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RESEARCH AND DEVELOPMENT FOR MORE ENERGY EFFICIENCY

The article is devoted to the problem what will our energy sector look like in the near future and later on. Already, there are many indications that we will be relying less and less on large, central power stations for our heat and electricity needs. Our daily energy-use cycle could look something differ.

Keywords: *power station, climate change, energy, solar, new technologies, biomass, hydroelectric power.*

Introduction. Climate change, global warming and rising sea levels: by now, most people around the world have heard of these global problems. At the same time, many of the world‘s countries view economic development and technological progress as key ways of achieving peace and building prosperity. Observers may see a contradiction in these trends – that some people are working to slow and stop climate change even as others are pushing progress in ways that could ultimately add to our climate woes. The best way to see such seemingly contradictory trends is to see them as challenges. And energy – i.e. solving the problems involved in producing and usingenergy – is a key to meeting such challenges.

Electrical energy already accounts for 40 percent of the energy consumed world-wide, and experts expect that share to increase to 60 percent by 2040. In the many different types of electrical devices now in use – including MP3 players, power supply units and electric cars – electricity is converted in many different ways. Electrical energy is converted and distributed by means of power electronics devices and systems, which represent yet another key technology for efficient resources use. It is estimated that optimization of power-electronics components has the potential to provide energy savings of 20 to 35 percent. On the basis of the „ICT 2020 – Research for Innovation“ framework programme, therefore, the Federal Government is promoting interdisciplinary research and development projects on the topic of „Power electronics for increasing energy efficiency“ .

Developing new sources of energy –research and science for new resources

Researchers and politicians alike understand that, in the medium term, the world will not be able to meet its growing energy needs without continuing to rely on fossil fuels. And yet the world‘s natural gas, oil and coal reserves are limited. While coal reserves are expected to last for another 100 years, oil and gas reserves are expected to run out significantly sooner. While nuclear power is not subject to such limitations, its suitability as a substitute for conventional energy sources is a matter of public controversy. In Germany, nuclear power is seen as a technology that can serve

in a transitional role for a limited period of time. Clearly, renewable energies are the most important option for the future. In particular, energy researchers have great hopes for use of solar energy, of which there is a great surplus. A simple relationship highlights the enormous potential of solar energy: In only six hours, enough solar energy reaches the earth‘s surface to meet the world‘s electricity needs for an entire year. What is more, solar energy is clean energy. The decisive challenge, then, is to find the most effective way of using
this inexhaustible energy source.

The forces of the future

Solar energy is already being used in many ways to produce heat and electricity. The solar cells in photovoltaic systems generate electricity directly from sunlight, while the solar collectors in solar-thermal systems turn sunlight into heat. The heat from solar-thermal systems, in turn, can be used either for heating or for operation of heat pumps that generate electricity. Plants store solar energy as biomass. Biomass, as well as biofuels and biogas, can be burned in order to release such energy in the form of heat. And even the wind that drives wind turbines is ultimately solar in origin, since the sun powers our global wind system. The sun‘s energy is present on the earth in many different forms, and thus there are many options for using solar energy in the future. Scientists are even developing processes for controlled nuclear fusion, i.e. for turning mass into energy the way the sun does. Nuclear fusion technology is also seen as climate-friendly and environmentally friendly.

Hydroelectric power world-wide

Moving water also holds a great deal of energy: River currents can be harnessed todrive turbines that generate electricity. In mountain regions, dammed reservoirs and hydroelectric generating systems are important energy suppliers. Hydroelectric power currently meets some 3.2 percent of Germany‘s annual electricity requirements.Among renewable energies in Germany, hydroelectric power thus ranks third in importance. On a global scale, hydroelectric power plays a far more significant role,however. Hydroelectric power stations meet a total of 16 percent of the world‘s power requirements – thereby surpassing even nuclear power, which currently supplies some 15 percent. The growth potential of hydroelectric power tends to be especially great in countries with low population densities.

Combined solar power:linked rooftops create enormous power stations

Experts forecast that by 2050 photovoltaic systems will be meeting some 25 percent of our electricity needs and solar-thermal systems will supply 30 percent of our heating requirements. German researchers are making important contributions to the improvement of these technologies. Such contributions are seen, for example, in the world‘s largest solar-thermal power station, which is located in Andalusia (Spain) and was commissioned in 2009. With a total area of nearly two square kilometres, the facility has over 600 parabolic-trough collectors and a heat-storage system, and it supplies power for 200,000 people. The facility is now in commercial operation, and two additional solar-thermal power stations will soon be added. One of those will be a solar-tower system of Julich research centre that is expected to feed one million kilowatt-hours of electricity into the German grid.Recently, a scientific project that experts long thought would always remain a fantasy has been generating a great deal of excitement: Desertec. This project, which is being moved forward by a consortium of twelve European and African companies, is built around an idea that is at once simple and highly appealing: Building largesolar-thermal power stations on thousands of square kilometres of Saharan desert.Special transmission lines will transport the electricity generated by the power stations to Europe. Theoretically, a 90,000 square-kilometre complex of such solar-thermal systems would suffice to meet all of the world‘s electricity needs. That area is equivalent to about one percent of the Sahara‘s area. The co-operating partners have set their sights on a more modest first goal, however: Having the desert power meet 15 percent of Europe‘s electricity requirements by 2050. By 2020, electricity from the desert could already be cheaper than electricity from domestic power stations.

The sun on the earth:nuclear fusion

Energy researchers also have great hopes for nuclear fusion. In its basic principle, nuclear fusion differs radically from the nuclear fission normally used to produce „nuclear power“. While man-made nuclear fusion would draw on the same mechanisms that power the sun, it would be adapted to circumstances on the earth. In the fusion process, atomic nuclei would fuse with each other within a low-pressure gas heated to over 100 million degrees Celsius. Future fusion reactors would use deuterium and tritium as their fuels. Both are heavy isotopes of hydrogen. From a single gram of hydrogen, a fusion reaction would release as much energy as is contained in eight tonnes of oil.

Deuterium, one of the two basic fuels for nuclear fusion, can be obtained from water and thus would be available in nearly unlimited amounts. Tritium, by contrast, is extremely rare. Although it has to be added to the reactor before the process begins,it is produced continually during the actual fusion reaction. Nuclear fusion has a great advantage: It is absolutely climate-friendly. At the same time, while nuclear fusion is considered safe, it presents a major challenge. Temperatures of 500 million degrees have been reached in research reactors. Nonetheless, nuclear fusion is an extremely sensitive process, relatively vulnerable to disruption. In all fusion experiments conducted to date, more energy had to be invested in heating the plasma than the nuclear fusion reaction was able to produce.

Heat from the depths of the earth

The interior of our own planet also holds a nearly inexhaustible supply of energy –geothermal energy. The earth‘s geothermal energy is continually escaping – unused –into the atmosphere. The amounts involved add up to about 2.5 times our total global energy requirements. In Germany, the southern German Molasse basin, the Upper Rhine Plain and the North German Plain are considered to be particularly suitable for large geothermal-energy systems. In those areas, temperatures of about 150 degrees Celsius prevail at depths of several kilometres – and such temperatures provide an excellent basis for heat production, and even electricity generation, at the earth‘s surface.

There are various ways of using geothermal energy. In one proven method, two or more deep wells are used to pump water from hot, deep rock layers to the surface. Heat exchangers remove the thermal energy from the hot water that rises in a production well. Once the water has cooled, it is returned to the earth via an injection well.One advantage of geothermal power stations is that they, unlike wind power or solar energy systems, can produce heat and electricity around the clock. They thus can serve as base-load power stations. Such systems still contribute little to Germany‘s overall energy mix: As of the end of 2008, their contribution amounted to one gigawat of geothermal energy output.

Biomass-stored energy

Impressive amounts of energy can be obtained from plants: In 2008, a total of 4.5 percent of the electricity consumed in Germany was generated from solid and liquid biomass.The specific energy sources involved include biogas, landfill and sewage gas and collected garden and kitchen waste. In addition, biomass provides 90 percent of Germany‘s heat from renewable energies. Biomass thus ranks ahead of hydroelectric power and wind power on Germany‘s list of most important renewable energies Use of biomass as a fuel calls for a special sense of responsibility. In light of limited available croplands, biomass cultivation must not be permitted to stand in the way of food production. What is more, cultivation of crops that require intensive fertilisation, such as corn, can release nitrous oxide, a potent greenhouse gas. One alternative can be the use of algae, which have a high energy density. The overall ecological balance is also favourable for residual biomass, such as waste wood or straw. One project currently underway is aiming to produce synthetic fuels from such biomass. The great advantage of such an approach: Like petrol and kerosene, such fuels can be used in conventional engines and combustion systems. Thisis why aviation-sector researchers are driving the development of this technology.

How the world is learning to save energy

Saving energy is an important key to a peaceful future on a healthy earth. Experience has shown that energy-saving is dependent on incentives provided via intelligent policies. One such incentive is trading in CO_2-emissions allowances. Reducing emissions primarily means reducing use of fossil fuels. The advantage of emissions trading is that it places a cap on total greenhouse-gas emissions. A price on CO_2 emissions cannot fail to have a wide range of economic consequences, however – and thus the emissions trading scheme needs to be supported by careful economic analysis. In the EU, this effective instrument will prompt power station operators and energy intensive industrial sectors to seek efficiency gains. In a next step, Europeans, as important energy consumers, need to find similarly intelligent solutions to the emissions problems in their transport, agriculture and residential sectors. The EU has enacted numerous individual regulations aimed at reducing energy consumption of automobiles, household appliances and lamps. But no one can currently predict how much energy-saving and CO_2 reductions such fragmentary individual measures will bring – especially since, as sociologists have discovered, labeling of devices as „efficient“ tends to prompt users to intensify their use.

Energy use in the European Economic Area has already grown at least somewhat more efficient: Since 1990, the region's energy intensity has decreased by 25 percent. Due to strong economic growth, total energy consumption during the same period declined by only ten percent, however. Europe's eastern Member States still have poor energy efficiency standards. Globally, energy efficiency is especially low in threshold and developing countries. If „old Europe" can assist such other countries in this area, both politically and technologically, all of Europe and the world alike will benefit. And Germany, as an economic, technological and scientific heavyweight, can have a great positive impact.

The recent natural gas dispute between Russia and Ukraine hit the new EU Member States particularly hard with sudden supply disruptions. And the conflict put a spotlight on a European weakness: National boundaries can still function as barriers within Europe's gas and electricity distribution networks. During the conflict, gas levels in European gas reservoirs would have sufficed for emergency deliveries to the affected countries. The importance of a well-developed natural gas network within Europe is thus not limited to the task of promoting competition in the energy market.It also lies in the ability to protect the European Community against such critical supply disruptions.

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Conclusion

Greater Europeanisation – and, later, globalisation – of the energy sector also means the following: The participating countries have to be willing to phase out their own energy policy sovereignty in favour of greater international interconnection. Participating countries will accept such losses of power and influence in energy policy only if energy networks are controlled by new, strong international institutions in which all connected countries play a role. Such institutions would necessarily safeguard transparency, fair conditions and a framework of solidarity. They would offer many other advantages as well. For example, they could exert effective political leverage in favour of more intelligent technologies that would save energy and reduce greenhousegas emissions.

For the European Union, this step into a common future represents a major challenge. For the world as a whole, it will call for a great deal of finesse, patience, endurance and courage.

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