Green Cities
Sustainable Solutions for Buildings, Traffic and Energy

Infrastructures
Developing solutions that are both economical and sustainable

Buildings and Mobility
Energy-efficient and intelligent technologies for tomorrow’s cities

Energy Technologies
Innovative answers for a livable, low-carbon future
A Sustainable Future for Cities

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A nna Kajurulo Tabinjika, who was the Executive Director of the United Nations Human Settlements Programme (UN-HABITAT) until 2010, summed up a crucial trend of our time when she said, "2007 was the year in which Homo sapiens became Homo urbanus." That year marked the first time in history that the worldwide number of city dwellers surpassed the number of people living in rural areas — and the urbanization process is far from finished. It is primarily the cities of the developing nations and emerging markets that will have to absorb almost the entire increase of the global population — approximately 1.3 billion people — in the next two decades. This development poses tremendous challenges for forward-looking and sustainable urban development programs. In developing and industrialized countries alike, the quality of life depends on clean water and clean air, efficient transportation systems, a climate-conserving energy supply, and smart building technology.

In Europe, 73 percent of the population already lives in cities — in China that figure is only about 47 percent. How are European cities dealing with this development? Siemens commissioned the Economist Intelligence Unit, an independent research and consulting company, to find an answer to this question. The result of its study is the European Green City Index (p. 13), which ranks the European countries’ largest cities in terms of their CO₂ emissions, energy supply, buildings, transportation, water, air quality, waste disposal and use, and environmental management. The cities investigated range from Athens to Zagreb, from Paris (p. 20) to Istanbul, and from Oslo (p. 18) to Berlin. The index not only provides information about the investigated cities’ strengths and weaknesses but also aims to support their efforts to become more sustainable. The initiative was a total success, and similar indices have now been created for Asian and Latin American cities. It will be followed by further indices for North America, Africa, and Germany.

In recent years the Hanseatic city of Hamburg has impressively demonstrated that urban ecological and economic goals can be harmonized. This port city beat many rivals to become the European Commission’s European Green Capital 2011. It owes its victory in large part to its extensive utilization and expansion of renewable energies, climate-friendly renovation of buildings, and systematic expansion of its local public transport network.

All of these areas in which Siemens is active as a global provider of infrastructure services ranging from smart building technology (p. 32) to sustainable transportation solutions, such as driverless subways...
Brussels
The Belgian capital has approximately 1.1 million inhabitants. On its way towards a more sustainable future, the city is focusing on reducing its energy consumption and, by extension, its emissions. This will apply to both its historical center and the road and rail traffic. Siemens will facilitate the city’s efforts to introduce over 300 regional trains, energy-saving wastewater treatment solutions for public buildings (p. 4), and public transport solutions for the urban tram. (p. 18)

Barcelona
With about 1.6 million inhabitants, Barcelona is Spain’s second-largest city. One of the city’s major goals is to expand public transportation and energy supplies. For instance, the city has introduced bus rapid transit and urban rail, which can supply the city with power from the city’s public grid system rather than from the city’s own diesel power plants. The city has also introduced an extensive bike path system.

Paris
Paris is France’s capital and has about 2.2 million inhabitants. For seven years now, the city has placed its sustainability focus on public transportation and energy-efficient building systems — and Siemens is helping with this effort. In 2011, the Paris metro turns 150 years old. For 30 years Siemens has equipped the subway with signal and safety systems that allow subway drivers to maintain shorter intervals between trains, a higher average speed, and lower maintenance costs. At the same time Siemens technologies are helping to reduce energy consumption and emissions rates by introducing low-emission hybrid buses, efficient dc plants for the conversion of wind energy, and solutions for the production of electricity — whether through biomass, wind or solar energy. For instance, the roof of the Fitness building contains 19,000 solar panels that provide 2.2 megawatts of power. In the future, Siemens aims to start operating one of the most efficient solar power plants in Europe to reduce carbon dioxide emissions, and to serve public buildings with sustainable technology.

Amsterdam
Approximately 2.5 million inhabitants live in Amsterdam, which is one of Europe’s highest density of inhabitants. The city is already proving that these ambitious goals can be achieved. (p. 21)

Warsaw
About 1.7 million inhabitants make the Polish capital the largest city in the country. With many new buildings, the city continues to grow, and this will lead to greater energy demands and destruction. But the city continues to introduce a large number of energy-saving measures, and energy consumption noticeably. (p. 5)

Malmö
With 285,000 residents, the third-largest city in Sweden, the city has set itself a target to become by 2030 one of Europe’s highest density of inhabitants. Siemens has helped with for example energy-efficient solutions for schools and swimming pools, solutions for energy-efficient water treatment plants, and improvement of road traffic. (p. 7)

Hamburg
With approximately 1.8 million inhabitants, Hamburg is Germany’s second-largest city. In 2011 the city became the European Green Capital of the EU Commission. Over the past years the Hamburg city has successfully implemented a number of sustainable development and environmental protection measures. Nowadays, Hamburg is amongst the most environmentally friendly city in Europe. That’s mainly due to the reduction of energy supply and climate protection measures which the city has implemented. The goal is to become carbon-free by 2050 — aided in part by Siemens. This will be achieved through the production of carbon dioxide free electricity from renewable energy sources (p. 10). At the same time, Munich’s municipal utility has set itself the target of becoming carbon-free through green electricity as well. As part of Siemens’ technology. (p. 21)

Copenhagen
Copenhagen has about 500,000 inhabitants and is the capital of Denmark. According to the European Green City Index, Copenhagen is currently the most environmentally friendly city in Europe. That’s mainly due to the reduction of energy supply and climate protection measures which the city has implemented. The goal is to become carbon-free by 2050 — aided in part by Siemens. This will be achieved through the production of carbon dioxide free electricity from renewable energy sources (p. 10). At the same time, Munich’s municipal utility has set itself the target of becoming carbon-free through green electricity as well. As part of Siemens’ (p. 21)

Zurich
Zurich is Switzerland’s largest and most densely populated city. It will work towards becoming a sustainable city, centered on efficient public transportation and encouraging electrically powered mobility. (p. 32)

Oslo
With about 600,000 inhabitants Norway’s capital is one of Europe’s highest density of inhabitants. Siemens and Norway’s capital have already taken many of them steps towards greater efficiency, starting with the Technical University of Denmark. (p. 16)

Vienna
The Austrian capital Vienna has an estimated 1.7 million inhabitants and is the country’s largest city. In 2011 it became a “Smart City” with an ambitious technology. (p. 41)
**Onshore Power**

Germany’s first onshore electrical power supply station for merchant ships went into operation in the city of Lübeck in August 2008. The facility enables ships to tap into the local grid for their electricity needs, rather than producing power themselves with pollutant-emitting diesel generators. At the heart of the Siemens solution is the Siplink system, which makes it possible for the first time to link ship and landside power networks, even if their frequencies differ.

**High Savings**

The new Monte Rosa Hut in the mountains above Zermatt provides a foretaste of how smart building systems can help save costs. Situated at an altitude of 2,883 meters, the hut is largely self-sufficient, thanks to a concept developed by the ETH Zurich and the Swiss Alpine Club (SAC). For example, the electricity for the water treatment facility and the lighting is supplied by a photovoltaic system, which is supplemented by a small power-heat-unit when necessary. The hut is equipped with a Siemens facility automation system that takes weather forecasts into account, enabling it to cut energy costs by up to one third.

**The CO₂ Catchers**

Coal as a fuel is going to remain a cornerstone of the energy supply for a long time to come. New technologies are expected to free power stations of greenhouse gas carbon dioxide, thus making a decisive contribution to environmental protection. Experts worldwide are working on concepts for generating power without releasing CO₂ into the atmosphere. Among the methods Siemens is focusing on is the IGCC process, in which the CO₂ is separated before combustion, and flue-gas purification methods that separate CO₂ after combustion. For example, Siemens experts at a pilot facility in Freiberg, Germany, are studying how different types of coal behave in the gasifier.

**The Future on Wheels**

The European Commission has awarded Hamburg the title “European Green Capital 2011,” thus providing a platform for the discussion of environmental issues and urban development between citizens, experts, and the business community. In line with this aim, Hamburg will launch the “Train of Ideas” in order to learn from other European cities and enter into a dialogue with people in Germany and abroad.

The train will turn Hamburg into a Green Capital on wheels, featuring a state-of-the-art, interactive exhibition that shows visitors an exciting and informative manner how the cities of the future may become sustainable.

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As the train’s official Premium-Partner, Siemens also has exhibits in the Train of Ideas. The company will, for example, present a variety of films that allow viewers to experience the smart grids of the future. At the push of a button, visitors will be able to see how smart grids differ from conventional power networks and what their advantages are.

The Train of Ideas will stop at a total of 18 cities throughout Europe, including Hamburg, Copenhagen, Malmö, Oslo, Zurich, Munich, Warsaw, Vienna, Barcelona, Paris, Brussels, and Amsterdam. In all of these places, Hamburg is planning to cooperate with Siemens to hold events on the topic of sustainable cities.

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13 Masters of Sustainability
The Economist Intelligence Unit conducted a study to find out which European cities had done their ‘green’ homework best. The top markets went to Copenhagen, Oslo and Stockholm.

20 To Petit Noir without a Driver
Paris has one of the world’s most dense subway networks. New technologies from Siemens are helping city residents to reach their destinations even more quickly.

21 A CO₂-free Future
Cities today consume 75 percent of the world’s energy. They are also responsible for 80 percent of greenhouse gas emissions. Yet many existing technologies can help us make great strides toward CO₂-free cities.

24 Wet Labor
In Singapore, clean water is at the top of the agenda. Companies from around the world come to this small city-state to test their treatment innovations. This is also where Siemens coordinates its worldwide research in this field.

27 Frugal Airports
Airports are the biggest energy consumers in large cities. However, relatively simply technologies can be deployed to significantly reduce this energy consumption.

Talk of the Town
It’s June 2020. Municipal manager John Gardiner is explaining to a visiting student how he has improved the quality of life in his urban neighbourhood while cutting energy consumption in half.

"Jennifer, you’ll just have to stay for dinner," says John Gardiner, looking over the edge of his glass. "I’m expecting a couple of important people who can contribute to our discussion on environmentally friendly urban planning."

"Thanks for the invitation," replies Jennifer Miles, a student of applied ecology who had approached John after he gave a presentation at an international conference on energy efficiency. She had asked him a few questions, and he had spontaneously invited her to his apartment — in order to continue their interesting scientific discussion. "You wanted to tell me how you managed to more than halve energy consumption," Jennifer prompts. "Saving energy is very important, but it’s not everything,” John replies. "A city shouldn’t sacrifice any of its charm in the process. Its inhabitants have to enjoy living there."

John walks over to the panorama window. "Some 800,000 people live in my neighbourhood. For years now, it’s been the most popu-
Urban Nature

More and more people are moving to cities, which now account for 80 percent of greenhouse gas emissions. To steer this rapid urbanization toward a greener future, major cities are increasingly turning to new, energy-efficient technologies.

In Europe, there’s particularly great need for green and livable cities, as there already live 73 percent of the population in cities — compared to around 47 percent in China. The primary challenge for European metropolitan regions is therefore to make existing infrastructures more energy efficient and environmentally compatible. A study by Moran Stanley Investment Management estimates the costs for the renewal of power and water infrastructures. Yet the battle to limit climate change could be fought most effectively in large population centers. Cities already account for 75 percent of the energy consumed worldwide and are responsible for 80 percent of greenhouse gas emissions. Today, architects such as Libeskind see a gradual change in attitude. “There’s a rethink taking place,” he says. “Municipal authorities are now looking at more sustainable ways of shaping rapid urbanization. That creates a lot of potential for innovation.” The HSBC bank estimates that around 15 percent of current measures to stimulate the economic worldwide are going into green infrastructure projects such as energy-efficient building systems.
The metropolis of Munich could reduce its CO$_2$ emissions by 80 to 90 percent until 2058.

Why it Pays to be Green. The example on Copenhagen illustrates that environment and the economy need not be mutually exclusive. On the contrary, energy efficiency measures generally pay for themselves quickly — above all in the field of building technology and urban public transport (p.30 onward).

The following example illustrates the type of technology to reduce energy consumption, water consumption, waste, and emissions by over 40 percent by 2025. What’s more, it would be possible to do so without negatively impacting the lifestyles of the city’s residents. The investment required over 20 years would be equal to less than 1 percent of London’s annual economic output.

Energy-efficient buildings offer the quickest route to reducing cities’ greenhouse gas emissions — here Madrid’s Torre de Cristal. But also LEDs, for example in traffic lights, or modern trains are energy savers.

Munich, for its part, could reduce its CO$_2$ emissions by 80 to 90 percent by 2058 (p.21). Here the emphasis is on measures for increasing energy efficiency. The list includes heat insulation and recovery systems in buildings, the exploitation of energy-saving electrical devices and lighting systems, more extensive use of buses, trains, and electric cars; the construction of combined heat and power plants and renewable energy facilities; and the transmission of low-CO$_2$ electricity over long distances.

There’s certainly no lack of creative ideas beside the solutions already mentioned about how to realize this vision of the green city. Siemens researchers have plans for special façade coating that exploits the principle of photosynthesis. Like plants, buildings would then be able to convert carbon dioxide from the air into energy costs just by replacing the lights. In this era of tight budgets, LED traffic lights offer a perfect example of how ecological and economic goals can be achieved simultaneously.

Technically, cities could therefore soon be energy-saving champions. But sustainability contains more than just energy-saving technology. Solutions for a sustainable transport have to be established, too — for example for the foodstuff transport. Today, oranges end up not only in local markets but often on supermarket shelves 1,000 km away. On the way there, they produce tons of CO$_2$.

According to scientists such as Dickson DeSpommer, the time has come for city planners not least of all to turn to the example of termites in the long term in order to ensure sustainable urban development. In harmony with nature, sky-scrapers in the megacities of the future would then be able to serve as tremendous greenhouses in which vegetables, fruits, grains, and poultry are grown exclusively for local use. Then vegetables, fruits, grains, and poultry can generate: The ratio between a country’s gross domestic product — adjusted to take pure-protection measures, including an efficient district heating system, the use of wind power, and the introduction of electrically-powered buses in local public transport. These are elements of a plan by municipal authorities to turn Copenhagen into a completely CO$_2$-free city by the year 2025.

The European Green City Index — a ranking of the most important European cities that is unique in terms of its broad scope — was developed by the EIU in cooperation with independent urban experts and Siemens. “The result is the European Green City Index — a ranking of the most important European cities,” says James Watson, managing editor of the study.

“The European Green City Index provides insights into the strengths and weaknesses of each city,” says Stefan Deng, project manager at Siemens. “In this manner, it supports the efforts of these cities to develop more effective climate protection measures, and it also helps with prioritization of environmental activities.” Most important, however, is the fact that the study allows the cities to learn from each other, something that is well worth the effort. Whether it’s Europe’s largest biomass power plant in Vierna, the continent’s most modern offshore wind power facility in Denmark, the recycling lottery system in Ljubljana, free rental bikes in Paris, landfills with methane production facilities in Istanbul, or buses equipped with systems that cause traffic lights to turn green faster in Tallinn, the

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What Makes a City a Winner?

The European Green City Index, a study by the Economist Intelligence Unit in cooperation with Siemens, published in December 2009, compares the environmental compatibility of 30 European cities. Top-ping the list is Denmark’s capital, Copenhagen.

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Europe’s Green City Index

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Scandinavia has invested in environmental protection for years—resulting in top rankings in the Index.

What’s more, environmental awareness is increasing. Of the 30 European cities studied, 26 have developed their own environmental plan. Half of the cities also have firm, feasible CO₂-reduction targets. Copenhagen is planning to achieve CO₂-free electricity by 2025, and Stockholm intends to do the same by 2050. Still, all the cities are facing major challenges. For example, on average, renewable energy sources account for only around seven percent of their total energy supply—well under the EU target of 20 percent by 2020. Less than 20 percent of the waste in the cities studied is currently recycled, and one of every four liters of water is lost through leaky pipes. Clearly, one of the key indicators determining a city’s ranking in the index is its relative level of affluence. For example, nine of the cities that made it to the Top 10 have above-average gross domestic products (GDPs). These cities not only have better, more environmentally-friendly infrastructures than are found in less affluent cities; they also are pursuing more ambitious climate and environmental protection goals—a surprising result given the fact that affluence and a higher level of development are often associated with higher energy consumption and emissions.

Getting Involved. But money isn’t everything, as Berlin and Vilnius impressively demonstrate. Despite having the ninth-lowest GDP of all 30 cities, Berlin still managed to finish eighth in the overall rankings, ahead of other large and more affluent cities such as Paris, London, and Madrid. Berlin also shared the best ranking in the Buildings category with Stockholm. Vilnius, with the sixth lowest GDP in the index, leaves all other cities behind in the Air category—has the best overall ranking (13th place) among the Eastern European cities.

One option here is citizen participation as it’s being practiced in Brussels, which launched an initiative on energy efficiency (sustainable neighborhood). The initiative calls on residents to develop green ideas for their neighborhoods. The most promising ideas receive technical and financial support from the city.

Raising awareness of environmental and climate change issues and providing information are also indispensable elements in the battle against climate change. “Many decision-makers still don’t realize that investments in energy-efficient technologies tend to pay off financially,” says Deng. Whether it’s better building insulation, energy-saving lighting systems, or efficient building management systems, more widespread application of energy-saving technologies require a higher initial investment, but it’s one that pays off in the form of lower energy costs throughout product life cycles (see Pictures of the Future, Spring 2009, p. 35). “What’s more,” says James Watson, “if most of the residents of a city use public transport, conserve water and energy, and make ‘green’ purchasing decisions, the change in their behavior can add up to far greater results than what can be achieved with restrictive city regulations.” —Karen Steiner

Gross Domestic Product: A Major Factor Affecting the Ranking of almost all European Cities

Ranking of Europe’s Greenest Cities

In Stockholm, 68 percent of residents ride their bicycles to work. Berlin (right) modernized most of its buildings in accordance with strict energy efficiency criteria after 1990.
Wind, Wood & Two Wheels

With its first-place ranking in the European Green City Index, Copenhagen outshines 29 other major municipalities. Its title as Europe’s most environmentally-friendly city is the result of a wide range of climate-protection measures, such as pellet-powered district heating, wind parks, bike paths and integrated public transit.

The bicycles are a perfect symbol of Copenhagen. "If there’s one instantly recognizable sign of Copenhagen’s green credentials it’s the vast number of bicycles on its streets. A considerable number of the city’s 520,000 residents are avid bicyclists, even when clouds are low and the rain is pouring down. The city’s broad cycling lanes literally team with bicycles, bikes with trailers, and even sporty-looking tricycles complete with transport box for carrying a child passenger or packages. "If you look at photographs from the 1930s, you see a very similar picture," says Peter Olmari, deputy finance director of the city of Copenhagen. "Back then, not many people were able to afford a car; but today, having a bicycle is just part of the Copenhagen way of life. Almost 40 percent of the city’s population travels by bike every day to their place of work or study."

The city’s broad cycling lanes literally teem with power (CHP) plant, rather than having each household produce its own heat. All in all, while eliminating the need for private heating systems, the city’s CHP plant is 90 percent efficient. Copenhagen started laying twin pipes for superheated steam and hot water from the CHP plant to households and back again. For many years, the plant, which also serves several communities in the surrounding area, was fired with coal. No longer. One of the cogeneration units is now fired with environmentally-friendly bio material, and a second is scheduled to be converted to this fuel in the near future.

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"We have no intention of resting on our laurels," said Ritt Bjerregaard (top left), Copenhagen’s mayor until the end of 2009, at the presentation of the European Green City Index. She went on to announce an ambitious goal. "We intend to turn Copenhagen into a CO2-free city by the year 2025."

In concrete terms, carbon dioxide-free means two things. First, reducing the current emissions level of 2.5 million metric tons of carbon dioxide per year by 1.15 million metric tons by 2025 with measures that either have been already implemented or are scheduled. Secondly, offsetting the remaining CO2 emissions by means of projects such as new wind farms and the planting of woodlands. As the improvements of recent years show, this ambitious target looks quite realistic. While CO2 emissions in many other cities have increased, Copenhagen’s — already low to begin with — have been cut by 20 percent since 1990.

The package of measures adopted by Copenhagen also extends to transport. Buses on the city’s downtown routes, for example, are now electrically powered, which reduces exhaust fumes and noise levels in the narrow streets. The city also intends to fit its entire fleet of vehicles, 600 in all, with electric or hybrid drive systems.

"We intend to turn Copenhagen into a carbon dioxide-free city by the year 2025."

And all of Copenhagen’s publicly-owned real estate is to be brought up to the latest energy efficiency standards. Copenhagen's approved plan of action for achieving carbon dioxide neutrality by 2025 includes construction of a new subway ring, which will connect the southern area of the city to the rail network by 2018. Already, almost everyone in the city lives within 350 meters of a public transport station. In addition, a former harbor area is to make way for a new district by the name of Nordhavn, with homes for 40,000 people. Publicity campaigns are one way to encourage this, but we also want to make sure the people are directly involved in the development of solutions. With one-fifth of all CO2 emissions caused by transport, the plan is to encourage even more residents to use their bikes. The city is thus looking to improve conditions for cyclists even further, with facilities such as covered bike paths and bike parks. In fact, as of last fall, there are even special warning lights set into downtown roads to alert truck drivers turning right to the presence of cyclists in their rearview blind spot. If a cyclist approaches a the blind spot, the lamps start to flash. In other words, cyclists are taken very seriously in Copenhagen — another good reason to visit this city. City dwellers here live within 350 meters of a public transport station. In addition, a former harbor area is to make way for a new district by the name of Nordhavn, with homes for 40,000 people. Publicity campaigns are one way to encourage this, but we also want to make sure the people are directly involved in the development of solutions. With one-fifth of all CO2 emissions caused by transport, the plan is to encourage even more residents to use their bikes. The city is thus looking to improve conditions for cyclists even further, with facilities such as covered bike paths and bike parks. In fact, as of last fall, there are even special warning lights set into downtown roads to alert truck drivers turning right to the presence of cyclists in their rearview blind spot. If a cyclist approaches a the blind spot, the lamps start to flash. In other words, cyclists are taken very seriously in Copenhagen — another good reason to visit this city.

With its first-place ranking in the European Green City Index, Copenhagen outshines 29 other major municipalities. Its title as Europe’s most environmentally-friendly city is the result of a wide range of climate-protection measures, such as pellet-powered district heating, wind parks, bike paths and integrated public transit.
Green Milestones

According to a study conducted for the European Green City Index, Oslo is one of the greenest cities in Europe. The city’s sustainable approach is made possible by numerous environmentally-friendly technologies, some of them from Siemens. The city has opened an electromechanical substation and high-efficiency lighting in the opera house.

Most people wouldn’t be thrilled about having to get underneat a subway train. But Tor Hasselknippe sees it as a welcome challenge. Every day Hasselknippe, a technical manager at Oslo’s Vognskap pub- lic transport company, inspects the Siemens trains that since 2006 have gradually been replacing the more than 30-year-old subway trains previously used in the Norwegian capital. At the maintenance center, the subway cars are jacked up on rail platforms in a vast hall. Technicians work on the underbodies and put the finishing touches on the cars before sending them out into the city’s approximately 84-kilometer-long subway network. “This is one of the electric motors,” Hasselknippe says, pointing to a large rectangular block underneat one of the cars. “The complete drive unit has an output of 1,680 kilowatts and sends the electricity it produces back into the grid.” Hasselknippe then knocks on the white outer wall of a car: “The entire shell is made of aluminum,” he says. “This makes the train extremely light.” As a result, the new subway trains consume 30 percent less energy than the old ones. “And that’s not all,” says Hasselknippe as he climbs into a passenger cabin and runs his hands over the seat covers. “These textiles are made of a very sophisticated mate- rial that not only meets all fire protection requirements but can also be recycled — which is true of 95 percent of the components in these trains. All of this makes our subway one of most sustainable systems in the world.”

Heating on Demand. It isn’t always easy to combine sustainability with the effective oper- ation of the new subway. For one thing, around 80 percent of Oslo’s subway system is above ground, which negatively impacts its en- ergy balance, especially in winter. “The heating system still accounts for nearly 20 percent of required energy — so we need to keep working on that,” says Hasselknippe. Engineers at Siemens Mobility in Vienna, Austria, are looking at ways to reduce the energy consumption of heating and climate control systems. “We’ve developed a heating control unit that regulates the system in line with real-time requirements,” says project manager Dr. Walter Struckl. “The unit is linked to a carbon dioxide sensor that determines how many passengers are in a car based on the principle that the CO2 content rises with the number of people pres- ent.” According to Struckl, the unit can heat up air from the outside in line with actual heating needs. By contrast, conventional systems con- tinually heat subway cars, regardless of whether or not passengers are on board. “Our technology should generate heat-energy sav- ings of up to 30 percent,” says Struckl. Sustain- ability and energy efficiency have been top pri- orities in Oslo for some time. In 2002 the city, which has a population of 550,000, launched its ambitious Urban Ecology Program to cut pollutant emissions and improve its citizens’ quality of life. Among other things, the associ- ated plan calls for a 50 percent reduction of Oslo’s 1990 greenhouse gas emission levels by 2030. This green program is already producing results. A sustainability study of 30 European cities for the European Green City Index (p. 17) ranked Oslo third behind Stockholm and Copenhagen. The study even gave the Nore- gian capital a top ranking for CO2 emissions, as the city produces only slightly more than two tons of the greenhouse gas per capita — mainly because Oslo covers around 60 percent of its electricity requirement with power from Nor- way’s large hydropower plants.

Another Oslo green milestone is near the city center just a few minutes from the Jern- banetorget subway station. Resembling a giant iceberg transformed into concrete, the new opera house rises up out of the harbor. The im- posing building houses one of the most energy-efficient opera houses in the world — a feat made possible in part by an innovative lighting system concept that relies on light-emitting diodes (LEDs). “We equipped the entire concert hall with LEDs — there’s nothing else like it in the world,” says Kato Joh- hannesen, who is managing the project for Osram Norway.

Johannesen is particularly proud of the eight-ton chandelier that hangs 16 meters above the seats. “That chandelier contains 9,100 LEDs,” he says. “We’ve also got special dimmers for individually adapting the LED modules to the most diverse lighting require- ments.” The small LEDs are highly efficient, with an output of 45 lumens per watt as com- pared to a maximum of 12 lumens per watt for conventional incandescent lamps. At maxi- mum brightness, the 8,100 LEDs consume just 14 kilowatts. They are as powerful as they are robust, says Johannesen. “On average, only one out of every million LEDs fails during its six-year service life, and so far we haven’t had to replace a single unit,” he says. Johannesen believes Oslo will step up its use of energy-efficient lighting in the future. Small and flexible LEDs in particular offer great potential with regard to climate protection — and not just in magnificent buildings like the new opera house. “Oslo has drawn up initial plans to show that LEDs can also make street- lights greener,” he says.

For more on future developments in LED technology, please see our article in this issue’s Extracts from the Future section. For more information on the LED lighting project in Oslo, visit the following websites:

1. http://www.oslooperasenteret.no

2. http://www.oslooperasenteret.no/konferanser/led


5. http://www.oslooperasenteret.no/konferanser/led

But there’s still work to be done, so the Ur- ban Ecology Program, scheduled to run until 2014, also focuses on expanding the local pub- lic transport network. Studies have shown that road traffic is responsible for the lion’s share of Oslo’s CO2 emissions. Despite high tolls for en- tering the city center, some 360,000 vehicles continue to drive through Oslo every day. The city government believes that improving the bus and subway system will get more com- muters to leave their cars at home. Indeed, the new subway system has already demonstrated that the government may be right. “Polls show that passengers are extremely satisfied,” says Hasselknippe. “Since the introduction of the new trains, ridership has increased by around 10 percent to 73 million in 2008.” He thinks even more people will switch to the subway in the future, especially now that intervals be- tween trains have been cut in half. “Trains have been running every seven minutes 20 hours per day for a year now — and that eliminates many people’s need to drive.”

Another Oslo green milestone is the city—with annual emissions of about 30 percent of the greenhouse gas per capita—a large hydropower project that not only meets all fire protection requirements but can also be recycled—which is true of 95 percent of the components in these trains. All of this makes our subway one of most sustainable systems in the world.”

The city has introduced a range of green measures—such as the 2012 City’s Environment Ministry. In 2003 the city was the third largest city in the world and the environmental organization Bellona as part of a pilot project entitled “Energy Smart City.”

The study looks at ways to save energy in residential and commercial real estate, street lighting, the power grid, and industry. It shows that by using technology already available, Trondheim could cut its energy consumption of five terawatt-hours per year by 22 percent without compromising the quality of life of its citizens. “We will realize most of these potential savings in one or two years,” says Rita Ottervik, Mayor of Trondheim. A good way of cutting power consumption is to install new building management systems that intelligently control lighting, heating, and ventila- tion systems. In Trondheim’s office properties alone, this would save as much electricity as is con- sumed over the same period by 4,000 households. Street lighting also offers big savings potential, despite the fact that 25,000 installations are already very efficient. Dimming them by 50 percent, for example, would cut their annual power consumption by over five gigawatt-hours (GWh) and save around 470,000 euros on energy costs. Even greater savings could be achieved by upgrading the city’s power grid, where every five percent of the electricity is lost as heat while being transmitted to the consumer.

Efficient high-voltage systems could cut these losses by as much as 50 GWh, thus saving around 38 million euros. A good example of the kind of project that has been publicized in a wide-ranging campaign since Fall 2009. Energy saving is being promoted in the media, at symposia, in school competitions, on buses, and in messages printed on roadways.

Hydroelectric power plants and an energy-efficient new metro have helped reduce Oslo’s per capita CO2 emissions to just two tons. Small things such as an LED chandelier in the city’s Opera House also help.
Fast Tracks, Bright Lights

Paris has one of the world’s densest and oldest subway networks. Automation technology from Siemens is making the system more energy efficient. Meanwhile, light sensors are helping buildings to cut power consumption.

One way of raising throughput is to reduce intervals between trains. This is now being done on Line 1 — the oldest and, with 750,000 passengers a day, one of the most frequented routes — in a joint project between the Paris transit authority RATP and Siemens. In fact, Siemens has been supplying the Paris Metro lines with signaling technology and advanced driver assistance systems for the past 30 years. Now there are plans to introduce driverless trains on Line 1 — with Siemens technology.

At present, stations are being fitted with glass walls to separate platforms from tracks. These will incorporate automatic doors that open to let passengers enter the trains. This will help to reduce maintenance costs and cut the current intervals between trains from 105 to around 85 sec.

seashore, as well as increasing flexibility and reliability. Such fully automatic passenger trains with Siemens technology have been in service on Line 14 of the Paris Metro for 7.2 years. With an average speed of 40 km/h, it is substantially faster than the other lines, which operate at around 25 km/h.

Seventy Percent Less for Lighting. Energy saving continues after the daily Metro ride to work — at least for employees at the Parisian headquarters of the OECD, the Organisation for Economic Co-operation and Development. Although parts of the building are 50 years old, it is now able to adapt automatically to prevailing weather conditions. In the course of general refurbishment, a Dai Multi-intelligent lighting system from Siemens’ subsidiary Osram was installed. The system comprises around 1,000 lamps with sensors that determine how much light is actually required and then tailor the lamps’ output accordingly. The lamps have replaced conventional ceiling lighting that provided each workstation with constant illumination throughout the day. Whenever employees leave their offices for a longer period, the lights now go off automatically. Similarly, when it’s cloudy and natural light enters through the windows, the lamps automatically brighten.

Independent measurements have shown that energy consumption for lighting has fallen by as much as 70 percent compared to before the refurbishment. Bernard Balia, former head of facility management at OECD, was responsible for the project. “The system makes sense and is adaptable. Instead of everyone having uniform lighting, employees can now help to determine the right amount of light for their needs. And the system is economical, since lights only get switched on when they are actually needed,” he says.

Outside, on café terraces, patio heaters continue to singe the Parisian air whether anyone is there or not. Perhaps one day they too will be fitted with sensors, allowing them to blight into life only when actually needed. After all, when it comes to preserving the French way of life, some small sins should be permissible — if, that is, real crimes against the environment are avoided.

The Metro is Paris’ most important mode of transport. Glass walls between platforms and trains and new Siemens driverless systems will increase throughput on overloaded lines.

| Study of a Carbon-Free Munich

Cities are attractive places to live. They promise work, a vibrant cultural life, and a host of leisure activities. All of which is very true of Munich, Bavaria’s capital. From here, it’s only a short hop to go climbing or skiing in the Alps, to reach crystal-clear lakes, or to drive to Italy and the Mediterranean. Little wonder then that Munich is one of the few cities in Germany that is set to grow in the coming decades. Although an exception in Germany, the city is, however, very much in line with the trend toward ever-larger metropolitan areas.

In the world’s newly industrializing and developing countries people flock to cities in search of work and education and in hope of a better life. And in 2008 a watershed was reached. For the first time ever, half of the world’s population lived in cities. By 2050 this figure is forecast to grow to 70 percent. This will result in huge urban sprawls that consume resources and pollute environments.

Although metropolitan areas cover only one percent of the earth’s surface, they are responsible for 75 percent of the world’s energy consumption and only 10 percent of the CO₂ emissions in Germany. That means that effective steps to cut emissions in urban areas can have profound effects on the environment. A new study based on the city of Munich shows how a major metropolitan area could make itself virtually carbon-free within a few decades.

Munich is a medium-sized city with 1.5 million inhabitants. The city is, however, very much in line with the trend toward ever-larger metropolitan areas. This, it says, will require close cooperation between municipal authorities, energy companies, and the population, along with a clear commitment to efficient technologies, ranging from energy-saving refrigerators to power plants, as well as a general willingness to invest in greater use of renewable energy sources such as wind, solar power, biomass, and geothermal energy.

Cutting CO₂ by 80 to 90 Percent. The study sketches two alternative scenarios for Munich. The so-called ‘target scenario’ adopts the very optimistic view that the vision of a carbon-free future can be more or less achieved over the 50-year span under consideration in the study. Another scenario — the so-called bridge scenario — is somewhat more conservative and assumes, for example, that increased efficiency in power generation will be offset by rises in demand and that individual transport will remain similar to its present day form. Nevertheless, the results are impressive in both cases. The optimistic target scenario predicts...
that through the implementation of comprehensive efficiency measures the average CO₂ emissions per inhabitant can be curbed by around 90 percent to 750 kilograms per annum by the middle of the century.

The more conservative bridge scenario, on the other hand, results in a reduction of CO₂ emissions that through the implementation of comprehensive efficiency measures the average CO₂ emissions by the middle of the century. This is not an unrealistic proposition.

The study analyzes in detail which measures will achieve the greatest reduction in CO₂ emissions and whether they are economically feasible. Almost half of Munich’s CO₂ emissions are the result of energy used to heat the city’s homes and buildings. Improving the insulation of roofs, facades, and basements would thus yield significant savings. It is therefore crucial not to scrimp in this area. In fact, the study assumes that the refurbishment of existing housing in Munich will conform to the Passive House standard and that all future housing will also conform to this standard. This includes the use of not only the best insulation and vacuum-insulated windows but also ventilation systems that recover residual heat from the houses’ exhaust air before it is blown outside.

Based on the above steps, the study finds that it should be possible to reduce heating requirements for existing buildings from the current figure of around 200 kilowatt-hours per square meter per annum (kWh/m²) to between 25 and 35 kWh/m², while new housing will require only between 10 to 20 kWh/m². At the same time, new buildings are to be fitted with solar power systems, so that most of them will be able to cover their remaining energy requirements autonomously and even feed excess energy into the grid. In order to ensure that the energy efficiency of most buildings is raised to the requisite level over the next 50 years, the rate at which such refurbishment is being carried out must increase from the current figure of 0.5 percent to 2.0 percent per annum. This means that four times as many homeowners must implement such energy improvements than is currently the case.

The idea of improving the energy efficiency of a city like Munich on a more or less wholesale basis over 50 years sounds like a major challenge. Yet such efforts are worthwhile. Although it is more expensive to build according to the Passive House standard than to implement the Energy Conservation Act of 2007, the additional costs involved in such refurbishment and the construction of new housing would amount to around €13 billion for the entire city of Munich. That would mean extra costs of approximately €200 a year per inhabitant — about one third of an average annual gas bill. By 2058, however, this additional investment would result in energy savings of between €1.6 and €2.6 billion per year, which translates into an annual sum of between €1,200 to €2,000 per inhabitant. The refurbishment of existing and construction of new housing in line with the Passive House standard would — according to the study — result in energy savings of almost 80 billion by 2058. Moreover, this scenario also applies to other areas, since the study comes to the conclusion that measures designed to enhance efficiency generally pay for themselves over their lifetime.

Home Power. Of course, insulation is by no means the end of the story. More has to be done if CO₂ emissions are to be cut to almost zero. Greenhouse gas emissions can also be reduced by the use of combined heat and power (CHP) systems. Such heating systems are particularly efficient, since they utilize around nine tenths of the energy contained in their primary fuel. Both Munich scenarios also assume that the use of district heating will rise from the current figure of 20 percent to 60 percent. This is not an unrealistic proposition. In Copenhagen, for example, around 70 percent of all households are heated this way.

Other measures designed to reduce CO₂ emissions include the use of economical electric appliances and lighting as well as renewable and low-carbon energy sources such as photovoltaic systems, solar collectors, and geothermal systems. The study assumes that electricity will be increasingly generated on a decentralized basis — for example, by CHP plants for individual areas of the city or even micro CHP units for individual buildings, which supply not only heat but also electricity for residents. This is not an unrealistic proposition.

At the same time, better town planning can help reduce the amount of traffic in Munich and therefore reduce its CO₂ emissions. Both scenarios are based on reduced travel require-ments for existing buildings from the current figure of around 200 kilowatt-hours per square meter per annum (kWh/m²) to between 25 and 35 kWh/m², while new housing will require only between 10 to 20 kWh/m². At the same time, new buildings are to be fitted with solar power systems, so that most of them will be able to cover their remaining energy requirements autonomously and even feed excess energy into the grid. In order to ensure that the energy efficiency of most buildings is raised to the requisite level over the next 50 years, the rate at which such refurbishment is being carried out must increase from the current figure of 0.5 percent to 2.0 percent per annum. This means that four times as many homeowners must implement such energy improvements than is currently the case.

Improving the energy efficiency of buildings will cost €13 billion but result in energy savings of €30 billion.

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Water Purification

An innovative desalination technology from Siemens requires only half as much energy as the best previous systems to turn salt water into pure, potable water.

The building on Toh Guan Road is a functional structure with a plain facade, plenty of parking, and a foyer straight out a typical high school. And in fact schoolchildren often visit on class trips. But the people who actually study here are older. They are researchers from around the world who have come to Singapore’s “Water Hub” to develop solutions to one of the century’s greatest challenges — how to provide everyone with clean water, and to do so inexpensively, with the minimum of energy and an environmentally responsible way.

The answer to this question just might be right here in this building, in a large hall that houses dozens of devices — networks of water tanks, tubes, hoses, new water purification technologies and blinking instruments for analysis. Monitors in the hall display measurements from around the world who have come to Singapore’s “Water Hub” to develop solutions to one of the century’s greatest challenges — how to provide everyone with clean water, and to do so inexpensively, with the minimum of energy and an environmentally responsible way.

The procedure for this is currently in the pilot phase, one of the numerous projects on which we are working closely with PUB, the National Water Agency Singapore. "The procedure for this is currently in the pilot phase, one of the numerous projects on which we are working closely with PUB, the National Water Agency Singapore. "

Siemens requires only half as much energy as the best previous systems to turn salt water into pure, potable water.
Trillions of Dollars for the Modernization of Infrastructures

A well-developed, properly functioning infrastructure is the prerequisite for prosperity and sustainable growth. Roads in disrepair, data and power networks with inadequate capacity, and deteriorating water networks cripple the economy. Modernizing the infrastructure and providing roads, rail lines, water, and power supply systems in emerging economies will require investments totaling $41 trillion worldwide in the next 20 years. That’s what experts from Morgan Stanley Investment Management conclude in a February 2009 study.

The European Union sees a need for $900 billion for expansion of transport infrastructure alone—from high-speed rail lines to satellite navigation. The EU is planning to realize a cross-border network of rail, highway and water infrastructures by 2020, with a growing number of seaports and airports. A major portion of the stimulus programs intended to revitalize the European economy in coming years encompasses infrastructure projects for transport and communication networks, energy efficiency, building modernization, and hospitals. These measures add up to a total of about €42 billion in Germany, France, and Italy.

The single most important factor in reducing energy consumption and costs will be improving the energy efficiency of buildings. This is because the largest share by far—95 percent—of the energy used to provide heat, hot water, air conditioning, lighting, and ventilation for buildings in Europe is consumed by structures that were built before 1980, says an analysis developed by TH Projektmanagement GmbH in Berlin.

The government of China has also launched various programs for infrastructure measures—with total funding equivalent to €520 billion, including €166 billion—from programs that existed before the economic crisis, and €84 billion in the form of additional economic stimulus elements. China is earmarking €73 billion for development of the nation’s rail system alone. Also slated for extensive upgrading are the drinking water and waste removal infrastructures in Chinese cities and the energy efficiency of buildings. Market experts from Morgan Stanley predict that China will account for approximately 80 percent of the total infrastructure expenditures in East Asia.

Worldwide, stimulus programs for recovery from the economic crisis of 2008 with a total volume of about €2.5 trillion have been announced and are already being implemented in part. Roughly one third of this sum—€700 billion—will be in the form of infrastructure investments, with the rest to be used for measures such as tax breaks for private households. For Siemens, analyses show that the market volume relevant to the company in terms of planned spending on infrastructure in the three fiscal years from 2010 to 2012 is about €150 billion. The largest share of this total, more than €65 billion, will be spent in the U.S., followed by China with €42 billion and Germany with about €45 billion. In all these countries, plans call for devoting major shares of the stimulus programs to green technologies. In China the figure is about 52 percent, in Germany it amounts to 60 percent, and in the U.S. it adds up to 31 percent. Based on Siemens’ current share of the global market, calculations indicate that the markets served by Siemens could generate a potential contract volume of approximately €45 billion for the company, including about €4 billion, or 40 percent, for environmental technology.

Sylvia Torge

flight from Carbon Dioxide

Rising energy prices, growing environmental awareness, and increasingly stringent legal requirements are forcing airports to sustainably reduce their energy consumption. Solutions from Siemens demonstrate the kinds of energy savings that are possible if complex airport infrastructures are looked at holistically. Siemens already serves as an energy manager at many airports worldwide.

Denver International Airport is a majestic facility. The roof of its passenger terminal is adorned with 34 pinwheels made of translucent Teflon as a tribute to the nearby Rocky Mountains. With 51 million passengers in 2008 (2010 numbers are available from ACD), the airport is one of the world’s busiest. Its passenger traffic is the 11th-highest in the world, and its number of flights is the fifth-highest. However, its complex infrastructure also makes it a huge consumer of energy. In 2007 it used 216 million kilowatt hours (kWh) of electricity, or more than 4 kWh per passenger.

In early 2008, the airport’s operating company therefore asked Siemens’ Building Technologies (BT) division to draw up concepts to cut airport energy consumption. In mid-2009 BT released a study offering optimization proposals aimed at reducing the airport’s overall natural gas demand by 10 percent and electricity consumption by 12 percent. For its study, BT examined the terminal, waiting halls, and office and equipment buildings. Along with energy-saving considerations, the study also took into account the impact the proposed measures would have on the environment, operating capacity, and on passenger comfort. The study produced a total of 26 proposals, the most effective of which involve measures that would address heating, cooling, ventilation, lighting, and baggage transport systems, which together account for more than 80 percent of total energy consumption. “Naturally, airports are looking to achieve extensive savings in terms of not only costs but also energy consumption and carbon dioxide emissions—and to do so as simply as possible and at a low level of investment,” says Uwe Karl, head of Airport Solutions at BT. There are also more expensive measures, such as the use of alternative energy generation systems. These can achieve immediate high carbon dioxide reductions, but pay for themselves only after a long period. To help the airport operator with its decisions, the study lists the cost of each individual measure, as well as the associated energy reduction and its amortization period. A good example of how to achieve a major effect at relatively low cost is offered by systems that control terminal ventilation in line with utilization. The installation of these systems, which employ CO2 sensors and intelligent ventilation control units, would cost $215,000—but would lead to annual energy-cost savings of $425,000. Such an investment would thus pay for itself after only six months. Another relatively simple way to save energy is to install energy-saving lamps and LED lighting systems. Lights in the passenger terminal at Denver International are left on.
A CO2-free airport is possible if a facility’s complex infrastructure is looked at holistically.

Siemens is responsible for the efficient energy management of the Airport Stuttgart (below). In addition to monthly, quarterly, and yearly reports, hourly values also play a key role in reducing the consumption.

With energy performance contracting, the customer doesn’t have to spend any of its own money, but benefits from the savings once the investment has been paid off. The operator of Detroit Airport assessed numerous energy service company offers, and the savings were then used to replace old machines in the lighting system with energy-efficient models. Siemens offered the lowest price and guaranteed the savings, and was awarded the contract.

In new buildings, the energy required for heating and air conditioning can be reduced by up to 40 percent just through architectural measures and new insulation and ventilation concepts. CO2 emissions can be reduced by 70 percent or even more if alternative energy sources, such as wind, solar, and geothermal energy, are used to generate the required energy. In German energy companies, biomass and biogas, and cogeneration are used, if equipment is replaced with devices that use little energy, and this equipment is operated on an as-needed basis.

To achieve a goal, you need an airport at any time to use energy-saving lights that operate in accordance with ambient light conditions and utilization requirements. This means you’re dealing with just one main switch for all the lights,” says Karl. “But if you optimize lighting systems to function in line with ambient light conditions and the utilization of specific areas, you can cut costs substantially.” The second area addresses the use of renewable energy-efficient energy sources such as wind, biomass/biogas, geothermal sources, and fuel cells. “Here, decisions have to be made based on individual circumstances,” says Uwe Karl. “Denver’s airport covers almost 140 square kilometers, for example, making it by far the largest in the United States in terms of area, so it makes sense to consider the use of biomass/biogas and wind energy.” The Siemens study thus proposes such measures as well.

The third area focuses on solutions in the fields of power generation, alternative energy, baggage and freight logistics, IT services, and building technologies. The goal here is to manage the many energy-hungry systems in use with the help of intelligent IT solutions aligned with airport processes, and to regularly monitor and process energy consumption over time. “Many airports have distributed independent systems, however, which makes it difficult to gain a good overview,” Karl explains. Here, as well, the key is to implement intelligent controls that eliminate the problem of constant energy consumption.

Investments that Pay for Themselves. The comprehensive analysis of energy consumption patterns at an airport forms the basis for the generation and implementation of energy-saving measures by specialists. This is the approach being taken at Detroit Airport, where Siemens has been serving as an “energy manager” since 2001. “Our objective here is to increase the comfort and safety of existing systems and reduce energy and maintenance costs — and to do so with as little expenditure as possible,” says Karl. The airport operator therefore sought out a company that had the comprehensive expertise that was necessary and could also offer energy performance contracting. With this form of financing, the vendor contractually guarantees the savings; the savings are invested in the utility and thus financed. In return, the saved energy costs are paid to the vendor until its expenses for financing, planning, and in return are paid to the vendor until its expenses for planning, and monitoring are paid in full.

With a CO2-neutral airport, Siemens is developing energy-efficient water treatment technologies, with its worldwide water R&D activities in the Wuppertal Institute for Climate, Environment, and Energy of 30 European cities. Topping the list are for Copenhagen, which is developing the environmental compatibility of 50 European cities. The Siemens BT is also active at Stuttgart Airport where it is responsible for efficient energy management on the basis of values calculated from the consumption of roughly 500 water meters and 400 heat and cooling meters. The setpoints as well as the controller settings from the automation and field level are documented and processed by the airport’s energy management system. In addition to monthly, quarterly, and yearly reports, hourly values also play a key role in assessing the efficiency of the systems. The program for analyzing the energy data compares current values with the building’s numerical model. Energy savings of up to 40 percent can thus be achieved.

These examples illustrate how major energy savings can be achieved through smart modernization and optimization. At the same time, more pleasant temperatures and lighting plus better air quality make the time spent at airports more comfortable for passengers and employees. In new buildings, the energy required for heating and air conditioning can be reduced by up to 40 percent just through architectural measures and new insulation and ventilation concepts. CO2 emissions can be reduced by 70 percent or even more if alternative energy sources, such as wind, solar, and geothermal energy are used to generate the required energy of geothermal energy, which corresponds to an 80 percent energy consumption improvement for the customer. Siemens has already installed such systems in several airports around the world, but has not yet announced these projects.

Siemens is already carbon-neutral at the world headquarters. “Here, savings were achieved with systematic operation and modifications to cut power consumption. (p.20)

In Brief

Rising energy prices, growing environmental awareness, and increasingly stringent legal requirements are forcing airports to sustainably reduce their energy consumption. Solutions from Siemens demonstrate the kinds of energy savings that are possible if complex airport infrastructure are tackled holistically. Siemens already serves as an energy manager at many airports in Europe and US. (p.27)

Siemens BT is also active at Stuttgart Airport where it is responsible for efficient energy management on the basis of values calculated from the consumption of roughly 500 water meters and 400 heat and cooling meters. The setpoints as well as the controller settings from the automation and field level are documented and processed by the airport’s energy management system. In addition to monthly, quarterly, and yearly reports, hourly values also play a key role in assessing the efficiency of the systems. The program for analyzing the energy data compares current values with the building’s numerical model. Energy savings of up to 40 percent can thus be achieved.

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Siemens has already installed such systems in several airports around the world, but has not yet announced these projects.
32 Intelligence is their Model
Buildings are coming to life. Thanks to automated management systems that ensure optimal lighting and ventilation via sophisticated sensors, building energy consumption can be reduced immensely. The pays are based on energy savings – as Siemens is already demonstrating with its Performance-Contracting. Pages 32, 36

38 Meters that Stabilize the Grid
By allowing customers to benefit from flexible electricity rates, intelligent meters can reduce grid loads and save users money.

49 A Toll Booth in Every Truck
Road pricing for trucks, phased traffic lights, hybrid buses and driverless subways are major trends that are set to transform the way we travel. Pages 43, 45, 49, 51

52 From Wind to Wheels
Electric cars could play a stabilizing role in tomorrow’s power grid, as mobile electricity storage units. Siemens is investigating how vehicles, the grid, and renewable energy sources interact.

55 Get a charge!
Siemens researchers are developing technologies that will make it possible to recharge electric vehicles in just a few minutes.

Master of Efficiency

Fun Jie, I’m thrilled — it’s exactly as you described it on the phone,” says Tan Xiao, who clearly cannot believe what his friend Fun Jie Fan, a famous efficiency planner in England, has done with the smallest neighborhood of the British capital London. “This neighborhood is really thriving and beautiful now,” Tan remarks. “There’s no noise, no smog, you’ve got a light rail system instead of all those cars, and there are parks where streets used to be. I can hardly recognize it any more.”
Fun Jie grins sheepishly. “I’m pleased to hear those words from you, my friend.” He says. “Another thing that makes me proud is that the government has acknowledged the success of our pilot project by awarding us new contracts for the gradual modernization of the rest of the city.”

A city of 12 million consisting of... Fun Jie, please excuse me, but I’m an old man and I forget things quickly,” Tan says. Fun Jie laughs. “You mean energy-self-sufficient buildings — like the one we’re standing in front of now.”

The two men look up at the skyscraper before them. “The government issued strict guidelines,” Fun Jie explains. All the energy used by every building has to come from renewable sources, and each building also has to purify its own water and reduce its need to buy drinking water from external sources by at least 90 percent. The government also wanted the neighborhood to have a better quality of life.

“But I know this building from back when I used to work in the area,” says Tan. “It looks the same — only the glass facade is darker.”

“That’s because of the solar foils mounted on the front of the glass,” Fun Jie explains. “The foils not only provide electricity but also cool the building by shading it from the sun. But you’re right — you can’t see most of the technology we use because it does its work inside the building. For example, we’ve got an anaerobic biogas plant that transforms organic waste into combustible gas that’s used to fire the cogeneration units we installed in the offices and apartments, which in turn generate electricity and heat.”

While Fun Jie continues his explanation, Tan makes a discovery as he looks at the upper floors of the skyscraper. “Am I seeing things?” he asks. “Every other floor is missing on the top stories of the building.”

“Oh, sorry,” says Fun Jie, “I almost forgot that. We gutted some of the floors at the top, left the elevator shafts in place, statically stabilized the free-standing floors, and installed flat-lying windmills that optimally harness the wind up there to produce electricity. In this sense, the building is also a power plant that not only meets its own energy needs but also transfers the energy surplus to the local grid. For example, in this building wind up there to produce electricity. In this sense, the building is also a power plant that not only meets its own energy needs but also transfers the energy surplus to the local grid.

Another thing that makes me proud is that the government is actually thinking about running a competition for a prize for the most efficient building.”

Tan looks a little confused. “But what about the summer, when the air conditioning is running in all of these buildings all day?”

Is the energy they produce themselves enough to cover demand?” he asks.

“We came up with solutions for that issue as well,” Fun Jie replies. “For example, the windows don’t open, which means no hot air from outside can get into the building. Instead, outside air is channeled through ducts into the basement, where it cools off before being fed into the ventilation system. We’ve also got small sensors that create a balanced climate by adjusting temperature, light, and fresh air levels precisely to predefined values. For lighting, we use both efficient LEDS and OLEDs, which are flat, luminous, flexible plastics that can illuminate entire walls inside a building. So, as you can see, despite all the conservation measures we’ve taken, no sacrifices were made in terms of comfort or convenience. Our automatic fresh air intake system makes for an ideal climate, and this has led to greater productivity among office workers. The effect is further enhanced by air flows that were optimized using simulations. To ensure that the building remains either warm or cool for the longest possible time — depending on the season, of course — all the floors were fitted with a combination of a double-layered facade and vacuum windows. In the winter, we also use special heat accumulators installed in the ceilings. These absorb heat during the day and emit it again at night.

“Are you saying you reduced the residents’ need to buy drinking water from outside?” Tan asks. “Oh, that’s simple,” says Fun Jie. “We utilize proven membrane technology that we’ve been employing for years. This technology is now so versatile that we can desalinate and purify water from the nearby sea without using much energy at all. We no longer use steam here but instead desalinate the water with the help of the membranes. Then we use a facing that I had that stank of the sea from the sea in the other buildings. This system actually reduces the neighborhood’s need for externally-produced energy by more than 40 percent.”

Fun Jie also installed special meters on each floor. Anybody who’s saving energy to more or less zero. We also installed a biogas plant that transforms organic waste into combustible gas that’s used to fire the cogeneration units we installed in the offices and apartments, which in turn generate electricity and heat. In this sense, the building is also a power plant that not only meets its own energy needs but also transfers the energy surplus to the local grid. For example, we’ve got an anaerobic biogas plant that transforms organic waste into combustible gas that’s used to fire the cogeneration units we installed in the offices and apartments, which in turn generate electricity and heat.

Simple Steps that Save a Bundle

Buildings account for almost 40 percent of energy consumption worldwide, and approximately 21 percent of all greenhouse gas emissions. Simple measures can make it relatively easy to save at least a quarter of energy and money in buildings.

Any reader may have been astonished by an article about the future of conventional energy sources. The article may have even stated that the total energy market was too large to change. However, many building owners are convinced that the potential for installing efficient solutions is great. They often prefer less expensive technologies that consume more energy. However, many building owners are convinced that the potential for installing efficient solutions is great. They often prefer less expensive technologies that consume more energy.

But by 2025 the British capital could cut its CO2 emissions by ten tons by implementing currently-available technologies. Associated energy savings alone would be sufficient to cover nearly 90 percent of the solution.

In Sydney, Australia, the office complex at 30 The Bond, illustrates the extent to which emissions can be decreased using a combination of energy-saving measures. Optimal air conditioning inside the office complex is achieved through integrated building management systems and a specialized cooling system that works with cold water instead of air conditioning units, producing around 30 percent less greenhouse emissions than conventional office buildings of a similar size and has correspondingly lower energy costs.

Abu Dhabi would like to prove that it is possible to save even more. In 2016 solar fields with a capacity of 500 MW provide shade and generate electricity at the same time for the newly established Masdar City. Which is expected to boast a population of 80,000 residents. Masdar will provide natural cooling, and electric trains will almost make cars unnecessary. The Emirate’s ambitious target is to create a CO2-neutral city. Those examples illustrate the growing awareness of buildings’ potential to reduce the burden on the environment — not least because efficient solutions are expensive. Consequently, the push for lower prices for raw materials. Political decision-makers are also backing legislation that promotes

Buildings and Mobility | Scenario 2020

Reprinted (with updates) from Pictures of the Future | Fall 2008

Efficient building technologies save money and reduce the burden on the environment. In London, such technologies reduce the amount of CO2 emitted annually by millions of tons.
the efficient use of energy. For instance, from 2009 on, all houses in Germany will require an Energy Performance Certificate that documents their energy consumption. Thus, in turn, is expected to put pressure on building owners whose prospective tenants will be comparing the energy costs of different properties.

In January 2008 the European Union (EU) also put forward a package of laws in its “20-20-20” legislation, according to which the EU should reduce greenhouse gas emissions by 20 percent by 2020. At the same time, the total proportion of renewable energy should increase to 20 percent by 2020 and energy efficiency should rise by 20 percent.

In Brickmann’s opinion, however, such political leverage is not enough to introduce efficiency solutions in buildings. “Saving energy through technologies that require a high initial investment is often a real dilemma for the managers of public buildings. They need new system solutions to cut their electricity bills and to take pressure off of their budgets, but in many cases they can’t get over the investment hurdle,” he says.

**Selling Efficiency.** An answer to the energy-investment challenge is Siemens’ combination of consulting, installation service, and financing models. Here, the customer does not need to make any preliminary investment. In stead, it pays for improvements over a contracted period based exclusively on energy savings. By way of such so-called Energy Saving Contracts, Siemens has renovated over 1,600 buildings to date in Germany alone. According to Brickmann, this has been a huge success. “We have invested in efficient technologies with a contract value of around €120 million in total, thus saving €15 million and reducing energy consumption by 10 percent in Germany alone. According to Brickmann, this has been a huge success. “We have invested in efficient technologies with a contract value of around €120 million in total, thus saving €15 million and reducing energy consumption by 10 percent.”

**A spill over in the historical city center of Regensburg, Germany, raises a question. Do modern LED streetlights fit in harmoniously in the narrow medieval lanes of a World Heritage Site? The light comes from quite a variety of lamps. Some alleys are bathed in a yellowish, almost otherworldly light. Then, just a few steps away, a newly-focused light cones create a pattern of light and darkness on the cobblestones. Illuminating narrow lanes, streets and squares are cylinders with many tiny points of light — lamps with light-emitting diodes (LEDs) developed by Oram Opto Semiconductors. The lamps were manufactured by Siemens in Regensburg and are designed to be screwed directly into the streetlight sockets. Up to 54 individual LEDs fit into one cylinder. The warm light cast by LEDs on the city’s historic facades makes the city appear every bit as picturesque by night as by day. The alleys are also more brightly lit, with hardly any dark corners.”

**World Her itage in a New Light**

Streetslights that use light-emitting diodes (LEDs) cut electricity consumption by up to 80 percent. Not only are LEDs efficient; their light can also be optimally directed.

LED streetlights from Osram light Regensburg’s historic center. The lamps cut electricity consumption by 80 percent and have twice the lifespan of conventional lamps.

**New LED street lamps from Osram light Regensburg’s historic center. The lamps cut electricity consumption by 80 percent and have twice the lifespan of conventional lamps.**

**Green Building Program.** Siemens informs building owners about the program and helps participants to successfully implement their action plans with the aid of technologies and Energy Saving Contracts. “The program allows us to kill two birds with one stone,” says Brickmann. “For one thing, our Energy Saving Contracts generally allow us to fulfill the Green Building Initiative’s energy-saving criteria from the outset. For another, the EU is offering our partners an incentive — their environmental activities can be publicized with the help of the Green Building Certificate.”

The Berlin University of the Arts and Italian banking giant UniCredit are two of the most prominent partners to hold the certificate thanks to Siemens. After a comprehensive “technology faceoff,” the bank’s headquarters in Milan today uses up to 32 percent less electrical energy per year. These and a lot of other examples show that energy-efficiency truly pays off.

**Siemens Webel**

That’s because many of the LEDs create long light cones along the narrow streets, while a few also focus light tightly upward. The LEDs that are focused are adjusted to use only 30 percent of the electricity required for lighting sideways. This is another reason why the lamps require only 40 watts compared to the 90 watts required by their predecessors. “Another advantage of LEDs is that their light can be directed at specific points,” explains Dr. Martin Moczk, Project Manager at Osram. “This isn’t possible with conventional lamps, so they often have to be overly bright in order to illuminate areas they otherwise couldn’t reach. LED lamps can focus their light more effectively, so they’re a lot more energy efficient.”

**Allons Szwaczyna, Head Construction Manager and Director of the Civil Engineering Office of the municipality of Regensburg, also likes the new lamps. “The LEDs have reduced light pollution, meaning light that used to glare into residents’ windows or up into the sky,” he says.**

85 LEDs stand out due to their high energy efficiency and their light’s excellent color reproduction. And they can do much more than conventional lighting. LEDs are immediately bright when turned on and can be dimmed continuously all the way down to full darkness. With many conventional lamps, the gas discharge that produces light stops working if it drops below a certain level. And in the future it will be possible to automatically regulate the color of LED streetlights by, for example, mixing light from a white LED with that of a red one. All this makes the little diodes ideal partners for smart controls. Their longevity also makes them very attractive for municipalities. At over 50,000 hours of light, their service life is twice that of conventional lamps, and they need to be replaced only every ten years.

Energy-efficient street lighting becomes an important issue in many cities — especially following the European Union’s regulation that in 2009 heralded the end of incandescent lamps. The regulation also progressively phase out less efficient streetlight lamps by 2015, including widely used mercury vapor lamps, which only deliver 50 lumens of cool white light per watt ( lm/W).

An alternative is the high-efficiency sodium lamp, which illuminates many highways with 120 lm/W. “However, sodium’s energy efficiency comes at a cost. The quality of light is inferior,” says Matthias Seifert, who is responsible for Siemens’ global product portfolio for outdoor lighting. People often find it difficult to recognize colors and contrasts in yellow light, which also often gives them an uneasy feeling. This is why these lamps are less suitable for residential areas. Among conventional technologies, ceramic metal halide lamps are now leading the way. The powerful beams of white light produced by these lamps reproduce colors very well. They are mostly used in areas requiring a tremendous amount of light, such as stadiums. Today’s LEDs, with their 100 lm/W energy efficiency and a color rendering index of 80, are almost on a par with ceramic metal halide lamps. The index measures the extent to which a lamp can reproduce colors in comparison to natural daylight (index 100). Nevertheless, there’s still room for improvement with LEDs. Researchers hope to achieve 150 lm/W and are working on reaching a color rendering index of 90. All in all, LEDs offer the greatest potential for savings. Compared to the old tracting models in combination with municipalities, energy providers, and financing partners like Siemens Financial Services. Such models enable cities to use energy savings to pay for the investment in installations. Oram also plans to cut lamp costs by half, so that the purchase prices of future LED systems will be at most only 50 percent more than those conventional lighting systems.

Many projects are now being financed through funding programs, as is the case in Regensburg. The city won first prize with its LED lighting concept in Germany’s “Energy-Efficient City Lighting” competition. It will therefore receive a refund of 60 percent of the costs incurred if it replaces all 250 lanterns in the historic city center with LEDs within two years. In the future, Regensburg’s street lighting will enchant visitors and inhabitants at night — while using only half as much electricity as it did in the past.

Christine Küth
Reprinted (with updates) from Pictures of the Future | Fall 2009

Buildings and Mobility | Networking

The environmentally-friendly city of the future is being built in a desert in the United Arab Emirates. Not far from Abu Dhabi, workers from all over the world are building Masdar City. When complete, the city is expected to have 50,000 inhabitants, meet its energy requirements entirely from renewable sources, and produce zero carbon dioxide, a major greenhouse gas. (Pictures of the Future, Fall 2008, p. 76.) Power is to be generated primarily by solar thermal receiver plants and photovoltaic facilities.

City planners expect improved efficiency to offset the high cost of implementing advanced energy solutions. In fact, the energy required per person in Masdar, which was developed by Sir Norman Foster, is scheduled to be completed in 2016. If it proves a success, urban developers and architects from around the world may orientate their plans according to the technologies that prove themselves here. Siemens is involved in the project. “The Masdar initiative is not only a fascinating environmental footprint right from the start? How often do you have the opportunity to build a complete city with a focus on minimizing its environmental footprint right from the start?” says Norman Foster, is scheduled to be completed in 2016. If it proves a success, urban developers and architects from around the world may orientate their plans according to the technologies that prove themselves here. Siemens is involved in the project. “The Masdar initiative is not only a fascinating environmental footprint right from the start? How often do you have the opportunity to build a complete city with a focus on minimizing its environmental footprint right from the start?” says Norman Foster. The building technology and components supplied by Siemens (p. 7) are being developed by Siemens Building Technologies (TBS). Here, a variety of systems are being linked into one unit. They include building control and security technologies, heating, ventilation, air conditioning, refrigeration, room automation, power distribution, fire and burglary protection, access control, and video surveillance. “Only if all of these systems harmonize perfectly can their economic potential be fully realized,” says Dragon. “Whether in a stadium, an office complex, a hospital, a hotel, an industrial complex or a shopping mall — TBS will ensure that the facility is working productively, users are being reliably protected, and energy is being used optimally.”

Large Savings Potential. The amount of energy that can be saved through the intelligent networking of power utilities and consumers varies from case to case. However, experts generally agree that savings of 20 to 25 percent are realistic. “This figure fluctuates depending on the type of building,” says Dragon. “Shopping malls and office buildings often have a potential of up to 50 percent. For hospitals, we’re talking about five to ten percent.”

Managing Demand. Conversely, consumers can also selectively switch off devices at peak times to ease network loads. The key is to know when rates are lower. For example, washing machines and dryers can be run at night when electricity is cheaper. But which hours offer the best prices? “Many appliances are already capable of determining this through signals in power lines,” says Dragon. “On- and off-times can be determined by a smart meter.” This scenario would give utilities the advantage of being able to manage demand within their networks. It would also help them to prevent sudden peak loads from occurring — for example, when large numbers of consumers turn on appliances at the same time.

However, consumers would have to consent to having their appliances turned on or off by a utility depending on the network’s load or based on the premise that they would be paying less for their energy. Ultimately, both parties have an interest in a flat load curve, which is achieved by leveling demand over each 24-hour period.

The challenge is to coordinate each building’s sub-systems with one another and control their communication with their surroundings. In other words, the goal is to prevent the various systems from not even the smallest amount of energy is wasted. — Christian Buck
Smart meters enable consumers to monitor and manage their power use. Utilities also save money and, for the first time, gain detailed insight into network dynamics.

“The near-real-time transmission of data from households, special contract customers, and the power distribution structure gives us the kind of insight we need as to what’s going on in the grid,” says Arbon Energie’s Knaak. “This allows us as a supplier to make more precise forecasts of peak load times, and thus plan more efficiently.” Arbon residents are the first in Switzerland to know exactly how much electricity they’re using every month, instead of having to pay estimated fees, as was the case in the past, and then receiving a huge bill at the end of the year. So living in the dark about one’s own electricity consumption will soon no longer be an issue, at least not in Arbon.

The benefits that smart energy meters offer utility companies go far beyond improved grid load planning. For one thing, the manual reading of conventional meters is subject to errors that generate additional costs, such as the need for a second readings. These require disproportionate amounts of time and energy in comparison with standard reading trips. Smart meters, on the other hand, are read automatically. “On average, around three percent of the readings of conventional meters need for a second readings,” says Knaak. “Andreas Heine, head of Services at Power Distribution. “Smart meters reduce this error rate to nearly zero. So, if you’ve got an area with a million customers, you can save more than €1.6 million in error adjustment costs, which corresponds to 5.3 percent of the previous cost for readings.”

No More Flying Blind. Most smart meters are now being used in highly developed countries, with dozens of projects currently under way in the U.S. and Europe. Direct economic benefits are generated in such nations mainly through a decrease in blackouts and efficiency gains in service processes. By installing around 30 million smart meters with feedback channels, Italian energy supplier ENEL, for example, has been able to automatically carry out 210 million meter readings. The initial investment of €2.1 billion can be amortized relatively quickly through savings of around €500 million per year, while service costs per customer and year have been reduced from €80 to €50.

AMIS units along with the complete meter data management system. Ninety percent of the company’s new meters communicate with a central server that processes the huge amounts of data, with most of this data transfer occurring via power line communication — in other words, the grid itself.

Siemens prepared itself well for such new types of cooperation models for smart metering systems by partnering with U.S.-based el, their systems to reduce electricity theft and increase supply reliability. Smart meters will thus also be installed in many areas in these markets. Finally, in many of the more developed countries, legislation enacted as part of electricity market deregulation is leading to the rapid introduction of smart meters. The European Union, for example, has an energy efficiency and services directive that stipulates that all conventional meters be replaced by smart meters by 2020. In-
## Buildings and Mobility | Facts and Forecasts

### Huge Growth Market for Green Urban-Infrastructure Solutions

Cities are growing at a breathtaking pace worldwide. More than half of the world’s population already lives in cities, and this figure is set to grow to 70 percent by 2050. This trend is creating huge challenges for city managers, who will have to greatly expand municipal infrastructures because 6.4 billion city residents will need electricity, water, and transportation services in 2050, compared to 3.3 billion today. At the same time, cities will have to reduce their energy consumption and CO₂ emissions. At present, they already account for 75 percent of the energy consumed worldwide and are responsible for 80 percent of greenhouse gas emissions. Climate protection measures thus promise to be particularly effective in cities—and will open up market opportunities for green urban-infrastructure solutions.

The potential in this regard is huge. After all, a large part of the infrastructure in emerging markets and developing countries will have to be completely renewed, as these countries account for 95 percent of the world’s population growth. Many industrialized countries will also have to modernize their infrastructures. Business consulting firm Booz Allen Hamilton estimates that the world’s cities will have to spend around €27 trillion over the next 25 years to modernize and expand their infrastructures. Of this amount, €15 trillion will be spent on water management systems, €6 trillion on power grids, and €5 trillion on rail and road networks.

To allow cities to satisfy their infrastructure needs in a climate-friendly manner, they will have to employ energy-efficient technologies. Using Munich as an example, the Wuppertal Institute and Siemens conducted a study that showed that energy-efficient solutions could transform a city with some one million inhabitants into an almost completely CO₂-free area (Pictures of the Future, Spring 2009, p. 6). Major reductions in CO₂ emissions could be achieved by expanding local mass transit systems and introducing technologies such as state-of-the-art building systems, traffic management systems, and electric vehicles. Growing demand for electricity could also be met in an environmentally-friendly manner by boosting energy efficiency. The systems that could be employed here range from combined heat and power plants to smart grids and techniques for transmitting electricity with minimal losses.

The German Environmental Ministry (BMU) estimates that the global market for environmental technologies will more than double between now and 2020, to over €3 trillion. This development will be boosted by the financial crisis. For example, London-based investment bank HSBC estimates that around €300 billion or about 15 percent of the amount being spent on economic stimulus programs worldwide with guaranteed savings of €2 billion and a reduction of 2 million tons of CO₂. For the affected cities this means greener buildings—for free. Anette Freise

### Rail Vehicle Optimization

It’s a sunny day and Vienna’s trams are packed. The air conditioning is running full blast. “In extreme cases, heating, air conditioning, and ventilation systems (HVAC) can account for 30 to 40 percent of a tram’s energy use,” says Dr. Walter Struckl, an expert on sustainable public transport systems at Siemens. That’s ample reason to think about energy conservation. But how can climate control be made energy efficient while at the same time keeping costs under control and satisfying passengers? Since March 2010 the Ecotram research project has looked at this challenge. Involved are Siemens, the Vienna University of Technology, local Vienna transport-related companies, the rail infrastructure company, and climate control system manufacturer Vossloh Kiepe. The project will run for 18 months and is being funded by Austria’s Climate and Energy Fund. The partners cover all pertinent technologies – from air conditioning units to climate test labs and the production and operation of rolling stock. Thereby the railways’ efficiency together with their systems should be analyzed and – where possible – optimized.

Climate and ventilation systems for a state-of-the-art tram use about 100,000 kilowatt hours of electricity per year. The Ecotram project would like to reduce this figure. Gunter Steinbauer, the managing director of the city’s transportation authority, anticipates at least a 10 percent reduction. Applying that figure to the city’s 300 modern trams would allow annual savings of over 3,000 megawatt hours. This corresponds to the electricity consumed by 1,200 households.

Ecotram partners plan to study the effectiveness of 20 energy-saving ideas. For example, forward-looking regulators which adapt air-conditioning to its surroundings and cool less in tunnels, are on trial. Carbon dioxide sensors for air regulation, since CO₂ content provides an indication of how many passengers are on board also seem promising to Struckl. He’s also thinking about the color of the light used to illuminate the trams – that’s important for the feel temperature. “Using the type of lighting provided by LEDs, for example, would be a lot of energy because it would enable you to alternate between warm and cold-white colors as needed,” Struckl says.

### Economic Stimulus Programs Include €300 Billion for Green Solutions Worldwide

The global market for environmental technologies will grow to over €3 trillion by 2020.

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<th>The Global Market for Environmental Technologies Will Grow to over €3 Trillion</th>
<th>Economic Stimulus Programs Include €300 Billion for Green Solutions Worldwide</th>
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Climatic Chambers for Trams. Rail Tec Arsenal is a unique climatic test facility for rail vehicles. Experts have fitted Vienna’s latest tramway model with measurement systems at the facility, which is co-owned by Siemens (see Pictures of the Future, Spring 2009, p. 4). In the site’s two chambers (100 and 34 m long) entire trains are exposed to extreme weather conditions. Here, giant rotors generate air-streams, and powerful halogen lamps simulate hot summer days. Technicians can alter humidity, and even make it rain or snow. Even a storm is possible, which is also used by competitive athletes like the ski jumpers from the Austrian national team in the climate test laboratory, says Gregor Richter, a project manager at Rail Tec Arsenal.

Thanks to the facility’s weather simulation capabilities, Ecotram has been tested under typical Vienna conditions, at temperatures ranging from —20 to +22°C. Train doors have been opened and closed during tests, and different speeds have been simulated to account for the fact that heat escapes to the outside more rapidly at higher speeds. Heating pads were put on the seats to simulate body heat and a varied number of passengers. As during normal operations, the climate control and ventilation systems automatically adjusted temperatures to target values. Richter continuously monitored external and internal temperature, wind speed, sunlight, and the power input of climate control and ventilation components. “For the first time we are seeing how much energy individual systems use,” he says. Richter has already devised initial energy-saving approaches. “Sometimes it gets cooler than it should in the trains because the air conditioning doesn’t step down until it actually registers temperatures that are too low,” he says, adding that this can be solved by optimizing the control software.

On-the-Job Testing. After leaving the test facility in May 2010, Ecotram entered regular service for several months of evaluation. During that period, its sensors have been collecting data 24 hours per day. The data from the tests will help the program simulate operations, including tunnel segments, train stops, and varying passenger counts. The completed software will send trains on virtual runs and calculate the impact on use and comfort.

Siemens will be able to use the model to demonstrate which measures are most economical. “I expect that this will help to provide evidence against the preconception that energy efficiency drives up costs and reduces comfort,” says Richter. The model will also boost energy transparency under a range of conditions. Many tram operators scale their systems in line with extreme situations such as a rush of festival-goers in the summer, but forget that the tram has to pay for the overweight for the rest of the year,” he says. The results will be incorporated into an eco-tram prototype in the follow-up project Ecotram II as of October 2011, and will be compared to the projected energy savings. Passenger reactions will then show if all the work was worth it. “The key is to save energy in such a way that nobody notices,” says Richter.

What might the energy-efficient streetcar of the future look like? “The trend is toward high-efficiency climate control and ventilation systems, lightweight design, and onboard energy management,” says the managing director of the management system. “The latter involves regaining energy released by braking and waste heat from climate control units. This is already possible in some places. That’s why the intelligent power grids now being developed in conjunction with renewable energy systems are a key idea for rail traffic. If you combine all possible energy-saving measures for the vehicle and infrastructure, the fuel energy consumption could be cut in half by 2030,” says Nikola Wolfishb.
Digital Drivers. An onboard computer (Automatic Train Operation) in the subway train itself uses this data to control the entire driving process. A second computer (Automatic Train Protection) monitors the actions of the first and makes corrections if necessary. The ATC system registers all train movements via a retransmission channel, which means it always knows where each train is at any given moment and how fast it is moving. The latter capability is made possible by Siemens’ two-car train sets equipped with navigation units and reception antennas, among other things. Thanks to these, the ATC system can monitor and control subway train movements completely autonomously.

Experience in other cities with automated systems has confirmed this. In Paris, for example, where Metro line 14 has been in driverless operation since 1998, the system has proved itself primarily through improved capacity and safety. As a result, the Paris Metro’s historic platform edge if a person or object falls onto the track or between a train coupling, the system will immediately stop all trains in the area. Solid sills extend from doors when trains are in stations to ensure that no one can get caught in the gap between train and platform.

Nuremberg was the first place where conventional and driverless subway trains shared a track. When it’s time to go, an infrared sensor in the rubber edges of the door halves registers even the slightest pressure — the seam of a coat stuck in between is all it takes to keep the train from leaving the station. The control center monitors train-car interiors via video cameras. Passengers who activate an alarm are automatically put in direct contact with the control center via digital voice radio. Control center staff can immediately dispatch maintenance or rescue services to the train.

In general,” says the former leader of the overall project, Trummer, “the trend in Europe today is toward fully automated systems — at least for closed systems like subways. Unlike streetcars or buses, subway trains don’t have immediate contact with street traffic, which means it’s much easier to monitor and secure them.” The “driverless future” is already reality in Nuremberg — and the seats with the best view in the gap between train and platform.

This wasn’t possible in Nuremberg due to the former mixed automatic/driver operation, and because the platforms of some stations are curved,” explains Trummer. Absolute safety is ensured by video monitoring and a new high-frequency transponder system that sends a dense grid of sensing beams out over the tracks from transmitter and receiver rails installed underneath the track. Other benefits of the driverless system are improved capacities and significantly reduced safety. As a result, the Paris Metro’s historic...
A hybrid bus emits up to 26 tons less carbon dioxide per year than a conventional bus.

Starting for the latter, buses can use stored braking energy to quietly accelerate without producing any emissions. MVG, Munich’s public transport company, currently operates two hybrid buses on its routes. One of these is the Lion’s City Hybrid from MAN, for which Siemens supplies the drive technology. “We want to test and compare different hybrid buses,” says Herbert König, who heads MVG. “By doing so, we are supporting the manufacturers as they strive to develop this innovative vehicle technology.” Drivers and passengers are enthusiastic everywhere hybrid buses are in operation. There is no rearing up noise while the bus is idling and it provides a contrast to the sometimes jerky ride typical of conventional vehicles, hybrid buses seem to glide.

What makes ELFA, as the Siemens drive technology is known, so special is its serial hybrid solution. With the parallel hybrids typically used today, both a combustion engine and an electric motor drive the axle via the drive shaft. But with a serial hybrid the drive shaft is turned solely by the electric motor that preferentially draws its energy from a storage device called an UltraCap — a high-performance capacitor installed on the roof of the bus. The UltraCap’s high energy density and high efficiency make it superior to a conventional battery (see Pictures of the Future, Fall 2007, p. 74). The UltraCap can therefore store a lot of energy in a small package. It is also largely maintenance-free and has a substantially longer service life than conventional lithium-ion batteries. When the UltraCap is depleted, the diesel engine springs to life and powers a generator, which in turn produces electricity for the energy storage unit. A hybrid bus of this type can generally drive an average of 200 meters from a bus stop before its UltraCap is empty. The UltraCap is then ready to store all of the energy generated during the next braking phase. Added up over the course of the day, that amounts to major fuel savings.

More Storage. Hybrid technology enables more braking energy to be fed in than is the case with conventional parallel systems because the dimensions of the electric motor can be increased — with a corresponding reduction in carbon dioxide (CO₂) emissions. Depending on the number of hills and bus stops on a route, a typical bus consumes between 40 and 60 liters of fuel per 100 kilometers. Assuming roughly 60,000 kilometers per year, this amounts to 30,000 liters of diesel fuel. With a hybrid, however, this figure is just 20,000 liters. Because the combustion of one liter of diesel fuel produces 2.6 kilograms of carbon dioxide, a hybrid bus can save around 26 metric tons of carbon dioxide each year compared with a conventional bus.

Siemens engineers employ a trick to throttle back this diesel fuel consumption even further. The drive typically includes two three-phase, asynchronous machines that are “linked together” by a combining gearbox. If synchronous machines based on permanent magnets are used instead, less electricity has to be fed into the machine to generate the magnetic field that then turns the motor. This reduces losses, the machine has a higher efficiency and transfers more energy to the axle, which results in an additional 10 percent savings of diesel fuel. In addition, such a setup also reduces wear. Granted, a hybrid bus is still more expensive than a conventional diesel bus that costs around €250,000. Schmidt estimates the additional cost for the hybrid bus to be around €100,000. However, he is convinced that economies of scale resulting from mass production will cut the added cost in half, in which case the price would be only about 20 percent above the normal price.

The subject of hybrid buses is picking up steam. If the Chinese capital city Beijing makes agreements to follow through on its announcement and replace half of its bus fleet with hybrids by 2015, this alone would represent tremendous demand for the vehicles. “Interest around the world is already extremely high,” says Schmidt. “In fact, we can hardly keep up with orders.” Siemens in Nuremberg is working with numerous bus manufacturers, with ELFA orders coming from MAN, but also from Mercedes-Benz, Belgium commercial vehicle manufacturer Van Hool, and Indian transportation giant Tata Motors.

In Use around the World. Wrightbus, a bus manufacturer from Northern Ireland, has ordered Siemens’ drive technology for double-decker buses in London. When London Mayor Boris Johnson presented the plan for the new vehicles in May 2010, he raved not only about the slick design, but also about “innovative green technology.” Johnson said that Londoners would have every reason to be proud of their new, fuel-efficient, and quiet means of transportation.

He predicted that hundreds of these hybrid buses would be ferrying passengers around the streets of the United Kingdom’s capital in the future. ELFA buses are now in operation throughout Europe in Spain, Belgium, the Netherlands, and Italy. In addition, they can also be seen in Turkey, the U.S. and Brazil. In Germany, Hamburg’s municipal transport company is planning to deploy ELFA-based hybrid buses that use a combination of batteries and fuel cells. Beginning in 2020, every new bus in Hamburg is to be a hybrid model. “The development of Emission-free inner city areas is a political issue,” says Schmidt. In this case, even garbage trucks would be suitable candidates for the hybrid drive. MAN already developed a 12-ton truck with a 220-hp four-cylinder engine and 60 kW electric motor. The vehicle is primarily suited for longer distribution runs with frequent stops. And Faun, a German company, offers a garbage truck with ELFA. The ‘Roto press Dualpower’ is currently hauling waste to a disposal facility in Leipzig. “Hybrid buses,” says Schmidt, “are just a stop along the way to zero-emission transportation.” After all, the goal is zero-emission traffic. Schmidt sees two possible ways to achieve this with battery-powered buses, whose energy storage devices are charged at the terminal or station or at the depot, or with a hybrid model that uses both a battery and a fuel cell for motive power. The fuel cell would be used to charge the battery during operation. However, Schmidt is reluctant to predict when and where buses will be used. “Whether hydrogen or electric engines will be a standard technology in the future, how and where we produce our electricity in the future,” he says.

Jeanne Rubner
Danger Made Visible

Trucks with defective engines, faulty brakes or hazardous freight can trigger an inferno in a tunnel. Siemens researchers are investigating how to use RFID technology, video analysis, and thermal imaging cameras to spot vehicles that are at risk.

The driver of the tanker truck doesn't know that he's heading for disaster. He's unaware that the braking system on one of his rear wheels is blocking and beginning to glow red hot. There's a tunnel coming - in three kilometers - but the potential catastrophe doesn’t have a chance to unfold thanks to safety systems that have already detected the rolling time bomb and triggered an alarm in the tunnel operator's control center.

This is still a future vision. Nevertheless, the three-year research project “Protection of Critical Bridges and Tunnels on Roads” (German acronym: SKRIBT) is moving closer to making this vision a reality. Ten partners from government agencies, industry, and research institutes, including Siemens Corporate Technology (CT) and the Mobility Division, are participating in the project, which is being funded by the German Ministry of Education and Research. Most major accidents in tunnels are caused by trucks with burst tires or defective engines. That's why Alla Heidenreich, infrastructure project manager at Siemens CT, has been working to make this vision a reality. Ten partners from government agencies, industry, and research institutes, including Siemens Corporate Technology (CT) and the Mobility Division, are participating in the project, which is being funded by the German Ministry of Education and Research.

The situation becomes high-risk when it comes to materials transport. Some materials like gasoline may only be transported through certain tunnels. Although trucks carry orange sticker bearing coded information on how dangerous their freight is. But it can't be controlled automatically and reliably if they only travel through specified tunnels. However, using Siemens' RFID-Chips (Radio Frequency Identification) information on the load can be selected.

Transmission-Enabled Stickers. Such a system would function roughly as follows. When a truck transporting hazardous materials passes a tunnel, its cargo data would be registered by the RFID system and forwarded to a control center. Only one truck would be permitted in the tunnel at a time. Should an accident occur, firefighters would tackle the blaze using precisely the right extinguishing agent. Any truck attempting to enter a tunnel with prohibited freight would be stopped by a red light in front of the entrance.

The CT team is particularly proud of its newly developed RFID transponder system's ability to meet extremely high standards. The chip can transmit its signal to the unit's reading device over a distance of around 50 meters - and send the data at least twice within two seconds. “Conventional passive radio-based chips have a range of only six meters,” says Daniel Evers, an RFID expert at CT. “That's why we use an active chip that has a built-in battery and transmits in the high-frequency range of 2.45 gigahertz. To ensure the battery lasts as long as possible, the transmitter in the transponder sleeps until it's woken by a radio pulse issued by the reading device at the checkpoint.” To ensure this is the case, Siemens researchers employ an encryption technique they previously developed for passive RFID chips in the future (Spring 2009, p. 45). “Previous solutions needed too much energy,” says Hermann Seuschke, an IT security expert at CT. “However, our cryptograph is so energy efficient that the transponder can run for at least three years without needing a replacement battery.”

Research activities were followed by road tests in mid-2010 when Siemens researchers installed truck detection system components at the Aubinger Tunnel near Munich. Plans call for the tunnel safety system to be tested until the end of July 2011. “Up until now, activities have focused on improving safety within the tunnel,” says Heidenreich. “But in the future, we're going to be able to detect and prevent danger before a vehicle gets there. Video, RFID, and infrared technologies will play a key role in this process.”

Road Pricing

Christoph Wondracek needs just a few moments to start the system. First he uses suction cups to fasten a small non-descript box to the windshield, after which he inserts a plug into his vehicle's cigarette lighter. "Now we can get going," he says as he turns the key. The car Wondracek is now driving through the streets of Vienna is a laboratory on wheels. Siemens is using the vehicle to test its latest ideas for making future road traffic more economical and more environmentally friendly.

This onboard unit contains all the technologies we need,” Wondracek explains. The unit's navigation system utilizes satellite signals to pinpoint the vehicle’s current location, and then sends the positioning data to a central computer via GSM technology familiar to cell phone users. This technology can be employed to set up a highway toll system for trucks or an inner-city congestion charge system for reducing traffic during rush hours.

Siemens is developing these state-of-the-art solutions in Vienna, Austria, where it operates a Toll Systems Competence Center that it established in 2006. “We were already working on toll systems before that,” says the center's director, Dr. Karl Strasser, “but developments didn’t start moving toward extensive complex systems until a few years ago.” That's why Siemens is utilizing the center as a base for pooling the required expertise from throughout its worldwide organization. As a result, experts from the fields of satellite navigation, mobile data transfer, traffic guidance, and other areas are now working together in Vienna.

Research at the center's labs is both virtual and physical. Specialists not only design onboard units that incorporate the latest navigation and data transfer technologies but also develop software that enables the reliable collection of hundreds of thousands of data sets. Whenever an urban congestion charge or highway toll system is being planned anywhere in the world, technicians in Vienna go to work on customized solutions that are included in the company's bids.

No Toll Plazas Required. Strasser's core team comprises 40 specialists. Once a project is up and running, the teams are expanded to include experts from related areas. The acid test involved the introduction of a state-of-the-art truck toll system to Slovakia in the spring of 2010, for which Siemens supplied the onboard units and software. “One hundred of our people refined the various technologies before the system was launched,” Strasser reports.

Toll fees in Slovakia vary depending on whether a truck travels on a major highway or a state road. In similar projects, such as in the future of road traffic more economical and more environmentally friendly.

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Road Pricing

Reprinted (with updates) from Pictures of the Future | Fall 2010

“Road Pricing is a key element of a sustainable urban transport system,” says Matthias Mayer, Head of the Siemens Business Unit City Transport. “It is essential to ensure that road space is used efficiently, and that the costs of using it are shared by all road users.”

Siemens is working on an intelligent system for road pricing that can be implemented worldwide. The system, based on satellite technology, allows tolls to be charged on the basis of distance traveled, traffic congestion, or locations visited. The system can be customized to meet the needs of individual cities and countries.

Highway toll systems are one of two areas where Siemens experts in Vienna specialize in; the other is city toll systems, the most well-known of which is to be found in London. Every vehicle that enters the city is equipped with a satellite device, which passes on data to the central computer. The system can then adjust traffic light intervals every five to 15 minutes. Traffic lights can be switched to red or green to prevent traffic jams and improve traffic flow.

The system used in London is based on a mathematical method that can simulate the effects of different toll and traffic light settings on traffic flow. The method, called Sitraffic Motion MX, is being used in many cities around the world. In Münster, Germany, for example, the city has installed the system on a major road to reduce traffic congestion.

The system is also being used in Copenhagen to reduce traffic congestion in the city center. The city decided to test the system on a 6 km route to assess its impact. The results were impressive: a reduction in CO2 emissions of around 20% and a 25% reduction in traffic congestion.

The system is also being used in other cities, including Warsaw, Vilnius, and Prague. The system has been shown to be effective in reducing traffic congestion and improving traffic flow.”

Kilian Kirchgeßner
to send this surplus electricity to neighboring countries — and pay for doing so. It is therefore not surprising that Denmark is a pioneer in the development of storage technologies to accommodate excess electricity, with researchers focusing mainly on the batteries used in electric vehicles. Current plans call for EDISON to develop and prepare for use in 2011.

Practical testing will begin in 2011 on the Danish island of Bornholm in the Baltic Sea. There, test vehicles will be charged with wind power from the public grid. When demand in the grid rises — at breakfast time, for example — parked cars will feed electricity back into the network. The Danes are hoping that a fleet of thousands of vehicles will be able to offset fluctuations in the wind-power supply in the near future. Instead of having separate electricity storage units to buffer against the fluctuations, the cars and their batteries would provide additional storage capacity, which is why EDISON will focus on achieving a bidirectional flow of electricity from the grid into vehicles and back. The result could be significant. If, for instance, 200,000 vehicles, each rated at 40 kW, are connected to the grid, a total output of 8 GW would be available at short notice — more than Germany requires — be it a garage, supermarket, or company parking lot. In a manner similar to cell phone invoicing, the electricity used will be billed by a provider. However, for such a system to work it will be necessary to identify the vehicle and exchange data between its onboard electronics and the charge pump.

Siemens is pursuing the development of electromobility through a comprehensive approach involving not only automotive engineering — as in the case with Roadster and Stormster — but also systems for connecting vehicles to the power grid. Here, both the charging process and communications are being addressed. Siemens refers to these two areas as “Inside Car” and “Outside Car.” “We’ve started our own corporate project named ‘Smart Grid Ap- proach’ to the fluctuating power of the wind. The associated technologies for vehicles and the grid will be developed and prepared for use in 2011.” Practical testing will begin in 2011 on the Danish island of Bornholm in the Baltic Sea. Test vehicles will be charged with wind power from the public grid. When demand in the grid rises — at breakfast time, for example — parked cars will feed electricity back into the network. The Danes are hoping that a fleet of thousands of vehicles will be able to offset fluctuations in the wind-power supply in the near future. Instead of having separate electricity storage units to buffer against the fluctuations, the cars and their batteries would provide additional storage capacity, which is why EDISON will focus on achieving a bidirectional flow of electricity from the grid into vehicles and back. The result could be significant. If, for instance, 200,000 vehicles, each rated at 40 kW, are connected to the grid, a total output of 8 GW would be available at short notice — more than Germany requires — be it a garage, supermarket, or company parking lot. In a manner similar to cell phone invoicing, the electricity used will be billed by a provider. However, for such a system to work it will be necessary to identify the vehicle and exchange data between its onboard electronics and the charge pump.

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Holthusen: “We need batteries that are designed for higher temperatures, exhibit lower power losses. Rising temperatures then dis- place the charging time to three hours.”

S parks can sometimes fly in the Siemens En- ergy Sector labs in Erlangen and Fürth, both of which are located in southern Ger- many. When several high- and am- plifier passing through testing systems consisting of large in- verters, capacitors, and transformers, techni- ci ans have to be extremely careful — in order to protect not only themselves but also the components they’re testing.

We develop stationary direct-current (DC) chargers with an output of between 12 and 100 kW,” says Dr. Heike Barg, who manages the tests. “The devices are designed for traction batteries in fast, changing capability is expected to be ready for market launch in the near future. However, new battery technologies will have to be devel- oped if a car is to be charged in as little as three minutes.

The double-motor concept uses an electron- ic control system that ensures optimal propulsion of the right and left wheels, which are exposed to different loads in a curve. It’s thanks to this phe- nomenon that a driver can still handle a vehicle perfectly in extreme situations. With a central mo- tor concept, all the power must be transferred via a bulky and heavy differential, which adds weight to the car. With the double-motor concept, however, a small control unit is all that’s need- ed to send commands by wire to the individual electric motors. It’s already clear to Spiegelberg what will hap- pen next. “The coming years will see the devel- opment of electric vehicles whose four wheels will each be equipped with their own small drive unit,” he says. These motors will recover brake en- ergy and eliminate the need for a large central motor and the transmission and axle shafts, there- by creating more space.

Moreover, unlike axle shafts, electronic com- ponents can be installed anywhere in the car and don’t necessarily have to be located near the elec- tric motors. This will offer designers completely new possibilities for things like side-mounted tri- cic motors. This will offer designers completely new possibilities for things like side-mounted tri- cichal gears, actuators, and steering wheels, which don’t necessarily have to be located near the elec- tric motors. This will offer designers completely new possibilities for things like side-mounted tri- cichal gears, actuators, and steering wheels, which don’t necessarily have to be located near the elec- tric motors. This will offer designers completely new possibilities for things like side-mounted tri- cichal gears, actuators, and steering wheels, which don’t necessarily have to be located near the elec- tric motors. This will offer designers completely new possibilities for things like side-mounted tri- cichal gears, actuators, and steering wheels, which don’t necessarily have to be located near the elec- tric motors. This will offer designers completely new possibilities for things like side-mounted tri- cichal gears, actuators, and steering wheels, which don’t necessarily have to be located near the elec- tric motors. This will offer designers completely new possibilities for things like side-mounted tri- cichal gears, actuators, and steering wheels, which don’t necessarily have to be located near the elec- tric motors. This will offer designers completely new possibilities for things like side-mounted tri- cichal gears, actuators, and steering wheels, which don’t necessarily have to be located near the elec- tric motors. This will offer designers completely new possibilities for things like side-mounted tri- cichal gears, actuators, and steering wheels, which don’t necessarily have to be located near the elec-
Electric Vehicles

Researchers are therefore testing the most diverse types of charging techniques, one of which is known as pulse charging. The battery is charged at a high current for a short time, after which the heated cells are cooled down and the charging process begins anew. “Our rapid charging tests in Risø will show us if we can save time and transfer a higher output with pulse charging, or whether a continuous charging curve would be better,” says Barlag. “We’re hoping to achieve a charging rate of two to three kW.”

Communication between external charging units and a vehicle’s battery management system will be a must.

Managing Charging Peaks. In addition to determining how quickly batteries can be charged, Siemens researchers are also striving to evaluate what effect charging will have on the grid infrastructure. This is important because the German federal government expects one million electric vehicles to be on the road by 2020. Because these cars will obtain their energy from the power grid, there’s a risk that load peaks will occur — for example when hundreds of vehicles simultaneously recharge at airports or stadiums. To ensure the power grid doesn’t fail, energy suppliers will have to compensate for such peaks with expensive electricity from pumped storage or gas-turbine power plants. “Different ideas are being explored to address this problem,” says Holthusen. “For example, we could use a setup in which several DC charging stations are not directly connected to the grid but instead operate via a large inter-mesh battery that acts as a buffer. This solution would make DC charging more expensive, however. So we’ve got a lot of development work to do, especially because we still have almost no standardized procedures and technologies for DC charging.”

It needs to be decided which communication channel will be used to exchange data between chargers and batteries. There are basically three possibilities. The first involves the CAN (Controller Area Network) bus technology already used in cars to digitally link their control devices. The second option is to utilize a communication standard known as Powerline Communication (PLC), which would allow permit information to be transmitted “piggy-backed” on AC power current by low or high-frequency signals up to 30 MHz. Siemens is now testing this concept in several vehicles, including one since September 2010 with BMW and the Munich municipal utility. For this project, a prototype DC charging unit is being used with a modified BMW 1 Series model.

The third option is wireless communication via a system such as Bluetooth. “We’re looking into all of the possibilities,” says Barlag. “The standardization commission will decide which one will ultimately be utilized, but Siemens already has the expertise required for all three technologies.”

Despite the extensive work being carried out on charging technology, with cables and plugs, specialists like Barlag and the members of her team are also exploring other charging techniques, such as battery replacement at filling stations, a process that could be carried out by robot-controlled devices within just a few minutes. Siemens experts already have a concept for such an approach.

Electricity in the Air. It’s also possible that the electricity needed for recharging tomorrow’s cars might be delivered wirelessly — in other words, inductively via electrical and magnetic fields.

This is already possible at the low powers that are needed to recharge electric toothbrushes, for example. Holthusen also finds this idea appealing because inductive charging would be much more convenient for drivers, who would no longer have to handle plugs and could enjoy the benefits of a largely automat-ed charging procedure.

On the other hand, alternative is expensive compared to the plug in model. “There still aren’t any sufficiently advanced solutions for higher outputs in the kilowatt range,” says Barlag, “but we’re working on initial ideas in the lab.” These ideas are already flowing into the “Contactless Charging of Battery-Electric Vehicles” project with BMW. The project is focusing on the development of inductive charging stations that are scheduled to undergo testing at the end of 2011 in Berlin.

One of the things being tested in the EDISON project is how renewable energy can be integrated into the power grid. Electric car batteries could be the ideal intermediate storage medium. This will require, however, if DC charging is to become the established international norm. Siemens is therefore working with the automobile industry in various standardization commissions. Among other things, these bodies focus on safety concepts designed to prevent drivers from starting their vehicles or pulling out plugs during the charging process, for example. The key thing here is that communication between charging units and vehicle batteries should function properly. For example, the charger needs to know what power level the battery can handle — information that it will receive from the battery management system. This procedure therefore also needs to be standardized, given the variety of electric vehicles that will be on the road in the future.

Buildings in a Smart Grid:

In Brief

- Buildings account for about 40 percent of energy consumption worldwide, and approximately 21 percent of greenhouse gas emissions. However, the implementation of a number of simple measures can make it relatively easy to save at least a quarter of energy in most buildings. And in the future, intelligent building management systems will ease the load on power and heat networks — and even feed self-generated electricity into the grid. (p. 32, 37)
- Smart meters to that one light-emitting diodes (LEDs) cut electricity consumption up to 80 percent. Not only are LEDs efficient, their light can also be optimally directed, as an example in Hegnsburg shows. (p. 31)
- Power companies worldwide have begun installing electronic smart meters that allow customers to monitor consumption practically in real time and thus conserve energy. Such companies benefit from better grid load-planning and lower costs. Siemens offers complete solutions that include everything from hardware to software. (p. 38)
- To reduce traffic-related pollution in cities, engineers are developing green mass transportation systems. In particular, buses could operate more efficiently if their diesel drives were augmented with electric motors. Siemens engineers are also developing smart solutions that reduce traffic congestion while preserving the environment. These solutions include toll systems that utilize cutting-edge satellite technology to reduce traffic in metropolitan areas. (p. 43, 49, 50)

Siemens researchers are therefore developing devices that will make it easy for drivers to recharge their cars within minutes. (p. 55)

Siemens researchers are therefore developing devices that will make it easy for drivers to recharge their cars within minutes. (p. 55)
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64 Colossus with a world record
The world's largest turbine entered trial service in December 2007. It will help to ensure that the power plant in Irsching achieves a record-breaking efficiency in 2011.

66 Virtual Power Plants
In order to link decentralized power plants and renewable energy sources to the power grid, they are being integrated into power station networks.

68 Fine-tuning Power Plants
There are hundreds of fossil fuel power plants throughout the world that can dramatically increase their efficiency by modernizing. Siemens has the necessary solutions at the ready.

74 Trapping the Wind
In the future, fluctuations in wind power will have to be balanced by storage systems in order to prevent power grids from being overloaded. One option could be gigantic underground hydrogen storage centers.

79 The Desert lives
The goal of the Desertec initiative is to help Europe meet its future energy requirements by supplying solar power from North Africa. The necessary technology exists already today.

The Electric Caravan

Morocco in 2030. Karim works as an engineer in the world's largest solar thermal power plant, which transmits energy from the desert to faraway Europe. Every evening he takes the time to admire the sunset above the countless rows of parabolic mirrors. But today he's not doing it alone.

The reflected image of the man walking past the glittering parabolic mirrors is oddly distorted. It wanders like a mirage through the seemingly endless row of mirrors, stops briefly and then continues on its way. There's not a breath of wind, and even though the sun is now low, the temperature is still over 30 degrees Celsius. Karim is in a hurry, because he doesn't want to miss the daily evening show. Before the sun sets he wants to reach the hill above the "frying pan"—his colleagues' name for a huge solar thermal installation in the Moroccan desert.

In the glow of sunset, the level field of countless mirrors is transformed into a sea of red flames. It's a spectacle Karim has never yet missed in the five years since he was sent here to help manage the world's biggest solar thermal power plant.

Together with his colleagues, he lives and works in a small settlement on the edge of the installation. With the help of thousands of sensors, solar thermal power experts here monitor the power plant, which covers 100 square kilo-
Energy Technologies | Scenario 2030

meters. As soon as these tiny digital assistants register a defect, Karim and the rest of his maintenance crew go to work.

Karim, a true son of the desert, moves through the heat very slowly and carefully — and in contrast with his European colleagues, who rush around, sweating, his shirts always remain dry. But now he too is in a hurry, and he’s relieved when he has reached the garage with the off-roaders.

Trained as an engineer, Karim is a calm and deliberate man. He seldom uses bad language — only in the rare cases when there isn’t enough sugar in his tea or when one of his colleagues has forgotten to “tank up” the off-roader, as has just happened.

The electric vehicle wasn’t plugged into an electrical socket — sockets that are supplied with power from the solar thermal installation. Nevertheless, Karim gets into the driver’s seat and presses the starter button. The vehicle’s 150 kilowatt electric motor starts up with a soft purr. A pictogram on the control panel indicates that the battery only has 10 percent of its full capacity. When fully charged, the vehicle has a range of 350 kilometers — and ten percent is not enough to get him up the hill.

But the off-roader is equipped with a small, highly efficient gasoline engine for emergencies, which works like a generator and gives the vehicle an additional range of 300 kilometers. And the gas tank is still full. Karim is satisfied, steps on the gas pedal, and the off-roader jolts off almost silently along the sandy trail toward the hill.

The final meters are the most difficult ones. The electric off-roader pushes through the sand with great effort, but eventually it reaches its destination.

“Here we are!” says Hussein as he hands Karim a glass of tea. “What brings you here? Are you looking for water or something else?”

“We need water for the maintenance crew to work flowing is no easy task. Already hopelessly congested under the best of circumstances, such networks can easily face gridlock. All it takes is a few tender benders — to say nothing of circumstances such as a subway strike or a snowstorm. As a result, sooner or later, every city government must decide whether to expand its transportation infrastructure or face collapse.

The situation with our power grid is similar. Electricity flows on copper “highways” from power plants to centers of demand. Along the way, it passes through various “load networks” that are separated by substations. These facilities function as traffic lights or railroad switchers, managing the flow of power from the transmission to the distribution grid, in particular, is often a total mystery to utilities. Because it includes hardly any components capable of communication in its components and is subject to a number of circumstances that challenge the grid’s ability to handle the electricity generated today. However, old grids can scarcely cope with the new challenges. They will not only have to integrate large quantities of fluctuating wind and solar power, but also incorporate an increasing number of small, decentralized power producers.

Today’s infrastructure is not up to this task. The solution is to develop an intelligent grid that keeps electricity production and distribution in balance.

Our power grids are facing new challenges. They will not only have to integrate large quantities of fluctuating wind and solar power, but also incorporate an increasing number of small, decentralized power producers. The today’s infrastructure is not up to this task. The solution is to develop an intelligent grid that keeps electricity production and distribution in balance.

More and more electricity will be generated in the future. However, old grids can scarcely handle the electricity generated today. Electric “gridlock” is a real threat.

Switching on the Vision

Motorists who venture into the maze of a major city are part of a larger whole. Tens of thousands of vehicles stream along highways from all directions and find their way through a dense network of roads. But keeping that network flowing is no easy task. Already hopelessly congested under the best of circumstances, such networks can easily face gridlock. All it takes is a few tender benders — to say nothing of circumstances such as a subway strike or a snowstorm. As a result, sooner or later, every city government must decide whether to expand its transportation infrastructure or face collapse.

The situation with our power grid is similar. Electricity flows on copper “highways” from power plants to centers of demand. Along the way, it passes through various “load networks” that are separated by substations. These facilitate function as traffic lights or railroad switchers, while also adjusting the electricity before forwarding it to the next grid. In the highest voltage, alternating current lines, electricity flows at 220 to 380 kilovolts (kV) across hundreds of kilometers from power plants to substations, where the voltage is reduced to 11 kV before the electricity is then fed into the grid. This grid is used for the general distribution of power to population centers or large industrial sites, where, depending on the region, the voltage is stepped down again to between six and 30 kV for the medium-voltage grid that is followed by local distribution. Here, substations reduce the voltage to 230 and 400 volts and send the power into the low-voltage grid, which feeds consumers’ outlets.

Needed: Electricity Highways. Until now, electrons have flown relatively smoothly through Europe’s grids, despite the fact that many of the continent’s power lines are now over 40 years old. Gridlock is inevitable, however, as traffic continues to increase. According to the International Energy Agency, the European Union generated roughly 3,400 terawatt hours (TWh) of electricity in 2008. This is expected to reach 4,500 TWh by 2030. In addition, the energy mix is getting more environmentally friendly. In 20 years, some 30 percent of the world’s electricity is expected to come from renewable sources. Today the figure is only 18 percent. But as the percentage of electricity generated by renewables grows, so does the instability of the grid (p. 27). Because eco-friendly electricity is primarily generated by wind farms much more energy than can be used is pumped into high voltage network in stormy weather, while supply cannot be guaranteed on calm days. In addition to being able to accommodate a fluctuating supply of wind-generated electricity, tomorrow’s grids will have to accommodate a growing number of small, regional power producers. The generation of electricity will become increasingly decentralized, as it is used to supply small solar installations on rooftops, biomass plants, mini cogeneration plants and much more,” says Dr. Michael Weinhold, CTO of Siemens Energy. “As a result, the previous flow of power from the transmission to the distribution grid will be reversed in part or for periods of time in many regions.” According to Weinhold, our grid infrastructure is not yet prepared for that. Grid operators and governments agree on how the challenge should be met. In addition to a massive expansion of electricity highways, the grids must undergo a fundamental change.

“Right now they are not very intelligent,” says Weinhold. “The level of automation for the system as a whole is very low.” The low-voltage distribution grid, in particular, is often a total mystery to utilities. Because it includes hardly any components capable of communication in its
present configuration, a lot of important information remains concealed, such as the actual amount of energy being used by consumers and the condition and efficiency of the line system.

According to an Accenture study, up to ten percent of energy disappears from the grid either due to inefficiency or electricity theft without being noticed by power providers. In large cities in some developing nations, as much as 50 percent of electricity disappears this way, and power providers are often unaware of outages — at least until the first complaint is received. With a view to heading off impending problems, in 2005 the European Union came up with a concept, which it called the “smart grid” — a vision of an intelligent, flexibly controllable electrical generation and distribution infrastructure. “The energy system plus information and communications technology all enter into a symbiosis in the smart grid,” says Weinhold. “Not only does this make the grid transparent and thus observable, it also makes it easier to monitor and control.” Governments and enterprises are committing large amounts of money to ensure that this vision becomes reality. The U.S. Department of Energy, for instance, has provided roughly $4 billion in subsidies for smart-grid projects in the U.S. German energy utilities are planning to invest roughly €25 billion in smart-grid technology by 2020. Key components for the power grid of the future are already available and have even been installed on a limited basis in some countries. One example is smart meters — intelligent, electronic electric meters.

“Smart metering is a key technology for the smart grid,” says Eckardt Günther, who heads the Technology by 2020. Key components for the power grid of the future are already available and have even been installed on a limited basis in some countries. One example is smart meters — intelligent, electronic electric meters.

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Smart Grid Competence Center at Siemens Energy in Nuremberg, Germany. “With smart metering, energy providers and consumers can for the first time record in detail where and how much electricity is being used and fed into the grid.” The advantage is obvious: If electricity consumption is precisely recorded, flexible rates can be used to match consumption to supply. This lowers electric bills and CO₂ emissions. In contrast, at present if more electricity is being consumed than was forecast, the production of electricity must be increased. Shedding some light on the distribution of the economic advantage associated with smart meters. “Smart meters heighten energy use awareness and help to better control it,” adds Günther. “In addition, they are a prerequisite for actively participating in electricity markets.”

Sebnem Rusitschka of Siemens Corporate Technology is also convinced that tomorrow’s grid will have to be smart. As part of the E-DeMa (development and demonstration of locally-produced energy marketplace) project, which is subsidized by the German federal government, Rusitschka is responsible for developing the information and communication interface between smart meters, the system for meter data management, and the electronic marketplace. “Among the things we are investigating is how these digital links need to be configured, i.e. what data should be transmitted and how can we obtain useful information from it,” she explains. The interfaces will connect both private and commercial electricity customers within model regions to an electronic marketplace and link them to energy traders, distribution grid operators, and other participants. The project is scheduled for completion in 2012. Rusitschka believes that projects like E-DeMa will boost the smart grid’s prospects. “The technology is available and it works,” she says. This is shown by the project of the Energy Ag Upper Austria, which gets support from Siemens, apart of provision of control and supervisory techniques, with more than 20,000 intelligent electricity meter. With these, the Energy Ag will provide an electricity tariff which arrange different price brackets in 2011 (p.38).

Virtual Networks. Another component of the smart grid is the “virtual power plant” (p.66). Here, the idea is that small energy producers such as cogeneration plants, wind, solar, hydro or biomass plants, which have previously fed their power into the grid individually and inconsistently, could be connected to form a virtual network. “This would allow them to bundle their power and sell it in a marketplace that is inaccessible to small suppliers,” says Günther. The grid would benefit too. “Consolidated into a virtual power plant and acting as a flexible unit, small plants could make balancing power available and thus help to stabilize the grid,” says Günther. Balancing power is provided in addition to the base load to cover peaks in demand. As this type of power requires power plants that can begin producing energy quickly, the price for a kWh of balancing power is much higher than for a kWh of base load power. Base load power is generally provided by the workhorses of power generation — coal-fired or nuclear power plants that run around the clock. Stability will be crucial to tomorrow’s grid. But intelligent systems alone will not be enough to manage the large amounts of energy provided by the growing numbers of wind farms or solar-thermal power plants. “There is also work to be done on the hardware side,” says Weinhold. “We need to greatly expand the number of power lines, as physics limits the transmission of electrical energy to wires or cables.” According to the German Energy Agency (DENA) study, some 400 kilometers of high-voltage grid needs to be reinforced and an additional 850 kilometers of lines need to be erected by 2015 simply to transmit the wind energy that will be generated in Germany.

Super Grids. The steadily increasing distances between power generation sites and consumers must also be bridged. One element of a solution to this problem could be high-voltage direct current (HVDC) transmission, which is capable of transporting large amounts of electricity across thousands of kilometers with low losses. Siemens has put the world’s highest capacity HVDC transmission system in China with a voltage of 800 kV into operation. Since the end of 2010 the system transmits electricity generated at hydro-electric plants with a record voltage of 800 kV across a distance of 1,400 kilometers by 2010. Weinhold believes that these electricity highways will not only cross borders in the future, but will link entire continents. “We will see the establishment of super grids in regions that can be interconnected across climate and time zones,” he says, adding that this would allow seasons changes, times of day and geographical features to be used to their optimal benefit. Super grids could be used to transport enormous quantities of solar energy from Northern Africa to Europe, as described in the Desertec project. “Electricity will draw the world together,” predicts Weinhold.

In addition to new electricity highways, tomorrow’s grid will need more buffers to stop it from bursting at the seams. Intermediate storage is needed for the excess power fed into the grid by fluctuating energy sources (p.74). Traditionally, this has relied on pumped storage power plants, but there is hardly any capacity for further expansion in Central Europe. As a result, wind farms will either have to be shut down to prevent them from overloading the grid during periods of overproduction or producers will have to pay someone to take the electricity.

One future solution could be electric cars, which temporarily store excess energy and later return it to the grid when needed — at a higher price (p.52). For example, 200,000 electric cars connected to the grid could make eight gigawatts of power available very quickly. That would be more than is currently required in Germany. As part of the EDISON project, in which Siemens is also participating, testing will begin on the electric cars concept and other solutions in Denmark in 2011. It is abundantly clear to Weinhold that we are moving into a new era. “Just yesterday the big issue was oil, but climate change is moving things in a different direction,” he says. Weinhold believes that we are currently on the threshold of a new era. Electricity is increasingly becoming an all-encompassing energy carrier. This is good for the climate, because electricity can be generated ecologically and transmitted very efficiently. — Florian Martini
The world’s largest turbine, with an output of 375 megawatts (MW), entered trial service in December 2007. In combination with a downstream steam turbine, it will help ensure that a new combined cycle power plant achieves a record-breaking efficiency of more than 60 percent when it goes into operation in 2011.

In 2007, residents of the town of Insching in Bavaria came out in large numbers to witness the traditional raising of their white and blue maypole. Three weeks later, they appeared in droves again—this time out of concern for the pole, as an oversized trailer had shown up carrying a new turbine for the town’s power plant. The residents were worried that the turbine, which measured an oversized trailer at its destination.

The turbine is also slated to be used at a number of other locations besides Insching. In 2013, six of the record-setting systems will be operating in Florida, where Florida Power & Light is modernizing its power plants in order to achieve net savings of almost $1 billion over the life cycle of the turbines. A company in South Korea also ordered one of the turbines. In early 2011, making the system a very successful export item for increasing sustainability.

Unmatched Efficiency

The world’s largest turbine, with an output of 375 megawatts (MW), entered trial service in December 2007. In combination with a downstream steam turbine, it will help ensure that a new combined cycle power plant achieves a record-breaking efficiency of more than 60 percent when it goes into operation in 2011.

The turbine can produce enough electricity to supply the population of a city the size of Hamburg.

After assembly at Siemens’ gas turbine plant in Berlin (below), the world’s largest gas turbine hits the road. Right: The turbine arrives on a flatbed trailer at its destination.

Siemens’ Power Generation plant in Berlin, traveled 1,500 kilometers to get to Insching—initially by water to Kelheim, where it was loaded onto a truck for the final 40 kilometers. This odyssey was the only way to test such a powerful turbine is to put it into operation at a power plant. “It was a nice coincidence that the turbine’s size correlates with the population of a city the size of Hamburg.”

The turbine can produce enough electricity to supply the population of a city the size of Hamburg.

Energy Technologies | World’s Largest Gas Turbine

The turbine can produce enough electricity to supply the population of a city the size of Hamburg.

Engineers at Siemens Energy overcame two challenges while designing the turbine. They increased the amount of air and combustion gases that flow through the turbine each second, which causes output to rise more than the losses in the turbine, and they raised the temperature of the combustion gases, which increases efficiency.
It networks multiple small power stations to form a large, smart power grid.

棕色小的分布式电源的连接和组合

与财政部的年度预算相比，小规模的发电厂在电力市场的应用逐渐增多。

Small, distributed power plants, fluctuating energy sources such as wind and sunlight, and the deregulation of electric power markets have one thing in common. They increase the need for reliable and economical operation of electric power grids. The virtual power plant is an intelligent solution from Siemens. It networks multiple small power stations to form a large, smart power grid.

Tense competition. The virtual power plant concept complements the big utility companies with their large, central power plants by creating new suppliers with small, distributed power systems linked to form virtual pools that can be operated from a central control station. Such a pool can unite wind power, cogeneration, photovoltaic, small hydroelectric, and biogas systems as well as large power consumers such as aluminum smelters and large process water pumps to function as a single supplier. With the Sauerland project Siemens and RWE have achieved the technological and economic utility of virtual power plants and expanded their knowledge base for further applications. “The project and the technology worked so well that we’ve connected nine additional power plants,” says Martin Kramer, RWE Project Manager for Distributed Energy Systems.

Cool Controls. At the heart of Sauerland's virtual power plant is Siemens' Distributed Energy Management System (DEMS). The system displays the current status of all systems, generates prognosis and quotations, and controls electric power generation as scheduled. The system overview is subdivided into producers and loads, contracts, and power storage. Conveniendy positioned at the center of the display is the “balance node” (the sum of the incoming and outgoing power must equal zero). Additional information is provided on forecasting and usage planning and “monitoring and control.” As a result, a portfolio manager can view color bar graphs showing which power stations are currently running at peak load or at base load and how much power they are producing.

Using plant status information, such as electric power output, and combining it with market forecasts, DEMS generates a forecast that also takes into account the next day’s prices and the total power available. Even weather data is factored into the energy management system to provide a forecast of the power available from sources with fluctuating availability, such as wind and sun. Before a quotation is placed on the energy market through an energy trader, it is checked and approved by the portfolio manager. Once it has been approved and accepted by the market, DEMS generates an operating schedule for the individual power plants in the virtual plant. The schedule specifies exactly when and how much power must be available from which plant. "DEMS does such a good job of modeling that its schedules can be run exactly the way it defines them," says Dr. Thomas Werner, Product Manager, Smart Grid Solutions at Siemens Energy. No manual corrections are needed.

DEMS generates an operating schedule for the virtual power plant and iterates the schedule with the portfolio manager until it is controlled in the demand mode (left).

Distributed Energy Management System software shows the current status of all systems included in a virtual power plant and generates an operating schedule (right) for its power generation. This schedule is controlled in the demand mode (left).

As part of a virtual plant, even small energy producers can sell their power on the electricity market.

Energy Technologies | Virtual Power Plants

Lucrative Reserve Power. Existing business models for virtual power plants already promise attractive profits. As a case in point, power grid operators need to maintain a constant balance in the power grid despite fluctuations in consumption and electric power generation. This is where the virtual power plant’s operator can sell reserve power and make a specific capacity available as a minute reserve. When needed, the purchaser places an order for a specific amount of reserve power at a specific price. If the seller then starts up or shuts down generators as specified in the contract within the agreed-on timeframe to stabilize the net frequency at 50 or 60 hertz.

Prof. Christoph Weber of Duisburg-Essen University estimates that an energy trader with a virtual power plant can increase earnings by several hundred thousand euros by paying less to the power grid operator for “compensation power.” Such payments are due when less or more power is fed into the grid than had been
According to Dr. Oliver Geden, an expert for EU climate policy at the German Institute for International and Security Affairs in Berlin, effective climate protection begins when “many people consume in an environmentally sustainable way, without having to think twice about what they’re doing.” For this to happen, says Geden, it will take huge structural changes in how we generate and consume electricity, including expanded use of renewable energy, and more efficient conventional power plants.

Significant progress has already been made in the construction of new power plants. Over the period from 1992 to the present, the efficiency of the latest coal-fired power plants in the industrialized West has risen from 42 to 47 percent. This amounts to a huge advance in climate protection. For instance, for a 700-megawatt (MW) generating unit, an increase in efficiency of five percentage points translates into a reduction in annual CO₂ emissions of around 500,000 metric tons. This is particularly important for the Middle Kingdom China, where, according to the International Energy Agency, one new coal-fired power plant with an efficiency of over 44 percent enters commercial service every month.

Advanced IT is the Core Element of a Virtual Power Plant

When it comes to upgrading existing power plants, however, there is still massive untapped potential, both in economic and environmental terms. The average efficiency of Europe’s coal-fired power plants is a mere 37 to 38 percent. Only about one in 10 plants tops the 40 percent mark. That’s hardly surprising, given that steam turbines in Europe are, on average, almost 20 years old. Gas turbines, on the other hand, are usually a little more recent vintage, with an average age of just under 12 years. Nevertheless, the German Association of Energy and Water Industries (BDEW) estimates that around one-quarter of Germany’s power plants will need to be modernized in the immediate future.

When Dr. Norbert Henkel, responsible at Siemens for the modernization of the turbine, we can tease an extra 15 to 20 years. As a rule, Siemens combines a new turbine with the modernization and thus for power plant upgrades.

As Ralf Hendricks from Siemens Energy explains, the increasing exploitation of alternative energy sources is also accelerating the pace of modernization. “In Europe, power companies will have to convert a lot of older combined-cycle power plants from base- to peak-load operation,” says Hendricks, who is responsible for so-called lifetime management and thus for power plant upgrades. The reason for the conversions is that Europe is ramping up use of land-based and offshore wind farms. When winds are strong, these farms generate lots of electricity, which means conventional plants can scale back output. But when winds die down, the latter have to be able to reach peak load rapidly to compensate for load fluctuations. The ability to react rapidly not only secures a power company high prices on the power market, an upgraded power plant also reaches its operating point more quickly, which cuts CO₂ emissions.

Siemens is a specialist in upgrading steam turbines, a job that primarily involves replacing the rotor and the inner casing. The latest in turbine blade technology and enlarged flow areas boost the efficiency and performance of the turbine. In addition, the use of new seals in high- and intermediate-pressure turbines reduces clearance losses, which likewise increases efficiency. These measures lengthen the service life of the turbine, allowing it to remain in operation for an additional 15 to 20 years. As a rule, Siemens also renews the control system for the turbine set or the power plant as a whole (Pictures of the Future, Spring 2009, p. 27). According to Dr. Norbert Henkel, responsible at Siemens for the modernization of fossil-fuel and nuclear power plants, it costs between €20 million and €60 million to comprehensively upgrade a steam turbine system for a medium-sized power plant. “By modernizing the turbine, we can ease an extra 30 to 40 megawatts out of the plant. As a result, the initial capital expenditure is amortized within just a few years,” he explains.

Power generator EnBW Baden-Württemberg (EnBW), for example, has invested around €300 million.
mill on upgrading its cogeneration plant in Altbach, near Stuttgart, a measure that will keep it in action for the next 30 years. Siemens re-equipped the plant’s control systems and upgraded its steam turbine, replacing the blades and seals, which boosted its output by 11 MW. The entire outer casing could be retained. With around 4,000 operating hours at full load per year, the plant has benefited from the upgrade with a reduction in its annual CO₂ emissions of 50,000 metric tons. As a result, the plant is now classified as one of EnBW’s “green” facilities and may, if required, rack up additional operating hours.

In Europe alone, there are over 500 steam turbine plants that now require modernization.

North America’s power plants are even older than Europe’s, with an average of 34 years for steam turbines in the U.S. and Canada, and 17 years for gas turbines. Siemens is involved in a number of major upgrades in this area. Some of these cover more than just the turbines: Siemens renewed the complete control system for a number of plants, including a coal-fired facility in Carneys Point, New Jersey, a combined cycle plant in Redding, California, and combined cycle installations in Syracuse and Beaver-Falls, New York, all of which are being fitted with the SPPA-T3000 web-based instrumentation and control system. This system integrates the power plant and turbine control functions in a common, easy-to-use platform. For the operators of Carneys Point, for example, this will provide greater flexibility to tailor operation of the individual generating units to actual demand, along with greater reliability and reduced maintenance costs. In contrast to fossil-fired power plants, many of which were commissioned over the last few decades, most of the world’s nuclear plants date from the 1970s and 1980s. “The conventional components of these plants, including the turbines, all need upgrading at around the same time,” Henkel explains. At present, a contract awarded by Flori-da Power and Light (FPL), Siemens is overhaul- ing the generator and renewing a high-pressure turbine and two low pressure turbines at the St. Lucie nuclear plant in Florida. This will increase the output of each of the two reactors by 100 MW. In addition, Siemens is installing new high pressure turbines and modernizing the generator at FPL’s Turkey Point nuclear plant, which will boost its output by around 100 MW. Both projects are scheduled for completion by 2012. With the exception of France, which generates the lion’s share of its power using nuclear plants, the energy mix in Europe still includes a large number of coal-fired power plants, the energy mix in Europe still includes a large share of coal. This applies particularly to Central European countries, including Poland, which meets over 90 percent of its power needs from coal.

A new control system and upgraded steam turbine from Siemens boost output at EnBW’s cogeneration plant in Altbach, Germany by 11 MW and reduce CO₂ emissions by 50,000 metric tons a year.

The construction of the world’s largest offshore wind farm — the Horns Rev II offshore wind farm — is a challenge from the production of rotors and trans-shipment at the harbor to assembly on the open sea.

Rewarding Efficiency. Back in Europe, power companies in the western member states are rapidly upgrading their facilities. In this sector, climate protection is still largely a corpor ate affair. Unlike its stance on the automotive industry, the European Union is prepared to let market forces, rather than regulation, bring about power plant modernization. That said, climate expert Geden foresees a major upheaval in the power plant market from 2013 onward, when CO₂ emission certificates in this sector will all be auctioned. Power companies will therefore have to pay for a percentage of their CO₂ emissions through the purchase of emission certificates. An exception, however, has been made for many Central and Eastern European countries, giving them until 2020 to catch up.

Some are rotating energetically in the
breeze, others are waiting to be commissioned, while a few more are mere foundations protruding out of the sea. Horns Rev II is the name of this wind farm, which is situated on a sandbank about 30 kilometers off the Danish coast.

The park is still under construction but when completed in Fall 2009, it will be the largest offshore wind farm in the world. A total of 91 turbines from Siemens will then be able to pump around 210 MW of electrical power into the national grid. The Siemens turbine is the largest in the world. It is 80 meters high and has 170-meter blades. Every second, the 120-tonne blades stretch into the sky, their tips roaring like a kind of “sandwich.” The bottom and top sections are subsequently joined and a vacuum is created inside. The vacuum sucks liquid epoxy resin through the fiberglass mats and the balsa wood. Here, the resin finds its way through all of the layers and evenly joins the two sides of the blade. Finally, the blades are “baked” in a gigantic oven at a temperature of 70 degrees Celsius for eight hours. “At the end of this process we have a seamless rotor blade with no weak points,” says Niels Nielsen.

A wind turbine produces enough energy to boil six liters of water in just one second.

How to Become a Windmill Builder

In August 2009, Siemens opened one of Europe’s most up-to-date training centers for wind energy in Bremerhaven, Germany. Aptly named the Wind Power Training Center, it has a floor area of about 1,100 square meters, and is situated between the European and Industrial harbors of the north German Hanseatic city, where it serves primarily as a training center for service technicians. Progress- making workers are not only offered theory courses covering the construction and operation of wind power plants, but are also given the opportunity to carry out practical maintenance work on real objects.

A hall measuring about 600 square meters forms the heart of the building, which houses a 2.3 MW wind turbine from Siemens, a simulator for the control technology, ladder constructions, a scaffolding, and crane and tower models. “In this Eil- dorado for technicians, our employees can demonstrate their knowledge of the technical procedures and the wind turbine, as well as relevant safety aspects of wind turbine construction, management, and servicing — all in a practical setting,” says project manager Bernd Flachmann. “In this experience, you will be able to perform maintenance work for customers faster and more efficiently.” Wind power plant opera- tors particularly benefit because the maintenance requirements and costs fall, while the reliability of the turbines increases.

According to Genkel, the ten-meter turbines, which weigh more than 300 tonnes, are more than just training objects that provide hands-on experience. “With the help of these turbine nacelles, we want to increase safety for our technicians,” he says. That’s why the training program offers emergency exercises under real-life conditions — up to now for this type of training center. “Regardless of whether an employee becomes stuck during maintenance work or simply gets cramps — at a height of a hundred meters even minor incidents are considered emergencies that call for swift action,” says Møller. He points at an old ferry that is anchored not far from the wind farm. “That’s our so called hotel ship. It’s home for the workers who are responsible for the installation and cabling of the wind mills. They spend two weeks at a time here at sea.”

In contrast, stays in the nacelles above the sea, which are far from comfortable, are of course much shorter. The limit is three days. In case evacuation is impossible in the face of a rapidly de- veloping storm, each worker is equipped with emergency storage facilities for fresh water and energy bars.

On the other hand, there are visitors who have climbed the tower with Jesper Møller who have indicated that they would rather stay a little longer because, even when there is no emergency, the cramped nacelle seems preferable to the idea of coming back down to a swirling boat at the foot of the mast — especially when you’d forgotten your seasickness pills.

Reprinted (with updates) from Pictures of the Future | Fall 2007, p. 60). What’s remarkable is that the rotor blades are manufactured as a sin- gle component without seams — a method that only Siemens is masterly at. At the start of the process, workers roll out long alternate layers of fiberglass mats and balsa wood in a form to make

Reprinted (with updates) from Pictures of the Future | Fall 2009

Reprinted (with updates) from Pictures of the Future | Fall 2009

Reprinted (with updates) from Pictures of the Future | Fall 2009
Power produced from renewable sources such as wind and sunlight is irregular. Experts are therefore looking at ways of storing surplus energy so that it can be converted back into electricity when required. One option is underground hydrogen storage, which is inexpensive, highly efficient, and can feed power into the grid quickly.

The ideal solution is to cache the surplus electricity and feed it back into the grid as required. The power network itself is unable to assume this function, since it is a finely balanced system in which supply and demand have to be carefully matched. If not, the frequency at which alternating current is transmitted deviates from the stipulated 50 hertz, falling in the case of excess demand, or rising in the case of oversupply. Both scenarios must be avoided, as there would otherwise be a danger of damage to connected devices such as motors, electrical appliances, computers and generators. For this reason, power plants are immediately taken offline whenever an overload pushes the grid frequency below 47.5 hertz.

Storage Power with Water. By far the best solution is to cache the surplus electricity and then feed it back into the grid whenever the wind drops or skies are cloudy. Here, a proven method is to use pumped-storage power plants. When the wind power isn’t sufficient, the surplus power is used to pump water up to a reservoir. As soon as demand increases, the water is allowed to flow back down to a lower reservoir — generating electricity in the process by means of water turbines. It’s a beautiful simple and efficient idea. Indeed, pumped-storage power plants have an efficiency of around 80 percent, reflecting the proportion of energy generated in relation to the energy used in pumping the water to the top reservoir. At present, no other type of storage facility is capable of supplying power in the GWh range over a period of several hours. In fact, more than 99 percent of the energy-storage systems in use worldwide are pumped-storage power plants.

Germany’s largest pumped-storage power plant is in Goldisthal, about 350 km southwest of Berlin. The facility has an output of 1,060 megawatts (MW) and could, in an extreme situation, supply the entire state of Thuringia with power for eight hours. In all, 33 pumped-storage facilities operate in Germany, providing a combined output of 6,700 MW and a capacity of 46 gigawatt-hours (GWh). Each year, they supply around 7,500 GWh of so-called balancing power, which covers heightened demand at peak times — in the evenings, for example, when people switch on electric appliances and lights. The energy held in reserve by pumped-storage plants can be called up within a matter of minutes.

In Germany, however, simply increasing the number of pumped-storage power plants isn’t such a simple option. There is a lack of suitable locations, and such projects often trigger obstacles," explains Dirk Ommeln from EnBW.

Batteries and Compressed Air. Other major industrialized countries such as the U.S. and China also make significant use of pumped-storage power plants. In addition, major ef-forts are being made to find alternative meth-ods worldwide. The best-known of all electricity storage devices is the rechargeable battery, which can be found in every mobile phone and digital camera. Although the amounts of energy involved here are tiny by comparison, this has not stopped some coun-tries from using batteries as a cache facility for the power network. "In Japan, for example, this method is used practically throughout the country," says Dr. Manfred Waidhas from Siemens Corporate Technology (CT). "Batteries store the energy in a charging container that can store about 5 MWh of electrical energy and are in- stalled in the grid close to the consumer. They are used as an emergency power supply, as a reserve at times of peak load, and as a buffer to balance out fluctuations from renew-

Comparative Energy Stored per Unit of Volume

<table>
<thead>
<tr>
<th>Energy Store</th>
<th>kWh/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumped-storage power plant</td>
<td>0.28</td>
</tr>
<tr>
<td>Compressed air</td>
<td>0.27</td>
</tr>
<tr>
<td>Lead-acid battery</td>
<td>0.15</td>
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<tr>
<td>NaS battery</td>
<td>0.10</td>
</tr>
<tr>
<td>Lithium-ion battery</td>
<td>0.07</td>
</tr>
<tr>
<td>Hydrogen storage</td>
<td>0.05</td>
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</tbody>
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Oversupply can likewise pose problems. Germany’s Renewable Energy Act stipulates that Ger-man network operators must give preference to power from renewable sources. But an abundance of wind power means that conventional power plants have to be ramped down. This applies particularly to gas- and coal-fired plants, which are responsible for providing the inter-mediate load — in other words, for buffering pe-riodic fluctuations in demand. For the power plants assigned to provide the base load — pri-marily nuclear power and lignite-fired plants — ramping up and down is relatively complicated and costly.

On windy days, this can have bizarre conse-quences. For example, it may be necessary to sell surplus power at a giveaway price on the Euro-pean Energy Exchange (EEX) in Leipzig. In fact, the price of electricity may even fall below zero. Such negative prices actually became a reality on May 3, 2009, when a megawatt-hour (MWh) was briefly traded at minus €152. In other words, the operator of a conventional power plant chose to pay some one to take the power rather than to temporarily reduce output.

The wind blows when and where it will, and it rarely heeds our wishes. These days, that is not a problem. The wind blows when and where it will, and many by the year 2020.

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"On the other hand, we need to remember that such batteries will be relatively expensive due to their compactness, safety specifications, and low weight," warns Dr. Christian Dötsch from Energy Technologies. "We believe electricity produced from renewable sources will be the most important form of future energy in the future," says Prof. Ulrich Wagner, member of the Executive Board of the German Aerospace Center (DLR). The range of future application possibilities for clean electricity is enormous, from household appliances, lighting, and machines to heat pumps, desalination facilities, and electric vehicles. A study conducted by the German Physical Society (DPG) in 2010 concluded that "electricity is easy to generate and transmit, and it can also be used very conveniently and flexibly." The DPG adds that for "no other form of final energy" will there be such a sharp increase in demand as for electricity. In facts, global electricity consumption could likely rise by around 70 percent by 2050, with most of the increase to be accounted for by emerging markets such as China. Many homes and offices around the world are still heated with gas or oil. If electricity is to be produced in the future with low CO2 emissions, then emissions will be essential for heating and electricity production.

Hydrogen: Ideal Storage Medium?

As compressed air energy storage (CAES), hydrogen is the perfect storage medium. "We believe such batteries will be relatively expensive due to their compactness, safety specifications, and low weight," says Wolf. "We need to remember that such batteries will be relatively expensive due to their compactness, safety specifications, and low weight," warns Dr. Christian Dötsch from Energy Technologies. "Electricity produced from renewable sources will be the most important form of future energy in the future," says Prof. Ulrich Wagner, member of the Executive Board of the German Aerospace Center (DLR). The range of future application possibilities for clean electricity is enormous, from household appliances, lighting, and machines to heat pumps, desalination facilities, and electric vehicles. A study conducted by the German Physical Society (DPG) in 2010 concluded that "electricity is easy to generate and transmit, and it can also be used very conveniently and flexibly." The DPG adds that for "no other form of final energy" will there be such a sharp increase in demand as for electricity. In fact, global electricity consumption could likely rise by around 70 percent by 2050, with most of the increase to be accounted for by emerging markets such as China. Many homes and offices around the world are still heated with gas or oil. If electricity is to be produced in the future with low CO2 emissions, then emissions will be essential for heating and electricity production.

Highspeed for Mobility and Economy

The key to launching the new age of electricity is to ensure rapid de-carbonization of power generation. The IEA anticipates that the share of the world’s electricity produced with coal, gas, and oil will fall from 68 percent to about 55 percent by 2035. During the same period, the proportion of power from renewable sources such as water, wind, and the sun will rise from 19 percent to 32 percent. And these forecasts are reflected in the outlook for the market. Siemens expects that in 2020 more than half of total global investment in the power plant market will be accounted for by renewable energy facilities. HSBC expects the global market volume for low-CO2 energy production to increase from $424 billion in 2009 to $1.041 trillion in 2020. Alongside hydropower, the main sources of CO2-free energy in the future will be wind — and to a lesser extent solar energy. HSBC expects that in 2020 the wind-power industry will boost the world’s share of the renewable energy market with a stake of $250 billion.

In the future, electric vehicles could provide temporary storage of electricity, which could be fed back into the grid as required, thereby improving the network’s stability. In the future, electric vehicles could provide temporary storage of electricity, which could be fed back into the grid as required, thereby improving the network’s stability. In the future, electric vehicles could provide temporary storage of electricity, which could be fed back into the grid as required, thereby improving the network’s stability. In the future, electric vehicles could provide temporary storage of electricity, which could be fed back into the grid as required, thereby improving the network’s stability.
What a Fireplace!

In order to accelerate a planned phaseout of coal and gas, Sweden utilizes market-oriented incentive systems and innovative technologies. The country’s biggest biomass power plant was recently opened in Södertälje. A Siemens turbine is helping to enhance its efficiency.

In March 2010, the Igelsta biomass power plant entered service in Södertälje, west of Stockholm. The system is based on biomass as a fuel. Mats Strömberg, the project manager responsible for the development of the power plant at power company Söderenergi, had already worked on a similar project in Gavle, north of Stockholm. As in Södertälje, a Siemens SST-800 steam turbine is in use there. Three quarters of the fuel for Igelsta consists of biofuels; the other quarter consists of recovered waste materials from offices, shops, and industry. From this fuel mix, the plant produces 200 megawatts (MW) of heat and 85 MW of electricity. “Siemens made the best offer in Gävle and Igelsta,” says Strömberg. “Performance is the key aspect, because the power plant is designed to operate for 40 years. Our efficiency gains over that period will be enormous.”

In 2003, a system of trading in green certificates was introduced in Sweden, promoting the use of renewable energies and making fossil fuels more expensive. “These certificates are allocated for free to producers that use renewable energies (one certificate for each MWh produced). All suppliers of electricity must acquire such certificates in line with their total sales of electricity. The quota is set by the state and increases over time, for 2010 it is 17.9 percent. The certificates are freely traded, their prices rise as demand increases.”

In this way, the “invisible hand” of the market is used to promote those types of green energy that can be produced most economically. But not all emission-free technologies are part of the national certificate system. Nuclear power and existing large hydroelectric plants are excluded, for example. Haglund sees this state regulation in Sweden as a model to be emulated. “The state stepped in and removed an assumed market dysfunction, the relative underpricing of fossil fuels. The results speak for themselves. Without this system, Igelsta would most likely have been designed to burn gas rather than wood waste,” he explains.

With their biomass-enthusiasm, the Swedes are both pioneers and traditionalists. During excavation for the Igelsta power plant’s foundations, workers found a Stone Age fireplace. To keep themselves warm, the people are burning wood just as their ancestors did thousands of years ago. But thanks to the technology, they are doing it efficiently. — Andreas Kleinschmidt

The King of Sweden expressed his pride when the Igelsta biomass power plant entered service in Södertälje, west of Stockholm in March 2010. “The time has never been better for an investment like this,” stated Karl XVI Gustaf. “The plant we have built sets an example for Sweden, for Europe and for the whole world.” Compared with a conventional power plant fired by fossil fuels, the new biomass facility saves as much carbon dioxide as is emitted by 140,000 cars per year. To promote green energies, the Swedish government decided in favor of the “carrot and stick” approach known as the “invisible hand.” Economic incentives for renewable energy and financial sanctions for conventional technologies make the construction of new coal-fired power plants unprofitable. Swedish utilities reacted quickly by investing in power plants that burn biomass or waste instead of fossil fuels.

Sweden’s targets are ambitious. By 2020, fossil fuels are to be eliminated from electricity generation. But nature is helping here. Hydro power already covers nearly half of Sweden’s electricity needs; nuclear power provides a significant share; and two percent was generated from biomass (one certificate for each MWh produced). All suppliers of electricity must acquire such certificates in line with their total sales of electricity. The quota is set by the state and increases over time, for 2010 it is 17.9 percent. The certificates are freely traded, their prices rise as demand increases.

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engineers have been striving to generate power from solar thermal energy for a century. Now, the technology is finally about to come of age. With the acquisition of Soli, Siemens has become a market leader at the cutting edge of several key solar-thermal technologies: parabolic mirrors, receiver tubes and steam turbines.

There is nothing more powerful, the saying goes, than an idea whose time has come. Solar thermal technology — the generation of energy from the heat of the sun — has tried to get off the ground three times already. In 1912, the American Frank Shuman built a parabolic reflector system in Egypt that was expected to produce 50 kilowatts (kW) of power. “Twenty thousand square miles of collectors in the Sahara,” he wrote, “could permanently supply the world with the 270 million horsepower it needs.” But the world did not wait; it needed more and more horsepower and increasingly drew its power from oil and other fossil fuels. Solar thermal energy seemed to become a footnote in the history of power generation. It was only the huge increase in the price of oil in the 1970s that aroused new interest in the technology. Sixty years after Shuman’s attempt, the Israeli company Luz developed new parabolic trough power plants. Nine plants from this period are still generating energy today in California’s Mojave Desert. But as the price of oil began to fall again, interest in solar thermal systems also waned. Power station projects were postponed or canceled, and Luz went bankrupt.

Now, almost 100 years after Shuman’s first project, the day finally seems to have come for solar thermal technology. Avi Brenmiller is one of the authors of this success. He remembers how this technology suddenly lost support.” But Brenmiller was persistent. In the course of a boycott, Luz became Soli, one of the leading suppliers of components for power generation systems using concentrated solar power (CSP) and Brenmiller became CEO. In the first six months of 2009, Soli posted sales of almost $90 million. Then, in late 2009, Siemens purchased the company. With its staff of more than 500, Soli subsequently became Siemens Concentrated Solar Power Ltd. Brenmiller’s dream has come true.

Now, thanks to the acquisition, the key components, systems and solutions for solar thermal power stations covering the entire conversion chain can be supplied from a single source. Siemens Renewable Energy Division offers everything from parabolic mirrors to
The basic principle of solar thermal power generation is simple. Energy from the sun heats water, either directly or indirectly through a heat transfer medium. The water turns to steam, and the steam drives a turbine at high pressure (see Photograph, Herbst 2009, S.23). Parabolic mirrors focus the needed sunlight onto a small surface in order to achieve sufficiently high temperatures. A receiver tube is fixed in the focal line of a row of concave mirrors. A liquid flows through these tubes as a heat transfer medium — synthetic oil and molten salt are the most commonly used substances today. The heat transfer medium is heated to approximately 400 degrees Celsius — molten salts allow temperatures of up to 550 degrees and are therefore more efficient — and in a second step releases the heat via a heat exchanger to water, which turns to steam and ultimately drives a turbine.

The receivers have a considerable influence on the overall efficiency of the plant. Siemens is therefore pursuing intensive research on further improvements to these high-tech tubes. The coating is crucial: multiple layers of various materials, including a ceramic-metal mixture, prevent re-radiation of the heat stored in the transfer medium. The structure of the receivers is complex, however, and sensitive. Up to 7,000 mirrors arrive each week. Almost 170,000 are needed to fit it out what will soon be a 50-megawatt (MW) power plant. All in all, the mirrors account for approximately six percent of the plant’s total cost of almost €300 million. Receiver tubes — pipes that receive solar radiation from the mirrors and transfer it to a fluid — are another major expense.

The components are assembled on-site in Lebrija in a specially-built hall. “When we arrived, we found a cotton plantation at the site,” says Siemens Concentrated Solar Power Vice President Moshe Shitamper, who is responsible for the construction of the thermal solar facility at Lebrija. 1. His project team first had to move the cotton and then have drains laid in the marshy delta of the Guadalquivir River. Now there are concrete pillars extending down as far as 40 meters into the ground, and the 6,048 parabolic troughs are mounted on top of these. Each trough consists of 28 individual mirrors that focus light onto the receivers. The parts are now being put together in the assembly hall by former plantation workers. Using hydraulic hosting cranes, they are combining individual mirrors to create parabolic troughs, which are then transported to the solar field by a tractor and trailer. There, cranes host the two-ton troughs into position.

The plant will go online in 2011 and, with the help of a steam turbine from Siemens, is expected to supply over 50,000 Spanish households with electricity (see box).

Israel: Perfect Place for PV

Israel is an ideal location for harnessing the sun’s energy — not only in the form of solar thermal power plants, but also with photovoltaic systems that promise big yields. Siemens has taken a 40 percent stake in Arava Power, Israel’s leading developer of photovoltaic systems. Siemens is also the general contractor on a project to build the first PV power plants in the desert — including one at Kibbutz Ketrua in the south of Israel. Here, in this desert region between the Red Sea and the Dead Sea, the conditions for solar power couldn’t be better. In 2011, the Kibbutz Ketrua plant could be feeding energy from a five-megawatt photovoltaic facility into the grid. Apart from solar panels themselves, which are being supplied by Suntech, almost all of the components of this first plant will come from Siemens. Mike Green, Chief Electrical Engineer at Arava Power, is proud to be a pioneer for green energy in Israel. “My big hope is that this will mark the beginning of a lucrative future for renewable energy in Israel,” he says.

With parabolic mirrors, getting just the right curve is essential to maximizing efficiency. Meticulous quality control takes place in a plant in Israel, helping to ensure at least 25 years of operation.

The individual mirrors that make up parabolic troughs are manufactured near the town of Nataf in the north of Israel. Siemens project manager Shud Epstein puts on safety goggles that protect his eyes from flying shards and opens a second button on his shirt. The closer he gets to the oven, the hotter it gets. At approximately 1,500 degrees Celsius, the special-purpose siliate in the oven melts into glass. At other times, glass for armored vehicles is made here. We do a separate shift for parabolic mirrors,” says Epstein. “In this case, we use glass with a low iron content. This ensures that they absorb only a minimal amount of solar energy and therefore reflect most of it. The hot liquid glass flows out of the oven over steel rollers in a river of molten light. Sheets measuring 1.6 by 1.7 meters in diameter are broken out, ground down at the edges and then heated again. The glass sheets are placed on stainless steel mats and then passed through another oven that was specially built for this purpose. Here, in the course of about 1.5 hours, they slowly take on the desired
Solar Thermal Power

curved shape needed for perfectly focusing solar radiation. “During this stage, it’s important that there be no stresses left in the material that could later lead to fractures. After all, we guarantee a service life of 25 years.” A single parabolic trough consists of 28 individual mirrors. Since the trough must be able to reflect sunlight in such a way as to perfectly focus it on a nearby receiver tube, each mirror must have a curvature of a fraction of a degree in order to minimize scattering losses. What’s more, the mirrors themselves must absorb as little solar radiation as possible. As is the case with receiver tubes, coatings play a key role in terms of maximizing desirable characteristics and minimizing undesirable ones. Thus, Epstein’s team ensures that a silver solution, as well as a coating of copper and several layers of corrosion-inhibiting paint are sprayed on the back of each mirror Epstein walks past a long line of finished mirrors. Depending on how they are standing, he seems to become either widened to comical proportions or extended back of each mirror. Depending on how they are standing, he seems to become either widened to comical proportions or extended back of each mirror.

COMPETITIVE PRODUCTION. While some solar thermal power plants have entered service in Spain and the U.S. state of Arizona, plans are only now being made for the first facilities in Israel. “The irradiance data for Israel are perfect. The whole Negev Desert is an ideal area for CSP plants,” says Brenmiller. “And if the plants were also equipped with gas turbines, you could generate power competitively right now in Israel, even without any subsidies.” The downstream steam turbine in such gas-solar hybrid power plants can be powered by solar heat, and by the waste heat produced by the gas turbine. This means that the power plant can also generate electricity during the hours of darkness. At least for a transitional period, solar energy and fossil fuels will coexist to muffle the effects of darkness. At least for a transitional period, solar energy and fossil fuels will coexist to muffle the effects of darkness. 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