A blanket of illumination as seen from space is a reminder of our planet's hunger for energy, which is expected to increase by 55 percent by 2030. By 2020, Earth will be home to eight billion people.

Light at the End of the Tunnel

The world's population is growing — as is its thirst for energy, which is increasingly being quenched, especially in emerging markets, by streams of coal. But solutions are in sight. Emissions can be cleaned and CO_2 can be sequestered. Efficiency can stretch supplies and cut pollution. And new, renewable energy technologies are right around the corner.

Astronauts working at the International Space Station (ISS) are treated to a spectacular view as they orbit the earth. With each revolution, the earth grows dark, and billions of lights 390 kilometers below join to form a shimmering meshwork that extends across land masses like a spider web. This light is, in fact, the only visible sign of civilization on our planet, at least as seen from space.

The sea of light continually expands as the earth's population grows. According to the UN, there will be eight billion people living on our planet in 2020. As prosperity spreads, these people will seek a higher standard of living, and will thus begin buying more and more electrical appliances, cars, and other products, which in turn will necessitate the construction of new factories and offices. More than anything else, all of this will require huge amounts of energy.

"Energy is a necessity of life," says Professor Peter Hennicke, former head of the Wuppertal Institute for Climate, Environment, and Energy. "But it can also be a curse if you look at it in terms of climate change, resource depletion, and the failure to use and produce it efficiently and economically." Unfortunately, we're still far from doing that, according to the International Energy Agency (IEA), and things won't get any better if current trends hold up. The IEA predicts that global primary energy consumption will increase by 55 percent between 2005 and 2030 if the current environmental policy framework remains unchanged (see p. 15). Consumption would thus rise to 18 billion tons of oil equivalent (toe) per year, as compared to 11.4 billion toe in 2005.

The IEA study says developing countries will be responsible for 74 percent of this increase in primary energy consumption — with China and India alone accounting for 45 percent. Moreover, both of these countries will meet most of their energy needs with coal because, unlike other raw materials, coal remains abundant and is currently cheaper than renewable energy sources. China already has a huge hunger for coal. The country put 174 coal-fired power plants online in 2006 alone, which averages out to one new plant every two days. This is a climate-change nightmare, says Hennicke, especially when you consider the fact that facilities built today will remain in operation for the next 30 years. "In order to contain the associated risks to the climate, we have to exploit the most effective, fastest, and least expensive potential solution: energy efficiency."

China is aware of the problem, and has therefore included in its 11th Five-Year Plan strict stipulations for reducing environmental pollution and improving energy efficiency. New technologies from Siemens are pointing the way here.

Take, for example, China's most modern electrical power plant, the Huaneng Yuhuan coal-fired facility (see p. 18). Since November 2007, so-called ultra super-critical steam turbine units and generators from Siemens have made possible an efficiency rating of 45 percent at Huaneng Yuhuan. That's 15 percentage points higher than the global average for hard-coal power plants and seven percentage points more than the EU average. This is significant, since one percentage point of higher efficiency translates for a mid-sized power plant into around 100,000 fewer tons of CO_2 per year. "If we use the same technology in future projects, it will make a huge contribution to improving energy efficiency and environmental protection

in China's electrical power generation industry," says Hu Shihai, Deputy Managing Director of the China Huaneng Group.

Scientists at Siemens' Energy unit in Mülheim an der Ruhr, Germany, are working on so-called 700-degree technology (see p. 32) as a means of increasing the efficiency of coal-fired power plants, which remain in great demand. Here, experts are trying to get turbines to withstand extremely high steam temperatures, since the higher the temperature, the more efficient the system will be. New materials and manufacturing techniques are being studied in an effort to achieve a temperature of 700 degrees Celsius and pressure of 350 bars, which is around 100 degrees and 65 bars more than the norm in today's power plants. Only at those new high levels can an efficiency rating of 50 percent be achieved.

Separation and Sequestration. Development engineers are also looking at other concepts for making coal-fired power plants more climate friendly. One approach involves separating the carbon dioxide created by the coal-burning process, and storing it below ground to keep it out of the atmosphere. This would amount to nearly CO_2-free electricity production (see p. 36). One promising technique is coal gasification in Integrated Gasification Combined Cycle (IGCC) power plants. IGCC plants transform coal and other fuels like oil and asphalt into a synthetic gas that drives a turbine. This gas is a mixture of hydrogen and carbon monoxide from which the CO_2 can be separated relatively easily, leaving only pure hydrogen behind. "We're ready to start construction of a major IGCC facility anytime," says Dr. Christiane Schmid from Siemens Fuel Gasification Technology GmbH, in Freiberg, Germany. "Siemens, after all, has been involved in the development of optimized IGCC concepts for years now." Spain and the Netherlands, for example, already have IGCC power plants with Siemens technology in operation.

But before such plants can be built, a number of hurdles will have to be overcome. The problem is that the legal framework for efficient CO_2 sequestration still hasn't been clarified, and locations where CO_2 might be stored have yet to be found and tested. Today, a handful of oil and natural gas companies pump the CO_2 that reaches the surface as a result of drilling back into the cavities it came from — and they do this mainly to increase gas and oil yields through the increased pressure such pumping creates.

The world's most extensive study of underground CO_2-storage possibilities is currently being carried out in the small town of Ketzin (near Berlin) by scientists from the German Research Center for Geosciences in Potsdam (see p. 40), who plan to deposit 60,000 tons of carbon dioxide in special rock strata 700 meters below ground over the next two years. CO_2SINK, as the EU-sponsored project is known, will examine how the gas reacts after being pumped underground and will determine whether it could threaten to find its way back to the surface.

Geologists believe that CO_2 can be trapped for thousands, or perhaps millions, of years, which means commercial CO_2 storage and climate-friendly coal power plants may become a reality. "Still, it's going to take time before such facilities can operate economically," cautions Hennicke. "That's why, in addition to focusing on producing energy more efficiently, we should be trying to use it much more efficiently as well." A country such as Japan could reduce CO_2 emissions by 70 percent between now and 2050 through more efficient utilization of energy, with only marginal additional costs, according to Hennicke.

Operators of an indoor swimming pool in Vienna, Austria, are already reaping the benefits of more efficient energy use. Thanks to a clever energy-saving model and building management system from Siemens, the pool facility now produces around 600 tons less greenhouse gas per year than in the past. The Siemens setup not only helps the environment; it's also saving the pool's operator €200,000 per year on heating and water costs (see p. 29).

Siemens has already implemented nearly 2,000 such projects worldwide. It's a win-win situation for companies and the environment alike, as the savings potential is huge. According to the IEA, buildings account for around 40 percent of global energy consumption and 21 percent of CO_2 emissions.

> "We have to exploit the most effective, and least expensive potential solution: energy efficiency."

74 percent of the increase in global primary energy consumption will take place in emerging economies.

Also in need of an energy diet are the approximately 30 million servers around the world that keep the Internet up and running. According to Stanford University, operating these computers requires the energy generated by 14 power plants in the 1,000-megawatt class. Cutting down on energy consumption here would also produce impressive results (see p. 54). "Computer centers could reduce electricity consumption by more than one-third if they switched over to more efficient technologies," says David Murphy, who coordinates "Green IT" projects at Siemens IT Solutions and Services. Such projects will become more and more important in the face of rising energy prices and growing CO_2 emissions.

For all its negative publicity, carbon dioxide has one positive characteristic: it has led to a huge innovation boom in the areas of energy efficiency and environmentally-friendly technologies. A perfect example is the state of California, whose universities, strict environmental regulations, and venture capitalists make it possible for companies that produce clean technologies, among them Siemens, to flourish (see p. 22). Environmental technology is currently the fastest-growing sector for venture capital investment, accounting for one-third of all such investment in the U.S. in 2007.

The solutions being developed — ranging from extremely efficient computer chips to plug-in hybrid vehicles that "fill up" on sunlight — are pioneering, says Hennicke. "Moreover," he adds, "if the U.S. would even come close to exploiting its potential for renewable energy, we would see a huge wave of innovation that would bring us a lot closer to our goal of providing energy to billions of people in a sustainable manner." ■ *Florian Martini*