Usability Lab. "Human beings and the way they interact with computers and machines largely determine how productive a company will be."

That's why systems must be well adapted to people and how they work, rather than the other way around. "We need to understand users' needs," says Schwichtenberg. "Otherwise, it's impossible to design systems that fit in with a specific working environment." To this end, Schwichtenberg goes into the field, works with ethnographic techniques, and tries to tap into the implicit knowledge of the "natives," as she refers to workers. "You need this knowledge to analyze things that are taken for granted and identify behaviors and word choices, for example," Schwichtenberg says. Her specialty is observing German hospitals. Over the last six years, she's visited 40 of them.

Schwichtenberg's reference to Papua New Guinea as a metaphor is not as exaggerated as

it sounds. She studied under Prof. Edwin Hutchins in the Department of Cognitive Science at UCSD — and Hutchins, a cognitive ethnographer, studied the natives of the island nation of Papua New Guinea in the 1980s. He later applied his methods to his work with the U.S. Marines and his analyses of company cultures. "Basically, the workings of a hospital are as foreign to us as Papua New Guinea," Schwichtenberg says. Every culture has rules that all its members are familiar with but that outsiders find difficult to understand.

Together with experts from Siemens Healthcare, Schwichtenberg and her colleagues incorporated the results of their studies into a high-tech hospital administration system. The system has an intuitive operating concept tailored to the typical work habits and work context of all the professional groups at a hospital — from admissions staff to surgery coordinators and medication monitors. "The software's interface needs to be familiar to all users," says Schwichtenberg. "If an administrator likes to work with post-it notes because he or she needs to take lots of notes, the software can be made to do this." In other words, it is tailored to the normal work practices of occupational groups in hospitals.

Consider the following example. Hospital stays are often planned weeks in advance and occupancy managers are responsible for allocating beds, scheduling examinations and operations, and ensuring that enough beds remain available for emergencies and that distribution is fair. All of this is meant to achieve a good occupancy balance among the various stations. During her analyses, Schwichtenberg paid close attention to how the hospital's occupancy manager worked and which types of documents and tools he used. Today, the administration system she worked on combines all this information in an application that displays a graphic overview of the number of occupied beds, generates a calendar for patient admissions, and includes a search function for available beds.

Users only need to know how to operate the application they need for their own work. The system's modules cover areas such as outpatient administration, surgery, and patient data management. The system also links the clinical and administrative sections of a hospital. "The clinical departments deal with people — the patients," Schwichtenberg explains. "Administrators don't; they just work with case numbers." The software thus networks these two completely different areas.

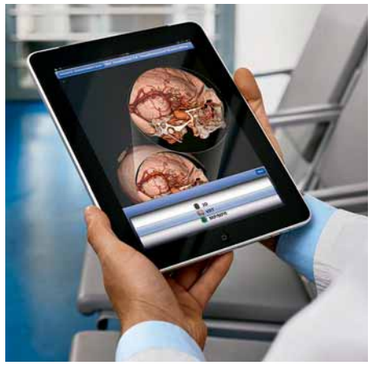
An App for Train Conductors. Usability experts are constantly exploring unfamiliar worlds. One of Schwichtenberg's colleagues, Martin Kessner, recently observed conductors in the German railway system. Kessner examined a range of situations and tried to determine which types of applications could make the conductors' work easier. He's now using what he learned to design a smartphone app for staff in modern trains — for example, trains of the ICx high-speed fleet that will be introduced in the near future. Kessner discovered that conductors do not like having to carry several devices as they move through a train that is up to 400 meters long. They also complained that even with the devices, they still can't do everything they need to do.

"With the right smartphone app, conductors could do much more on the move," says Kessner. For instance, a new app would allow them to make announcements even when they're not in the conductor's compartment. They could also communicate with one another, adjust climate controls, and intervene in the door control system. Up until now, all these things had to be done via a console in the conductor's compartment. But with the new app, a train control system could also send information about defective toilets or unlocked doors straight to a conductor's smartphone. In other words, a train and its conductor could "talk" more or less in real time.

Working on the Move. Creating apps for the working world — that's the goal of Siemens' "Mobility First" approach. The idea is to combine the key tasks performed by an occupational group into one app — be it in a hospital, on a train, or in a factory. Siemens is now focusing intensely on the latter, with mobile applications for production facilities. For example, it is testing a prototype called Sinumerik Mobile at its Test Application Center in Erlangen. The center serves as a lab for machine tools that work with Sinumerik controls. Sinumerik Mobile is an app that monitors and diagnoses electronically-controlled machine tools.

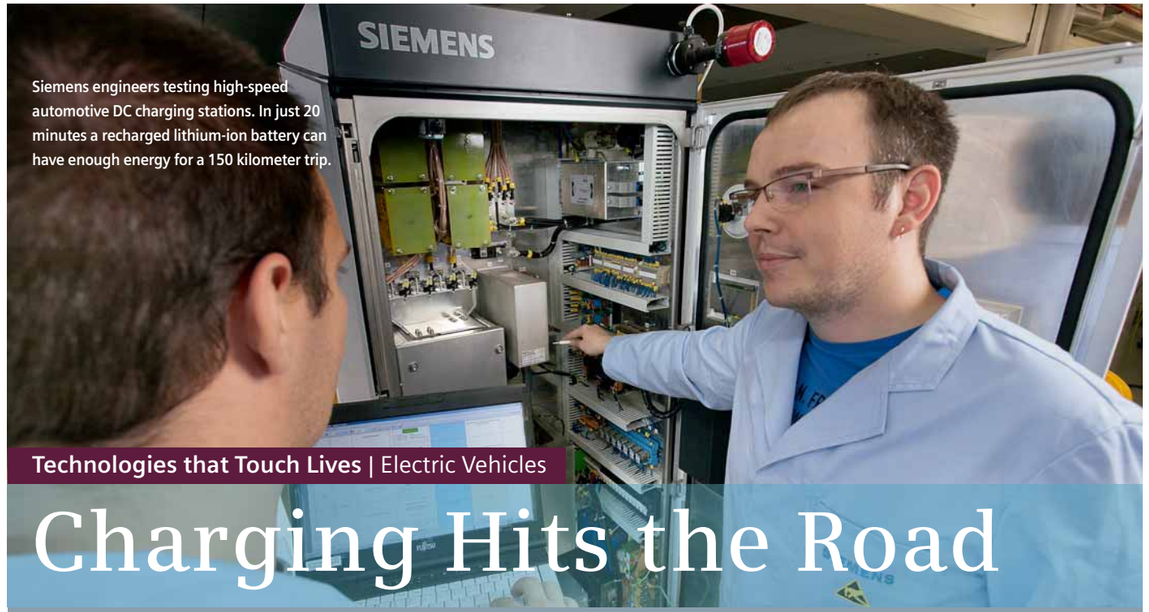
The app enables employees to control machines conveniently via their smartphones. "However, the main thing is that the app offsets certain machine limitations," says Corporate Technology researcher Christian Butter, who is managing the app project in conjunction with Uwe Scheuermann from Siemens Industry Motion Control.

Sinumerik technology is used in computer numerically-controlled milling machines, lathes, and die-casting and injection-molding units all over the world. But up until now, machine touch panels have not supported text in some languages, such as Chinese. But the new app allows users to send messages about errors to machines in any language. Their colleagues can then, for instance, immediately see in which mode a machine is operating. Previously, gaining such information was complicated. Thanks to the new app, it is becoming increasingly user-friendly. ■ *Silke Weber*



Self-evident interfaces help tablet PCs simplify work.

Researchers are developing phone-based apps for use in production environments.



Siemens engineers testing high-speed automotive DC charging stations. In just 20 minutes a recharged lithium-ion battery can have enough energy for a 150 kilometer trip.

Technologies that Touch Lives | Electric Vehicles

Charging Hits the Road

In the future, it should be easy to quickly recharge an electric car regardless of where you happen to be. To help achieve this goal, researchers at Siemens are running several major projects that evaluate how charging technologies perform in real life.

A location in Germany in 2013. An electric BMW leaves the A9 autobahn, which links Munich with Leipzig, and glides into a gas station. The driver gets out and opens the fuel tank flap. But instead of reaching for a gas pump, she pulls out a charging cable. Because the cable transmits electricity at up to 50 kilowatts, the lithium-ion battery can be quickly recharged. After a 20-minute coffee break, the motorist has enough fuel for another 100 to 150 kilometers.

Although no decision has been made as to the specific locations of such charging stations, they will definitely be set up as part of a recently launched showcase project called "Electric mobility links Bavaria and Saxony." Germany will launch four such showcase demonstration projects to evaluate how well users accept electric cars in everyday life.

"It will be particularly exciting to see how effective our fast charging technology is and how much it will be used," says Matthias Felten, who coordinates Siemens' contribution to the project. Siemens plans to set up nine charging stations along a 400-kilometer stretch of the A9 on what will be Europe's first full-length electric vehicle highway.

Siemens has been researching fast charging systems for years (see *Pictures of the Future,* Fall 2009, p. 44, Spring 2010, p. 92, Fall 2010, p. 34) and has found solutions for some of the associated problems. For example, a powerful rectifier is needed to turn the alternating current from the grid into direct current for a car's lithium-ion battery. Although this can be done onboard the vehicle, Siemens has also developed direct current charging stations that supply the right kind of electricity.

Progress has also been made regarding plug development. Almost all automakers in Germany now support the "Combo" plug (IEC 62196-3), which is apparently also becoming the standard throughout Europe. This plug, which is also known as the combined charging system, works with the direct current of fast charging stations as well as with the 230-volt alternating current used in private garages. The system is so simple that even people lacking any kind of technical know-how can't use it incorrectly.

All you have to do is insert the plug, and the current begins to flow. For a long time, experts were uncertain about how electricity would be transmitted. Although charging should be fast, batteries age quickly when they become hot. However, for safety reasons alone, it is already necessary to equip lithium-ion batteries with

temperature sensors. As a result, the charging current can be regulated in line with the battery's temperature: The hotter the battery, the lower the current. This approach strikes a good balance between aging and charging speed.

Batteries and charging stations need to speak the same "language" if they are to understand one another. To ensure this is the case in the showcase project, the systems use power-line communication technology, in which data piggy backs along charging cables. Using an additional, high-frequency signal, a battery can always tell the charging station how strong a current it can tolerate. However, it's not always necessary to transmit as much energy as possible to a battery at the fastest possible rate. That's because electric cars, like their conventionally-powered counterparts, are stationary for 22 hours per day on average. In private garages, the 3.6-kilowatt connection to the household network will therefore continue to dominate. Completely recharging a car at home will thus take six to eight hours, depending on battery size. According to Dr. Dieter Barnard, who is responsible for the lifecycle management of charging infrastructures at Siemens' Infrastructure and Cities Sector, charging stations at public parking places will have a "medium-fast" 20-kilowatt speed and a charging time of about one hour.

Roaming Vehicle Charging. Due to their limited range, electric cars face a major challenge when it comes to long-distance trips — particularly if the destination is abroad. Questions that remain to be answered include whether a car's navigation system can reliably depict the location of available charging stations, and whether charging stations will be able to reliably communicate with a vehicle's battery.

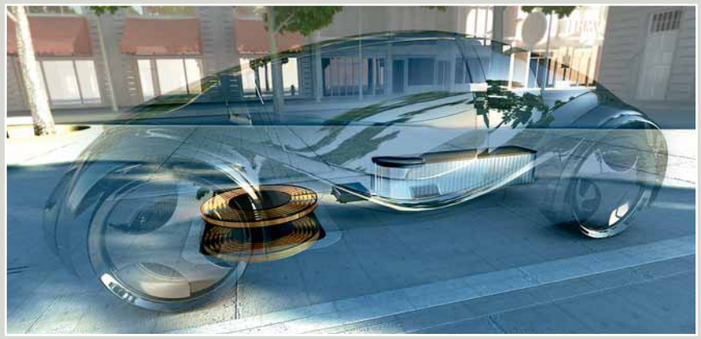
A joint research project called Green eMotion was launched in Europe to find answers to these and other questions. With a budget of €42 million, the initiative is one of the largest electric mobility projects ever conducted. Like the projects previously mentioned, Green eMotion studies real-life mobility conditions on the road. The project partners include ten cities and regions in eight countries, ranging from the Danish island of Bornholm to cities such as Berlin, Dublin, Rome, and Malaga. A total of 2,000 electric vehicles are currently on the road in the participating regions, and this figure is scheduled to reach 70,000 by 2015, when the project comes to a close. The number of charging stations is to increase from 2,500 to 80,000 during this period.

The project is being coordinated by Dr. Heike Barlag, a researcher from Siemens' Infrastructure and Cities Sector (see *Pictures of the Future,* Spring 2011, p. 63). Her goal is to combine various isolated solutions by harmonizing the associated information. For example, the standardization of data formats will enable organizers to provide services throughout Europe in a manner similar to the roaming process used in mobile communications. "Here, we're talking about much more than just charging and payment processes. These are also possible using credit cards or cell phones," says Barlag. It's more important to ensure that a range-oriented route planning service will work abroad and reliably guide drivers to available charging stations at all times. Where possible, electric cars should be recharged whenever renewable sources of energy, such as solar and wind power are abundantly available. This last requirement can only be met with the help of a smart, interregional system for managing battery charging.

Unlike charging infrastructures that are being extensively tested on the road, vehicle-to-grid (V2G) technology is still limited to lab environments. Such systems enable power suppliers to use the batteries inside electric vehicles as buffers that store excess wind and solar energy. This allows electricity that was previously used to charge vehicle batteries to be fed back into the grid when required — a process that enables car owners to earn money. The vehicle-based and charging systems parts of this technology have been developed. What's more, a solution has been found to the frequently voiced concern that using batteries in this way could cause them to age prematurely. The trick is to feed the energy back into grid in such a way that the battery's charge level doesn't become too low and the battery always operates within a specific temperature range (generally between 30 and 40 degrees Celsius). When treated in this manner, batteries lose only 20 percent of their capacity after 3,000 to 4,000 complete charging cycles.

Researchers are also striving to standardize the communication protocols that inform network operators of each car's charge status. The results are promising. However, many more electric vehicles will have to hit the road before "V2G" evolves into more than just an abbreviation on PowerPoint slides. And that's where the current projects come in.

■ *Johannes Winterhagen*



Cordless Charging: Now Cars Can Do it Too

Even though cordless inductive charging has long been a standard feature for electric kettles and toothbrushes, developers have found it difficult to create such a system for automobiles. Inductive electricity transmission works best if the position of the magnetic coils in the road surface and the cars are precisely defined. The bigger the air gap between them, the stronger the electromagnetic field must be in order to transmit a specific amount of electricity. Between 2010 and 2011, as part of the joint IndiOn project, BMW and Siemens demonstrated that inductive charging does indeed work in cars. In a research vehicle, the two companies managed to transmit electricity with over 90 percent efficiency, provided the coils were not displaced by more than 14 cm from one another. A positioning assistant developed by BMW enabled test drivers to park the vehicle within the tolerance limits with the help of signals in a dashboard display. The solution created during the IndiOn project uses a conventional household network with a power output of 3.6 kilowatts. In other words, drivers can use even brief stops to recharge their vehicle's batteries. The system creates a magnetic field that covers an exactly defined area between the coils — an area that is inaccessible to driver and passengers alike.

Siemens' new metros are based on a cost-effective platform concept and a user-friendly interior design.

Technologies that Touch Lives | Light Rail Systems

Riding in Style

With its trend-setting interior, the new Inspiro metro is a real eye-catcher. But there's more to the concept than just outstanding design. The railcars themselves are carefully tailored to meet the needs of passengers, including those with reduced mobility.

The subway train is waiting at the platform. It's a familiar situation for subway users — having to decide whether to make a dash for it or wait for the next train. At Siemens' Mobility facility in Vienna, Austria the answer is simple. In the door windows, strips of red light that diminish in length, similar to an hourglass, show there is still enough time to board before the strips start to flash and the doors shut. Seconds later, you're safely aboard, though slightly out of breath.

Not that anyone has to hurry to catch the test subway at Siemens Mobility in Vienna. It's not about to go anywhere and doesn't even have any wheels, sitting instead on a fixed cradle. Part of the railcar wall has been removed, thus affording potential customers a proper look inside. The view is "revolutionary," according to engineer Werner Chmelar. He is the platform manager for Inspiro, a light rail train developed in recent years by Siemens here in Vienna. The latest generation is based on a platform concept, which means that most of the components — coachwork, bogie, electrical systems — are always the same (see *Pictures of the Future,* Fall 2010, p. 18). This brings substantial cost benefits compared to predecessor models, which sometimes had to be partly redesigned to meet customer specifications. Chmelar's job is to ensure that the railcar concept can be matched to market requirements as efficiently as possible.

A closer look reveals what this means. Alongside the mock-up are railcars destined for a new subway in Poland's capital, Warsaw. These are the first to be based on the Inspiro platform and are scheduled for delivery in April 2013. Hanks of cable still hang out from the roof. It all looks pretty chaotic to the layperson, but in fact the design is amazingly simple. Aluminum sections stretching the full length of the car provide stability and serve as cable ducts and fixtures for LED lamps. Mounted to the edge are vent panels of soft fabric for the air conditioning. Standing nearby are railcars for the Oslo subway system. Their predecessor model caused a sensation a few years back since it was 95 percent recyclable. Here, however, the roof consists of substantially more aluminum sections, which have to be bolted together, and the air conditioning is provided via individually mounted hoses. Similarly, the lights have to be mounted separately. Even the untutored eye can see that this design is much more complicated and costly.

Not that passengers need be aware of the platform concept and all its benefits. What interests them primarily is the look and feel of the interior. In fact, the various elements of the new Inspiro — seats, poles, lighting — all look slightly out of the ordinary, while still seeming absolutely right. "The design is going to cause quite a stir," Chmelar predicts.

He could well be right, as some of the details are truly exceptional. For example, the light strips described above are a completely new feature. They consist of LEDs mounted in the edges of the door windows. When the train enters a station, the light strips shine yellow, so that pas-

sengers know from which side of the train to exit. While the doors are open, the light strips shine green. They then change to red and the strips of light start to descend like sand falling through an hourglass. This tells passengers on the platform how much time they have to board the train. When the strips start to flash, it's time to stand clear of the doors.

The light strips are much more than just a design feature. As Chmelar rightly observes, they offer a genuine benefit for passengers — as do other aspects of the Inspiro concept. "No other subway is quite so passenger-friendly, without having any negative impact on the overall look," he says. Take the design of the grab handles, for instance. Once these would have been loops of leather or rubber; today, all unless they were expressly requested by the customer. However, without them railcar bodies would tend to buckle at a crash speed of 15 kilometers per hour. To study the performance of these elements, a number of crash tests were conducted. A high-speed camera showed how the corrugated ends of the absorbers mesh and thereby prevent the front of the train from rearing up.

Intelligent design has also been applied to the lighting concept, which utilizes low-energy LEDs that change color. In the morning they shine bright blue, which helps people wake up; in the evening they change to a more subdued, warmer light, which has a soothing effect. Such a concept exploits the findings of lighting experts from Osram, who have many people as possible, including people with disabilities or special needs. Wegge and his team have been advising Siemens engineers in this field for a number of years now. In the spring of 2012 he and his colleague Markus Dubielzig were in Vienna to give the Inspiro mock-up a thorough going-over during a period of two days. They examined and documented all the passenger-relevant railcar components with respect to their accessibility to people with various disabilities.

Wegge was very impressed with the concept of the light strips on the doors, even though he couldn't see it in action and an acoustic counterpart is still lacking. He also commended the fact that there is plenty of room for guide dogs under the seats.

evacuation of large buildings and sports arenas. The DLR model simulated the speed at which passengers typically board and exit from subway cars and how they move inside the train when looking for a seat.

The simulation clearly showed that doors 1.40 meters wide were perfectly adequate and that doors 1.60 meters in width would result in a time saving of only a fraction of a second. Narrower doors were not investigated, but experience shows that they increase passenger crush and therefore platform times for trains.

In this respect, seating configuration is a more significant factor than door width. Lateral seating, the traditional configuration, impedes the flow of passengers and extends passenger changeover times by quite a few seconds. In

Left: Strips of colored LEDs mounted in doors fall like sand through an hourglass, indicating that the train is about to leave. Below: A simulation of passenger flow on a platform and in a railcar helped to determine the optimal door width.

Right: New box-shaped crash elements fold like an accordion during impact and absorb the impact of a collision, thus preventing the coachwork from buckling. Siemens engineers conducted crash tests to investigate their effectiveness.

rapid transit trains have grab poles. The new Inspiro takes this idea one step further. Here the poles are in the form of stylized trees with branches that fork upwards. They are the fruit of a brainstorming session that was aimed at creating a symbol of sustainability that also has a practical function. The branches are set at various heights, thus providing handholds for people of different heights. All in all, there is room for dozens of hands.

New Metro in Crash Test. In the unlikely event of a collision, passengers are protected by new box-shaped crash elements mounted under the driver's cabs. These crumple during impact and can absorb the force generated at crash speeds of up to 25 kilometers per hour without any buckling of the coachwork. In the past these crash elements were not installed demonstrated that specific colors of light can influence users' moods — and save energy. Indeed, the color of light even has an influence on the sensation of temperature. Blue light, for example, suggests cold, and red light warmth. Incredibly, blue light on a hot summer day reduces the demand for air conditioning, and red light in winter helps cut heating costs (see *Pictures of the Future,* Fall 2010, p. 90). Indeed, studies indicate that the color of light can influence the sensation of temperature by as much as two degrees Celsius, which corresponds to an energy saving of five percent.

Klaus-Peter Wegge from Siemens Corporate Technology in Paderborn has expertise in another vital area. Being visually impaired, he's very much in demand as a specialist regarding accessibility, i.e. ensuring that a product, service, installation or environment is available to as

One area of criticism was the lack of grab poles right next to the doors. In railcars with longitudinal seating the poles are set back by 60 centimeters from the doors, and in those with lateral seating they are set back by 90 centimeters. "Our designers are now looking at ways to improve this feature," Wegge explains. The Paderborn team also praised the wide doors, which at a span of 1.40 meters, provide ample room for wheelchairs, visually impaired passengers accompanied by a sighted guide, and people using walkers. But are they also wide enough to allow faster boarding and exiting?

In order to find out, designers at Siemens Mobility in Vienna commissioned a computer simulation. The German Aerospace Center (DLR) in Braunschweig has extensive experience in the use of mathematical models to calculate flows of people. Such data is vital in planning for the

other words, there is good reason behind the growing trend on the part of light rail operators to request a longitudinal configuration with the seats mounted along the railcar walls.

The mock-up in Vienna is unlikely to provide the template for any order from a real customer. Featuring stylish light-brown leather seats and bronze-colored grab poles, it was specially designed for a trade show in Dubai. The trains that will be rolling in Munich's subway network as of 2013, on the other hand, will feature Inspiro components and their very own styling based on the corporate design of the city's urban transport operator, Münchener Verkehrsbetriebe. Pictures hanging in Werner Chmelar's office show what awaits passengers in Munich: a blue-and-white color scheme for the interior, with large doors and wide passageways to make travel faster and more comfortable. ■ *Bernd Müller*

In Brief

■ Healthcare is undergoing radical changes throughout the world. "Diseases of affluence" such as diabetes and cancer are no longer just a problem in industrialized countries; they also impact developing nations and emerging markets. This is leading to a steady increase in demand for medical care — and its costs. Many countries will have to reform their healthcare systems. Technological advances can help here — for example, by detecting diseases at an early stage.
(pp. 82, 84, 86)

■ Many technologies have become an essential part of everyday life. Be it weather forecasts, hearing aids or cars, they help make life more manageable. And such systems will be able to do even more in the future. For example, thanks to the SmartSenior project, intelligent information and communication technologies could soon be helping senior citizens to stay longer in their own homes. Another project that addresses home life is E-DeMa. In a practical test in Germany, this research project is studying new ways of supplying energy to private households.
(pp. 80, 89, 94, 98)

■ Innovations need to be as user-friendly and convenient as possible if they are to enjoy widespread acceptance. That's why Siemens' new Inspiro subway system is tailored to the needs of passengers. Usability experts at Siemens are also looking at the work routines of train conductors, doctors in hospitals, workers in factories, and other professionals. The experts' goal is to design mobile applications that will help make the work processes of a variety of professions as pleasant and efficient as possible.
(pp.111,115)

■ "Our modern means of communication need to be improved. The problem is that humans are still expected to adapt to technology. and not the other way around, as it should be," says Prof. David Gelernter, who is developing a revolutionary concept for the Internet of the future. (p. 110)

■ New technology isn't available to everyone. In fact, many people even lack essential services such as healthcare and water. Siemens is therefore supporting various projects around the world, including programs in rural areas of Cameroon and India. (p. 100, 102)

PEOPLE:

Hearing aid technology:
Dr. Torsten Niederdränk, Corporate Technology
torsten.niederdränk@siemens.com
SmartSenior:
Dr. Jens-Christian Holst, Corporate Technology
jens-christian.holst@siemens.com
Digital detectives:
Professor Maximilian Fleischer, Corporate Technology, maximilian.fleischer@siemens.com
Rural development in India:
Prashant Chandwadkar, Siemens India
prashant.chandwadkar@siemens.com
Lightning information service:
Stephan Thern, Siemens BLIDS
stephan.thern@siemens.com
Building evacuation systems:
Dr. Wolfram Klein, Corporate Technology
wolfram.klein@siemnes.com
Christian Frey, Building Technologies
christian.frey@siemens.com
Translational biotechnology:
Dr. Emil Wirsz, Corporate Technology
emil.wirsz@siemens.com
Dr. Andreas Keller, Siemens Healthcare
keller.andreas@siemens.com
E-DeMa, smart power supply:
Michael Hufnagel, Smart Grids
hufnagel.michael@siemens.com
Ergonomics at the workplace:
Dr. Norbert Wagner, Siemens EHS
wagnernorbert@siemens.com
Research for local public transportation:
Werner Chmelar, Siemens Mobility in Vienna
werner.chmelar@siemens.com
Usability:
Dr. Martin Scheurer, Usability Lab
martin.scheurer@siemens.com

External:
Professor Patrick Baudisch,
Hasso Plattner Institute in Potsdam
patrick.baudisch@hpi.uni-potsdam.de
Professor David Gelernter, Yale University
www.cs.yale.edu

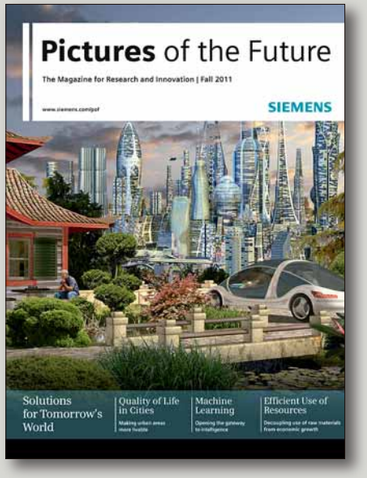
LINKS:

Alzheimer's Disease International:
ww.alz.co.uk
E-DeMa: www.e-dema.de/en/
SmartSenior project:
www1.smart-senior.de/enEN/

Would you like to know more about Siemens and our latest developments?

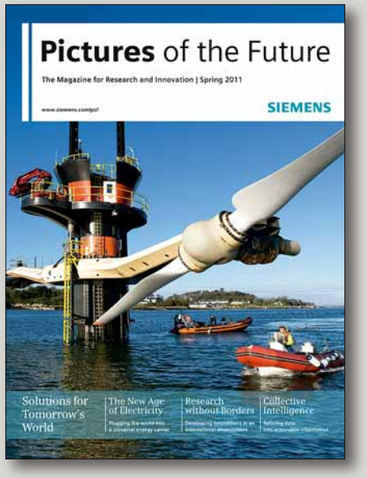
We would be glad to send you more information. Please check the box next to the publication you wish to order and the language you need, and fax a copy of this page to +49 (0)9131 9192-8513 or mail it to: Publicis Publishing, Susan Grünbaum-Süß — Postfach 3240, 91050 Erlangen, Germany, or contact us at: publishing-address@publicis.de. Please use *Pictures of the Future,* Fall 2012" as the subject heading.

Books:
Life in 2050 — How We Invent the Future Today **(€19.95) and *Innovative Minds* (€34.90). More information is available at: www.siemens.com/innovation/lifein2050 or via the book trade**



Available issues of *Pictures of the Future* (free of charge):

- ☐ ***Pictures of the Future*, Fall 2012** (German, English)
- ☐ ***Pictures of the Future,* Spring 2012** (German, English)
- ☐ ***Pictures of the Future,* Fall 2011** (German, English)
- ☐ ***Pictures of the Future*, Spring 2011** (German, English)
- ☐ ***Pictures of the Future*, Fall 2010** (German, English)
- ☐ ***Pictures of the Future*, Spring 2010** (German, English)



- ☐ ***Pictures of the Future,* Special Edition Green Technologies** (English)
- ☐ **German Green City Index,** environmental analyses of 12 major cities (German)
- ☐ **European Green City Index**, assessing the environmental performance of Europe's major cities (English)

Your Pictures of the Future, youth issue 2012 (German)

Additional information
about Siemens innovations is also available on the Internet at:
www.siemens.com/innovation (Siemens' R&D website)
www.siemens.com/innovationnews (weekly media service)
www.siemens.com/pof (*Pictures of the Future* on the Internet — also in Spanish, Chinese, French, Portuguese, Russian, Romanian, and Turkish)
Pictures of the Future is also available as a free app at the App Store.

- ☐ **I would like a free sample issue of *Pictures of the Future***
- ☐ **I would like to cancel my *Pictures of the Future* subscription**
- ☐ **My new address is shown below**
- ☐ **Please also send the magazine to...**

(please check the respective box(es) and fill in the address):

Title, first name, last name

Company *Department*

Street, number

ZIP, City

Country

Telephone number, fax or e-mail

Manufacturing and Innovation

Around the world, manufacturing is an engine of innovation. It plays a major role in driving private sector research and development, as well as patent applications. Indeed, investments in manufacturing have been found to result in "knowledge spillovers" that lead to enhanced productivity in a wide range of areas, thus stimulating ecosystems of innovation. Considering the essential role this sector plays in economies around the world, the Spring 2013 issue of *Pictures of the Future* will take a look at the trends driving manufacturing and where they are likely to take us over the coming decades. How, for instance, will information technology affect automation? What will be the role of renewable energy in tomorrow's manufacturing environments? Will we see environmentally-benign manufacturing or even energy-independent factories? What's the future of rapid prototyping, and micro- and nano-scale manufacturing? And how will such trends affect knowledge, wealth, competitiveness, and, above all, innovation in the societies that lead these fields?

Maximizing Efficiency

How can power generation be increased without the need for new power plants and additional resources? How can a subway system transport many more passengers without additional subway lines — while simultaneously boosting comfort and safety? And how can production plants significantly increase their output without the need for larger facilities, while decreasing their demand for energy and raw materials? Whether the issue is entire infrastructures or individual software solutions, in order to avoid expensive new investments, systems must be optimized and efficiency increased — even if these improvements have to be made in an environment that is extremely difficult to influence. Nonetheless, achieving success in this area is worth the effort. Systematic optimization leads to better production processes, lower costs, and, in many cases, enhanced competitiveness in international markets.

Where Mobility is Going

More than 2,000 years ago, the Romans discovered that transportation networks improve security, boost trade, and enhance prosperity. Their revolutionary road network reached a total length of about 80,000 kilometers and brought the far-flung regions of Europe closer together. This principle is still valid today. In addition to data and financial connections, transportation is one of the key engines of globalization. The steady growth of the world's population will also cause a tremendous increase in demand for mobility. How will our traffic and transport systems change in the future, and what consequences will this have for the world's transportation hubs? How will people and goods travel from A to B, within large cities and across continents? What technologies will further improve our mobility and make it faster, safer, and more efficient — on land, water, and in the air? These technologies range from new systems for railroads and highly efficient drive systems for vehicles to networked transportation systems and hydrogen-based mobility.

Publisher: Siemens AG
Corporate Communications (CC) and Corporate Technology (CT)
Otto-Hahn-Ring 6, 81739 Munich, Germany
For the publisher: Dr. Ulrich Eberl (CC), Arthur F. Pease (CT)
ulrich.eberl@siemens.com (Tel. +49 89 636 33246)
arthur.pease@siemens.com (Tel.+49 89 636 48824)

Editorial Office:
Dr. Ulrich Eberl (Editor-in-Chief)
Arthur F. Pease (Executive Editor, English Edition)
Florian Martini (Managing Editor)
Sebastian Webel
Hülya Dagli
Nicole Elflein

Additional Authors in this Issue:
Christine Auer, Tanja Berbalk, Andreas Beuthner, Dr. Hubertus Breuer, Christian Buck, Anita Bruckmüller, Nils Ehrenberg, Marc Engelhardt, Urs Fitze, Dr. Rolf Froböse, Ines Giovannini, Susanne Gold, Maximilian Heinrich, Andrea Hoferichter, Carolyn Joiner, Bijesh Kamath, Ute Kehse, Justus Krüger, Dr. Michael Lang, Bernd Müller, Katrin Nikolaus, Bernd Schöne, Stefan Schröder, Hans Schürmann, Dr. Sylvia Trage, Silke Weber, Johannes Winterhagen

Picture Editing:
Judith Egelhof, Irene Kern, Doreen Thomas, Publicis, Munich
Photography:
Dietmar Gust, Nils Hendrik Mueller, Rupert Oberhäuser, Volker Steger, Andreas Teichmann, Jürgen Winzeck
Internet (www.siemens.de/pof): Florian Martini, Stefan Schröder
Internet: (www.siemens.com/pof): Volkmar Dimpfl, Florian Martini
Historical Information:
Dr. Frank Wittendorfer, Siemens Corporate Archives
Address Database:
Susan Grünbaum-Süß, Publicis Erlangen
Layout / Lithography:
Rigobert Ratschke, Seufferle Mediendesign, Stuttgart
Illustrations:
Wolfram Gothe (42-43), Arnold Metzinger (8-9, 76-77)
Graphics:
Jochen Haller, Seufferle Mediendesign, Stuttgart
Translations German – English: Transform GmbH, Cologne
Translations English – German: Karin Hofmann, Publicis Munich
Printing: Bechtle Druck&Service, Esslingen

Picture Credits:
ddp images (11, 14 l.), Georg Lukas (6 b.l., b.m.,12 t.), dpa/picture alliance (14 t.r., 17, 34 l., 37, 51, 62), AP (14 b.r., 63 l.), Bundesnetzagentur (15), Schapowalow/Jachens (32), Jeff Goldberg / Esto (36r.), Salzburg AG (38), Blickwinkel (45), University St. Gallen (52), private (53), NASA/JPL-Caltech (cover and 55-57), getty images (61 r., 92), Glow Images (63 r.), 3D Media Agentur (66), Martinos Center for Biomedical Imaging at MGH, Boston / University of California, Los Angeles (70-71), Center for Magnetic Resonance Research, Minneapolis / Washington University, St. Louis (72), Oceanário de Lisboa/Mafalda Frade (75 t.l.), augenklick (79 l.), Pudenz/Deutscher Zukunftspreis (81 t.r.), Bernd März (94), 1. FC Kaiserslautern (96 t.r., 97 t.), Shisong Hospital (101 b.l.), HPI / K.Herschelmann (108-109), Gelernter Studio (110). All others: Copyright Siemens AG

Pictures of the Future appears twice a year.
Printed in Germany. Reproduction of articles in whole or in part requires the permission of the editorial office. This also applies to storage in electronic databases and on the Internet.

Order number: A19100-F-P194-X-7600
ISSN 1618-5498

www.siemens.com/pof