

Energy efficiency and environmental care

Innovation for climate protection

Answers for the environment

SIEMENS

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Message from the CEO



Peter Löscher President and Chief Executive Officer of Siemens AG Climate change is probably the greatest and most demanding challenge that confronts mankind today. To mitigate global warming to the greatest extent possible, we must decouple economic growth from energy usage; and we must do this worldwide.

Two megatrends, however, make it increasingly difficult to separate economic growth from energy use: demographic change and increasing urbanization have resulted in skyrocketing energy costs, shortages of natural resources including water, cities whose existing infrastructures are overextended, and myriad other challenges.

Clearly, we have no choice but to rethink how we produce and use energy on a planet that will have 9 billion people, most of them living in large cities, by mid-century. We will have to answer the following tough questions: How will we cover the rising global demand for energy in the future? At the same time: How will we supply energy in a way that is compatible with the climate and environment, reliable and also affordable?

For the last 160 years, Siemens has been answering tough questions like these. Today's problems, while of a different magnitude, can be answered in the same way: the solutions lie in technological innovation. Energy efficiency will play a major role in meeting our current challenges, including helping to reduce the carbon emissions causing climate change. As this brochure shows, most of these innovative technologies are readily available today from Siemens.

For example, we are the leading provider of renewable energies, including wind and solar power. You can also read how the German power company E.ON Energie and Siemens have installed the world's largest, most efficient gas turbine in Irsching, Germany. When fully operative in 2009, the 530-megawatt combined cycle power plant in Irsching will have a 60 percent efficiency rate and produce 40,000 fewer tons of CO_2 emissions than the next most efficient plant of its kind. This reduction is equivalent to the emissions of 9,500 cars driven 20,000 kilometers (12,000 miles) a year. Siemens is already helping its customers reduce their carbon footprint; this publication provides more details on this as well.

However, we are not only helping our customers reduce their carbon emissions. We have also set demanding emission-reduction targets for ourselves. Until 2011, for example, we want to reduce our own CO_2 emissions (in relation to revenue) by 20 percent (compared to 2006 figures).

Our environmental portfolio not only provides many answers to the current energy and growth challenges: it is also a triple win. Customers win because they can lower energy costs, improve productivity and make their businesses more profitable. Society wins because environmental care and living standards are improved. And Siemens wins because we can tap attractive markets and achieve profitable growth.

This brochure provides an overview of our environmental portfolio, which currently represents nearly one-quarter of our business. Siemens is fully committed to environmental protection and will continue to make every effort to meet the challenge of climate change.

Piter Lescher

Summary

Climate change represents one of humanity's greatest challenges. To counteract global warming and guarantee economic growth and prosperity in the future, energy must be generated and utilized in an environmentally and climate friendly way. Technological innovations play a key role in increasing the efficiency of power generation, transmission, and consumption and avoiding greenhouse gas emissions. The good news is that many of these solutions are already available. In many cases, they can save so much energy that they pay for themselves. They just have to be implemented.

Siemens answers

Siemens makes a substantial contribution to environmental protection with its energy-efficient products and solutions and its renewable energy and environmental technologies. Products and solutions installed by Siemens for its customers between 2002 and 2007 that are still in use today reduce CO₂ emissions by 114 million metric tons per year. The volume of carbon dioxide emissions saved through the use of Siemens products is more than 20 times higher than Siemens' own emissions (see also page 44).

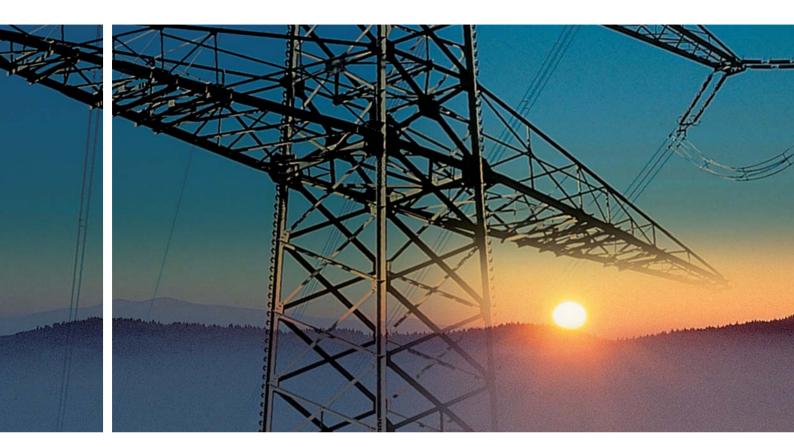
Siemens has also set itself a target of reducing its own carbon dioxide emissions by 20 percent (in relation to revenue) by the year 2011 compared with 2006 figures. In addition, Siemens is involved in various climate protection initiatives around the world. It is a member of the "Business for Climate Protection" initiative sponsored by the Federation of German Industries (BDI) as well as the U.S. Climate Action Partnership, and the Clinton Climate Initiative, to name just a few.

What does Siemens offer ?

No other company worldwide can probably offer its customers such a broad portfolio of economical and ecological technologies. Here are some examples:

- Higher efficiency means less fuel is consumed and fewer pollutants are emitted. Siemens combined cycle power plants will soon achieve efficiencies of more than 60 percent. Combined heat and power can even achieve overall efficiency factors of over 90 percent. Customized modernization projects can fully upgrade older facilities.
- Over 6,400 Siemens wind turbines have been installed with a peak performance of 5,700 megawatts, reducing CO₂ emissions by 8 million metric tons per year.
- Thanks to high-voltage direct current (HVDC) transmission technology from Siemens, electricity can be transmitted





over distances of up to 2,000 kilometers with minimum loss.

- Variable-speed drives with frequency converters reduce the electricity consumption of pumps and fans by up to 60 percent.
- Compared to conventional procedures, Siemens' Corex technology reduces CO₂ and sulfur dioxide emissions resulting from iron production by 30 and 97 percent respectively.
- By means of special wastewater purification plants for the paper industry, Siemens helps reduce wastewater contamination of the environment. The resulting biogases produced are used to generate power, which in turn decreases the plants' CO₂ emissions.
- Consistently applied lightweight construction as well as braking energy

recovery has enabled subways such as the Oslo Metro to use 30 percent less energy than conventional ones.

- By optimizing heating, ventilation, and air-conditioning systems, Siemens increases the energy efficiency of buildings and decreases greenhouse gas emissions. Siemens has modernized 6,500 buildings worldwide, thereby reducing CO₂ emissions by 2.4 million metric tons and saving more than 1 billion euros.
- Siemens also designs energy-efficient and environmentally friendly solutions for consumers, such as lighting. LEDs use 80 percent less electricity than lightbulbs and have a service life that is 50 times longer. Compared to 1993 models, today's washing machines use 35 percent less electricity and 46 percent less water.

Siemens is in a unique position of being able to offer efficiency-increasing products, solutions, and environmental technologies throughout the entire value chain – from power generation to power transmission and distribution to energy applications and energy-saving services. Here, cutting-edge IT solutions for energy management are increasingly being used.

Siemens intends to grow in particular in the area of sustainable technologies. With these the company enables its customers to operate according to both economical and ecological principles. That's why Siemens has set itself the goal of significantly expanding its environmental portfolio (see also page 44 and *www.siemens.com/environmentalportfolio*): to improve quality of life around the world.



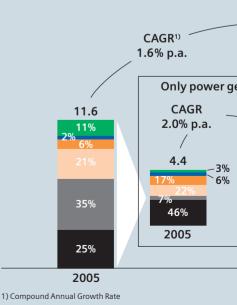
Energy is the driving force behind mankind's progress. However, it must be available in sufficient quantities, it must be affordable, and consumers must use it in an environmentally responsible manner. Bringing these somewhat conflicting objectives into positive alignment is an increasingly urgent task, especially given that the demand for electricity will increase dramatically by 2030. The Middle East, the Asia/Pacific region Latin America will account for the greatest increases in terms of percentages. When measured in absolute figures, obviously the Asian countries, especially China and India, will be the largest energy consumers.

All potential solutions must be utilized

Today the power supply is broadly based on fossil fuels worldwide. Siemens assumes that renewable energy sources will play a bigger role in the future, but that fossil fuels will remain dominant at least for the forseeable future. Coal in particular will remain indispensable worldwide. However, the mix will increasingly shift in favor of natural gas and renewable energies. Wind energy in particular will play a greater role in supplying power.

The world population will continue to grow quickly, as will the global economy. In order to decouple the demand for energy from this growth, all energy sources must be used more efficiently. For solar, wind, biomass, and geothermal energies, this means increasing efficiency, reducing their respective power generation costs, as well as evening out their fluctuating availability. Compared to fossil fuels, renewable energies have the advantage that they are practically inexhaustible and generate no emissions.

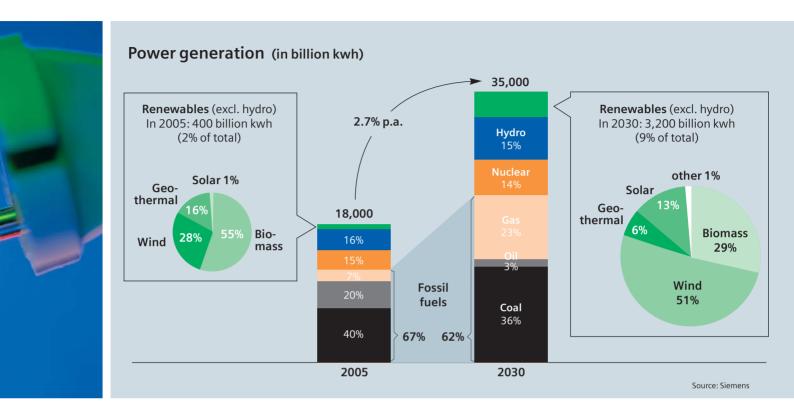
Consumption of primary energie



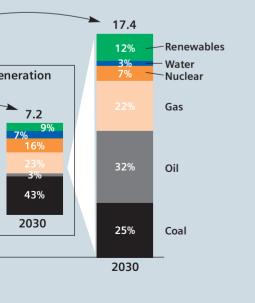
Percentage values may add up to more than 100 percent due to rounding.



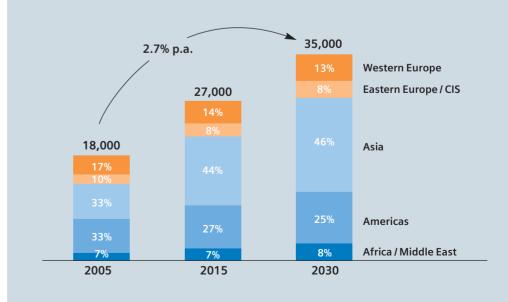
7



s (in billion tons of oil equivalent)



Development of power demand by region (in billion kwh)



Source: International Energy Agency, Siemens

Efficient power generation, transmission, and distribution

2. Efficient power generation, transmission, and distribution



How can the global energy demand be covered without damaging the environment?

The strong growth in demand for energy, and the challenges this poses for power supply and the environment, can be met by continuing to develop technology to save energy and protect the environment - in other words, by developing more efficient technologies. Improving the efficiency of energy systems will be the most important factor in solving the energy and environmental problems of the future. Additionally, the developing and newly industrializing countries need assistance to cover their rising demand for energy in an environmentally friendly way. Using ultramodern technologies for the energy supply infrastructure will enable energy sources, especially fossil fuels, to be used more efficiently so that less damage is done to the climate and resources are not used up.

Siemens answers

Siemens, along with its partners, is the world's only supplier to offer the complete spectrum of modern power plant technology. This ranges from conventional thermal power plants and advanced technologies such as combined cycle power plants with integrated coal gasification, through wind power plants and hydropower, to fuel cells for centralized and decentralized electricity generation. Siemens is also the global market leader in the field of steam turbines for solarthermal power plants.

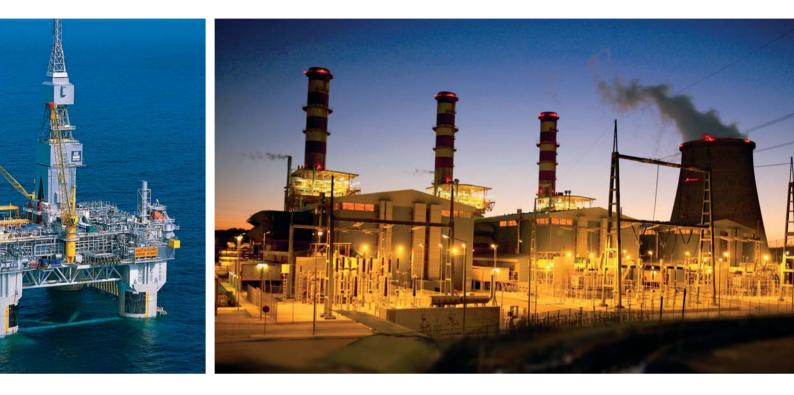
The Energy Sector of Siemens also offers a broad range of products, solutions, and services for the industrial applications of customers in the oil and gas industry and in other industrial sectors. Additionally, the Siemens portfolio comprises products for efficient power transmission and distribution. With these products the generated electricity can be transported and distributed without any unnecessary losses.

More efficiency in fossil power generation

Fossil energy sources make up the largest proportion of the global energy supply today. This will continue over the next few decades, at least through the middle of the 21st century.

Combined cycle power plants

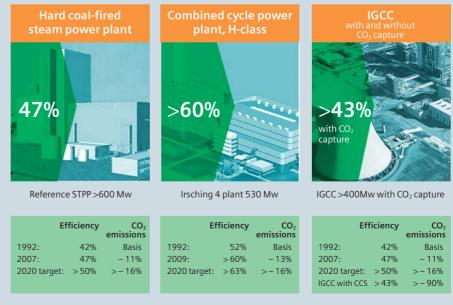
Combined cycle power plants are the conventional power plants that offer the most protection for our environment and climate. The best combined cycle power plants had achieved an efficiency of 52 percent by as early as 1992. The Mainz-Wiesbaden plant in Germany reached an efficiency of over 58 percent in 2002, the world record for that time. Carbon dioxide emissions per kilowatt-hour were only about 345 grams, thanks to high efficiency and the use of natural gas, a low-carbon fuel. To further increase the efficiency of gas-fired combined cycle



power plants, the steam/water cycle must be optimized and the gas combustion temperature must be further increased. That will require new materials with new crystalline structures. In addition, an improved coating must be used to protect the materials against corrosion and high temperatures. Once these materials are developed, combined cycle power plants fueled with natural gas could have an efficiency ratio of more than 63 percent by 2020.

E.ON Energie, a German power company, and Siemens are building a new power plant in Irsching, Bavaria, which will set new standards for efficiency and economy. Siemens is building a new type of gas turbine system as a first step. At 340 megawatts, this promises to be the world's largest, most powerful gas turbine. In December, 2007, the turbine system was started up for the first time, right on schedule. That marked the start of the trial operation phase, which is estimated to continue for 18 months. After

Development of efficiency: Fossil-fired power plant types at the world market level



New technologies are essential to meet economical low-emission power mix.

Source: Siemens

the test phase, the gas turbine system will be expanded into a high-efficiency combined cycle power plant with an output of approximately 530 megawatts and efficiency of over 60 percent. This increase in efficiency represents a quantum leap in today's power plant technology.

Compared with existing combined cycle power plants, increasing efficiency by two percentage points means that 40,000 metric tons less carbon dioxide are produced every year compared to today's state-ofthe-art power plant technologies. That corresponds to eliminating the annual emissions of 9,500 mid-sized cars, each driving 20,000 kilometers (12,400 miles). words, the combined cycle process is used. Today's gas turbine technology in combination with integrated coal gasification can achieve efficiencies of over 47 percent.

Fossil-fueled power plants with carbon dioxide capture

The low-carbon-dioxide power plant can be achieved using several technological approaches:

In existing and new power plants – through special flue gas scrubbing. In new power plants – by burning the fossil fuel with pure oxygen, so that, in principle, the flue gas contains only water and carbon dioxide. In integrated gasification



The SGT5-8000H – the largest and most powerful gas turbine in the world. After the test phase in Irsching, near Ingolstadt in Bavaria, the system will be expanded into a high-efficiency combined cycle power plant with an output of approximately 530 megawatts and efficiency of over 60 percent.

Combined cycle power plants with integrated gasification

Due to the particular advantages of the combined cycle process, this technology will be used in the future not only for natural gas, but also for fuels such as coal, which is abundantly available worldwide, biomass, and residues from refineries. The greatest success is promised by combined cycle power plants with integrated gasification systems. In Europe this concept has already been implemented in Buggenum, Netherlands, using coal, and in Puertollano, Spain, using a mixed fuel made of coal and oil residue from a refinery.

First, the fuel is gasified. Then the generated synthetic gas, mainly a mixture of carbon monoxide and hydrogen, is purified and used in a gas turbine with an unfired heat recovery steam generator. In other combined cycle (IGCC) plants carbon dioxide can be captured before combustion relatively simply with existing technologies. See page 41 for further information.

Renewal of German power plants

Thanks to reduced emissions, high efficiency and lower investment costs, natural gas-fired combined cycle power plants will play an important role particularly in the "repowering" of Germany – the renewal of its power plants. In Germany alone, power plants with a total output of 40,000 megawatts will need to be replaced by 2020 since by then they will have outlived their service life of 40 years. Upgrading existing plants also offers many opportunities to increase efficiency and reduce the environmental impact. In the Farge power plant in Germany, various upgrades increased efficiency by just under three percentage points. In terms of the overall energy balance, this means that 40,000 fewer tons of coal have to be burned each year to generate the same amount of energy, thereby eliminating 100,000 tons of CO_2 emissions.

Coal-fired power plants

Coal-fired power plants had an efficiency ratio of 7 percent in 1900, whereas today's modern coal-fired power plants are up to 47 percent efficient. That means they consume 270 grams of coal and emit 700 grams of carbon dioxide per kilowatt-hour.

Further improvements in efficiency depend primarily on two variables: increasing the two steam parameters, pressure and temperature, and reducing losses in the steam-water cycle. Efficiency is expected to exceed the 50 percent mark by 2020.

Information technology makes power plants more efficient

In order to extract maximum power from the fuel burned in fossil fuelfired power plants, they must be operated at the thermodynamically optimum point, and unnecessary startup and shutdown operations must be avoided.

The Siemens information technology solution Energy Management Suite (EMS) helps operators of power plants in this respect. The Thermodynamics software module included in the suite enables the optimum operating parameters for high efficiency to be determined by means of simulation. The choice of the optimum maintenance strategy for the plant components and the use of diagnostic systems and early warnings also increase the reliability of the plant as a whole.

Combined Heat and Power

When it comes to energy efficiency, combined heat and power (CHP) plays an important role: CHP plants achieve a significantly greater degree of energy efficiency by generating electricity and heat simultaneously. The result is fuel savings. However, CHP requires either the presence of a district heating grid or an industrial buyer of process steam.

Thanks to CHP, the Rya district heating power station built by Siemens in Göteborg, Sweden, achieves a fuel efficiency of 92.5 percent, which means that the city can reduce its CO_2 emissions by 600,000 tons per year as it additionally covers up to 35 percent of Göteborg's heat demand. Another example is the combined cycle CHP power plant at the Ludwigshafen site of the chemical company BASF which is producing process steam. The resulting fuel efficiency is about 90 percent with more than 500,000 tons in CO_2 savings per year.

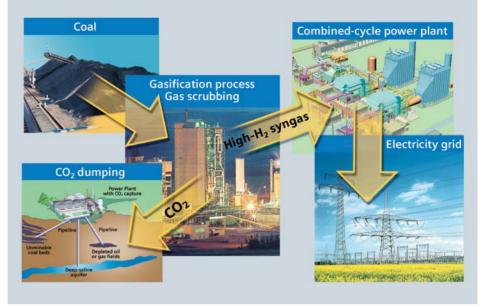
Nuclear power plants

The joint German-French company AREVA NP, in which Siemens holds a 34 percent stake, has developed the most advanced reactor, the European Pressurized Reactor (EPR), with unprecedented safety features. The first EPR is currently under construction in Finland, and a second is to be built in France. The EPR has a number of improvements compared with earlier nuclear power plants, including: efficiency increased from 35 percent to 37 percent, power output increased to over 1,600 megawatts, and operating time increased to 60 years. Another product in the AREVA NP portfolio is the SWR-1000 boiling-water reactor developed jointly with various European partners, which boasts some of the best safety standards in the world. In the nuclear power plant sector, Siemens is responsible for the conventional part (including the steam turbine set) and the operating control technology.

Fuel cells

Another way to achieve high efficiency is the direct electrochemical conversion of

IGCC (integrated gasification combined cycle) technology for the most efficient, clean power generation using coal



Unlike conventional coal-fired power plants, CO_2 sequestration in IGCC plants is relatively simple. This gives it the potential of becoming the most innovative, economical CO_2 -free coal-fired power plant solution. CO_2 is kept out of the atmosphere by injecting it into existing oil or gas fields.

the chemical energy in fuel into electrical energy and heat using fuel cells. Hydrogen, natural gas, or coal gas is combined with oxygen or air in the fuel cell to produce electric power and heat. The emissions from a fuel cell are almost zero for carbon monoxide and sulfur dioxide and very low for nitrogen oxides. The value for carbon dioxide depends on the fuel that is used, and due to its high efficiency is very low for natural gas and zero for hydrogen. Siemens is the world leader in solid oxide fuel cells (SOFCs). SOFC plants have an electrical efficiency of about 50 percent for simple systems and up to 70 percent for SOFC/gas turbine hybrid systems. The pre-commercial SOFC-200 has an electrical output of 125 kilowatts and thermal output of 100 kilowatts.

Energy efficiency in the oil and gas industry

Along the oil and gas value chain, an average of 90 percent of the energy is used for pumping and compression of oil and gas in the production and transport processes and in the process industry during heat transfer with burners, steam generators, and coolers. Energy efficiency is about 20 percent.

The efficiency of these processes can be boosted to over 50 percent with electrical solutions using an electrical drive system instead of the mechanical drives in the compression and pumping process. The electricity is produced by a gas turbine power plant or in a combined cycle plant.

Siemens is the only supplier to offer power generation, power supply, electrical drive systems, and compressor solutions from a single source. In one realization of this concept, Siemens acts as partner in the development of seabed compressor solutions for natural gas extraction, electrical gas liquefaction systems (E-LNG), electrical FPSO ships for processing crude oil (EFPSO), and pipeline solutions. As the market leader for industrial steam turbines, Siemens offers perfect solutions for power generation and gas compression for utilizing the exothermic energy produced in the process industry.



25 wind turbines from Siemens are in operation in the Burbo Offshore Wind park off the coast of Liverpool. The wind power plants, of type SWT-3.6-107, have an output of 3.6 megawatts each. The wind park supplies 80,000 households with eco-friendly electricity and has a total capacity of 90 megawatts.

More efficient use of renewable energy

In addition to economical use and efficient transformation of fossil raw materials, the focus will shift increasingly to renewable energy sources for the generation of electrical energy. Over the past few years renewables have gained considerably in importance, and in 2007 they accounted for over 14 percent of the electricity generated in Germany alone. Renewable energy sources reduce dependence on fossil raw materials, particularly in countries that have no deposits of raw materials of their own, and thus help safeguard the production of energy. Renewable energy frequently comes from domestic or local sources, which occur virtually everywhere in the world. In developing and emerging countries they can play an important role in rural electrification, and thus help to stimulate economic growth.

Optimized utilization

The focus on the use of solar, wind, biomass, and geothermal energy sources is not only to increase their efficiency, but also to reduce the costs of generating electricity. Apart from the inherently low energy density of sunlight and wind, the fluctuating supply of renewables poses a challenge. For example, while a capacity of up to 8,000 hours annually is possible with a nuclear power station, and a coalfired power plant can be operated for about 7,000 hours a year at full load, wind power plants achieve a much smaller 1,800 to 3,300 operating hours annually, depending on location. The differences due to season and time of day have to be forecast and taken into account in renewable power plant management. Although these differences lead to an increase in peak loads, they also result in lower average capacity utilization of the networks. However, innovations in the transmission and distribution networks make both renewables and fossil fuel-fired power plants increasingly effective and attractive in the energy mix.

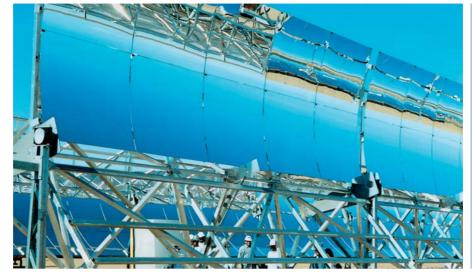
Wind energy

Wind energy is a booming business. Today, there are more than 6,400 installed wind turbines bearing the Siemens name. These have a peak capacity of 5,700 megawatts, and save over eight million metric tons of carbon dioxide a year. In the offshore wind park sector, Siemens is the global market leader in

Floating wind power plants

Siemens and the Norwegian energy company Hydro have agreed to cooperate on the development of floating wind power plants. The first floating wind turbine will soon be tested off the Norwegian coast. Floating power plants have a number of advantages. For example, they can be positioned in deep-water coastal regions and thus profit from the more stable wind conditions found there. Furthermore, they can be used virtually anywhere on the open sea.

the delivery of wind turbines. Siemens is also responsible for Europe's largest onshore wind park, in Whitelee, Scotland. The largest turbine model in the wind power product portfolio has a rated capacity of 3.6 megawatts and a rotor diameter of 107 meters. The rotor blades, which are manufactured using the patented integral blade method, consist of seamless fiberglass, and are Siemens is delivering four steam turbines for four solar-thermal power plants in Spain. When they go into service, the power plants will be the biggest plant of this kind in Europe, and thanks to a thermal salt reservoir, will be able to operate 24 hours a day in the summer months



Solar energy the Italian way

In 2007, Siemens put into operation the largest connected solar power plant in Italy, the size of one and a half soccer fields. Its 5,500 solar modules produce a total of 1.4 gigawatt-hours of electric power each year, with a rated capacity of 180 Wp/module. About 350 households in the province of Calabria in southern Italy profit from this climate-friendly method of producing power.

Solar energy the Spanish way

Besides wind energy, Spain is also spearheading the development of solarthermal plants. Siemens has already delivered two steam turbines of type SST-700 for the solar-thermal power plants Andasol 1 and Andasol 2 in Andalusia. After their scheduled connections to the grid in 2008 and 2009, they will be the largest power plants of this type in Europe, with a total collector area of 512,000 square meters and a power output of 50 megawatts. Thermal reservoirs consisting of salt are also being installed in Andalusia to ensure that electricity can still be generated at times when there is little or no sunshine. These reservoirs absorb the energy for steam generation and ensure that the power plant can continue operating for six hours. These salt reservoirs transform these power plants into predictable electricity generators.

designed to withstand even hurricaneforce winds. The rotor blades planned for the future will be as long as 60 meters and able to drive even more powerful turbines. The most efficient wind turbine in service today can produce 100 times as much power as the windmill turbines used 25 years ago. To meet high regional demand, Siemens has built its own production facilities, for example in Iowa in the U.S.

Solar energy

Photovoltaic, solar-thermal, and upwind power plants are three examples of ways

in which solar energy can be transformed into electrical energy. Photovoltaic power plants work directly via solar cells. In solar-thermal power plants, sunlight is focused onto an absorber tube which heats up to a very high temperature. The heat is used to heat a synthetic thermal oil to a temperature of 400°C, which then generates steam by means of a heat exchanger to drive the power plant turbines. These plants can usually only operate economically in regions with plenty of sunshine. A third possible way of harnessing the sun is upwind power plants. These collect hot air that is then allowed to rise up a high tower, driving pressure-graduated wind turbines as it rises.

Further renewable energies

Biomass and geothermal energy are considered renewable energy forms since they are generally carbon dioxide neutral. In contrast to wind and solar, biomass plants – biomass needs exactly as much carbon dioxide to grow as is later released during combustion – and geothermal energy are available on demand, so it is easier to plan their use. With its turbo machines, Siemens delivers the key components to generate renewable electricity from these natural sources. How can electricity be transmitted over long distances with low loss?

Efficiency in power transmission and distribution

A secure, efficient power supply means more than just efficient power generation. The transmission of electricity from the power plant to the consumer must also function smoothly every hour of the day and night. The potential consequences of even the most minor faults have been highlighted by blackouts around the world in recent years, many of which were caused by weaknesses in the power supply grids. Stable networks that can react quickly and flexibly to changes in load cannot be taken for granted. The increasing presence of renewable forms of energy and international energy trading represent just two of the changes that power supply networks are already coping with. In view of these developments, far-sighted and innovative concepts for power transmission and distribution are more important than ever today.

Electricity highways – high-density power transport over long distances

High-voltage direct-current transmission (HVDC) has already proven a viable

means of transporting electrical power from producers to consumers worldwide, over long distances with minimum loss in numerous projects. Basically, the higher the voltage, the lower the losses. One of our showcase projects in terms of technology and performance is the HVDC "electricity highway" between the provinces of Yunnan in southwestern China and Guangdong in southern China. This long-distance HVDC transmission link will have a capacity of 5,000 megawatts and a transmission voltage of 800 kilovolts, the highest transmission voltage of any such link in the world. When it goes into operation in mid-2010, electricity generated by

An HVDC transmission link will connect the tourist island of Mallorca for the first time ever to the power supply system on the Spanish mainland. Beginning in May 2011, the 250-kilometer (155mile) submarine cable link will supply the island with electricity from the European grid, especially during the hot summer months.



several hydroelectric power plants will be transported over this 1,400-kilometer (870-mile) direct-current link. Hydroelectric power generation is economical, environmentally friendly, and does not emit any carbon dioxide. This HVDC link will help to prevent the emission of over 30 megatons of climate-damaging carbon dioxide a year that would have been produced with conventional, local power generation.

Stable network links

HVDC technology, in the form of the newly developed HVDC PLUS system, also plays an important role in providing a stable and low-loss link to the grid for electricity produced from climate-saving, regenerative energy sources such as offshore wind parks and large solar power plants.

HVDC transmission links in Europe

High-voltage DC transmission technology will also be employed to an increasing extent by European network operators. It is already used to exchange power via submarine cable across the Storebælt strait between the Danish islands of Fünen and Seeland, and between the Netherlands and Britain. The latest project is the link between the Spanish mainland and the Balearic Islands. Beginning in May 2011, a 250-kilometer (155mile) 250-kilovolt HVDC submarine cable, with a power capacity of 400 megawatts, will provide the tourist island of Mallorca with power supply from the Spanish mainland. It is designed especially to cover peak loads during the main vacation season. This will prevent the emission of over 1.2 megatons of carbon dioxide a year that would be emitted if this power were to be generated locally by conventional means.

HVDC PLUS provides a low-loss method of transporting electrical power from offshore wind farms to the coast and a costeffective and environmentally friendly means of supplying energy to oil drilling rigs from the power supply network on the mainland. It is suitable for setting up DC connections in the capacity range up to 1,000 megawatts, where today classic linecommutated converters are still used exclusively.



Efficient power generation, transmission, and distribution



This key power-supply technology also enables oil and gas platforms to be supplied with electricity from onshore supply networks via submarine cable. In this way, thanks to HVDC PLUS, carbon dioxide and nitrogen oxide emissions from small power plants at sea can be obviated.

High voltage close to consumers

Efficient products and systems have great energy-saving potential, particularly for power distribution in major population centers. The aim here is to bring the high-voltage supply as close as possible to the final consumers, making it possible to limit the extent of the lowervoltage distribution networks and thus reduce losses. Special low-noise "whisper" transformers operate so quietly that they can be installed even in densely populated areas. The increasing efficiency of transformers opens the way for further energy savings. Gas-insulated lines (GIL) and switchgears (GIS) provide an environmentally benign means of transporting and distributing energy, and don't take up much space thanks to their highly compact design.

Harmonization of networks

The medium-voltage direct current network coupling system Siplink (Siemens Power Link) provides a flexible and reliable link between different distribution networks. Siplink makes possible a reciprocal exchange of power and also improves voltage quality and reliability without coupling the networks electrically.

Siplink is used for connecting municipal supply networks, such as those of Ulm and Neu-Ulm in Germany, which could never have been connected using older technology. Siplink improves voltage stability in both networks and enables power to be exchanged between the networks.

Ships lying at anchor in ports can be supplied from the harbor supply system via Siplink. Normally the onboard power systems are supplied with power by the ship's engines, which burn heavy oil. Via Siplink, the 60-hertz onboard system can be connected to the 50-hertz harbor network . Supplying an average container ship with electricity from the harbor system obviates the emission of 12.6 metric tons of carbon dioxide a day as well as a considerable amount of soot, fine dust and noise.

Information technology is indispensable for networks

Software plays an ever more important role in the technically and economically efficient operation of power transmission and distribution networks, and in preventing interruptions in supply.

Apart from the classic control technology, other software solutions are available, such as asset management, workforce management, and condition monitoring. These are used to record and manage the operational equipment and its condition in use, and to plan long-, medium-, and short-term equipment



The SmartGrids initiative was set up in 2004 with the appointment of 25 leading international experts from 12 countries in the European Union. Germany provides three experts for this body, one of them from the Siemens Energy Sector. The mission of this initiative is threefold: to make the European networks fit for the challenges and opportunities of the 21st century, to fulfill the expectations of society, and to stimulate the free market.

Gas-insulated high voltage switchgear in Abu Dhabi, United Arab Emirates.

maintenance and renewal. Continuous monitoring of the condition of operational equipment may well enable damage to be identified before a breakdown, and reduce losses due to damaged equipment. Energy management systems such as DEMS (Decentralized Energy Management System) will play a bigger role in the control of energy flows because of the integration of decentralized power generating facilities. Power flows must be controlled so that energy purchasing, energy consumption, and voltage quality are optimized, and network losses are reduced to a minimum.

Outlook for the future

In the future the power transmission and distribution networks will play an even more important role in the energy supply chain. Today's static network operation must become more flexible to meet new requirements, and to enable producers and consumers to communicate. Small power plants with continuous feed capacities must be integrated into the network, as must the fluctuating infeed from renewable energy sources. The SpectrumPower CC network control system already enables several small decentralized power plants to be linked together to create a virtual power plant. Demandside management will be necessary to control network loads, and to set incentives for matching consumption behavior to the energy supply.

The European SmartGrids technology platform also pursues these goals. The European initiative was founded in December 2004, with the aim of devising a vision for the electrical power supply in Europe in the 21st century. It pursues the goal of creating an efficient and more reliable power supply system, including distributed and renewable energy generation. SmartGrids are not restricted to a technical vision for the European network, but also take into account commercial aspects such as increased trading with electrical energy and regulatory issues.

Cooperation on virtual power plants

RWE and Siemens are jointly developing business models and technical concepts for the construction and operational management of virtual power plants. Coordination of the decentralized producers is expected to play a role in reducing carbon dioxide emissions, as well as offering economic advantages. In a two-year pilot project to be completed by mid-2009, decentralized plants such as block heating power plants, biomass plants, and wind power plants will be linked to create a virtual power plant controlled from a central point.

Efficient energy applications

3. Efficient energy applications

What environmentally friendly products and solutions for energy consumption does Siemens offer?

Solutions for industry

Industry causes about 34 percent of global greenhouse gas emissions. It therefore bears a special responsibility for continually improving energy and resource efficiency as well as climate protection. In addition, rising energy and raw material prices and new legal framework conditions make the efficient use of resources an increasingly urgent requirement.

Siemens answers

The technologies developed by Siemens and already used in a large number of projects show that environmental protection and profitability are not mutually exclusive in industrial solutions but are increasingly conditional on each other.

Efficient power distribution in industrial and functional buildings

With Totally Integrated Power (TIP), Siemens provides end-to-end solutions for the distribution of electrical power in buildings, from the medium voltage level down to the ultimate comsumers. That begins with compatible products and systems and harnesses all energy savings potential in the planning, construction and operating phase by linking the power distribution systems to the industrial automation and building automation systems. As early as the design planning phase, the planning software from the Simaris family analyzes project data as the basis for calculating an appropriate scale and the most cost-effective solutions.

The Power Management System from Siemens optimizes the use of energy and in this way can reduce energy costs by up to 20 percent. This integrated system makes energy consumption transparent and ensures a reliable distribution of power. The Power Management software displays the energy figures measured by a multifunctional device online and evaluates them. A procedure for assigning costs on a causation basis and automatic load management are coupled to this. The software also calculates cyclical trends, issues a warning before the limit is reached, and disconnects loads if necessary in accordance with the specifications. Savings potential can be identified easily on the basis of the calculated consumption profile, and compliance with the contractually agreed power limit can be monitored. The data analyses give customers leverage in purchasing negotiations with energy suppliers to help them attain an optimum power supply in line with their needs and to further reduce the costs. The associated improvements in efficiency reduce CO₂ emissions by about 10 percent - the equivalent of saving 400 to 600 million metric tons of CO₂ annually on a global scale.



Efficient energy applications





- Totally Integrated Automation (TIA) and Totally Integrated Power (TIP) are the key to efficient energy management. The Siemens Industry Automation Division is putting its mark on the automation and power distribution market with its platform strategy. Productivity potential can no longer be increased by optimizing stand-alone solutions, but first and foremost by the seamless horizontal and vertical integration of information, communications and automation technologies in operating processes.
- "Green solutions" from the Siemens Industry Solutions Division optimize not only the environmental balance but also the entire process in industrial projects. This approach opens up new potential for the reduction or avoidance of greenhouse gases, for the avoidance of residues or waste and for the more efficient use of residual heat in industrial production.
- Companies can develop and test their products and their production process virtually with software from Siemens. Possible production or functional faults can be remedied on the computer, before the first component in the real world is manufactured.

Siemens helps reduce electricity comsumption in industrial plants

Drive technology has enormous potential for energy saving. Worldwide, 20 million industrial motors consume 65 percent of industrial electricity. Energy optimization could in this case result in a reduction of 360 million metric tons of CO_2 annually. This is almost equivalent to the CO_2 emissions of Australia.

In order to fulfill its obligations under the Kyoto Agreement, the European Union has adopted directives for electrical drive technology aimed at bringing about a saving of 39 million metric tons of CO_2 by 2010 (compared with 1990).

In the European Union alone about 7 million euros in unnecessary electricity costs are incurred every day because systems are not equipped with speed-variable drive systems and are in some cases oversized. Some 1.3 millions euros a day could be saved and 3 million metric tons of CO₂ could be avoided annually through the systematic use of energy-saving motors. Another 15 million metric tons of CO₂ could be saved annually by retrofitting frequency converters. In sum, this is equivalent to the emissions from 19 fossil fuel-fired power plant blocks or 4.5 million mid-sized cars, each driving 20,000 kilometer per year.

The Siemens Drive Technologies Division has developed the Internet-based software SinaSave, which computes energy savings potential free of charge and indicates how long it takes for an investment to pay off. The program is suitable for the planning of new plants as well as for plant modernization. SinaSave is designed for the operation of fixed-speed motors as well as variable-speed motors when used with frequency converters. To make its analysis the program not only records the individual drive in each case, but also the complete drive train.

Energy-saving motors from Siemens fit into virtually every drive concept and are characterized by a 40 percent lower power loss compared with standard motors. The new NEMA motors from Siemens achieve maximum efficiencies thanks to the copper diecast rotor, which reduces the power loss and has a low overall length. As such the motors even exceed the American NEMA premium standards. By contrast with conventional techniques such as choke controls, electric drives used together with frequency converters from Siemens can be operated exactly according to demand. This counts particularly when operating fans, pumps or compressors, with savings of up to 60 percent – and in exceptional cases even as much as 70 percent. Thanks to the

large savings in electricity, energy-saving motors and frequency converters usually pay back the investment after a year.

The savings effect can be increased even more by capturing the energy released when a variable-speed drive is braked and by feeding it back into the electricity supply network. The technology for converting kinetic into electric energy, which is familiar from railway technology, can also be applied in manufacturing technology and in the process industry, for example in cranes, centrifuges and pump systems, and also for ship propulsion units. Depending on the application, 3 to 10 percent of the energy used can also be saved here.

Loss-free with superconductor wires – ceramic replaces copper in electric motors

At a temperature of about minus 200 degrees Celsius (80 Kelvin) superconductors manufactured from ceramic materials and cooled with nitrogen conduct electricity without resistance. They do not require much space because wires made of superconductors with a conductor cross-section of a square millimeter can conduct currents of over 100 amps compared with 2 amps for copper cables. Siemens is playing a crucial role in the

The coolest way to generate electric power: In 2005 Siemens put the first generator with a hightemperature superconductor into operation.



further development of this energysaving technology and uses wires made of superconducting material for the windings of electric machines, among other applications. This improves the efficiency of motors and generators.

Industry examples

The following examples show how the theoretical savings potential can also be harnessed by industrial companies in practice. In addition, waste heat recovery has an important part to play to foster energy efficiency. Approximately onethird of the energy used in industry is heat. Industrial waste heat is generated in many processes and often discharged into the atmosphere. Whenever surplus process heat can no longer be used in downstream process steps, producers should consider transforming it into electrical power.

Environment-friendly Corex process for iron production

The traditional method of producing steel from iron ore in a blast furnace is a

High-temperature superconductor (HTS) technology is being used initially in electric propulsion systems for ships. Siemens has already developed a 4-megawatt HTS generator for onboard power generation that is being prepared for a permanent test following successful trials. An HTS propeller motor is curently under development as part of an all-electric propulsion system which is designed to replace the conventional diesel drive unit. High-temperature superconductors can carry a current density up to 100 times higher than copper conductors and have lower electrical losses, which enables more compact and efficient machines to be constructed. For the same power, the weight can thus be reduced by as much as 50 percent and efficiency increased by up to 1.5 percentage points. Consequently, primary energy can be saved and CO₂ emissions avoided.



The Corex production process makes the manufacture of iron in a steelworks in South Africa considerably more environmentally friendly.

highly energy-intensive process. In this process, the coke is first mixed with a charge consisting of pellets, sinter or lump ore and then fed into the blast furnace and burned at a temperature of about 2,000 degrees Celcius, producing carbon monoxide. As the carbon monoxide passes up to the top of the furnace it removes the oxygen from the iron oxide in the iron ore. Because of the high temperatures prevailing in the furnace the reduced iron ore melts into liquid pig iron. A big disadvantage of this classic blast furnace process, however, is the need to use expensive coke, since the operation of a coking plant requires large investments and causes severe pollution of the environment as well as high energy costs.

Unlike the conventional process with blast furnaces, the Corex technology from Siemens only needs ordinary hard coal for producing pig iron. This means that there is no need for a coking plant or for a sintering plant in which the iron ore is processed before smelting. Corex uses lump ore in the form in which it comes directly from the mine or pellets. The Corex technology is a two-stage smelting reduction process. Coal gasification, iron ore reduction and the liquefaction of the resulting iron are combined in one process. The gases produced, which have a calorific value of around 7,500 kJ/ m³, can also be used after cleaning for heating, for generating electricity in a combined cycle power plant, or for producing direct reduced iron.

The Corex technology reduces CO_2 emissions by up to 30 percent and sulfur dioxide emissions by 97 percent compared with conventional processes. On top of that, the wastewater produced contains considerably less ammonia, phenols and sulfides than in the case of conventional blast furnaces.

China is increasingly becoming a testing ground for advanced iron and steel technologies. The world's largest Corex plant, in Shanghai, with an annual production of 1.5 million metric tons of pig iron, went into operation in November 2007. In January 2008, Siemens was awarded another order for a Corex plant by Baosteel in China.

Higher energy and material efficiency in copper mining

The Siemens Industry Solutions Division has developed an innovative solution that saves valuable energy and resources in the mining sector as part of a pilot project implemented jointly with the Los Pelambres copper mine in Chile. The system, which went into operation in 2007, is a flotation cell for separating molvbdenum into its metallic and rock components. The new development has some outstanding features that distinguish it from conventional systems of this kind. It has exceptional floatability of microparticles, up to four times higher concentration, lower gas requirement and low energy consumption. The innovation lies in the combination of a so-called pneumatic spray-in principle with a column method. Nitrogen is added to the ore slurry before it is fed into the cell in order to improve

the frequency of contact between the gas bubbles and very fine molybdenum particles as well as the ability of the particles to stick to these bubbles. The resulting mixture is then sprayed into the flotation cell. As a result the plant can be operated with only three pumps in all and without an agitator. The new flotation cell therefore needs up to 70 percent less energy compared to conventional solutions. About 60 to 100 cubic meters of nitrogen an hour are needed to operate the cell. This is also considerably below the hourly consumption rate of 1,000 to 1,400 cubic meters associated with conventional systems.

Energy efficiency and climate protection as a service package

The improvement in the energy efficiency of production plants is also a question of optimum consulting. For this reason Siemens also offers a tailored program of services under the name "Energy Optimization Services" (EOS) to help companies make efficient use of electricity and other energy sources. EOS usually starts with an evaluation of the energy efficiency of operational processes. Then a sector-specific benchmarking process is carried out to highlight any potential for improvements. In order to identify initial energy efficiency measures, experts from the Industry Solutions Division of Siemens inspect the plant and hold discussions with relevant employees. At this point it is already possible to estimate the costs for implementation and to ascertain the expected payback period. In the following phase the defined measures are appraised with respect to their technical and economic feasibility. After obtaining quotations for implementing

the project and making a detailed calculation of the return on investment and the savings potential, the experts draw up a concept for implementing the measures. This is followed by the implementation and controlling phase. The latest EOS project from Siemens is the energy management system for a paper factory belonging to Mondi Packaging in northern England. After only the first two phases of the intelligent optimization program the Siemens experts estimated that a saving of about a guarter of the annual energy costs combined with a substantial reduction in greenhouse gas emissions would be feasible.

Mobility and transportation

Demand for mobility is set to grow strongly over the next two decades. This development is being driven by two megatrends – urbanization and demographic change. At the same time, climate change has brought about stricter requirements for the environmental compatibility of transit. Mobility nowadays is a key factor of the competitiveness of cities.

It's clear what needs to be done. Traffic on roads, by rail, and in the air must be controlled intelligently and networked, so that the existing infrastructure is used more efficiently and with less impact on climate. The transportation sector is already responsible for 25 to 30 percent of final energy consumption.

Velaro: the world's fastest series-produced multiple-unit train is particularly environmentally friendly.

Consequent lightweight construction: the Oslo Metro.

Ruhrpilot: control technology and telematics enable an optimized use of rail and road traffic.



Siemens answers

With its "complete mobility" approach, Siemens creates efficient mobility solutions aimed at the rational interlinking of different transportation systems to provide an economical, safe, and environmentally sound means of transporting people and freight.

High-speed passenger trains and highperformance locomotives for freight transport are two examples of efficient and carbon-sparing mobility between urban population centers. The Velaro high-speed train, the fastest series-produced multipleunit train in the world, for instance, consumes the equivalent of only two liters of gasoline per person per 100 kilometers (62 miles), operating at 50 percent passenger capacity. On the German line between Cologne and Frankfurt am Main, the train travels at a speed of 300 kilometers per hour, emitting up to 75 percent less carbon dioxide than an airplane. On the Madrid-Barcelona line, where the Velaro has been operating since February 2008, the train offers an attractive alternative to flying, taking 2 hours 38 minutes to cover the 630-kilometer (390-mile) route.

A Siemens multisystem locomotive of the type Eurosprinter, which can be deployed on the various railway systems in Europe, is capable of hauling a 700-ton train over grade ratios of up to 2.5 percent. This means that on the Alpine transit route from Austria to Italy, the Eurosprinter can match the transport capacity of 28 trucks. Comparison of the carbon dioxide emissions of these two forms of transport highlights the advantage of the railway in this case. Whereas the train releases about 3,400 kilograms of carbon dioxide on the 270-kilometer (167-mile) route from Innsbruck in Austria to Verona in northern Italy, the trucks on this route would pollute the environment with 9,260 kilograms of carbon dioxide, not to mention the higher fine dust emissions.

For mobility within highly populous regions, Siemens offers exceptionally efficient vehicles and automation solutions for rail transportation, as well as intelligent management systems for road transport and logistics.

Thanks to the lightweight construction techniques used throughout, metro vehicles from Siemens such as those in service on the Oslo Metro are particularly environment-friendly. They use 30 percent less energy than the vehicles used previously. Due to the Norwegian energy mix, with its high share of hydropower, the Oslo Metro causes emissions of only two grams of carbon dioxide per kilometer and ton of vehicle weight, and thus make an important contribution to climate protection. Also, thanks to the vehicles' lightweight design, the track system is subject to less stress, which considerably reduces total life cycle costs.

Siemens also supplies energy feed systems, allowing the braking energy of a train either to be fed into a trackside stationary energy storage unit or, via a power inverter, directly into the power supply system, where it can be used by a second vehicle for acceleration. Siemens also offers mobile energy storage units that store energy produced during braking and release it again during subsequent acceleration or to bridge sections with no catenary. A saving of drive energy of up to 25 percent is possible by using these three energy-saving systems. If all local transport networks in the world were equipped with a combination of these systems, carbon dioxide emissions could be cut by 11.6 million metric tons globally.

Further reductions in energy consumption could be made by using an integrated planning and simulation process when drawing up the timetable. Fewer trains would be needed if the sequence of trains were optimized, but that would not be the only benefit. The electrical energy fed back into the power supply during braking could be used more effectively by designing the timetables so that the energy of braking trains could be picked up again by



By 2030 the number of cars in the world will have risen from 700 million in 2000 to 1.3 billion. Freight transport measured in metric tons per kilometer will increase from 15 billion in 2000 to 30 billion in 2030. Today the impact of the steady increase in demand for mobility within and between centers of population is already immense. By 2010 the incidence of traffic jams in Western Europe will rise by 188 percent. The cost to the economy of road traffic congestion in Europe is estimated at 100 billion euros. and in the U.S. at 78 billion dollars annually.





trains starting at the same time. Additional energy savings could be made by spreading the travel time reserves in the timetable over the individual line sections. In this way the maximum speed on these sections could be reduced. In tests on the Vienna U-Bahn rapid transit system, energy savings of up to 5 percent were verified.

In addition, Siemens is currently running practical trials with the Syntegra motor bogie, a totally new gearless drive for rail vehicles in which the wheelsets are directly driven by permanent magnet motors. Compared with conventional motor bogies it is up to 30 percent lighter, has a higher drive efficiency, and energy consumption can be reduced by up to 20 percent.

However, rail vehicles are not the only candidates for boosting energy efficiency. There is also potential in road transport, for example, by using LED technology for traffic lights. An average system at an intersection with 30 signal lights fitted with conventional incandescent bulbs has a power consumption of around 2 kilowatts. With about 100,000 intersections in Germany this adds up to 196 megawatts, equivalent to the capacity of a small power plant. If all systems were fitted with 40-volt LEDs from Siemens they would only need 16 megawatts of power, less than a tenth of current consumption.

Emissions can also be reduced by avoiding superfluous transport processes, as the following example from the postal sector demonstrates. Some 17 percent of Americans move to a new home within the U.S. each year, so some 6 billion pieces of mail used to go to the wrong address each year. The automatic forwarding system built by Siemens during 2002 and 2007 for the United States Postal Service helps reduce the volume of mail misdirected to addresses that are no longer correct. The Siemens solution thus prevents unnecessary transportation processes, thereby saving effort, expense, and energy. Modern convevor and sorting systems are also controlled in such a way that they only operate when goods need to be moved. Energy-wasting continuous operation is no longer necessary.

Outlook

In view of the growing volume of traffic, our target in the years ahead will be to assure and further improve mobility in cities and population centers. It is imperative to keep traffic on the roads flowing and to systematically avoid traffic jams. At the same time, rail services must be made so attractive that as many people as possible choose this exceptionally environment-friendly means of transportation. In addition, information about the prevailing traffic situation plays a key role in optimizing mobility. Information systems with up-to-date data about the current and expected traffic situation on each individually planned travel route will enable passengers to select the optimum transportation according to the situation. An actual example that points the way forward is the Ruhrpilot, a traffic management system installed by Siemens in the Ruhr area of Germany in 2006, which is the largest system of its kind in Europe.

In the Ruhrpilot system, control technology and telematics in Europe's largest conurbation ensure that the existing local and regional road and rail traffic networks are used as effectively as possible. The Ruhrpilot relieves pressure on the transportation infrastructure by providing up-to-date information on the capacity utilization of roads, multilevel parking lots, expressways, buses, and railways in a region with 600 kilometers (370 miles) of expressways, 53 towns and cities, over 6 million commuters, 70 stations, and 1,200 trains per day. The system transmits information via Internet or mobile phone so road and rail users can optimize their travel route. Traffic congestion is minimized, unnecessary energy consumption is avoided, and carbon dioxide emissions are reduced. Simulations show the benefits that traffic management systems bring for our environment and resources. Savings of as much as 20 percent are possible both in carbon dioxide emissions and fuel consumption simply by helping traffic flow more evenly.



An integral component of the complete mobility approach by Siemens is environmentally friendly mobility. "Complete mobility" is Siemens' answer to the question of which mobility solutions reduce greenhouse gases and save resources.

"Complete mobility" combines all environmentally protective aspects of products and solutions for all carriers and the intermodal traffic. "Complete mobility" begins with vehicle design and analysis of the vehicle life cycle, includes systems for energy savings and recovery, and extends to timetable optimization and the perfect coordination of all means of transportation.

A London example shows how "complete mobility" and environmental compatibility can be networked intelligently in megacities and surrounding areas.

In 2001, Siemens was awarded the order to deliver 1,200 regional train cars of type Desiro UK to build up an effective regional transportation system. Another measure to prevent gridlock in London was the introduction of a city toll, the so-called congestion charge for road traffic. The technology for automatic number plate recognition by more than 870 cameras was also delivered by Siemens. Without efficient shuttle trains, though, and the comfortable and rapid connections into the city that they provide, it would not have been possible to reduce traffic congestion in the London inner city successfully by means of the congestion charge alone.

London is resolved to further intensify measures to improve its air quality in the years ahead. At the beginning of 2008, a "low-emission zone" (LEZ) was introduced in the Greater London area. Only buses and trucks fulfilling the Euro III or Euro IV standard for fine dust emissions are allowed to enter the LEZ without paying a fee. The London company Transport for London (TfL) awarded Siemens the order for the installation and operation of the monitoring system. This system uses more than 320 digital cameras networked with a database for automatic number plate recognition.

Due to these measures, the British capital now has 30 percent fewer traffic jams and prevents an estimated 150,000 metric tons of carbon dioxide emissions per year.

In addition, the first electrical hybrid bus from the Drive Technologies Division of Siemens, with the traditional red double-decker design, has been operating in London since 2007. Transport for London uses the Wright bus on the 141 route to London Bridge. According to TfL it produces up to 38 percent less emissions, and uses about 40 percent less fuel, than its conventional diesel counterparts. What makes this possible is the hybrid drive, a combination of diesel electric drive and a storage battery. The Siemens hybrid drive from the ELFA series consists of a generator, inverters, drive motors, and an intelligent drive control system that includes energy management. Two motors accelerate the bus smoothly with no jolts due to gear changing, and act as generators when braking to feed the energy produced into lithium-ion batteries. Instead of being lost as heat, the energy is available to supply the electric motors that boost the diesel engine during the next acceleration phase. This also allows the hybrid bus to leave the bus stop extremely quietly, under allelectric drive with the diesel engine switched off. The innovative energy management system controls the energy flow between the battery and the diesel engine and helps ensure that the double-decker hybrid bus produces about three metric tons less carbon dioxide each year. Transport for London has already ordered more of these doubledecker hybrid buses as well as hydrogen and fuel cell buses with the ELFA hybrid drive system.







On an environmental course with the Green Ship

Today, about 95 percent of all goods and raw materials transported globally are carried by ship. Costs and competitive pressure are stimulating environmentally sound developments in shipbuilding. The "Green Ship" concept from Siemens packages different solutions into an integrated overall approach that enables emissions as well as costs to be reduced through efficient energy management. The greatest savings effects, both financially and ecologically, come from fuel that does not ever need to be burned, which can add up over the 30-year useful life of a ship.

A core element of the concept is the hybrid drive, a combination of mechanical and electrical drive systems. Depending on the load profile and load situation, the entire drive power installed in the ship can be optimally divided between the main drive and the onboard electrical system. Compared with conventional main drives, power savings of 15 to 35 percent are possible.

The energy extracted from thermal primary energy converters (such as diesel engines) can also be fed into the onboard power supply with the Waste Heat Recovery System (WHRS). This saves the need to run onboard generating sets. Energy costs can be easily reduced 10 percent by means of WHRS. Investment in the WHRS can thus be paid back within three to four years depending on fuel costs.

Energy that is not needed temporarily in the onboard power supply system can be transmitted to the propeller shaft by using an electric booster motor in addition to the main engine power. This results in a substantial improvement in power output for the same energy input.

Building technologies

About 40 percent of the world's energy is consumed by buildings. Worldwide, buildings also account for 21 percent of greenhouse gas emissions. Building owners now face growing pressure globally to reduce energy consumption and minimize the impact of such consumption on the environment.

The biggest energy consumers in a building are technical installations and lighting fixtures, which account for 40 to 60 percent of total energy costs. This need not be the case. A refurbished building can reduce energy consumption by over 40 percent through optimizing the performance of its heating, ventilation, and air-conditioning (HVAC) equipment. Furthermore the investment needed for these measures can be paid for from the savings in energy and operating costs.

Siemens answers

The Building Technologies Division of Siemens is a leader in energy efficiency expertise for buildings, offering comprehensive solutions and innovative technologies to reduce the energy costs of buildings while maintaining maximum comfort. These solutions increase the reliability and operational performance of buildings and have a positive effect on the environment. Together with customers, Siemens develops cost-saving solutions for energy purchasing, energy efficiency, and energy management over the entire life span of buildings. Siemens also supports its customers in reducing greenhouse gases and developing strategies for the efficient use of energy resources.

To date, Siemens has optimzed 6,500 buildings worldwide, which has reduced 2.4 million tons of CO_2 emissions and saved more than 1 billion euros.

Energy savings thanks to intelligent building automation

Intelligent and integrated building and room automation can produce considerable energy savings. The European Norm EN 15232 ("Energy performance of buildings – Impact of building automation") has created standards of building automation effectiveness that fall into four energy-efficiency classes, from A to D. In the high energy-efficiency class A, for example, energy savings in office spaces can reach 30 percent in relation to the standard.

Energy-saving contracting

In 2006, UniCredit Bank began working with Siemens to refurbish its headquarters in Milan as part of an energy savings contracting plan.

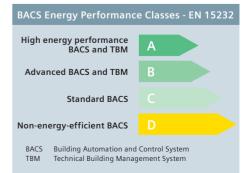
An analysis of the existing systems revealed where a particularly large amount of power was being consumed and which equipment was not being used to full capacity. Improvement measures were then defined.

Among the measures, refurbishment of the air-conditioning and ventilation systems greatly improved the air quality, which significantly raised the level of comfort in the complex as a whole. Through the energy savings plan UniCredit has not only been able to reduce consumption, but also cut CO₂ emissions released into the atmosphere. One year after commissioning, the headquarters' CO₂ emissions were down by 2,400 tons. In light of these results, the European Commission awarded UniCredit Bank the GreenBuilding Partner status.

The Siemens Building Technologies Division has been awarded the GreenBuilding Award 2008 for its outstanding encouragement of the initiative.



Siemens' Building Automation and Control Systems deliver important prerequisites that ensure compliance with energy-efficiency Class A. They are flexible and energy efficient; integrating systems that cover all relevant building services, including lighting, window blinds, safety and security, access control and electrical power distribution, for example. The ability of Siemens' systems to continuously record and evaluate energy consumption also makes it possible for building owners to realize potential savings and evaluate the success of their optimization measures. This can then be coupled with a full service package and customer training to ensure sustained optimization of the building.



Consumption Monitoring as part of Siemens' e-home service

In combination with new communication technologies and new electronic meters, it is now possible to record real-time consumption data from household appliances using electronic meter systems and then provide these data as part of the e-home services or Web services. The power consumption is totaled for each household so the user can easily figure out how the overall power consumption changes if a household appliance like a washing machine or a dishwasher is switched on or off. This increases the awareness of the users. The power consumption of any single household appliance can be measured and displayed separately if the house is equipped with a special electricity network and a device is placed between the electricity grid and the appliance.

High-quality room controls ensure energy savings

Room controls from Siemens that bear the eu.bac certification label stand for tested quality, control accuracy and energy efficiency in compliance with the relevant European norms and international test standards. Our high level of control accuracy optimizes the room climate and does away with unnecessary readjustments of the room temperature set point. Energy savings are the result – a set point reduction of only 1°C generates energy savings of up to 6 percent. Eu.bac certified controllers even ensure energy savings of up to 14 percent compared to noncertified controllers, depending on the local climate. DESIGO RX was the first of many high-quality Siemens individual room controllers to earn the eu.bac certification.

Energy-Saving Performance Contracting – putting energy savings back into your facilities

Energy-saving performance contracting is an economical method for funding building automation to modernize HVAC and power supply plants, water supplies, and lighting. Siemens' customers use energy savings to optimize the performance of their buildings. We work with building owners to design and implement customized performance-based solutions that allow facility, capital and technology improvements to be made within existing budgets. These improvements reduce operating costs while providing the value of new energyefficient equipment.

Through performance contracting, investments can be financed by Siemens and paid back by the guaranteed energy savings. In essence, the energy and operational cost savings pay for the customer's investment. The Siemens guarantee ensures that facility improvements made today will decrease costs, increase comfort and productivity, and improve quality – all while minimizing the impact to the environment.

Energy and Operational Services – helping your building work for you

The Building Technologies Division of Siemens offers services enabling building owners and managers to secure the full energy-saving potential of their buildings. Siemens' building optimization program allows customers to achieve energy savings and reduction of other operational costs without compromising on comfort.

First the savings potential is assessed, based on the building's current energy consumption and event history. Using the outcome of this Building Performance assessment, an initial optimization recommendation is made and a customer-specific optimization plan developed. After implementation, continous monitoring and optimization by our remote center – the Siemens Advantage Operational Center – helps customers achieve ongoing savings. New optimization measures are presented during periodic customer meetings.



Sustaining success! Siemens wins the European Energy Service Award for the second consecutive year

In 2007, Siemens once again won an European Energy Service Award, this time for the best energy-efficiency project. The project honored was an energy performance contract carried out at Brigittenau Swimming Pool in Austria.

Many swimming pools built over 30 years ago incur increasing maintenance costs, jeopardizing their operational viability. The Brigittenau Swimming Pool is the first project which not only tackled and improved heating and electricity for swimming pools, but also addressed energy-efficiency measures for saving water, with very high results. Energy savings have been guaranteed throughout the entire 10-year contract period, including a 200,000-euro reduction in consumption costs and a 600-ton reduction in CO₂ emissions per year. This Siemens solution has become the benchmark, not only in Austria, where over 10 similar projects have been completed, but throughout Europe.

In 2006, Siemens won the European Energy Service Award for being the best solution provider for its activities in developing energy-efficiency solutions in Europe.

Lighting

About 19 percent of global electricity consumption is currently used for producing artificial light. More than 33 percent of that electricity could be saved through the use of energyefficient lamps. That corresponds to more than 900 billion kilowatt-hours, or half of China's annual electricity consumption. If this were to happen, the 1.3 billion metric tons per year of carbon dioxide currently emitted to produce light would be reduced by 450 million tons!

Siemens answers

The energy-saving lightbulbs produced by Siemens subsidiary Osram are fluorescent bulbs with a compact design and a high light yield. Their two main advantages over incandescent lightbulbs is that they use 80 percent less electricity, and their service life is up to 15 times longer. A comparison of the costs of electricity for the lightbulbs shows that by using, for example, a Dulux EL Longlife 20-watt bulb, which is comparable in brightness to a 100-watt incandescent lightbulb, you can save around 210 euros in the course of the bulb's average service life of about 15,000 hours. Some 1,200 kilowatt-hours of electricity and half a metric ton of carbon dioxide are saved during the service life of a Dulux EL Longlife 20-watt lightbulb. That is why the incandescent lamps that are used most often should be replaced by energyefficient lamps first.

The most innovative and climatecompatible halogen lamps available are

Light-emitting diodes (LEDs) last many times longer than conventional incandescent lightbulbs, and also use much less power. They are increasingly used in the signal lamps on cars, and can also replace incandescent bulbs to light the edges of airport runways.



In terms of size and shape, the Dulux EL Classic A energy-saving bulb from Osram is nearly identical to the classic lightbulb. Offering energy savings of up to 80 percent, it not only lightens the impact on your wallet but on the environment as well.

Osram's Halogen Energy Savers, which not only offer a high quality of light but also use up to 30 percent less energy than conventional incandescent lightbulbs.

Another source of light with low energy consumption, and an extremely long service life of more than 50,000 hours, is the light-emitting diode, or LED. These lights are based on compound semiconductors that convert electricity directly into light. LEDs consume up to 80 percent less energy than fluorescent lamps. They are also much more robust and shock-resistant.

A good example of a lamp with a long service life is Planon, the mercury-free flat lamp from Osram. It functions in a similar way to a fluorescent lamp but is filled with the inert gas xenon, and is operated using an electronic ballast. Wear on the electrodes is prevented by an insulation layer. With a service life of 100,000 hours, Planon lasts more than six times longer than a conventional fluorescent lamp.

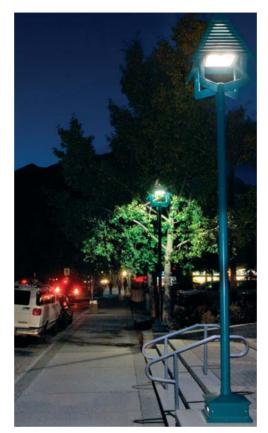
Street lighting

The town of Banff in the heart of the Banff National Park in the Canadian Rocky Mountains is setting a good example. In cooperation with Osram, Banff is gradually converting its street lighting to LEDs. It began by exchanging the lighting in the City Hall square, and the remaining street lamps will be converted to LEDs progressively. There is no need to buy new lamp standards because, with the retrofit systems used, only the lamp and electronic ballast are exchanged. Moreover, the long service life of up to 50,000 hours (compared with a life of 15,000 hours for the lamps used at present) also cuts maintenance costs substantially and reduces electricity consumption and carbon dioxide emissions. Thanks to their specially designed lenses, the LEDs only

illuminate the street, not the surrounding natural environment or the night sky. This was one of the key objectives for the Osram engineers, apart from the energy saving aspect. And the tourists and residents of Banff benefit from yet another advantage. The LEDs do not attract mosquitoes, thereby making the old situation of street lights surrounded by swarms of mosquitoes a thing of the past.

Recycling of used lamps

The aim of Osram's recycling concept is to close the material flows in order to have no leftover waste requiring disposal. Because the energy originally consumed in mining and producing the materials does not have to be expended again, recycling materials such as glass, metal, mercury, and fluorescent substances represents a considerable energy savings.



Efficiency potential in street lighting

The German Electrical and Electronic Manufacturers' Association (ZVEI) estimates that nearly half of the street lighting in Germany is at the technical level of the 1960s. In Europe generally, over 30 percent of street lighting is of this vintage. That means that 3.5 million tons of carbon dioxide is needlessly emitted each year from European street lighting. According to the ZVEI, though, cities and municipalities in Germany renew only 3 percent of their street lighting each year. If this rate is not increased, it will take another 30 years before the obsolescent lights are replaced missing a considerable potential reduction in carbon dioxide emissions.

Home appliances

Reducing carbon dioxide emissions requires consumers to believe that they must adjust their behavior. Siemens-Electrogeräte GmbH employs several initiatives to help energy efficiency become a reality, and achieve the Kyoto Protocol targets for reducing greenhouse gases in Europe and around the world.

Siemens answers

Siemens home appliances work economically, using a minimum of electricity and water so they can spare the environment and significantly reduce operating costs. In particular, refrigerators and freezers of energy-efficiency classes A+ and A++ not only perform very well, but actively contribute to environmental protection. That's why these highly efficient appliances from Siemens are marked with the "eco Plus" logo.



Appliances that conserve resources

One effective contribution toward climate protection that can be implemented quickly is replacing outdated devices with energy-saving models. If the approximately 188 million appliances in Europe that are over ten years old were replaced by new, efficient devices, 44 billion kilowatt-hours of electricity would be saved - an amount equivalent to the annual demand of about 10 million homes. Siemens has long followed the principle that water and energy are valuable resources that must be used conscientiously. Ninety percent of the environmental impact of an appliance occurs during use, which is why our most important contribution toward protecting the

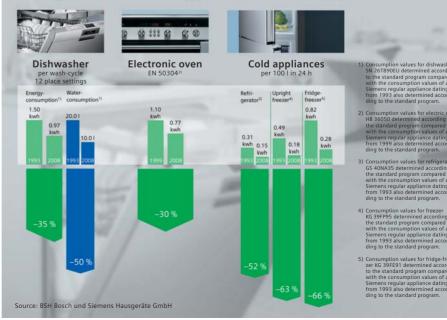
environment is to develop products that conserve resources when used. A comparison of consumption between the appliances of 1993 and those of 2008 shows that today's dishwashers, for example, use about 35 percent less electricity and only half as much water. The energy use of washing machines – like that of stoves – has been reduced by one-third, and water consumption has also been sharply curtailed. While a washing machine 15 years ago used 13 liters of water per kilogram of laundry, modern machines require only 7 liters today for the same amount of clothes. The energy balance is even more impressive for refrigerators – in this case the savings are up to 66 percent.

Siemens refrigerators, equipped with innovative, low-consumption compressors, today use one-fifth the amount of electricity of the 1993 models. But using such energy-saving devices certainly doesn't mean that consumers have to forgo performance. On the contrary, the more the technology advances, the more functionality and efficiency go hand in hand. Siemens refrigerators are already setting new standards in energy efficiency. A prime example of superb costeffectiveness is the GS 40NA35 freezer, which even surpasses A++ specifications and is as functional as any high-quality freezer.

To lessen the impact on both the climate and household budgets in the future, Siemens developers are steadily working on lowering consumption even further. The company and other home appliance manufacturers have also voluntarily undertaken to contribute, through energy conservation in dishwashers alone, toward a 3-million-ton reduction in carbon dioxide emissions across Europe by 2010.



Saving Potentials of Energy and Water Consumption





Healthcare

More than 75 percent of the entire primary energy requirement of medical equipment is caused by the use of the products. If used devices are refurbished with the latest technology and new products are getting more efficient, the environmental impact can be reduced.

Siemens answers

By providing state-of-the-art medical technology systems, Siemens is able to improve climate and resource conservation in this sector. In order to accomplish this, the Healthcare Sector of Siemens considers the environmental impact of its products during all phases of the product life cycle as well as during raw materials production, use, and disposal. More than three-quarters of the environmental impact of medical equipment results from energy consumption during its use – a fact that is taken into account during product specification and development. When you save energy, you not only protect the environment, you save money, too.

Environmentally compatible from the outset

The entire product life span, from material supply via production and use to its proper disposal, must be environmentally sensitive, to minimize a product's impact on the environment. Introduction of internal quality guidelines for product-related environmental protection enables environmental issues to be taken into account already during the product development process. This early integration results in cost savings over the product's entire life.

Eco-Profile for complex products – knowing your materials

The Eco-Profile helps Siemens improve energy efficiency and thus environmental performance. To prepare the profile, a life cycle analysis is needed. The Healthcare Sector of Siemens has worked with Siemens Corporate Technology to develop a method that shows which phase of a product's life generates the highest carbon dioxide emissions, and for which phase an investment in ecological improvements is most beneficial.

The materials used in a product are the basis for every product life cycle analysis. For efficient implementation, Siemens records the materials of the product, divided into groups such as steel, plastic, and hazardous materials such as lead and mercury.

Efficient energy applications



SOMATOM Definition

- Energy savings up to 30%¹⁾
- Reduction of lead roughly 83%¹⁾
- Material recycling rate up to 97% (by weight)



MAGNETOM ESSENZA

- Low installation costs
- Low energy consumption
- Low operating costs that could reduce your energy bill by up to 50%²⁾
- Zero helium boil-off during normal operation



"Refurbished Systems"

- Savings of 10,400 tons of carbon dioxide per year³⁾
- Energy savings equivalent to 3,000 three-person households per year³⁾

- 2) compared to an existing MR system
- 3) for systems refurbished in fiscal year 2005/06 compared to production of new systems

An environmental declaration for every system

More and more, Siemens customers are paying attention to energy consumption and the environmental impact of medical products. That's why Siemens is using the Eco-Profile and each product's environmental performance as a sales argument, in the form of an Environmental Product Declaration. This document helps to show that better environmental performance leads to improved cost-effectiveness.

More output with less input

The Eco-Profiles clearly show that the use of electricity during the use of the product accounts for more than 75 percent of the product's entire primary energy requirement. Therefore, when developing new products Siemens focuses on reducing energy consumption.

The Somatom Definition computed tomography system (CT scanner) uses 30 percent less energy for a standard scan than does the previous model. The radiation dose was reduced by the same amount as well. Image quality was also improved at the same time, proving that better performance doesn't always mean higher energy consumption.

The new MAGNETOM ESSENZA magnetic resonance (MR) tomography scanner also delivers energy savings for customers. The system is outstanding, with its low installation costs and low demand for power and cooling. This system uses up to 50 percent less electricity than conventional MR systems do. Used devices are refurbished with the latest technology based on our Proven Excellence quality process, and are then marketed worldwide. This provides our customers with the latest technology, at a fair price, tailored to their needs. The Proven Excellence Process also benefits the environment by extending the overall product life cycle and thereby saving resources in material provisioning and production. Thanks to its work, the Refurbished Systems business unit saves energy equivalent to the electricity consumption of 3,000 three-person households. This results in a cut of emissions by more than 10,000 tons of CO₂ each year.

¹⁾ compared to previous model

Environmental technology

4. Environmental technology



How can the world's water resources be used sustainably?

Environmental technology for ensuring water purity

Climate change will have a farreaching impact on the availability of water in many regions. According to current UN studies, water consumption will increase by 40 percent by the year 2025. Forecasts by UNESCO predict, in addition, that nearly 40 percent of the world's population will suffer from severe water shortages by 2025 (1990: only about 6 percent). All this presents new challenges for efficient handling of the water resource.

Siemens answers

Siemens has solutions for the treatment of process water and industrial effluents, for municipal sewage treatment, and for the purification of drinking water. Membrane technology from Siemens, for instance, is used for the treatment of approximately 5 million cubic meters of water a day. In this way Siemens ensures that global water resources are used more effectively, and that purified wastewater can be fed back into the water cycle.

Processing of wastewater cuts volume of biological solids

Europe's first Cannibal system for wastewater treatment from the Siemens Industry Solutions Division was put into operation in April 2008 at the Levico Terme sewage treatment plant in Levico, Italy. Compared with conventional systems, the Cannibal technology produces fewer biological solids, which means that landfilling and transport costs can be reduced. For example, in Levico, which has 100,000 inhabitants, biological solids have been reduced by about 50 percent to 370 metric tons a year. The special design of the decomposition and dewatering process also reduces energy and personnel costs.

Energy-efficient wastewater purification in the paper industry

Siemens has implemented a sustainable, and at the same time extremely energyefficient solution for the purification and treatment of industrial wastewater for Austrian paper producer Mondi Packaging GmbH. As part of an intelligent expansion of the company's existing mechanical/biological effluent treatment process, a fiber extraction system



and an anaerobic pre-stage have been integrated in the proven plant concept. The highlight in terms of climate protection and energy efficiency is the anaerobic stage that Siemens installed between the mechanical cleaning and activation stages. The expansion module not only enables the continued use of existing sections of the plant without modification, but also delivers up to 6,400 cubic meters of biogas per day that can be used for generating power at the facility. The carbon dioxide emissions of the entire plant are also reduced, thanks to the use of the biogas and the lower power consumption of the anaerobic stage.

All products, systems, and components used are elements of the Siemens Sipaper Water solution concept that has been specially developed for wastewater treatment in the paper and pulp industry.

Environmental technologies for keeping air cleaner

Apart from the carbon dioxide emissions, air pollutants such as nitrogen oxides and sulfur dioxide also contaminate the environment. Whereas in many industrialized countries, emissions of pollutants have remained stable or decreased as a result of intensified environmental activities, air pollution is still a serious problem, especially in the megacities of emerging nations.

Siemens offers a comprehensive portfolio of solutions for cutting emissions of air pollutants.

Technologies for flue gas desulfurization

Flue gas purification systems have been used for decades by Siemens as an effective means of controlling emissions from coal-fired boiler plants and industrial processes. Thanks to this experience, Siemens engineers can develop a reliable system tailored precisely to the customers' environmental requirements, as they have, for example, for U.S. power provider Reliant Energy. The system to be used there will remove pollutants such as suspended particles, heavy metals, and organic substances from the wastewater of the flue gas desulfurization plant, so that water can be discharged safely as effluent. The facility will go into operation in the second half of 2009.

Flue gas scrubbers are used in the U.S. to comply with the emission requirements of the Environmental Protection Agency

The principle of the electrostatic precipitator

In an electrostatic precipitator, ions electrically charge the soot or dust particles of the process gas. These charged particles are then taken up by an anode, known as the collecting electrode, and adhere to it because of their charge. They can then be removed mechanically by rapping. Up to 10 metric tons of dust a day can be filtered out at a coal-fired power plant in this way. In conjunction with modern power electronics, the carbon dioxide emissions of the plant can also be reduced by about 1,000 tons a year by optimizing energy efficiency.

(EPA). The core element of a flue gas desulfurization plant of this type is the scrubbing tower in which the unpurified flue gas is sprayed with a suspension of finely ground limestone.

The sulfur dioxide is largely absorbed by this scrubbing solution, and finally converted into gypsum that can be used, for example, for the production of plasterboard walls, or as an additive for cement.

Electrostatic precipitators: Lower dust emissions and higher energy efficiency

Siemens also makes an important contribution to increasing air purity with its newly developed electrostatic precipitators, which are used in waste gas purification at power plants, industrial companies, and garbage incineration plants, and achieve precipitation rates of nearly 100 percent. The Siemens Industry Solutions Division offers a comprehensive product portfolio over the entire life cycle, including high-voltage generators with thyristor plate and filter control, detailed concepts for the control of emissions including expert software, conversion kits for modernizing and improving existing filter systems, as well as consulting and services.

Cost-efficient environmental protection in steel production

Siemens has commissioned the world's first Meros (Maximized Emission Reduction of Sintering) system for cleaning sinter exhaust gases at the Austrian steel producer voestalpine Stahl GmbH in Linz,



one of the companies in the listed voestalpine Group.

This system is capable of treating up to 1,000,000 cubic meters of sinter exhaust gases per hour. The novel Meros dry scrubbing process reduces the emission of dust, heavy metals, sulfur dioxide, and organic compounds by significantly more than 90 percent in some cases.

In the Meros method, special absorbents and desulfurization agents are blown into the exhaust gas stream at high speed and are homogeneously distributed. In this way the heavy metals and organic components contained in the exhaust gas, as well as sulfur dioxide and other acid gases, are effectively bound. The sinter exhaust gas is then cooled and humidified in a specially designed reactor, thereby speeding up the chemical reactions for binding and precipitating sulfur dioxide and other acid gas components.

In a following step the dust particles flow with the exhaust gas stream into a fabric filter, where they are separated out efficiently. Some of the dust that is deposited in the filter is fed back into the exhaust gas stream to increase the effectiveness of the gas scrubbing process. Absorbents and desulfurization agents that have not been completely converted can in this way be brought back into contact with the exhaust gas, thereby increasing their effective utilization and substantially reducing operating costs.

Electrostatic precipitator as an environmentsaving solution in use: The US Steel Slovakia steelworks in Kosice, Slovakia, equipped by Siemens.

> Meros plant at voestalpine Stahl GmbH in Linz, Austria.



Sustainable development for cities



5. Sustainable development for cities

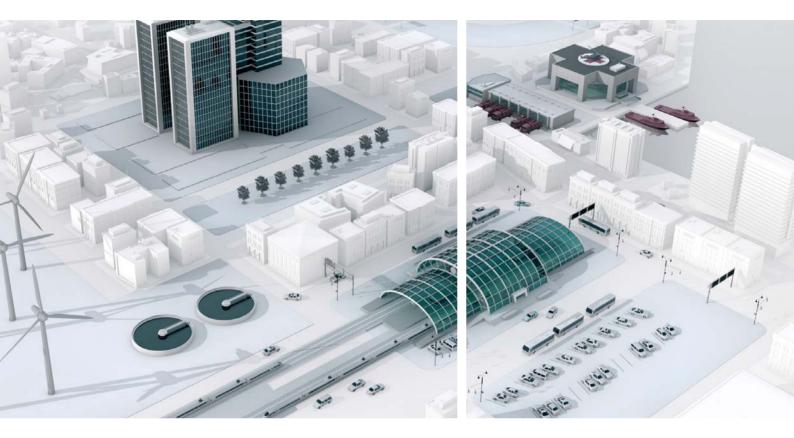
As dynamic markets for energy and goods, cities influence our way of life and the way entire regions use resources. Today, more than 50 percent of the human race lives in towns and cities, but that proportion is expected to increase. In fact, the further growth of cities and urban centers of population will be one of the megatrends in the coming decades. By 2025, the urban population will increase to 60 percent, according to United Nations forecasts. And by 2050, city and town dwellers will make up as much as 70 percent of the world's population. All told, about 90 percent of population growth by 2030 will take place in cities.

This urban-based population expansion will put enormous strain on our cities' and towns' infrastructure as well as on the environment. Already, today's cities directly and indirectly account for about 60 percent of drinking water consumption, around 75 percent of energy consumption and 80 percent of global greenhouse gas emissions. It is cities, therefore, that will determine whether we succeed or fail in combating climate change and environmental pollution.

Many cities have already recognized this problem and have placed environmental protection high on their list of priorities (described also in the Siemens Megacity Challenges report). However, cities have to maintain a difficult balance between environmental protection, quality of life and competitiveness. Unfortunately, concerns about the environment are often outweighed by the need for competitiveness. Yet medium- to long-term investments in protecting the environment pay for themselves many times over: first, they improve the quality of life for city dwellers; and second, they increase cities' economic efficiency.

Another study, "Sustainable Cities," has revealed that the use of currently available technologies can bring cities a big step closer to achieving their environment and climate protection targets. The study, which used London as an example and was co-funded by Siemens, showed that by using these technologies, cities can reach their environment and climate goals without a massive reduction in the quality of life of city dwellers. There are technological solutions for every aspect of the infrastructure, including buildings, the transportation system and the power supply system. Not only can these technological solutions play a significant role in reducing CO₂ emissions but they are also economically viable. In fact, two-thirds of the carbon dioxide abatement potential addressable with the technological levers analyzed in the study would pay for itself through the energy savings they generate. This amounts to about 30 percent of London's total emissions.

Sustainable development for cities



Siemens answers

With its unparalleled portfolio of efficient and environmentally friendly products and solutions, Siemens can help cities improve the sustainability of their urban infrastructures. The Siemens portfolio addresses the entire energy chain. That includes efficient power generation and its use in households, industry and transportation as well as the transmission and distribution of power. Our portfolio also includes state-of-the-art air and water pollution control technologies.

With its products and solutions, Siemens can create an efficient and environmentally benign power supply for cities – for example, low-emission combined cycle power plants, wind power plants, and smart grids that integrate renewable energy sources. And there are still other ways to save fuel. If a city has already installed a district heating network, for instance, or if there is an industrial buyer for processed steam, the waste heat from fossil fuel-fired power plants can be used via a combined heat and power system.

The process of modernizing buildings also offers great potential for better climate protection. Improving the insulation of houses can save a significant amount of energy. Technical equipment and lighting contribute to up to 60 percent of energy costs. But here, too, Siemens can help significantly reduce costs and trim a building's CO₂ footprint. For this Siemens offers, for example, energy-saving lamps, energy-efficient domestic appliances, efficient building automation, and optimized heating, ventilation and airconditioning systems. Energy-saving contracting from Siemens can also finance investments in modernizing building technology, with amortization guaranteed by savings on energy and operating costs.

Transportation is another area that offers considerable potential savings by using Siemens technologies. Siemens' Complete Mobility approach can create efficient solutions by interlinking different transportation systems. The Complete Mobility approach is also an effective and economical way to transport people and goods both safely and with minimal harm to the environment. LEDs in traffic lights and for street and airport lighting provide further potential for reducing transportation-related CO₂ emissions.

The environmental pollution generated by cities impacts the availability of clean drinking water as well as the level of airborne pollutants. But Siemens' technologies for controlling air and water pollution help reduce air pollution in cities and ensure that purified sewage water can be recycled into the water supply. Further technologies and financial solutions

6. Further technologies and financial solutions



The rapid growth in data volumes, the dramatic pace of development of computer power, and continually rising energy costs are forcing companies to modify the infrastructure of their data centers in line with the new fundamentals. In response to these challenges, Siemens IT Solutions and Services has developed the Transformational Data Center, an integral solution portfolio. Under the master concept of sustainability, it brings three conflicting areas, economy, ecology, and flexibility, into line, and addresses all aspects of a computer center, from plan-

ning, construction, and operation to outsourcing. The portfolio also comprises functionalities for the assessment and definition of the target architecture, a virtual enterprise computing platform, components for active energy management and for automation of the computer center.

It also benefits from Siemens' many years of experience in the operation of efficient computer centers. Through the consolidation of computer centers and the use of state-of-the-art virtualization technologies, capacity utilization levels have been raised to over 80 percent at the computer centers operated by Siemens. In addition, Siemens offers concepts for recycling energy which are used according to the situation at the location. These include, for instance, using waste heat or cooling by means of groundwater."



Further technologies and financial solutions



CCS – climate-friendly power plant technology

Power supply over the next few decades will be marked by a balanced mix of centralized and decentralized power plants, and of power taken from all available resources. Efficient and innovative technologies will become more important than ever for climate-compatible electricity generation.

Increasing importance of CCS

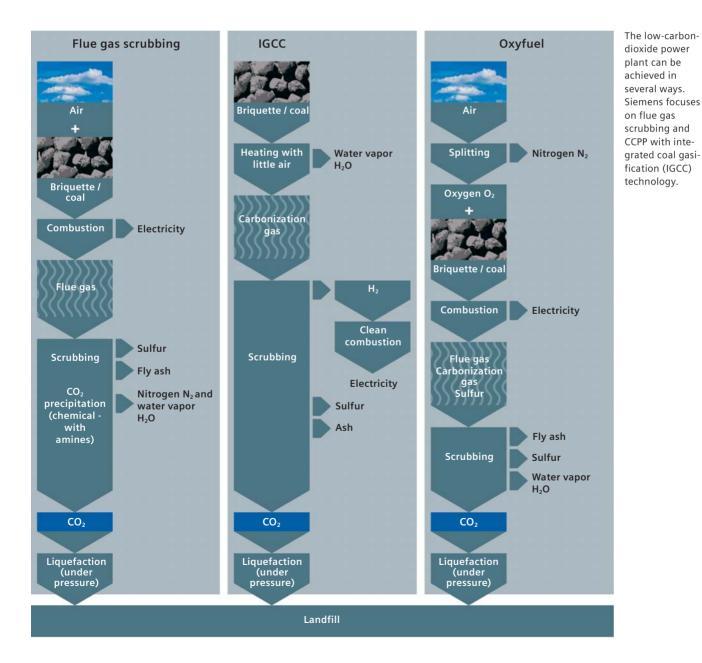
Technologies for carbon dioxide capture and storage (CCS) in coal-fired power plants will provide a crucial bridging solution, enabling substantial reductions in carbon dioxide emissions from coalfired power plants. Up to 90 percent of carbon dioxide emissions produced in the combustion process can be reduced with this technology. CCS describes the chain of processes whereby carbon dioxide is sequestered from the power plant process before or after combustion, compressed, and then stored in geological formations.

Siemens is developing two technologies in the area of clean coal electrification

for existing and new power plants. The first, for existing steam power plants and new plants, is the scrubbing and capture of carbon dioxide after combustion. The other technology, carbon dioxide capture before combustion, is used for new IGCC (Integrated Gasification Combined Cycle) plants. These are combined cycle power plants with integrated coal gasification and upstream carbon dioxide capture. Having acquired the coal gasification business of the Swiss Sustec Group, Siemens can offer the GSP entrained-flow gasification process, which forms a central element of climate-friendly IGCC power plants. Siemens technologies are also used for carbon dioxide transport and subsequent storage. Compressors supply the necessary pressure in the pipelines, and the pressure required for forcing the carbon dioxide deep underground. Here again, efficiency is called for, to minimize line losses.

State of the art

The various processes for carbon dioxide capture are presently being developed and tested. From today's technological viewpoint, flue gas scrubbing is the main process available as a retrofit for existing power plants (if these plants are captureready). However, to enable CCS technology to be used on a large scale, a reliable political and regulatory framework must first be put in place for implementing CCS and for constructing CCS demonstration plants to verify environmental compatibility and economic viability. If this succeeds, the zero-carbon-dioxide coal-fired power plant will be able to play an important role in delivering climate-friendly and reliable energy from 2020 onward.



Financing energy-efficient products and solutions

Although energy-efficient products and solutions to prevent carbon dioxide emissions often pay for themselves within an economically reasonable time frame, they usually require an initial investment that should not be underestimated. To enable the use of these innovative and energy-efficient products and solutions, Siemens not only manufactures them, but, when desired, it helps its customers to finance their purchase and use.

As an international provider of financial solutions in the business-to-business sector, Siemens Financial Services is able to offer its customers integrated technology and financing solutions.

LEDs for the city of Freiburg, Germany

The latest LED technology from Siemens is providing optimum safety in the traffic light system of the city of Freiburg. Siemens Financial Services developed a specific financing program for this purpose with a term of 15 years. The special highlight: The individual installments can be fully financed from the energy savings made possible by the new LED technology. It's not only good for the city of Freiburg, due to the lower electricity costs, it's also good for the environment, because of the lower carbon dioxide emissions.

In the energy sector, for example, Siemens Financial Services provided the financing for a Siemens turbine for the gas power plant of Solvay GmbH. In addition, WKN AG was established, a joint venture for the development of wind parks in Central and Eastern Europe. Siemens Financial Services not only provides a comprehensive set of solutions for equipment and sales financing, but, together with partners, it makes equity capital available worldwide through Siemens Project Ventures GmbH for infrastructure projects involving Siemens technology.

Siemens Venture Capital promotes the innovative start-up Zolo Technologies

Through Siemens Venture Capital GmbH Siemens invests its capital in young companies working with the Siemens Sectors, to develop innovative solutions for our customers, and to open up new markets.

In 2007, for example, Siemens Venture Capital invested several million dollars in the American start-up company Zolo Technologies, headquartered in Boulder, Colorado. In addition, Siemens entered into a cooperative distribution agreement with the company.

Zolo Technologies works on innovative technologies to optimize combustion in coal-fired power plants, in order to make the operation of the plants more efficient and thus more environmentally sound. The start-up company works closely with the Siemens Energy Sector in this area.

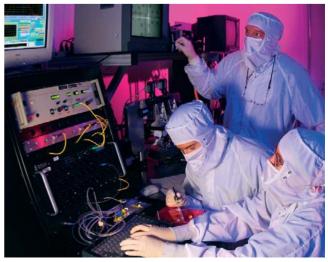
Using the laser-based smart measurement technology of Zolo Technologies, the air/carbon mixture in the combustion vessels of coal-fired power plants is analyzed in real time, and surface images of the processes in the vessel are calculated

> The new laserbased measuring technology from Zolo can help to significantly increase the combustion efficiency of coal-fired power plants.

by computed tomography methods. With the help of Siemens control technology, the control parameters of the vessel regulator can be optimized based on the values calculated by Zolo Technologies. By continually adjusting the fuel/air mixture, the most homogenous temperature distribution possible is ensured in the vessel so as to achieve an efficient and environmentally compatible power plant.

Through the use of this technology, the efficiency rate of coal-fired power plants can be increased by an estimated 3 percent. This means that 30 million tons of coal, or 0.7 percent of total energy, could be conserved every year in the United States alone, assuming this method to be used throughout the industry. That would correspond to 75 million tons of carbon dioxide emissions prevented.

The system is already installed with nine customers in the United States. In addition, in early 2008, the first equipment was supplied to South Korea, and at the plant of one German customer a vessel was made ready so that the system could be installed without interrupting power plant operation.



7. Our answer for the environment: the Siemens environmental portfolio



We help our customers reduce their carbon dioxide footprint, cut their life cycle costs and protect the environment with energy-efficient products and solutions, renewable forms of energy, and environmental technologies, as the numerous examples in the previous chapters illustrate. With our environmental portfolio we generate a threefold benefit: more cost efficiency and superior environmental performance for our customers, which in turn, benefits society and creates sustainable economic growth for Siemens.

Our environmental portfolio contains some outstanding products and solutions that make a direct, verifiable con-

Siemens' environmental portfolio: Triple win for customers, society and the company



tribution to environmental protection. These include:

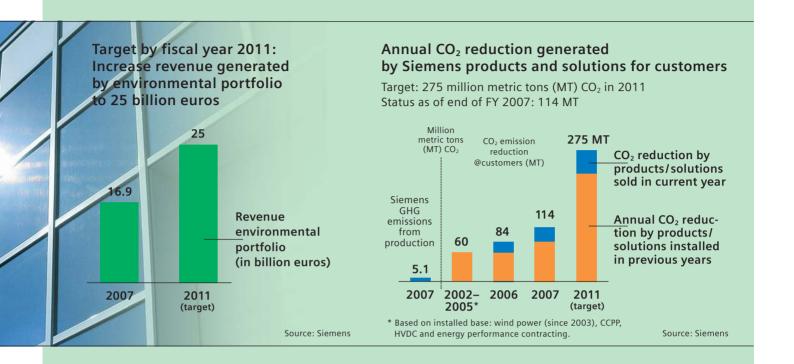
- Products and solutions that are significantly more energy-efficient than a reference solution (e.g. the average energy-efficiency of the installed base);
- Systems and components for renewable forms of energy;
- Environmental technologies.

Siemens' environmental portfolio is unique in that it spans the entire energy chain, as illustrated on the inside of the back cover.¹⁾

Ambitious growth targets

We are pursuing ambitious revenue targets with our environmental portfolio. In 2006, revenue totaled about 14.7 billion euros; in 2007 revenue totaled 16.9 billion euros, and we plan to achieve revenue of 25 billion euros annually with our environmental portfolio by 2011.

Our joint ventures such as BSH Bosch und Siemens Hausgeräte GmbH and Fujitsu Siemens Computers GmbH offer a variety of products and solutions with outstanding energy and/or ressource efficiency. However, we have limited the Siemens' environmental portfolio to products and solutions of Siemens AG.



Today, our environmental portfolio already accounts for more than 20 percent of our revenue. The markets we serve with this portfolio promise above-average growth, which is why we anticipate revenue from our environmental portfolio to grow at least 10 percent a year.

Siemens reduces many times more emissions at customers than it produces itself

Our efficient products, solutions, and technologies in the area of renewable energy make a measurable contribution to reducing our customers' emissions. That's why we believe our products and solutions make a vital contribution to climate protection.

Products and solutions installed in the period from the beginning of 2002 through the end of 2005 help reduce carbon dioxide emissions by 60 million metric tons annually, and that's only taking into account combined cycle power plants, wind turbines, high-

Three types of products and solutions qualify for the environmental portfolio



Grid access for wind power

Steam turbines for solar power

All environmental

technology qualifies

Environmental



Examples:

- Water technologies
- Air pollution control

B Efficient products/ solutions

Products/solutions that are especially energy efficient qualify



Examples:

- Combined Cycle Power Plants (CCPP)
- High-voltage DC (HVDC) power transmission
- Efficient lighting
- Intelligent building technologies

Source: Siemens

voltage DC power transmission (HVDC), and the energy savings achieved through performance contracting by Siemens Building Technologies. The new products and solutions of the environmental portfolio our customers installed in 2006 and 2007 prevented emissions of another 24 and 30 million metric tons respectively of carbon dioxide, bringing the volume of carbon dioxide emissions saved in 2007 to a total of 114 million metric tons. That's equivalent to nearly 13 percent of Germany's total carbon dioxide emissions in 2006, and over 20 times Siemens' own greenhouse gas emissions of 5.1 million metric tons in 2007.

Our aim for 2011 is to help our customers reduce greenhouse gas emissions by 275 million metric tons.

Transparent calculation of the reduction in emissions

The calculation of the savings of greenhouse gas emissions is based on a specific comparison for every relevant product and solution in the environmental portfolio.

We mainly applied three different methods for determining the reduction in emissions:

- Direct before-and-after comparison of the emissions; as, for example, in the case of modernizing power plants, or optimizing the energy consumption of buildings through Energy Performance Contracting.
- Direct comparison with a reference technology; for example, the reduction of emissions when using lowloss, high-voltage DC (HVDC) power transmission is determined by comparing HVDC with conventional AC power transmission.
- Comparison with the installed base. This method was used for combined cycle power plants and trains. Here, global average emission factors for electricity generation were applied.

Category	Emission factor (g CO₂/kwh)	Benchmark for product/solution from the environ- mental portfolio
Global power generation – all primary energy carriers	578	Power generation except renewables
Global power generation – fossil energy carriers	870	Power generation Renewables/wind
Global power generation – primary energy carrier coal	940	Service for electrostatic precipitators
Utilization of electricity – (including transmission losses of 9.3%)	631	All types of utilization of electricity apart from trains
Utilization of electricity – railway power supply (incl. 6% transmission losses)	612	Trains

On the basis of data from the International Energy Agency (IEA Electricity Information 2007) on gross electricity generation and transmission losses, data from the Intergovernmental Panel on Climate Change (IPCC) on fuelspecific emission factors, and our own analysis of power generation efficiencies, we applied the following emission factors, which are shown in the table as the baselines.

When calculating emission reductions at our customers' locations we concentrated on the carbon dioxide saving in the utilization phase.²⁾ For the products and solutions installed during a fiscal year the decrease in emissions for the entire fiscal year was calculated. The

The procedure for calculating emission reductions can be clearly illustrated using the example of our current generation combined cycle power plants. These have an efficiency of about 58 percent. Combined cycle power plants using gas as fuel thus have an emission factor of about 345 grams of carbon dioxide per kwh. As a comparison value we used the global average emission factor for electricity generation for all energy sources, which is 578 grams of carbon dioxide per kwh. The difference multiplied by the annual electricity production in the combined cycle power plants annually installed by Siemens gives the figure for the emission reduction.

carbon dioxide emissions from the manufacture of the individual products are shown in our own carbon dioxide footprint and are not included in the emission calculations shown here.

Details regarding our greenhouse gas emissions are available in our Corporate Responsibility Report 2007 (www.siemens.com/responsibility).

An independent review by PricewaterhouseCoopers (PwC) confirms our figures

Siemens commissioned PricewaterhouseCoopers to conduct an independent review (a so-called limited assurance engagement) of the Siemens environmental portfolio. Among other things, PwC reviewed the quality of the information on revenues from our environmental portfolio and our customers' carbon dioxide reduction according to the five criteria specified in the Greenhouse Gas Protocol's Accounting and Reporting Principles: relevance, completeness, consistency, transparency and accuracy. The result of this review is shown in the Independent Assurance Report on the following pages.

²⁾ In the case of gas-insulated substations we have additionally converted sulfur hexafluoride into carbon dioxide equivalents in order to carry out an overall comparison of the systems.

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Independent assurance report

To Siemens AG, Munich

We have been engaged to perform a limited assurance engagement on selected data regarding the environmental portfolio 2007 as reported in the publication "Energy efficiency and environmental care – Innovation for climate protection" of Siemens AG.

Responsibility of Siemens AG's Managing Board

Siemens AG's Managing Board is responsible for the compilation of the environmental portfolio 2007 in accordance with the criteria

- Relevance,
- · Completeness,
- Consistency,
- Transparency and
- Accuracy

as set out in the publication "A Corporate Accounting and Reporting Standard – Revised Edition" of the Initiative Greenhouse Gas Protocol (pp. 8 to 9, hereinafter the "criteria of the GHG protocol").

This responsibility includes the selection and application of criteria as well as of appropriate methods to prepare the environmental portfolio and the use of assumptions and estimates of individual data which are reasonable in the circumstances. Furthermore, the responsibility of Siemens AG's Managing Board includes designing, implementing and maintaining systems and processes relevant for the preparation of the environmental portfolio.

Practitioner's Responsibility

Our responsibility is to express a conclusion based on our work performed as to whether any matters have come to our attention that cause us to believe that the following data in the publication "Energy efficiency and environmental care" has not been prepared in accordance with the criteria of the GHG protocol:

- The data on page 44 regarding the revenues of Siemens AG arising from products and solutions of the environmental portfolio in the fiscal year 2007;
- The data on page 45 regarding the quantity of CO₂, which is saved due to the use by customers of products and solutions of the environmental portfolio sold in the fiscal year 2007.

Furthermore, it is our responsibility to express a conclusion based on our work performed as to whether any matters have come to our attention that cause us to believe that

- the criteria and overall guidelines underlying the environmental portfolio,
- the baselines respectively reference values underlying the CO₂ savings and
- the methods of calculating the CO₂ savings

as reported on pages 44 to 46 of the publication "Energy efficiency and environmental care" have not been selected and applied in accordance with the criteria of the GHG protocol.

Moreover, we have been engaged to express recommendations for further developments of the environmental portfolio based on the results of our limited assurance engagement.

We conducted our work in accordance with the International Standard on Assurance Engagements (ISAE) 3000. This Standard requires that we comply with ethical requirements and plan and perform the assurance engagement to express our conclusion with limited assurance.

In a limited assurance engagement the evidencegathering procedures are more limited than in a reasonable assurance engagement (for example, an audit of financial statements in accordance with § (Article) 317 HGB ("Handelsgesetzbuch": "German Commercial Code")), and therefore less assurance is obtained than in a reasonable assurance engagement. The procedures selected depend on the practitioner's judgment. This includes the assessment of the risks of material incompliance of the data regarding the environmental portfolio set forth above as well as of the additional subject matters set forth above with the criteria of the GHG protocol.

Within the scope of our work we performed amongst others the following procedures:

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- Verification of the application of the criteria and overall guidelines underlying the environmental portfolio by inspecting the documentation of the systems, processes and documents of the environmental portfolio;
- Evaluation of the procedures and systems, which represent the basis for the determination of the baseline / reference values regarding the products and solutions of the environmental portfolio;
- Inquiries of the Corporate Environmental Affairs & Technical Safety Department responsible for the preparation of the environmental portfolio;
- Inquiries of the personnel of the involved Divisions in the Industry, Energy and Healthcare Sectors as well as inspection of the respective documentation of the environmental portfolio;
- Verification of the determination of the sum of CO₂ emission saved by the environmental portfolio as well as of the revenues of Siemens AG arising from products and solutions of the environmental portfolio in the fiscal year 2007 by
 - Understanding the single steps of calculation,
 - Checking the consistent application of baselines and reference values in the steps of calculation,
 - Comparing on a sample basis the calculation of the input transaction data with data from the company-own systems and documentations of product sales in the fiscal year 2007;
- Comparison of the calculations of the percentage of revenues of the environmental portfolio to the overall revenues of Siemens with the respective revenue data as set forth in the annual reports of the company for the fiscal year 2007.

Conclusion

Based on our limited assurance engagement, nothing has come to our attention that causes us to believe that the following data in the publication "Energy efficiency and environmental care" has not been prepared in accordance with the criteria of the GHG protocol:

- The data on page 44 regarding the revenues of Siemens AG arising from products and solutions of the environmental portfolio in the fiscal year 2007;
- The data on page 45 regarding the quantity of CO₂, which is saved due to the use by customers of products and solutions of the environmental portfolio sold in the fiscal year 2007.

Furthermore, nothing has come to our attention that causes us to believe that

- the criteria and overall guidelines underlying the environmental portfolio,
- the baselines respectively reference values underlying the CO₂ savings and
- the methods of calculating the CO₂ savings

as reported on pages 44 to 46 of the publication "Energy efficiency and environmental care" have not been selected and applied in accordance with the criteria of the GHG protocol.

Emphasis of matter – Recommendations

Without qualifying our conclusion above, we recommend for the further development of the environmental portfolio the following:

- The systems and processes for the preparation of the environmental portfolio as yet developed on a project basis should be transferred into regular operations. We recommend putting the internal control system and the documentation underlying the systems and processes on an institutional basis.
- We recommend designing the processes for the calculation and documentation as well as the approval procedures for the calculation results in the divisions consistently in the whole group.
- For the addition of Siemens products into the environmental portfolio and for the further development of criteria, overall guidelines and calculation methods we recommend implementing a Review Board.

PricewaterhouseCoopers Aktiengesellschaft Wirtschaftsprüfungsgesellschaft

Frankfurt am Main, June 5, 2008

signed Michael Werner signed ppa. Dieter Horst

The Siemens environmental portfolio



*) Further information regarding the Siemens environmental portfolio, including the solutions not presented here, is available at: www.siemens.com/environmentalportfolio





























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The information in this document contains general descriptions of the technical options available, which do not always have to be present in individual cases. The required features should therefore be specified in each individual case at the time of closing the contract.

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